Food Prices in Sub-Saharan Africa: Four Essays on Grain Prices, Food Aid, Cross-border Trade and Fuel Prices

Matvareprisene i Afrika Sør for Sahara: Fire Essay om Kornpriser, Matbistand, Handel Over Landegrensene og Drivstoffpriser

Philosophiae Doctor (PhD) Thesis

Meron Assefa Arega

NMBU School of Economics and Business
Norwegian University of Life Sciences

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Dedication

To my father

Assefa Arega Alemu

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Meron Assefa Arega

Ås, 2014

Content

Summary

The central concern of this thesis is the measurement and explanation of food price movements in Ethiopia and Malawi. The main objective is to examine how food grain prices respond to domestic and international commodity price shocks and government policies. It contributes to growing body of methodological and empirical literature regarding food price movements in sub-Saharan Africa (SSA). It consists of four independent papers in conjunction with an introductory chapter.

Paper 1 examines the independent and joint impacts of the Ethiopia's Productive Safety Net Program (PSNP) and emergency relief programs on producer prices for *teff*, wheat and maize. Results indicate that food aid allocated both from PSNP and emergency relief programs have either no discernible correlation with subsequent prices or a weak negative correlation. Cash transfers are found to raise prices slightly, especially those of *teff*. The magnitudes of the correlations between prices and seasonal and time trends are substantially stronger than those associated with cash and food transfers to local markets. Paper 2 extends the first paper to directly measure whether food aid discourages food production due to its price disincentive and labor reallocation effects, and whether food aid responds to production shortfalls. Results indicate that previous year food aid allocated from PSNP and from emergency relief programs have no evident negative correlation with subsequent crop production and area planted. A low level of rainfall triggers more emergency relief and PSNP food aid. Thus, findings in papers 1 and 2 imply food and cash transfers are sufficiently well-targeted and timed overall in the PSNP districts in Ethiopia over the period examined, and that any unintended effects on local price and production are negligible.

Paper 3 examines cross-border maize market integration between Malawi and the neighboring countries, Mozambique, Tanzania and Zambia. Results indicate intra-regional market integration within Malawi. Additionally, significant cross-border maize market integration between border markets of Malawi and its neighbors exist, mainly with that of Mozambique. Consequently, cross-border trade potentially plays an important role in Malawi from the perspective of food price stabilization and food security, by enlarging maize markets for traders along the borders of Malawi and the neighboring countries.

Paper 4 examines whether food grain (*teff*, wheat and maize) prices respond to fuel price shocks through effect on transportation cost, using evidence from Ethiopia. Results show that change in the world crude oil price transmits to maize and wheat prices in Addis Ababa (AA), but not to *teff* prices. However, there is no observed transmission from fuel (benzene and diesel) prices in AA to other local grain prices. As well, the volatility of world crude oil is not correlated with the volatility of grain prices in AA, whilst there is no apparent linkage between the volatility of local fuel and grain price. Thus, findings imply world oil price as one of the drivers of the tradable food grain prices, maize and wheat in Ethiopia.

The overall conclusion and major implications of this thesis are first, policy interventions, such as large safety net program may not necessarily distort markets and incentives if well designed and properly implemented. Second, the performance of markets in SSA has increased in terms of internal and external price transmissions. This indicates markets are linked by a process of arbitrage that potentially decreases price differences to the level of transfer costs and enables efficient product movements. However, it also implies that markets are more exposed to external commodity price shocks. Given the current global commodity price instability, this should be of high concern to policymakers. And last, sustained progress depends on government policy and investments to improve market fundamentals.

INTRODUCTION

Food Prices in Sub-Saharan Africa: Four Essays on Grain Prices, Food Aid, Cross-border Trade and Fuel Prices

Meron Assefa Arega

1. Background

The economy of sub-Saharan Africa (SSA) has recorded accelerated growth over the past decade with an average annual rate of 5%, projected to increase to 5.7% in 2014 (IMF, 2013). It also has shown resilience through the global financial crisis, owing to sound economic performance that prevailed before the global shocks (IMF, 2010). Despite robust economic growth rates and different development efforts, poverty and food insecurity have remained major challenges in the region. Most people are still confronted with extensive hunger, undernourishment and poverty. The agricultural sector plays a major role in these economies, where the majority of the population lives in rural areas. Food grain production is a large sub-sector within agriculture and is a major source of income and employment in most of SSA. Maize, rice, wheat and cassava constitute the four main food staples in SSA (Oyejide et al., 2012).

Achieving food security, whether through self-sufficiency or trade, has been a challenge in most parts of SSA over the past several decades. This is certainly true for Ethiopia and Malawi, the two countries of focus in this thesis. Demand for food is rapidly rising, mainly due to high population growth rates. On the supply side, production fluctuations and shortfalls mainly result from heavy reliance on rainfall for production, small farm size, limited use of modern inputs, and poor access to markets. These cause gaps and instability in food availability. Governments mainly stabilize food supply through large-scale food imports and emergency and program food aid. As shown in Table 1, SSA produces about 146 million MT of cereal in 2009, of which maize accounts for 40%. Average cereal import is 55 million MT, which is 28% of total cereal utilization and 40% of cereal consumption. The largest imported crop is wheat and it appears as the common food aid crop. Cereal exports are only 3% of total production, implying that cereals are non-tradable crop in SSA and thus, food grain prices are determined mostly by domestic food supply and demand.

Table 1 Production and Trade of Staple Food in SSA in 2009 (in thousands)

Item	Prod-uction	Import	Export	Food consumption	Total utilization[1]	Import as % of food consumption	Import as % of total utilization	Export as % of production
Cereals	146	55987	4 065	141037	199305	0,40	28	3
Wheat	26074	30288	897	46311	55346	0,65	55	3
Rice	15235	7212	904	19646	23118	0,37	31	6
Barley	5 828	1744	29	2777	7237	0,63	24	0
Maize	57702	14995	2132	39202	67067	0,38	22	4
Rye	103	13	0	17	115	0,76	11	0
Oats	205	64	2	122	267	0,52	24	1
Millet	14721	86	15	12674	17219	0,01	0	0
Sorghum	21969	1430	31	17254	24947	0,08	6	0
Others	4380	155	55	3034	3987	0,05	4	1

Source: FAOSTAT (2014). Note: Total utilization consists of food, food manufacturing, feed, seed, waste and other uses.

The role of agricultural commodity markets to enhance food grain productivity and production growth has been widely recognized (Jayne et al., 2010). Theoretically, well-functioning markets are desirable because they ensure welfare improvements at the micro level that may result in sustainable macroeconomic growth. Additionally, macro policies are more effective in well-functioning markets that transmit policy signals (Barrett & Mutambatsere, 2005). The most recognized role of food markets in developing countries is that they offer a mechanism to reduce adverse effects of shocks from food production shortfalls. That is, well-functioning markets allow for smooth transmission of price signals and information that enables efficient food movements quickly from surplus to deficit areas, thereby ensuring food security (Zant, 2012). However, the performance of agricultural commodity markets in SSA is far from that typically assumed in textbook models (Barrett & Mutambatsere, 2005). Market failures caused by incomplete institutional and physical infrastructure and imperfect competition are common in many developing countries.

1.1. An overview of food grain markets in SSA

In general, infrastructure, information, institutions, competition and government marketing and trade policies determine marketing and transaction costs and thus, market efficiency. Major constraints to agricultural market performances can be identified as those related to weak infrastructure and to missing institutions (Gabre-Madhin & Goggin, 2005). Poor physical infrastructure such as weak access to roads and limited storage facilities result in high cost of transport and marketing. Aggregated data from 2005 to 2011 shows in SSA paved road constitutes only 16% of total road network (World Bank, 2014). Poor road networks apparently increase the cost of transportation, such as costs for fuel and maintenance. Moreover, inadequate storage facilities in terms of availability, capacity and location obstruct grain traders from exploiting temporal arbitrage opportunities. In fact, poor storage facilities are one of the major reasons for post-harvest losses in SSA (Kaminski & Christiansen, 2014). Missing markets, for example for credit and financial services, also increase marketing costs.

Unlike physical marketing costs such as those for transportation and storage, transaction costs are related to conducting market exchanges that involve the cost of obtaining and processing information on prices, qualities and quantities of products; searching and screening of buyers or sellers; as well as negotiating, monitoring and enforcing a contract (Gabre-Madhin, 1999; Gabre-Madhin & Goggin, 2005). Market information helps traders to respond to arbitrage opportunities quickly, facilitates market exchange and transmission of price. Thus, it ultimately increases bargaining power and market share values of traders (Rashid & Minot, 2010). In SSA, access to market information is very limited and it is mainly obtained through friends, relatives and extension agents, which could be inadequate in terms of accuracy and timeliness (Mangisoni, 2006). Following the 1990's market liberalization policies and structural adjustment programs in SSA, market information systems (MIS) were introduced to provide market information in agricultural trading (Tollens, 2006). MIS were designed to improve market efficiency by reducing information asymmetry among the market actors, thus decreasing transaction costs associated with negotiating, signing and enforcing contracts and increasing the bargaining power of market players (Kizito, 2011; Tollens, 2006). However, many agricultural MIS failed to provide the intended information and were not financially sustainable after the donor's financial support to MIS ended (Kizito, 2011).

A rather recent phenomenon is the important role of mobile technology for agricultural marketing. Despite that SSA has the lowest levels of infrastructure in the world, many people have access to mobile technologies (Sterck, 2014). Based on data from World Development Indicator (WDI) database, in SSA only one in every one hundred people have a fixed telephone line, and only fifteen in every hundred are internet users, whilst sixty had mobile phone subscriptions as of 2011 (World Bank, 2014). Aker (2008) shows that in Niger mobile phones helped to reduce transaction costs and gave traders access to larger markets.

Market institutions potentially reduce transaction costs providing with rules and strategies that facilitate exchange among market participants. Informal institutions are common in SSA. They usually involve implicitly known rules that are enforced through social sanctions, such as relational transactions and client-based transaction through acquaintances and brokerage in rural areas (Tadesse & Shively, 2013). In contrast, formal market institutions involve publicly known rules that are enforced through formal legal contracts, such as contract farming, cooperative marketing, commodity exchange market, and organized auctions. However, grain markets in SSA involve high transaction costs associated with enforcing contracts and searching over buyers and sellers (Tadesse & Shively, 2013).

A popular institutional response to reduce transaction costs in grain marketing is the development of commodity exchanges (Rashid et al., 2010; Sitko & Jayne, 2012). A commodity exchange centralizes market exchange for a given commodity, thus potentially reducing transaction costs involved in marketing by identifying market outlets, obtaining buyers or sellers, informing about product qualities, etc. (Rashid et al., 2010). However, unlike in many other developing countries, African commodity exchanges are underdeveloped (Rashid et al., 2010; Sitko & Jayne, 2012). Out of five which were launched right after the market liberalization of the 1990s, only one from South Africa succeeded (Rashid et al., 2010). While commodity exchanges in Zambia and Zimbabwe terminated their operations, the ones in Kenya and Uganda continue to exist but have failed to fulfill their planned objectives (Rashid et al., 2010). After 2004, more countries introduced or reestablished commodity exchanges, notably Malawi in 2004, Nigeria in 2006, Zambia in 2007, and Ethiopia in 2008. The main reason why agricultural commodity exchanges have been unsuccessful in SSA is lack of sufficient market size and lack of conducive policy and infrastructure (Rashid et al., 2010).

Market failures often motivate government intervention to address inefficiencies. Government interventions in SSA mainly occur through marketing board operations, and discretionary use of trade policy (Jayne et al., 2006). Government interventions in grain trading through parastatal marketing boards continue to function despite agricultural market liberalization. However, their impacts in the grain trading remain controversial. Most government parastatals are mandated to stabilize staple food crop prices by participating into grain marketing, and also to maintain and manage grain buffer stocks or strategic grain reserves in the countries. These state grain trading enterprises are observed to generally operate in competition with private traders, thus undermining incentives to most private traders participating in the market (Rashid & Minot, 2010).

Governments also influence grain markets through discretionary trade policy instruments, such as export bans and changes in import tariff rates (Jayne et al., 2006). Trade policy instruments have been used for various objectives. Government use import tariffs and export taxes to raise revenues, whilst import licensing and export bans have been popularly used to stabilize domestic staple food supply and prices to ensure food security (Sarris & Morrison, 2010). International grain trade (imports and exports) or trade across national borders (such as cross-border trades) are mostly constrained by government's legislation, licensing, and trade policies in SSA. Intermittent trade policy changes have also become one of the obstacles to trade, increasing the risk premium and discouraging traders from participating in trade (Minot, 2011). Minot (2014) shows maize price volatility is more than 50% higher in countries where the government intervenes actively in the markets (Kenya, Malawi, Zambia and Zimbabwe), as compared to countries with relatively little intervention (Chad, Ethiopia, Mozambique, Niger, Nigeria and Uganda).

Recently, government responses to food price spikes and volatility in SSA mainly include safety net programs (cash transfer, food for work and school feeding) in the short-term, and reductions of tariff and value added tax on staple foods, consumer price subsidies and price controls, and restricting or banning grain export in the medium term (AERC, 2011; Demeke et al., 2009; Wodon & Zaman, 2010). In sum, grain markets in SSA are constrained by prohibitive transaction costs, public market protection, trade barriers, inefficient flow of information, imperfect competition and incomplete or missing markets for risk management like credit and insurance (Rashid & Minot, 2010; Van Campenhout, 2007).

1.2. Recent food grain price trend and volatility in SSA

Managing agricultural price instability is a long standing policy challenge that has gained especially more prominence since the two recent price spikes in international food markets, in 2007/08 and 2010/11. The growing recent literature on commodity markets have identified a set of forces that drive food prices, including extreme weather events (such as extreme heat, droughts and floods-exacerbated by global warming), biofuel demand, oil prices, speculation in commodity futures markets, stockpiling policies, trade restrictions and macroeconomic shocks to money supply and exchange rates (Abbott & Borot de Battisti, 2011; Abbott et al., 2009; Abbott et al., 2011; Baffes & Haniotis, 2010; Gilbert, 2010; Headey & Fan, 2008; Mitchell, 2008; Roache, 2010; Tadesse et al., 2013).

As shown in Figure 1, after a relative stable trend, food prices in SSA became higher and more volatile, with most notable two recent price spikes in 2008 and 2011. It is generally recognized that high food prices and extreme price instability have negative impacts on food security. High food prices adversely affect the majority of the consumers in developing countries who spend a very high share of their total budget on food and lack diet diversity. Urban wage rates do not adjust to food price rises and rural consumers are not able to produce market surplus that is more than their food consumption (Wodon & Zaman, 2010). High food crop prices do not necessarily benefit agricultural producers since they are net buyers of agricultural products. Price instability rather causes uncertainty among producers leading to less than optimal production investment decisions. Wodon & Zaman (2010) argue that the negative impact of rising food prices on net consumers is more than any positive impact of high prices to producers in SSA. They show that for a 50% price increase during the global crisis, average poverty head count increases by 4.4% if accounting only the consumer side, whilst it still increases by 2.2% if the positive impact on producer income is taken into account. Ivanic & Martin (2008) also indicate the recent global crisis results in additional 105 million people falling into poverty, which is 4.5% increase in poverty headcount, corresponding to loss of seven years of poverty reduction efforts. Moreover, even though the recent food price spikes and instabilities may remain temporary, they have long-term negative consequences on food security and welfare of the households in SSA (Dethier & Effenberger, 2011; Wodon & Zaman, 2010).

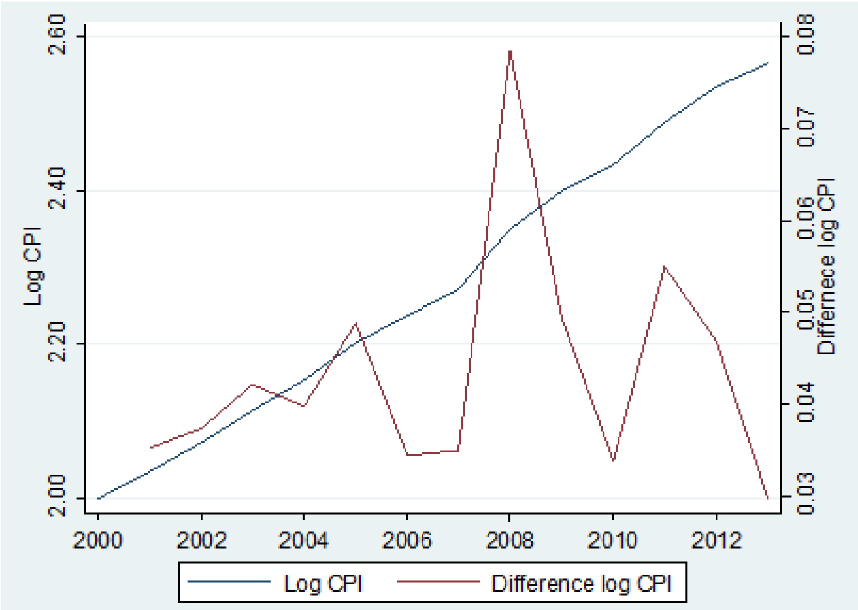

Figure 1: Food Consumer Price Index (CPI) Trend and Variability in SSA (2000-2013)
Source: Own calculation based on data from FAOSTAT (2014).

Average staple grain prices in SSA are higher and more volatile than their corresponding world prices as indicated by data in Table 2. Maize and wheat prices in SSA are more volatile than the estimated import parity price of maize and wheat. Higher grain prices in SSA are attributed to higher cost of production and marketing, as well as higher import tariffs, import restriction and more administrative bottlenecks that increase the cost of importing (Minot, 2011). In contrasts to the common view that food prices have recently become more volatile in SSA, Minot (2014) finds no evidence that food price volatility has increased based on price series from 2007 to 2010.

Table 2 Comparison of Food Grain Price Volatility between World and SSA (June 2007 to June 2008)

Commodity	Mean (USD/ton)	Standard Deviation	Coefficient of Variation (CV)	CV of import parity
World Price				
Maize	121	39	33	18
Rice	210	88	42	28
Wheat	167	61	36	23
Domestic price in SSA				
Maize	180	68	38	
Rice	477	105	22	
Wheat	261	99	38	

Source: Minot (2011).

The potential of world commodity price shocks to disrupt staple food markets in developing countries is of major concern to policymakers and practitioners. Price transmissions from global to local markets vary among countries and commodities in SSA (Dethier & Effenberger, 2011). It depends on domestic supply response and government policy interventions that are aimed to dampen the impacts on local food markets. Based on data from June 2007 to June 2008, Minot (2011) finds that 13 out of 62 staple food prices show long-run relationship with their corresponding world prices in seven SSA countries examined. Crop-wise, rice markets are found more connected to world markets as compared to maize markets, with half of the rice prices studied from different markets in SSA showing long-run relationship with world rice prices (Minot, 2011). Similarly, a recent study based on global and regional food price indices in SSA further show that it only takes two months to experience the maximum impact of world food price changes in eastern Africa, as compared to more than 7 months for the northern and western Africa (Table 3). Also, the international long-run price transmission elasticity reaches 100% in eastern Africa, followed by 90% in western Africa, 64% in southern Africa and 53% in northern Africa.

Table 3 Price Transmission from World to SSA, by Region (2001 to 2013)

		North Africa	Western Africa	Eastern Africa	Southern Africa
Highest effect		0.01	0.03	0.05	0.03
Horizon at which the highest effect occurs (months)		7	7	2	13
Domestic price responses after	2 months	0.01	0.03	0.05	0
	4 months	0.03	0.06	0.11	0.02
	8 months	0.07	0.16	0.21	0.1
	16 months	0.13	0.33	0.47	0.28
	32 months	0.25	0.6	0.79	0.54
	Long-run	0.53	0.9	1.05	0.64

Source: Cachia (2013).

2. Problem statement

The central concern of this thesis is the measurement and explanation of food price movements in Ethiopia and Malawi. The important and substantial role of food prices in shaping food security in developing countries motivates a need for a better understanding of the drivers of food price levels, volatility and extremes. This concern is even more acute when one considers the periods of high price spikes and instability observed over the past few years. Market analysis provides information commonly used for government policy interventions that bear considerable implications to poverty alleviation and food security programs.

This thesis contributes to a growing body of methodological and empirical literature regarding food price movements in SSA. I extend the analysis of food grain markets in SSA by focusing on how staple food grain prices respond to domestic and international commodity price shocks, and government policies. In particular, my main objective is to measure whether, and to what extent, domestic agricultural and trade policy interventions affect food grain prices. I also examine how domestic staple food prices respond to international commodity prices. In this context, four papers included in this thesis empirically investigate three major policy-relevant issues regarding food grain prices in SSA, using data from Ethiopia and Malawi.

