CEREAL MARKET PERFORMANCE IN ETHIOPIA:

Policy Implications for Improving Investments in Maize and Wheat Value Chains

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Acronyms and Abbreviations

ATA	Agricultural Transformation Agency
ADF	Augmented Dickey-Full
AGP	Agricultural Growth Project
AGP2	Second Agriculture Growth Project
AIC	Akaike information criterion
AMC	Agricultural Marketing Corporation
ANOVA	Analysis of Variance
ARCH	Autoregressive Heteroscedasticity
CSA	Central Statistics Agency
ECX	Ethiopian Commodity Exchange
ECM	Error Correction Model
EDRI	Ethiopia Development Research Institute
EFSRA	Ethiopian Emergency Food Security Reserve Administration
EGTE	Ethiopian Grain Trade Enterprise
ETB	Ethiopian Birr
ETBC	Ethiopian Trading Business Corporation
ECX	Ethiopian Commodity Exchange
FCA	Federal Cooperative Agency
FGD	Focus group discussions
GARCH	Generalized Autoregressive Heteroscedasticity
GoE	Government of Ethiopia
GSR	Gross storage return
HL	Half-Life
IDA	International Development Association
IFPRI	International Food Policy Research Institute
JEOP	Joint Emergency Operations Partners
LB	Lijung-Box
LM	Lagrange Multiplier
NDRMC	National Disaster Risk Management Commission
OLS	Ordinary least squares
PAC	Partial autocorrelation
PBM	Parity Bound Modeling
PP	Philipps-Perron

PSNP	Productive Safety Net Program
SBIC	Schwarz's Bayesian Information Criterion
SNNP	Southern Nations and Nationalities People
TAR	Threshold Auto Regressive
TVECM	Threshold Vector Error Correction Model
USAID	United States Agency for International Development
VC	Value Chain
WFP	World Food Program

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Executive Summary

I. Background and Justification

The efficient functioning of cereal markets is important given the significant share of cereals in food expenditures of households in low-income countries. Cereals comprise half of consumer food expenditures in Ethiopia, and about 75 percent of the land area under cultivation (Central Statistics Agency 2012). With the recent food price inflation and concerns regarding the impact of the 2015/26 drought related to *El Nino*, understanding the performance of food markets has found renewed interest among governments, development banks, and local and international organizations.

For Ethiopia, this is particularly relevant given the disastrous implications that poorly functioning food markets have had in the past on food security (Minten *et al*, 2014). Due to these concerns, price stabilization and food security have emerged as the two key objectives behind the government's policy on grain marketing. To stabilize grain prices and reduce the risk of high price volatility in the food sector, the government maintains a strategic stock reserve, and has banned grain exports in response to rising prices (2006-2008). In the case of wheat, it imports wheat and sells it at subsidized prices to selected mills that eventually sell to retailers at a fixed price. The retailers then sell the subsidized bread to consumers. In addition, relief agencies provide food aid to assist food insecure households. The Productive Safety Nets Program (PSNP) also assists through cash and food transfers.

How well cereal markets are integrated across time and space matters. This has implications for the efficiency of cereal markets and the effectiveness with which they can respond to food emergencies in the country. Further, post-harvest handling and storage investments are critical to ensuring the availability of grains, especially in enabling the government to respond to food emergencies. However, the level of price volatility affects marketing and storage decisions at all levels of the value chain. Volatile food prices would also affect the procurement decisions of agri-businesses involved in food distribution, processing, and retailing such that farmers would be faced with lower and more variable demand in selling markets. The aggregate effect is reduced economic activity in the food sector. This leads to a decreased and variable supply of food commodities and food products, which in turn further exacerbates price volatility. It also generates upward pressure on food prices for consumers (World Bank 2016). Hence, assessing the performance of cereal markets requires in-depth analysis regarding price volatility as it is a good indicator of the level of risk in the market, which in turn affects the behavior of the value chain actors.

Currently, there is little private sector investment in grain storage facilities. Most storage warehouses at the primary cooperative and farmers' union levels are funded by the public sector. About $32.7 million of International Development Association (IDA) funds under the Agriculture Growth Project (AGP) were allocated for market infrastructure development, including piloting the construction of forty-four storage warehouses with the objective of further scaling up. Under AGP 2, the government requested $11 million toward the construction of more storage warehouses for unions and primary cooperatives.

Before constructing more warehouses, though, it is important to shed light on why the private sector is not investing in grain storage. Is public sector investment in grain storage facilities crowding out private investment or are the incentives for the private sector to invest in storage low and, if so, why? Although the government regards cooperatives as private entities, public resources subsidize most of their marketing infrastructure investments.

The objective of this study is to provide an updated overview about the performance of cereal markets. Specifically, it aims to inform and guide project operations for the Government of Ethiopia (GoE) and the World Bank. First, it seeks to inform the government about incentives regarding grain storage before it makes more public investments in such facilities at the cooperative and union levels. Second, both the GoE and the World Bank need a better understanding about the performance of cereal markets, including the constraints on private sector investment in storage facilities. Further, to respond to increasing demand from the government for more food-based (non-market) interventions to provide access to food to the poor (instead of market-based (cash or voucher transfers) interventions), the PSNP program will need to be better informed about the level and extent of cereal market integration. Finally, the results from this study will also inform proposed IFC operations pertaining to the Ethiopia Commodity Collateralized Financing (CCF) project.

Wheat and maize are the most important cereals in Ethiopia. Maize provides the highest share of caloric intake for consumers, accounting for 17-20 percent of the total (Abate and others 2015; United States Agency for International Development [USAID], 2017). It is particularly important for poor households, as they mix maize flour with teff to make the national staple *injera* and the cost of maize is half that of wheat and teff. Maize represents 30 percent of total cereal production, with approximately 17 percent of the total cereal area characterized by a low level of productivity. As part of the government's policy to stabilize staple food prices for food security, the exporting of maize is banned. Wheat and wheat products represent 14 percent of total caloric intake for consumers. Unlike maize, demand for wheat increases as incomes rise, and the demand for wheat has grown significantly over the last decade. It is imported in large volumes (approximately 1.8 million MT per year). Indeed, the government has continuously imported wheat for the last several years and distributed it to contracted large millers to sell flour. It is argued that subsidized wheat has been creating disincentives related to domestic wheat marketing and production.

Thus, given the significant importance of maize and wheat, the analysis in this study focuses on these two commodities. Although some of the analysis and results provide insights on the general marketing conditions for other important cereals such as teff and sorghum, more time and resources are needed to extend the price analysis to these other cereals.

II. Methodology and Data

The research method combines market-level temporal and spatial price analysis with a detailed analysis at the producer, wholesale and retail levels for maize and wheat value chains. The goal is to shed light on market performance, and to identify factors affecting the capacity of value chain (VC) actors to expand and invest in grain marketing opportunities. Some of the key features modeled include: (1) maize and wheat price volatilities to gauge the level of risk in their respective markets; (2) seasonal price movements to assess the level of temporal arbitrage opportunities and efficiencies; and (3) spatial price linkages to assess the level of spatial arbitrage opportunities, efficiencies and market integration.

The spatial price analysis models were considered at the different stages, but the key questions they answer relate to the elasticity of price transmission between different markets and/or stages of marketing, and the size and the persistence of price shocks. Seasonal patterns of cereal prices were analyzed using seasonal decomposition methods. The method decomposed the time-series price data into four components: the seasonal, the random component, and the trend and cyclical components. The aim is to isolate and develop seasonal price indices (for both wheat and maize), which are important in storage decisions, as well as to shed light on the potential for temporal arbitrage.

The study is based on a review of literature, a rapid appraisal of maize and wheat production and marketing systems, and statistical and econometric analyses of time-series price data obtained from secondary sources. The time-series monthly nominal prices of maize and wheat were collected at different market levels (producer, wholesale and retail) for selected markets from both grain surplus producing and grain deficit regions. The wholesale price data for maize and wheat is reported in Ethiopian Birr per quintal (100 kilograms) and is obtained from the Ethiopian Trade and Business Corporation (ETBC[1]).

III. Main Findings

Maize and wheat markets are integrated in the long run, but price transmission is incomplete and asymmetric. The econometric results indicate that there is a long-run relationship between spatially separated maize and wheat markets. This is indicative of the improvements in road infrastructure, and the availability of trucks and mobile communications. However, the long-run price transmission between the deficient and surplus markets is less than complete, and the adjustments to price changes in different markets are asymmetric. A higher level of long-run price transmission is observed for maize. However, the long-run elasticity of price transmission is less than 50 percent in seven of the 21 wheat markets considered. This could be due to asymmetric market information, transaction costs, and government interventions. Overall, the results point to a need to provide, among other things, regular market intelligence and analytical support to the value chain actors.

There is a significant degree of unpredictability in wheat and maize prices, implying a high risk for the value chain actors. The results show that there has been a slight upward movement in nominal and real prices of maize and wheat in different markets and at all market levels (producer, wholesale and retail). However, there is significant unpredictability in maize and wheat prices, thus making spot market temporal and spatial arbitrage a risky business for value chain actors. For example, in the case of maize markets, about 6 to 33 percent (at the producer level), 0 to 72 percent (at the

[1] Formerly known as the Ethiopian Grain Trade Enterprise (EGTE) for the period from January 2001 to December 2016.

wholesale level) and 2 to 45 percent (at the retail level) of the overall maize price fluctuations are explained by unpredictable random price movements. The corresponding figures in the case of wheat are 0 to 27 percent (at the producer level), 1 to 27 percent (at the wholesale level) and 0 to 46 (at the retail level).

The consequence of increased volatility would be limited maize and wheat market transactions as market actors avoid risks. This also decreases the availability of maize and wheat both temporally and spatially. Furthermore, given the non-existence of efficient mechanisms for price risk management, such as a futures market, high risks would discourage necessary investments in maize and wheat production, marketing, distribution and logistics — which are all necessary to increasing the competitiveness of the maize and wheat value chains. This presents significant bottlenecks to the government's agricultural transformation agenda, which seeks to improve smallholder's adoption of modern agricultural inputs and increase their commercialization.

To address the risk of high price volatility would require changes at the policy level related to grain procurement and distribution, and investments in the institutions and infrastructure which would increase the transparency and stability of the maize and marketing systems. For example, investments could be made in agricultural market information systems, a strengthening of food safety and quality standards and grades, and development of a commodity exchange.

Although there is significant seasonality in maize and wheat prices, the returns are low with high volatility. There is significant seasonality for maize and wheat prices in different markets and at different value chain nodes. However, the implied storage periods for wheat and maize required between the seasonal low and high prices appear to be very long (5 to 10 months). The empirical results indicate that holding wheat and maize stock for such a lengthy period does not provide sufficient incentives, given the very low but highly volatile monthly price returns for maize and wheat stocks. The analysis shows excessive downward and upward movements in actual maize and wheat prices and returns at the producer and wholesale levels, which cannot be explained by the costs of storage alone. The field observations also indicate limited commercial maize and wheat storage at the wholesale level, which could be due to the perceived risk of very high price volatility. Overall, there are limited temporal arbitrage (storage) opportunities in the maize and wheat markets for producers and wholesalers.

With such high unpredictability and volatility in maize and wheat prices, it is risky for the private sector to invest in storage. The results imply low commercial incentives to invest in wheat and maize storage. This may partially explain the current low level of investment by the private sector in storage facilities. However, given the observed need for good quality storage to minimize post-harvest losses, the results imply that there is a role for the public sector in making investments in storage, but it is critical to debate how, at what level, and under what conditions such investments should be made. The government is currently making these investments at the cooperative level, but very little grain is sold through cooperatives. Thousands of individual farmers are members of primary cooperatives. This indicates that cooperatives are a useful organizational platform. In this regard, interventions related to effective and professional management are required to achieve effective staple food bulking and marketing through cooperatives. Further, results imply an urgent need to address various issues to improve transparency related to stock and price information, as well as grain marketing policy.

At the wholesale level, returns to maize and wheat aggregation (wholesale-to-produce price margin) are better than holding grain. For grain traders, the monthly returns from holding maize or wheat stock and the regional wholesale traders' margin[2] and the inter-regional grain trader's margin[3] indicate that grain traders in the surplus markets are more interested in buying grain from the farmers and selling it quickly to the inter-regional wholesale traders. The monthly spatial differential is higher than the monthly return on holding maize and wheat stock.

There are high levels of post-harvest losses and most farmers sell most of their marketable grain right after the harvest. Most farmers sell immediately after the harvest to meet different financial obligations, which are usually due right after the harvest. They also seek to minimize post-harvest losses, which are approximately more than 10 percent for maize and wheat. In areas where microfinance service providers are available, the timing of the loan provision is not designed in a way to prevent the farmers from selling their crops after harvest and debt collection. Furthermore, producers mostly sell to the traders on credit in advance of harvest time, with the agreement to pay in kind at cheap rates immediately after harvest when the price is the lowest of the season. Consequently, most producers do not benefit from better prices because of untimely sales and weak bargaining power. Although paradoxical, given the observed storage losses combined with results from temporal and spatial price analyses showing high volatility and unpredictability, and incomplete and asymmetric price adjustments, it seems that famers may currently be better off selling at harvest time rather than waiting for higher prices.

Producers sell a negligible amount of grain through primary cooperatives. Field data and information show that producers sell only a small fraction of their output through cooperatives. The 2016 AGP 2 baseline survey[4] of 10,924 randomly selected households reveals that farmers only sell 2.6 percent of their crops through cooperatives. The data further reveal that households sell 1.9 percent (wheat) and 3.8 percent (maize) of their output through cooperatives, whereas 66 percent (wheat) and 64 percent (maize) is sold through private traders. There are several reasons why so little grain is marketed through cooperatives by producers, including: (1)*cooperatives buy immediately after*

[2] The difference between the wholesale and producer prices in a market.

[3] The price difference between deficit and surplus grain market wholesale prices.

[4] Agricultural Growth Project (AGP) II Baseline Draft Survey Report (EDRI, 2017). The data covers four regions including high-surplus grain areas.

harvest during a short window of time when prices are low; (2) many producers view the *cooperatives as an unreliable marketing outlet* for the farmers in terms of the amount they purchase, their consistency in purchasing, the length of purchase and the price they offer; (3) most primary cooperatives have financial constraints and poor market linkages to purchase the desired quantity from their members, thereby making their purchasing pattern and quantities limited and unpredictable; and (4) other buyers such as traders pay immediately upon purchase

Storage warehouses, especially at the producer and trader levels, are of low quality and capacity. Producers, cooperatives, traders and wholesalers noted that there is a shortage of storage, especially modern storage facilities. One reason cited by farmers for selling a large proportion of their grain right after the harvest is to minimize post- harvest losses due to lack of proper storage facilities. In addition, losses during storage due to weevils, rodents and fungus discourage farmers from storing grain for long periods of time. Some cooperative unions are not able to buy all the grain from the cooperatives due to limited storage and working capital, which creates problems with primary cooperatives and their members. As a result, primary cooperatives sometimes sell grain at reduced prices to the unions due to limited cooperative storage. However, through field observations and interviews, it was found that most cooperatives primarily store inputs, such as fertilizers and seeds, to distribute to farmers. Furthermore, most of the existing one-structured storage facilities do not meet the multi-purpose storage needs at the farm, cooperative and union levels. Ideally, what the *farmers want is separate storage facilities for grains, fertilizers and improved seeds.* Currently, due to the shortage of proper storage facilities, the farmers use the same facility to store farm inputs and outputs simultaneously or alternatively. This creates potential food safety and health problems, as well as logistical issues due to small storage capacity.

There is a lack of coordination and planning among grain importing entities, leading to sub-optimal utilization of the existing public storage system. The lack of coordination and planning among the key entities involved in importation, including the ETBC — and among the Joint Emergency Operations Partners (JEOP), the World Food Program (WFP) and the National Disaster Risk Management Commission (NDRMC) — results in little swapping of warehouses within the public storage system. Consequently, at times, some public storage warehouses would be empty for months, while others are overfilled and not able to store any more grain. Each entity imports grains for their own program, with little synchronization with other importers. This sometimes results in large grain shipments arriving at the same time at the port in Djibouti, leading to congestion and delays in shipment deliveries. In this context, the simultaneous arrival of imported wheat in the country affects local prices.

Maize and wheat transactions are primarily volume-based; there are no market incentives to ensure the quality of the grain due to lack of regulations on quality and standards. Although many buyers assign grades, there are no formal maize and wheat grain standards. Furthermore, there are no formal and consistent quality enforcement mechanisms at the different nodes in either value chain. The grain is examined physically for breakage and obvious physical impurities. There are no quality checks for moisture content or to store the grain at the appropriate moisture and temperature levels. Indeed, many cooperatives do not provide important preconditioning services, such as sorting, drying, and grading before storing the grain. Traders handle low-quality wheat and mix wheat of different quality, thereby reducing the average quality of wheat flowing through the value chain. Farmers in Ethiopia can produce good quality bread, pasta wheat, and maize for maize flour, but the weak market linkages and the lack of quality enforcement do not encourage farmers to invest more in quality. The lack of third-party inspection of quality standards and grades — and different weighing scales used by various VC actors — contributes to mistrust and cheating in the cereal marketing system.

There is a lack of transparency on price discovery, and asymmetric cereal price information contributes to uncertainties in the marketing system. Many actors in the maize and wheat value chain reveal that there is a lack of transparency regarding how wheat and maize prices are determined. Prices are not announced to the grain value chain actors. Farmers noted that they do not have clear market information in the distant wholesale markets. Also, farmer-traders influence the price of wheat by spreading untruthful rumors that the supply of wheat is going to increase due to food aid wheat, so that they pay lower or constant prices to farmers. Some farmers obtain market information from brokers. However, because of conflict of interest, it is hard to expect complete disclosure of market information by brokers to the farmers. Furthermore, government officials reveal that cereal prices are determined internally and are not announced to VC actors. Government officials also noted that the data on expected supply is poor and not reliable. Also, the cost of production is not clearly factored into cereal price determination. In addition, information on the prices at which the processors are buying is not available and communicated to all stakeholders. Overall, there is a need for a more open and transparent grain marketing information system.

There are now more direct shipments of maize from the production areas to the consumption areas, bypassing the traditional transshipment wholesale market in Addis Ababa. This is indicative of the improvements in road infrastructure, the availability of trucks at competitive prices, and improvement in cereal traders' networking capacity due to increased access to mobile phones. In deficit areas (Wallale-Jijiga) of the Harar and Somali regions, big wholesale traders import maize directly from other areas, especially Wolega. There is also an emerging trend regarding importing hubs. Private investors are building modern warehouses and importing maize directly from Wollega. They then stock it for local distribution and exports to places further afield in the zone and to other regions such as Jijiga. However, in Tigray, millers noted that wheat from other regions is not coming there due to very high transportation costs.

Lack of trust is pervasive and discourages the use of cooperative and private storage facilities by producers. An issue consistently raised by farmers related to storing grain with private warehouses and cooperatives is *lack of trust*. There is a lack of trust in the capacity of cooperatives to keep the grain in good condition, given the existing infrastructure standards. Although producers are aware of the storage losses on the farms, they are reluctant to store grain elsewhere with private storage owners. Farmers do not trust their grain with anyone else. Some warehouse owners do not want to take the responsibility for storing grain for several individual farmers. Also, rent-seeking behavior (including favoritism, unfair handling of customers, and misuse of cooperative resources) by some cooperatives discourages them from selling and storing their grain with the primary cooperatives. Finally, there is mistrust between the primary and union cooperatives, primarily due to the lack of storage space when there is an oversupply of grain following bumper harvests.

Producers are frustrated that subsidized wheat is weakening their market potential to supply local processors, retailers and other buyers. Some medium-to-large processors do not source locally and rely primarily on imported subsidized wheat. In low wheat-producing regions like Tigray, large millers revealed that they largely depend on government-subsidized, imported wheat as a raw material for milling. Since the local wheat is more expensive, some processors are not interested in procuring raw wheat locally. Furthermore, some retailers and traders revealed that they buy subsidized wheat grain from rural PSNP households, and grain from other rural food aid household recipients who sell to wholesalers in their local areas, as well as directly to retailers (who perform both retail and wholesale functions). A key assumption of the wheat subsidy is that the subsidized wheat flour is not sold into the open market. However, there is a strong incentive as the open market price of wheat flour is significantly higher than the subsidized wheat flour price. Also, local processors prefer the uniformity of quality of imported grain compared to the local grain that has more variability in quality. Overall, local producers are frustrated that subsidized wheat is weakening their market. There is a need for careful inspection and regulation of subsidized wheat distribution and targeting. Further assessment is also required to determine how much subsidized wheat is sold into the open market.

Unpredictable public grain procurement related to the quantity and timing of distribution of wheat and maize presents a significant risk for the value chain actors. Farmers in high producing areas like Arsi revealed that the government distributes wheat to wheat flour mills at lower prices when there is no shortage of wheat in the market. This sends the wrong market signals, adversely affecting the smooth function of the wheat market — even under normal production conditions. Farmers expressed frustration that the government is urging producers to increase their production, while the (untimely) distribution of cheaper subsidized wheat negatively affects local markets. The lack of information on the planned volume of government procurement, stock of grain, release of stock to the market, and price contributes to market system unpredictability/instability. Government officials also acknowledged that data regarding the expectations about cereal supply are not reliable.

IV. Policy Recommendations

- More transparent information and a clearer policy direction related to grain procurement and distribution can help to reduce price unpredictability in Ethiopia's maize and wheat markets. Key components of this effort entail the improvement of the spatial efficiency of cereal marketing, as well as an increase private sector engagement and investment in grain storage. This would help to reduce both price unpredictability and volatility. Greater transparency would also help the government key value-chain actors, specifically in the areas of: government domestic grain procurement; pricing and distribution; grain imports; prices; the timing/release of imported grains on the markets; and information about the overall level of grain stocks in the country.

- An agricultural market information system should be established. Asymmetric price and production information, as well as a lack of clarity about price discovery, significantly contributes to price and market uncertainties. The introduction of an agricultural market information system would help to improve the reliability and accuracy of all relevant data for the government and for key value-chain stakeholders. Decisions need to be taken regarding which institution would be responsible for such a market information system. A detailed assessment is required to determine the willingness to fund and sustain such a system.

- The Government's tax policy needs to be reformed to deal with grain market issues. Arbitrary tax enforcement based on grain stocks held by traders and wholesale distributors at a given time — and not considering their turnover — creates huge disincentives for traders and wholesalers to engage in temporal arbitrage. The tax should not be based on output alone and it should be clearly enforced in a consistent manner.

- The Government and relevant stakeholders need to reassess the different needs for storage, as well as the different types of storage technologies/facilities required by various market levels. This includes clearly identifying the objective of storage at the farm, cooperative, union, processor, wholesaler and retailer levels. The objective for storage facilities could be for aggregation or arbitrage, or simply to minimize post-harvest losses. Each cause would have different implications regarding the required capacity and investments.

- The Government and stakeholders should encourage and support efforts to provide for independent verification of grain quality, as well as the enforcement of uniform grain standards. This would solve a host of problems plaguing the current system. Specifically, it would help to encourage producers to increase the quality of the grain that they sell to millers and other buyers. It would also minimize cheating in the grain marketing process. Importantly, it would reward the adoption of and investments in quality enhancing technologies and best practices. Finally, it would help to strengthen food safety.

- The capacity of primary cooperatives needs to be improved so that they can become effective aggregators for the cooperative unions. Cooperatives remain a key vehicle to linking smallholder farmers to processors and other market buyers. Turning primary cooperatives into effective aggregators for cooperative unions and increasing their marketing potential would require a strengthening of managerial capacity by the cooperatives — including building agribusiness leadership skills, hiring professional managers, and so on.

- The Government and relevant stakeholders should reconsider the timing and the scaling-up process of public investments in the cooperative warehouse facilities. Building more warehouses will not guarantee a substantial increase in farmers' sales and/or the storing of grain through primary cooperatives.

- Cash-based transfers by the PSNP and other organizations responding to food emergency situations should be taken cautiously, with due consideration for specific local conditions. Results indicate that maize and wheat markets are spatially integrated in the long-run, which supports the movement of grain from surplus to deficit areas. This result generally supports increasing cash transfers by the PSNP program, but the long-run elasticity of price transmission estimates indicate that the long-run price transmissions are less than complete for some markets, and that price transmission is asymmetric. Furthermore, there are inefficiencies in wheat and maize price transmission — despite the wheat and maize markets being integrated. Second, maize and wheat wholesale and retail prices are highly volatile. The price analyses indicate that there is limited incentive for the private sector to engage in grain storage. The implication is that the complete reliance on markets and the private sector to respond effectively under emergency situations is not advisable. There needs to a targeted approach, accompanied by careful and close monitoring. In the short-run it is advisable to maintain a reasonable mix of in-kind transfers and cash transfers in the PSNP. When cash is used in deficit areas, one would need a reliable trade network, storage capability, a market information system, and infrastructure based on regular market and price monitoring. Further price and market analysis at the local level would be required for the PSNP and other humanitarian entities to inform them about where and when to use cash or food transfers.

1. Introduction

The efficient functioning of cereal markets is important given the significant share of cereals in food expenditures by households in low-income countries. Cereals comprise half of consumer food expenditures in Ethiopia, and about 75 percent of land area under cultivation (Central Statistics Agency 2012). With the recent food price inflation and concerns regarding the impact of the latest drought related to *El Nino*, understanding the performance of food markets has stimulated renewed interest by governments, development banks, and local and international organizations. For Ethiopia, this is particularly relevant given the disastrous implications that poorly functioning food markets had in the past on food security (Minten *et al*, 2014). Due to these concerns, price stabilization and food security are two key objectives motivating the government's policy on grain marketing. To stabilize grain prices and reduce the risk of high price volatility in the food sector, the government maintains a strategic stock reserve. It has also banned grain exports in response to rising prices in 2006-2008. In the case of wheat, it imports wheat and sells it at subsidized prices to selected mills that then sell to bakers. The bakers eventually sell bread at a fixed/subsidized price to consumers. In addition, relief agencies provide food aid to assist food insecure households. through other relief agencies. The Productive Safety Nets Program (PSNP) also assists through cash and food transfers.

How well cereal markets are integrated across time and space matters. This has implications for the efficiency of cereal markets and the effectiveness with which they can response to food emergency situations in the country. Further, post-harvest handling and storage investments are critical for the efficient aggregation of grains, especially in enabling producer access to markets. Volatile food prices would affect the procurement decisions of agri-businesses involved in food distribution, storage, processing, and retailing such that farmers would be faced with lower and more variable demand in selling markets. The aggregate effect is reduced economic activity in the food sector. This in turn leads to the decreased and variable supply of food commodities and food products, further exacerbating price volatility. It also generates upward pressure on food prices for consumers (World Bank, 2016). In addition, price fluctuations are a common feature of well-functioning agricultural commodities markets. However, the efficiency of the price system breaks down when price movements are increasingly uncertain and have extreme swings. This can have a negative impact on the food security of consumers and farmers and entire countries (FAO, 2011). Hence, assessing the performance of cereal markets requires an in-depth analysis of price volatility because it is a good indicator of the level of risk in the market, which in turn affects the behavior of the value chain actors.

Storage is a key component of cereal marketing. For the government, maintaining grain reserves is a strategic food security measure which enables it to respond to food emergencies, as well as support safety net programs. Maintaining grain reserves can be expensive. It can also have price-depressing effects depending, among other things, on size of stock and timing of distribution. When there is uncertainty about when the government will release stocks, it can crowd out private investment in storage because it destroys the arbitrage and storage incentives of private traders (Rashid *et al*, 2011). Government agencies, international relief agencies, cooperatives, private traders and farmers are all involved in carrying out the role of grain storage keepers. Overall, though, the government appears to discourage traders from holding stock. Rather, it supports on-farm storage in various ways (Minot *et al*, 2015).

Farmers need storage to minimize post-harvest losses, and to avoid selling most of the marketable surplus right after harvest when prices are low. Providing grain storage is important to smoothing the income disparities of farmers. Farmers often sell their grain immediately after harvesting due to lack of storage capacity, among other reasons. During off-season, limited grain availability contributes to increases in grain prices. In response, the government is encouraging cooperatives to play an increasingly larger role in grain storage. More importantly, there is limited analysis using price data to evaluate the incentives to store grain. Such an analysis is important to gauging the implications for private and public-sector investments in storage facilities.

Previous work on the functioning of cereal markets in Ethiopia looked primarily at the extent of market integration. It did so by investigating the degree to which regional cereal markets are integrated, as well as the level and speed of price transmission. Compared to a decade ago, most price integration analytical studies [Getnet *et al* (2005); Negassa *et al* (2007); Rashid *et al* (2011); Tamru (2013); Minten *et al* (2014)] show that most cereal markets in Ethiopia are generally more spatially integrated. Further, prices co-vary among more markets, and price adjustments take less time. However, most of the previous work examined market integration considering Addis Ababa as a reference market, whereby the pairing of markets for testing market integration was mostly between Addis Ababa and other markets (surplus and deficit) — rather than between surplus and deficit markets. This study evaluates the extent of market integration between surplus producing areas and other cereal deficit areas beyond Addis Ababa. It also provides updates on the previous results using more recent data.

The objective of this study is to provide an updated overview on the performance of cereal markets in Ethiopia. Specifically, the study seeks to inform and guide project operations for the Government of Ethiopia (GoE) and the World Bank. First, it aims to inform the government about incentives concerning grain storage before the GoE makes more public investments in storage facilities at the cooperative and union levels. Second, both the GoE and the World Bank need a better understanding of cereal market performance, including the constraints for private sector investment in storage facilities. Further, to respond to increasing demand from the government for more food-based (non-market) interventions to provide access to food to the poor instead of market-based (cash or voucher transfers), the PSNP program will need to be better informed about the level and extent of cereal market integration.

The report is organized as follows: Section 2 provides an overview of the maize and wheat sub-sectors. It also summarizes key observations about maize and wheat value chain performance based on a field survey. Section 3 details the conceptual framework and the empirical strategy to assess the maize and wheat markets performance. Section 3 presents the empirical model. Section 4 discusses data and section 5 presents the empirical results. Finally, the conclusions and policy implications are discussed in section 6.

2. The Maize and Wheat Sub-sectors

2.1. The Role of maize and wheat in Ethiopia

Wheat and maize are the most important cereals in Ethiopia. Maize provides the highest share of caloric intake for consumers, accounting for 17-20 percent of the total (Abate *et al,* 2015; USAID 2017). It is particularly important for poor households as they mix maize flour with teff to make the national staple injera, and the cost of maize is half that of wheat and teff. Maize represents 30 percent of total cereal production, with approximately 17 percent of the total cereal area. In the 2016/17 meher planting season, maize production was 7.8 million tons, of which 95 percent is produced by smallholder producers. Oromiya accounts for approximately 58 percent of total production. It is followed by Amhara, which accounts for about 25 percent of total production. Total maize production has been growing over the past decade due to a higher annual growth rate in yields of about 5 percent. This increase in production yield corresponds to the adoption of improved seeds and extension services delivery. With only 13 percent of total production being marketed, maize remains predominantly a subsistence crop.

Although globally, Ethiopia's maize production lags high producing countries such as the US, it is the leading producer in Eastern Africa. As part of the government's policy to stabilize staple food prices for food security, the exporting of maize is banned. Maize exports are allowed occasionally when there is a bumper harvest, or in case of drought in neighboring countries. For example, with the recent drought in Kenya, limited maize exports were allowed in 2017 following bilateral discussions between the two governments.

Wheat and wheat products represent 14 percent of the total caloric intake of consumers. Unlike maize, the demand for wheat increases as incomes rise. As such, the demand for wheat has grown significantly over the last decade. It is imported in large volumes, and the government has continuously imported wheat for the last several years. The government subsidizes wheat imports. It sells subsidized wheat to contracted large millers who sell flour to bakeries at fixed prices. The primary goal is to make bread more affordable for the poor (Minot 2015). Approximately 25-35 percent of domestic consumption is satisfied by imported wheat with Oromiya accounting for over 50 percent of total production. The Southern Nations and Nationalities People (SNNP) and Tigray account for 13 percent and 8 percent of production, respectively. Given the importance of wheat for food security — as well as its increasing import burden — the government of Ethiopia gives high priority to increased wheat productivity (Minot 2015). Yet, subsidized wheat is creating disincentives related to domestic wheat marketing and production. Minot *et al* (2015) estimated the wheat import subsidy to be US$66 million per year. Furthermore, the subsidy is not targeted. Therefore, both the poor and high-income consumers benefit from it.