The first investigation focuses on how agricultural policy interventions affect food crop prices and, by extension, production incentives. I do this by measuring the impact of safety net program on food prices and production in Ethiopia over the period 2005/2007-2010. These issues are addressed in the first two papers. I then turn my attention to the question of how domestic trade policies and restrictions influence staple prices. I examine cross-border market integration, using as my example Malawi and its neighboring countries. This is the subject of the third paper. The third investigation expands the sphere of the study to examine price linkages between international commodity markets and domestic food markets in SSA. In my fourth and final paper, I study the relationship between fuel prices and grain prices over the period 2001-2012. As in the first two papers, I study the experience of Ethiopia in the fourth paper. I address the following specific research questions in this thesis:

1) How do food aid and cash transfers affect staple food grain prices and producer incentives? (Paper 1)
2) Does food aid discourage food production, by reducing prices? Is food aid a response to food production shortfalls? (Paper 2)
3) Are cross-border markets integrated, and if so how well integrated? (Paper 3)
4) Are fuel prices and food grain prices correlated? How closely are domestic food grain markets and international commodity markets linked? (Paper 4)

Although the primary focus for all of the papers in the thesis is to analyze food grain prices in SSA, the issues raised in the papers do not necessarily build on each other. An exception is the first two papers on impacts of food/cash transfers. I present a conceptual framework for assessing the above stated objectives of this thesis in Appendix 1. Below I provide country specific background and briefly motivate the three thematic issues studied in this thesis.

2.1. Ethiopia

Food grain production and marketing are important in the Ethiopian economy, accounting for 60% of rural employment, 80% of cultivated area, 70% of total production, 40% of household's food expenditure, and 60% of caloric intake (Rashid, 2010; Admassie, 2013). The major food grains are *teff*, wheat, maize, sorghum and barley, respectively. Consequently, the food grain sub-sector has been an important policy focus under all political regimes in the country over past decades (Rashid, 2010). Since early 1990s, the overall economic growth strategy of the current government has focused on agriculture. Major strategies and policies include (1) the Agricultural Development Led Industrialization (ADLI) strategy; (2) the Sustainable Development and Poverty Reduction Plan (SDPRP) of 2002/03-2004/05; (3) the Sustainable Development to End Poverty (PASDEP) program of 2005/06-2009/10; (4) the Five Year Growth and Transformation Plan (FYGTP) which began in 2010/11 and is expected to continue through 2014/15; and (5) the Agriculture Sector Policy and Investment Framework (PIF), which is a decadal plan running from 2010 through 2020. All of these strategies highlight the importance of the agricultural sector in general, and the food grain sub-sector in particular.

Agricultural production is vulnerable to weather shocks, which has strong implications on food grain prices. After adopting the ADLI strategy, the government focused on intensification to improve agricultural production and productivity growth of small farms, primarily through public investment in agricultural extension (Diao, 2010). The government launched the Participatory Demonstration and Training Extension Systems (PADETS), which aims to deliver fertilizer and improved seeds, and to combine these technological packages with credit and information about modern agricultural practices. PADETS was followed by a liberalization of the fertilizer market that mainly includes removing fertilizer subsidies (Diao, 2010). Recently, the FYGTP has emphasized increasing application of chemical fertilizer and improved seeds as a major driver to achieve an annual food grain production target for each region in the country. However, application of fertilizer has remained very limited with only 30% to 40% of smallholders use fertilizer, even those who use it apply much below the recommended rate (Rashid et al., 2013).

Even though production has failed to keep up with population growth (Diao, 2010), the official CSA data indicate an increasing trend of major food grain production since 2003/2004. Historically, all food grain production growth in the country was attributed to increase in crop area cultivated, whilst in recent years it appears to be due to a combination of both area expansion and yield increase (Diao, 2010; Rashid, 2010; Taffesse et al., 2011). Nevertheless, given farm land constraints and uncertainties about the effectiveness of agricultural extension programs, controversies surround the topic of agricultural productivity growth (Rashid, 2010). Overall, agricultural productivity and yield growth in the country are constrained by relatively modest application of modern inputs (fertilizer, pesticide, and improved seeds), low levels of irrigation, soil degradation and erosion, inadequate agricultural research and extension, and constraints in market development (Taffesse et al., 2011).

As elsewhere in SSA, food grain markets in Ethiopia are of a major concern due to their important implications to food security. Also, domestic trade of cereals is critically important since food grain production is highly concentrated geographically, with only two regions (Amhara and Oromia regions) accounting for almost 80% of total food grain area and production (Diao, 2010; Rashid, 2010).

Grain marketing policies in Ethiopia have evolved over the past decades mostly in response to the political ideologies of the governments in power (Rashid, 2010). These range from the feudalistic system with limited government intervention to the state-controlled markets in the past regimes. These have been followed by market liberalization and an increase in government investment in market infrastructure (Rashid, 2010). Governments in Ethiopia have traditionally intervened in the grain market through parastatal. The Grain Market Board, the government parastatal established during the monarchic regime was renamed the Agricultural Marketing Corporation (AMC) during the 1980s and fully took over grain marketing, reducing private sector participation (Rashid & Negassa, 2011).

The current government renamed the AMC the Ethiopian Grain Trade Enterprise (EGTE) and reorganized it as a public enterprise that operates in competition with the private sector (Rashid & Negassa, 2011). The government has been revising EGTE's mandates over the years. It attempted to gradually reduce EGTE's role in promoting price stabilization and refocus efforts on promoting exports, facilitating emergency food security reserves, and helping national disaster prevention and preparedness programs. For instance, the EGTE's market shares diminished from about 40% in the 1980s to about 3% when it almost withdrew from price stabilization in the early 2000s (Rashid &Negassa, 2011). Nevertheless, government intervened to stabilize prices during the price collapse of 2002/03 and price hikes in recent years. In fact, the government responded to the recent food crisis using mechanisms such as grain export bans (since 2008), government food imports, urban food rationing, and banning of local food aid procurement (Rashid, 2010).

The government has recognized the weaknesses in the agricultural marketing system (especially following the food price instability in early 2000's) and responded with accelerated investments in road and communication networks, among others. Notwithstanding the efforts to improve market infrastructures, market failure is still manifested in terms of limited storage capacity and facilities, inadequate road, poor access to market information and inadequate institutions in Ethiopia. In recent years, improvements in road networks are witnessed with strong implication in reducing transportation costs (Minten, et al., 2012;

Rashid, 2010). For instance, Rashid (2010) indicates that transportation costs associated with grain marketing in the country decline from 31% of total transaction costs in 1996 to 15% in 2008. However, the country still has one of the lowest road densities in the world (Von Braun & Olofinbiyini, 2007; Rashid & Negassa, 2011). Smallholders still highly depend on pack animals and human labor to transport their surplus to markets due to their limited access to mortised vehicles (IFPRI, 2010). Even the existing rural roads are mostly not all-whether, which increase pressure on the roads during the peak seasons and transportation costs (Rashid & Negassa, 2011). Thus, crop transport is both slow and expensive in the country (IFPRI, 2010).

Moreover, due to inadequate grain storage facilities, producers are not able to fully benefit from temporal arbitrage (Rashid, 2010). In fact, the majority of the smallholder farmers in the country usually opt to selling their output immediately after harvest to settle their loans, taxes and other social service payments (Tadesse & Guttormsen, 2011). Besides, even for those who are able to access storage facilities, the government discourages private speculative storage, with the assumption that it disrupts the food grain market through stockpiling. However, Tadesse and Guttormsen (2011) show that in Ethiopia intertemporal price formation is based on predictions of rational expectations and temporal arbitrage is competitive, which do not give rise to the current anti-speculative storage policy responses of the government.

Additionally, limited access to market information has repressed the efficiency of the market participants in grain trading in Ethiopia. Market actors have no or limited information on current grain prices, supplies, stocks and inter-regional grain flows (IFPRI, 2010), whereas a major source of price information remain largely informal, such as friends and neighbors and market visits, etc. (Rashid & Negassa, 2011). Mobile phone usage to exchange market information among the farmers and traders has increasingly become available in recent years

(Minten, et al., 2012). However, mobile phone subscription in the country is still one of the lowest even compared to other neighboring countries (Rashid & Negassa, 2011). At the same time, food grain marketing involves high transaction costs due to poor institutions in the country. Most exchanges are based on relational arrangements (such as social networks, personalized trust and client-based) established through repeated transactions, which are in turn found to be costly (Tadesse & Shively, 2013).

A recent institutional response toward reducing transaction costs in grain marketing is the introduction of the Ethiopian Commodity Exchange (ECX) since April, 2008. The ECX is intended to coordinate the exchange of commodities and futures among wholesalers, exporters, speculators, and millers (Tadesse & Guttormsen, 2011). Even though it has targeted six commodities (maize, wheat, *teff*, pea beans, sesame, and coffee), the volume of food grains traded remains very small. It rather focuses on coffee trading, whilst the government dismantled the traditional coffee auction floor and forced the private wholesalers and exporter to sell coffee only through ECX (Rashid & Negassa, 2011). Furthermore, in past years the government has scaled-up cooperatives to participate in food grain markets. It aims at achieving agricultural commercialization using cooperatives for grain trading (Rashid & Negassa, 2011). Accordingly, smallholder farmers' membership to agricultural cooperatives has increased, especially in major food grain crop producer regions. For instance, the number of smallholders participating in cooperative increased from 9% in 2005 to 36% in 2008, whilst on average 28% of the cooperative members sold grains through their cooperative in 2008 (Rashid & Negassa, 2011).

Given the above background on food grain market policies and fundamentals in Ethiopia, this thesis seeks to improve our understanding on how staple food prices respond to government policies, as well as domestic and international commodity price shocks. The following two sub-sections motivate those topics examined with this regard.

2.1.1. Food grain prices, production incentives and social safety net program

Ethiopia faces recurrent droughts and famines. The 1972-1974, 1984-1985, 1999-2000, and 2002-2003 famines are amongst the major ones which resulted in high mortality in various areas of the country. Chronic food insecurity is also unremittingly high. It is historically caused by high dependence on rainfed agriculture which is prone to adverse weather shocks, and also aggravated by lack of access to agricultural inputs, high agricultural input prices, and soaring food prices (USAID, 2012). These shocks are manifested in terms of low household incomes and food consumption, as well as loss of productive assets due to distress asset sales (USAID, 2012).

Emergency relief food aid had long been a typical response to both transitory and chronic food insecurity in Ethiopia. For instance, the government appealed for emergency food aid and other related relief assistances almost annually between 1993 and 2004 (Berhane et al., 2014). Despite that ad hoc food aid delivery has been credited for preventing starvation and saving lives, it is widely criticized as insufficient and unpredictable, thus failing to address underlying causes of food insecurity. In view of that, following the drought of 2002/03, the government in collaboration with consortium of donors initiated a large-scale social safety net program under the country's Food Security Program (FSP).

Ethiopia's Productive Safety Net Programme (PSNP) was launched in January 2005 as part of the FSP. The program aims to strategically tackle food insecurity in the country by ensuring timely and predictable cash and/or food transfers to chronically food insecure *woredas*,[1] which constitute more than 50 percent of all *woredas* in the country. Ethiopia's PSNP is the largest social safety net program in SSA, next to South Africa's (Gilligan et al., 2009). The program further is designed to prevent household asset depletion, build

[1]A *woreda* is an administrative unit, defined below the levels of regions and zones, and roughly equivalent to district designations elsewhere.

community asset stocks, and stimulate the growth and performance of agricultural and labor markets (MoARD, 2009). This program aims to overcome the potential adverse consequences of food aid that may mainly result from problems associated with timing and targeting of emergency food aid distribution in the country. The PSNP adopts the traditional community based targeting systems that were in place, and further refines them to include more criteria that enable identifying the chronically food insecure within each selected chronically food insecure *woreda's*.

Transfers subsequently occur through either direct supports for those who are vulnerable and unable to supply labor, or labor-intensive public works payments for those who can. PSNP participants receive payments in the form of cash, food or a combination of the two. Moreover, the PSNP is complemented by Other Food Security Program (OFSP), which was redesigned and renamed Household Asset Building Program (HABP) in 2009. These programs intend 'to increase income generated from agricultural activities and to build up assets,' by providing with access to credit and assistance with access to seeds, bee-keeping, soil conservation activities, and water harvesting or irrigation (Berhane et al. , 2014).

Food aid is delivered to the country in three ways: direct transfers from a donor to Ethiopia, local purchases within Ethiopia, and triangular transfers where donor transfers items purchased in another country as a food aid to Ethiopia. The first has traditionally been the most popular mode of food aid delivery to the country, whilst the second has increasingly become important, but controversial due to its potential effect on local food staple markets. In fact, as part of its price stabilization response during the 2007-2010 price spikes, the government suspended donors from locally purchasing food aid grains (Rashid, 2010). Data from WFP show local procurement of food aid amounts on average,16% of total food aid delivered to the country during 2000 to 2012 (WFP, 2014).

At the same time, an often raised concern is whether such kind of social safety net programs are effective in meeting their objectives. Accordingly, there are some recent evaluations of the PSNP (and OFSP/HABP) that examine the targeting system (Coll-Black et al., 2011). There are also some that study its impacts on household welfare, asset ownership, as well as agricultural and economic activity (Gilligan, D. et al., 2009), on improvements in agricultural productivity (Hoddinot et al. 2012), on household food security, asset accumulation and disincentives for work and private transfers (Berhane et al., 2014), and on children's time use between work and schooling (Woldehanna, 2010). Likewise, whether food aid/cash transfers from such programs induce any adverse effects on markets and agricultural production is a highly debated matter. Ethiopia's PSNP gives an ample opportunity to empirically examine this long standing issue. Using a dataset that I have constructed expressly for this thesis, Paper 1 analyze the impacts of PSNP food aid and cash transfers on prices and production incentives for major grains in Ethiopia. Paper 2 extends the first paper to directly examine whether food aid discourages food production due to its price disincentive and labor reallocation effects, and whether food aid responds to production shortfalls.

2.1.2. Drivers of food grain price spikes and volatility

Overall, studies show that performance of the food grain market has improved, with fairly strong spatial market integration, intercommodity staple food price transmission and vertical integration between wholesale and retail prices in Ethiopia (Getnet, 2007; Getnet et al., 2005; Negassa, 1998; Negassa et al., 2004; Rashid, 2011). On the other hand, food grain prices have shown substantial instability with detrimental effects on producers and consumers over the past many years in the country. Historically, weather shocks and seasonality of grain production are the major factors that affect levels and trends of food grain prices in Ethiopia (Admase, 2013). This has changed over the recent years, however.

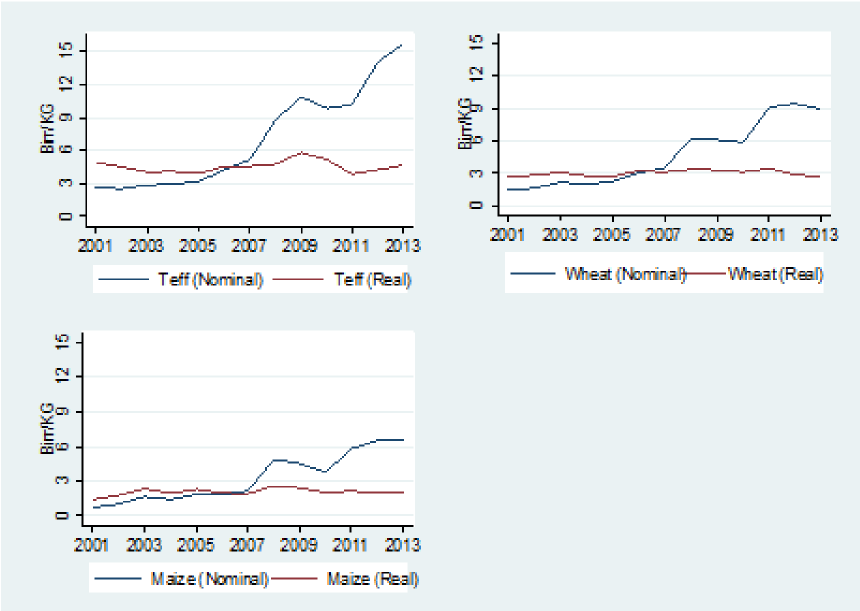

Figure 2 Nominal and Real Prices (Addis Ababa) in Ethiopia, by Commodity (2001- 20013)
Source: Own calculation based on CSA retail price data.

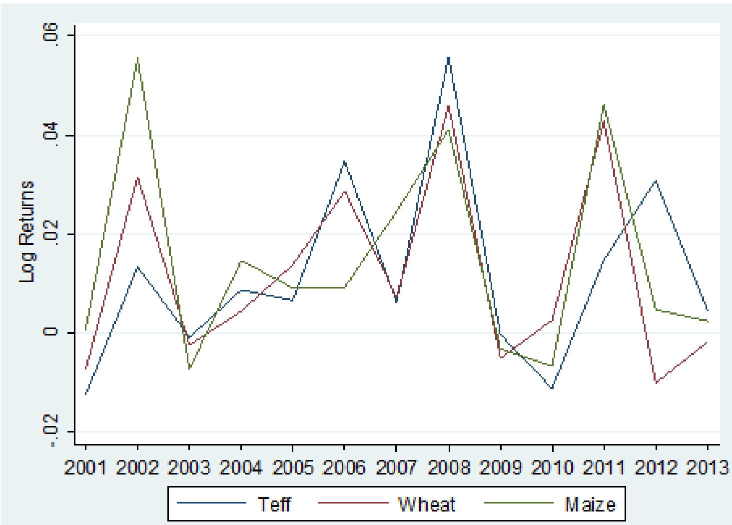

Figure 3 Price Variability in Ethiopia, by Commodity (2001-2013).
Source: Own calculation based on CSA retail price data.

Figure 2 shows a number of episodes corresponding to the price changes over the past decade. Irregular bumper harvests, which partly resulted from intensification of maize production in the 1990s (Spielman et al., 2011), depressed food grain prices during the period 2000/01 and 2001/02. Widespread drought occurred in 2002/03, because of shortage of rainfall during the main production season, and consequently pushed staple crop prices to higher level. With a return to favorable weather in the 2003/04 main season, food grain production once more improved. Yet, both nominal and real prices continued to increase in 2003/04, noticeably before the rise in the international food prices (Figure 2). Logical explanations have been offered as to why food grain prices rise in spite of stable increases in production of major food grain recorded in the last several years. This has been attributed to a range of factors, including rising domestic demand for food crops caused by population growth, rising per capita income growth, growth in urbanization, greater participation of cooperatives in food grain markets, cash transfers from PSNP and microcredit services, a rise in remittances, and increased crop stockpiling by farmers (Admase, 2013; Rashid and Dorosh, 2008). As Figure 2 further depicts, the upsurge in the prices peaked first in 2008, followed by decreasing trend afterwards with another peak in 2010 and 2011. The gap between the nominal and real[2] prices reflects sharp increase in food price inflation since 2008 (Figure 2). Furthermore, Figure 3 shows inter-annual staple food crop price variability is remarkably high and has even worsen in 2007/2008 and 2011. Overall, these figures illustrate that Ethiopia is one of the countries that have been affected by price surges following the global economic crisis.

One of the mechanisms through which global commodity prices transfer to domestic food prices is due to high correlation between agricultural and highly volatile energy markets. Transportation fuel cost is at least one channel by which agricultural and energy markets are

[2]Real prices are calculated based on food consumer price index with December, 2006 as a base year.

linked. A related issue studied in Paper 4 is whether there are any price linkages between fuel and food grain prices, using the case of Ethiopia.

2.2. Malawi

Achieving food security has been a fundamental policy priority of the Malawi government. Maize remains the most important food crop in the country's food security policies and strategies. Maize is a major consumption good (172 KG per person per year and 60 to 70 percent of dietary calorie intake), a major part of production (90 percent of farm households and 60 percent of total cultivated land), and is also the dominant staple food crop in the country (Ellis & Manda, 2012; Fisher & Lewin, 2013). Pronounced maize production shortfalls and volatility mainly result from heavy reliance on rainfed production. On the other hand, imports have failed to adequately compensate for national production shortfalls. Malawi's overall export potential is very limited, which results in insufficient foreign currency availability for food imports (Harrigan, 2008). Besides, external trade is restricted due to government trade policy and barriers.

The maize market in Malawi is known to be heavily influenced by the government, operating through parastatals the Agricultural Development and Marketing Corporation (ADMARC) and the more recently established National Food Reserve Agency (NFRA). ADMARC is mandated to stablize prices and mobilze surpluses for export (Minto, 2014). Its role in Malawi's maize econonomy has declined with the private sector increasing in its importance in the past few decades. However, it still is a key instituion in maize trade and in the delivery of subsidized fertilizers to farmers, whilst NFRA manages a strategic grain reserve (SGR) and provides a social safety net. In parituclar, its role was again enhanced during the recent food cirsis (Minot, 2014).

As shown in Figure 4, maize production in Malawi declined sporadically by 32% in early 2000s caused by erratic rainfall. The country faced a severe famine in 2001/02 that resulted in significant loss of lives from hunger. The drop in production reached a lowest level of 1.2 million tons in the 2004/05 season, mainly due to poor rainfall and delay in the implementation of the expected fertilizer subsidy program (Minot, 2010). However, from 2005/06 onwards, maize harvest has improved tremendously, due to a combination of favorable weather conditions and the introduction of a large-scale agricultural subsidy on the cost of seeds and fertilizer under the program called the Farm Input Support Program (FISP) since 2005/06. The program has increased the affordability and profitability of modern input applications to smallholder farmers, thus has successfully increased maize production and productivity, as well as improved food security through increased real wages and reduced food price (Dorward & Chirwa, 2011). However, the rise in international fertilizer and domestic maize prices observed in recent years reduced the food security impact of FISP (Dorward & Chirwa, 2011).

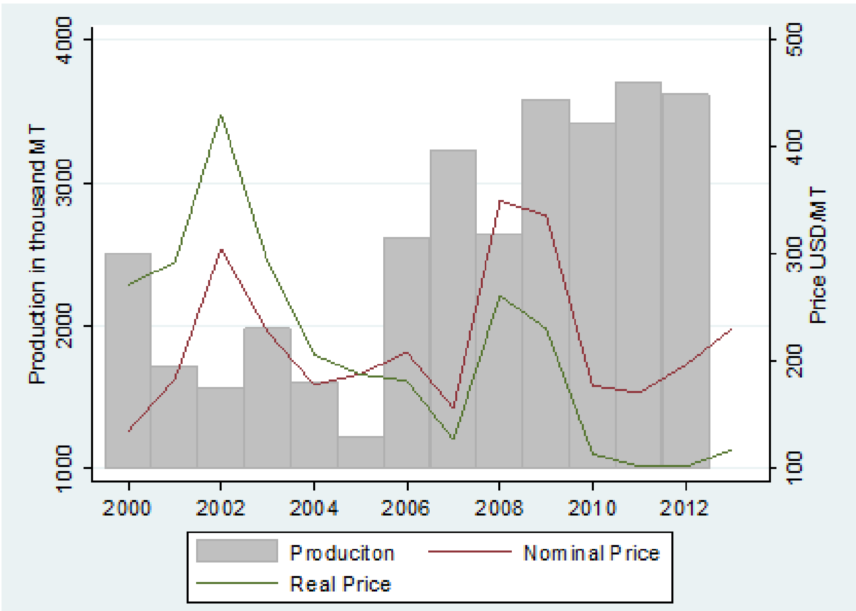

Figure 4 Maize production and retail price (Lilongwe) in Malawi (2000-2012/13).

Malawi experiences substantial maize price instability that adversely affects the food security situation in the country. In fact, maize prices in Malawi are much more volatile than international prices and compared to other SSA countries (Minot, 2010). Overall, Malawi faced four major maize price spikes in the 2000s: 2002, 2006, 2008 and 2009 (Figure 4). Different explanations have been given about these price events. The first two correspond to domestic maize production shortfalls in 2001/02 and 2004/05. When harvest dropped below average in a certain year, prices spiked in the following market year. On the other hand, the price spikes in 2008 and 2009 occurred following years of good maize harvests. Due to surplus for the 2008 market season, the government issued tenders committing to export overestimated amount of maize to other countries in the southern Africa (Minot, 2010; Chapoto & Jayne, 2009). However, the government opted to ban maize exports after the observed rapid increase in maize price. With another bumper harvest for the 2009 market season, prices again escalated. This time the government responded by banning private maize traders claiming high prices were due to private hoarding (Minot, 2010). This ban was later replaced with price ceiling, though the market prices increased outside the range. As more good harvest years succeeded, the government lifted the ban on private maize exports and also prices declined below the ceiling (Minot, 2010), however, remained above the period before the 2007/08 food crisis on average. In addition, the maize price falls in 2003, as well as, in 2006 and 2007 occurred since the government decided to sell some of its accumulated stocks despite a good production, and since the government banned exports despite the above average harvest, respectively (Chapoto & Jayne, 2009). These interventions depressed maize prices to low level that became disincentive to producers.

In sum, the price episodes in the 2000s show maize price instability remains a major challenge, with important implications on food security situation of the country. At the same time, the government attempts to stabilize maize price through pricing, marketing and trade policy instruments- most of which appeared to be implemented in ad hoc and unpredictable ways that created uncertainty among market actors and price variability in maize market. To that end, Paper 3 in this thesis touches on aspects of trade policy instruments in Malawi, by examining cross-border food market integration between Malawi and its neighboring countries. The following sub-sections motivate the topic examined with this regard.

2.2.1. Cross-border market integration

As described above, maize market in Malawi is known to be influenced by ad hoc government operations and trade bans and changes in tariff rates, which usually distort incentives of private traders to engage in external trade. In particular, maize imports and exports are constrained by episodically implemented government's legislation, licensing, and trade policies. With the objective of price stabilizations, the government regularly bans export of maize, as well as imports maize through its parastatals and operates in competition with private trader. These trade barriers notwithstanding, data from FEWSNET has shown smaller-scale traders operate in informal CBT between Malawi and its neighboring countries (Mozambique, Tanzania and Zambia) in the past decade. In fact, informal CBT has helped cope with shortage of domestic supply in Malawi during the production shortfall episodes of the 2000s (Ellis & Manda, 2012). This underlines the price stabilization and thus food security role that CBT potentially plays in these economies. At the same time, the extent to which the benefits from CBT can be exploited depends on how well integrated local border markets are with neighboring border markets. Understanding spatial price relationship guides policy interventions that help to reduce transaction costs associated with trade barriers, and to develop more stable and reliable trading networks. In view of this, Paper 3 in this thesis investigates cross-border market integration using the case of Malawi and its neighboring countries.

3. Data and method

Papers in this thesis use panel and time series datasets compiled from a range of secondary sources. Statistical and econometrics methods applied varies based on data used and research questions addressed in the specific papers.

The first two food aid related papers are based on a newly constructed panel dataset associated with Ethiopia's Productive Safety Net Programme (PSNP). The data covers four major regions in the country: Tigray, Amhara, Oromia, and Southern Nations and Nationalities People (SNNP) and three major cereals, *teff*, maize and wheat. Data for Paper 1 include monthly producer prices, food aid, cash transfers and rainfall, as well as annual production and population data extending from January 2007 to December 2010 from 37 zones. The analysis is based on systems of seemingly unrelated regressions (SUR), one equation per crop, using a Least-Squares Dummy-Variable (LSDV) estimator. It is expected supply and demand shocks that affect one crop to simultaneously affect the other crops, SUR is therefore appropriate given the assumption of correlation across the error terms for each crop in the system. Further, Paper 2 is based on annual dataset observed at the *woreda*-level from 2005 to 2010. The panel is unbalanced covering 109 to 215 PSNP *woreda*'s. Variables include food aid, population, rainfall, production, area, improved seed use and chemical fertilizer used. Regressions for three major crops, *teff*, wheat, and maize are estimated separately using the Arellano-Bond generalized method of moments (GMM).

Sources for the food aid data are the Ethiopia's Disaster Risk Management and Food Security Sector, Ethiopia's Food Security Coordination Bureau, and the World Food Program, whilst cash transfer data come from the Ethiopian Ministry of Finance and Economic Development. Production, area and input uses, price and population data come from Ethiopian Central Statistics Agency (CSA). Rainfall data come from the National Meteorological Agency of Ethiopia.

On the other hand, the third and fourth papers analyze market-level price series. Paper 3 is based on monthly retail maize prices from major and border markets of Malawi, as well as from border markets of Zambia and Mozambique and nominal wholesale prices from Tanzania. The data span from January 2004 to December 2012, providing 108 observations. We consider 19 urban center and border markets from Malawi, as well as 2 markets from Tanzania, 3 from Mozambique and 2 from Zambia that are close to borders of Malawi. Since some price series start too late or end too early, the time period covers all series that have the same length. Johansen likelihood-based cointegration procedure is used for analysis. Data sources are FEWSNET for maize price data and IMF's International Financial Statistics database for exchange rates.

Paper 4 analyzes monthly prices from July 2001 to June 2013, which is a total of 144 observations. Domestic retail prices from Ethiopia comprise of three major food crops, *teff*, wheat and maize and two fuel prices, benzene and diesel. The corresponding world prices include crude oil price that are the equally weighted average of Brent, Dubai, and West Texas Intermediate spot prices, maize price for number 2 yellow maize, f.o.b. at US Gulf ports and wheat price for number 2 soft red winter export price delivered at the US Gulf port for prompt or 30 days shipment. Analysis is based on vector error correction model (VECM) and constant conditional correlation, a class of multivariate generalized autoregressive conditional heteroskedasticity (CCC-MGARCH) model. Data sources are Ethiopia's CSA for domestic prices and World Bank Global Economic Monitor (GEM) commodity price database for the international prices.

As can be seen from above, most papers in this thesis are based on geographically and temporarily detailed data, compiled from various secondary sources. This has made the data generation process very challenging. Maximum effort was devoted to carefully compiling data from various sources and aggregating these data to the appropriate and feasible level of analysis. Data were also checked for any inconsistencies by applying the standard statistical procedures. That most data used here were obtained from government sources may introduce uncertainty about reliability, due to the politically-sensitive nature of statistical information, especially regarding food aid, food prices and food production/area planted. No tangible base was found to objectively challenge this concern. Although one might ideally compare data on the same variables from alternative sources, such opportunities are rare because there is often only a single reporting agency. Additionally, the limited capacity and resources of government institutions to produce quality standard data is an ongoing challenge in Ethiopia and Malawi, as in SSA in general. However, this concern can be fairly refuted by providing detail background information on data and sources. After all, measurement error in data is significantly correlated with quality of the operation at each stage of the data collection and processing.

Ethiopia's CSA-the source for producer and retail prices, agricultural production, area, input uses, and population data from Ethiopia-has been mandated to conduct, produce, disseminate and administer survey and censuses data in Ethiopia since its establishment in 1960. Recognizing the growing demand for statistical data in the country, CSA claims to increasingly improve the scope and coverage of surveys, as well as the quality standards of data collection and processing.[3] Data are collected by CSA enumerators who permanently live in the enumeration areas (EAs) (Taffesse, et al., 2011). Data collection and processing are managed by the head office and 25 branch offices covering all the regions in the country. To ensure the quality of survey data, CSA implements systematic data validation processes.

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[3] All the details with sampling design, data collection, and data processing are provided on the relevant CSA survey reports, available from http://213.55.92.105/nada4/index.php/catalog.

In particular, producer and retail price data are based on the monthly Ethiopian agriculture producer and retail price surveys[4]. These data are the basis for calculating consumer and producer price indices in the country. Retail prices are collected for about 400 consumption products in 119 markets from representative urban centers, and agricultural producer prices are collected for 99 agricultural products from a total of 446 EAs from all the regions in Ethiopia .[5] For each item, a maximum of three price quotations are collected from three different traders, retailers, and consumers for retail prices, as well as from private peasant households and producers' cooperatives for producer prices. Prices analyzed in this thesis are average of the three sources for selected markets for retail prices, and for selected zones for producer prices, by each item considered. To my knowledge, CSA is the only source of retail and producer price data in Ethiopia, at least for the spatial and temporal range of data required here.[6]

On the other hand, agricultural production data is available from at least two sources: the Ministry of Agriculture and Rural Development (also reported by FAO) and CSA. Comparison of agricultural production/area data from the two sources show negligible differences when considering ten years average since 1990s (Taffesse, et al., 2011: Table 3.1). All agricultural production related data in this thesis are based on CSA's Agricultural Sample Survey.[7] One of the four components of this survey, *Meher* (the main season) season post-harvest survey, provides information including, area and production, land use, farm management and crop utilization. The survey covers more than 2,000 EAs from the whole rural parts of the country, with the exception of Gambela and the non-sedentary population in Afar and Somali regions. From each EA, usually 20 to 30 farm households are selected.

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[4] Monthly retail and producer price surveys started in 1963 and 1981, respectively.

[5] According to CSA, EA covers less or equivalent to a farmers' association with an average 50 to 200 households. Thus, it is defined below region, zone, *woreda* and farmers' association.

[6] Except that wholesale prices can be obtained from EGTE.

[7] This survey started in 1980/1981.

Enumerators collect data by interviewing selected agricultural holders and physically measuring their fields to obtain data on crop area and production. Thus, data is observed at field level for each agricultural product. Related variables analyzed in this thesis are simply aggregated by zone (Paper 1) and by *woreda* (Paper 2) for the three crops studied. Last, population data is from CSA's annual population projection based on its recent national population and housing census conducted in the entire country.

Food aid and cash transfer data come from government agencies and WFP. In the past, these institutions faced difficulties in properly documenting and adequately administering the collection of emergency food aid data. This was essentially due to limited demand for reporting the data, at least at lower geographical levels. However, PSNP data is well documented and recorded, mainly for assessing and reporting performance of the program to stakeholders. Besides, during the time these data were obtained, systematic data recording processes were put in place in collaboration with WFP.

Turning to Malawi and neighboring countries, maize price data come from FEWSNET. This institution collects staple food price information from various national ministries of trade and agriculture in order to prepare its monthly price bulletin, among others. It is worth to note that even though the selected markets are located along borders, they are at the same time important markets locally. Given the shape of the map of Malawi, even the locally important markets are very close to border and are accessible to informal maize traders from across bordering countries. Therefore, price data for the selected markets have been fairly available.

Against this backdrop, secondary data used in this thesis are assumed to be dependable and reasonably accurate, and to constitute the best data available at present for the analysis of interest. In instances where data show inconsistencies, such as missing values and outliers, necessary steps have been pursued to correct these errors. Specific details are provided in the data sections of the papers. Although no objective estimate of measurement error in these data is available, the analysis proceeds under the assumption that such errors are tolerably small, idiosyncratic, and not likely to significantly affect the reliability and accuracy of parameter estimates, or the conclusions and policy implications drawn from the results.

4. Summary of main findings

This thesis presents four independent research papers. Below are brief summaries of the major findings from each paper.

Paper 1: Food aid, cash transfers and producer prices in Ethiopia

This paper contributes to on-going research regarding the potential impacts of food aid and cash transfers on producer prices in local markets in Ethiopia. We find no compelling statistical evidence in support of the hypothesis that PSNP and relief food aid have distorted grain prices. Once we control for possible factors contributing to food price changes, such as seasonality and rainfall, we are left with patterns that do not strongly point to disincentives at the household level, either for crop production or provision of labor. We find some evidence that cash transfers have exerted upward pressure on prices, especially for *teff*. Furthermore, conditioning food aid and cash transfers either on seasonality or on production levels does not alter the basic patterns observed. Revealed correlations between prices on the one hand and seasonal changes and time trends on the other are larger and stronger than those observed between prices and policy interventions.

Paper 2: Food aid and grain production in Ethiopia

This paper contributes to the contested debate regarding the relationship between food aid and production. We find no compelling statistical evidence in support of the hypothesis that PSNP and relief food aid decrease production. Controlling for the underlying factors affecting production (such as rainfall, chemical fertilizer used and improved seed uses), we conclude that the available evidence does not strongly point to disincentives that could possibly arise from market price effects or labor reallocation effects of food aid programs. Furthermore, we show that low levels of rainfall trigger both PSNP and a relief food aid allocation, suggesting that aid is responding in a sensitive manner to local growing conditions. On the other hand, level of production is not a major determinant to food aid allocation.

Paper 3: Cross-border maize market integration: The case of Malawi and its neighboring countries

In this paper, we examine to what extent markets are integrated across borders to exploit the benefits from CBT. Overall, results show integration of intra-regional markets within Malawi and also integration between border markets of Malawi and its neighboring countries, especially of those in Mozambique. Findings imply the potentials for regional maize trade between Malawi and the surrounding countries. Given that border markets are well linked both within Malawi and across border, we observe that CBT has expanded the size of the markets for maize traders in the country, facilitating inflows during shortage and outflows during surplus times. Although existing trade barriers have not stopped informal CBT among these countries, they potentially distort prices for both producers and consumers by increasing transaction costs. This implies the need for policy responses that deal with barriers to trade that prevents positive returns from regional trade.

Paper 4: Relationship between fuel and grain prices: The case of Ethiopia

This study contributes to current literature on the potential source of food price spikes and volatility, by examining whether fuel prices are linked to staple food prices, through effect on transportation cost. Results show strong price transmission and volatility correlation between world crude oil and AA benzene/diesel prices, as well as AA and other-local market fuel prices. Most important, AA maize and wheat prices do respond to world crude oil price and the corresponding world grain prices. However, *teff* prices do not adjust to world commodity prices examined. For both wheat and maize, results indicate higher long-run transmission elasticity from world grain prices than from world crude oil prices. However, results imply that the price volatility arising from world crude oil and world wheat/maize markets are not associated with the corresponding local markets in Ethiopia. Exception is maize price in AA, which shows volatility association with world crude oil. Turning to domestic markets, there is a strong price transmission from AA to all other-local fuel markets considered, which was also evidenced by high volatility association between these prices. On the other hand, it is found that local fuel price shocks do not transmit to local grain prices. The transmission from AA to other local *teff*, wheat and maize prices is rather significantly important, approaching close to unity in long-run equilibrium. Similarly, the volatility of *teff*, wheat and maize prices in the local markets are strongly linked with the volatility of *teff*, wheat and maize prices in AA, but not with the volatility of benzene (diesel) prices of the same markets. Overall, findings vary among crops examined, but there are no apparent spatial differences.

5. Contribution

Overall, this thesis seeks to improve our understanding on how staple food grain prices respond to domestic and international commodity price shocks and government policies in SSA, by taking the case of Ethiopia and Malawi. Major contribution in this thesis is empirical. I provide new policy insights by empirically assessing very relevant and timely topics based on newly own constructed and highly detailed data.

Paper 1 and Paper 2 contribute to the ongoing debate regarding the market and production effects of food/cash transfer in developing countries. I do this by studying one of the largest safety net programs in SSA. These papers are based on panel data covering all PSNP districts in four major regions of the country. In particular, results are derived from data that correspond to the period after the introduction of PSNP and during food price crisis. This enables wider assessment of these long standing issues than has been possible in the past. An additional strength of the analysis is that it is based on more highly disaggregated data across space and time than most past studies. Thus, these papers aim to provide a broad analysis of incentive/disincentive debate using a more detailed dataset and a more complete analysis than past studies.

Paper 3 examines an important policy issue that has not been adequately addressed before, to my knowledge. Past studies of market integration in SSA have mainly focused on analyzing market integration at an intra-country level, with very few studies evaluating how well integrated or efficient the maize markets are at regional levels. On the other hand, CBT remains important due to its potential to promote food security, enlarging market for food grain exporter and by reducing prices for food grain importer countries. Thus, understanding integration of border markets is important toward informing policies that help exploit the important benefits of regional trade in SSA.

Finally, Paper 4 deals with a contemporary issue regarding international commodity price transmission. Despite many recent studies examine the different channels through which energy prices affect agricultural commodity prices, most researchers have not paid sufficient attention to the transport cost effect of oil price shocks on agricultural commodity prices. Additionally, this study is important due to limited rigorous empirical studies on the potential source of food price spikes and volatility in Ethiopia. Most of the explanations on the current staple food price trends and instability in the country are based on logical reasoning rather than any strong empirical findings. Thus, this paper attempts to increase our understanding and inform policy on related issue.

6. Overall conclusions and policy implications

This thesis covers topics that examine food grain prices in SSA, taking the case of Ethiopia and Malawi. Even if it is difficult to come up with a single conclusion and implication, the following are drawn from the individual studies. First, it appeared that food and cash transfers are sufficiently well-targeted and timed overall in the PSNP *woreda's* in Ethiopia over the period examined, and that any unintended effects on local price and production are negligible. Thus, it implies that popular policy interventions, such as food aid and cash transfers, may not necessarily disrupt markets and undermine production incentives if well designed and properly implemented.

Second, CBT enlarges the size of the markets for traders along the border of the countries, facilitating inflows during shortage and outflows during surplus times. This implies CBT plays an important role for price stabilization and thus food security in trading countries. At the same time, even though existing trade barriers have not stopped informal CBT among countries, they potentially disrupt markets and thus traders' incentives by increasing transaction costs. This is primarily of concern given governments' responses to stabilize prices in the recent global food price crisis mainly involves ad hoc trade policy changes that adversely affect external trade. Thus, policy interventions addressing barriers to trade are necessary toward ensuring food security benefits from regional trade.

Third, despite steady agricultural production and productivity growth in recent years, food price shocks posed a major threat to food security in SSA. Thus, more empirical studies should explore emerging factors that potentially explain food price movements in SSA. To that end, it was found that world oil price exert influences on local food grain prices in Ethiopia. Thus, policy makers should consider international oil shocks as one of the drivers of domestic food grain prices.