Overview of Cereal Marketing Policies

This section provides a brief overview of past and recent policies and key institutions involved in grain marketing in Ethiopia.

During the Derg regime (1975-1990), the government controlled agricultural markets and trade. It set annual production quotas, and private trade and the interregional grain movement were restricted. In this context, the state-owned Agricultural Marketing Corporation (AMC) had a monopoly on grain imports. Rashid and Negassa (2011) summarized a body of literature, noting the negative consequences of these policies. Small farmers were badly affected by the delivery of the quotas set by the peasant associations because these quotas did not consider the capacity constraints and consumption requirements of the farmers. Furthermore, the forced delivery of a quota at a fixed price negatively affected farmers' production and incomes, and there was decreased regional market integration. In 1990, the government undertook major grain marketing policy reforms, including the removal of movement restrictions, the abolition of quota deliveries, and the elimination of the monopoly power of the AMC.

After the fall of the Derg regime, the government made additional reforms. The AMC was reorganized as a public enterprise, the Ethiopian Grain Trade Enterprise (EGTE), with the mandate to: stabilize prices by encouraging production and protecting consumers from price shocks; maintaining a strategic reserve for disaster and emergency response; and earning foreign exchange through grain exports. During this time, private sector trading was allowed and traders competed with the EGTE. However, the EGTE faced a constant tension regarding fulfilling its mandate of price stabilization while ensuring competitiveness and profitability (Bekele, 2002). Due to limited purchasing power of the grain and sales network, the EGTE was not effective in stabilizing prices. Farmers' confidence in the EGTE declined as it often could not guarantee purchases at the pre-announced prices. As a result, EGTE diminished its role in price stabilization in the early 2000s, and focused on export promotion.

With the sharp rise in prices of major cereals starting in 2005-2008, price stabilization and maintaining a strategic national reserve became a priority for the GoE as it sought to ensure food security. Again, because of rising food prices (2008-2009), the government imposed a ban on grain exports. It also began direct government imports of wheat for sale, which the ETBC then sold to selected commercial millers to provide subsidized bread to consumers.

Detailed analysis of the effects of subsidized wheat on the development of domestic production and marketing is not available. However, the fact that the production and productivity of wheat remains very low might also be explained by the disincentive effect of subsidized wheat distribution. A report by the International Food Policy Research Institute (IFPRI) and the Ethiopia Development Research Institute (EDRI) (2014) concluded that domestic wheat prices would not have exceeded import parity in the absence of ETBC's imports in any year except 2008 and 2009, implying that local procurement of wheat would have been justified. The report further notes that the government could have saved US$124-330 million by procuring wheat locally.

In 2008, the Ethiopian Commodity Exchange (ECX) was launched. It was designed to handle staple grains and to play a key role in aggregation, market information and help smooth the functioning of commodity trading. However, the ECX failed to attract large volumes of grain, and shifted its focus to coffee, sesame and pulses. Currently, the ECX does not play a role in wheat and maize marketing. However, given its experience in commodity trading thus far, it has a potential role to play in the establishment of an agricultural marketing information system with other relevant institutions

The key mandate of the Ethiopian Emergency Food Security Reserve Administration (EFSRA) is to serve as a custodian of grain to relevant governmental and non-governmental agencies (Rashid and Lemma 2011). It imports, and buys and holds grain stocks locally. Its main activities include the stock release to the NDRMC in response to drought or other disasters. It also lends grain to other food aid agencies such as the World Food Program (WFP), and engages in stock rotation. It plays an active role in price stabilization through its grain reserve mandate and buys from farmers when prices fall. The NDRMC holds food relief for people who need help due to displacement or other disasters. It releases stocks to other food aid agencies, such as the WFP. It imports wheat and buys other grains locally. Some key informants note that there is some duplication in terms of the roles that key institutions involved in grain marketing and distribution play. For example, the NDRMC is supposed to have a distribution role only; it is not expected to buy cereals. Both the EFSRA and the ETBC have price stabilization roles in grain marketing.

Overall, the grain marketing system in Ethiopia is characterized by the presence of both government and the private sector — but with unequal power and resources to participate in the marketing system. The policies are *ad hoc* at best, with the government following discretionary policies in domestic procurement, storage, distribution and trade, thereby creating a lot uncertainty for the private sector.

2.2. The maize and wheat value chains

There is a plethora of research describing maize and wheat marketing in Ethiopia. Recent reports (AACCSA, 2017; Abate *et al*, 2015; Gurmu e*t al* 2016; IFC 2017; Minot e*t al*, 2015; and USAID, 2017) provide detailed descriptions of the maize and wheat value chains. Hence, to avoid duplication but still provide the reader with contextual information on maize and wheat marketing, this section provides a brief description of the two value chains followed by a summary of field findings and observations at the various VC nodes.

2.2.1. Production of maize and wheat

There are approximately 4.7 million wheat farmers in Ethiopia, with approximately 78 percent farming in Oromia and Amhara. Small-scale farmers dominate, and large-scale commercial farms account for only 5 percent of wheat production. Likewise, small-scale producers dominate maize production, producing 95 percent of nearly 9 million tons of maize in 2015/16 (USAID,2017). The key maize-producing zones include East Wollega, West Gojjam, and West and South Eastern Shoa. Together, they produce over half of the total maize production in Ethiopia. Six zones account for over half of Ethiopian wheat production: Arsi, Bale, East Gojjam, East Shewa, South Wello and West Arsi (Minot *et al*, 2015). The key deficit areas include Addis Ababa, East and West Harege (Oromia), Fafan (Somali), Jimma, Sidama (SNNP), South Gonder (Amhara), and Western and Central Tigray. Both maize and wheat production have increased significantly over the past decade because of increased use of improved seeds and fertilizers; increased areas of cultivation; and improved extension service delivery. According to the Central Statistics Agency (CSA, 2015), wheat production has grown by 9.3 percent over the past decade. Despite these productivity gains, there is potential for more growth to meet domestic demand and to increase producers' incomes.

Although there has been an increase in the use of improved seeds, the use of modern inputs is still limited. Related issues include poor timing in the distribution of government-provided fertilizers, and high fertilizer prices as viewed by farmers. According to USAID (2017), many farmers prefer the Limu[5] seeds for maize production. However, cooperatives through which the farmers obtain the seeds, are not authorized to procure them. Rather, they are obliged to use the government provided seeds first. Likewise, the shortage of certified seeds is a problem. In this context, a key priority for wheat producers is to have better access to improved seed quality. This would help to increase production and address crop diseases, including yellow and stem rust and Fall Army worm. Access to finance is also a major constraint faced by producers.

2.2.2 Grain storage

Storage is a key aspect of grain marketing. It is profitable when the expected increase in price over time exceeds the cost of storage over the same period (Minot *et al*, 2015). Hence, uncertainties related to expected prices make the storage business risky. Grain storage in Ethiopia is carried out by farmers, cooperatives, private traders, government organizations and food aid relief agencies. Precise grain storage estimates are difficult to obtain. As the main grain importer, the ETBC plays a significant role in grain storage and it has over 700,000 tons of storage capacity. The storage estimates for the Ethiopian Food Security Reserve Administration are 322,000 tons (Rashid *et al* ,2011), with 460,000 tons in storage capacity (World Bulletin, 2014). The EFSRA plans to increase its storage capacity to 1.5 million tons. As such, it has budgeted for the construction of warehouses which are expected to be completed in the next two years. Cooperatives are the other key players in storage. IFPRI (2012) estimated cooperative union storage capacity to be 187,000 tons, and primary cooperatives to be 1,705,000 tons. Further, the government, working through the Agricultural Transformation Agency (ATA), piloted 44 cooperative storage warehouses facilities under the Agriculture Growth Project. The government plans to scale up more warehouses for primary and cooperative unions. However, little grain is marketed through cooperatives, and the main activity at the cooperative level is input distribution, especially fertilizers and seeds. The Federal Cooperative Agency (FCA) notes that the lack of good quality warehouses is one reason for the low share of farmers' output being marketed through cooperatives. However, farmers note that lack of trust in cooperatives, higher prices and immediate payments by other buyers are key factors for selling less of their output to cooperatives. The WFP (2013) estimated traders and wholesalers to have 300,000 tons of grain storage capacity. See table I.

[5] A DuPont Pioneer hybrid maize variety.

Table I: Estimated Grain Storage Capacity

Type by Owner	National Capacity ('000 tons)	Share (%) of Total Capacity	Source
ETBC	820	3	EGTE (2015)
EFSRA	322	1	WFP (2013)
Private Traders	300	1	WFP (2013)
Primary Cooperatives	1,720	6	Minot and Mekonnen (2012)
Cooperative Unions	187	1	Minot and Mekonnen (2012)
Farmers	25,950	89	IFPRI-ATA (2012) - Baseline data
Total	29,284	100%	

Source: IFPRI (2015).
Note: ATA= Agricultural Transformation Agency; EFSRA= Ethiopian Emergency Food Security Reserve Administration; EGTE= Ethiopian Grain Trade Enterprise; ETBC= Ethiopian Trading Business Corporation; IFPRI= International Food Policy Research Institute; WFP= World Food Program.

Farmers store wheat and maize using traditional storage methods, and most farm households store grain for an average of six months. Bachewe *et al* (2017) report that a high proportion of grain crops (49 percent) are stored in traditional locally-made storage material, followed by 35 percent stored using sacks or open drums. These two basic, unimproved storage technology methods account for approximately 83 percent of storage methods at the farm household level (Bachewe *et al*, 2017). Yet, post-harvest losses at the farm level are a major constraint. For example, based on field information of this study, the extent of maize post-harvest losses is about 10-20 percent. Although farm-level storage accounts for the largest part of the total national storage capacity, it is largely unsophisticated and of low quality. The overall quality of storage is low and the warehouses at the producer, trader and primary cooperative levels are further constrained by low capacity.

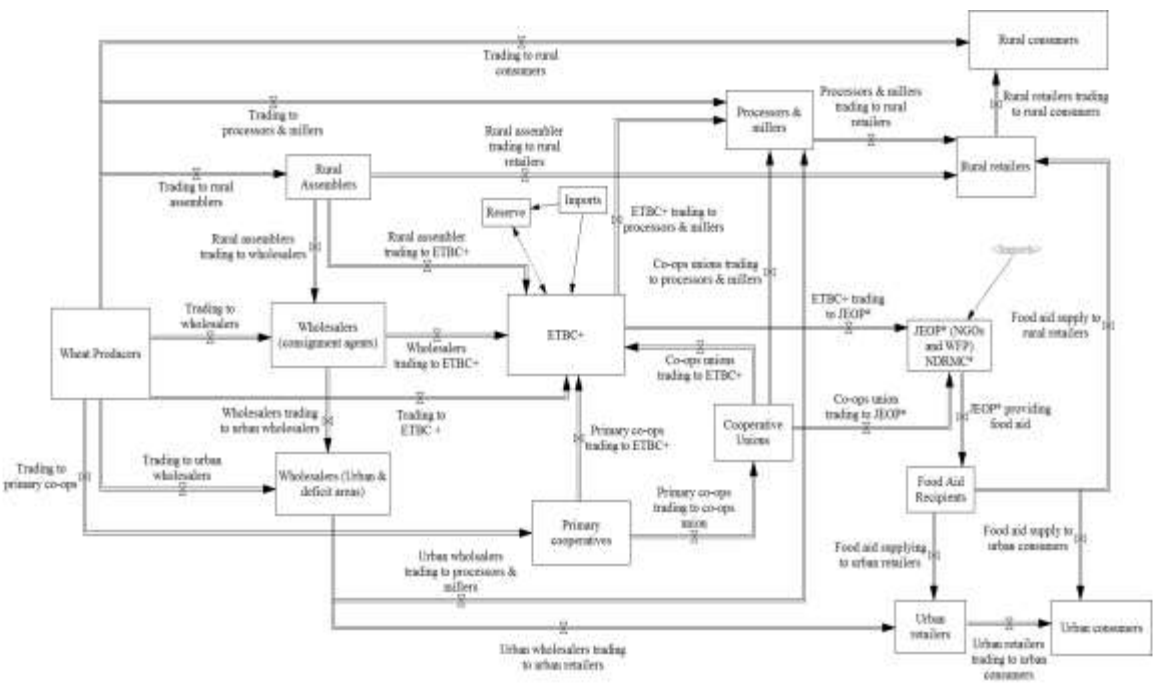
2.2.3. Maize and wheat marketing

The flow of maize and wheat from farm to fork is long and complex. Figures 1 and 2 depict the grain marketing of wheat and maize, respectively. Wheat and maize producers sell the grain to wholesale and small private traders and primary cooperatives, as well as directly to rural consumers and to the ETBC. Wholesale traders sell directly to the ETBC, millers and processors. They also sell directly to rural and urban retailers. Cooperatives sell to cooperative unions, processors and the ETBC. The ETBC sells subsidized wheat to large millers, and maize and sorghum to food aid distributors, including the WFP, the JEOP, the NDRMC and the PSNP. In addition, the ETBC and food relief agencies borrow grain from the reserve and replenish if after receiving their stock.

Millers sell the subsidized flour to urban wholesalers and retailers, including bakeries, at a fixed price. Retailers sell directly to consumers. Retailers also buy subsidized food aid wheat from PSNP farmers, who sell in their local markets to collectors. They then transport the food aid wheat to the cities. Other food aid recipients sell directly to traders and consumers. In the case of wheat, the consumers are more interested in buying flour rather than grain to use for custom milling. Custom milling is more common for maize, teff and sorghum.

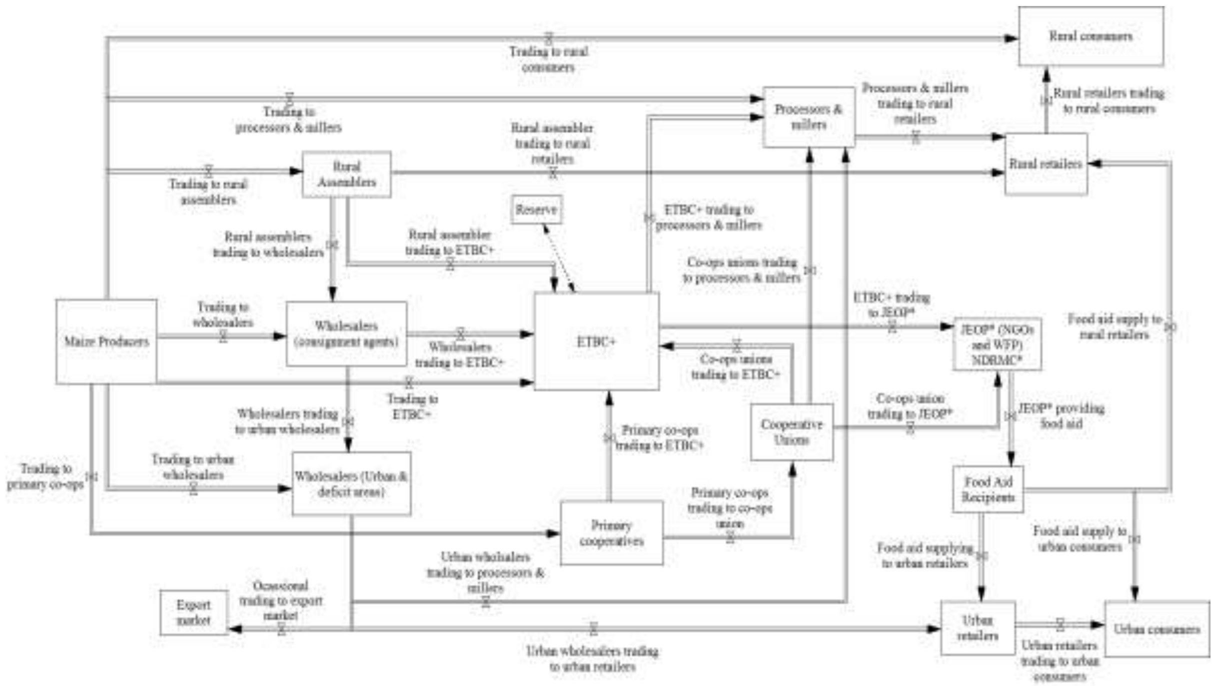
Competition is high among retailers, collectors and traders in the maize and wheat value chains. There are many retailers competing in terms of price, quality, customer handling (for example, selling on credit — although they face problems in credit collection). There are approximately 682 mills in Ethiopia. Minot *et al* (2015) note that the estimated capacity of small-scale mills (15 million tons) is almost double that of large-scale mills (7.9 million tons). The small-scale mills account for approximately 65 percent of total milling capacity. Most millers operate below capacity, primarily because of frequent power interruptions. Poor access to credit is common, and is a major limiting constraint reported by all the value chain actors. It limits maize and wheat value chain actors from expanding their businesses and adding value.

Figure 1: Wheat Value Chain Map



Source: Authors' schematic.
Note: JEOP=Joint Emergency Operations Partners; NDRMC= National Disaster Risk Management Commission; and WFP= World Food Program.

Figure 2: Maize Value Chain Map



Source: Authors' schematic.
Note: JEOP=Joint Emergency Operations Partners; NDRMC= National Disaster Risk Management Commission; and WFP= World Food Program.

The following descriptive summary of observations about the marketing aspects of the wheat and maize value chains is based on a survey of various actors including producers, cooperatives, traders, millers, retailers and key informants, as well as interviews with government officials and other stakeholders. The field survey covered selected *woredas* (districts) in the Amhara, Dire Dawa, Hereri, Oromiya, Somali, and Tigray regions. Focus group discussions (FGDs) and individual interviews with farmers, traders (both at the retail and wholesale levels) and millers were conducted in the woredas. In addition, approximately 22 key informant interviews were conducted. The purpose of this field survey was to reach a better understanding about the performance of wheat and maize value chains from the value chain actors, specifically relating to marketing, storage, and production. The survey sought to solicit VC actors' views on the opportunities and constraints about wheat and maize marketing, as well as to complement and inform the empirical price analyses which are based on secondary time-series price data.

1. **There is a shortage of high-quality storage facilities for both cereal inputs and outputs.** Producers, cooperatives, traders and wholesalers noted that there is a shortage of storage, especially of modern storage facilities. One reason cited by farmers for selling a large proportion of their grain right after harvest is to minimize post- harvest losses due to lack of proper storage facilities. In addition, losses during storage due to weevil, rodents and fungus discourage farmers from storing their grain for long periods of time. Some cooperative unions are not able to buy all their grain from the cooperatives due to limited storage and working capital,

which creates problems with primary cooperatives and their members. To meet demand, some cooperative unions rent storage space from the private sector. Sometimes, primary cooperatives sell grain at reduced prices to the unions due to limited cooperative storage. However, field observations also reveal that primary cooperatives primarily store inputs, such as fertilizers and seeds, to distribute to farmers.

2. **The lack of coordination and planning among grain importing entities leads to sub-optimal utilization of the existing public storage system.** Discussions with key informants reveal that there is a lack of coordination and planning among the key entities involved in the importation of wheat, including the ETBC, as well as among the JEOP, the WFP and the NDRMC. Interviews with the NDRMC indicate that the swapping of warehouses within the public storage system is weak. Consequently, at times some public storage warehouses are empty for months, while others are overfilled and not able to store more grain. In addition, each entity imports grain for its own program, with little synchronization with the other importers. This sometimes results in large grain shipments arriving at the same time at the port in Djibouti, leading to congestion and delays in delivering the shipment. Furthermore, the simultaneous arrival of the imported wheat in the country affects local prices.

3. **Most of the existing single-structured storage facilities do not meet the multi-purpose storage needs at the farm, cooperative and union levels**. Ideally, what the *farmers want is separate storage facilities for grain, fertilizers and improved seeds.* Currently, due to the shortage, the farmers use the same facility to store farm inputs and outputs simultaneously or alternatively. This can create potential food safety and health problems, as well as logistical issues due to the small storage capacity. In addition to grains, farmers grow different crops requiring storage. However, mostly one storage structures are built with no capacity to manage the storage of several crops. The storage structures are primarily used for storing dry grain, and there are no storage structures for fruits and vegetables. At the union level, there are different needs for storage including storing grains, fertilizers, chemicals and seeds. However, most unions only have one storage structure, and this creates a challenging situation when they mix grains with other things.

4. **Lack of trust in the maize and wheat value chains is pervasive; it discourages the use of cooperative and private storage facilities by producers.** A consistent issue raised by farmers in most of the regions related to storing grain with private warehouses and cooperatives is *lack of trust*. There is a lack of trust in the capacity of cooperatives to keep their grain in good condition, given the quality standards of the existing infrastructure. Although producers are aware of the storage losses on farms, they are reluctant to store grain elsewhere with private storage owners. Farmers do not trust their grain with anyone else. In other cases, the warehouse owners do not want to take the responsibility for storing grain for several individual farmers due to potential theft and storage losses. Although many farmers are aware of and appreciate the benefits of cooperatives, many noted corruption by some cooperatives. This discourages them from selling and storing their grain with the primary cooperatives. There is also mistrust between the primary and union cooperatives, mainly due to the lack of storage space when

there is oversupply after bumper harvests. When unions cannot buy all the grains from the primary cooperatives, the primary cooperatives then dispose of it in the local markets by selling it to traders at lower prices or by reselling the grain to members at the prices procured from the producers.

5. **Most farmers cannot use primary cooperatives' storage facilities for temporal arbitrage**. Due to cooperative by-laws, most farmers cannot use cooperative storage to store grain and then sell it later when prices are expected to rise. Most cooperatives do not provide storage services for individual farmers. Only a few cooperatives provide storage services to members. For example, in Galama, the primary cooperative stores grain for members by marking the grain sacks with the name of the cooperative member. The focus of most cooperatives is service provision (especially related to inputs, such fertilizers and seeds), with limited profit orientation.

6. **Producers sell a negligible amount of wheat and maize through the primary cooperatives.** Field data and information show that producers sell a small fraction of their marketable output through cooperatives. Consistent with this observation, a recent AGP 2 baseline survey[6] of 10,924 randomly selected households reveals that farmers only sell 2.6 percent of their crops through cooperatives. The data further reveal that households sell 1.9 percent (wheat) and 3.8 percent (maize) of their output through cooperatives, as compared with 66 percent (wheat) and 64 percent (maize) sold through private traders. This observation is consistent with previous research (Abate *et al,* 2015; EDRI 2017; and Minot *et al*, 2015) into wheat and maize marketing in Ethiopia. The FCA estimates are higher noting that producers sell approximately 10-11 percent of their agricultural output through cooperatives.

   There are several reasons why producers sell less of their marketable output through cooperatives. First, most farmers noted that the *cooperatives buy immediately after harvest over a short window of time when prices are low*. In addition, the primary cooperatives' management lacks flexibility in setting prices because the price is decided by the board. In this regard, there is a time lag in price setting, which means that the cooperatives could lose business opportunities. Second, and more importantly, many producers view the *cooperatives as an unreliable marketing outlet* for the farmers in terms of the price they offer, the amount they purchase, the consistency of purchasing, and the time length of purchasing. Third, most primary cooperatives have financial constraints and poor market linkages to purchase the desired quantity from their members. As such, their purchasing pattern and quantities are limited and unpredictable. In addition, because some cooperatives decisions about purchasing are influenced by external buyers' like the WFP, the *ad hoc* market participation of these external buyers results in inconsistent buying patterns of cooperatives from their members. Consequently, most cooperatives do not satisfy the farmers' needs in terms of the quantity they buy, the continuity of the market outlet and the price they offer. This further contributes to *high levels of side-selling*

[6] Agricultural Growth Project/AGP II Baseline Draft Survey Report (EDRI, 2017). The data covers four regions including high surplus grain areas

by cooperative members because they prefer to sell directly to traders who offer better prices, sustainable purchases and cash advances. Increasing marketing through cooperatives is an important ingredient to achieving agricultural commercialization and transformation in Ethiopia. However, field data and interviews reveal that most producers do not sell much marketable output through cooperatives. Thus, cooperatives provide an important service on the input side, but their output marketing function is weak.

7. **Most farmers sell immediately after the harvest to meet their financial obligations,** which are usually due then. Field observations and interviews reveal that most farmers sell at harvest time at lower prices due to cash shortages. For example, in Shashemene in West Arsi, about 60 percent of the farmers sell immediately after the harvest — not because of storage problems — but more because of the need for cash to meet financial obligations which are due right after the harvest. Although there are microfinance service providers in some areas, there are several problems with their use. First, the timing of the loan provision is not designed in such a way as to prevent the farmers from selling their crops after the harvest. Second, debt collection is undertaken right after the harvest, which compels the farmers to sell assets. Third, producers mostly use the loans from microfinance institutions for consumption purposes, and not for productive investments. Furthermore, producers mostly sell to the traders on credit in advance of harvest time. They then pay in kind at cheap rates immediately after the harvest when the price is the lowest of the season. Consequently, most producers do not benefit from better prices because of untimely sales and weak bargaining power.

8. **The lack of transparency in price discovery and asymmetric price information in cereal marketing contributes to many uncertainties in the maize and wheat value chain.** Many actors in the maize and wheat value chain emphasize that there is a lack of transparency regarding how wheat and maize prices are determined. In addition, prices are not announced to the grain value chain actors. Farmers noted that they do not have clear market information in the distant wholesale markets. They also noted that farmers-traders influence the price of wheat by spreading untruthful rumors that the supply of wheat is going to increase due to food aid wheat, so they pay lower/constant prices to the farmers. For example, farmers in the high producing area of Arsi indicated that the food aid wheat is depressing the market prices for wheat because traders spread the news of the food aid wheat to keep the prices low. Focal group discussion with farmers in Eteya Town (Arsi zone) reveal that farmers are not informed about cereal market prices for important destination markets, such as Adama and Addis Ababa. They obtain market information from brokers. However, because of a conflict of interest, it is hard to expect complete disclosure of market information by the brokers to the farmers. Furthermore, interviews with government officials reveal that cereal prices are determined internally and are not announced to VC actors. Key factors considered in determining the grain prices are the prevailing open market cereal prices and the expected supply. The cost of production is not clearly factored into cereal price determination. The ETBC makes the final price decision at its head office, and announces prices in localities during purchasing, and when prices are volatile. As such, it gives the mandate to its agents to determine the price. In addition,

information on the prices at which the processors are buying is not available and communicated to all stakeholders. Thus, there is a clear need to establish a grain marketing information system which includes price information, and forecasting on expected grain supplies based on reliable data and methods.

9. **Uncertainties about the quantity and the timing of distribution of subsidized wheat and maize negatively affects local prices.** Farmers in high producing areas like Arsi revealed that the government distributes subsidized wheat to wheat flour mills at lower prices when there is no shortage of wheat in the market. Consequently, this sends the wrong market signals, adversely affecting the smooth functioning of the wheat market. This is consistent with sentiment by government officials that the data about the expectations regarding the cereal supply are not reliable. Furthermore, many farmers, especially in grain deficit regions, noted that flour mills prefer to buy the subsidized imported wheat before they buy the local product because it is cheaper and more uniform in quality. Wheat retailers in Tigray and other regions buy subsidized wheat flour from food aid recipients at cheaper prices. Farmers revealed a frustration that the government is urging producers to increase their production, whereas the (untimely) distribution of cheaper subsidized wheat negatively affects their local markets. Thus, there is a need to clearly and reliably determine the marketable surplus for maize and wheat to plan investments in storage, processing and other logistical functions necessary for a well-functioning cereal marketing system.

10. **Unclear and arbitrary tax practices are turning cereal wholesale traders into retailers in some regions**. Field information based on focus group discussions with wholesale traders in the Amhara region reveal an emerging trend of tax practices, resulting in disincentives in the wholesale trading business. The tax is based on the amount of stock held at the time of a visit by the tax official. It is not based on the business turnover. Since the stock might be held for a very long time and the price can go up or down, the wholesalers reported price fluctuations resulting in high variability in the traders' income. In this context, there is a strong probability for over-taxing when the tax is based solely on the stock level. Hence, holding large stocks at the traders or wholesalers shed is a condition for imposing higher taxes by the tax authorities. Consequently, traders avoid holding large stocks or unloading from trucks in public. However, tax authorities have agents working for them who provide immediate reports of the location whenever they see the unloading of cereals from trucks outside the premises of the traders. Because of this tax system, wholesalers are not receiving the bulk transport of cereals from other regions. Indeed, they are now more interested in holding small stocks, and in retailing rather than wholesaling. Wholesale trading is an important function for commodity flows between surplus producing and cereal deficit regions. Unclear tax policies can weaken this link, restrict spatial arbitrage and hinder the effective functioning of cereal markets. They also reduce incentives for the private sector to invest in storage facilities.

11. **Cheating is a common phenomenon in the maize and wheat marketing chain.** Producers in Tigray and other deficit areas noted that due to the influx of cheaper subsidized wheat from the government, the millers are not honoring their contracts with the unions and subsequently

break them. Contractual defaults were also reported at the cooperative level, leading to a decrease in farmers' interest in working with cooperatives. At the same time, cooperative members engage in side-selling, as they prefer to sell to traders because they receive better prices and can rely on more consistent purchasing. A farmers group interview in West Arsi reveals that farmers prefer to sell to the farmer-trader in their area because the traders in town cheat on the weight. The traders adjust the weight downward by decreasing the weight of the grain by 5 to 10 kilograms (kg) per 100 kg weight of grain delivered by the farmers. It is almost a common practice that the farmers mix grain with impurities to increase the weight of the grain because they know that the traders will cheat on the weight. Further, some cooperatives are strict in terms of quality and weight of the grain. For example, the cooperative in Bako Tibe is strict about quality and does not buy if there is any weevil infestation. As such, it only pays for 95 kg of maize to account for some losses. However, the traders would buy even the weevil-infested maize and pay for 100 kg maize. They would then mix low quality maize with the higher quality maize. With the way that the business is conducted between traders and producers, the overall consistency of the average quality of grain delivered to the retailers and processors is poor. The retailers need to clean the grains more before they sell to their customers; otherwise, the consumers will not be willing to buy from the retailers.

In a focus group survey, producers in a high wheat producing zone (Bale) indicated that, in some cases, the procurement and marketing practices of the ETBC are prone to bribes. Some ETBC agents receive about 20 Birr/quintal to accept deliveries from the producers or traders, and return the truck load if the payment is not made. One consequence of this conduct is that ETBC agents do not pay careful attention to quality, and will accept any wheat delivered by the traders. Since ETBC agents do not prefer to buy from the farmers with small plots, the small farmers sell to traders who then aggregate the grains and sell them to the ETBC. However, the traders mix different qualities and sell it to ETBC agents. The traders are reported to pay up to 300 Birr per truck load in bribes to ETBC staff for their delivery to be accepted.

Overall, these adverse selection problems reduce the consistency of the average quality of locally procured wheat, leading processors to also prefer imported wheat. Thus, there is a need for regular third-party oversight of the weight and quality inspection process.

12. **Poor regulation and enforcement of quality and standards prevail in the marketing of maize and wheat.** Although many buyers assign grades, there are no formal maize and wheat grain standards. So too, there is no formal and consistent quality enforcement at the different nodes of both value chains. The quality requirements by cooperatives are higher, but the quality of the grain is examined only physically for breakage and obvious physical impurities. There are no quality checks for moisture content or for storing the grain at the appropriate moisture and temperature levels. In this context, many cooperatives do not provide important preconditioning services, such as sorting, drying, and grading before storing the grain. Traders handle low quality wheat and maize and mix grain of different qualities, reducing the average quality flowing through the value chain. Processors noted that the unions do not provide a continuous supply of good quality grain. In East Wolega, for example, some unions are proving

training to members regarding the quality management of maize. Many millers noted that the imported wheat flour is of high quality, especially in terms consistency. As a result, apart from the imported wheat being cheaper, many millers and retailers note that the subsidized wheat has more uniform quality.

Overall, although farmers can produce good quality bread, pasta wheat and maize flour, the weak market linkages and quality enforcement do not encourage farmers to invest more in quality. However, ATA's work in the wheat value chain and market linkages with factories was successful for the Gololcha Union (Arsi Zone). More effort will be needed to create such market linkages. Producers need to be convinced that they will obtain a better price through such linkages than in the open market. As such, they would be motivated to invest more in the production of high quality grain.