Fourth, overall, the performance of food markets in Ethiopia and Malawi has increased in terms of internal and external price transmissions. Domestic food markets are spatially well-connected with the international and border commodity markets. It is desirable that markets are linked by a process of arbitrage that potentially decreases commodity price differences between markets to the level of transaction costs and enables efficient product movements. However, it at the same time implies that domestic food markets are more exposed to external shocks. In light of the recent high and instable global commodity price trends, this should be of high concern to policymakers in SSA.

Last, market fundamentals do matter. Basic to the proper functioning of agricultural markets is the cost of doing business. Investments in public goods and infrastructure to reduce marketing and transaction costs are a central component of agricultural and economic development. Addressing market failures requires ongoing public commitment to investing in market infrastructure, market information systems, institutions, and agricultural extension systems that promote the functioning of viable staple food markets. Therefore, sustained progress depends on government policy and investments to improve the market fundamentals. Results reported in this thesis underscore this basic lesson of economic development.

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Appendix 1 Conceptual framework

To provide a structure for assessing the objectives of this thesis, I present a framework of potential transmission mechanisms through which issues raised in the research questions can affect food grain prices, following Ricker-Gilbert et al. (2013).

First, consider a producer aggregate supply function of food crop,

$$Q^s = Q^s(p^p, \mathbf{A}^s, \mathbf{Z}^s) \tag{1}$$

where, Q^s is food crop quantity produced; p^p is producer price of food crops; $\mathbf{A}^s$ is the vector of variables that indicate supply side agricultural policy interventions; and $\mathbf{Z}^s$ is a vector of other supply shifters, which mainly include rainfall shocks, modern input uses and seasonality.

Also consider an aggregate consumer demand function for food crops,

$$Q^d = Q^d(p^r, \mathbf{A}^d, \mathbf{Y}, \mathbf{Z}^d) \tag{2}$$

where, Q^d is food crop quantity demanded, p^r is retail price of food crop, $\mathbf{A}^d$ is the vector of variables that indicate demand side agricultural policy interventions, $\mathbf{Y}$ represents farm and non-farm incomes and $\mathbf{Z}^d$ is a vector of other demand shifters, which include population and the prices of other goods.

The equilibrium retail food crop price can be vertically linked with producer price, p^p and also spatially linked with external (international or cross-border) food crop price, p^i. Thus, equilibrium retail food crop price is a function of producer price (p^p) and the marketing price margin ($M(\mathbf{Z}^r)$),

$$p^r = p^p + M(\mathbf{Z}^r) \tag{3}$$

where, $\mathbf{Z}^r$ denotes a vector of variables affecting the associated price margins, such as transport of fuel prices, handling costs, taxes and fees, etc Also, given prices of commodity in two spatially separated markets, p^r and p^i, allowing for market margin, $M(\mathbf{Z}^i)$, the relationship between these prices gives,

$$p^i = p^r + M(\mathbf{Z}^\mathbf{i}) \rightarrow p^i = p^p + M(\mathbf{Z}^\mathbf{r}) + M(\mathbf{Z}^\mathbf{i}) \quad (4)$$

where, $\mathbf{Z}^i$ denotes a vector of variables that affect the associated transfer costs such as transport costs, handling cost, etc, as well as any trade and marketing costs imposed by the government, such as import tariffs, export bans, import and export licensing fees, etc.

Market clearing condition is,

$$Q^s = Q^d \quad (5)$$

Then, plugging equation (1) to (4) into (5) and solving for p^r gives,

$$p^r = p^r(p^p, p^i, \mathbf{A}^s, \mathbf{Z}^s, \mathbf{A}^d, \mathbf{Y}, \mathbf{Z}^d, \mathbf{Z}^r, \mathbf{Z}^i) \quad (6)$$

The same way, solving for p^p gives,

$$p^p = p^p(p^r, p^i, \mathbf{A}^s, \mathbf{Z}^s, \mathbf{A}^d, \mathbf{Y}, \mathbf{Z}^d, \mathbf{Z}^r, \mathbf{Z}^i) \quad (7)$$

Equations (6) and (7) are reduced form models of retail and producer food crop prices, respectively. Several factors influence the extent to which the explanatory variables in the above equations affect food crop prices. Discussions below proceed mainly related to the topics examined in this thesis.

The first factor is the degree to agricultural policy interventions ($\mathbf{A}^s$ and $\mathbf{A}^d$) affect producer food crop prices. Some of these popular policy interventions include food aid programs, and input and output subsidy programs. Related to this, Paper 1 studies the impact of cash and food transfers on producer prices. Theoretically, a positive cash transfer shifts the demand for food outward that leads to an increase in price. On the other hand, food aid increases the supply of food in the local market, and thus prices may be depressed, ultimately creating production disincentives for local producers. Paper 2 extends from the first paper to directly test whether food aid has really discouraged production and area cultivated, through its price disincentive and through its labor reallocation effects. The latter is mostly if food aid is tied with food-for-work (FFW) programs. Theoretically, a negative supply response of food crop prices leads to negative effect of food aid on agricultural output. As well, if wage from FFW program is at least as much as returns from farm production, the farm household prefers to participate in the former, ultimately adversely affecting agricultural output.

Second, the models include international prices (p^i) that could affect domestic prices, through formal and informal trade. The inclusion of international price into the models enables to control for the level of spatial market integration and price transmissions. Important external prices of interest could be global commodity prices or cross-border food crop prices. In principle, spatial arbitrage ensures that the difference between p^i and p^r (p^p) is only by an amount that is equal to transfer costs, leading to a condition when the Law of One Price holds and the domestic and international markets are said to be spatially integrated. However, factors affecting marketing margin between domestic retail/producers prices and international prices, $\mathbf{Z}^i$ include national and international level polices, such as import tariffs, export bans and levies. High tariff, taxes and bans reduce arbitrage opportunities and discourage trade. In relation to this concern, two issues are examined in this thesis. First, Paper 3 investigates cross-border market integration and price transmissions. Second, part of the analysis in Paper 4 deals with price linkages between global oil/ food crop prices and domestic food grain prices.

Third, marketing margins ($\mathbf{Z}^{r}$) affect the relationship between producers and retail prices. Most market margins in SSA are affected mainly by transport costs, interest rates, and other transactions costs. And transport fuel costs constitute a significant proportion of total transportation costs in most cases in SSA. In this context, Paper 4 investigates the relationship between fuel prices and food crop prices, through their effect on transportation cost.

PAPER 1

Food Aid, Cash Transfers and Producer Prices in Ethiopia

Meron Assefa Arega
NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), Ås, Norway
+47 46268785 (phone); +47 64965701(fax); meron.arega@nmbu.no

Gerald Shively
Department of Agricultural Economics
Purdue University, West Lafayette, IN USA
+1 765 494 4218 (phone); +1 765 494 9176 (fax); shivelyg@purdue.edu
and
NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), Ås, Norway

ABSTRACT. We measure the producer price impacts of food and cash transfer programs in Ethiopia using monthly panel data from 37 zones in four major regions over the period January 2007 to December 2010. We study the independent and joint impacts of the Ethiopia's Productive Safety Net Programme (PSNP) and emergency relief programs on producers' prices for *teff*, wheat and maize. We estimate a series of dynamic, fixed-effects seemingly unrelated regression (SUR) models. Results indicate that food aid allocated both from PSNP and emergency relief programs have either no discernible correlation with subsequent prices or a weak negative correlation. This suggests no strong disincentive effect of food aid on agricultural producers. Cash transfers are positively correlated with prices slightly, especially those of *teff*. The magnitudes of the correlations between prices and seasonal and time trends are substantially stronger than those associated with cash and grain transfers to local markets. We argue that conditioning food and cash distributions based on season and levels of food production will further mute any adverse impacts these policy interventions might exert on local producers.

JEL classification: O13, Q11, Q18

Keywords: emergency relief, Ethiopia, food aid, LSDV, PSNP, seasonality, SUR

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1. Introduction

Food aid and cash transfers have long been popular public responses to food crises. Whether delivered through humanitarian or emergency relief efforts, or through national-level social protection programs, these efforts are seen as saving lives and protecting the livelihoods of famine- and drought-affected households, as well as those who are chronically food insecure. Nevertheless, the effects of these policy interventions on local food prices and their potentially deleterious impacts on local producers have been widely acknowledged, at least since Schultz (1960). Although both food aid and cash transfers can be viewed more generally as income transfers to recipients, from a conceptual point of view they may have different effects on food markets. For example, a long-acknowledged potential problem with food aid is that by increasing the supply of food in the local market, prices may be depressed, ultimately creating production disincentives for local producers and discouraging job-seeking among those in the labor force. On the other hand, cash transfers are seen as stimulating demand for food in local markets and thereby increasing food prices. While potentially beneficial to some producers, these higher food prices generally harm net-buyers and those not targeted to receive cash transfers.

In this paper we study the effects of food aid and cash transfers on food prices in Ethiopia, one of the most food-aid-dependent countries in the world. For decades, Ethiopia has experienced recurrent episodes of drought and famine, as well as severe chronic food insecurity. Food aid, especially emergency food aid, has been a typical response to both transitory and chronic food insecurity in the country, even during periods in which weather and market conditions were generally favorable. Overall, food aid distribution has averaged roughly 500,000 metric tons per annum over the past 20 years, and the ratio of annual food aid to cereal production has averaged about 6 per cent, within a range of 5 to 18 per cent.

Recognizing the need to strategically tackle food insecurity in the country, the government of Ethiopia launched the Productive Safety Net Programme (PSNP) in January 2005. By ensuring timely and predictable cash and/or food transfers to chronically food insecure areas of the country, the program seeks to prevent asset depletion at the household level, build asset stocks at the community level, and stimulate the growth and performance of agricultural and labor markets (MoARD, 2009). The two main components of the program are direct support for those who are vulnerable and unable to supply labor, and labor-intensive public work projects for those who can. PSNP participants receive payments in the form of cash, food or a combination of the two. The program covers more than 50 per cent of Ethiopia's *woreda's* [1]. These same *woreda's* also receive emergency relief food aid whenever transitory emergencies arise.

Food aid is delivered to the country in three ways: (i) direct transfers from a donor to Ethiopia; (ii) local purchases within Ethiopia; and (iii) triangular transfers in which donors deliver items purchased in another country as food aid to Ethiopia. Direct transfers have normally been the most popular mode of food aid delivery to the country. However, local procurement of food aid grain has become increasingly important, although controversial due to its potential effects on local markets for staples. In fact, as part of its price stabilization response during the 2007-2010 price spikes, the government suspended donors from locally purchasing food aid grains (Rashid, 2010). Our calculation using WFP database shows local procurement of cereal food aid amounted to an average of 16% of total cereal food aid delivered to the country during 2000 to 2012 (WFP, 2014).

[1] A *woreda* is an administrative unit, defined below region and zone, and roughly equivalent to district designations elsewhere.

Below we analyze the impacts of food aid and cash transfers on the prices of major grains using a dataset of our own construction. Monthly data cover three crops (*teff*, wheat and maize), 37 zones over the period January 2007 to December 2010. We use these data, in conjunction with a series of dynamic, seemingly unrelated regression (SUR) models to examine three issues. First, we directly test the disincentive hypothesis, asking whether observed levels of food aid, which are largely delivered in the form of wheat, have been negatively correlated with subsequent grain prices. Since, at various times, some PSNP districts have simultaneously received regular food aid as well as emergency relief food aid, we also compare the impact of "predictable" food aid arising from safety net programs with that of "unpredictable" food aid resulting from emergency relief efforts. Second, we test whether cash transfers have had discernible and differential correlations with grain prices, taking advantage of the fact that in some settings the PSNP transfers cash, in other settings food, and in some situations both. This gives us the opportunity to advance a comparative analysis of the differential impacts of cash transfers and food aid on prices, something that, to our knowledge, has not been attempted in the literature. Third, we test whether the impacts of cash and food aid are sensitive to seasonal considerations and underlying levels of domestic production.

An important consideration for any food aid study is that the price effects arising from a program's activities in any given location may be transmitted to other, non-program areas, particularly if grain markets are spatially integrated and if the markets covered by the program are large enough to influence prices in areas not covered by the program (Rashid & Taffesse, 2009). Past studies (Dercon, 1995; Negassa & Jayne, 1998; Negassa & Myers, 2007; Rashid & Negassa, 2011) have shown that cereal markets in Ethiopia are spatially integrated. As a result, one cannot ignore the potential spillover effects of government interventions such as the PSNP across markets. Furthermore, since more than half of the *woreda's* in Ethiopia have been directly affected by the PSNP, it seems plausible that the program could have indirectly affected markets not directly covered by the program. Accordingly, a major contribution of this study is the dataset we have assembled for the analysis. As Awokuse (2011) points out in his recent review of the food aid literature, one of the major challenges confronting many researchers has been the lack of appropriate spatially and temporally detailed data on food aid deliveries and cash transfers. As a result, many studies are conducted at a highly aggregate level both across geography and time. As examples, Tadesse & Shively (2009) used annual World Food Program (WFP) food aid shipment data to approximate monthly food aid allocation in Ethiopia, but were able to examine only three local markets. And in their study of Mozambique, Tschirley et al. (1996) were forced to use data from a period in which prices were highly affected. We overcome these data-related shortcomings by building up from detailed *woreda*-level monthly reports of food and cash transfers. By aggregating up from these data, we account for zonal-level confounders that may be correlated with both food aid and producer prices. Our analysis, which relies on a Least-Squares Dummy-Variable approach to control for zonal-level fixed effects, is specifically designed to account for such possibilities. We also account for seasonal patterns in prices, the underlying production levels of each crop, and any underlying price trends.

Results provide no compelling statistical support for the hypothesis that PSNP and relief food aid have negatively affected grain prices. However, we do find some evidence that cash transfers have exerted upward pressure on prices, especially for *teff*. The magnitudes of the correlations between prices and seasonal and time trends are substantially stronger than those associated with cash and grain transfers to local markets.

2. Background and framework

In an early paper, Isenman and Singer (1977) suggested that financial aid would likely be preferable to food aid in many instances to avoid the deliterious effects of food shipments on local prices. In contrast, using a highly stylized general equilibrium model, Lavy (1990) argued that the positive effect of food aid on overall economic activity tends to offset the negative price effects that are driven by additional supply in the domestic market. Similarly, Maxwell (1991) argued that, on net, food aid was likely to have a limited disincentive effect on prices and production. Bezuneh et al. (2003) used macro and household level data for sub-Saharan Africa (SSA) to show how food aid could create growth through income effects. Abdulai et al. (2005) showed that the disincentive effect of food aid disappeared after controlling for factors correlated with food aid receipt and production. This work is consistent with Lowder (2004) and Barrett et al. (1999) who report findings that food aid does not affect food production in recipient countries, but instead displaces food imports. Further, Levinsohn & McMillan (2007) argue that the welfare impact of food aid resulting from low prices depends on whether the recipient households are net buyers or net sellers of the crop. Using household data from Ethiopia, they find that the net benefit from lower food prices as a result of food aid distribution is disproportionately higher for poorer households who are also net buyers of wheat as compared to those who are net sellers.

In contrast, market level studies for Ethiopia and Mozambique, by Tadesse & Shively (2009) and Tschirley et al. (1996), respectively, provide support for the hypothesis of a disincentive effect. Tadesse & Shively (2009) show that, beyond a threshold level of imports, food aid shipments reduce prices in producer and consumer markets. Tschirley et al. (1996) argue that the availability of food aid in the form of yellow maize, provided at prices below import parity, created disincentives to producers and traders in Mozambique, and undermined investments in white maize production and marketing. However, in a more recent study, Zant (2012) uses simulations to show that whether the food aid impacts on production of a staple are positive or negative mainly depends on the share of domestic food production in total staple food demand and the share of income from sample food production in total household income. Using a district-level panel from the Malawi maize market, he finds no support for a negative impact of food aid on maize market prices and production. Instead, the results suggest a small positive impact of food aid on prices and production.

Renewed concern regarding the potential price effects of cash transfers has been triggered by recent increases in global food prices. Moreover, the relative effectiveness and impacts of transferring cash versus in-kind aid remain important subjects for policy study and intervention in Ethiopia. Sabates-Wheeler & Devereux (2010) compare the advantages and disadvantages of cash versus food aid deliveries using two rounds of household data, concluding that cash transfers are generally favored, but that food transfers or cash plus food have greater effects on income growth, livestock accumulation and food security. There are several reasons why observers have tended to favor cash transfers. First, cash transfers may be more cost-effective to deliver than food aid, since food aid generates the costly logistical challenges of delivery and storage. For example, Gelan (2006) found that by saving on logistics costs, cash transfers resulted in larger positive gains in household welfare in Ethiopia than direct food aid. Second, cash may more reliably stimulate production and support market development. However, in some settings cash transfers have been found to result in price hikes that undermine the welfare of those who do not receive cash transfers. As an example, Kebede (2006) studied cash transfers in two districts covered by Ethiopia's PSNP and found that shifting from food to cash transfers had implications for targeting and food prices in local market, observing that cash transfers affected prices even in areas not covered by the safety net program.

To provide some structure for assessing these competing forces, we begin with a framework to understand the potential supply and demand effects of food and cash transfers on local markets. Impacts depend on a number of factors, including the amount of cash or food that are provided, the own and cross-price elasticities of food demand, income elasticities of demand, and the overall degree of market integration and price transmittal across space. We introduce food aid and cash transfers into the standard demand and supply functions for food, and show how equilibrium market prices change given a shift in demand, supply or both, as a result of food and cash transfers in the domestic market.

We assume aggregate demand for food (Q^D) is a function of own price (P), income (Y), and demand shifters (Z^D). The latter includes population and the prices of other goods. The aggregate supply of food (Q^S) depends on own price (P), food aid (A), and supply shifters (Z^S). These shifters include rainfall shocks and seasonality. We introduce food aid directly into the supply function since the additional supply of food to the local food market is translated into net sales of food aid in the market. Food aid may also enter into the income equation because it increases household income. Induced changes in market demand for food arise from induced increases in household food demand due to cash transfers added to income. Thus, cash transfers affect household demand through income, which consists of farm income ($P \times Q^S$), the monetary value of food aid ($P \times A$), cash transfers (C), and other non-farm income (R). The equilibrium system is then formulated as equations (1) to (4):

$$Q^D = D(P, Y, Z^D) \tag{1}$$

$$Q^S = S(P, A, Z^S) \tag{2}$$

$$Y = P \times Q^S + P \times A + C + R \tag{3}$$

$$Q^D = Q^S \tag{4}$$

Total differentiation of the above equations yields:

$$dQ^D = \frac{\partial Q^D}{\partial P} dP + \frac{\partial Q^D}{\partial Y} dY + \frac{\partial Q^D}{\partial Z^D} dZ^D \tag{1'}$$

$$dQ^S = \frac{\partial Q^S}{\partial P} dP + \frac{\partial Q^S}{\partial A} dA + \frac{\partial Q^S}{\partial Z^S} dZ^S \tag{2′}$$

$$dY = dPQ^S + dQ^S P + dPA + dAP + dC + dR \tag{3′}$$

Log-linearization of equations (1′) to (3′) provides a set of equations expressed in terms of shares and elasticities:

$$\dot{Q}^D = \mathrm{E}_P^D \dot{P} + \eta \dot{Y} + \mathrm{E}_Z^D \dot{Z}^D \tag{1″}$$

$$\dot{Q}^S = \mathrm{E}_P^S \dot{P} + \mathrm{E}_A^D \dot{A} + \mathrm{E}_{Z}^S \dot{Z}^S \tag{2″}$$

$$\dot{Y} = \alpha_Q (\dot{P} + \dot{Q}^S) + \alpha_A (\dot{P} + \dot{A}) + \alpha_C \dot{C} + \alpha_R \dot{R} \tag{3″}$$

$$\dot{Q}^D = \dot{Q}^S \tag{4″}$$

where , $\dot{P} = \frac{dP}{P}$; $\dot{C} = \frac{dC}{C}$; $\dot{A} = \frac{dA}{A}$; $\dot{Q}^S = \frac{dQ^S}{Q^S}$; $\dot{Q}^D = \frac{dQ^D}{Q^D}$; and $\dot{Y} = \frac{dY}{Y}$ are rates of change in the respective variables, $\mathrm{E}_P^S > 0$, $\mathrm{E}_A^S > 0$ and $\mathrm{E}_{Z^S}^S > 0$ are supply elasticities with respect to price, food aid and other factors (such as rainfall); $\mathrm{E}_P^D < 0$ and $\mathrm{E}_{Z^D}^D < 0$ are demand elasticities with respect to price and other factors (such as population); and $\eta > 0$ is a food demand (income) elasticity. The terms $\alpha_Q = \frac{PQ^S}{Y}$; $\alpha_C = \frac{C}{Y}$; $\alpha_A = \frac{PA}{Y}$ and $\alpha_R = \frac{R}{Y}$ denote the shares of farm income, cash transfers, monetary value of food aid and other off-farm income in total income, respectively.