13. **Some medium-to-large processors do not source locally and rely on imported subsidized wheat**. In low wheat producing regions like Tigray, some large millers noted that they largely depend on the government-subsidized imported wheat as a raw material for their milling. Since the local wheat is more expensive (when buying and selling flour), the company is not interested in obtaining the raw wheat locally. Thus, the raw wheat used for processing is entirely imported or supplied by the government through the ETBC. A large industrial miller *used to import wheat from Addis Ababa, but with the subsidy, the miller stopped the importation of wheat as it could not compete with subsidized wheat flour or bread.* Other small-to-medium millers in Mekele noted that the demand for wheat from Amhara and other regions to Tigray is insignificant. Therefore, they only procure wheat occasionally from within the region. The demand for wheat in Mekele is for industrial milling, which is mostly satisfied by imported, subsidized wheat. Traders in Dessie noted that subsidized wheat is of good quality and cheaper. Hence, sourcing wheat from a distant or local market is not profitable. Flour mills buy food-aid wheat as much as possible to meet their requirements. They then buy from the cooperatives as a last resort if they cannot obtain sufficient supplies of food aid wheat. Overall, local producers are frustrated that subsidized wheat is weakening their market potential to supply to local processors, retailers and other buyers.

A key assumption of the wheat subsidy is that the subsidized wheat flour does not leak into the open market if well targeted. However, there is a strong incentive to do just that because the open market price of wheat flour is significantly higher than the subsidized wheat flour. For example, at the time of field work, the price of wheat flour was 1,200 Birr per quintal in the open market, which is significantly higher than the subsidized wheat flour price of 726 Birr per quintal. Field interviews with retailers and traders reveal that many retailers and traders buy subsidized wheat from food aid household recipients. Hence, there is a need for careful inspection and regulation of the distribution of subsidized wheat. In addition, careful consideration is also required regarding the right mix and appropriateness of food versus cash transfers to food insecure households in some locations where recipients are selling their cereals to other consumers, retailers and traders.

There are now more direct shipments of maize from the production areas to the consumption areas, bypassing the traditional transshipment wholesale market in Addis Ababa. This is indicative of the improvements in road infrastructure, the availability of trucks at competitive prices, and improvements in cereal traders' networking capacity due to increased access to mobile phones. In deficit areas (Wallale-Jijiga) of the Harar and Somali regions, large wholesale traders import maize directly from other areas, especially Wollega. There is also an emerging trend of importing hubs, where some private investors are building modern warehouses and importing maize directly from Wollega. They then stock it for local distribution and exports to more distant places in the zone and other regions like Jijiga.

3. Conceptual Framework and Empirical Strategy

3.1 A conceptual framework for cereal market performance analysis

In Ethiopia, grain production is dominated by geographically-dispersed smallholder farmers. There are clear regional variations in the volume of different grains produced in the country. Some of the major consumption markets are in grain deficit regions, relying on grain imports from the surplus-producing regions or imports — giving rise to both temporal and inter-regional grain trading opportunities. Since liberalization in 1991, the grain marketing system in Ethiopia has been characterized by the coexistence of the state-owned marketing agency, cooperative marketing and private sector grain trade, each with different resources and capacities to engage in the market. Given this general context, in this study, the performances of maize and wheat markets are evaluated based on statistical and econometric models using historical time series price data collected in different markets and at different marketing levels (producer, wholesale and retail). This section provides a brief discussion of the conceptual framework guiding the statistical and econometric analyses and interpretation of cereal market performance in Ethiopia.

Grain marketing involves several different functions such as storage, transportation, processing and arbitrage. The evaluation of marketing system performance is essential to identifying the defects in the marketing system, as well as to suggesting possible ways of improvement. Pricing efficiency is one of the measures of the performance of agricultural marketing systems based on the economic model of perfectly competitive markets. It is concerned with how the market allocates resources to their best use, and coordinates production and marketing process to obtain the maximum output. It is indicated that "pricing efficiency is less than perfect when prices fail to (1) fully represent consumer preferences; (2) direct resources from lower to higher values uses; or (3) coordinate the buying and selling activities of farmers, marketing firms and consumers" (Kohls and Uhl, 1993). The efficiency of a given agricultural marketing system is influenced by several factors such as competition, government marketing policy, and marketing infrastructure development.

Some of the key variables used in evaluating the pricing efficiency of agricultural marketing systems are based on a perfectly competitive market model. These include: price levels, price variability, marketing margins, and the degree of market integration. It is possible to classify marketing margins into three categories: spatial, temporal, and form change, that is, the marketing margin for the product.

In terms of spatial marketing margins, when there are no impediments to trading between two regions, with trade, the price difference will equal transfer costs; with no trade, it will be less than or equal to transfer costs (Tomek and Robinson, 1993). This is based on the concept of the spatially-competitive equilibrium model; deviations from these outcomes are assumed to indicate inefficiencies.

In the case of temporal price margins, the increase in the prices of physical commodities from one-time period to the next is assumed to be equal to the costs of storage from one period to the next, plus "normal profits" for the traders (Delgado, 1986). This is based on the concept of inter-temporal competitive market equilibrium. Delgado (1986) suggests that the implication of high inter-temporal price variabilities (seasonal price spreads) — independent of storage and transaction costs — are indications of inefficiencies in the marketing system. The marketing margin for the product form changes must also be reflected in the processing costs for an efficient market.

Small farmers in most developing countries are responsive to prices. Consequently, agricultural prices play an important role in achieving the efficient allocation of resources (Ahmed and Mellor, 1990; Timmer, 1987). In this context, Timmer (1987) indicates that market performance and its welfare impact depend on the efficiency with which markets generate and transmit price signals.

The level of prices determines the profitability of farmers' investments. Hence, their incentive to invest is also important to the improvement of the national economy. The level of prices also determines what proportion of the product must be sold in the market by the farm households to meet their financial obligations, as well as for the purchase of farm inputs. In the case of food shortages in the family, price levels affect farmers' capacity to buy in the market, thereby influencing farmers' food security. Price level also affects urban consumers' purchasing power, and their food security situation as well.

Price variability or stability is related to the pattern of price level changes over time, which might be predictable or unpredictable. In the case of prices varying in an unpredictable pattern, the means and variance of prices will change from time to time. However, in the case of stable or less variable prices, there is no significant change in the means and variance over time. As such, the price will vary around known trends or it may vary around mean values with constant variances. However, it is argued that in the efficient market, the prices should vary to account for the changes in the costs of marketing services, such as transportation and storage costs (Delgado, 1986).

Price stability can be an important efficiency indicator of agricultural market performance. Unstable and unpredictable prices will result in insecure farm incomes, and this complicates the farmers planning process (Kohls and Uhl,1990). Thus, under the condition of highly variable or unstable prices which are unpredictable, the role of prices in allocating resources to their best use is minimized. The accuracy by which price changes can be predicted is important for both food producing and consuming households to adjust their sale and storage strategies to achieve food consumption objectives (Sahn and Delgado,1989). It is also found that the risk of price instability tends to decrease aggregate supply and increase marketing margins (Brorsen *et al*, 1987).

The variability of price can be analyzed at different levels, including the producer, wholesale and retail levels. These analyses on price responsiveness at different levels in the marketing channel can provide an indicator of market performance (Pick *et al*, 1990). If the market is efficient, it is expected that there would be a very fast and symmetric transmission of price changes from one level to another. The same also applies for efficiently linked spatial markets. Different market levels are expected to have similar levels of variability measures.

Market integration as a test of market performance is based on the concept that markets are integrated only if their prices do not behave independently — and that changes in prices at one marketing level are reflected at all other levels (Ahmed, 1998; Faminow and Benson, 1990). Heytens (1986) also indicates that in an "efficiently integrated" marketing system, there will be positive price correlation over time among prices at different market locations. Specifically, there is no price divergence among integrated markets. If two markets are integrated, the price difference between the two markets equals the transfer costs (Ravallion, 1986).

Market integration through infrastructure development is expected to reduce temporal price variability and spatial price disparities (Fafchamps, 1992). However, markets that are not well integrated may convey inaccurate price information that might also distort producer marketing decisions and contribute to inefficient product movements (Goodwin and Schreder, 1991). The other factors affecting market integration include: market information and knowledge; the ability to respond to market opportunities; and the resources and ease with which produce can be moved from one market to another (Southworth *et al*, 1979). Thus, the spatial market efficiency also has implications for food security.

Given this conceptual framework, this section presents the various statistical econometric methods used to analyze the fluctuations of maize and wheat prices over time and space. Some of the key features modeled include: (1) maize and wheat price volatilities to gauge the level of risk in their respective markets; (2) seasonal price movements to assess the level of temporal arbitrage opportunities and efficiencies; and (3) spatial price linkages to assess the level of spatial arbitrage opportunities, efficiencies and extent of market integration.

3.2. Measuring the levels and variability of maize and wheat prices

3.2.1 Analyzing maize and wheat price levels and variability

3.2.1.1 Overall maize and wheat price fluctuations

In general, the cereal price fluctuation over time can be disaggregated into two major components — predictable and unpredictable components. The important question then becomes: Which component plays an important role in the overall price fluctuation? The level of uncertainty or unpredictability is usually associated with the riskiness of cereal markets. The risks present in the marketing system prevent the realization or occurrence of advantageous spatial and temporal arbitrage opportunities. However, it can also prevent optimal investments in production, and distribution marketing activities. Therefore, it is important to discern the level of unpredictability or uncertainty present in the cereal price fluctuations. This data will help to inform strategies and polices to prevent, mitigate or reduce such price risks.

In analyzing maize and wheat price fluctuations, quantifying the overall magnitude of unpredictability in the price fluctuation is key to determining the extent of risk present in the cereal market. For this purpose, analysis of variance (ANOVA) is used to decompose maize and wheat price fluctuations for the entire study period into the predictable (trend-cycle and seasonal components) and the unpredictable random components as follows:

$$TV = TC + S + I \quad (1)$$

where TV denotes the total price variance; TC denotes the percentage of price variance due to the trend-cycle component; S denotes the percentage of price variance due to the seasonal component; and I denotes the percentage of price variance due to irregular or random components. Use of the ANOVA allows for the testing of the statistical significance of various components of price fluctuations. Thus, the ANOVA decomposition allows for an assessment of the general level of price uncertainty (or risk) observed in maize and wheat prices in different markets —and at different market levels (producers, wholesale and retail) —over the entire study period. In general, a higher percentage of price variance due to the random component indicates higher risk in the cereal marketing system.

It is equally important to identify the causes for the different types of price fluctuations. Tomek and Robinson (1993) provide a detailed discussion of the causes for different types of price fluctuations. In general, they indicate that the inelastic nature of supply and demand for agricultural products, coupled with very high annual production instabilities, are the main reasons for cereal price fluctuations. The growth in income, population and urbanization are among the factors which affect the long-run price movements. However, the seasonal price movement could be due to: (i) the seasonal nature of production and/or consumption; (ii) inadequate market infrastructure (for example, road access limited to the dry season, thereby forcing farmers to sell at harvest time or early in the season before the road network becomes inaccessible — instead of selling during the rainy season when the prices could be favorable); (iii) lack of instruments for managing the risk of adverse movements in future prices (such as forward contracts, futures and options markets for cereals); (iv) imperfect insurance (lack of insurance for price and/or yield risk); (v) imperfect credit markets (no or limited credit to smooth consumption or to wait for better prices during lean seasons); (vi) government policies (government tax); and (vii) financial lenders' loan repayment collection (coming right after harvest). The random price movement could be due to *ad hoc* policy changes (discretionary grain pricing, procurement, storage and distribution) and trade policies (imports and exports) and weather shocks, and so on.

3.2.1.2 Measuring seasonal price movements and temporal arbitrage opportunities

The various components of price fluctuations are also analyzed for seasons using historical monthly price data, following Goetz and Weber (1986). This analysis provides information about average seasonal price movements, which is useful to informing decisions about storage, marketing, food security and government policy. There are several methods which are used to separate and analyze the seasonal price movements, including: the econometric regression methods using seasonal dummy variables or trigonometric functions to capture seasonality; and the seasonal decomposition using a multiplicative or additive statistical model. In this study, the seasonal multiplicative model (which provides more information) is used to deconstruct the time series price data into four major components; trend, cycle, seasonal and random components[7] as follows:

$$P_t = T_t . C_t . S_t . I_t \quad (2)$$

where P_t is monthly price series (producer, wholesale or retail) data at a certain time, denoted by *t*. T_t denotes the trend component and is measured in the units of actual prices. C_t denotes cycle index, S_t denotes seasonal index, and I_t denotes the index for the random component. The trend and cycle represent long-term fluctuations, whereas the seasonal and random components represent short-term fluctuations. A brief discussion on the steps involved in seasonal decomposition of the maize and wheat price indices using the multiplicative model is illustrated below.

The first step in the seasonal decomposition is to isolate the trend-cycle components by using a 12-month centered moving average for a given month *t* ($CMA_{12,t}$) and the regression method. The 12-month moving average ($MA_{12,t}$) is obtained as:

$$MA_{12,t} = \frac{1}{12} \sum_{i=-6}^{5} P_{t+i} \quad (3)$$

Then, the $CMA_{12,t}$ is obtained by centering the $MA_{12,t}$ as follows:

$$CMA_{12,t} = \frac{1}{2} \sum_{i=0}^{1} MA_{12,t+i} \quad (4)$$

The $CMA_{12,t}$ has two components (trend and cycle). Therefore, there is a need to determine the pure trend component. The pure trend component is then derived from the Trend-Cycle component by regressing the $CMA_{12,t}$ on the constant and time trend variable (*t*) as:

$$CMA_{12,t} = a + b.t + e_t \quad (5)$$

Then, the pure component ($CMA_{T,t}$) is given as the difference between $CMA_{12,t}$ and the residual from the regression in Equation (5). Second, to derive the cycle component, the trend cycle component is divided by the pure trend component as:

$$C_t = \frac{CMA_{12,t}}{CMA_{T,t}} = \frac{T_t . C_t}{T_t} \quad (6)$$

[7] As opposed to the ANOVA method, which provides the point estimates of different components of price fluctuations, the seasonal decomposition method generates time-series observations of different components of price fluctuations.

The seasonal index is obtained as follows. First, the seasonality factor is computed by dividing the actual price series by the centered moving average; hence, the name ratio-to-moving average method:

$$S_t I_t = \frac{P_t}{CMA_{12,t}} = \frac{T_t.C_t.S_t.I_t}{T_t.C_t} \qquad (7)$$

Then, to calculate the pure seasonal component for each month, we simply sum and average the indices of the same month over all years (N). For example, the average of all j^{th} month indices is computed as follows:

$$\bar{S}_j = \frac{1}{N}\sum_{t=1}^{N} S_{jt}\,;j\ = 1,2,3,\ldots,12; t\ = 1,2,3,\ldots,N \qquad (8)$$

where j denotes the month (1=January, 2=February, 3=March, etc.); t denotes the year. The summation of a given month is over the entire study period. The final step is to calculate the random component as:

$$I_t = \frac{S_t.I_t}{S_t} \qquad (9)$$

Finally, the purely seasonal component is obtained as:

$$S_t = \frac{S_t.I_t}{I_t} \qquad (10)$$

The stability of the pattern of seasonal price movement is analyzed by fitting the time trend regression to the pure seasonal index. The significant coefficient on the time trend variable indicates the change in pattern of seasonal price movement over the time. The standard deviation of the seasonal index also shows the variability of the seasonal index.

Finally, the Grand Seasonal index (GSI_j) for j^{th} month utilizes the entire historical price dataset and satisfies the condition that all indices add up to 12. This is given as:

$$GSI_j = \overline{S}_j.\frac{12}{\sum \overline{S_j}} \qquad (11)$$

In relation to grain storage, the key parameter which can be derived from the seasonal decomposition of cereal prices is the seasonal price spread. The seasonal price spread is given as the difference between the highest and the lowest seasonal index. This spread can also be expressed as the ratio to the lowest seasonal index:

$$GSR = \frac{Highest\ GSI - Lowest\ GSI}{Lowest\ GSI} * 100 \qquad (12)$$

This ratio is also called gross storage return (GSR) and measures the average seasonal price movement based on historical price data, which shows the potential for temporal arbitrage (Tshirely 1995).

However, the seasonal price spread alone cannot be used to assess storage profitability in making storage decisions. It needs to be compared with the costs of storage. Under the competitive market conditions, the profit maximization rule by different economic agents gives rise to the temporal arbitrage condition given as (Wright 2011):

$$\frac{1-\pi}{1+r} E_t P_{t+1} \leq P_t + C_t \text{ ; } Stock \geq 0 \qquad (13)$$

where π denotes the assumed storage loss or grain product depreciation over the storage period; r denotes the interest on capital used to buy the grain (P_t) and to pay for the storage rent (C_t); and E_tP_{t+1} denotes the expected price of grain at the end of storage period ($t+1$). The temporal arbitrage condition states that for storage to occur, the discounted future price must be less than or equal to the current price —plus the costs of storage. With competition, the equality constraint holds. It is important to note that in the absence of historical data on storage costs, the efficiency of existing storage can be evaluated by computing the return (φ) required to break even given the current assessed grain storage loss and the market interest rate by solving for φ in the following equation:

$$\frac{1-\pi}{1+r} = \frac{1}{1+\varphi} \qquad (14)$$

Then, accounting for the appropriate storage period, the breakeven return can be compared with the average return to storage for a given period. This can be done by utilizing the monthly return computed from the historical price data and assessing whether the realized returns are below or above the breakeven return — indicating whether the realized returns are small, excessive or reasonable. For example, if the storage period is for six months and the computed average monthly return is 2 percent, then the return for the six-month storage period is given as 12 percent (6*2 percent). Then this return is compared with the breakeven return rate for six months ($\varphi * 6$). It should also be noted that reducing storage losses increases the profitability of storage.

The constructed seasonal price indices can be used to inform storage or marketing decisions at harvest time by enabling forecasts about the future price based on the harvest time price. For example, the forecast for a given month (at the end of the planned storage period) in the future can be determined as follows. First, the seasonal average price is obtained by dividing the harvest month price by its index. Second, the forecasted price for a given month in the future is obtained by multiplying the seasonal average price by the index of the forecast month. This procedure allows the producers or private traders to estimate the expected price increase in the lean season. Thus, the computed expected price increase can be compared to the costs of on-farm storage. These include grain depreciation and other costs to determine whether undertaking grain storage would be profitable, assuming other factors affecting prices during the storage period remain constant. The forecast information can also be used by governmental and non-governmental organizations involved in productive safety net programs (PSNP). Specifically, it can be used to predict the expected future prices required for determining proper intervention prices, as well as for budgeting purposes.

In analyzing storage decisions by famers, especially smallholder farmers, it is important to note that they may have different objectives for holding grain stocks — other than waiting for better prices. For example, farmers hold (or have the incentive to hold stocks of grain) to avoid the risk of selling low and buying high for own consumption later in the season. Therefore, it is important to critically assess what the advantage of grain storage is as opposed to selling at harvest and assessing the efficiency of rural credit and insurance markets.

3.2.1.3 Measuring the volatilities of maize and wheat prices

In the literature, the volatility of cereal prices is measured by using the variance of monthly price returns (for example, see Minot, 2014; and Tadesse, 2001). The monthly price return is given as the changes in the monthly logarithm of prices (continuously compounded percentage changes of prices) as:

$$R_{it} = lnP_{it} - lnP_{it-1} \quad (15)$$

where R_{it} denotes the price return for i^{th} cereal crop for month t; and lnP_{it} is the natural logarithm of the monthly real price (producer, wholesale or retail) for i^{th} cereal crop for month t; and lnP_{it-1} is the natural logarithm of the i^{th} cereal crop price, lagged by one month[8].

Simply stated, the volatility is measured by point estimates of variance, standard deviation and a coefficient of variations using the entire time series dataset. However, it is argued that the problem with such point estimates of volatility is that these estimates do not allow for the assessment of the evolution of price volatility over time. To assess the evolution of maize and wheat price volatility over time, then monthly estimates of volatilities are computed in two ways. First, the rolling method with a 12-month window is used. Second, the one-step ahead variance forecast using the generalized autoregressive heteroscedasticity (GARCH) model is utilized.

There are two steps involved in the rolling method of computing price volatility. First, the rolling method with the n-month window converts the entire T monthly price data observations into T-n+1 sub-samples of monthly price data observations. Then, the rolling descriptive statistics (for example, mean, variance, standard deviation, and so on) are obtained for each sub-sample of T-n+1. Thus, the rolling method generates time series data of monthly point estimates of measures of price volatilities. This then allows for a picture of the evolution of price volatility over time. However, the problem with the rolling method is that the variance is assumed to be constant over time, whereas several empirical analyses indicate the changing nature of variance of cereal prices over time. Therefore, there is a need to test whether the variance is constant over time for the proper modeling of cereal price volatility.

The more advanced modeling of price volatility involves the isolation of the predictable and the unpredictable components in the time series price movements, whereby the unpredictable component is used in measuring price volatility. In general, the GARCH model of volatility in monthly price returns involves two steps. First, the conditional mean equation of the monthly price return is given as a function of the predictable component (a constant, own lagged monthly price return, seasonal dummy variables, other exogenous variables, and so on), which explain the price returns) and the unpredictable (random) component. It is estimated using the ordinary least squares (OLS) regression:

[8] The monthly return can be annualized by multiplying the monthly return by 12.

$$R_{it} = \theta_0 + \sum_{i=1}^{P} \theta_i R_{t-i} + \sum_{j=1}^{11} d_j D_i + \varepsilon_{it}; \quad \varepsilon_{it}|\Omega_{t-1} \cong N(0, \sigma_t^2) \quad (16)$$

where θ_i and d_j are parameters to be estimated; D_i is the seasonal dummy variable for i^{th} month; and ε_t is the random error term, which is normally distributed with mean zero and variance of σ_t^2. The appropriate specification of the conditional mean equation is ensured by determining the proper lag (P) structure, using the Schwarz's Bayesian information criterion (SBIC), or the Akaike information criterion (AIC), as well as by examining the plots of autocorrelation (AC) and partial autocorrelation (PAC) functions of the residuals from the mean return Equation (16). Formally, the statistics of the Lijung-Box (LB) Q-test is also used to test for the presence of any remaining serial correlation in the residuals from the regression. Although slightly different lag structures are suggested from the SBIC and AIC for different price series and examination of plots, in order to keep uniformity, AR (6) is selected in all conditional mean equations.

After proper specification of the conditional mean equation and its estimation, the Engel's Lagrange multiplier (LM) test is used to assess the null hypothesis of the autoregressive heteroscedasticity (ARCH) effect in the error term from the conditional mean equation of price return. The presence of the ARCH effect indicates what is known as volatility clustering, or the tendency that if the volatility is small, there is a tendency to remain small; if large, the tendency is to remain large. The smaller the volatility, the better. The test of ARCH effect by LM is conducted by running the following OLS regression of the residual from the conditional mean Equation (17):

$$\sigma_t^2 = a_0 + \sum_{i=1}^{m} a_i \, \varepsilon_{t-i}^2 + u_t \quad (17)$$

where a_is are the parameters to be estimated and u_t is the random error. The null hypothesis of ARCH (m) effect is given as: H_0: a_i=0 for all i=1,…,m. If the null hypothesis is accepted, the volatility of the price return is measured using unconditional variance. However, in the second stage, if the presence of the ARCH effect is confirmed, the GARCH (1, 1) which is considered adequate in most empirical applications (.) is used and given as follows:

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \quad (18)$$

A similar method used in the specification of the conditional mean equation. It is also used here to determine the appropriate lag structure for the ARCH (m) model. Several measures of the conditional volatility of the monthly price return are derived from the conditional variance equation (18). First, the long-term conditional variance (unconditional variance of returns) to which the volatility converges in the long-run is given as:

$$\sigma_{LR}^2 = \frac{\omega}{1-\alpha-\beta} \quad (19)$$

The coefficient α measures the persistence of the shock in return innovation, and β measures the persistence of the past conditional variance. The sum of both coefficients gives the magnitude of the persistence of volatility; the closer the sum is to unity, the more persistent is the volatility. If the sum is greater than unity, it indicates overshooting of the volatility. The condition characterized by the volatility is always getting higher. The existence of positive, long-run unconditional variance requires the covariance stationarity process which implies that $\omega>0$; $\alpha > 0$; $\beta > 0$; and $(\alpha + \beta) < 1$. The size of volatility and its persistence measure the risk that exists in the marketing system. The monthly conditional volatility can also be annualized by taking the square root of the product of the conditional variance and 12 multiplied by 100, as follows:

$$\sigma_a = \sqrt{12 * \sigma_t^2} * 100 \qquad (20)$$

where σ_a is the annual standard deviation of price returns. The half-life of shock is another important measurement of cereal price volatility, which measures the speed of the decay of cereal price volatility. The half-life of shock in the price volatility, that is, the time taken for the half of the shock in volatility to adjust back to the long-run conditional variance, is given as: $HL=ln\ (0.5)/ln\ (a+\beta)$.

3.2.1.4. Measuring maize and wheat markets integration: A spatial price analysis

This section presents the econometric models used to analyze spatial price linkages and spatial market efficiency. The standard co-integration methodology[9] developed by Engel and Granger (1987) starts by identifying the long-run equilibrium relationship between the prices of two markets. It is given by the following ordinary least squares (OLS) regression:

$$p_{it} = \alpha_0 + \alpha_1 P_{jt} + u_t \qquad (21)$$

where α_0 is a constant term; α_1 is the so-called a co-integrating parameter; u_t is a random error term; and P_{it} and P_{jt} are the log of prices of a given commodity (for example, maize or wheat) for the i^{th} and j^{th} markets, respectively. It is important to note that the coefficient α_1 gives the long-run elasticity of price transmission from the j^{th} to i^{th} market. The closer this coefficient is to one, the more complete (or one-to-one) is the transmission of price changes from the j^{th} market to the i^{th} market in the long-run. The Johansen maximum likelihood method is also used to determine the number of the unique long-run relationship (co-integrating vector) among the time series economic variables. Similar results from the different methods build confidence in the existence or lack of long-run equilibrium relationships among economic variables.

In general, the co-integration relationship stipulates two conditions. First, the two time series variables have the same order of integration, or require the same number of differencing to become stationary (having constant mean and variance). Second, the residual from the co-integration relationship given in Equation (21) is stationary. Taken together, these conditions imply the use of the two-step Engel-Granger econometric estimation procedure to test the cointegration relationship between two-time series variables. First, the time series properties (such as the presence of unit root and stationarity) of the individual time series variables is investigated. The stationarity is investigated using different methods, such as the Augmented Dickey-Fuller (ADF) (Dickey and Fuller 1979) and Philipps-Perron

[9] Fackler and Goodwin (2011) provide a recent, detailed review of empirical methods used in spatial price analyses.

(PP) (Phillips and Perron, 1980). If the price series are non-stationary, the unit root analysis determines the level of differencing required for the various time series variables to become stationary. The number of unit roots present in the price series indicates the number of differencing required to make the series stationary. The tests of stationarity are required to avoid spurious relationships in the implementation of econometric models used in the price analysis. The spurious regression occurs when the coefficients of regression are due to some common trends influencing both variables, rather than due to the true underlying economic relationship between the two variables — hence, giving wrong results leading to erroneous recommendations.

Second, the ordinary least square regression is run between the two-time series variables found to have the same level of integration. If the two series have a different order of integration, it is already considered that the two variables are not co-integrated and any such regression is spurious. For the variables to be co-integrated, the residual from the OLS regression needs to be stationary. The stationarity of the residual from the linear co-integrating relationship is tested by running the following OLS regression:

$$\Delta u_t = \rho u_{t-1} + \sum_{j=1}^{p} \delta_j \Delta u_{t-j} + e_t \quad (22)$$

where ϱ and δ_j are parameters to be estimated and e_t is the white noise error term. In this residual-based regression, the inclusion of an appropriate number of lagged u_{t-1} terms in the regression, as indicated by P, ensures that e_t is the white noise error term — and that there is no remaining serial correlation. As noted, the optimal lag length is determined based on the AIC, as well as by examining the plots of the AC and PAC functions for the residual term e_t. The null hypothesis of co-integration between the two variables is given by the coefficient on lagged equilibrium error equal to zero (H_0: $\varrho=0$). Similar to the unit root tests for the individual time series data, the critical values used for the t-test statistic in this case are also non-standard, and the well-known ADF and PP test statistics are used. The rejection of the null hypothesis indicates the u_t is stationary, and that there is a long-run equilibrium relationship between the two variables. Furthermore, it is indicated that if the two variables are co-integrated, then the short-run dynamic relationship between the two variables can be analyzed by using the error correction model (ECM) and Granger causality tests. The key idea in the co-integration relationship is that even though the two variables diverge in the short run, in the long run they move together. Here, it is important to note the speed at which the price movements adjust toward their equilibrium relationships.

In the ECM and Granger causality test, the short-run price dynamics are analyzed by regressing the current price changes on the constant, lagged equilibrium error, lagged own and other price changes as follows:

$$\Delta P_{1t} = \rho_{10} + \rho_{11} u_{t-1} + \sum_{j=1}^{P} \delta_{11,j} \Delta P_{1t-j} + \sum_{j=1}^{P} \delta_{12,j} \Delta P_{2t-j} + e_{1t} \quad (23)$$

$$\Delta P_{2t} = \rho_{20} + \rho_{22} u_{t-1} + \sum_{J=1}^{P} \delta_{21,j} \Delta P_{1t-j} + \sum_{J=1}^{P} \delta_{22,j} \Delta P_{2t-j} + e_{2t} \quad (24)$$

where ϱ_{10}, ϱ_{20}, ϱ_{11}, ϱ_{22}, $\delta_{11,j}$, $\delta_{12,j}$, $\delta_{21,j}$, $and\ \delta_{22,j}$ are parameters to be estimated and e_{1t} and e_{2t} are error terms for the P_{1t} and P_{2t} equations, respectively. The coefficients ϱ_{11} and ϱ_{22} are the speed of adjustment parameters, which show the extent, speed and direction in which the variables adjust to a given period deviation from the equilibrium relationship. The parameters $\delta_{11,j}$, $\delta_{12,j}$, $\delta_{21,j}$, $and\ \delta_{22,j}$ represent short run effects.

However, the major criticism leveled against the standard Engle and Granger (1987) method concerns its linearity assumption in the analysis of the long-run relationship and short-run price dynamics. It is argued that the linearity assumption can be violated due to several reasons: the existence of transaction costs; information asymmetry; market power; adjustment costs in the marketing system; discretionary policy measures; or irregularities, and so on. Therefore, the analysis based on the assumption of linearity —when there are, in fact, non-linear long-run and short-run relationships — is a kind of model misspecification. As such, it might lead to an incorrect assessment and understanding of the operation of these markets, including erroneous conclusions and policy recommendations.

In response to the observed weaknesses in the standard co-integration analysis using Engel and Granger (1987), the threshold co-integration method has been developed and applied (Balcombe, Enders and Siklos, 2001). If there is no threshold effect, the standard linear cointegration method is used. However, if there is threshold effect, then the threshold co-integration method developed by Enders and Siklos (2001) is used. The Enders and Siklos (2001) extends the Engel and Granger (1987) two-step, co-integration method by introducing non-linearity in the test of the long-run equilibrium relationship by modifying Equation (22). The simple threshold autoregressive regressive (TAR) cointegration model is given as follows:

$$\Delta u_t = \rho_1 I_t u_{t-1} + \rho_2 (1 - I_t) u_{t-1} + \sum_{j=1}^{P} \delta_j \Delta u_{t-j} + e_t \quad (25)$$

where ρ_1, ρ_2 and δ_j are parameters to be estimated; P is the number of appropriate lags to ensure correct model specification; e_t is assumed to be a white noise error term; and I_t is an indicator function defined as:

$$I_t = \begin{cases} 1\ if\ u_{t-1} \geq 0 \\ 0\ if\ u_{t-1} < 0 \end{cases} \quad (26)$$

The u_{t-1}, the lagged equilibrium error term, is used as the threshold variable with the threshold value of zero. In the current set-up a u_{t-1} greater than zero indicates a situation in which there is positive deviation from the long-run spatial marketing margin between the markets. The u_{t-1} less than zero indicates a negative deviation. In a simple TAR case, the threshold value is determined exogenously as zero, and it can also be determined endogenously from the data[10]. As in Engel and Granger (1987), the appropriate lag length for P is determined by examining the plots of AC and PAC functions, and using AIC and SBIC so that the model selected is well specified, which results in the white noise error term e_t.

[10] The combination of the choice of threshold variable and the method of determining the threshold value gives rise to four possible classes of threshold autoregressive models (TAR). Among the four classes of TAR models, the best model is to be selected based on the Akaike information criteria (AIC) and Bayesian information criteria (BIC). In this case, due to time constraints, and to deal with several market pairs, we have limited ourselves to the use of a simple TAR model, whereby one-period lagged error term is used as the threshold variable and the threshold parameter is exogenously determined. We leave the selection of best TAR models for each market pairs for future research.

Based on the coefficients estimated from Equation (25), two main tests are conducted. First, the null hypothesis of threshold co-integration is given as: H_0: $\varrho_1=\varrho_2=0$. The test statistic for this hypothesis is the F-statistics, but there are separate critical values developed and tabulated by Enders and Siklos (2001). The rejection of the null hypothesis indicates the existence of a cointegration relationship of either a symmetric or asymmetric nature. It is important to note that the acceptance of the null hypothesis corresponds to the Engel and Granger (1987) specification. Second, once the null hypothesis of threshold cointegration is rejected, the null hypothesis of symmetric adjustment can be tested as follows: H_0: $\varrho_1=\varrho_2$. In this case, the null hypothesis is tested using the standard F-test statistic. The rejection of the null hypothesis indicates the existence of an asymmetric adjustment. The ϱ_1 and ϱ_2 are used to measure the extent and direction of adjustment of shocks toward equilibrium conditions under different trade regimes. In this regard, the speed of adjustment toward equilibrium is obtained based on these parameters by computing the half-life (HL) of the shock. Therefore, HL=ln (0.5)/ln (1+ ϱ) and gives the number of months required for half of the shock to adjust toward the equilibrium.

If the presence of asymmetric adjustment is rejected, the standard linear ECM is used to analyze short-term price dynamics. However, if the presence of an asymmetric adjustment is confirmed, then the short-run price dynamics are investigated by estimating the threshold vector error correction models (TVECM) of the following form:

$$\varDelta P_{1t} = \rho_{10} + \rho_{11} I_t u_{t-1} + \rho_{12}(1 - I_t)u_{t-1} + \sum_{j=1}^{P} \delta_{11,j} \Delta P_{1t-j} + \sum_{j=1}^{P} \delta_{12,j} \Delta P_{2t-j} + e_{1t} \quad (27)$$

$$\varDelta P_{2t} = \rho_{20} + \rho_{21} I_t u_{t-1} + \rho_{22}(1 - I_t)u_{t-1} + \sum_{j=1}^{1} \delta_{21,j} \Delta P_{1t-j} + \sum_{j=1}^{P} \delta_{22,j} \Delta P_{2t-j} + e_{2t} \quad (28)$$

Where ϱ_{10}, ϱ_{20}, ϱ_{11}, ϱ_{12}, ϱ_{21}, ϱ_{22}, $\delta_{11,j}$, $\delta_{12,j}$, $\delta_{21,j}$, and $\delta_{22,j}$ are parameters to be estimated, and e_{1t} and e_{2t} are the error terms for P_{1t} and P_{2t} equations, respectively. The coefficients ϱ_{11}, ϱ_{12}, ϱ_{21}, and ϱ_{22} are the speed of adjustment parameters for different prices and regimes. They show how fast and in what direction the prices adjust to deviations from the equilibrium relationship.[11]

Regardless of the introduction of the non-linearity as a factor, the long-run equilibrium relationship analysis based on price data alone has also been criticized for not incorporating trade flow data (Barret and Li 2002). By combining trade flow and price data, Barret and Li (2002) provide a very rich interpretation of market performance. However, it is difficult to obtain historical flow and transaction cost data matching the historical price data.

The parity bound modeling (PBM) is another modeling technique that tries to explicitly or implicitly incorporate the idea of trade flow and transaction costs in the spatial price analysis (for example, Baulch, 1999; Barret and Li, 2002; Negassa and Myers, 2007; and Park *et al*, 2007). Recently, Myers (2013) used trade flow data within the framework of the TAR model specification. In general, in view of these data difficulties, the choice of threshold models grounded on a solid understanding of the institutions and structure of markets investigated is the better way forward, at least in the short run.

[11] In the above TVECM specification, it is important to note that the non-linearity or asymmetric effect is considered only for the error correction terms. The lagged dynamic price effects are assumed to be symmetric under different regimes — which needs to be tested in future research.

One of the questions to be answered from the analysis of the short-run dynamic is: Which market plays an important role in price formation? In this regard, the Granger causality test is used to examine the lead-lag relationship between changes in prices in the two markets. Two types of causality tests are conducted: one for short-run causality and another for long-run causality. For example, in the case of short-run causality, Equation (27) is used to test the null hypothesis, that is, that changes in P_{2t} do not Granger cause changes in P_{1t} , and is given as:

$$H_0:\ \delta_{12,j} = 0\ for\ j = 1, \dots, P \qquad (29)$$

Similarly, the null hypothesis that the changes in P_{1t} do not Granger cause changes in $P_{2t,}$ and is given as:

$$H_0:\ \delta_{21,j} = 0\ for\ j = 1, \dots, P \qquad (30)$$

There are four possible causal relationships between the two price variables: (1) only P_{1t} causes P_{2t}; (2) only P_{2t} causes P_{1t}; (3) there is bi-directional causality, such that P_{2t} causes P_{1t} and P_{1t} causes P_{2t} and; (4) there is no causal relationship between the two variables. -run causality is determined by testing the null hypothesis that the coefficients of adjustments are jointly zero in the respective threshold error correction models, as given in Equations (27) and (28).

4. Data Sources and Limitations

4.1 Sources of Data

Maize and wheat are the two cereal crops considered in this study. The study is based on a review of the literature; a rapid appraisal of maize and wheat production and marketing systems; and statistical and econometric analyses of time-series price data obtained from secondary sources. The time-series monthly nominal prices of maize and wheat are collected at different market levels (producer, wholesale and retail) for selected markets from both the grain surplus producing and grain deficit regions. The wholesale price data for maize and wheat is reported in Ethiopian Birr per quintal (100 kilograms) and is obtained from the Ethiopian Trading and Business Corporation (ETBC), formerly known as the Ethiopian Grain Trade Enterprise (EGTE), for the period from January 2001 to December 2016.

The producer and retail prices are reported in Ethiopian Birr per kilogram are obtained from the Central Statistical Authority for the period from April 2000 to December 2016. To facilitate data comparison and analyses, the producer and retail prices are converted to Ethiopian Birr per 100 kg unit. Relatively few missing data points were observed for wholesale price datasets as compared to the producer and retail price datasets. The few missing data points for wholesale prices are imputed using linear interpolations. Regarding producer and retail prices, the missing data points are imputed using the multiple imputation method. In all cases, where the price analysis is desired in real terms, the nominal prices are converted into real prices by deflating the nominal prices by the general consumer price index (December 2011=100) as obtained from the CSA. Finally, all the prices are expressed in log form to easily derive the percentage price changes, as well as to obtain measures of elasticities of price transmissions from econometric estimations.

Naturally, the markets selected fall into either major grain producer (or surplus) or grain deficit regions. The regions selected include: Amhara, Oromiya, Southern Nations and Nationalities People (SNNP), Tigray and the Dire Dawa special administrative region. A total of 18 markets each are considered for maize and wheat price analyses.

In terms of the selection of market pairs for the spatial market integration study, many of the past cereal market integration analyses in Ethiopia used Addis Ababa as a reference market, following the Ravallion radial market structure. The selection of Addis Ababa as a reference market assumed that it played an important role both as the center of consumption and grain aggregation for transshipment to other markets. However, during the rapid appraisal assessment of the market, it was observed that there has been an increasing trend toward direct shipment of maize and wheat between surplus and deficit markets, bypassing the Addis Ababa market. This assessment also revealed that the shipments made to Addis Ababa have been mainly for distribution and use within the Addis Ababa market, rather than for transshipment to other deficit markets.

Further, shipments to Addis Ababa are made using trucks of smaller capacity as compared to the shipments made directly to the deficit markets from surplus regions. These shipments were made using trucks with larger capacity trailers. This might be due to improvements in the marketing infrastructure (road networks and communications, such as mobile phones), which provide opportunities for the direct links between the markets in the surplus and deficit regions. Also, the traffic congestion in Addis Ababa has made some of the past grain trading practices more difficult. For example, truck-to-truck grain transfers for shipment to other regions — as well as the use of trucks as a temporary storage until the grain is unloaded or transferred — are difficult. Therefore, in this study, the trading routes for the spatial price analysis are determined based on the information gathered about the grain shipment patterns during the rapid market appraisal survey. Recently, with the improvements in market information, road networks, and mobile phone uses, the concept of the reference market is relaxed in grain market integration analysis because the grain can be shipped directly where it is most needed. This means the inclusion of more direct cereal trade routes between grain surplus and deficit markets in the spatial price analysis.

Due to time constraints, however, not all of the possible market pairs (or trade routes) could be considered in the spatial price analysis. Only a few representative market pairs were selected for detailed spatial price analysis. The focus is on relatively representative routes, with the assumption that the results can be generalizable to other market pairs not included in this analysis as well.

4.2 Data Limitations

The evaluation of the spatial and temporal grain market performance of the maize or wheat markets is based mainly on price data. Such data is used to examine how the observed temporal and spatial price behaviors are similar, or how they deviate from what would be expected under the competitive market model discussed under the conceptual framework. For example, it was not possible to obtain time-series data on grain flows, stocks, and transfer costs to match the time-series price data. This would have been useful in evaluating the spatial market performance in detail. In the same way, to evaluate storage incentives, one would require time-series data on storage costs and the amount of maize stored in different locations. In Ethiopia, the lack of such historical time-series data on grain transfer costs, flows and stocks limits the capacity to conduct detailed analysis of the efficiency of inter-regional grain trade and storage.

5. Empirical results on the performance of maize and wheat markets

5.1 Trends in maize and wheat price levels

The summary statistics of monthly real producer, wholesale and retail prices of maize and wheat in selected markets in Ethiopia are presented in Tables 1-3 and 4-6, respectively. In general, the descriptive analyses indicate that the real prices are characterized by high levels of variability, as can be seen from the higher levels of standard deviations and coefficient of variations. It is also important to note that the real prices are characterized by positive skewness and excess kurtosis, which indicate maize and wheat price observations with extreme low or high values (far away from the average maize and wheat prices) during this period.

Table 1: Summary Statistics of Monthly Real Producer Prices for Maize in Selected Markets in Ethiopia, (Birr/100kg, 2002-2016)[12]

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	413.44	49.82	925.03	125.60	30.38	0.90	5.64
Ambo	362.25	184.52	835.75	110.10	30.39	1.03	4.77
Bahir Dar	399.70	150.21	826.38	112.89	28.24	0.69	4.75
Dessie	568.27	315.97	951.07	131.95	23.22	0.60	3.07
Gonder	415.33	177.58	778.38	112.48	27.08	0.52	3.29
Jimma	355.52	116.89	875.22	128.51	36.15	1.20	5.75
Mekele	530.56	280.79	1156.19	133.69	25.20	1.03	5.54
Nekemte	328.35	91.84	786.95	112.86	34.37	1.06	5.79
Shashemene	618.78	226.25	1699.49	331.34	53.55	1.13	3.71
Woliso	415.27	210.17	780.51	94.87	22.85	0.74	4.61

Source: Computed by authors based on data from the CSA and ETBC.

Table 2: Summary Statistics of Monthly Real Wholesale Prices of Maize in Selected Markets in Ethiopia, (Birr/100kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	442.00	253.34	897.72	106.96	24.20	0.95	5.12
Addis Ababa	440.91	232.60	927.54	117.69	26.69	1.30	6.05
Ambo	409.93	177.74	955.86	110.72	27.01	0.84	5.66
Bahir Dar	431.63	207.50	878.64	120.60	27.94	0.99	5.01
Dessie	462.19	289.08	935.18	119.07	25.76	1.43	6.41
Debre Markos	445.41	174.49	906.15	127.57	28.64	0.77	4.93
Dire Dawa	519.15	285.99	1145.60	143.10	27.56	1.63	6.79
Gonder	473.87	266.52	918.52	123.95	26.16	0.81	4.49
Jimma	400.31	180.69	1191.90	135.46	33.84	2.11	11.35
Mekele	515.42	309.78	1165.90	136.83	26.55	1.32	6.57

[12] C.V. – coefficient variation: measures relative variability or dispersion around the mean. Skewness – refers to symmetry around the mean. Kurtosis – peakness of the distribution with high kurtosis indicating higher frequency of outcomes at extremes (positive or negative).

Nekemte	383.33	37.40	958.08	131.39	34.28	1.27	6.20
Shashemene	441.47	213.98	904.62	115.22	26.10	1.14	5.37

Source: Computed by authors based on data from the CSA and ETBC.

Table 3: Summary Statistics of Monthly Real Retail Prices of Maize in Selected Markets in Ethiopia, (Birr/100kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	531.28	273.66	1207.02	120.29	22.64	1.78	10.08
Addis Ababa	593.04	332.00	1120.56	122.25	20.61	1.58	7.27
Ambo	507.72	208.79	833.45	116.84	23.01	0.21	3.13
Assela	503.72	192.81	1147.08	131.94	26.19	1.11	6.82
Bahir Dar	477.30	191.32	815.63	98.41	20.62	0.40	4.49
Bale Robe	481.64	210.40	1066.33	156.48	32.49	1.03	4.45
Dessie	559.76	340.77	1955.91	181.28	32.39	3.93	25.96
Debre Birhan	512.14	308.64	1018.43	123.75	24.16	1.50	6.71
Dire Dawa	606.59	429.72	1112.35	119.80	19.75	1.63	7.21
Gonder	575.66	306.89	1583.73	245.02	42.56	2.57	10.15
Hosana	499.79	250.95	784.98	96.37	19.28	0.24	3.71
Jimma	459.85	192.81	1112.00	128.58	27.96	1.73	8.70
Mekele	563.00	369.62	971.72	109.54	19.46	0.26	2.99
Nekemte	439.72	188.85	1142.84	47.16	10.73	1.96	8.87
Shashemene	508.35	286.26	1030.38	104.49	20.55	1.35	6.84
Woldeya	589.35	355.08	1276.49	151.51	25.71	1.84	8.35
Woliso	509.71	216.91	1184.10	157.29	30.86	1.42	7.09

Source: Computed by authors based on data from the CSA and ETBC.

Table 4: Summary Statistics of Monthly Real Producer Prices for Wheat in Selected Markets in Ethiopia, (Birr/100kg, 2000-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	649.97	367.78	1115.93	112.36	17.29	0.62	4.48
Ambo	604.73	276.41	1208.48	153.03	25.31	1.14	5.85
Assela	594.50	239.27	1030.28	119.83	20.16	0.22	5.01
Bahir Dar	615.78	240.51	1060.41	123.18	20.00	0.54	5.07
Bale Robe	548.02	191.74	961.63	129.92	23.71	0.11	4.43
Dessie	737.72	424.49	1170.92	114.31	15.50	0.97	5.57
Debre Birhan	699.89	413.98	1274.57	125.77	17.97	1.01	5.52
Gonder	732.93	465.27	1177.00	121.68	16.60	0.81	4.25
Hosana	610.09	288.00	927.85	109.02	17.87	0.80	3.75
Jimma	624.11	285.31	1073.62	169.22	27.11	0.48	2.79
Mekele	724.97	535.24	1411.10	128.13	17.67	1.98	8.72
Nekemte	553.05	186.13	1036.65	143.75	25.99	0.38	3.84
Shashemene	771.09	450.58	1285.71	219.25	28.43	0.68	2.47
Woliso	838.49	473.50	1298.09	164.46	19.61	0.45	2.54
Ziway	600.87	363.23	1021.41	105.93	17.63	1.12	5.05

Source: Computed by authors based on data from the CSA and ETBC.

Table 5: Summary Statistics of Monthly Real Wholesale Prices for Wheat in Selected Markets in Ethiopia, (Birr/100kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	693.33	450.16	1151.30	107.82	15.55	0.83	5.53
Addis Ababa	702.75	465.20	1020.09	99.64	14.18	0.30	3.24

Ambo	617.65	361.52	970.80	97.68	15.81	0.26	3.79
Assela	649.62	363.43	1024.10	109.07	16.79	0.60	4.85
Bale Robe	580.14	268.80	981.40	116.96	20.16	0.53	4.85
Debre Birhan	698.22	450.00	1187.66	127.05	18.20	1.09	5.36
Dire Dawa	820.83	600.64	1546.53	141.23	17.21	1.80	7.80
Gonder	714.15	449.87	1144.91	107.58	15.06	1.06	5.98
Hosana	657.04	336.00	1131.44	124.90	19.01	0.52	4.27
Jimma	756.87	419.36	1191.07	126.40	16.70	1.01	5.19
Mekele	774.36	498.07	1265.86	133.86	17.29	1.50	6.00
Shashemene	663.23	387.66	993.25	104.93	15.82	0.24	3.97

Source: Computed by authors based on data from the CSA and ETBC.

Table 6: Summary Statistics of Monthly Real Retail Prices for Wheat in Selected Markets in Ethiopia, (Birr/100kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	779.75	482.74	1182.76	126.58	16.23	0.57	3.75
Addis Ababa	851.03	587.06	1250.32	110.55	12.99	0.72	4.27
Ambo	709.34	289.39	1235.53	152.62	21.52	0.55	4.30
Assela	689.44	361.79	1120.15	129.54	18.79	0.43	3.90
Bahir Dar	834.38	370.44	1141.95	115.26	13.81	-0.37	4.06
Bale Robe	656.34	325.19	1192.83	148.92	22.69	0.49	4.20
Dessie	779.21	187.32	1288.76	138.27	17.74	0.62	6.78
Debre Birhan	740.42	510.39	1443.57	113.82	15.37	2.05	11.44
Dire Dawa	909.27	733.48	1286.69	108.01	11.88	1.11	4.22
Hosana	720.23	337.30	1528.33	153.46	21.31	0.98	7.38
Jimma	831.69	506.13	1203.29	135.98	16.35	0.36	3.18
Mekele	866.76	657.55	1375.26	141.02	16.27	1.08	4.04
Nekemte	860.02	586.08	2005.18	345.48	40.17	2.29	7.30
Shashemene	791.28	433.82	1233.52	121.09	15.30	0.42	4.30
Woliso	711.06	298.49	1176.79	140.30	19.73	0.17	3.84
Ziway	874.45	628.41	1482.64	150.72	17.24	1.66	6.50

Source: Computed by authors based on data from the CSA and ETBC.

The evolution of monthly nominal and real prices for maize and wheat show that there have been upward trends in prices, which might indicate increasing demand for cereal crops as a result of an increase in population and income growth, and urbanization, among other factors[13]. Detailed data on production and marketing costs are required to assess whether, and by how much, the value chain actors have been benefiting from the trend of general increases in the level of producer prices.

5.2 Fluctuations in maize and wheat prices

5.2.1. Results of variance decomposition

The results of price variance decomposition provide point estimates of the various components of real price fluctuations. The results for maize and wheat prices at different market levels in selected markets in Ethiopia are provided in tables 7 and 8, respectively. It is important to note the variation in relative importance of the various components of price fluctuations by market and market level. In efficient and well-integrated markets, similar levels of price fluctuation components are expected in

[13] The evolution of nominal, real producer, wholesale, and retail prices for maize and wheat are provided in annexes 1-3 and 4-6, respectively.

various markets and along the value chains. The relative importance of price variance components is also indicative of the limited nature of market integration across the value chains.

In general, the trend-cycle component accounts for the highest proportion of maize and wheat price fluctuations in different markets, as well as at different market levels. This is an indication of the importance of demographic trends in explaining the fluctuations in maize and wheat prices. However, the role of different components varied by markets and commodities. For example, in the case of maize, the proportion of maize producer price fluctuations explained by the trend-cycle component varied from 37 to 87 percent. The seasonal component accounted for 7 to 35 percent of the price fluctuations. The random component of the price fluctuation also explained a significant component of price fluctuations; it varied from 0 to 33 percent. Similar to the producer level, at the wholesale and retail levels, the trend-cycle component also accounted for the highest percentage of price variance. However, it is important to note that the random component is relatively higher for producer and retail prices as compared to the wholesale level. Similar results are obtained for wheat markets.

One clear finding from the variance decomposition is that there is a significant differential role in the random component of maize and wheat prices fluctuations in most of the markets and market levels. It shows the different levels of risk faced in different markets. In this context, there is a need to identify the reasons for the variations in the levels of price randomness, as well as the level of risk in the different markets.

Table 7: Variance Decomposition of Fluctuations in Real Prices of Maize in Selected Markets in Ethiopia, 2002-2016

Market	Producer price			Wholesale price			Retail price		
	T-Cycle (%)	Seasonal (%)	Random (%)	T-Cycle (%)	Seasonal (%)	Random (%)	T-Cycle (%)	Seasonal (%)	Random (%)
Adama	48.4	18.7	32.9	62.1	17.6	20.3	51.4	10.5	38.1
Addis Ababa	--	--	-	73.0	20.9	6.1	76.2	21.8	2.0
Ambo	63.0	20.9	16.1	74.6	19.2	6.2	64.1	13.7	22.2
Assela	51.7	26.9	21.4	--	--	--	52.8	15.7	31.5
Bahir Dar	74.7	24.9	0.04	80.1	19.9	0.0	62.2	25.8	12.0
Bale Robe	51.7	26.9	21.4	--	--	--	52.3	6.0	41.7
Dessie	44.3	35.5	20.2	76.2	18.6	5.2	61.9	8.6	29.5
Debre Birhan	64.1	17.9	18.0	--	--	--	68.0	11.1	20.9
Debre Markos	--	--	--	80.8	17.0	2.2			
Dire Dawa	--	--	--	76.4	16.0	7.6	71.5	12.9	15.6
Gonder	64.4	20.5	15.1	84.0	15.5	0.5	53.0	2.1	44.9
Hosana	51.7	26.9	21.4	--	--	--	59.3	17.3	23.4
Jimma	65.0	23.3	11.7	67.8	14.9	17.3	50.8	14.1	35.1
Mekele	63.0	7.1	29.9	19.6	7.7	72.7	65.5	9.6	24.9
Nekemte	69.2	19.2	11.6	74.8	21.1	4.1	67.4	13.2	19.4
Shashemene	77.9	20.1	2.0	71.7	29.3	--	45.1	22.4	32.5
Woldeya	87.5	6.8	5.7	--	--	--	71.1	9.3	19.6
Woliso	37.4	31.5	31.1	--	--	--	68.8	15.9	15.3

Source: Computed by authors based on data from the CSA and ETBC.
Note: T-Cycle denotes trend cycle.

Table 8: Variance Decomposition of Fluctuations in Real Prices of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Producer price			Wholesale price			Retail price		
	T-Cycle (%)	Seasonal (%)	Random (%)	T-Cycle (%)	Seasonal (%)	Random (%)	T-Cycle (%)	Seasonal (%)	Random (%)
Adama	60.2	17.1	22.7	67.8	9.2	23.0	67.5	11.6	20.9
Addis Ababa	--	--	--	75.0	10.9	14.1	78.4	16.5	5.1
Ambo	68.1	13.7	18.2	73.3	8.0	18.7	74.0	26.0	0.0
Assela	62.1	12.3	25.6	74.4	13.5	12.1	76.1	18.6	5.3
Bahir Dar	67.4	13.7	18.9	--	--	--	59.2	17.0	23.8
Bale Robe	73.0	15.8	11.2	72.5	10.2	17.3	66.6	11.4	22
Dessie	60.5	9.6	29.9	--	--	--	68.8	11.0	20.2
Debre Birhan	57.8	7.3	34.9	82.3	10.1	7.6	56.1	14.1	29.8
Dire Dawa	--	--		70.1	2.6	27.3	71.1	8.4	20.5
Gonder	63.9	18.8	17.3	72.4	11.1	16.5	68.9	13.8	17.3
Hosana	52.0	21.3	26.7	78.8	22.1	-0.9	70.0	33.0	0.0
Jimma	72.0	28.0	0.0	68.4	9.5	22.1	79.5	12.9	7.6
Mekele	61.1	26.0	12.9	77.0	17.8	5.2	62.4	14.1	23.5
Nekemte	65.9	14.2	19.9	--	--		52.8	1.00	46.2
Shashemene	91.8	8.2	0.0	72.2	16.1	11.7	74.0	26.0	0.0
Woldeya	78.9	13.0	8.1	--	--	--	74.5	5.0	20.5
Woliso	61.4	15.2	23.4	--	--	--	68.9	19.1	12.0

Source: Computed by authors based on data from the CSA and ETBC.
Note: T-Cycle denotes trend cycle.

5.2.2. Time series decomposition of maize and wheat prices

The time series decomposition of maize and wheat prices are made using the model used in Equation (2). This decomposition provides times-series estimates of the various components of price fluctuations. The main results are provided in terms of the grand seasonal index computed for various markets at different market levels (producer, wholesale and retail). The key results of the analysis inform policy, production, marketing and food security decisions in the maize and wheat sub-sectors. First, the seasonal index indicates the month with the lowest price and the month with the highest price. Second, it indicates the months for which prices are below and above the annual average prices. Third, it indicates the seasonal price gap, which is determined as the difference between the highest and lowest seasonal index. This in turn indicates the potential for temporal arbitrage opportunities. Finally, the price indices can be used for price forecasting.

The grand seasonal price indices for maize prices at the producer, wholesale and retail levels are provided in Tables 9-11, respectively. In most of the maize markets, the highest seasonal producer index is observed for the months of June to September, that is, just before the harvest period. The months of the lowest seasonal index are from October to January. Across the producer markets, the seasonal gap between the lowest and highest index varied from 26 to 40 percent. The observed seasonal gap indicates that 6 to 10 months of storage period is required to capture the favorable seasonal price movements. However, the most profitable length of storage time might not necessarily imply storing a given crop up to the month of the highest seasonal index implied by the seasonal gap. In this context, it could be lower or of the same length as the implied storage period. The determination of the optimal storage period requires further detailed computation of the costs required to store grain. Similar patterns of maize price seasonality are observed at the wholesale and retail levels (tables 10 and 11). At the maize wholesale level, the seasonal gap varied from 13 to 47 percent, and the storage period implied by the observed patterns of seasonality varied from 6 to 9 months for the wholesale market. As such, it requires 4 to 8 months of storage to capture the seasonal price increases in retail markets.

Table 9: Grand Seasonal Producer Price Indices for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Gap (%)[2]
Adama	94.9 (14.4)[1]	87.6 (13.9)	96.9 (11.8)	100.3 (13.1)	108.3 (12.5)	111.8 (11.3)	111.1 (16.9)	114.2 (16.3)	111.1 (17.9)	92.1 (22.6)	84.6 (9.2)	87.1 (13.2)	29.6 (35.0)
Ambo	91.9 (11.8)	88.9 9.4()	92.6 10.8(.)	97.0 (11.7)	102.9 (10.3)	104.2 (11.5)	113.2 (14.7)	114.5 (15.0)	117.5 (22.1)	100.4 (20.8)	91.4 (10.9)	85.4 (12.4)	28.1 (34.1)
Bahir Dar	89.9 (7.4)	90.6 (8.7)	90.7 (9.1)	92.9 (9.9)	99.2 (9.4)	107.8 (10.7)	109.4 (9.7)	112.1 (14.5)	114.1 (13.2)	107.1 (19.5)	97.7 (12.3)	88.2 (9.6)	25.9 (29.4)
Jimma	93.9 (11.3)	92.5 (9.3)	95.9 (11.4)	100.3 (11.9)	101.7 (9.8)	117.2 (13.2)	120.4 (18.4)	115.5 (21.5)	101.5 (26.1)	86.9 (18.9)	82.7 (9.6)	91.3 (16.4)	37.7 (45.6)
Nekemte	95.5 (14.4)	90.2 (13.9)	92.3 (11.8)	96.4 (13.1)	104.6 (12.5)	114.2 (11.3)	113.3 (16.9)	109.1 (16.3)	110.9 (17.9)	100.1 (22.6)	88.4 (9.2)	85.8 (13.2)	28.4 (33.0)
Shashemene	92.5 (21.5)	92.2 (20.1)	93.7 (17.2)	96.3 (16.3)	108.5 (15.3)	117.7 (14.7)	117.6 (19.8)	123.8 (27.8)	93.3 (27.0)	83.9 (16.9)	86.3 (21.1)	94.1 (26.1)	39.8 (47.6)
Woliso	88.0 (11.3)	90.0 (13.6)	98.0 (14.6)	99.0 (10.9)	114.0 (17.8)	114.0 (16.5)	118.0 (16.3)	117.8 (17.3)	96.2 (21.5)	87.6 (15.8)	87.5 (17.2)	90.0 (16.3)	30.0 (34.0)

Source: Computed by authors based on data from the CSA and ETBC.
Authors' calculations
Notes:
[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.
[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

Table 10: Grand Seasonal Wholesale Price Indices for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Gap (%)[2]
Adama	93.6 (7.4)[1]	94.9 (7.8)	96.6 (7.3)	99.0 (9.4)	100.3(6.9)	106.0 (7.0)	110.5 (10.0)	112.1 (11.9)	105.1 (8.4)	96.6 (12.9)	91.0 (10.8)	94.3 (9.9)	21.1 (23.2)
Addis Ababa	92.6 (5.1)	93.8 (6.5)	94.9 (5.5)	99.6 (8.5)	99.4 (9.4)	106.9 (8.3)	109.9 (7.5)	110.8 (8.5)	106.8 (9.8)	97.4 (9.4)	95.0 (11.1)	92.8 (11.6)	18.2 (19.6)
Ambo	93.0 (7.3)	94.6 (6.0)	95.0 (8.3)	99.1 (11.1)	98.9 (10.0)	108.6 (8.9)	105.8 (7.5)	106.7 (9.2)	107.7 (15.7)	105.1(1 5.7)	93.3 (7.6)	92.0 (11.0)	16.6 (18.0)
Bahir Dar	92.1 (4.4)	93.6 (5.9)	92.3 (6.6)	96.9 (12.8)	98.3 (9.1)	103.0 (7.5)	105.6 (7.4)	107.8 (9.0)	105.5 (8.3)	107.8 (15.9)	99.7 (12.0)	98.0 (6.9)	15.1 (17.1)
Dessie	95.3 (4.2)	95.9 (7.0)	101.1 (11.3)	99.9 (8.8)	100.2 (6.1)	102.5 (7.3)	107.4 (6.9)	109.6 (7.9)	105.3 (8.6)	97.1 (9.6)	92.9 (7.6)	92.5 (9.9)	17.1 (18.5)
Dire Dawa	97.3 (23.6)	93.5 (7.2)	95.5 (8.0)	98.8 (10.3)	101.0 (6.0)	104.6 (6.8)	106.5 (10.3)	107.2 (10.1)	106.0 (10.1)	102.9 (13.3)	96.4 (12.1)	90.0 (14.1)	17.2 (19.1)
Gonder	95.4 (4.8)	94.1 (6.1)	96.1 (5.1)	98.7 (9.0)	99.8 (6.3)	100.7 (7.4)	102.1 (5.1)	107.2 (5.7)	107.2 (6.8)	103.3(9 .6)	98.1 (4.0)	97.2 (7.4)	13.1 (13.9)
Jimma	99.2 (23.6)	94.5 (6.2)	94.3 (7.7)	100.5 (10.0)	102.7 (8.4)	108.7 (8.5)	109.8 (7.8)	113.6 (8.1)	104.2 (11.5)	89.9 (11.3)	87.3 (9.0)	95.0 (12.0)	26.3 (30.1)
Mekele	95.8 (4.2)	90.9 (7.0)	94.4 (11.3)	96.1 (8.8)	95.9 (6.1)	101.5 (7.3)	102.5 (6.9)	138.3 (7.9)	102.0 (8.6)	96.2 (9.6)	92.4 (7.6)	94.0 (9.9)	47.4 (47.1)
Nekemte	91.6 (10.9)	91.4 (8.3)	93.4 (9.1)	90.6 (25.8)	98.8 (8.8)	104.0 (7.8)	108.9 (7.0)	111.9 (12.8)	109.6 (10.5)	111.4 (21.4)	93.9 (10.0)	94.4 (11.2)	20.5 (22.2)
Shashemene	90.0 (8.0)	94.3 (10.3)	93.6 (6.7)	101.7 (10.3)	104.4 (7.4)	109.6 (8.4)	111.8 (9.1)	113.8 (10.7)	105.8 (10.2)	89.4 (15.4)	91.6 (14.2)	93.9 (11.0)	23.8 (26.4)