We are interested in how the rate of change in food aid ($\dot{A}$) and cash transfers ($\dot{C}$) affect the rate of change in the equilibrium price ($\dot{P}$) in the local market. Equations (1″) to (4″) can be used to derive the key relationships, which are:

$$\frac{d\dot{P}}{d\dot{C}} = \frac{\eta\alpha_C}{\mathrm{E}_P^S - \mathrm{E}_P^D - \eta(\alpha_Q + \alpha_A)} \tag{5}$$

$$\frac{d\dot{P}}{d\dot{A}} = \frac{\eta\alpha_A - \mathrm{E}_A^S}{\mathrm{E}_P^S - \mathrm{E}_P^D - \eta(\alpha_Q + \alpha_A)}\,. \tag{6}$$

Equations (5) and (6) show that the impact of cash and food transfers on prices depends on the signs and the magnitudes of the elasticity coefficients and also the shares through income and substitution effects. In equation (5) the numerator on the right hand side indicates the impact of cash transfers on prices due to an income effect. A positive cash transfer shifts the demand for food outward and, *ceteris paribus*, leads to an increase in price. In equation (6) the first term in the numerator on the right hand side shows the impact of food aid on prices due to an income effect, which is positive. The second term indicates the responsiveness of food supply in the local market as food aid deliveries increase, which could be positive or negative. The denominators in equations (5) and (6) indicate the effects of cash and food aid, which depend on how responsive prices are to demand, supply and income changes. If one assumes a negative price elasticity of demand and positive supply and income elasticities, then the total impact of changes in the denominators depend on the magnitude of the share of farm income and food aid in the household's total income. If the sum of these shares is sufficiently large, these effects will offset the combined effects of the supply and demand elasticities, leading to a positive denominator. In that case, the total net effect of equation (5) will be positive. And depending on the magnitude and the signs of the food supply responsiveness to change in food aid, the net effect of food aid represented by equation (6) can be positive or negative. As equations (5) and (6) indicate, the actual relationships cannot be easily signed, and depend on empirical realities.

3. Empirical strategy

We are interested in estimating the parameters of the model in equation (5) and (6) using a reduced form inverse demand function for three crops, *teff*, wheat and maize. Our unit of analysis is the price of crop *g*, observed during month *t* in zone *i*. We estimate systems of seemingly unrelated regressions (SUR), one equation per crop, using a Least-Squares Dummy-Variable (LSDV) estimator. In our case, we expect supply and demand shocks that affect one crop to simultaneously affect the other crops. SUR is therefore appropriate given the assumption of correlation across the error terms for each crop in the system. We allow lagged prices to enter the equations, thereby giving rise to a system of three dynamic regressions as follows:

$$\mathbf{P}_{\mathbf{git}} = \alpha_g + \mathbf{P}_{\mathbf{git}\text{-}l}\boldsymbol{\gamma} + \mathbf{A}_{\mathbf{git}}\boldsymbol{\beta} + \mathbf{X}_{\mathbf{git}}\boldsymbol{\lambda} + \boldsymbol{\mu}_{gi} + \mathbf{v}_{git} \quad i = 1,...,N;\ t = 1,...,T \text{ and } g = 1,...,G \tag{7}$$

In the g^{th} equation, α is a scalar intercept; $\mathbf{P}$ represents a vector of prices; l denotes the lag length, and $\boldsymbol{\gamma}$ is a vector of parameters to be estimated. $\mathbf{A}$ denotes a ($n \times k$) matrix of food aid related variables, where $n = N \times T$ and k is the number of variables. These include monthly per capita PSNP food aid allocation, relief food aid allocation and quarterly cash distribution; and the interactions of each with a measure of production and a binary indicator for season. The primary item of interest for this study is $\boldsymbol{\beta}$, a vector of parameters to be estimated. These measure the marginal impacts of food aid and cash transfers on local prices. $\mathbf{X}$ is a ($n \times k$) matrix of other exogenous control variables. These include annual population, annual production, monthly rainfall, a binary indicator for the harvest season, and a unit-step time trend; $\boldsymbol{\lambda}$ is a vector of parameters to be estimated; $\boldsymbol{\mu}$ is unobserved individual zone level effects and $\mathbf{v}$ is a white noise disturbance such that $E(\mu_i) = 0$, $E(v_{it}) = 0$ and $E(\mu_i v_{it}) = 0$.

Equation (7) represents a dynamic panel model, which specifies the dependent variable, P_{it} as a function of its values in previous periods P_{it-k}. We know that P_{it-k} is correlated with the unobserved individual effect, μ_i by construction. Because OLS estimation of the equations in the system produces inconsistent parameter estimates of equation (7), we estimate the system using LSDV. This method requires that we first remove μ_i using individual dummies as represented by equation (8):

$$\mathbf{P}_{\mathbf{git}} = \mathbf{P}_{\mathbf{git}\text{-}l}\boldsymbol{\gamma}_g^{'} + \mathbf{A}_{\mathbf{git}}\boldsymbol{\beta}_g^{'} + \mathbf{X}_{\mathbf{git}}\boldsymbol{\lambda}_g^{'} + \mathbf{D}_{\mathbf{git}}\boldsymbol{\eta}_g^{'} + \mathbf{v}_{\mathbf{git}}^{'} \tag{8}$$

where in the g^{th} equation, $\mathbf{D} = \mathbf{I_n} \otimes \boldsymbol{\iota}_\mathbf{T}$, is a matrix of zone specific dummies; $\mathbf{I_n}$ is an identity matrix of dimensions N; $\boldsymbol{\iota}_\mathbf{T}$ is a vector of ones of dimension T, and $\otimes$ denotes the Kronecker product. All other notation is the same as described in equation (7).

It has long been recognized that for a panel with large N and small T the use of fixed effects in combination with lagged dependent explanatory variables can lead to inconsistent estimates. This is commonly referred to as the "incidental parameter" problem. Monte Carlo evidence shows that the fixed effects approach achieves consistency as $T \to \infty$ (Baltagi, 2005; Bruno, 2005; Bun & Kiviet, 2001; Kiviet, 1995). In our case, with T=48 and N=37, we have a somewhat smaller N and substantially larger T than are typically encountered in empirical studies. We therefore rely on the asymptotic properties of the fixed-effect estimator and proceed under the assumption that bias, if any, associated with the use of the dynamic panel estimator is likely to be small. An additional consideration is that LSDV estimators usually suffer from a large loss in degrees of freedom, due to the inclusion of extra parameters in the model. However, for the current sample we employ a large number of observations ($N \times T$ = 37 × 48=1776), so that the inclusion of individual dummies for zones does not result in a large loss of degrees of freedom. As further confirmation that our approach is justified on statistical grounds, we tested for unit roots in all of the real producer price series using the Im–Pesaran–Shin (IPS) test (Baltagi, 2005). Results confirm that all the prices we consider were stationary over the period under study.

4. Data and sources

Our panel covers three major cereals, *teff*, maize and wheat. These crops are individually and jointly important in terms of both production and consumption of grains in Ethiopia. For example, in 2010 *teff*, wheat and maize represented 14, 17, and 25 per cent of grain production in the country, respectively. We observe prices for 48 consecutive monthly time steps extending from January 2007 to December 2010. We begin with data observed at the *woreda* (district) level. We focus on 252 *woreda's* that have been identified as chronically food insecure and therefore targeted for inclusion in the PSNP. These come from four major regions in the country: Tigray, Amhara, Oromia, and Southern Nations and Nationalities People (SNNP). However, because a large number of *woreda*-level prices are missing, we aggregate data from the 252 *woreda's* to 37 zones. We do so as follows. We first compute zonal average prices and rainfall amounts, as well as zonal sums of food aid and other exogenous variables using available data observed at the *woreda* level. Once we have the zonal aggregated values of these variables, we convert relevant quantities to per capita values by dividing the relevant indicator by the total population in the zone.

The variables used in our regressions include producer prices, relief food aid, PSNP food aid, PSNP cash transfers, production/rainfall, population, binary indicators for season, and a time trend. We also consider various interactions among season and production variables and the policy variables of interest, food aid and cash transfers. We compile data from a range of sources. Nominal monthly producer prices (in *birr*/kg) come from the

Ethiopian Central Statistics Agency (CSA).[2] We deflate these nominal prices using CSA's regional consumer price index, thereby controlling for general price increases in the country. We include in each regression a lagged value for the own price. We choose a lag length of three months determined using the Akakie Information Criterion (AIC).

Our primary policy variables of interest are the monthly per capita relief food aid allocation (in MT), the monthly per capita PSNP food aid allocation (in MT), and a quarterly measure of the per capita cash transfer to each PSNP *woreda* (in 1000 *birr*).[3] We include the current value of the food aid variables, as well as their one-month lags, and the current cash transfer, as well as its one-quarter lag. The lags allow us to capture any delays in delivery of food and cash to beneficiaries, and also some possible storage effects. Evidence in support of the disincentive hypothesis will be found in negative correlations between producer prices and PSNP/relief food aid. In contrast, positive correlations between producer prices and cash transfers undermine the disincentive hypothesis by indicating that cash injections increase local demand and raise prices. Sources for the food aid data are the Disaster Risk Management and Food Security Sector (DRMFSS), the Food Security Coordination Bureau (FSCB), and the World Food Program (WFP). Cash transfer data come from the Ethiopian Ministry of Finance and Economic Development.

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[2] In 2010, 1USD = 12.58 *birr*. Producer price data are based on the monthly Ethiopian agriculture producer surveys. These data are the basis for calculating producer price indices in the country. They are collected for 99 agricultural products from a total of 446 enumeration areas (EAs) from all the regions in Ethiopia . For each item, a maximum of three producer price quotations are collected from private peasant households and/or producers' cooperatives. Prices analyzed in this paper are a simple average of the three sources for each item within the selected zone.

[3]From a statistical point of view, a conceptually accurate way to deal with a model using variables observed in different time periods might be to use mixed (hierarchical) models that allow the variance structure to change with different time period nests. We acknowledge that, as estimated, the models may underestimate the size of standard errors on variables observed on a quarterly or annual basis, but at this time we are not aware of any straightforward way to estimate the chosen models using a hierarchical framework. This is left for future work.

To control for supply-side shocks we include in the regressions variables for current-year annual aggregate production for each crop (in MT) as well as one-year lagged values. By including the production variable in the model, we also control for other, less easily observed, supply side factors such as technology adoption. We believe this is an especially reasonable approach since data show that usage rates for chemical fertilizer, improved seeds and irrigation are very low for food crops in Ethiopia. Rather than work with the production values directly, we instrument the production variable to purge it of any endogeneity with food prices that originates from the correlation of food aid with production and rainfall. To obtain instrumented values we employ a random effects panel model, regressing annual production on average annual rainfall (in mm), average rainfall during the harvest season (in mm) and a series of binary indicators for years. Rainfall data come from the National Meteorological Agency of Ethiopia. Production data come from Ethiopia's CSA.[4] We expect a negative correlation between the instrumented production variables and prices.

To control for demand side effects on prices, we include annual current population (in 1000s). In general, we expect to find a positive correlation between population and prices. Population data come from the Ethiopian CSA's annual population projection, based on regional average population growth rates obtained from recent national population and housing census conducted in the country.

[4]Production data are based on CSA's Agricultural Sample Survey. One of the four components of this survey, the Meher (main season) post-harvest survey, provides information including area and production, land use, farm management and crop utilization. The survey covers more than 2,000 EAs from all rural parts of the country, with the exception of Gambela and the non-sedentary population in Afar and Somali regions. From each EA, 20 to 30 farm households are typical selected. Enumerators collect data by interviewing these families and physically measuring their fields to obtain data on crop area and production. As a result, data are observed at a field level for each agricultural product. Related variables analyzed here are simply aggregated by zone for the three crops studied.

We include a unit-step time trend variable to account for any underlying price trends during the time we consider. We also include a control for possible seasonal price changes by including a binary indicator equal to 1 during the primary harvest months (September through March) and 0 otherwise. We expect a negative correlation between the seasonal indicator and prices, since under normal circumstances prices tend to be lower during the harvest season.

Finally, in order to assess potential heterogeneity in the impact of food aid on food prices within seasons, or due to production levels, we include a series of interaction terms. These include interactions between binary season indicators and the food aid and cash transfer variables, as well interactions between current production levels and food aid and cash transfer variables. We generally expect to find positive correlations among price and aid interactions, and negative correlations between prices and cash interactions. This is because food aid delivered in the lean period or during periods of production shortfall, and cash transfers in the post-harvest seasons or during normal production periods should exert less influence on prices.

5. Results and discussion

Descriptive statistics for the variables used in the regressions are presented in Table 1. Figures 1 to 3 provide graphical representation of the price series under consideration. For the periods considered, the average producer price was highest for *teff* (4.2 *birr*/kg), followed by wheat (3.0 *birr*/kg) and maize (2.2 *birr*/kg). All prices declined slightly over the interval examined, with the highest prices recorded in mid to late 2007 (see Figure 1). This is a period when food price spikes were recorded in many parts of the world, including Ethiopia. The gaps between the nominal and real prices shown in Figure 1 reflect general price inflation in Ethiopia during this period. Coefficients of variation in prices calculated using the statistics provided in Table 1 indicate that price instability was highest for maize (50%) and lowest for *teff* (30%). Figure 2 further shows that prices fluctuate greatly for all crops. Figure 3 indicates that, on average, all prices follow a similar seasonal pattern. Pre-harvest prices (March through September) are higher than post-harvest prices (October through February).

Data in Table 1 indicate that the average monthly amount of PSNP food aid (0.73 kg/person) was roughly 70% greater than that of relief food aid (0.43 kg/person). The combined average total food aid allocation was approximately 1.2 kg/person in the PSNP area. Figure 4 illustrates that the annual food aid distribution accounts for a large share of production in the given areas. The average cash transfer is 11.15 *birr*/person/quarter. Per capita annual *teff* production in the PSNP districts average 33 kg, while similar figures for wheat and maize are 31 kg and 47 kg. Average monthly rainfall is about 76 mm, with a monthly maximum of 496 mm. Average population was 839,881 during the study period.

Table 2 contains regression results for three sets of regression systems. Model 1 consists of regressions that include the policy variables of interest, lagged own prices, Model 2 adds to these regressors a set of control variables for rainfall and production, seasonality, the unit-step time trend, and population. Model 3 is a long regression that adds to the control variables of Model 2 a comprehensive set of interaction terms. Table 2 reports point estimates and standard errors, as well as goodness-of-fit measures for each crop-specific regression. No near-perfect multicollinearity problems were observed in any of the models.

5.1. Do food aid and cash transfers affect the local market?

The primary policy variables of interest to us are PSNP and relief food aid allocations, and PSNP cash distributions. Model 1 employs these variables and provides cursory evidence regarding their importance. Most of the estimated coefficients indicate strong effects of food aid and cash transfers, both in statistical significance and magnitude. Current period and lagged food aid from relief programs are negatively correlated with prices. In contrast, current period food aid and PSNP cash transfers are positively correlated with prices. Wald tests of the joint significance of PSNP food aid, relief food aid, and PSNP cash transfers in explaining prices produce chi-squared statistics of 6.7, 8.7 and 7.2 for the three crops. The limited evidence provided in Model 1 therefore allows one to reject the null hypothesis of no policy effect on prices at the 90% confidence level.

To examine how robust these finding are to inclusion of important conditioning variables we turn to Model 2. Note that including 12 months of lagged production results in a loss of observations (from 1575 to 1260). As expected, we find strong evidence of seasonal patterns across all crops, with lower prices in the harvest season. We also find evidence of declining prices over the period covered by our data, especially for wheat and maize. We find no consistent pattern with respect to the correlations between prices and production or population. Higher output of maize is associated with lower maize prices, but higher production of *teff* is correlated with higher *teff* prices. Most important, we find that once we control for some of these exogenous factors, the policy variables decline in both economic magnitude and statistical significance. For all crops, the point estimates in Model 2 provide no evidence of a statistical link between prices and PSNP food aid, and both weak and mixed evidence regarding a statistical link between prices and relief food aid. Out of six estimated coefficients, two are significant, but of opposite signs: contemporaneous relief aid is positively correlated with the maize price, whilst lagged relief aid is negatively correlated with the *teff* price. In the case of cash transfers, however, evidence is somewhat more convincing and robust, and points to a positive correlation between current and lagged cash transfers and producer prices.

Although absence of evidence is not necessarily evidence of absence, we are left with the impression that, once we are able to control for the confounding effects that are likely correlated with both food aid distribution and prices, among them rainfall, production, seasonality and underlying price trends, most of the "observed" effects of food aid disappear. We find that neither contemporaneous nor lagged food aid allocations from the PSNP have statistically significant correlations with producers' grain prices. Relief food aid allocations may potentially be depressing the subsequent price of *teff* with some lag, and levels of food aid may be positively associated with contemporaneous maize prices, but relief food aid does not seem correlated with prices in the other cases we consider.

Under three plausible scenarios the theoretical model given by equation (6) suggests that food aid will have little or no impact on prices. These are defined by (i) a modest supply response to an increase in food aid (E_A^S); (ii) a small income effect associated with food aid ($\eta\alpha_A$); and (iii) a relatively large share of food aid and farm income in total income (α_A and α_Q respectively). In the first case, if food aid is delivered in a timely manner and well targeted to beneficiaries who are not in a position to produce, the responsiveness of food supply to an injection of food aid will be small, and will not exert downward pressure on price. The regression results show that relief food aid is in some cases negatively and significantly correlated with prices, but that PSNP food aid has either no price effect or a small positive effect. This is in line with our expectation that PSNP food aid is more predictable and carefully targeted than emergency relief food aid deliveries and is therefore less influential in the local market. In the second case, it could be that the income effect of food aid, $\eta\alpha_A$ is small, such that food aid does not induce an increase in household food demand sufficient to put upward pressure on prices. Of course, holding constant the income elasticity of food demand (η) of poor households, larger shares of food aid in total income (α_A) will generate larger income effects. Figure 4 shows that food aid as percentage of food production has been quite large, reaching 18% for *teff*, maize and wheat combined in 2009. This helps to explain the positive and significant food aid effects on prices that are observed in some cases. Given an assumption of low supply response to PSNP food aid, demand side effects will dominate. That is, the demand side effect of food aid as an addition to income offsets the supply side effect of food aid as an addition to the local food supply. However, relief food aid in some cases shows a negative association with prices, perhaps when its supply side effect dominates. In the third case, the impact of food aid could be small (and positive) if the share of income from staple food production and the share of food aid in total income are both sufficiently large to offset the price effects of food aid resulting from the price elasticity of demand and supply. For food insecure farmers, one would expect a large share of income to come from staple food production, and the share of food aid in total income to be large.

Tadesse & Shively (2009) and Zant (2012) show that the disincentive effect of food aid arises when the proportion of food aid in total food supply is large (greater than 10 percent in the case of Ethiopia and greater than 4.5% in the case of Malawi). To examine whether the effects of food aid on prices might be sensitive to the proportion of food aid in total food production, we estimate a variant of Model 3 that includes a variable for PSNP food aid as a share of food production.[5] These results are not reported here, but reveal a negative correlation between the PSNP food aid share and prices of *teff* and wheat. However, we find no evidence to support the hypothesis that results are sensitive to the share of relief food aid in total food availability.

On the other hand, the positive correlations between cash transfers and prices seem to be relatively robust, with an especially strong association in the case of *teff*. This result indicates that grain supply in the local market does not measurably respond to any increased demand arising from cash injections. However, the effect of cash transfers on maize and

[5]We also estimated an extension of Model 3 by including a quadratic term for food aid and cash transfers to determine any threshold or turning point. The results, which are not reported here, were weak and mixed.

wheat prices is weakened once we introduce the interaction terms (as shown by the parameter estimates in the last three columns of Table 2). Comparing the effects of cash transfers to those of food aid suggests that food aid may be a more appealing policy tool than cash transfers, since it does not appear to disrupt prices.

Comparing results across crops, we would expect the effect of food aid to be strongest in the case of wheat, since it is the food aid crop. However, we find the effect of food aid to be nearly uniform across all the crops we consider. The price of the one non-traded commodity in the group, *teff*, seems rather strongly influenced by both current and lagged cash transfers (at least in comparison to the internationally traded crops, maize and wheat). Given that *teff* is the most costly grain, and the preferred staple in most parts of Ethiopia, these results may reflect a pattern in which people buy more *teff* when their incomes rise, and less during periods of hardship. Demand side effects, in this case, may be much more important than supply effects.