Source: Computed by authors based on data from the CSA and ETBC.
Notes:
[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.
[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

Table 11: Grand Seasonal Retail Price Indexes for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Gap (%)[2]
Adama	91.2 (9.3)[1]	94.1 (10.6)	96.6 (7.5)	95.5 (12.4)	97.5 (14.3)	101.2 (8.2)	109.6 (13.4)	109.5 (22.2)	107.6 (14.7)	106.5 (14.0)	97.8 (9.8)	92.7 (15.4)	18.4 (17.9)
Addis Ababa	94.1 (8.1)	92.4 (7.9)	92.8 (5.4)	93.4 (6.4)	95.6 (7.2)	102.8 (9.5)	106.9 (10.4)	106.6 (11.2)	109.8 (8.9)	108.1(8.2)	102.7(10.0)	95.0 (7.5)	17.4 (18.8)
Ambo	90.4 (8.6)	93.0 (12.8)	96.0 (15.5)	96.0 (7.3)	96.6 (16.1)	108.2 (11.9)	109.4(11.7)	103.5 (13.7)	109.3 (5.8)	108.6(15.8)	97.0 (15.9)	91.9 (12.0)	19.0 (21.0)
Assela	90.3 (14.2)	86.2 (12.0)	92.4 (12.6)	94.8 (12.4)	98.7 (12.0)	114.3 (45.9)	105.7(11.7)	108.8 (19.3)	114.9 (14.7)	108.0(15.6)	96.2 (14.1)	89.5 (13.3)	28.7 (33.3)
Bahir Dar	94.9 (7.4)	89.0 (26.3)	88.6 (10.1)	90.9 (10.2)	93.2 (13.0)	97.1 (7.4)	113.2(14.0)	109.1 (10.7)	111.3 (9.3)	107.7(8.4)	108.5 (16.6)	96.4 (8.1)	24.6 (27.8)
Dessie	93.6 (8.0)	89.0 (13.0)	97.0 (10.3)	102.4 (14.9)	100.5 (11.5)	107.0 (14.2)	105.2(13.1)	111.4 (30.7)	105.2 (5.9)	101.2(9.7)	92.8 (9.5)	94.8 (11.2)	22.4 (25.2)
Debre Birhan	98.9 (18.2)	94.7 (9.6)	93.1 (7.1)	95.2 (5.2)	99.1 (7.2)	103.6 (10.1)	108.7(10.4)	109.1 (14.3)	110.0(11.4)	101.0(9.9)	92.6 (12.2)	93.9 (9.2)	16.9 (18.1)
Dire Dawa	94.8 (7.2)	93.8 (4.6)	94.6 (6.2)	94.0 (8.3)	97.4 (7.1)	101.1 (6.2)	105.6(11.9)	108.2 (9.9)	106.6(8.9)	105.7(6.1)	101.4(6.6)	96.6 (7.8)	14.4 (15.4)
Gonder	94.4 (6.8)	94.0 (7.9)	97.7 (8.0)	94.8 (9.4)	96.9 (11.7)	99.6 (14.9)	102.3(17.1)	102.9 (20.3)	108.1(16.3)	110.2(12.6)	99.9 (13.6)	99.1 (8.8)	16.3 (17.2)
Hosana	95.7 (18.7)	92.6 (7.2)	96.4 (19.0)	98.7 (6.3)	103.4 (11.5)	109.4 (9.3)	110.2(9.0)	109.2 (13.5)	105.1(19.0)	98.5 (14.4)	91.6 (8.4)	89.1 (13.3)	21.1 (23.7)
Jimma	90.3 (11.2)	94.0 (8.8)	91.7 (10.7)	100.2 (34.2)	99.3 (15.0)	114.3 (22.9)	112.9 (18.7)	106.3 (17.2)	113.9(20.7)	98.8 (13.2)	92.1 (16.9)	86.3 (7.0)	28.0 (32.4)
Mekele	94.6 (6.2)	92.7 (6.2)	94.1 (4.3)	98.0 (6.2)	97.2 (9.2)	102.1 (11.9)	101.9(8.4)	101.8 (7.8)	106.7(8.6)	111.2 (18.4)	103.2 (8.1)	96.2 (4.5)	17.1 (18.2)
Nekemte	92.8 (19.4)	91.6 (6.8)	92.8 (8.1)	93.7 (10.9)	93.8 (8.6)	104.8 (18.4)	104.6(14.4)	109.7 (11.7)	117.3 (24.9)	107.3 (15.2)	95.8 (15.4)	95.7 (13.5)	18.5 (20.0)
Shashemene	90.4 (9.3)	92.4 (10.4)	93.6 (10.3)	96.3 (7.5)	101.0 (12.5)	113.2 (11.1)	110.7(12.1)	114.8 (20.2)	109.7(16.0)	97.3 (15.2)	91.1 (13.8)	89.3 (8.2)	25.7 (28.0)
Woliso	91.4 (8.9)	90.9 (12.7)	91.3 (10.9)	94.5 (13.9)	98.9 (12.9)	108.7 (12.0)	111.6(15.0)	107.8 (20.2)	117.1(26.9)	106.1(16.5)	92.4 (13.7)	89.1 (12.2)	28.0 (31.4)
Woldeya	95.6 (10.6)	91.3 (10.2)	93.7 (9.0)	94.2 (7.0)	97.1 (10.1)	101.4(11.3)	104.8 (12.9)	107.7 (13.2)	107.6(10.5)	107.8(11.4)	101.0 (8.9)	97.7 (9.5)	16.5 (18.1)

Source: Computed by authors based on data from the CSA and ETBC.

Notes:

[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.

[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

The grand seasonal price indices for wheat producer, wholesale and retail prices are provided in tables 12-14, respectively. In most of the wheat markets, the highest seasonal producer index is observed during the months of July to October, whereas the months of the lowest seasonal index are observed during December to January. As compared to maize, in the case of the producer price, the observed seasonal gap is lower for wheat. The seasonal gap between the lowest and highest index varied from 14 to 26 percent. The observed seasonal gap indicates that 5 to 8 months of storage period is required to capture the maximum highest seasonal price difference at the producer level. In the case of wholesale prices, the seasonal gap is much lower. It varied from about 6 to 14 percent, and the suggested storage period is about 5-10 months. In the case of retail prices, the suggested storage period varied from 5 to 9 months.

Table 12: Grand Seasonal Producer Price Indices for Wheat in Selected Markets in Ethiopia, 2002-2016

Market	**Jan.**	**Feb.**	**Mar.**	**April**	**May**	**June**	**July**	**Aug.**	**Sept,**	**Oct.**	**Nov.**	**Dec.**	**Gap (%)[2]**
Adama	90.6 (8.3)[1]	94.4 (6.0)	92.5 (8.6)	107.0 (24.1)	98.3 (8.3)	106.0 (11.2)	108.8 (7.6)	104.5 (6.1)	104.9 (8.8)	101.5(11.4)	95.2(4.2)	96.2 (5.9)	18.2 (20.1)
Ambo	96.4 (14.0)	89.9 (5.7)	94.3 (8.1)	97.7 (6.5)	99.8 (7.8)	104.9 (6.3)	107.1(9.9)	101.7(6.6)	111.4 (13.3)	106.7(15.3)	100.9 (18.3)	89.3 (14.5)	17.8 (19.9)
Assela	92.1 (9.5)	92.4 (9.9)	94.6 (6.0)	97.8 (7.8)	104.7 (9.7)	105.0 (9.3)	111.7(11.2)	104.8(6.5)	106.3(14.3)	98.8(16.0)	96.4 (8.9)	96.2 (12.4)	19.6 (21.3)
Bale Robe	91.9 (7.2)	90.7 (8.6)	93.0 (8.6)	98.3 (7.6)	103.2 (7.8)	107.2 (8.4)	108.6(12.9)	107.1(16.3)	101.4 (9.8)	100.9(13.5)	98.0 (9.3)	99.5 (10.1)	17.9 (19.7)
Dessie	95.4 (7.1)	94.8 (6.8)	93.9 (7.8)	97.5 (6.9)	98.2 (6.1)	102.5 (8.6)	105.0(12.7)	99.8 (9.5)	104.5(6.4)	106.8(8.5)	104.7(13.4)	96.8 (10.5)	12.6 (13.7)
Debre Birhan	93.7 (12.9)	92.3 (6.4)	92.2 (8.3)	99.6 (7.5)	102.6 (11.8)	103.7 (9.5)	101.6(5.7)	101.9(7.1)	105.9(11.1)	104.3(9.6)	104.2(21.7)	97.8 (10.0)	13.7 (14.5)
Gonder	92.4 (9.0)	93.7 (6.7)	96.3 (7.6)	95.1 (9.6)	102.5(9.0)	104.9 (12.1)	105.7(7.8)	109.0 (9.7)	109.9(9.8)	103.0(12.5)	94.7 (8.6)	92.6 (11.0)	17.5 (18.9)
Hosana	89.3 (13.6)	94.7 (11.5)	98.4 (7.7)	101.1(8.6)	101.9(8.7)	105.1 (5.7)	114.8(19.1)	110.1 (8.9)	103.0(16.4)	96.9 (7.9)	92.2 (11.1)	92.2 (8.5)	25.5 (28.6)
Mekele	90.6 (6.1)	93.4 (6.5)	97.4 (5.8)	99.0 (7.5)	100.5 (4.7)	106.8 (11.4)	109.1(10.0)	111.7(10.2)	107.7(15.9)	101.8(10.0)	93.8 (6.6)	88.2 (8.8)	29.5 (33.4)
Nekemte	100.9 (11.2)	95.2 (10.9)	94.5(13.5)	93.4 (15.6)	99.4 (8.7)	98.0 (22.8)	103.0(18.8)	102.4 (16.5)	118.8(16.8)	100.0(12.9)	97.3 (11.1)	96.5 (10.6)	25.4 (27.2)
Shashemene	93.1 (8.8)	95.3 (5.7)	93.3 (6.2)	96.7 (4.8)	100.5 (4.8)	103.4(5.6)	102.7(9.1)	106.8(7.6)	107.2(10.2)	106.9(9.5)	98.0 (6.0)	96.1 (5.5)	14.1 (15.2)
Woliso	93.2 (10.1)	93.1 (5.9)	94.3 (7.2)	98.4 (7.3)	99.3 (5.6)	102.7(6.7)	108.9(6.0)	109.4(12.0)	108.8(14.8)	103.3(14.0)	95.1 (9.2)	93.4 (11.9)	16.3 (17.5)
Woldeya	90.4 (10.4)	95.9 (5.9)	97.8 (10.5)	99.8 (7.4)	101.9 (8.6)	102.4(6.0)	109.6(14.7)	105.7(6.9)	100.0(9.4)	102.6(10.1)	99.6 (5.8)	94.2 (9.1)	19.2 (21.2)

Source: Computed by authors based on data from the CSA and ETBC

Notes:

[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.

[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

Table 13: Grand Seasonal Wholesale Price Indices for Wheat in Selected Markets in Ethiopia, 2002-2016

Market	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Gap (%)[2]**
Adama	96.9 (4.1)[1]	98.9 (4.1)	99.1 (4.6)	98.6 (8.4)	101.1 (3.4)	103.8 (11.5)	100.8 (3.8)	102.8 (5.6)	104.4(6.8)	102.0(6.1)	96.1 (5.0)	95.3 (6.5)	9.1 (9.5)
Addis Ababa	95.5 (4.9)	98.0 (4.3)	97.4 (5.1)	100.7 (7.0)	100.8 (6.0)	100.9 (6.0)	103.2(7.0)	104.0(5.7)	102.9(4.3)	101.9(5.5)	97.6 (6.8)	96.8 (7.2)	8.5 (8.9)
Assela	93.6 (9.5)	98.3 (5.9)	97.1 (4.6)	100.9(7.0)	101.9(5.3)	102.4(3.6)	103.4(4.3)	102.7(4.5)	105.0(7.0)	103.3(6.4)	95.5 (5.3)	95.9 (7.6)	11.4 (12.2)
Bale Robe	95.0 (7.6)	98.0 (6.9)	97.1 (4.8)	103.1(6.7)	104.6 (6.3)	105.2(4.5)	102.6(12.0)	101.7(10.1)	102.4(11.3)	99.9 (7.0)	99.4 (9.2)	96.0 (10.0)	10.2 (10.7)
Dire Dawa	100.3 (17.9)	97.3 (7.6)	97.3 (4.3)	99.5 (9.1)	97.7 (11.0)	98.6 (3.4)	99.7 (5.6)	101.9(6.1)	102.9(7.1)	102.6(8.3)	101.5(8.8)	100.5(15.0)	5.6 (5.8)
Hosana	93.7 (5.4)	96.9 (5.4)	95.7(5.1)	101.6(8.0)	102.7(4.1)	102.5(3.5)	105.0(6.3)	105.1(6.2)	103.7(5.5)	106.7(8.5)	94.0 (7.3)	92.3 (6.5)	14.4 (15.6)
Mekele	96.0 (8.2)	97.4 (8.4)	101.3 (8.7)	100.7 (6.7)	103.1(4.5)	102.1(3.0)	103.9(6.9)	103.9(7.8)	101.9(7.5)	98.3 (7.5)	93.2 (9.0)	97.8 (8.5)	10.7 (11.5)
Shashemene	95.2 (6.5)	95.9 (5.6)	95.6 (5.7)	100.2 (6.9)	101.9(4.9)	104.8(5.5)	105.1(5.4)	104.0(6.8)	102.9(7.4)	102.9(6.3)	94.8 (7.7)	96.9 (7.6)	10.3 (10.9)

Source: Authors' calculations based on ETBC price data for wholesale prices.

Notes:

[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.

[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

Table 14: Grand Seasonal Retail Price Indices for Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Gap (%)[2]
Adama	94.4 (6.5)[1]	96.6 (11.9)	94.0 (4.6)	97.4(8.5)	100.0(9.0)	100.7(7.0)	98.1(6.7)	105.1 (9.8)	106.1 (6.8)	108.3 (6.2)	101.9(7.2)	97.3 (7.8)	14.3 (15.2)
Addis Ababa	98.1 (4.7)	93.5 (4.6)	95.9 (3.6)	99.3 (4.4)	99.7 (4.8)	102.3(5.6)	101.3 (3.9)	102.9 (3.4)	103.0(4.5)	102.3 (4.7)	102.6(5.2)	99.0 (6.2)	9.4 (10.1)
Ambo	87.8 (11.1)	88.3 (6.7)	89.5 (8.2)	91.7 (9.0)	99.1 (10.5)	102.1(6.9)	105.1 (11.7)	111.5 (10.3)	111.4(9.5)	113.5 (12.1)	108.2(8.0)	91.7 (15.0)	23.7 (27.0)
Assela	93.1 (8.5)	91.3 (4.3)	93.9 (4.9)	94.6 (8.4)	99.1 (9.3)	102.0(6.9)	102.9(8.9)	105.4 (7.7)	107.1(10.7)	108.7 (10.4)	103.6(9.1)	98.4 (8.6)	17.4 (19.1)
Bahir Dar	96.1 (10.2)	91.3 (15.5)	93.1 (6.0)	96.0 (11.0)	99.1 (10.3)	102.8(10.6)	106.3(8.4)	101.0 (10.6)	106.6(10.9)	106.0 (10.7)	102.1(6.9)	99.6 (6.9)	15.3 (16.8)
Bale Robe	99.6 (6.7)	98.0 (6.8)	95.3 (4.6)	95.2 (5.8)	100.2(13.3)	97.1 (10.2)	93.9 (12.2)	97.3 (13.8)	107.4(13.0)	106.7 (12.3)	103.0(15.2)	106.2(16.3)	12.2 (12.8)
Dessie	96.4 (8.1)	92.2 (6.0)	94.1 (5.4)	97.7 (7.2)	100.1(10.0)	103.7(10.5)	102.5(9.0)	105.3 (6.9)	105.2(7.7)	95.9 (20.7)	105.3(7.0)	101.5(6.5)	13.1 (14.2)
Debre Birhan	98.0 (9.1)	93.9 (8.1)	94.1 (3.8)	94.3 (5.2)	97.5 (6.1)	98.9 (6.0)	102.1(8.3)	105.1 (9.3)	103.9(6.7)	104.0 (7.6)	109.9(26.1)	98.1 (5.2)	16.0 (17.0)
Gonder	94.3 (7.0)	91.3 (6.2)	96.5 (5.6)	96.7 (5.8)	99.4 (5.2)	100.6(9.3)	105.4(7.1)	103.7 (5.0)	105.0(4.6)	105.2 (8.8)	103.3(8.9)	98.3 (5.8)	14.1 (15.4)
Hosana	86.3 (7.8)	89.8 (7.1)	94.0 (10.4)	94.5 (11.2)	103.2(8.4)	102.6(8.3)	102.5(7.7)	106.1 (10.1)	115.5(17.7)	110.2 (7.4)	108.0(12.0)	87.2 (10.2)	29.2 (33.8)
Jimma	98.9 (7.9)	96.3 (8.4)	95.1 (5.5)	95.3 (5.6)	97.3 (6.4)	99.9 (6.3)	102.6(6.8)	100.6 (8.2)	104.6(8.0)	104.7 (7.1)	103.7(5.3)	100.9 (7.3)	9.6 (10.1)
Mekele	93.8 (6.6)	91.1 (9.2)	99.3 (5.6)	101.3(4.8)	102.1(8.0)	103.3 (3.6)	108.6(11.5)	103.8 (8.7)	101.9(10.3)	100.3 (10.8)	100.2(11.2)	94.1 (6.9)	17.5 (19.2)
Nekemte	99.4 (11.2)	97.2 (7.6)	97.8 (4.5)	95.8 (11.9)	98.1 (11.5)	100.9(15.2)	97.6 (17.9)	99.6 (20.6)	104.7(16.8)	102.2 (18.0)	103.9(14.3)	102.4(12.6)	8.9 (9.3)
Shashemene	90.6 (6.6)	91.2 (6.1)	92.6 (6.7)	94.6 (5.3)	99.1 (5.8)	103.9(5.9)	107.0(5.5)	108.7 (7.8)	109.1(4.9)	109.5 (9.3)	100.7(7.9)	92.9 (6.9)	18.9 (20.1)
Woliso	92.9 (11.3)	95.1 (11.3)	95.7 (8.7)	92.3 (15.1)	95.4 (8.1)	98.0 (12.7)	105.4(10.1)	109.2 (9.6)	109.7(7.2)	109.4 (13.9)	103.8(10.8)	92.9 (11.1)	16.8 (18.0)
Woldeya	96.8 (4.8)	98.3 (7.4)	96.6 (8.6)	96.9 (6.7)	99.4 (6.3)	97.6 (5.1)	101.0(6.3)	105.7 (5.2)	103.6(6.2)	103.8 (7.2)	102.6(6.4)	97.6 (6.5)	9.1 (9.4)

Source: Authors' calculations based on CSA price data for retail prices.

Notes:

[1]The figure in parenthesis is the standard deviation for a given month's seasonal indices computed over a number of years.

[2] The seasonal gap is computed as the difference between the maximum and minimum seasonal index, and the figure in parenthesis is the gross return to storage (GRS). It is computed as a percentage of the seasonal gap to the minimum index.

5.2.3. Descriptive statistics of monthly price changes and returns for maize and wheat crops

The descriptive analysis of monthly price changes of maize and wheat producer and wholesale prices in selected maize markets in Ethiopia are provided in Tables 15-18, respectively. The simple descriptive statistics that indicate the levels of returns and risks of holding maize stock in different markets and market levels are clear. The observed average monthly price changes are very lows which indicates that the gross return or profit from holding maize and wheat stocks could be very low, thus limiting temporal arbitrage opportunities. However, it is important to note that the observed extreme values of the minimum and maximum monthly price changes are hardly indicative of monthly storage costs, a measure of the inefficiency of the maize storage system. The large positive and negative price changes represent excessive windfall gains and losses in holding maize stocks at the producer and wholesale levels. The results for wheat are presented in tables 17 and 18. Similar results are observed in terms of the returns and risks of holding wheat stock at the producer and wholesale levels.

The summary statistics of monthly real producer, wholesale and retail maize and wheat price returns are also given in tables 19, 20 and 21, respectively. The monthly price returns could also be annualized and compared to the opportunity costs of capital in the market to assess the relative profitability of holding maize stocks. The observed average monthly producer and wholesale price returns are less than one percent, and negative in most of the cases. The annualized maize producer and wholesale returns are also less than 5 percent, which is hardly comparable to the current opportunity costs of capital in the market which are greater than 10 percent.

The summary statistics of monthly real producer, wholesale and retail wheat price returns are also given in Tables 22, 23 and 24, respectively. The monthly price returns could be also annualized and compared to the opportunity costs of capital in the market to assess the relative profitability of holding wheat stocks. The observed average monthly producer and wholesale price returns are less than one percent, and negative in most of the cases. The annualized wheat producer and wholesale returns are also less than 5 percent, which is hardly comparable to the current opportunity costs of capital in the market which are greater than 10 percent.

Table 15: Summary Statistics of Monthly Nominal Producer Price Changes for Maize in Selected Markets in Ethiopia, (Birr/100 kg, 2002-2016)

Market	Mean	Min	Max	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	2.01	-348.67	262.17	67.86	3376.12	-0.84	9.58
Ambo	2.12	-242.10	200.41	53.82	2538.68	-0.53	8.11
Bahir Dar	1.77	-216.05	114.06	37.00	2090.39	-1.36	11.36
Dessie	3.08	-490.86	646.22	105.40	3422.08	0.43	15.42
Gonder	1.87	-235.94	207.82	44.33	2370.59	-0.54	9.83
Jimma	2.21	-286.56	256.86	52.62	2380.99	-0.71	12.43
Mekele	2.86	-317.26	265.91	67.45	2358.39	-0.43	8.30
Nekemte	1.80	-219.99	208.55	46.09	2560.55	-0.71	10.39
Shashemene	1.86	-242.54	221.29	74.78	4020.43	-0.39	4.10
Woliso	1.27	-197.74	172.57	55.34	4357.48	-0.52	5.11

Source: Computed by authors based on data from the CSA and ETBC.

Table 16: Summary Statistics of Monthly Nominal Wholesale Price Changes for Maize in Selected Markets in Ethiopia, Birr/100 kg, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	1.96	-157.0	211.97	36.39	1856.63	-0.13	12.93
Addis Ababa	2.15	-150.0	196.28	37.68	1752.56	0.69	10.26
Ambo	2.12	-226.0	275.28	45.28	2135.85	0.41	15.44
Bahir Dar	2.37	-150.0	171.55	39.17	1652.74	0.80	10.00
Dessie	2.16	-185.0	178.50	37.22	1723.15	-0.23	12.66
Debre Markos	2.61	-197.0	164.00	35.61	1364.37	0.05	11.76
Dire Dawa	1.83	-245.75	328.25	54.25	2964.48	0.73	14.92
Gonder	2.23	-151.0	140.22	34.54	1548.88	-0.51	7.72
Jimma	2.26	-340.0	415.0	58.39	2583.63	0.41	24.41
Mekele	2.47	-384.0	369.0	63.26	2561.13	0.32	34.38
Nekemte	2.11	-270.0	210.0	44.15	2092.42	-0.73	14.37
Shashemene	2.35	-201.0	189.55	48.72	2073.19	-0.33	8.14

Source: Computed by authors based on data from the CSA and ETBC.

Table 17: Summary Statistics of Monthly Nominal Producer Price Changes for Wheat in Selected Markets in Ethiopia, (Birr/100 kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	3.95	-167.30	176.16	46.18	1169.11	0.01	5.39
Ambo	4.30	-568.82	366.14	86.59	2013.72	-1.35	16.33
Assela	3.84	-156.56	218.46	50.77	1322.13	0.73	6.30
Bahir Dar	3.12	-249.31	281.36	62.85	2014.42	0.03	6.20
Bale Robe	3.92	-135.07	146.82	46.56	1187.75	-0.30	4.39
Dessie	3.25	-307.10	176.16	70.06	2155.69	-1.39	7.78
Debre Birhan	3.15	-198.31	177.41	56.48	1793.01	-0.10	6.18
Gonder	3.60	-300.21	209.44	65.14	1809.44	-0.40	6.80
Hosana	3.56	-242.45	225.83	58.88	1653.93	-0.65	6.86
Jimma	4.37	-253.35	289.01	82.50	1887.87	0.35	5.45
Mekele	4.24	-182.16	228.37	58.78	1386.32	0.12	6.06
Nekemte	3.71	-417.38	430.78	83.43	2248.78	-0.15	10.54
Shashemene	2.84	-194.98	144.47	45.49	1601.76	-0.87	7.83
Woliso	3.33	-192.36	148.98	48.88	1467.87	-0.39	5.63

Source: Computed by authors based on data from the CSA and ETBC.

Table 18: Summary Statistics of Monthly Nominal Wholesale Price Changes for Wheat in Selected Markets in Ethiopia, (Birr/100 kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	3.66	-202.00	214.82	45.36	1239.34	-0.56	9.67
Addis Ababa	3.80	-117.00	126.00	32.33	850.79	0.43	6.72
Ambo	3.17	-125.00	202.14	33.02	1041.64	0.54	12.33
Assela	3.40	-149.00	128.00	37.85	1113.23	-0.40	7.33
Bale Robe	3.06	-166.00	184.00	44.00	1437.91	0.17	6.84
Debre Birhan	3.51	-114.00	321.87	35.11	1000.28	1.40	13.83
Dire Dawa	4.11	-273.00	354.83	57.97	1410.46	0.52	14.51
Gonder	3.04	-150.00	241.36	48.15	1583.88	0.52	7.17
Hosana	3.32	-214.00	159.00	47.39	1427.41	-0.95	8.97
Jimma	4.01	-145.00	184.44	45.04	1123.19	0.07	5.20
Mekele	3.00	-120.00	236.50	35.14	1171.33	1.28	13.26
Shashemene	3.11	-137.00	161.55	38.10	1225.08	0.24	7.69

Source: Computed by authors based on data from the CSA and ETBC.

Table 19: Summary Statistics of Monthly Real Producer Price Returns: Percentage for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	0.06	-219.56	232.00	32.82	54700.00	0.06	26.70
Ambo	0.14	-67.32	61.11	18.27	13050.00	-0.16	4.72
Bahir Dar	0.14	-40.00	43.92	12.55	8964.29	-0.12	4.9
Dessie	-0.16	79.78	71.69	20.72	-12950.00	-0.44	4.92
Debre Birhan	-0.33	-69.67	49.02	19.20	-5818.18	-0.50	4.46
Gonder	-0.06	52.83	45.33	15.94	-26566.67	-0.23	4.18
Jimma	0.20	-89.09	56.67	19.49	9745.00	-0.61	6.77
Mekele	-0.07	-59.04	51.97	17.79	-25414.29	-0.16	4.18
Nekemte	0.03	-56.99	83.99	18.98	63266.67	28.63	5.57
Shashemene	-0.61	-127.9	87.35	27.73	-4545.90	-0.68	6.98
Woldeya	-0.43	-78.66	59.02	18.89	-4393.02	-0.71	5.22
Woliso	-1.08	-124.35	115.54	28.90	-2675.93	-0.15	7.13

Source: Computed by authors based on data from the CSA and ETBC.

Table 20: Summary Statistics of Monthly Real Wholesale Price Returns: Percentage for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	-0.03	-87.41	90.54	13.47	-44900.00	0.18	22.57
Addis Ababa	0.09	-32.66	45.87	10.41	11566.67	0.61	6.27
Ambo	0.17	-38.54	55.22	12.63	7429.41	0.59	6.83
Bahir Dar	0.20	-41.45	47.63	10.78	5390.00	0.73	7.57
Dessie	-0.05	-35.88	41.59	9.49	-18980.00	0.18	6.34
Debre Markos	0.28	-34.08	64.68	10.11	3610.71	1.52	13.05
Dire Dawa	-0.31	-71.99	105.10	13.64	-4400.00	1.81	26.06
Gonder	0.03	-31.35	36.42	8.14	27133.33	24.89	6.34
Jimma	0.26	-65.03	85.85	14.47	5565.38	15.71	12.28
Mekele	-0.11	-238.73	225.65	26.99	-24536.36	-0.53	60.68
Nekemte	0.26	-241.88	222.72	27.75	10673.08	-0.88	54.98
Shashemene	0.20	-44.77	37.30	12.58	6290.00	-0.53	4.75

Source: Computed by authors based on data from the CSA and ETBC.

Table 21: Summary Statistics of Monthly Real Retail Price Returns: Percentage for Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min	Max	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	0.25	-35.32	68.23	12.80	5120.00	1.06	8.68
Addis Ababa	0.19	-31.41	49.94	7.75	4078.95	1.48	14.52
Ambo	0.37	-53.33	66.92	15.25	4121.62	0.32	5.62
Assela	0.40	-103.26	116.04	20.07	5017.50	0.26	13.71
Bahir Dar	0.09	-85.32	72.49	18.42	20466.67	-0.33	9.63
Bale Robe	0.33	-59.44	126.36	19.72	5975.76	1.29	12.27
Dessie	-0.01	-70.79	41.53	13.43	-134300.00	-0.49	8.06
Debre Birhan	0.13	-49.91	58.94	11.84	9107.69	0.43	7.79
Dire Dawa	-0.07	-28.47	31.21	7.44	-10628.57	1.06	8.59
Gonder	0.06	-47.54	142.76	14.54	24233.33	5.34	55.38
Hosana	0.08	-74.25	74.12	16.94	21175.00	0.09	8.79
Jimma	0.33	-99.01	96.58	22.61	6851.52	0.14	8.84
Mekele	-0.14	-39.55	42.23	9.86	-7042.86	0.97	8.66
Nekemte	0.20	-67.89	66.59	15.40	7700.00	-0.10	6.60
Shashemene	0.19	-49.14	72.74	15.16	7978.95	0.64	7.73
Woliso	0.08	-40.90	29.14	10.27	12837.50	-0.30	4.90
Ziway	-0.01	-77.94	81.59	17.24	-172400.00	20.52	8.55

Source: Computed by authors based on data from the CSA and ETBC.

Table 22: Summary Statistics of Monthly Wheat Producer Price Returns: Percentage of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	-0.0.9	-89.86	107.08	14.68	-16311.11	0.87	25.27
Ambo	0.19	-76.50	86.80	16.43	8647.37	-0.22	10.08
Assela	0.12	-53.28	64.57	14.23	11858.33	0.27	7.11
Bahir Dar	-0.16	-55.63	100.57	17.05	-10656.25	1.08	10.01
Bale Robe	0.24	-44.31	37.63	11.62	4841.67	-0.24	4.29
Dessie	-0.21	-52.55	33.63	11.86	-5647.62	-0.77	5.71
Debre Birhan	-0.28	-81.42	66.70	14.14	-5050.00	-0.47	10.72
Gonder	-0.10	-30.07	40.42	12.56	-12560.00	0.24	3.77
Hosana	-0.13	-74.39	86.83	15.72	-12092.31	0.09	10.33

Jimma	0.01	-44.72	64.44	16.92	169200.00	0.31	4.33
Mekele	-0.12	-41.64	38.55	10.88	-9066.67	-0.07	5.25
Nekemte	0.11	-106.35	105.69	21.53	19572.73	0.09	9.10
Shashemene	-0.52	-30.03	31.08	7.85	-1509.62	0.01	5.98
Woldeya	-0.34	-37.08	48.18	12.28	-3611.76	0.29	6.05
Woliso	-0.19	-43.76	40.98	11.37	-5984.21	-0.12	4.85

Source: Computed by authors based on data from the CSA and EGTE.