The regression results further indicate strong negative correlations between the harvest season indicators and price changes (also shown in Figure 2). These negative correlations support the intuition that local prices fall in the harvest season and rise in the lean season. The estimated coefficients for maize and wheat show greater statistical significance than other variables included in our models, suggesting price variability is more sensitive to seasonality than to aid transfers.

5.2. Does conditioning on seasonality and domestic production alter the price effects?

Tadesse and Shively (2009) argue that the timing of food aid deliveries and cash transfers can exert a strong influence over the impact of these interventions on the local market. In principle, if food aid and cash transfers occur in response to production shocks, caused by either seasonal changes or production shortfalls, they will stabilize prices and the food supply in the market. Thus, seasonality and the level of domestic production are some of the factors that influence the timing of food aid and cash deliveries to beneficiaries. Under normal conditions, hunger prevails in the pre-harvest season, when markets are slow or unable to respond to demand, as compared to the post-harvest period. Thus, the price effects of food aid and cash transfers may be less pronounced if food aid deliveries occur during lean periods, and if cash transfers occur during the post-harvest season. In the same way, domestic food production shortfalls should motivate food aid deliveries, so that these augment rather than supplant local supply. And cash transfers should be sensitive to the domestic food production situation, so that cash infusions do not put too much upward pressure on prices by stimulating demand that cannot be satisfied out of domestic production. Unfortunately, however, poor timing of food aid deliveries and cash transfers is often unavoidable, due to administrative dysfunction, lags in food aid delivery from donors, or complex procurement and transportation bottlenecks.

Model 3 is designed to examine this issue. The last three columns of Table 2 correspond to Model 3, which includes all variables from Model 2 and also adds a set of six interaction terms designed to identify sensitivities in the potential effects of food aid and cash transfers to season or production level. Most of the main results from Model 2 carry over into Model 3, although some of the positive correlations between cash transfers and prices are weaker. Furthermore, we find no strong evidence that price effects are particularly sensitive to seasonality or production levels. From the entire set of 18 point estimates for interaction terms, only two are statistically significant. Moreover, for each crop, a Wald test of the joint significance of the six interaction terms also fails in every case. We surmise from the results of Model 3 that the correlations between program assistance and prices are unaffected by seasonality and domestic production levels, at least in the regions studied here and over the time period considered. We observe only a slightly significant positive correlation between maize prices and the interaction term of seasonality and cash transfers, providing weak counterintuitive evidence that cash transfers produce larger positive effects on maize prices when the transfer occurs during the harvest season.

6. Robustness check

To check the robustness of our results, we estimate Model 3 for the four regions separately. As shown in Table 3, overall most of the results fairly replicate Model 3, except in the case of one policy variable, PSNP food aid. Unlike before, we now find that lagged PSNP food aid is positively correlated with prices with some statistical significance for Amhara and Oromia regions, whilst a negative relationship arises with maize and wheat prices for SNNPR. The positive correlation indicates that the local grain markets are not able to distribute adequate quantities of grain without stimulating significant food price increases. However, we observe little or no effect of relief food aid on producer's prices comparable to Model 3. Out of twenty four estimated coefficients of current and lagged relief food aid, only four are statistically significant. Relief food aid allocation increases prices of wheat and maize in SNNPR and it has a depressing effect on the price of wheat in Oromia. We find no effect of cash distribution on producer prices in SNNPR; however, we observe statistically significant positive correlations of lagged cash distribution and prices of *teff* and wheat in Amhara; with price of *teff* for Oromia and with prices of *teff* and maize in Tigray. Thus, similar what we find in Model 3, the positive effect of delayed cash distribution on *teff prices* remains important (except for Oromia). We also observe comparable results of the other confounding variables included in the model. The coefficient estimates for the seasonality variable indicate that prices are lower in the harvest season for all regions, except in Amhara. Also *teff* prices in Oromia and SNNPR are not affected by seasonality. We also observe an overall negative trend in of prices, except for a few cases in which the point estimates are not statistically significant. As before, we observe inconsistent and mostly insignificant effects of production on prices. Considering the interaction terms, results are mixed and most coefficient estimates are not statistically significant.

7. Conclusions and policy implications

This paper contributes to on-going research regarding the impacts of food aid and cash transfers on producer prices in local markets. We studied one of the largest safety net programs in SSA, Ethiopia's PSNP. We used a newly constructed dataset based on monthly prices from January 2007 to December 2010 and food aid allocations observed at the zonal-level to estimate a series of fixed effects Seemingly Unrelated Regression (SUR) models. Using data that correspond to the period after the introduction of PSNP and contemporaneous with the recent food price crisis enables us to carry out a wider assessment of these long standing issues than has been possible in the past. An additional strength of the analysis is that it is based on more highly disaggregated data across space and time than many past studies.

We measured and tested the strength of correlations between food aid and cash transfers, and producer prices for three major grains produced and consumed in Ethiopia: *teff*, maize and wheat. The analysis controlled for supply side drivers such as rainfall and seasonality. We also examined the differential price effects arising from food aid distributed through predictable channels such as the PSNP and through emergency relief programs. We compared the price impacts of cash transfers to those of food aid. We also examined whether conditioning these policy interventions on seasonality or production levels would alter the observed price effects. We also checked the robustness of our results by repeating the analysis for each of the four regions separately, which confirms the basic findings.

Overall, we find no compelling statistical support for the hypothesis that PSNP and relief food aid have affected food grain prices. Once we control for possible factors contributing to food price changes, such as seasonality and rainfall, we are left with patterns that do not strongly point to disincentives at the household level, either for crop production or provision of labor. We find some evidence that cash transfers have exerted upward pressure on prices, especially for *teff*. Furthermore, conditioning food aid and cash transfers either on seasonality or on production levels does not alter the basic patterns observed here. Revealed correlations between prices on the one hand and seasonal changes and time trends on the other are larger and stronger than those observed between prices and policy interventions.

Our results imply that food and cash transfers are sufficiently well-targeted and timed overall in the PSNP *woreda's* in Ethiopia over the period examined, that any unintended effects on local price are negligible. This is in line with the expectation that PSNP food aid is more predictable, timely and carefully targeted than past emergency relief deliveries. Thus, food aid and cash transfers may not necessarily disrupt markets and undermine production incentives if well designed and properly implemented, especially since the unintended consequences of such policy interventions likely arise from problems related to the timeliness and successful targeting of the food and cash transfers. However, the introduction of the PSNP was highly motivated by observations that ad hoc emergency food aid delivery to Ethiopia had been insufficient and unpredictable, thus failing to address underlying causes of food insecurity. As a response, the major objective of the PSNP has been to bring predictable and timely food and cash transfers to chronically food insecure *woreda's*. Moreover, the PSNP uses traditional community based targeting systems, refining these to include more criteria that enable the program to identify chronically food insecure households within each food insecure *woreda*. All of these efforts may have contributed to mute the negative effects of food/cash transfers on food markets in Ethiopia.

Our results differ from those of Taddesse and Shively (2009), who conclude that food aid shipments reduce prices in producer and consumer markets in Ethiopia. Differences in results could emanate mainly from differences in the data used for the analyses. They examined the statistical link between annual emergency food aid shipments and monthly food prices for three markets over the period 1996-2006. We observe prices over a different period, in particular one that post-dates a major policy shift in food aid delivery that began with the introduction of Ethiopia's PSNP in 2005. This policy shift, and the different periods covered by these two studies likely lie at the heart of the divergence in results.

One caveat to the current study is that we have conducted this analysis at the zonal level. Although this provides a broad perspective on patterns associated with food aid and PSNP activities and a more detailed analysis than past studies, it may nevertheless mask important effects that may be occurring at the *woreda* level that we fail to discern. Another possible limitation is that our analysis does not control for the possible effects of local and regional procurement of food aid grains on market prices. These modes of food aid delivery to Ethiopia have become increasingly important over the past decade. However, during the time period covered by our data, local procurement of food aid was relatively small in quantity, in large part because the government suspended donors from locally purchasing food aid grains as part of its price stabilization response during the 2007-2010 price spikes. Additionally, we were not able to account for the fact that high prices observed during some years covered by our study could have affected the budget available for food aid and, consequently, costs and performance of WFP activity. Similarly, if the food value of cash transfers declines when prices rise, a feature that could have some effect on our findings. Uncovering sufficient data to conduct an analysis that overcomes these limitations would be difficult, if not impossible, and is left for future efforts.

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Table 1 Descriptive Statistics for Variables Used in the Analysis

Variables	Mean	Std. Dev.	Min	Max
Teff real producers price (*birr*/kg)	4.17	1.25	1.68	10.56
Wheat real producers price (*birr*/kg)	3.00	1.08	0.67	8.33
Maize real producers price (*birr*/kg)	2.21	1.08	0.52	7.32
Monthly per capita PSNP food aid (kg)	0.73	1.60	0.00	13.00
Monthly per capita relief food aid (kg)	0.47	1.02	0.00	7.68
Quarterly per capita cash transfers (*birr*)	11.15	16.09	0.00	130.48
Annual per capita *teff* production (kg)	33.20	29.40	0.00	145.80
Annual per capita wheat production (kg)	31.20	39.20	0.00	319.30
Annual per capita maize production (kg)	47.70	72.70	0.00	452.40
Monthly rainfall (mm)	75.79	79.78	0.00	496.00
Population (1000s)	839.88	710.38	49.99	3,122.49

Note: Statistics computed for 37 zones covering the period January 2007 to December 2010.

Table 2 SUR Regression Results, Dependent Variable is Real Producer Price (*birr*/kg)

	Model 1			Model 2			Model 3		
Variables	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize
Per capita PSNP food aid	35.3	35.64**	0.611	21.23	20.50	-10.14	25.44	16.47	-10.72
(MT)	(21.63)	(16.8)	(17.01)	(15.89)	(12.67)	(10.78)	(30.95)	(23.54)	(21.04)
Per capita PSNP food aid,	71.63***	48.28***	61.00***	18.94	3.922	7.056	19.59	1.812	10.65
1 month lag (MT)	(19.99)	(15.56)	(15.65)	(15.10)	(12.05)	(10.24)	(15.44)	(12.39)	(10.47)
Per capita relief food aid	-47.61*	-48.18**	-28.33	12.81	-0.424	48.01***	60.40	1.817	46.80*
(MT)	(25.16)	(19.73)	(19.85)	(17.86)	(14.25)	(12.20)	(37.97)	(28.64)	(25.54)
Per capita relief food aid,	-90.20***	-78.97***	-75.34***	-35.80*	-21.49	11.19	-39.94**	-23.25	11.36
1 month lag (MT)	(25.82)	(20.23)	(20.36)	(18.56)	(14.80)	(12.68)	(18.76)	(15.07)	(12.85)
Per capita cash transfer	0.00369**	0.00304**	0.00246*	0.00424***	0.00180*	0.00162*	0.00458**	0.00193	0.000370
(*birr*)	(0.00161)	(0.00126)	(0.00128)	(0.00129)	(0.00106)	(0.000896)	(0.00185)	(0.00148)	(0.00129)
Per capita cash transfer,	-0.000182	-0.00139	-0.00285**	0.00279**	0.000867	-0.000481	0.00305**	0.000856	-0.000699
1 quarter lag (*birr*)	(0.00149)	(0.00117)	(0.00118)	(0.00117)	(0.000934)	(0.000808)	(0.00119)	(0.000951)	(0.000819)
Seasonal indicator				-0.0749*	-0.123***	-0.188***	-0.118**	-0.124***	-0.245***
(1=harvest season)				(0.0439)	(0.0350)	(0.0305)	(0.0525)	(0.0425)	(0.0369)
Time trend				0.00244	-0.0132***	-0.0221***	0.00277	-0.0131***	-0.0217***
(unit time step)				(0.00202)	(0.00189)	(0.00170)	(0.00206)	(0.00191)	(0.00172)
Predicted production				0.0406***	0.00047	-0.00707*	0.0433***	0.000288	-0.00617
(MT)				(0.0060)	(0.00258)	(0.00406)	(0.00615)	(0.00263)	(0.00417)
Predicted production,				0.0274***	-0.000518	-0.00355	0.0276***	-0.000507	-0.00371
1 year lag (MT)				(0.00685)	(0.00221)	(0.00427)	(0.00683)	(0.00222)	(0.00426)
Population				0.000392	1.32e-05	0.000197	0.000377	1.39e-05	0.000140
(in thousands)				(0.000415)	(0.000360)	(0.000283)	(0.000415)	(0.000361)	(0.000283)
Season × PSNP food aid							-16.37	-5.454	27.21
							(25.68)	(20.47)	(17.38)
Season × Relief food aid							26.32	-13.00	11.23
							(34.07)	(27.30)	(23.26)
Season × PSNP cash							0.00505	0.00114	0.00364*
							(0.00310)	(0.00246)	(0.00210)

Production × PSNP food aid							0.196	0.203	-0.222
							(0.755)	(0.477)	(0.442)
Production × Relief food aid							-1.940**	0.115	-0.265
							(0.896)	(0.543)	(0.506)
Production × PSNP cash							-4.91e-05	-1.25e-05	2.41e-05
							(5.30e-05)	(3.17e-05)	(2.94e-05)
Observations	1,575	1,575	1,575	1,260	1,260	1,260	1,260	1,260	1,260
R-squared	0.96	0.96	0.92	0.98	0.97	0.96	0.98	0.97	0.96

Note: Standard errors in parentheses. Single, double and triple asterisks represent statistical significance at the 10%, 5% and 1% test levels respectively. All regressions estimated with zonal level fixed effects.

Table 3 SUR Regression Results by Regions, Dependent Variable is Real Producer Price (*birr*/kg)

	Tigray			Amhara			Oromia			SNNPR		
Variables	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize
Per capita PSNP food aid	-99.47	-172.7*	-83.36	-2.296	-54.31	-6.260	31.46	-106.8	-199.8	32.02	93.84**	-3.335
(MT)	(100.2)	(99.34)	(88.40)	(50.19)	(65.89)	(54.83)	(292.7)	(84.56)	(187.6)	(46.43)	(37.93)	(28.68)
Per capita PSNP food aid,	28.04	9.090	4.676	28.95	41.88*	68.31***	311.4***	148.1***	164.4***	1.112	-61.23**	-55.19***
1 month lag (MT)	(17.38)	(18.99)	(15.73)	(17.75)	(22.78)	(19.46)	(84.54)	(53.29)	(53.35)	(30.39)	(24.42)	(18.81)
Per capita relief food aid	62.24	45.90	38.71	-85.25	-108.1	64.51	64.08	-97.99*	25.00	46.95	80.83*	100.5***
(MT)	(132.0)	(170.2)	(125.5)	(67.27)	(87.99)	(71.57)	(97.47)	(57.86)	(60.72)	(56.34)	(46.13)	(34.79)
Per capita relief food aid,	18.24	-13.22	11.12	-30.85	12.91	25.97	-50.59	-3.648	33.13	0.952	-58.12**	-11.66
1 month lag (MT)	(25.14)	(26.87)	(22.28)	(27.16)	(33.22)	(28.40)	(55.45)	(34.60)	(35.20)	(33.60)	(26.93)	(20.97)
Per capita cash transfer	0.00382	0.00112	0.00897	0.00358	0.00975**	0.000755	0.0137	-0.000612	0.00155	0.00292	-0.00120	-0.000480
(birr)	(0.0133)	(0.0137)	(0.0128)	(0.00305)	(0.00393)	(0.00344)	(0.0103)	(0.00614)	(0.00657)	(0.00239)	(0.00203)	(0.00149)
Per capita cash transfer,	0.00659***	0.00244	0.00442**	0.00333**	0.00542***	-5.94e-06	0.0114*	-0.00376	-0.00221	0.00207	-0.00173	-0.00149
1 quarter lag (birr)	(0.00204)	(0.00219)	(0.00189)	(0.00144)	(0.00183)	(0.00161)	(0.00588)	(0.00356)	(0.00359)	(0.00193)	(0.00157)	(0.00122)
Seasonal indicator	-0.286**	-0.291**	-0.294***	-0.0222	0.177	-0.124	-0.162	-0.259***	-0.364***	-0.0670	-0.207***	-0.198***
(1=harvest season)	(0.115)	(0.130)	(0.105)	(0.0958)	(0.123)	(0.104)	(0.141)	(0.0891)	(0.0891)	(0.0808)	(0.0667)	(0.0526)
Time trend	0.0152*	-0.0191	-0.0284***	-0.0123***	-0.0159**	-0.0266***	-0.0200***	-0.0124***	-0.0199***	-0.00400	-0.0098***	-0.0200***
(unit time step)	(0.00919)	(0.0118)	(0.00934)	(0.00411)	(0.00623)	(0.00475)	(0.00677)	(0.00369)	(0.00395)	(0.00323)	(0.00311)	(0.00258)
Predicted production	0.0860***	-0.256***	-0.0216	0.0199**	0.00423	-0.0138	0.0261*	0.00312	-0.00699	0.102***	-0.0173	-0.00712
(MT)	(0.0234)	(0.0988)	(0.0281)	(0.0100)	(0.00981)	(0.0103)	(0.0144)	(0.00305)	(0.00822)	(0.0159)	(0.0135)	(0.0116)
Predicted production,	0.0514	-0.262***	-0.0433	0.00417	-0.00648	-0.00658	0.0166	0.00266	-0.00344	0.0442***	-0.000914	-0.00654
1 year lag (MT)	(0.0489)	(0.0894)	(0.0372)	(0.0104)	(0.00904)	(0.0130)	(0.0119)	(0.00235)	(0.00702)	(0.0140)	(0.00759)	(0.0100)
Population	-0.0147***	0.0950**	0.00132	0.00310	-0.00372	0.00152	0.000679	-0.000366	-0.000197	0.0129***	-0.00105	-8.99e-05
(in thousands)	(0.00542)	(0.0372)	(0.00514)	(0.00298)	(0.00355)	(0.00293)	(0.000646)	(0.000411)	(0.000396)	(0.00204)	(0.00151)	(0.00170)
Season × PSNP food aid	66.28**	17.75	-10.10	-101.8***	-48.14	17.80	-138.3	274.4***	107.3	-20.59	-99.26**	49.45
	(29.39)	(33.12)	(27.74)	(33.81)	(42.85)	(37.69)	(137.0)	(84.42)	(83.71)	(57.92)	(47.32)	(35.76)
Season × Relief food aid	18.87	13.78	110.4***	98.76**	19.71	-44.84	171.7*	34.40	9.185	18.53	-93.31*	-37.31
	(43.24)	(47.22)	(39.13)	(47.11)	(59.05)	(50.92)	(103.0)	(64.61)	(65.03)	(62.00)	(51.09)	(39.27)
Season × PSNP cash	0.00629	0.00391	0.00475	0.0105*	-0.00614	0.0115*	0.0126	0.00448	0.0160**	-0.00275	0.00638	0.00174

	(0.00423)	(0.00508)	(0.00400)	(0.00572)	(0.00751)	(0.00635)	(0.0104)	(0.00653)	(0.00665)	(0.00558)	(0.00451)	(0.00344)
Production × PSNP food aid	2.612	3.121*	1.462	1.094	1.766	-0.904	-3.040	-2.019	2.439	1.867	-0.808	1.003
	(2.244)	(1.797)	(1.718)	(1.445)	(1.456)	(1.314)	(4.869)	(1.785)	(2.828)	(2.002)	(2.168)	(1.072)
Production × Relief food aid	-1.733	-1.090	-1.308	0.335	1.033	-0.278	-4.933**	2.751**	0.290	1.513	-1.279	-1.702*
	(2.973)	(2.885)	(2.444)	(1.215)	(1.231)	(1.052)	(2.508)	(1.375)	(1.366)	(2.021)	(2.068)	(1.026)
Production × PSNP cash	-5.52e-05	-3.82e-05	-0.000162	-4.51e-05	-9.41e-05	4.44e-05	-0.000456*	4.50e-05	-4.08e-05	-4.94e-06	-0.000115	0.000160**
	(0.000288)	(0.000212)	(0.000230)	(7.89e-05)	(7.53e-05)	(7.11e-05)	(0.000265)	(0.000162)	(0.000151)	(0.000132)	(0.000143)	(6.93e-05)
Observations	144	144	144	288	288	288	324	324	324	504	504	504
R-squared	0.99	0.99	0.98	0.99	0.98	0.97	0.97	0.97	0.95	0.98	0.96	0.96

Note: Standard errors in parentheses. Single, double and triple asterisks represent statistical significance at the 10%, 5% and 1% test levels respectively.
All regressions estimated with zonal level fixed effects.