Table 23: Summary Statistics of Monthly Real Wholesale Price Returns: Percentage of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	-0.01	-34.31	34.20	7.31	-73100.00	-0.24	9.38
Addis Ababa	-0.04	-18.41	25.14	5.85	-14625.00	0.50	6.67
Ambo	0.04	-33.34	36.23	7.48	18700.00	0.21	8.99
Assela	0.03	-48.35	49.39	8.22	27400.00	0.09	15.80
Bale Robe	0.08	-27.45	39.12	9.19	11487.50	0.38	5.23
Debre Birhan	-0.03	-16.96	43.35	6.38	-21266.67	1.56	14.19
Dire Dawa	-0.19	-56.23	72.95	11.22	-5905.26	0.73	18.13
Gonder	-0.20	-30.83	51.13	8.58	-4290.00	87.66	10.68
Hosana	0.14	-29.78	29.53	7.81	5578.57	-0.22	5.43
Jimma	0.02	-25.99	35.64	7.69	38450.00	0.13	5.71
Mekele	-0.32	-30.63	45.93	7.55	-2359.38	1.26	14.00
Shashemene	0.02	-30.87	25.46	7.14	35700.00	-0.17	5.97

Source: Computed by authors based on data from the CSA and EGTE.

Table 24: Summary Statistics of Monthly Real Retail Price Returns: Percentage of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	0.21	-36.23	36.73	8.82	4200.00	0.06	6.42
Addis Ababa	0.13	-15.73	17.84	4.41	3392.31	0.47	6.03
Ambo	0.11	-66.25	41.51	13.99	12718.18	-0.63	5.61
Assela	0.21	-41.33	40.45	10.04	4780.95	-0.02	6.47
Bahir Dar	0.28	-79.52	76.23	13.23	4725.00	-0.10	16.05
Bale Robe	0.32	-0.40	75.96	13.02	4068.75	2.33	15.59
Dessie	-0.14	-138.84	139.65	17.22	-12300.00	0.11	50.02
Debre Birhan	0.11	-75.55	79.26	10.73	9754.55	0.39	32.49
Dire Dawa	0.05	-11.67	16.16	5.03	10060.00	-0.16	2.96
Gonder	-0.05	-34.57	24.32	7.80	-15600.00	-0.11	5.10
Hosana	0.48	-62.24	47.33	13.90	2895.83	-0.30	6.67
Jimma	0.13	-32.81	33.35	8.88	6830.77	0.20	6.00
Mekele	-0.07	-41.23	25.36	8.91	-12728.57	-0.48	6.25
Nekemte	-0.02	-44.24	114.61	14.76	-73800.00	3.12	28.60
Shashemene	0.24	-29.73	27.44	7.64	3183.33	0.26	5.79
Woliso	-0.14	-36.71	22.31	8.26	-5900.00	-0.45	5.03
Ziway	0.05	-72.06	71.06	15.67	31340.00	-0.07	9.86

Source: Computed by authors based on data from the CSA and EGTE.

In general, the descriptive statistics of monthly price changes and returns for maize and wheat indicate that there is a very low level of return and a high level of risk in holding such stocks. These statistics might indicate why the storage system is currently less developed. They also highlight the need to design appropriate policies to encourage private sector sector investment in strorage facilities.

5.2.4. How volatile are maize and wheat prices?

Annexes 1-4 depicts figures showing the evolution of nominal and real maize and wheat prices for selected markets trends, and the historical volatility for 2001-2016. The summary statistics of unconditional volatilities for maize producer, wholesale and retail prices are summarized in tables 25-27, and those for wheat prices are provided in tables 28-30. Furthermore, the econometric analyses indicate that some of the very important maize and wheat producer and wholesale markets are also characterized by volatility clustering (tables 31 and 32). This represents an extreme situation of maize price volatility[14].

In general, the simple descriptive and econometric analyses indicate that, given the current market environment, there is no apparent incentive for producers to delay the selling of their maize and wheat for better prices. Furthermore, there is no commercial incentive for commercial maize and wheat storage at the wholesale level. This is in line with the observation made during the rapid market appraisal. The levels of return on maize and wheat stocks are very low and highly volatile. There is too much risk for too little return in holding maize and wheat stocks, and the farmers might be better off selling right after the harvest. The wholesale traders also indicated that they are not interested in holding stocks of maize and wheat for several reasons, including the risk of price drops. Also, traders also expressed concern about the arbitrary nature of the tax levied on stocks held at the time of inspection rather than based on turnover volume.

The observed strategy of wholesale traders in the regional markets is to act as assemblers or aggregators from the farmers or farmer-traders for immediate sell to inter-regional grain traders. Their interest is in high turnover during peak harvest time, when the activities of regional grain traders are also at their active level. Therefore, in the following section the behavior of wholesale margins for maize and wheat in the regional markets will be analyzed. The wholesale margin is given as the difference between the wholesale price and the producer price in the same market.

Table 25: Summary Statistics of Unconditional Volatilities of Real Producer Prices of Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	98.84	28.58	340.94	72.13	72.98	2.44	8.47
Ambo	62.91	24.39	122.50	23.60	37.51	0.60	2.56
Bahir Dar	39.75	15.80	74.29	13.10	32.96	0.83	3.36
Jimma	62.96	16.69	125.58	30.44	48.35	0.61	2.09
Nekemte	61.12	19.51	136.99	27.76	45.42	1.07	3.45
Shashemene	85.18	31.79	204.62	44.27	51.97	1.17	3.51
Woldeya	98.38	41.89	189.75	39.78	40.44	0.88	2.71
Woliso	63.07	26.20	116.66	25.87	41.02	0.40	1.99

Source: Computed by authors based on data from the CSA and ETBC.

[14] The evolution of maize and wheat prices is also provided in annexes 1 to 4.

Table 26: Summary Statistics of Unconditional Volatilities of Real Wholesale Prices of Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	30.45	9.38	79.82	15.69	51.53	1.22	4.44
Addis Ababa	31.76	12.69	81.67	16.55	52.11	1.25	3.71
Ambo	39.68	13.02	82.15	17.00	42.84	1.00	3.11
Bahir Dar	33.59	7.23	73.64	17.66	52.58	0.69	2.47
Dessie	30.28	14.49	73.63	13.66	45.11	1.32	4.24
Debre Markos	30.91	8.17	66.87	13.26	42.90	0.71	3.02
Dire Dawa	37.92	10.28	155.10	32.21	84.94	2.42	8.10
Gonder	25.24	8.94	53.35	10.87	43.07	0.43	2.09
Jimma	44.65	20.55	134.26	26.12	58.50	2.11	7.09
Mekele	54.58	11.06	357.05	84.93	155.61	2.99	10.57
Nekemte	63.33	8.26	344.94	81.12	128.09	2.80	9.78
Shashemene	42.08	13.23	80.29	15.12	35.93	0.31	2.73
Woliso	43.23	16.56	104.06	21.86	50.57	1.29	4.14

Source: Computed by authors based on data from the CSA and ETBC

Table 27: Summary Statistics of Unconditional Volatilities of Real Retail Prices of Maize in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	39.76	10.70	80.72	19.85	49.92	0.33	2.04
Addis Ababa	22.10	2.85	60.80	13.08	59.19	0.85	3.62
Ambo	48.91	12.45	98.99	15.50	31.69	0.87	4.11
Assela	54.84	3.56	182.54	38.32	69.88	1.26	4.79
Bahir Dar	54.00	15.59	139.10	30.79	57.02	1.03	3.09
Bale Robe	65.11	25.46	130.92	25.21	38.72	0.75	3.20
Dessie	43.48	13.31	108.49	19.99	45.98	1.49	5.51
Debre Birhan	37.84	17.76	86.93	17.32	45.77	1.49	4.70
Dire Dawa	23.35	9.40	58.20	11.32	48.48	1.10	3.64
Gonder	39.00	6.58	147.82	34.14	87.54	2.12	7.19
Hosana	53.44	6.63	133.04	31.81	59.52	1.07	3.06
Jimma	71.28	19.09	151.65	39.96	56.06	0.75	2.15
Mekele	30.50	8.32	80.73	16.85	55.25	1.37	4.60
Nekemte	49.76	13.16	115.97	23.53	47.29	1.22	4.21
Shashemene	48.59	18.57	129.57	24.92	51.29	1.68	4.94
Woldeya	34.09	14.01	66.65	11.95	35.05	0.48	2.57
Woliso	54.17	19.65	126.30	24.21	44.69	1.22	4.31

Source: Computed by authors based on data from the CSA and ETBC.

Table 28: Summary Statistics of Unconditional Volatilities of Real Producer Prices of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	35.00	12.41	153.62	23.23	66.37	3.28	16.25
Ambo	51.75	19.34	140.44	27.87	53.86	1.96	6.24
Assela	38.82	16.40	73.83	16.82	43.33	0.63	1.94
Bahir Dar	49.27	20.04	130.09	26.63	54.05	1.26	3.88
Bale Robe	37.85	15.29	72.26	13.45	35.54	0.80	2.94
Dessie	40.13	20.79	88.17	15.47	38.55	1.43	4.93
Debre Birhan	42.43	12.73	120.05	24.60	57.98	1.86	6.58
Gonder	41.53	17.88	74.66	14.66	35.30	0.16	1.93

Jimma	56.28	25.97	100.56	17.51	31.11	0.86	2.79
Mekele	35.52	18.52	71.27	14.49	40.79	0.90	2.66
Nekemte	67.75	22.76	163.65	31.45	46.42	1.67	5.88
Shashemene	26.23	8.05	51.14	11.55	44.03	0.18	1.80
Woldeya	41.24	12.82	87.01	19.91	48.28	0.54	2.45
Woliso	39.23	20.33	76.46	13.39	34.13	1.02	3.65

Source: Computed by authors based on data from the CSA and ETBC.

Table 29: Summary Statistics of Unconditional Volatilities of Real Wholesale Prices of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	22.07	8.30	65.51	13.37	60.58	1.80	5.90
Addis Ababa	18.65	6.88	34.35	7.80	41.82	0.30	1.83
Ambo	22.63	7.90	55.26	12.84	56.74	1.46	3.95
Assela	25.04	8.84	73.29	15.02	59.98	2.05	7.16
Bale Robe	28.66	12.48	62.01	11.94	41.66	0.92	2.66
Debre Birhan	20.13	8.30	51.61	9.38	46.60	1.65	5.87
Dire Dawa	33.46	7.54	103.13	23.90	71.43	1.55	4.88
Gonder	26.55	5.82	75.66	15.47	58.27	1.82	6.09
Hosana	25.84	7.84	52.72	9.09	35.18	0.39	3.57
Jimma	25.84	12.97	46.97	8.67	33.55	0.70	2.65
Mekele	22.75	8.21	54.20	12.60	55.38	1.31	3.62
Shashemene	22.85	7.93	49.91	9.76	42.71	0.87	2.94

Source: Computed by authors based on data from the CSA and ETBC.

Table 30: Summary Statistics of Unconditional Volatilities of Real Retail Prices of Wheat in Selected Markets in Ethiopia, 2002-2016

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	35.01	12.41	153.62	23.23	66.35	3.28	16.25
Addis Ababa	14.29	3.10	29.01	5.86	41.01	0.41	2.59
Ambo	51.75	19.34	140.44	27.87	53.86	1.96	6.24
Assela	38.82	16.40	73.83	16.82	43.33	0.63	1.94
Bahir Dar	49.28	20.04	130.09	26.63	54.04	1.26	3.88
Bale Robe	37.85	15.29	72.26	13.45	35.54	0.80	2.94
Dessie	40.13	20.79	88.17	15.47	38.55	1.43	4.93
Debre Birhan	42.43	12.73	120.05	24.60	57.98	1.86	6.58
Dire Dawa	17.27	7.77	27.55	4.50	26.06	0.13	2.67
Gonder	41.53	17.88	74.66	14.66	35.30	0.16	1.93
Jimma	56.28	25.97	100.56	17.51	31.11	0.86	2.79
Mekele	35.52	18.52	71.27	14.49	40.79	0.90	2.66
Nekemte	67.76	22.76	163.65	31.45	46.41	1.67	5.88
Shashemene	26.23	8.05	51.14	11.55	44.03	0.18	1.80

Source: Computed by authors based on data from the CSA and ETBC.

Table 31: Results of GARCH Parameter Estimates of Monthly Real Producer and Wholesale Maize Prices for Selected Markets in Ethiopia, 2002-2016

Market	ω	A	β	H_0: α+ β=0	H_0: α+ β=1	α + β	Wald- χ^2 Statistics
Producer Prices							
Bahir Dar	0.001	0.028	0.957^{***}	4.751^{***}	0.78	0.99	60.82^{***}
Jimma	0.005^{*}	0.379^{**}	0.486^{***}	62.68^{***}	1.50	0.87	79.65^{***}
Nekemte	0.001	2.217^{***}	0.022	43.53^{***}	11.80^{***}	2.24	639.12^{***}

Wholesale price							
Adama	0.001	0.919***	0.415***	164.74***	4.67**	1.33	37.96***
Addis Ababa	0.001	0.261**	0.711***	298.20***	0.23	0.97	111.61***
Ambo	0.001	0.207**	1.206***	30.99***	2.06	1.41	316.65***
Bahir Dar	0.001	0.129***	0.855***	1179.49***	0.27	0.98	64.801***
Dessie	0.001	0.102	0.807***	90.04***	0.83	0.91	58.34***
Jimma	0.002	1.893***	0.041	31.52***	6.37**	1.93	650.08***

Source: Computed by authors based on data from the CSA and ETBC.
Note:
*, **, and *** denote statistical significance at the 10, 5 and 1 percent levels, respectively. Lagrange multiplier (LM) test for ARCH residuals: H_0: No ARCH effects.

Table 32: Results of GARCH Parameter Estimates of Monthly Real Producer and Wholesale Wheat Prices for Selected Markets in Ethiopia, 2002-2016

Market	ω	α	β	H_0: α+ β=0	H_0: α+ β=1	α + β	Wald- χ^2 Statistics
Producer price							
Assela	0.002	0.863***	0.150	19.70***	0.00	1.013	66.64***
Bale Robe	0.001	0.194**	0.769	258.94***	0.36	0.963	52.21***
Hosana	0.013	0.114	0.969***	1.59***	1.93	1.083	66.35***
Wholesale price							
Adama	0.001	0.659***	0.330**	46.79***	0.02	0.989	25.74***
Ambo	0.001	1.132***	0.305	32.04***	0.99	1.437	100.41***
Assela	0.001	1.644***	0.074	26.77***	4.02**	1.718	649.00***
Bale Robe	0.001	0.496***	0.496***	75.52***	0.00	0.992	189.83***
Shashemene	0.001	0.762***	0.057	13.93***	0.68	0.819	118.63***

Source: Computed by authors based on data from the CSA and ETBC.
Note: *, **, and *** denote statistical significance at the 10, 5 and 1 percent levels, respectively. Lagrange multiplier (LM) test for ARCH residuals: H_0: No ARCH effects.

Thus, the results captured in the tables above and the related discussion show that maize and wheat storage at different levels is not profitable and is very risky.

5.3. The relationship between producer and wholesale prices

5.3.1. Descriptive analysis of maize and wheat wholesale price margins

The summary statistics of nominal wholesale margins for maize and wheat in selected markets in Ethiopia are provided in tables 33 and 34. The average wholesale maize price margin is positive in seven of the nine wholesale markets, and it is higher than the average monthly price changes. This shows why the regional wholesale traders are less interested in holding stocks than in buying grain from the farmers, and then selling it to the inter-regional grain traders. However, it is also important to note that the wholesale margins for maize and wheat are also volatile. This is characterized by extreme negative and positive values, indicating the pervasiveness of price risk in the whole maize and wheat marketing systems.

Table 33: Summary Statistics of Nominal Wholesale Price Margins for Maize in Selected Markets in Ethiopia, (Birr/100 kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	20.37	-202.44	328.67	57.54	282.47	0.94	9.34
Ambo	35.63	-166.36	214.36	47.99	134.69	0.01	6.64
Bahir Dar	24.49	-111.61	187.34	37.99	155.12	0.82	6.92
Dessie	-63.30	-768.22	325.70	111.63	-176.35	-1.95	14.03
Gonder	47.84	-121.11	208.68	55.55	116.12	0.32	3.78
Hosana	46.84	-161.62	435.10	88.20	188.30	1.23	6.15
Jimma	23.76	-145.23	371.57	51.87	218.31	1.94	17.91
Nekemte	42.08	-103.85	340.00	53.42	126.95	1.46	9.08
Shashemene	-22.34	-307.06	324.61	115.55	-517.23	-0.03	2.78

Source: Computed by authors based on data from the CSA and ETBC.

Table 34: Summary Statistics of Monthly Nominal Wholesale Price Margins for Wheat in Selected Markets in Ethiopia, (Birr/100 kg, 2002-2016)

Market	Mean	Min.	Max.	Std. Dev.	C.V. (%)	Skewness	Kurtosis
Adama	27.29	-124.04	247.53	52.17	191.17	0.98	5.73
Ambo	-6.08	-474.11	159.82	74.10	-1218.75	-2.20	12.77
Assela	32.56	-95.15	160.79	40.92	125.67	0.53	3.96
Bale Robe	24.15	-149.24	337.13	55.86	231.30	1.35	9.63
Bahir Dar	60.98	-83.63	301.72	078.28	128.37	0.78	3.00
Gonder	-9.11	-204.09	178.76	60.46	-663.67	-0.45	4.73
Hosana	37.00	-173.09	415.96	78.18	211.30	1.21	7.69
Jimma	76.46	-111.67	368.00	93.46	122.23	0.76	3.37
Shashemene	-3.01	-184.55	176.36	56.12	-1864.45	-0.25	2.11

Source: Computed by authors based on data from the CSA and ETBC.

5.4. Are maize and wheat markets integrated?

5.4.1. Descriptive analysis of maize and wheat spatial differentials

The summary statistics of monthly spatial nominal price differentials and price returns for selected maize and wheat market pairs in Ethiopia are given in tables 35-38. About 25 maize market pairs are considered for this analysis. Bahir Dar, Jimma and Nekemet are considered the major markets in maize surplus-producing regions, whereas other markets are considered as markets in major deficit and/or transshipment centers for maize. The average spatial price differential is positive for 23 of the 25 market pairs, indicating the existence of spatial arbitrage opportunities in maize markets in the direction of trade. This is the case assuming that the observed differential is relatively higher than the transport costs observed for many markets during our field observations. However, once again, it is important to note the existence of a positive average spatial margin with excessive negative or positive margins, which cannot be explained by transfer costs alone in any direction. The monthly inter-regional returns are also found to be better than the returns on temporal arbitrages in maize markets (as shown in table 36).

Table 35: Summary Statistics of Monthly Spatial Real Price Differentials for Maize in Selected Maize Market Pairs in Ethiopia, (prices deflated by consumer price index (CPI) (Dec 2011=100), 2002- 2016)

Market		Summary Statistics						
Dependent	**Independent**	**Mean**	**Min**	**Max**	**Std. Dev.**	**C.V. (%)**	**Skewness**	**Kurtosis**
Addis Ababa	**Nekemet**	32.36	-195.0	145.0	37.37	115.48	-1.38	11.23
Adama	**Nekemet**	34.19	-202.0	202.0	45.36	132.67	-1.39	10.06
Dire Dawa	**Nekemet**	84.04	-65.0	330.0	57.77	68.74	0.68	5.02
Dessie	**Nekemet**	42.78	-180.0	163.5	41.21	96.33	-0.95	8.10
Mekelle	**Nekemet**	74.32	-107.0	486.0	58.86	79.20	2.85	21.1
Shashemene	**Nekemet**	45.23	-165.0	315.0	62.89	139.04	0.33	5.56
Addis Ababa	**Jimma**	25.53	-366.0	188.00	48.63	190.48	-2.17	26.29
Adama	**Jimma**	27.36	-368.0	197.0	54.15	197.92	-1.71	19.22
Dire Dawa	**Jimma**	77.21	-288.0	368.0	73.97	95.80	0.43	7.14
Dessie	**Jimma**	35.95	-32.60	202.0	46.90	130.46	-1.95	22.35
Mekelle	**Jimma**	67.60	-298.0	466.0	61.90	91.57	1.25	20.75
Shashemene	**Jimma**	38.40	-370.0	282.0	69.53	181.07	-0.15	10.24
Addis Ababa	**Bahir Dar**	1.33	-253.0	240.55	55.31	4158.65	-0.89	9.92
Adama	**Bahir Dar**	3.16	-182.0	249.56	47.61	1506.65	0.35	9.79
Dire Dawa	**Bahir Dar**	53.01	-146.0	311.55	56.62	106.81	1.09	7.27
Dessie	**Bahir Dar**	11.75	-215.0	199.55	44.84	381.62	-0.38	10.26
Mekelle	**Bahir Dar**	43.0	-158.0	392.1	49.9	116.05	3.0	25.9
Shashemene	**Bahir Dar**	14.20	-203.0	269.55	58.45	411.62	0.54	6.91
Addis Ababa	**Shashemene**	-12.86	-253.0	178.0	55.16	-428.93	-0.91	6.40
Dire Dawa	**Shashemene**	38.81	-101.0	294.75	59.88	154.29	1.55	8.01
Adama	**Shashemene**	-11.03	-160.0	148.0	45.1	-408.88	0.31	5.09
Dire Dawa	**Addis Ababa**	51.67	-53.5	339.0	51.61	99.88	1.81	9.19
Adama	**Addis Ababa**	1.83	-182.0	163.0	33.17	1812.57	-0.32	12.55
Dessie	**Addis Ababa**	10.41	-77.0	173.0	32.86	315.66	1.29	9.16
Mekele	**Addis Ababa**	42.12	-61.0	445.0	51.86	123.12	3.85	26.45

Source: Computed by authors based on data from the CSA and ETBC.

Table 36: Summary Statistics of Monthly Inter-regional Price Returns to Maize Trade between Selected Markets in Ethiopia, (price deflated by CPI (Dec 2011=100), 2002-2016

Market		Summary Statistics						
Dependent	**Independent**	**Mean**	**Min.**	**Max.**	**Std. Dev.**	**C.V. (%)**	**Skewness**	**Kurtosis**
Addis Ababa	**Nekemet**	0.16	-0.53	2.47	0.22	137.50	6.40	70.97
Adama	**Addis Ababa**	0.16	-0.50	2.39	0.22	137.50	5.18	55.88
Dire Dawa	**Addis Ababa**	0.30	-0.19	2.33	0.24	80.00	3.42	27.92
Dessie	**Addis Ababa**	0.20	-0.48	2.56	0.23	115.00	5.38	54.64
Mekelle	**Addis Ababa**	0.32	-0.26	2.77	0.31	96.88	4.88	37.05
Shashemene	**Addis Ababa**	0.16	-0.39	2.32	0.23	143.75	4.25	42.46
Addis Ababa	**Jimma**	0.11	-0.71	0.40	0.14	127.27	-1.11	8.72
Adama	**Jimma**	0.11	-0.72	0.43	0.15	136.36	-1.28	7.56
Dire Dawa	**Jimma**	0.25	-0.51	0.83	0.20	80.00	0.02	4.24
Dessie	**Jimma**	0.15	-0.60	0.54	0.15	100.00	-0.30	5.67
Mekelle	**Jimma**	0.27	-0.54	2.53	0.24	88.89	4.49	43.23
Shashemene	**Jimma**	0.11	-0.72	0.53	0.18	163.64	-0.75	5.81
Addis Ababa	**Bahir Dar**	0.02	-0.48	0.48	0.14	700.00	-0.71	5.51
Adama	**Bahir Dar**	0.02	0.46	0.49	0.14	700.00	-0.52	4.79
Dire Dawa	**Bahir Dar**	0.17	-0.39	0.86	0.17	100.00	-0.05	4.66

Dessie	**Bahir Dar**	0.06	-0.43	0.54	0.13	216.67	-0.09	4.71
Mekelle	**Bahir Dar**	0.18	-0.24	2.59	0.23	127.78	6.78	71.90
Shashemene	**Bahir Dar**	0.02	-0.54	0.52	0.16	800.00	-0.60	4.39
Addis Ababa	**Shashemene**	-0.003	-0.40	0.38	0.13	-4333.33	-0.18	3.50
Dire Dawa	**Shashemene**	0.14	-0.28	0.89	0.16	114.29	0.80	5.29
Adama	**Shashemene**	-0.004	-0.45	0.32	0.11	-2750.00	-0.22	4.15
Dire Dawa	**Addis Ababa**	0.15	-0.27	0.74	0.14	93.33	0.52	5.61
Adama	**Addis Ababa**	-0.01	-0.46	0.27	0.08	-800.00	-0.86	9.36
Dessie	**Addis Ababa**	0.04	-0.17	0.37	0.09	225.00	0.49	4.41
Mekele	**Addis Ababa**	0.16	-0.10	2.43	0.21	131.25	7.10	75.30

Source: Computed by authors based on data from the CSA and ETBC.

The summary statistics of monthly spatial nominal wheat price differentials for selected market pairs are given in table 37. The results are similar to those of maize. The observed average spatial price differentials are positive in most cases. However, the spatial price differentials are also characterized by very large extreme values (negative and positive), which indicate the inefficiency in the wheat spatial marketing system. The monthly returns obtained are positive, and the distribution of monthly returns is characterized by high variability (table 38).

Table 37: Summary Statistics of Monthly Nominal Spatial Wheat Price Differentials for Selected Market Pairs in Ethiopia, (prices deflated by CPI (Dec 2011=100), 2002-2016)

Market		**Summary Statistics**						
Dependent	**Independent**	**Mean**	**Min.**	**Max.**	**Std. Dev.**	**C.V. (%)**	**Skewness**	**Kurtosis**
Addis Ababa	**Assela**	36.17	-82.0	157.0	43.1	119.16	0.51	3.66
Adama	**Assela**	26.09	-100.0	282.0	42.46	162.74	1.77	11.65
Dire Dawa	**Assela**	109.21	-61.80	366.0	85.18	78.00	0.76	2.74
Mekelle	**Assela**	69.5	-198.5	318.0	89.97	129.45	0.34	3.97
Shashemene	**Assela**	10.59	-93.0	98.0	34.16	322.57	0.38	3.73
Addis Ababa	**Bale Robe**	75.90	-168.0	214.0	57.92	76.31	-0.29	5.24
Adama	**Bale Robe**	65.82	-165.0	256.0	51.37	78.05	-0.03	6.14
Dire Dawa	**Bale Robe**	148.94	-193.8	408.0	102.02	68.50	0.25	3.59
Mekelle	**Bale Robe**	109.24	-167.0	363.0	89.10	81.56	0.16	3.88
Shashemene	**Bale Robe**	50.32	-167.0	186.0	44.36	88.16	-0.34	7.74
Addis Ababa	**Hosana**	22.98	-162.0	193.0	54.89	238.86	-0.37	5.05
Adama	**Hosana**	12.83	-164.0	229.0	51.44	400.94	0.22	6.53
Dire Dawa	**Hosana**	95.95	-160.80	379.0	92.16	96.05	0.71	3.74
Mekelle	**Hosana**	56.23	-267.5	277.0	97.27	172.99	-0.28	3.54
Shashemene	**Hosana**	-2.67	-170.0	117.44	38.35	-1436.33	-0.64	5.25
Addis Ababa	**Shashemene**	25.58	-103.0	163.0	41.95	164.00	0.02	4.89
Dire Dawa	**Shashemene**	98.62	-148.0	367.0	94.98	96.31	0.68	3.49
Adama	**Shashemene**	15.50	-134.0	249.0	47.82	308.52	0.96	7.47
Dire Dawa	**Addis Ababa**	73.03	-204.0	343.5	73.32	100.40	0.31	4.21
Adama	**Addis Ababa**	-10.08	-175.0	249.0	50.14	-497.42	0.02	7.63
Mekele	**Addis Ababa**	33.34	-146.5	298.0	89.94	269.77	0.34	3.86

Source: Computed by authors based on data from the CSA and ETBC.

Table 38: Summary Statistics of Annualized Inter-regional Price Returns to Wheat Trade between Selected Markets in Ethiopia, (price deflated by CPI (Dec 2011=100), 2002-2016

Market		Summary Statistics						
Dependent	**Independent**	**Mean**	**Min.**	**Max.**	**Std. Dev.**	**C.V. (%)**	**Skewness**	**Kurtosis**
Addis Ababa	**Assela**	0.08	-0.13	0.58	0.08	100.00	1.62	11.91
Adama	**Assela**	0.07	-0.13	0.56	0.08	114.29	2.07	13.46
Dire Dawa	**Assela**	0.23	-0.08	0.85	0.15	65.22	1.17	6.72
Mekelle	**Assela**	0.18	-0.34	0.66	0.18	100.00	0.15	3.44
Shashemene	**Assela**	0.022	-0.19	0.48	0.07	318.18	1.43	12.31
Addis Ababa	**Bale Robe**	0.200	-0.21	0.87	0.13	65.00	1.12	8.88
Adama	**Bale Robe**	0.19	-0.20	0.74	0.13	68.42	1.05	6.95
Dire Dawa	**Bale Robe**	0.35	-0.24	1.20	0.20	57.14	0.92	6.54
Mekelle	**Bale Robe**	0.30	-0.26	1.06	0.22	73.33	0.65	4.36
Shashemene	**Bale Robe**	0.14	-0.20	0.68	0.11	78.57	1.40	9.27
Addis Ababa	**Hosana**	0.07	-0.24	0.42	0.10	142.86	-0.11	4.09
Adama	**Hosana**	0.06	-0.25	0.38	0.10	166.67	0.28	3.58
Dire Dawa	**Hosana**	0.23	-0.20	0.98	0.18	78.26	0.85	5.81
Mekelle	**Hosana**	0.17	-0.44	0.71	0.20	117.65	0.01	3.34
Shashemene	**Hosana**	0.01	-0.26	0.28	0.08	800.00	0.04	3.42
Addis Ababa	**Shashemene**	0.06	-0.16	0.29	0.07	116.67	-0.15	3.95
Dire Dawa	**Shashemene**	0.21	-0.20	0.79	0.15	71.43	0.95	6.63
Adama	**Shashemene**	0.05	-0.17	0.43	0.08	160.00	0.42	5.26
Dire Dawa	**Addis Ababa**	0.15	-0.27	0.71	0.13	86.67	0.71	6.43
Adama	**Addis Ababa**	-0.02	-0.25	0.43	0.08	-400.00	0.48	9.48
Mekele	**Addis Ababa**	0.09	-0.26	0.51	0.15	166.67	0.16	3.03

Source: Computed by authors based on data from the CSA and ETBC.

5.4.2. Econometric tests results

5.4.2.1. Unit root tests

The first step in the analysis of spatial market integration is to test for the existence of unit root and stationarity of the price series[15]. The stationarity tests are carried out under three alternative hypotheses: (1) without drift or trend, (2) with drift; and (3) with drift and trend. The results indicate that all the log of monthly real price series of maize and wheat are non-stationary at the 5 percent significance level. However, the monthly differenced log of real prices of maize and wheat are stationary in all cases at the 5 percent significance level. These results indicate that the monthly log maize and wheat real prices have one unit root; to make these series stationary, differencing once is required. In other words, the percentage changes in monthly maize and wheat prices are stationary and the coefficients in the long-run equilibrium relationship can be used as a long-run elasticity of price transmission.

[15] The results are not provided here for space reasons, but can be provided by the authors upon request.

5.4.2.2. Long-run spatial equilibrium relationship in maize markets

The results of the tests for the long-run equilibrium relationship between selected wholesale maize markets is provided in table 39. The Engel-Granger Test indicates that all the market pairs identified are characterized by a long-run equilibrium relationship. The Johansen Maximum Likelihood Trace Test also indicates that there is at least one cointegration vector relationship among the maize market pairs considered. The level of integration is assessed by looking at the size of long-run elasticity of price transmission. In an efficient market, close to 100 percent price transmission is expected. In this regard, it is important to note that the Nekemet market, which is in the maize surplus producing area, is the one which is least integrated with other markets. The long-run elasticity of price transmission between Nekemet and other markets varied from 45 to 56 percent. This indicates that only 45 to 56 percent of price changes in the Nekemet market are transmitted to other markets in the long-run. The highest long-run price transmission is observed between Addis Ababa and the other markets, indicating that Addis Ababa still plays a very important role in cereal marketing in Ethiopia. Its key role may be attributable to better information and coordination, rather than providing physical logistical and transshipment services.