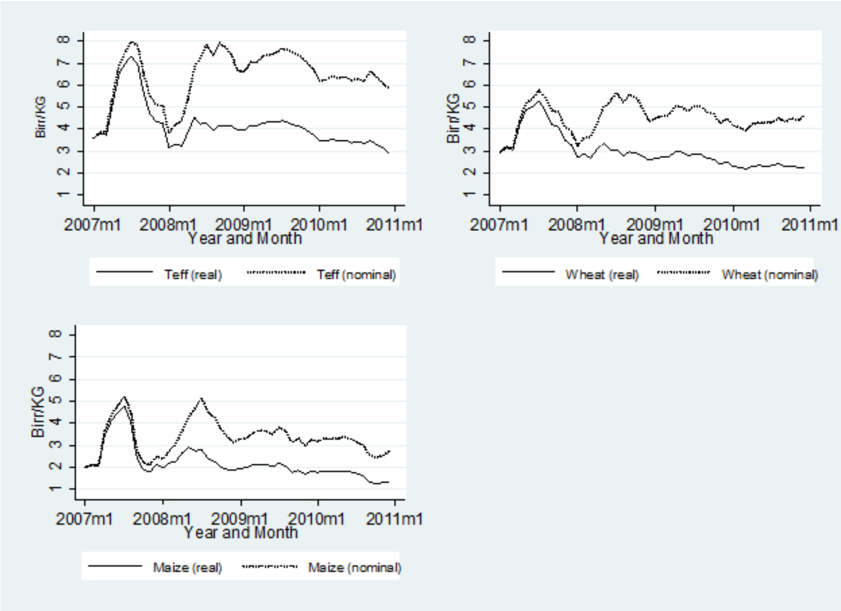

Figure 1 Nominal and Real Monthly Producer Prices, by Commodity (2007-2011)

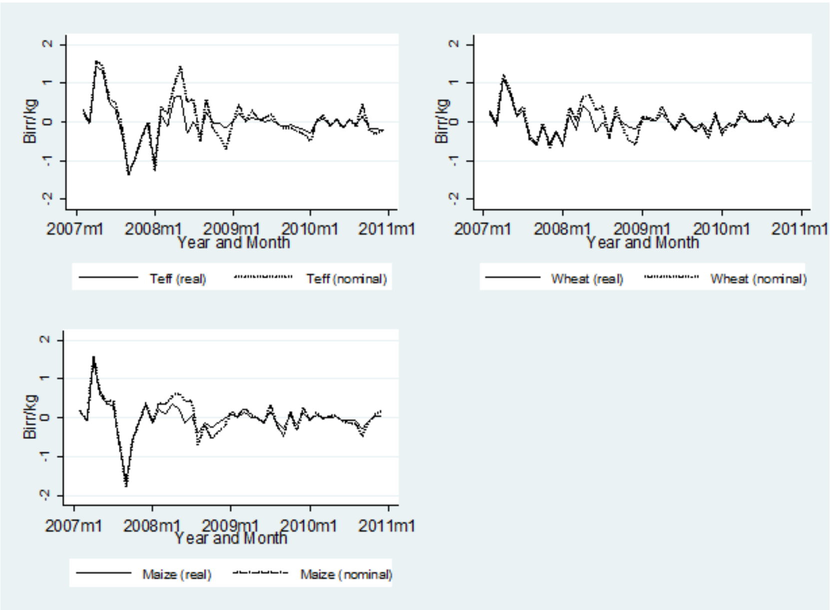

Figure 2 Change in Real and Nominal Prices, by Commodity (2007-2010)

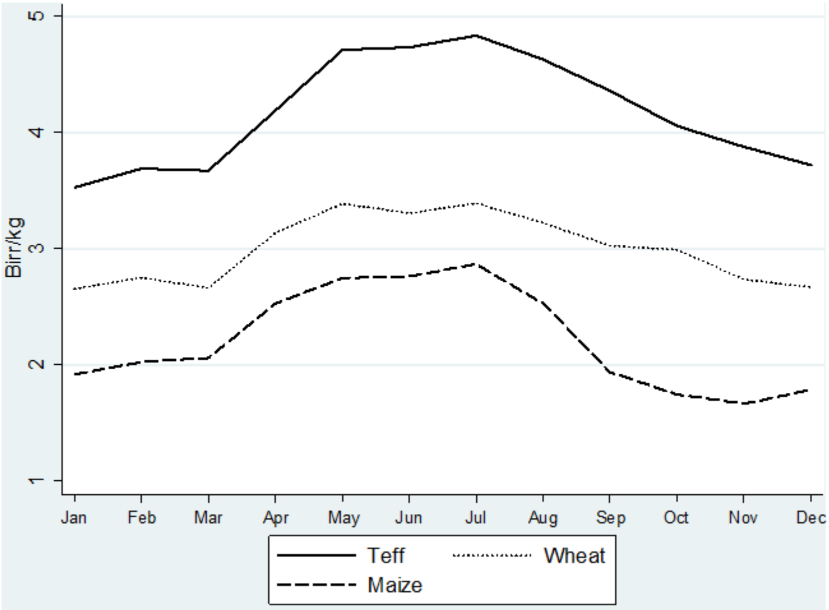

Figure 3 Seasonal Patterns in Real Prices, by Commodity (2007-2010)

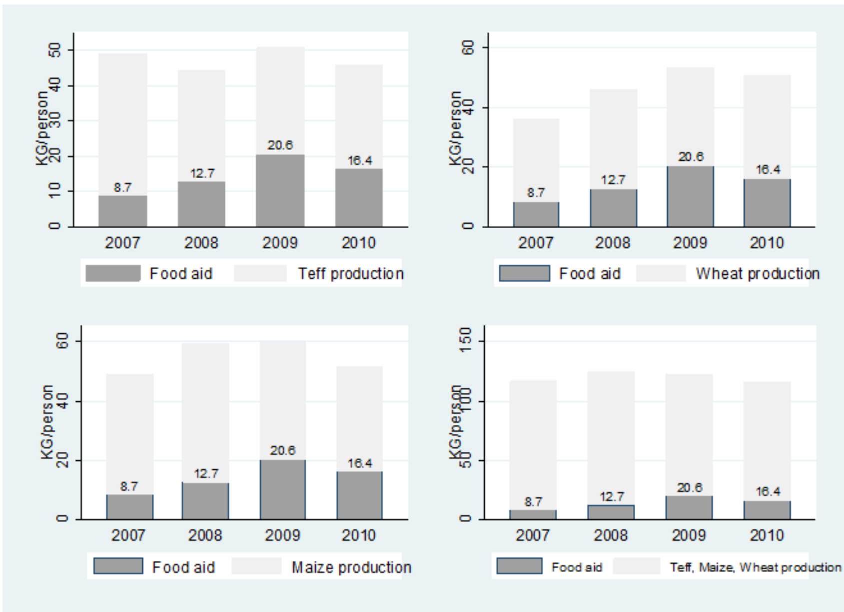

Figure 4 Food Aid and Grain Production, by Commodity

PAPER 2

Food Aid and Grain Production in Ethiopia

Meron Assefa Arega
NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), Ås, Norway
+47 46268785 (phone); +47 64965701(fax); meron.arega@nmbu.no

Gerald Shively
Department of Agricultural Economics
Purdue University, West Lafayette, IN USA
+1 765 494 4218 (phone); +1 765 494 9176 (fax); shivelyg@purdue.edu
and
NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), Ås, Norway

ABSTRACT. Does food aid discourage food production? Does food aid respond to production shortfalls? We investigate these questions by analyzing panel data from Ethiopia for the period 2005 to 2010. Regressions for three major crops, *teff*, wheat, and maize are estimated separately using the Arellano-Bond generalized method of moments (GMM). Results indicate that previous year food aid allocated from Ethiopia's Productive Safety Net Program (PSNP) and from emergency relief programs have no evident negative correlation with subsequent crop production and area cultivated. On the other hand, a low level of rainfall triggers more emergency relief and PSNP food aid, whilst we find no correlation between observed levels of production and food aid. Thus, food aid has been sufficiently well-targeted and timed overall in the PSNP *woreda*'s in Ethiopia over the period examined, and that any unintended disincentive effects on local production are negligible.

JEL classification: O13, Q12, Q18

Keywords: Arellano-Bond, emergency relief, Ethiopia, food aid, GMM, PSNP

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1. Introduction

Despite a range of global development efforts, poverty and food insecurity remain major challenges in low-income countries. In 2010, 925 million people were estimated to be undernourished (FAO, 2010). Over the past few decades, food aid has emerged as an obvious mechanism for responding to food crises. Globally, about 5.5 million MT of food aid was delivered to countries in 2009, of which Sub-Saharan Africa received the largest proportion, 64%. However, the proper role of food aid in economic development has been debated. Many practitioners, donors and policymakers question the overall performance and effectiveness of various food aid programs. Several have argued that food aid can be counterproductive to long-term efforts to sustain reductions in hunger and poverty (Bizuneh, et al, 1988; Barrett, 2006). Major concerns surround self-interested donor requirements and worries that food aid programs may have unexpected and negative effects on local food production.

Disincentives are typically viewed as working through three different mechanisms. First, by increasing food supply in the local market, food aid may depress prices received by farmers, thereby discouraging food production. Second, food aid can discourage households from allocating labor to production, since households may prefer leisure to working. This dependency effect may reduce the capacity of food aid beneficiaries to meet their own needs in the future. Third, when aid is tied to work, for example as part of a food-for-work (FFW) program, such aid may generate a crowding-out effect if the program offers better wages than returns to farming.

These potential adverse consequences of food aid may mainly result from problems associated with timing and targeting of food aid distribution. Barrett (2006) argues that even the best designed and managed food aid programs suffer from 'errors of exclusion of intended recipients' and 'errors of inclusion of the unintended beneficiaries'. In Ethiopia for instance, Clay et al. (1999) found no significant association between households who were food insecure and those who received food aid. Jayne et al. (2001) also found large differences in food aid allocations across regions that could not be explained by observable regional characteristics such as per capita income and rainfall. In a more recent study, however, Coll-Black et al. (2011) showed that Ethiopia's Productive Safety Net Programme (PSNP) is well-targeted. In addition, food aid deliveries, mainly emergency relief often lack timeliness, due to administrative dysfunction, lags in food aid delivery from donors, or complex procurement and transportation bottlenecks (Del Ninno et al., 2007).

After Schultz, (1960), who analyzed the negative impact of food aid on production, there have been numerous empirical studies related to food aid, but findings are on the whole inconclusive. Awokuse (2011) provides a fairly comprehensive review of empirical studies on food aid impacts over the past few decades. Isenman & Singer (1977) and Maxwell (1991) showed that food aid has limited disincentive effect on prices and production. Lavy (1990) found a positive effect of food aid on production, which offsets the negative price effects that would have been caused as a result of the additional food supply in the domestic markets. Bezuneh et al. (2003) also showed a positive effect of food aid on food production that becomes an incentive to growth as a result of its income and policy effects. Using macro and household level data, Abdulai et al. (2005) further showed that food aid has no disincentive effect once one controls for factors that are correlated with food aid receipt and production. Lowder (2004) and Barrett et al. (1999) found that food aid does not affect food production in the recipients' countries, while it displaces food imports.

In contrast, market level studies by Tadesse & Shively (2009) showed that food aid shipments in Ethiopia reduced prices in all producer and consumer markets and Tschirley et al. (1996) found that the availability of yellow maize food aid at prices lower than import parity was a disincentive to producers and traders to invest in the white maize production and marketing system. In a more recent study, Zant (2012) finds no support for a negative impact of food aid on maize market prices and production, using a district-level panel from the Malawi maize market. Instead, the results suggest a small positive impact of food aid on prices and production.

In this paper we extend the analysis of food aid and production incentives by studying the dynamic relationship between food aid and food grain production in Ethiopia. We address three issues with our empirical investigation. First, we directly test whether food aid has discouraged production. Second, we test the effect of food aid on crop area cultivated. And third, we investigate whether food aid is triggered by production failure.

We use data associated with Ethiopia's PSNP, which was launched in January 2005. The PSNP is aimed to strategically tackle food insecurity in the country. The program helps to prevent asset depletion at the household level and to create assets at the community level, as well as to stimulate markets. It is designed to ensure timely and predictable cash and/or food transfers to chronically food insecure *woreda's*[1]. The two components of the program are direct support (for those who are vulnerable and unable to supply labor) and labor-intensive public work. PSNP participants get payments in the form of cash or food or in combination of the two. The program covers more than 50 percent of the *woreda's* in the country. The same districts also receive emergency relief food aid whenever there are unpredictable emergencies. This design enables us compare the effects of relief versus PSNP food aid.

We use panel data aggregated annually from January 2005 to December 2010 covering PSNP *woreda'*s that were identified as chronically food insecure from four major regions in the country, Tigray, Amhara, Oromia, and Southern Nations and Nationalities People

[1]A *woreda* is an administrative unit, defined below region and zone, and roughly equivalent to district designations elsewhere.

(SNNP). We find no disincentive impact of food aid, either from the PSNP or from emergency relief programs, on production of the food crops we consider. We also find insufficient evidence to conclude that area cultivated is adversely affected by food aid distribution. However, data do suggest that low levels of rainfall trigger more food aid allocation.

2. A model of food aid and production

We provide a framework to understand the potential effects of food aid on production using a non-separable household model with imperfect markets for labor and land. We introduce food aid and labor for FFW into the standard farm household utility maximization problem and show how production and labor allocation decisions change as a result of food transfers in the domestic market.

We assume a household maximizes a concave, continuous and non-decreasing utility function defined over consumption of food and manufactured products (C_a) and leisure (C_l):

$$\underset{\mathbf{C},\mathbf{Q}}{Max}\, U(C_a, C_l) \tag{1}$$

Subject to the following constraints:

Technology constraint: $Q = Q(X, L_q; Z)$ (2)

Budget constraint: $p_a C_a \leq P_q Q - p_x X + wL_f + A$ (3)

Time constraint: $L_q + L_f + C_l \leq T_l$ (4)

And the non-negativity constraints: $C_a \geq 0; C_l \geq 0; L_q \geq 0; L_f \geq 0; T_l \geq 0; X \geq 0$ (5)

We assume production of crops (Q) uses labor (L_q), inputs (X) and a fixed amount of land (Z). T_l represents the household's time endowment which is allocated to agricultural production (L_q), FFW(L_f) and leisure (C_l). We assume that L_f[2] is exogenously determined by the administrators of the FFW program and that prices associated with tradable agricultural and manufactured consumption goods (p_a), FFW labor (w), inputs used in agriculture (p_x) and output price (p_q) are also exogenously determined. A represents exogenous income transfers such as food and cash transfers. Keeping with the stylized features of the districts considered, we assume there is no market for land or labor for agriculture. The Lagrangian associated with the constrained maximization problem can be written as:

$$L = U(C_a, C_l) + \lambda(p_q Q(X, L_q; Z) - p_x X + wL_f + A - p_a C_a) + \mu(T_l - L_q - L_f - C_l)) \tag{6}$$

with the first order necessary conditions,

$$\frac{\partial L}{\partial C_a} = \partial U \big/ \partial C_a - \lambda p_a = 0 \rightarrow \partial U \big/ \partial C_a = \lambda p_a \tag{7}$$

$$\frac{\partial L}{\partial C_l} = \partial U \big/ \partial C_l - \mu = 0 \rightarrow \partial U \big/ \partial C_l = \mu \tag{8}$$

$$\frac{\partial L}{\partial L_q} = \lambda p_q \, \partial Q \big/ \partial L_q - \mu = 0 \rightarrow p_q \, \partial Q \big/ \partial L_q = \mu \big/ \lambda \tag{9}$$

$$\frac{\partial L}{\partial L_f} = \lambda w - \mu = 0 \rightarrow w = \mu \big/ \lambda \tag{10}$$

$p_l^* = \mu \big/ \lambda$ denotes the unobservable shadow wage for nontradables (C_l and L_q), and μ and λ are the Lagrange multipliers associated with the time and income constraints, respectively.

[2] In principle, FFW activities under the PSNP are carried out outside the main agricultural season, and thus it is quite possible that much FFW labor is provided only during slack periods in the agricultural calendar. However, our theoretical model takes a general form where FFW labor competes with agricultural labor since we are interested in empirically testing whether farmers' labor allocation decisions are affected by the presence of a FFW program in their districts.

After manipulation of the first order conditions, the reduced form of the model can be written in four pieces.

Production decisions regarding all tradable and nontradables are represented by a system of supply and factor demand functions in the decision prices, p_q^*: $Q = Q(p_q^*)$

Optimal levels of products and factors yield maximum profit of: $\pi^* = p_q^* Q - p_x X$

The full-income constraint is $Y^* = \pi^* + p_l^*(T_l - L_f) + wL_f + A$

The demand system is $C = C(p_a^*, w^*, Y^*)$

Price incentive effect of food aid

From the above, we see that the price effect of food aid (A) comes through its influence on Y^* and the price of tradable goods, p_q^*. Thus, we can derive the response of output to increase in food aid as:

$$\frac{dQ}{dA} = \frac{\partial Q}{\partial p_{q^*}} \frac{dp_{q^*}}{dA} \tag{11}$$

Equation (11) shows that the impact of food aid on food production depends on the sign of the effect of food aid induced price changes, $\frac{dp_{q^*}}{dA}$ (since $\frac{\partial Q}{\partial p_{q^*}}$ is always positive). We expect a negative partial equilibrium supply response of food prices leading to overall negative effect of food aid on output.

Labor reallocation incentive effects of food aid

From the first-order conditions, we can derive labor allocation condition of the farm household as:

$$\frac{\partial U / \partial C_l}{\partial U / \partial Ca} = p_{q^*} \left.\frac{\partial Q}{\partial L_q}\right|_{q^*} = p_l^* = \frac{w^*}{p_a} \tag{12}$$

Equation (12) shows that at the optimum the farm household allocates labor to agricultural production until the marginal value of leisure (the marginal rate of substitution between leisure and consumption, $\frac{\partial U / \partial C_l}{\partial U / \partial Ca}$) or the shadow wage of labor (p_l^*) equals the marginal value of labor in agricultural production ($p_{q^*} \left.\frac{\partial Q}{\partial L_q}\right|_{q^*}$) and the real wage from the FFW labor (w^* / p_a). Thus, if the return from the FFW program is at least as much as the return from farm production, the household chooses to participate in the FFW program over farm production (i.e. L_q decreases) and output falls. The marginal value of labor in agriculture is the reservation wage that drives the farm household's FFW participation decision. Overall, given equations (11) and (12) the actual relationships depend on empirical realities that we examine in the next sections.

3. Empirical strategy

We are interested in testing the relationships provided in equation (11) and (12) for three major cereal crop types (*teff*, wheat and maize) separately. We use empirical models, equations (13) to (14') below to investigate the dynamic relationship between food aid and production and equation (15) to investigate whether food aid responds to production shortfalls.

For a given crop, equation (13) estimates production functions to study the possible effects of food aid controlling for the underlying factors affecting production, such as rainfall and input use.

Production function I:

$$\mathbf{Q_{it}} = \alpha + \mathbf{Q_{it\text{-}l}}\boldsymbol{\gamma} + \mathbf{A_{it}}\boldsymbol{\beta} + \mathbf{X_{it}}\boldsymbol{\omega} + \rho_{\mathrm{i}} + \varepsilon_{\mathrm{it}} \quad i = 1,...,N\,;\; t = 1,...,T \tag{13}$$

In equation (13) above, α is a scalar intercept; $\mathbf{Q}$ represents a vector of crop production; l denotes the lag length, and $\boldsymbol{\gamma}$ is a vector of parameters to be estimated. $\mathbf{A}$ denotes a ($n \times k$) matrix of food aid related variables, where $n = N \times T$ and k is the number of variables. These include annual per capita PSNP and relief food aid allocation. The primary item of interest in this equation is $\boldsymbol{\beta}$, a vector of parameters to be estimated. These measure the marginal impacts of food aid on food production. $\mathbf{X}$ is a ($n \times k$) matrix of other exogenous control variables. These include rainfall, chemical fertilizer used, improved seed used, and a series of binary indicators for years; $\boldsymbol{\omega}$ is a vector of parameters to be estimated; ρ is unobserved individual *woreda* level effects and ε is a white noise disturbance.