The linear cointegration assumption of the Engel and Granger approach is also relaxed. The threshold cointegration approach was used to test the asymmetric nature of price linkages following Enders and Siklos (2001) test. In the case of maize, the null hypothesis of cointegration is rejected in all cases at the 5 percent significance level. This confirms the Engel and Granger test results that there is long-run equilibrium relationship among the pairs of maize markets selected. However, the null hypothesis of symmetric adjustment among markets pairs is rejected in 16 of the 25 market pairs. Most maize market pairs adjust toward equilibrium when there is a positive spatial arbitrage opportunity. Based on the half-life measure, the speed of adjustment is found to be relatively fast, that is, less than 2 months in all cases. However, it is less than one month for 12 of the 25 market pairs. It is observed that less of an adjustment is made to restore the equilibrium relationship when the margin is negative. The implications are that the maize market is not responding well when the margin is decreasing, such as when producer prices are increasing due to input price increases and/or when the retail prices are decreasing.

Table 39: The Results of Tests for the Long-run Equilibrium Relationship between Selected Wholesale Maize Market Pairs in Ethiopia, 2002-2016

Market		Long-run Relationship				Engel-Granger Test on Residuals	Johansen Trace Test	
Dependent	**Independent**	β_0	β_1	**Adj. R^2**	**F-Stat.**	**ADF**	**H_0: r=0 vs H_a: r≥1**	**H_0: r≤1 vs. H_a: r≥2**
Addis Ababa	**Nekemet**	2.749	0.561***	0.630	320.36***	-4.811***	111.38**	10.36
Adama	**Nekemet**	3.240	0.479***	0.530	215.13***	-6.431***	66.29**	11.59
Dire Dawa	**Nekemet**	3.535	0.454***	0.403	128.11***	-3.216***	30.91**	5.49
Dessie	**Nekemet**	3.284	0.478***	0.511	195.57***	-4.081***	48.41**	7.49
Mekelle	**Nekemet**	3.362	0.485***	0.301	82.10***	-3.498***	49.27**	9.32
Shashemene	**Nekemet**	2.937	0.530***	0.579	259.16***	-6.933***	75.41**	13.95

Addis Ababa	**Jimma**	1.682	0.735***	0.775	650.38***	-3.941***	28.86**	9.76
Adama	**Jimma**	2.283	0.636***	0.672	386.74***	-5.097***	69.64**	12.33
Dire Dawa	**Jimma**	2.834	0.568***	0.452	156.18***	-2.997***	22.13**	8.45
Dessie	**Jimma**	2.146	0.666***	0.706	453.22***	-3.353***	27.31**	5.80
Mekelle	**Jimma**	2.036	0.704***	0.456	158.85***	-2.278***	30.92**	9.25
Shashemene	**Jimma**	2.090	0.667***	0.658	363.03***	-4.781***	31.97**	8.53
Addis Ababa	**Bahir Dar**	1.222	0.801***	0.749	562.67***	-4.900***	38.33**	8.59
Adama	**Bahir Dar**	1.934	0.685***	0.634	327.37***	-6.228***	63.29**	10.22
Dire Dawa	**Bahir Dar**	2.272	0.654***	0.487	179.41***	-3.562***	28.40**	9.13
Dessie	**Bahir Dar**	1.616	0.744***	0.719	481.24***	-3.884***	30.84**	6.49
Mekelle	**Bahir Dar**	1.369	0.805***	0.486	178.52***	-5.189***	36.05**	6.32
Shashemene	**Bahir Dar**	1.576	0.743***	0.664	372.79***	-6.042***	50.79**	12.13
Addis Ababa	**Shashemene**	0.742	0.877***	0.744	546.81***	-5.400***	47.41**	9.46
Dire Dawa	**Shashemene**	1.705	0.744***	0.524	207.91***	-3.560***	32.08**	6.15
Adama	**Shashemene**	1.143	0.812***	0.741	538.62***	-4.170***	45.68**	14.83
Dire Dawa	**Addis Ababa**	1.348	0.803***	0.631	322.86***	-4.021***	32.00**	10.21
Adama	**Addis Ababa**	1.023	0.832***	0.804	770.60***	-8.493***	62.68**	10.52
Dessie	**Addis Ababa**	0.788	0.878***	0.857	1126.67***	-3.758***	34.36**	5.34
Mekele	**Addis Ababa**	0.614	0.926***	0.551	231.83***	-5.138***	31.01**	7.65

Source: Authors' calculations based on ETBC price data for wholesale prices.

Note: ADF= Augmented Dickey-Full.

*, **, and *** denote statistical significance at the 10, 5 and 1 percent levels, respectively. The first market in the market pair is the dependent variable for the regression.

Table 40: The Results of Threshold Co-integration Tests for Selected Maize Wholesale Market Pairs in Ethiopia, 2002-2016

Market		**TAR Parameter Estimates and Half-lives in Months**				**Test for Cointegration (φ-test)**	**Test for Symmetry (F-test)**	**TAR Model Goodness of Fit**		
Dependent	**Independent**	ϱ_1	**HL 1**	ϱ_2	**HL 2**	**H0:** $\varrho_1=\varrho_2=0$	**H0:** $\varrho_1=\varrho_2$	**Adjusted R^2**	**F-Test Statistic**	**Q(12)**
Addis Ababa	**Nekemet**	-0.599***	0.8	-0.160		13.90***	4.37**	0.339	24.70***	6.78
Adama	**Nekemet**	-0.967***	0.2	0.053		36.73***	26.61***	0.362	36.16***	13.31
Dire Dawa	**Nekemet**	-0.483***	1.1	-0.021		8.13**	5.77**	0.268	14.49***	8.98
Dessie	**Nekemet**	-0.570***	0.8	0.036		14.79***	12.03***	0.278	18.80***	6.90
Mekelle	**Nekemet**	-0.709***	0.6	0.283*		16.77***	20.11***	0.435	29.32***	1.50
Shashemene	**Nekemet**	-0.778***	0.5	-0.282**	2.1	27.60***	6.07**	0.300	27.62***	8.60
Addis Ababa	**Jimma**	-0.206		-0.421***	1.3	8.34**	1.22	0.227	11.79***	5.00
Adama	**Jimma**	-0.636***	0.7	-0.160		16.61***	6.59**	0.278	18.79***	4.20
Dire Dawa	**Jimma**	-0.381***	1.4	0.005		7.21**	5.33**	0.197	10.01***	6.49
Dessie	**Jimma**	-0.221*		-0.205*		5.57	0.01	0.177	8.92***	7.62
Mekelle	**Jimma**	-0.621***	0.7	0.041		12.57***	8.90***	0.430	28.77***	8.22
Shashemene	**Jimma**	-0.463***	1.1	-0.259**	2.3	12.06***	1.33	0.196	9.97***	4.49
Addis Ababa	**Bahir Dar**	-0.183*	3.4	-0.394***	1.4	12.80***	1.65	0.172	13.87***	12.94
Adama	**Bahir Dar**	-0.653***	0.7	-0.132		23.96***	7.89***	0.245	21.15***	5.51
Dire Dawa	**Bahir Dar**	-0.254**	2.4	-0.148		6.49*	0.43	0.205	12.95***	14.27
Dessie	**Bahir Dar**	-0.289***	2.0	-0.202*		7.62**	0.25	0.247	13.06***	19.85
Mekelle	**Bahir Dar**	-0.723***	0.5	0.233		21.58***	14.42***	0.432	36.11***	2.68
Shashemene	**Bahir Dar**	-0.421***	1.3	-0.313***	1.8	18.29***	0.39	0.160	12.81***	26.69***
Addis Ababa	**Shashemene**	-0.510***	1.0	-0.182*		16.18***	3.04*	0.183	14.92***	18.17
Dire Dawa	**Shashemene**	-0.426***	1.2	-0.042		8.91***	4.95**	0.209	10.72***	18.91
Adama	**Shashemene**	-0.538***	0.9	-0.127		11.06***	4.49**	0.346	25.46***	10.16

Dire Dawa	**Addis Ababa**	-0.394***	1.4	-0.084		10.04***	3.75*	0.232	14.99***	8.27
Adama	**Addis Ababa**	-0.934***	0.3	-0.365**	1.5	41.18***	7.93***	0.360	35.95***	11.49
Dessie	**Addis Ababa**	-0.494***	1.0	-0.115		9.28***	4.12**	0.346	17.15***	6.26
Mekele	**Addis Ababa**	-0.715***	0.6	-0.128		18.51***	9.54***	0.448	38.58***	6.85

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: TAR= Threshhold Auto Regressive.
*, **, and *** denote statistical significance at the 10, 5 and 1 levels, respectively.

5.4.2.3. The short-run dynamic relationship between selected wholesale maize markets

The results of the estimated short-run dynamic relationship between spatially-integrated maize markets based on the Threshold Vector Error Correction Model (TVECM) given in Equations (27) and Equation (28) are provided in table 41. The diagnostics of the TVECM are provided in the last four columns of table 41. The key results presented are the parameter estimates on the dis-equilibrium errors and the test statistics of pairwise Granger long-run and short-run causality tests. The positive shock is when the observed spatial price differential between the markets is higher than the long-run spatial price differential. The negative shock is when the observed spatial price differential is less than the long-run spatial price differential. The parameter estimates regarding the dis-equilibrium error provide a measure of how the price in one market adjusts to one-period, lagged equilibrium errors under the two regimes. The test on long-run causality is the test for the joint coefficient restriction on lagged disequilibrium errors, whereas the short-run causality is based on the tests of coefficient restrictions on the coefficients of lagged other prices.

The results show that the coefficient on the positive shock regime is negative and significant in most of the markets. This indicates that the maize market reacts to spatial arbitrage opportunities and price adjustments because competition restores the long-run spatial-equilibrium relationships. It is important to note that in some markets, up to 80 percent of the past positive spatial price differentials will be removed in a one-month period. The maize markets respond mostly when there is a positive spatial margin in the markets.

The null hypothesis of long-run causality is rejected in 25 of the 36 cases, indicating that the markets adjust toward long-run equilibrium — at least by adjusting their prices when the spatial price differential is positive or negative. However, the significant causal relationship is observed in only less than half of the cases and it is observed only in one direction. In most cases, the direction of causality is from the deficit to surplus markets. This indicates the importance of deficit markets in price discovery. There is also a uni-directional causality from Addis Ababa to the major grain markets, such as Adama, Dire Dawa, Mekelle, and Shashemene. The overall pattern shows the importance of Addis Ababa in maize price discovery. This may be due to the historical presence of a strong network of brokers in Addis Ababa who are very knowledgeable about the price, supply, and demand situations throughout the country.

Table 41: Short-run Dynamic Relationships between Selected Wholesale Maize Markets in Ethiopia, 2002-2016

Market		Parameter on Disequilibrium Error		Pairwise Granger Causality Tests (F-Stat.)		Diagnostics of TVECM			
Dependent	**Independent**	**Positive Shock**	**Negative Shock**	**Long-Run**	**Short-Run**	**Adj. R^2**	**F-Stat.**	**Q(6)**	**Q(12)**
Addis Ababa	**Nekemet**	-0.084	-0.229*	2.84*	0.03	0.012	1.37	2.871	15.029
Nekemet	**Addis Ababa**	0.793***	0.164	8.17***	0.62	0.306	14.60***	4.465	5.502
Adama	**Nekemet**	-0.78***	0.108	14.33***	6.27**.	0.140	8.60***	3.877	11.002
Nekemet	**Adama**	0.754***	0.220	8.81***	1.87	0.239	15.67***	5.344	6.560
Dire Dawa	**Nekemet**	-0.282**	-0.082	4.45**	0.37	0.115	4.00***	3.805	14.325
Nekemet	**Dire Dawa**	0.359	-0.024	1.42	1.32	0.233	7.97**	1.246	3.983
Dessie	**Nekemet**	-0.099	-0.047	1.03	0.00	0.0170	1.40	5.244	21.637**
Nekemet	**Dessie**	0.696**	-0.012	5.06***	0.14	0.270	9.53**	1.116	2.503
Mekelle	**Nekemet**	-0.578***	0.246	12.03**	0.49	0.396	16.07	0.519	4.107
Nekemet	**Mekele**	0.282	-0.072	2.18	4.43***	0.240	8.84***	0.328	2.899
Shashemene	**Nekemet**	-0.267**	-0.280**	8.88**	1.181	0.071	4.53***	8.833	17.637
Nekemet	**Shashemene**	0.729***	0.323	9.38***	0.05	0.252	16.66***	6.245	7.533
Addis Ababa	**Jimma**	-0.398***	0.046	4.66**	1.01	0.077	2.91***	7.089	12.437
Jimma	**Addis Ababa**	-0.275	0.690***	7.62***	0.63	0.117	4.04***	4.651	21.302
Adama	**Jimma**	-0.851***	0.194	22.08***	0.08	0.210	9.22	4.254	7.719
Jimma	**Adama**	-0.304**	0.544***	7.93***	6.31***	0.143	6.16***	12.954**	26.568***
Dire Dawa	**Jimma**	-0.375***	-0.008	6.86***	4.31***	0.204	6.91	3.717	14.527
Jimma	**Dire Dawa**	-0.015	0.013	0.01	2.00	0.053	2.29**	0.972	19.137
Dessie	**Jimma**	-0.270**	0.114	2.22	2.45*	0.085	3.14***	3.265	12.719
Jimma	**Dessie**	0.032	0.452	5.13***	4.91***	0.164	5.52***	4.069	21.830
Mekelle	**Jimma**	-0.735***	0.352**	18.10***	0.91	0.458	20.46***	0.999	4.121
Jimma	**Mekele**	-0.159*	0.434***	7.71***	2.22*	0.126	4.31***	2.504	15.153
Shashemene	**Jimma**	-0.484***	-0.138	8.98***	0.67	0.075	2.86***	5.280	11.280
Jimma	**Shashemene**	-0.029	0.201	1.12	5.86***	0.166	5.57***	2.698	21.881**
Addis Ababa	**Bahir Dar**	-0.160	-0.139	2.67*	1.97	0.029	2.39*	3.094	11.122
Bahir Dar	**Addis Ababa**	0.091*	0.306***	5.32***	0.39	0.071	4.56***	1.898	4.711
Adama	**Bahir Dar**	-0.696***	0.103	16.28***	0.04	0.158	9.72***	3.033	8.999
Bahir Dar	**Adama**	0.058	0.360***	6.23***	0.15	0.074	4.72***	1.321	8.376
Dire Dawa	**Bahir Dar**	-0.287***	-0.081	3.63**	8.84***	0.141	6.07***	7.973	12.242
Bahir Dar	**Dire Dawa**	0.085	0.057	1.01	0.72	0.021	1.66	1.793	3.247
Dessie	**Bahir Dar**	-0.187*	0.013	1.44	2.87**	0.069	2.70***	4.870	22.57**
Bahir Dar	**Dessie**	0.144	0.289**	4.10**	1.52	0.116	4.03***	0.123	6.823
Mekelle	**Bahir Dar**	-0.687***	0.467**	19.98***	1.05	0.439	25.14***	1.330	4.02
Bahir Dar	**Mekelle**	0.025	0.310***	4.71**	7.89***	0.140	6.02***	2.225	6.578
Shashemene	**Bahir Dar**	-0.39***	-0.187*	8.71***	1.92	0.070	4.53***	6.899	12.403
Bahir Dar	**Shashemene**	0.041	0.194**	2.83*	2.40	0.063	4.12***	1.432	6.088

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: TVECM= Threshold Vector Error Correction Model.
*, **, and *** denote statistical significance at the 10, 5 and 1 percent levels, respectively.

Table 41(Cont.): Short-run Dynamic Price Relationships between Selected Wholesale Maize Markets in Ethiopia, 2002-2016

Market		Parameter on Disequilibrium Error		Pairwise Granger Causality Tests (F-Stat.)		Diagnostics of TVECM			
Dependent	Independent	Positive Shock	Negative Shock	Long-Run	Short-Run	Adj. R^2	F-Stat.	Q(6)	Q(12)
Shashemene	Addis Ababa	0.190	0.158	2.40*	0.00	0.008	1.36	8.233	17.206
Addis Ababa	Shashemene	-0.342***	-0.043	5.55***	3.57***	0.098	6.06	4.918	8.471
Dire Dawa	Addis Ababa	-0.361***	-0.038	6.48***	4.73***	0.236	8.11***	3.678	10.296
Addis Ababa	Dire Dawa	0.022	0.020	0.05	1.16	-0.004	0.91	7.152	16.962
Adama	Addis Ababa	-0.599***	0.094	8.18***	5.88***	0.254	11.52	5.518	10.072
Addis Ababa	Adama	-0.084	0.267*	1.54	0.75	0.001	11.05	6.713	14.948
Dire Dawa	Addis Ababa	-0.308***	-0.158	6.08***	4.48**	0.203	8.86***	3.635	11.065
Addis Ababa	Dire Dawa	0.100	-0.100	0.87	3.15**	0.016	1.49	3.640	15.041
Adama	Addis Ababa	-0.958***	0.108	24.20***	4.02**	0.215	13.71***	3.12	7.795
Addis Ababa	Adama	-0.032	0.543***	5.84***	1.75	0.072	4.62***	4.451	10.852
Dessie	Addis Ababa	-0.131	-0.001	0.33	1.25	0.034	1.65*	4.465	16.625
Addis Ababa	Dessie	0.367**	0.139	3.02*	2.74**	0.138	3.93	2.292	8.196
Mekele	Addis Ababa	-0.706***	0.445**	18.22***	9.05***	0.502	32.10***	3.740	10.888
Addis Ababa	Mekele	-0.042	0.333**	4.13	1.55	0.033	2.07	2.402	9.244

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: TVECM= Threshold Vector Error Correction Model.
*, **, and *** denote statistical significance at the 10%, 5% and 1%, respectively.

5.4.2.4. The long-run spatial equilibrium relationship in wheat markets

The results of tests to determine the long-run equilibrium relationship between selected wholesale wheat markets are provided in table 42. The Engel-Granger Test indicates that all the market pairs identified are characterized by a long-run equilibrium relationship. The Johansen Maximum Likelihood Trace Test also indicates that there is at least one cointegration vector relationship among the wheat market pairs considered. The long-run elasticity of price transmission between markets varied from 17 to 95 percent. This indicates that only 17 to 95 percent of price changes in one market are transmitted to other markets in the long-run.

The results of the threshold cointegration test are presented in table 43. The null hypothesis of cointegration is also rejected in all cases at the 5 percent significance level. This confirms the Engel and Granger Test results that there is long-run equilibrium relationship among the pairs of wheat markets selected. The null hypothesis of symmetric adjustment among markets pairs is rejected in 10 of the 21 market pairs. All wheat market pairs adjusted toward equilibrium when there is a positive spatial arbitrage opportunity. Based on the half-life, the speed of adjustment is found to be fast in less than 6 months in all cases, but less than one month for 13 of the market pairs. However, it is observed that less of an adjustment is made to restore the equilibrium relationship when the margin is negative.

5.4.2.5. The short-run dynamic relationship between selected wholesale wheat markets

The results of the estimated short-run dynamic relationship between spatially-integrated markets based on the TVECM is provided in Equations (27) and Equation (28), and presented in table 44. The results show that the coefficient on the positive shock regime is negative and significant in 14 of the 30 markets. This indicates that the wheat spatial market reacts to the spatial arbitrage opportunities and price adjustments because competition restores the long-run spatial-equilibrium relationships. It is important to note that price adjustments in wheat markets are lower than those of maize markets. This may be because the government is more heavily intervening in the wheat markets.

The null hypothesis of long-run causality is rejected in 14 of the 30 cases, indicating that the markets adjust toward long-run equilibrium — at least by adjusting their prices when the spatial price differential is positive or negative. However, in the short run, a significant causal relationship is observed only in four of the cases and in only one direction. There is a limited short-run dynamic in the wheat as compared to the maize market. In most cases, the direction of causality is from the deficit markets to the wheat surplus markets. This indicates the importance of deficit markets in price discovery. There is also a uni-directional causality from Addis Ababa to the major grain markets such as Adama, Dire Dawa, Hosana and Mekelle. The overall pattern shows the importance of Dire Dawa in wheat price discovery.

Table 42: Results of the Tests for Long-run Equilibrium Relationships between Selected Wholesale Wheat Market Pairs in Ethiopia, 2002-2016

Market		**Long-run Relationship**				**Engel-Granger Test on Residuals**	**Johansen Trace Test**	
Dependent	**Independent**	β_0	β_1	**Adj. R^2**	**F-Stat.**	**ADF**	**H_0: r=0 vs H_a: r≥1**	**H_0: r≤1 vs. H_a: r≥2**
Addis Ababa	**Assela**	1.942***	0.712***	0.809	796.38***	-5.897***	57.755	7.278
Adama	**Assela**	1.719***	0.745***	0.773	642.27***	-4.112***	25.525	6.221
Dire Dawa	**Assela**	4.221***	0.384***	0.220	54.28***	-3.323***	21.038	4.996
Mekelle	**Assela**	4.927***	0.265***	0.089	19.310***	-3.456***	25.502	6.356
Shashemene	**Assela**	1.080***	0.836***	0.839	977.47***	-6.487***	71.464	9.134
Addis Ababa	**Bale Robe**	3.032***	0.553***	0.661	367.67***	-4.853***	38.698	8.289
Adama	**Bale Robe**	2.852***	0.579***	0.634	326.78***	-1.861***	38.237	7.274
Dire Dawa	**Bale Robe**	5.196***	0.237***	0.112	24.61***	-2.859***	18.917	5.433
Mekelle	**Bale Robe**	5.572***	0.168***	0.046	10.07***	-3.107***	23.741	7.563
Shashemene	**Bale Robe**	2.168***	0.680***	0.751	568.99***	-5.615***	47.755	8.019
Addis Ababa	**Hosana**	2.622***	0.606***	0.763	608.06***	-4.428***	37.263	7.204
Adama	**Hosana**	2.393***	0.639***	0.743	544.84***	-2.682**	21.828	5.712
Dire Dawa	**Hosana**	4.917***	0.276***	0.147	33.33***	-3.031***	19.065	4.940
Mekelle	**Hosana**	5.200***	0.223***	0.081	17.60***	-3.469***	26.712	5.654
Shashemene	**Hosana**	1.715***	0.737***	0.849	1060.05***	-6.400***	50.999	8.681
Addis Ababa	**Shashemene**	1.432***	0.788***	0.825	890.48***	-6.074***	54.236	6.670
Dire Dawa	**Shashemene**	3.744***	0.456***	0.261	67.25***	-3.289***	46.663	8.607
Adama	**Shashemene**	1.184***	0.824***	0.790	708.07***	-6.979***	67.190	6.116
Dire Dawa	**Addis Ababa**	2.149***	0.589***	0.328	92.71***	-3.519***	22.325	5.920
Adama	**Addis Ababa**	0.312***	0.950***	0.789	703.23***	-6.61***	49.697	7.062
Mekele	**Addis Ababa**	3.557***	0.471***	0.181	42.51***	-3.687***	24.798	5.122

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: ADF= Augmented Dickey-Full.
*, **, and *** denote statistical significance at the 10, 5 and 1 levels, respectively. The first market in the market pair is the dependent variable for the regression.

Table 43: The Results of Threshold Co-integration Tests for Selected Wheat Wholesale Market Pairs in Ethiopia, 2002-2016

Market		TAR Parameter Estimates and Half-lives in Months				Test for Cointegration (for φ-test)	Test for Symmetry (F-test)	TAR Model Goodness of Fit		
Dependent	Independent	ϱ_1	HL 1	ϱ_2	HL 2	H_0: $\varrho_1 = \varrho_2 = 0$	H_0: $\varrho_1 = \varrho_2$	Adjusted R^2	F-Test Statistic	Q(12)
Addis Ababa	**Assela**	-0.536***	0.9	-0.146		20.24***	5.11	0.217	18.24***	
Adama		-0.580***	0.8	-0.033		14.37***	11.02	0.302	16.90***	
Dire Dawa		-0.266***	2.2	-0.104		5.92	0.83	0.222	11.50***	
Mekelle		-0.114***	5.7	-0.135*		5.93	0.04	0.061	5.04***	
Shashemene		-0.663***	0.6	-0.230		23.69***	4.69	0.266	23.52***	
Addis Ababa	**Bale Robe**	-0.378***	1.5	-0.091		14.00***	4.18	0.120	9.49***	
Adama		-0.290***	2.0	0.017		4.09	4.74	0.174	6.46***	
Dire Dawa		-0.246***	2.5	-0.033		4.92	1.71	0.185	9.34***	
Mekelle		-0.142**	4.5	-0.060		5.06	0.57	0.053	4.44***	
Shashemene		-0.414***	1.3	-0.295**	2.0	15.86***	0.54	0.166	13.32***	
Addis Ababa	**Hosana**	-0.324***	1.8	-0.168*		10.35***	1.18	0.142	8.67***	
Adama		-0.493***	1.0	0.061		8.93***	10.38	0.264	11.96***	
Dire Dawa		-0.266***	2.2	-0.049		5.40	1.64	0.217	11.26***	
Mekelle		-0.407***	1.3	-0.431***	1.2	20.26***	0.02	0.182	14.81***	
Shashemene		-0.137***	4.7	-0.105		5.99*	0.08	0.056	4.68***	
Addis Ababa	**Shashemene**	-0.521***	0.9	-0.294***	2.0	19.22***	1.62	0.196	16.14***	
Dire Dawa		-0.323***	1.8	-0.194		11.22***	0.56	0.206	17.06***	
Adama		-0.872***	0.3	-0.197**	3.2	32.17	12.79	0.289	26.16***	
Dire Dawa	**Addis Ababa**	-0.281***	2.1	-0.155		6.42*	0.51	0.260	13.97***	
Adama		-0.637***	0.7	-0.227**	2.7	26.13***	6.77	0.212	17.73***	
Mekele		-0.133***	4.9	-0.147*		6.74*	0.01	0.076	6.11***	

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: HL=Half-Life; TAR= Threshold Auto Regressive
*, **, and *** denote statistical significance at the 10, 5 and 1 percent levels, respectively.

Table 44: Short-run dynamic relationships between selected wholesale wheat markets in Ethiopia, 2002-2016

Market		Parameter on disequilibrium error		Pairwise Granger Causality Tests (F-Stat.)		Diagnostics of TVECM			
Dependent	Independent	Positive Shock	Negative Shock	LR	SR	Adj. R^2	F-Stat.	Q(6)	Q(12)
Addis Ababa	**Assela**	-0.191**	-0.241**	4.56**	0.10	0.036	2.74**	3.931	7.522
Assela	**Addis Ababa**	0.466***	-0.082	5.69***	1.12	0.092	5.71***	5.421	8.056
Adama	**Assela**	-0.435***	-0.029	6.13	0.21	0.093	3.35***	3.486	6.498
Assela	**Adama**	0.173	0.016	0.78	3.09**	0.113	3.94***	1.853	3.407
Dire Dawa	**Assela**	-0.212**	-0.157	4.60**	1.95	0.212	7.18***	2.025	6.388
Assela	**Dire Dawa**	0.081	-0.066	0.54	1.93	0.039	1.93*	3.058	6.323
Mekelle	**Assela**	-0.118**	-0.118	5.08***	0.92	0.045	3.22**	6.372	15.050
Assela	**Mekelle**	-0.021	0.063	0.28	5.08**	0.038	2.82**	6.921	9.850
Shashemene	**Assela**	-0.287**	-0.423***	9.17***	0.09	0.101	6.25***	1.947	18.456
Assela	**Shashemene**	0.375**	0.160	2.98*	0.43	0.044	3.15***	3.906	7.335
Addis Ababa	**Bale Robe**	-0.115	-0.089	2.08	0.71	0.017	1.82***	4.356	6.261
Bale Robe	**Addis Ababa**	0.493***	0.029	8.02***	1.80	0.062	4.08***	4.341	8.172

Adama	**Bale Robe**	-0.156	-0.000	0.97	2.03	0.076	2.25**	1.230	3.997
Bale Robe	**Adama**	0.269*	0.040	1.86	0.60	0.040	1.63*	1.088	4.495
Dire Dawa	**Bale Robe**	-0.222**	-0.053	3.97**	1.64	0.197	6.62***	2.354	7.957
Bale Robe	**Dire Dawa**	0.080	-0.051	0.47	3.79**	0.048	2.15**	2.049	4.855
Mekelle	**Bale Robe**	-0.150	-0.052	4.99***	1.54	0.048	3.35**	5.502	13.018
Bale Robe	**Mekelle**	-0.014	0.015	0.02	0.56	-0.017	0.22	6.399	11.992
Shashemene	**Bale Robe**	-0.159	-0.244**	4.71**	1.24	0.055	3.72***	1.465	14.334
Bale Robe	**Shashemene**	0.377***	0.077	5.02***	0.03	0.039	2.88**	3.510	7.418
Addis Ababa	**Hosana**	-0.324***	0.017	4.43	0.16	0.043	2.38**	3.406	6.620
Hosana	**Addis Ababa**	0.004	0.321**	2.83*	0.16	0.019	1.59	2.486	17.816
Adama	**Hosana**	-0.505	0.165	6.91***	1.30	0.123	3.56***	3.145	6.653
Hosana	**Adama**	0.013	0.185	1.00	1.27	0.037	1.70	0.058	14.237
Dire Dawa	**Hosana**	-0.221**	-0.094	4.36**	2.27*	0.213	7.23***	1.665	5.656
Hosana	**Dire Dawa**	0.113	-0.097	1.40	3.03**	0.027	1.64	2.410	16.816
Mekelle	**Hosana**	-0.140**	-0.093	5.42***	0.80	0.048	3.39**	6.578	14.637
Hosana	**Mekelle**	-0.033	0.058	0.31	1.42	-0.010	0.54	2.284	16.475
Shashemene	**Hosana**	-0.397***	-0.278**	8.68***	2.35*	0.067	4.34**	3.077	17.655
Hosana	**Shashemene**	0.020	0.197	0.85	1.78	0.011	1.51	2.747	15.204

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: LR= long-run; SR=short-run; TVECM= Threshold Vector Error Correction Model.
*, **, and *** denote statistical significance at the 10, 5 and 1 levels, respectively.

Table 44 (Cont): Short-run Dynamic Relationships between Selected Wholesale Wheat Markets in Ethiopia, 2002-2016

Market		**Parameter on Disequilibrium Error**		**Pairwise Granger Causality Tests (F-Stat.)**		**Diagnostics of TVECM**			
Dependent	**Independent**	**Positive Shock**	**Negative Shock**	**LR**	**SR**	**Adj. R^2**	**F-Stat.**	**Q(6)**	**Q(12)**
Addis Ababa	**Shashemene**	-0.280**	-0.100	3.60**	0.09	0.032	2.56**	3.190	6.783
Shashemene	**Addis Ababa**	0.302**	0.262*	5.14***	1.30	0.071	4.56***	2.783	17.325
Dire Dawa	**Shashemene**	-0.313***	-0.211*	10.61***	1.00	0.191	11.99***	8.181	16.033
Shashemene	**Dire Dawa**	0.022	-0.037	0.11	0.020	-0.020	0.07	2.739	15.133
Adama	**Shashemene**	-0.662***	0.003	13.28***	1.12	0.112	6.85***	6.940	12.071
Shashemene	**Adama**	0.253*	0.238*	5.06***	2.20	0.093	5.79***	2.559	17.364
Dire Dawa	**Addis Ababa**	-0.242**	-0.189	5.38***	3.15**	0.252	8.74***	2.415	6.453
Addis Ababa	**Dire Dawa**	0.065	-0.074	0.85	1.30	0.016	1.37	1.906	3.234
Adama	**Addis Ababa**	-0.619***	-0.060	14.14***	1.57	0.118	7.22***	7.664	14.750
Addis Ababa	**Adama**	0.021	0.175*	1.78	0.03	0.005	1.23	5.726	10.059
Mekele	**Addis Ababa**	-0.116*	-0.199*	6.03***	1.60	0.062	4.07***	4.671	11.330
Addis Ababa	**Mekele**	0.044	-0.034	0.42	0.93	-0.004	0.81	5.473	8.773

Source: Authors' calculations based on ETBC price data for wholesale prices.
Note: LR= long-run; SR=short-run; TVECM= Threshold Vector Error Correction Model.
*, **, and *** denote statistical significance at the 10%, 5% and 1%, respectively

6. Conclusions and policy implications

6.1 Conclusions

The temporal and spatial market performance of the maize and wheat markets in Ethiopia are analyzed based on a rapid market appraisal, as well as on statistical and econometric analyses of historical monthly prices (2001-2016) collected for different markets and market levels.

The overall results indicate that the maize and wheat markets are well integrated in the long run, but that price transmission among some markets is inefficient. There is a significant long-run spatial equilibrium relationship between maize and wheat markets. However, there is incomplete price transmission and asymmetric price adjustments. There are excessive upward and downward movements in the spatial gross marketing margins. Thus, the spatial margins are very volatile, making inter-regional grain trade risky.

Although markets are integrated in the long run, there is significant unpredictability in wheat and maize prices, implying a high risk for the value chain actors. There are slight upward movements in maize and wheat prices at all levels, however there is significant unpredictability in maize and wheat prices. This makes spot market temporal and spatial arbitrages very risky. For example, in the case of maize markets about 6 to 33 percent (at the producer level), 0 to 72 percent (at the wholesale level) and 2 to 45 percent (at the retail level) of the overall maize price fluctuations are explained by unpredictable, random price movements. The corresponding figures in the case of wheat are 0 to 27 percent (at the producer level), 1 to 27 percent (at the wholesale level) and 0 to 46 (at the retail level).

In addition, maize and wheat price volatility have been increasing more in recent years. High and increasing volatility limits maize and wheat market transactions as market actors avoid risks. This decreases the availability of maize and wheat both temporally and spatially. Furthermore, the high risk (given the non-existence of efficient mechanisms to insure price risk) would discourage necessary investments in maize and wheat production, as well as along the value chains. This presents a significant bottleneck to the agricultural transformation agenda to improve smallholder adoption of modern agricultural inputs and increase commercialization.

The incentives for the private sector to invest in storage facilities are limited. There is significant seasonality for maize and wheat prices in different markets and at different value chain nodes, which presents business opportunities for storage. However, the implied storage periods required between the seasonal low and high appear to be very long (5 to 10 months) for both maize and wheat. Furthermore, holding maize and wheat stocks does not provide sufficient incentives, given their very low mean and highly volatile monthly returns. There are excessive downward and upward movements in actual prices and returns which are not explained by the costs of storage in several markets and at different market levels.

6.2 Policy Implications

Implications for Policy Options and Actions

The findings and conclusions of the study support the following proposed policy options and actions:

1. *Reduce price unpredictability through clearer policy directions and transparent information*. An important priority area is the necessity of improving the spatial efficiency of cereal marketing and private sector investment in grain storage. This would help to reduce price unpredictability and volatility. Under the current conditions, there are few incentives to hold wheat and maize for storage. Likewise, there is not much incentive for the private sector to invest in storage facilities. Greater transparency can help to reduce uncertainties faced by value-chain actors. In particular, greater transparency is required with regard to the level of government domestic grain procurement; pricing and distribution; grain imports; the timing and release of imported grain in the market; the price at which it will be sold; and information on the overall level of stock in the country. This will in turn help reduce price volatility in the short term — and increase private sector investment in cereal markets. Overall, predictable government policies that promote the participation of the private sector in grain trade and storage will generally decrease price volatility.

2. *Establish an agricultural market information system*. Asymmetric price and production information and a lack of clarity about price discovery significantly contributes to price and market uncertainties. It is important to improve the reliability and accuracy of data so that the government and key relevant institutions can make better policies and procurement decisions. There is a need also to identify an institution at which a market information system can be established to regularly collect and analyze production and price data, and improve data reliability, timeliness and frequency. Before such a MIS is established, though, a detailed assessment will be required to assess its value to key stakeholders, as well as their willingness to fund and sustain such a system. This could entail establishing a new institution or capacity building at existing institutions engaged in the provision of MIS, such as the CSA or ETBC.

3. *Reform the tax policy based on grain stocks alone.* Arbitrary tax enforcement based on grain stocks held by traders and wholesale distributors at a given time — and not considering their turnover — creates huge disincentives for traders and wholesalers to engage in temporal arbitrage. These are important value chain actors in grain storage and distribution, linking producers to the markets, thereby enabling the movement of grain from surplus producing areas to deficit areas. The tax should not be based on output alone. Rather, it should be clearly enforced in a consistent manner.

4. *Reassess the real needs for storage and the different types of storage technologies required at various market levels.* This includes clearly identifying the objective of storage at the farm, cooperative,

union, processor, wholesaler and retailer levels. The objective for storage facilities could be for aggregation or arbitrage, or simply to minimize post-harvest losses. Each cause would have different implications on the required capacity and investments. For example, improved access to low-cost hermetic bags at the household level can greatly minimize losses. If the cooperative's objective is simply to aggregate or bulk and sell quickly, then other technologies, such as this large volume storage hermetic cocoons or temporary sheds may be required. This may be the case for some primary cooperatives. However, if it is for storing large volumes for arbitrage which would require longer holding periods, then building a bigger storage facility with good aeration and higher standards would be required. This is often the case for cooperative unions.

5. *Encourage independent certification of grain quality and enforce grain standards*. This would help to: encourage producers to increase the quality of the grain that they sell to millers and other buyers; minimize cheating in the grain marketing; reward the adoption of and investments in quality enhancing technologies and best practices; and strengthen food safety. In addition, investments in post-harvest conditioning to make maize and wheat storable commodities increases the overall quality of the grain being marketed. As such, it can also create job opportunities for youth in the rural sector.

6. *Improve the capacity of primary cooperatives to become effective aggregators for the cooperative unions*. Cooperatives remain a key vehicle to linking smallholder farmers to processors and other market buyers. Turning primary cooperatives into effective aggregators for cooperative unions and increasing the marketing potential requires strengthening the managerial capacity of cooperatives. This would include building their agribusiness leadership skills, hiring professional managers, and fostering trust with their members.

7. *Reconsider the timing and the scaling-up process of public investments in the cooperative warehouse facilities.* Considering points (4) and (6), and given the negligible amount of marketed output being sold by the primary cooperatives, the lack of trust, and the current low capacity of cooperatives' marketing function, building more warehouses will not guarantee a substantial increase in farmers' sales and/or the storing of grain through primary cooperatives.

8. *Improve the coordination and planning among grain importing entities to utilize the existing public storage system optimally.* There is a need to improve coordination and planning among the key entities involved in grain importation to increase the swapping of public warehouses facilities and synchronize importation of grain in the country to avoid the simultaneous arrival of large quantities of grain into the local market.

9. *Increasing the proportion of cash-based transfers for PSNP beneficiaries and for aid recipients by other organizations in responding to food emergency situations should be taken cautiously considering the specific local conditions.* First, the results indicate that maize and wheat markets are spatially

integrated in the long-run, which supports the movement of grain from surplus to deficit areas. Although this result would generally support increasing cash transfers by the PSNP program, the long-run elasticity of price transmission estimates indicate that the long-run price transmissions are less than complete for some markets and the price transmission is asymmetric. Furthermore, there are limited short-term price dynamics among the spatially-linked markets. This indicates inefficiencies in wheat and maize price transmission — despite the wheat and maize markets being integrated.

Second, wheat wholesale and retail prices are highly volatile, with a large component of the volatility being unpredictable in some markets at retail, wholesale and producer levels. The price analyses indicate that there is limited commercial incentive for the private sector to engage in grain storage. The implication is that the complete reliance on markets and the private sector to respond effectively under emergency situations is not advisable. There needs to a targeted approach, accompanied by careful and close monitoring. Ideally this could entail using more cash responses during the harvest time, but in-kind food transfers during the lean period. But there are significant operational constraints for PSNP to implement such time sensitive responses. Given the weak storage system under the current market conditions, relying heavily on the market to respond to emergency situations is also not advisable.

Third, the high unpredictability of price fluctuations imply that the purchasing power of cash recipients is also uncertain. The complete adoption of cash transfer as the sole mode of payment assumes that products are available in the market and that the private sector and the market have adequate capacity to respond. Therefore, in the short-run it is advisable to maintain a reasonable mix of in-kind transfers and cash transfers in the PSNP. If cash is used in deficit areas, one would need a reliable trade network, storage capability, a market information system, and infrastructure based on regular market and price monitoring. An assessment to make timely adjustments in the amount of cash transfers would also be required. Further price and market analysis at the local level would be required for the PSNP and other humanitarian entities to inform them about where and when to use cash or food transfers.

Lastly, to provide clearer and location-specific evidence-based guidance for the PSNP program on cash vs food transfers and guidelines on policy negotiations, further analysis regarding food availability and prices using more local specific data combined with LSMS data to showing market position of households, and focusing on the lowland region where the PSNP program is struggling to implement cash-based transfers, are required, In addition, it is also important to conduct further analysis on the extent the random component of price volatility is related to policy, procurement, lack of market information and climatic shocks, and to consider other analyses[16] that point more toward moving for cash transfers.

V. Areas for Further Research

The following findings of the paper require further research before clear recommendations can be made:

(1) Evaluate how much subsidized wheat is sold in the open market, and how this affects the competitiveness of the local industries. This would also require finding ways to improve the effective targeting of assistance to poor households, as well as better targeting of the locations requiring food or cash assistance.

(2) The government may wish to consider and evaluate the impact of the wheat subsidy on producers and the local market. There is a need to evaluate the level and extent of market distortions created by the wheat subsidy to reform its targeting and cost effectiveness. This would require a detailed analysis because such a distortion makes local prices relatively high, thereby affecting the industry's competitiveness. A related question is: Who is the government really subsidizing? Poor and rich consumers alike, as well as foreign producers?

(3) Consider producer price support interventions. This will require detailed, regular production cost data (enterprise budgeting) collection. However, it can greatly help the government to know when it is necessary to intervene in the market, and at what price. It can also help to inform farmers ahead of time about the expected minimum price so that they can plan their production accordingly.

(4) Ways of strengthening the capacity, governance and the effective management of cooperatives. Primary and union cooperatives present a useful platform to aggregate from smallholder producers, who as a whole, dominate total cereal production in Ethiopia. Improving the capacity of cooperatives to become effective aggregators — and increasing smallholder market participation — is essential to achieving agricultural transformation and commercialization.

(5) Is the export ban on maize trade still necessary? When the price of maize is depressed due to over-production, exports might be one option to overcome this problem, along with other considerations pertaining to the government's price support options.

[16] Ruth Hill and Habtamu Fuje (2017), *What is the impact of drought on prices? Evidence from Ethiopia.*

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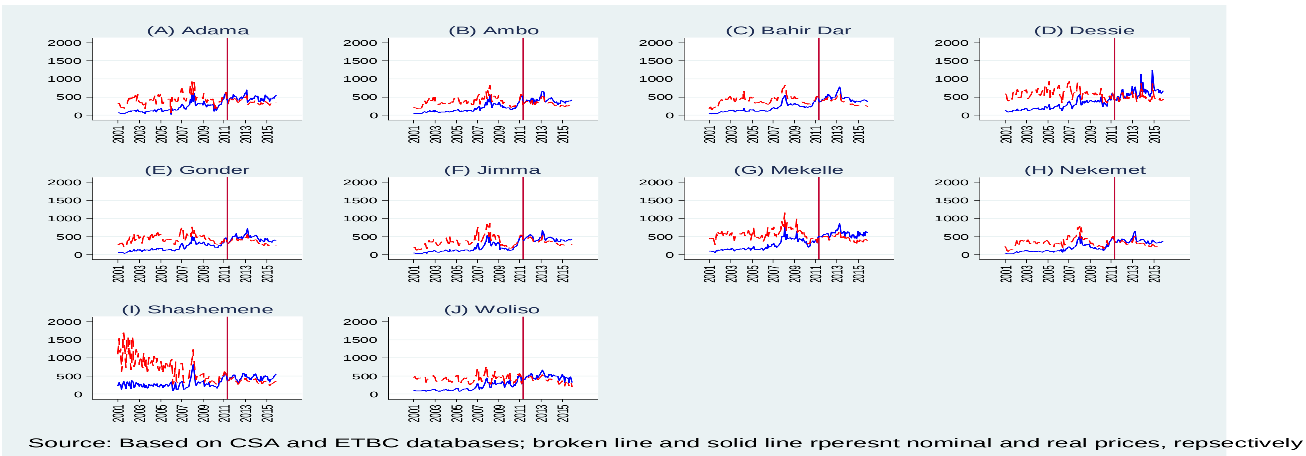
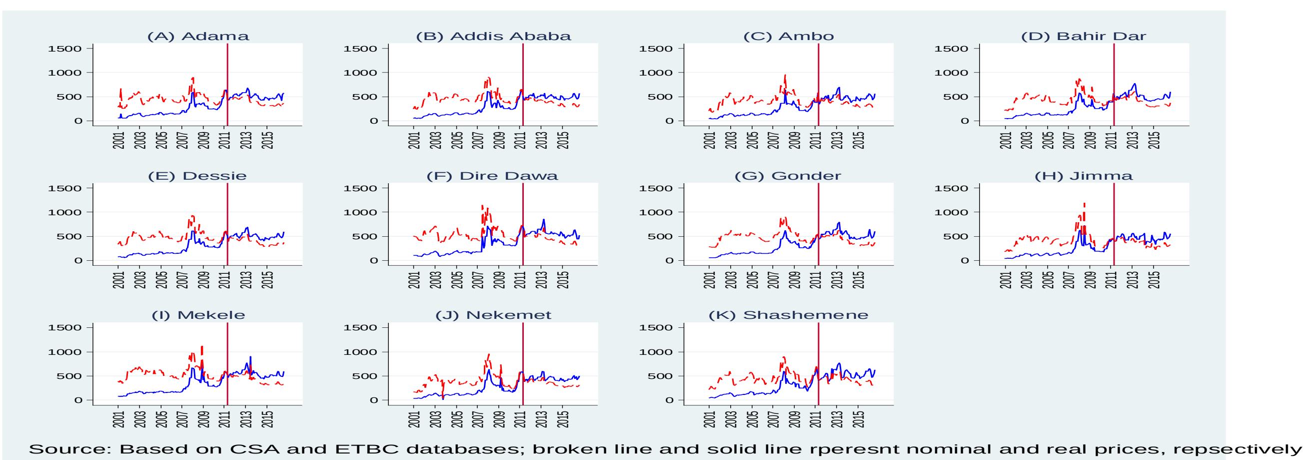
Annex 1 **Evolution of nominal and real maize prices (December 2011=100) for selected markets in Ethiopia, 2001 to 2017**

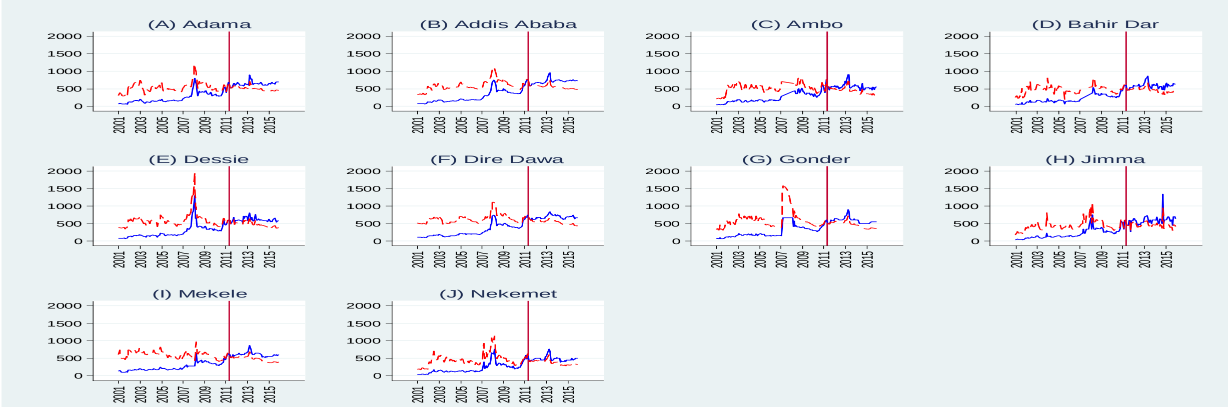
Panel A: Producer prices



Panel B: Wholesale prices



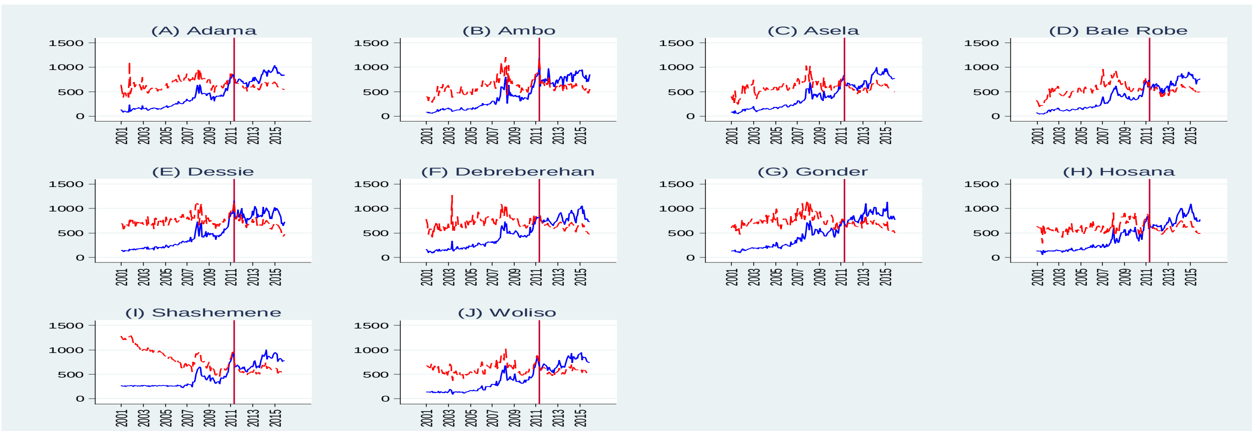
Panel C: Retail prices



Source: Based on CSA and ETBC databases; broken line and solid line rperesnt nominal and real prices, repsectively

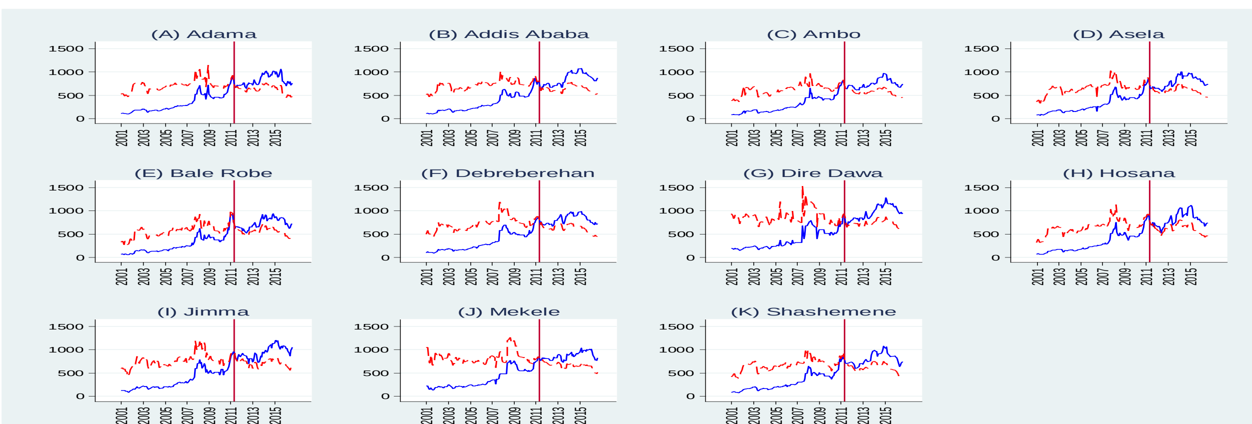
Annex 2 **Evolution of nominal and real wheat prices (December 2011=100) for selected markets in Ethiopia, 2001 to 2017**

Panel A: Producer prices



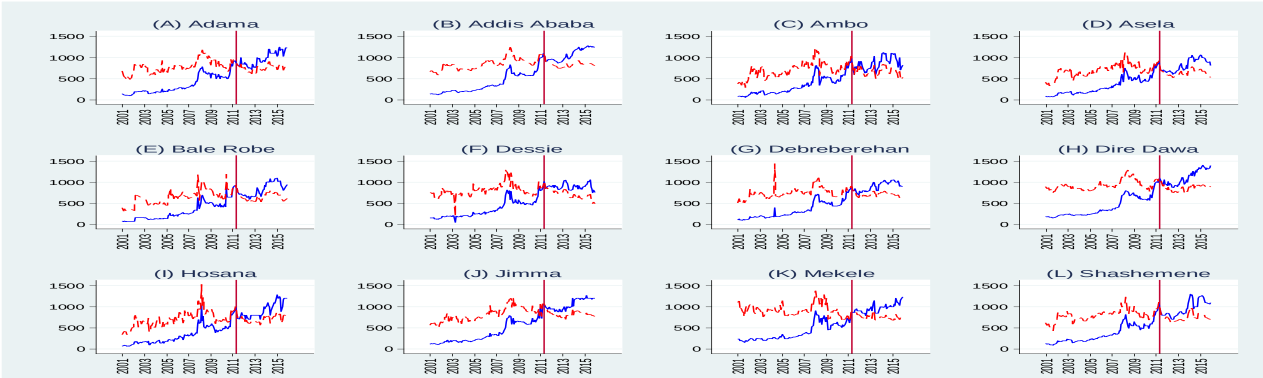
Source: Based on CSA and ETBC databases; broken line and solid line rperesnt nominal and real prices, repsectively

Panel B: Wholesale prices



Source: Based on CSA and ETBC databases; broken line and solid line rperesnt nominal and real prices, repsectively

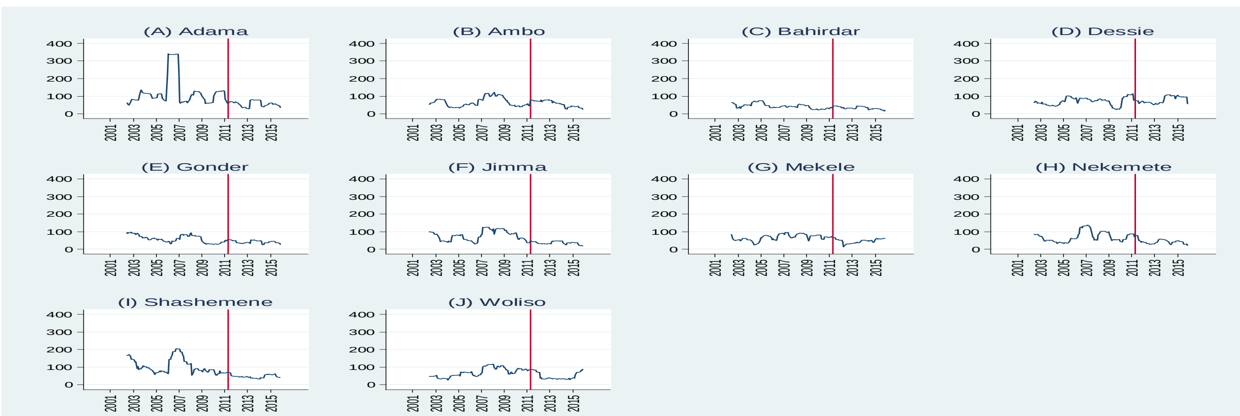
Panel C: Retail prices



Source: Based on CSA and ETBC databases; broken line and solid line rperesnt nominal and real prices, repsectively

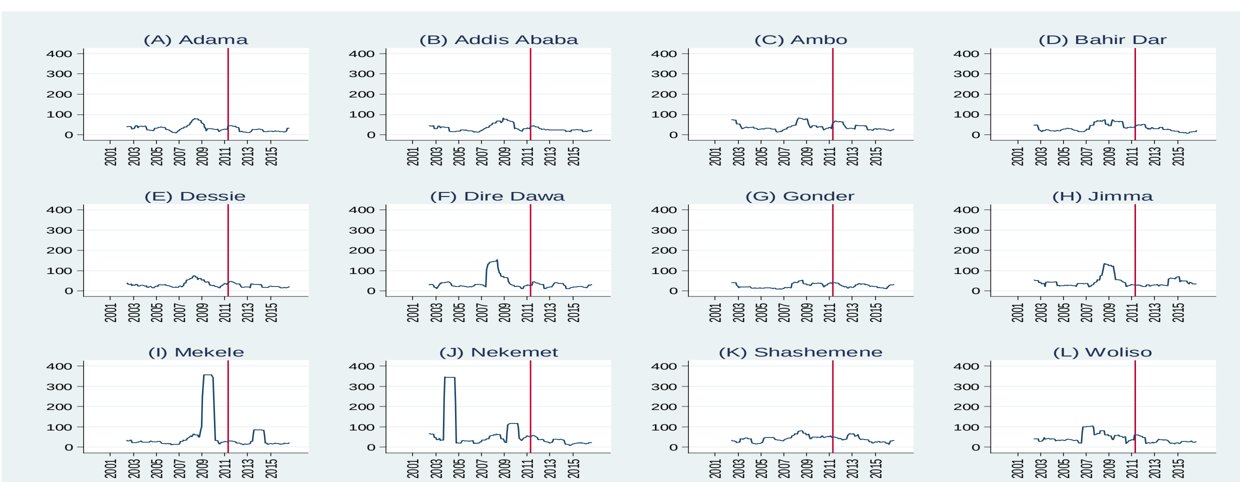
Annex 3 **Historical volatiltity of real producer maize prices, 2001-2016**

Panel A: Volatilties of maize producer prices



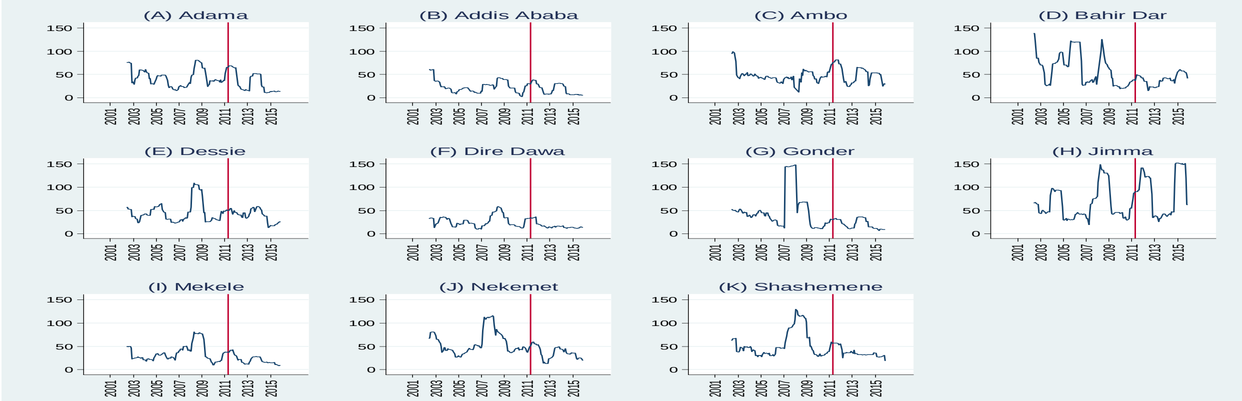
Source: Based on CSA and ETBC databases.

Panel B: Volatilties of maize wholesale prices



Source: Based on CSA and ETBC databases.

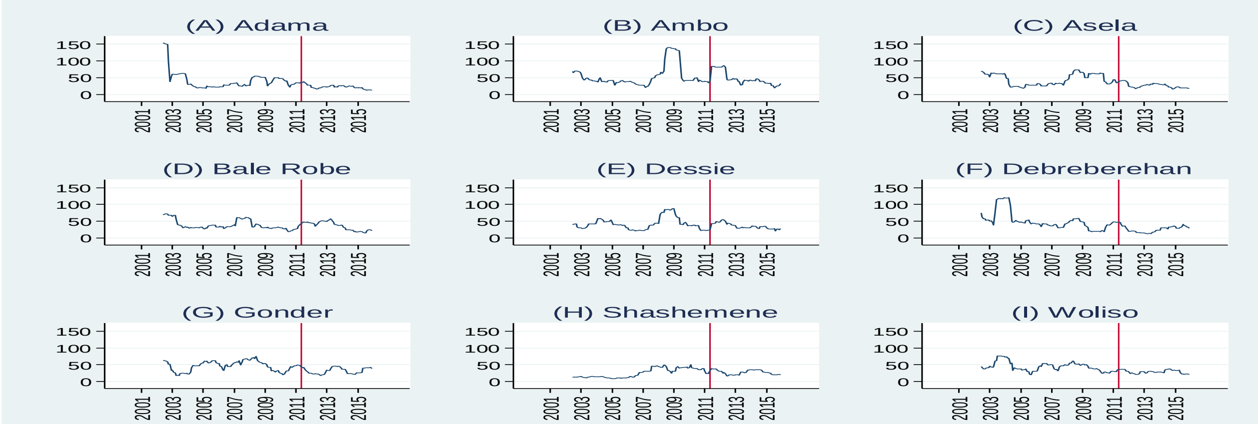
Panel C: Volatilties of maize retail prices



Source: Based on CSA and ETBC databases.

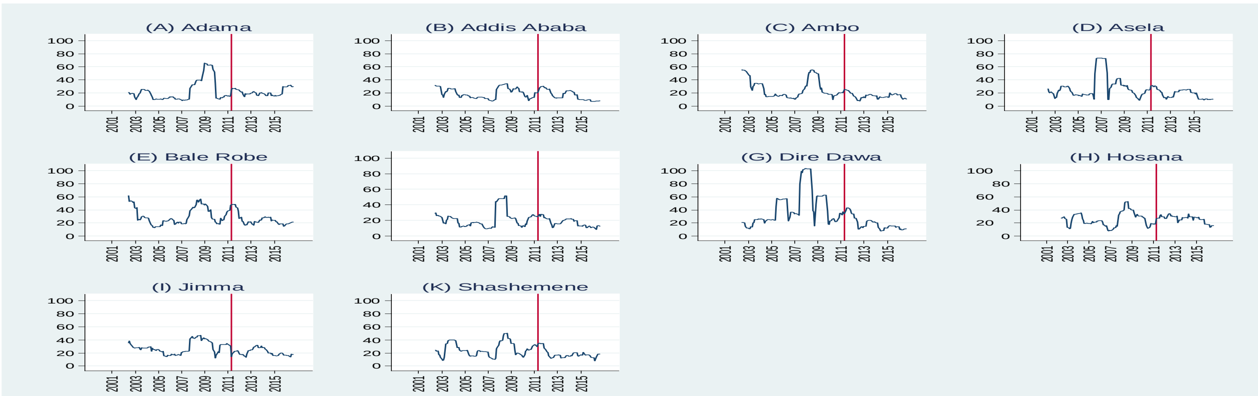
Annex 4 Historical volatiltity of real producer wheat prices, 2001-2016

Panel A: Volatilties of wheat producer prices



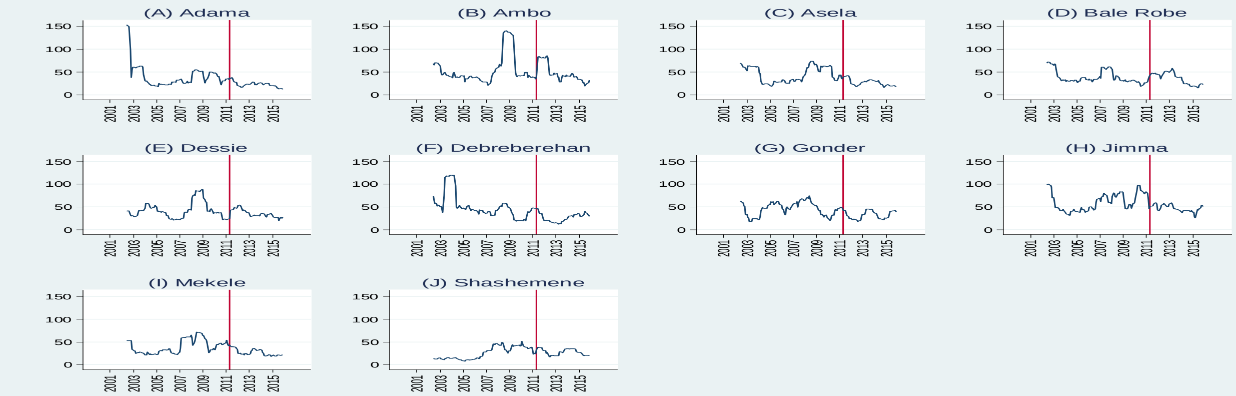
Source: Based on CSA and ETBC databases.

Panel B: Volatilties of wheat wholesale prices



Source: Based on CSA and ETBC databases.

Panel C: Volatilties of wheat retail prices



Source: Based on CSA and ETBC databases.