Production function II:

$$\mathbf{Q_{it}} = \alpha' + \mathbf{Q_{it\text{-}l}}\boldsymbol{\gamma}' + \mathbf{\hat{C}_{it}}\boldsymbol{\beta}' + \mathbf{X_{it}}\boldsymbol{\omega}' + \rho'_{\mathrm{i}} + \varepsilon'_{\mathrm{it}} \quad i = 1,...,N\,;\; t = 1,...,T \tag{14}$$

where, $\mathbf{C}$ denotes a $n \times 1$ vector of crop area cultivated and a vector of its predicted value ($\mathbf{\hat{C}}$) is obtained from equation (14') below. All other notation remains the same as described in equation (13). In equation (14), area cultivated serves as an instrument for food aid, under the assumption that area cultivated is primarily determined by farmers' decision on their labor allocation. Thus, we first test the effect of food aid on crop area cultivated controlling for rainfall as given by equation (14') and then use this information to study the labor allocation incentive effect of food aid on production, in equation (14). This empirical model is motivated by the observation that, historically, all food grain production growth in Ethiopia was attributed to an expansion of area cultivated (Taffesse et al., 2011). In recent years, growth appears to have been attributed to a combination of area expansion and yield growth

(Diao, 2010; Rashid, 2010; Taffesse et al., 2011). Nevertheless, given farm land constraints, uncertainties regarding the extent of fallow, and the overall effectiveness of agricultural extension programs, some controversy continues to surround the topic of agricultural production growth (Rashid, 2010).[3]

Area cultivated equation:

$$\mathbf{C_{it}} = \sigma + \mathbf{C_{it\text{-}\mathit{l}}}\boldsymbol{\psi} + \mathbf{A}_{it}\boldsymbol{\theta} + Z_{\mathbf{it}}\mathbf{v} + \rho_i^{''} + \varepsilon_{it}^{''} \quad i = 1,...,N\,;\; t = 1,...,T \tag{14'}$$

where, σ is a scalar intercept; $\mathbf{Z}$ is a $(n \times k)$ matrix of control variables, that include rainfall and a series of binary indicators for years. $\boldsymbol{\psi}$, $\boldsymbol{\theta}$ and $\mathbf{v}$ are vector of parameters to be estimated, where $\boldsymbol{\theta}$ measures the marginal impacts of food aid on crop area cultivated. All other notation remains the same as described in equations (13) and (14).

Food aid equation:

$$\mathbf{A_{it}} = \kappa + \mathbf{A_{it\text{-}1}}\boldsymbol{\eta} + \mathbf{S_{it}}\boldsymbol{\varphi} + \mathbf{Y_{it}}\boldsymbol{\xi} + \rho_i^{'''} + \varepsilon_{it}^{'''} \tag{15}$$

Equation (15) represents the food aid equation that estimates the effect of production level and rainfall on food aid; $\mathbf{S}$ denotes a $(n \times k)$ matrix of variables, production and rainfall; $\mathbf{Y}$ denotes a $(n \times k)$ vector of year dummies; κ is a scalar intercept; and $\boldsymbol{\eta}$, $\boldsymbol{\varphi}$ and $\boldsymbol{\xi}$ are vector of parameters to be estimated. All other notation follows equation (13).

Equations (13) to (15) represent a dynamic panel model, in which the dependent variable is specified as a function of its values in previous period. Since we know the lagged dependent variable is serially correlated with the unobserved individual effect by construction, OLS estimation with a lagged dependent variable and serial correlated error leads to inconsistent parameter estimates of equations (13) to (15). Besides, OLS estimation with fixed effects (by

[3]As a reviewer points out, the model developed here does not allow for complete flexibility in the treatment of area cultivated or fallow.

removing the individual effect using first differencing) produces inconsistent parameter estimates because the regressor (i.e. the lagged, differenced dependent variable) is correlated with the error by construction. However, it is possible to obtain consistent estimates of the parameters using the Arellano-Bover/Bundell-Bond method. This relies on instrumental variable estimation of the parameters in the first difference model, using appropriate lags of regressors as instruments and applying a one step system Generalized Method of Moments (GMM) approach. The method is suitable for datasets that include many units but few time periods (small T and large N) as we have here (Baltagi, 2005). It allows us to use lagged differences as instruments for the level equation and lagged levels as instruments for the differenced equation.

Furthermore, this method allows us to introduce variables as being strictly exogenous, predetermined or endogenous. Thus, we are able to control for the possible endogeniety of variables in our models. In equations (13) to (14'), the food aid variables are treated as endogenous assuming food aid is endogenous to production and rainfall (since food aid allocation could be a response to production failure or rainfall shortage). In equations (13) and (14), we treat chemical fertilizer and improved seed use as endogenous variables, to control for any likely endogeneity of input levels in the production functions. In equation (15), we treat production as endogenous since farmers may anticipate food aid and make their production decisions on the basis of that information. Contemporaneous and lagged rainfall enters all of our models as strictly exogenous variables.

In order to check for the validly of the instruments, we use the Hansen test of overidentification restrictions. We also test for serial correlation. We compute robust estimates of standard errors, clustered by *woreda*.

4. Data and sources

We use *woreda* level annual data from 2005 to 2010. The panel is unbalanced covering between 109 to 215 PSNP *woreda'*s that were identified as chronically food insecure. The panel dataset is unbalanced since the number of *woreda's* covered by PSNP increased over time. Thus, any potential bias caused by random attrition in our data is assumed to be tolerably small to affect our results. The dataset covers four major regions, Tigray, Amhara, Oromia, and Southern Nations and Nationalities People (SNNP) and three major cereals, *teff*, wheat and maize, which are individually and jointly important in terms of both production and consumption of grains in Ethiopia. For example, in 2010 *teff*, wheat and maize represented 14, 17, and 25 per cent of grain production in the country, respectively.

Our data are compiled from different sources. Variables included are: relief food aid (MT), PSNP food aid (MT), production (MT), area cultivated (Hectare), rainfall (mm), quantity of chemical fertilizer used (MT) and quantity of improved seeds (MT). Our major variables of interest are annual per capita relief and PSNP food aid allocation in MT. We include the one year lagged value of food aid variables. A negative correlation between food aid and production/area cultivated in general is evidenced in support of the disincentive hypotheses, through market and labor reallocation effects of food aid. Data sources for the food aid data are Disaster Risk Management and Food Security Sector (DRMFSS) in Ethiopia, Food Security Coordination Bureau (FSCB) in Ethiopia, and World Food Program (WFP).

Production, area, and input uses data are based on Agricultural Sample Survey of Ethiopia's Central Statistics Authority (CSA). One of the four components of this survey, the *Meher* post-harvest survey, provides information including area and production, land use, farm management and crop utilization. The survey covers more than 2,000 EAs from all rural parts of the country, with the exception of Gambela and the non-sedentary population in Afar and Somali regions. From each EA, 20 to 30 farm households are typical selected. Enumerators collect data by interviewing these families and physically measuring their fields to obtain data on crop area and production. As a result, data are observed at a field level for each agricultural product. Related variables analyzed here are simply aggregated by *woreda* for the three crops studied.

We include current and one year lagged rainfall in all of our regressions, and the data comes from National Meteorological Agency of Ethiopia. Population data come from the Ethiopian CSA's annual population projection, based on regional average population growth rates obtained from recent national population and housing census.

5. Results and discussions

Table 1 presents the descriptive statistics of all the variables used in the regressions. For the period considered, average annual amount of PSNP food aid (0.016 MT/person) is greater than that of relief food aid (0.008 MT/person), the combined average total food aid allocation being approximately 0.024 MT/person in the PSNP *woreda's*. Per capita annual *teff* production in the PSNP districts average 0.033 MT, while similar figures for wheat and maize are 0.040 MT and 0.034 MT respectively. Figure 1 further illustrates per capita annual food aid distribution accounts for a large share of production in the given areas, especially in the years 2005 and 2006. The proportion of food aid to production relatively declines in the later years; one possibility could be that food aid was being replaced by cash transfers in many of the PSNP *woreda's*.

Data in Table 1 further indicate that average annual per capita area cultivated in the PSNP districts are 0.031 ha. for *teff*, 0.024 ha. for wheat and 0.018 ha. for maize. It is also shown that application of per capita chemical fertilizers and improved seeds is low for the production of all crops. Average monthly rainfall is about 75 mm, with a monthly maximum of 162 mm.

To empirically assess the impacts of food aid on production, regressions representing three grain types for selected *woreda's* in the country are estimated separately using system GMM estimation method. Table 2a, 2b and 3 report point estimates and standard errors, as well as specification tests for each crop-specific three sets of five regressions. In Table 2a, Model 1 consists of regressions that include only the policy variables of interest and lagged own production. Model 2 adds to these regressors a set of control variables for rainfall and inputs used (quantity of chemical fertilizer and improved seeds used) and year dummies (year dummies are not reported in result tables). Model 3 uses the same control variables as Model 2, but food aid is instrumented with area cultivated, with Model 3' (Table 2b) presenting regression results from instrumental regression of food aid using area cultivation. In Table 3, Models 4 and 5 are regression results of the food aid equations.

As reported at the bottom of the regression result tables, the validity of the instruments is verified using the Hansen test of overidenfication restrictions in which, null hypothesis that the population moment conditions are correct should not be rejected at 5% significance level. Furthermore, for all of the regressions, the second test for zero autocorrelation in the first differenced errors of order 1 (AR(1)) and 2 (AR(2)) show that at order 2, the errors are serially uncorrelated because the p-values are greater than 5% significance levels. As desired, there is no serial correlation in the original error.

5.1. Does food aid discourage production?

Our main question is whether food aid stimulates or depresses food production. The primary policy variables of interest to us, therefore, are PSNP and relief food aid allocations. In Model 1 we estimate food production on its own lag and only on these policy variables to establish evidence regarding their importance. The estimated coefficients for all the crops indicate strong negative effects of previous period food aid from emergency relief, both in statistical significance and magnitude. And, a positive effect of lagged food aid from PSNP on *teff* production. Model 2 and 3 further examine how robust these finding are when we include important conditioning variables. In these two models, we further find some evidence of positive correlation between *teff* and wheat production and food aid from PSNP.

In Model 2, there is no evidence for the negative effect of previous year PSNP and relief food aid on production of *teff* and wheat. Rather, we observe positive coefficients of *teff* and wheat that are statistically significant at the 1% level. The magnitude of these estimates suggest that a one MT per capita increase in food aid allocation yields an expected net increase of about 1.14 and 3.95 MT per capita in the subsequent year production of *teff* and wheat, respectively. However, we still observe a strong negative correlation between maize production and relief food aid allocation. As one would expect, the coefficients for the rainfall variable indicate that positive rainfall deviation result in higher contemporaneous food production of *teff* and wheat, while negative deviations tend to lower production. However, we observe no effect on maize production from rainfall and also a counterintuitive effect for application of improved seeds. Furthermore, the point estimates in Model 2 provide no strong evidence of a statistical link between production and application of improved seeds for *teff* and wheat. However, application of fertilizer is positively correlated with production of these two crops.

In Model 3, we use predicted food aid values from PSNP and relief using regression results reported in Table 2a to study the behavior of farmers' labor allocation on food aid. Thus, in Model 3', we first estimate area cultivated on its lagged value, lagged food aid allocation and current and past amount of rainfall. With respect to correlations between previous year food aid allocations and area cultivated, out of six estimated coefficients, three are statistically significant with positive signs. Lagged PSNP food aid is positively correlated with *teff* and wheat area cultivated. Also lagged relief aid is positively correlated with maize area cultivated, but no statistically significant correlated with *teff* and wheat area cultivated. Further, the coefficients for rainfall show positive significant correlation with *teff* and wheat area cultivated, but no statistically significant link is observed for maize.

In Model 3, out of 18 estimated coefficients, only five are statistically significant. However, the same as in Mode 2, we find the estimated values of the instrumented food aid are positively and statistically significantly correlated with production of *teff* and wheat. Comparing results across crops, one would expect the strongest effect to be on wheat which is the food aid crop. However, we find that effect of food aid to be nearly the same across all the crops we consider, except some mixed results observed associated with maize.

We surmise that, after controlling for factors affecting production, such as rainfall and input uses, most of the negative production effects of prior year food aid allocations disappear. In contrast, lagged PSNP food aid allocations may potentially have some positive effects on the subsequent production of some of the crops considered. Thus, any disincentive effects due to depressed product prices and/or reallocation of labor away from agricultural production induced by food aid allocations must be more than offset the positive effects of food aid. For instance, Abdulai et al. (2005), who also found positive effect of food aid on production, argue food aid can relax financial liquidity constraints of farmers, in particular by increasing their access to inputs. The latter compensates the price depressing and possible labor reallocation effects of food aid.

5.2. Is food aid a response to production failure?

If food aid deliveries respond to production shocks caused by poor rainfall or other factors, food aid will stabilize prices and the local food supply. However, poor timing and targeting of food aid deliveries are common, among others due to various administrative hurdles in food aid management. Model 4 and 5 help us to examine this issue. We attempt to identify sensitivities in the potential food aid deliveries to rainfall and production level. Point estimates in Model 4 and 5 show strong evidence that PSNP and emergency relief food aid deliveries are particularly sensitive to current and past values of rainfall. From the entire set of six point estimates for rainfall variables, five are negative and statistically significant in both models. Specifically, results in Model 4 indicate that program assistance is highly driven by low amount of rainfall and results in Model 5 indicate relief food aid deliveries are responses of rainfall shortage, at least in the regions studied here and over the time period considered. However, neither contemporaneous nor lagged crop production are statistically significant in both models, except where we find strong but mixed effects of wheat production on PSNP and relief food aid and positive effect of *teff* current level production on relief food aid.

6. Conclusion and policy implications

This paper contributes to the contested debate regarding the relationship between food aid and production. Newly constructed annual dataset based on monthly food aid allocations observed at the *woreda*-level are used to estimate regressions using the Arellano-Bond system GMM. We measured and tested the strength of correlations between food aid and production/area cultivated for three major grains produced and consumed in Ethiopia: *teff*, maize and wheat. We controlled for rainfall and input uses (quantity of fertilizer and improved seeds applied). We also investigated if food aid is triggered by rainfall and production level. We compared the differential output effects arising from food aid distributed from predictable channels such as the PSNP and emergency relief programs.

Overall, we find no compelling statistical evidence in support of the hypothesis that PSNP and relief food aid decrease production. Controlling for possible factors contributing to food production changes, we conclude that the available evidence does not strongly point to disincentives that could possibly arise from market price effects or labor reallocation effects of the safety net programs. Furthermore, we show that low levels of rainfall trigger both PSNP and relief food aid allocations, suggesting that aid are responding in a sensitive manner to local growing conditions.

Given these findings, it would appear that the unintended disincentive effects of PSNP food aid on local production are negligible since PSNP food aid has been well-targeted and timed over the period examined. This is not surprising given the major objective of the PSNP has been to bring predictable and timely food to chronically food insecure *woreda's* in Ethiopia. In fact, the policy shift in food aid delivery with the introduction of the PSNP was highly motivated by observations that ad hoc emergency food aid delivery in Ethiopia had been insufficient and unpredictable. We surmise that if PSNP food aid is more predictable, timely and carefully targeted than past emergency relief deliveries in the country, food aid may not necessarily disrupt markets and farm households labor reallocation decisions that cause producers disincentives. Thus, our findings underscore the basic lesson that popular policy interventions, such as implementation of large social safety net programs in food insecure countries may not undermine local production incentives if well designed and properly implemented.

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Table 1 Descriptive Statistics for Variables used in the Analysis

Variables	Mean	Std. Dev.	Min	Max
PSNP food aid (MT/person)	0.016	0.015	0	0.100
Relief food aid (MT/person)	0.008	0.012	0	0.175
Total food aid (MT/person)	0.024	0.022	0	0.227
Teff production (MT/person)	0.033	0.040	0	0.418
Wheat production (MT/person)	0.040	0.126	0	3.145
Maize production (MT/person))	0.034	0.060	0	0.576
Teff area cultivated (Hectar/Person)	0.031	0.036	0	0.247
Wheat area cultivated (Hectar/Person)	0.024	0.039	0	0.491
Maize area cultivated (Hectar/Person)	0.018	0.023	0	0.213
Chemical fertilizer used for *teff* (MT/1000 persons)	0.62	1.44	0	15.31
Improved seed used *teff* (MT/1000 persons)	0.03	0.09	0	1.42
Chemical fertilizer used wheat (MT/1000 persons)	1.09	2.86	0	33.60
Improved seed used wheat (MT/1000 persons)	0.89	6.96	0	87.59
Chemical fertilizer used maize (MT/1000 persons)	0.79	4.07	0	81.23
Improved seed used maize (MT/1000 persons)	1.45	11.69	0	20.43
Rainfall (mm)	75	23	19.6	163
Population (thousand)	122	59	17	795

Note: Statistics computed for PSNP food aid *woredas* covering years 2005 to 2010.

Table 2a Arellano-Bond One-step System Dynamic Regression Results, Dependent Variable is Production (MT/person)

	Model 1			Model 2			Model 3		
Variables	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize
Per capita production,	0.457***	0.300***	1.010***	0.372**	0.0404	0.892***	0.239	0.0920	1.009***
1 year lag (MT)	(0.146)	(0.064)	(0.142)	(0.145)	(0.0682)	(0.158)	(0.227)	(0.201)	(0.0599)
Per capita PSNP food aid,	0.748**	1.645	-0.187	1.144***	3.945***	-0.666			
1 year lag (MT)	(0.305)	(1.001)	(0.59)	(0.440)	(1.082)	(0.676)			
Per capita relief food aid,	-2.344**	-9.603***	-8.149***	0.290	2.801	-5.635***			
1 year lag (MT)	(1.078)	(2.791)	(2.974)	(0.892)	(3.176)	(1.963)			
Per capita predicted food aid,							0.456**	1.142***	-0.273
1 year lag (MT)							(0.227)	(0.335)	(0.198)
Rainfall,				0.482**	2.024**	-0.595	-0.107	-0.122	-0.496**
(thousand mm)				(0.209)	(0.790)	(0.370)	(0.0946)	(0.142)	(0.246)
Rainfall,				0.473***	1.824***	-0.0707	-0.308*	-1.076***	-0.365
1 year lag (thousand mm)				(0.176)	(0.669)	(0.305)	(0.178)	(0.364)	(0.311)
Per capita improved seeds ,				98.36	-4.093	-0.385*	147.3	-0.817	0.00678
(MT)				(165.5)	(3.163)	(0.203)	(118.1)	(0.915)	(0.0702)
Per capita chemical fertilizer,				6.774**	12.95***	0.188	8.191***	5.288	1.055
(MT)				(2.945)	(4.948)	(0.703)	(3.039)	(4.391)	(0.814)
Hansen test (p value)	0.208	0.297	0.215	0.739	0.226	0.072	0.643	0.367	0.265
AR(1) (p value)	0.009	0.167	0.051	0.007	0.128	0.017	0.162	0.904	0.125
AR(2) (p value)	0.747	0.357	0.305	0.784	0.503	0.214	0.215	0.206	0.792
Observations	617	552	616	617	552	616	617	552	616
No. of *woredas*	195	181	197	195	181	197	195	181	197

Note: Standard errors in parentheses. Single, double and triple asterisks represent statistical significance at the 10%, 5% and 1% test levels, respectively. All regressions include year dummies.

Table 2b Arellano-Bond One-step System Dynamic Regression Results, Dependent Variable is Area Cultivated (Hectare/person)

	Model 3'		
Variables	*Teff*	Wheat	Maize
Per capita area cultivated,	0.560***	0.402***	0.987***
1 year lag (Hectare)	(0.156)	(0.122)	(0.0550)
Per capita PSNP food aid,	1.278***	1.817**	-0.157
1 year lag (MT)	(0.422)	(0.765)	(0.207)
Per capita relief food aid,	-1.062	-1.515	0.789*
1 year lag (MT)	(1.067)	(1.513)	(0.428)
Rainfall,	0.658**	0.959*	0.0681
(thousand mm)	(0.315)	(0.490)	(0.0814)
Rainfall,	0.549**	0.929**	0.0854
1 year lag (thousand mm)	(0.267)	(0.441)	(0.0813)
Hansen test (p-value)	0.405	0.683	0.107
AR(1) (p-value)	0.000	0.086	0.003
AR(2) (p-value)	0.719	0.503	0.949
Observations	617	553	616
No. of *woredas*	195	181	197

Note: Standard errors in parentheses. Single, double and triple asterisks represent statistical significance at the 10%, 5% and 1% test levels, respectively. All regressions include year dummies.

Table 3 Arellano-Bond System Dynamic Regression Results, Dependent Variables are PSNP and Relief Food Aid (MT/person)

	Model 4 (PSNP)			Model 5 (Relief)		
Variables	*Teff*	Wheat	Maize	*Teff*	Wheat	Maize
Per capita food aid,	0.437***	0.480***	0.442***	0.0155	0.201**	0.0186
1 year lag (MT)	(0.116)	(0.154)	(0.127)	(0.313)	(0.0997)	(0.340)
Per capita production,	-0.0988	-0.0171	-0.0225	0.0621**	-0.151**	0.000339
(MT)	(0.0703)	(0.0148)	(0.0441)	(0.0293)	(0.0757)	(0.0224)
Per capita production,	0.0699	0.0235***	0.0117	0.00702	-0.162**	-0.0176
1 year lag (MT)	(0.0518)	(0.00295)	(0.0233)	(0.0363)	(0.0758)	(0.0280)
Rainfall,	-0.354***	-0.353***	-0.0464	-0.0974**	-0.119***	-0.151**
(thousand mm)	(0.110)	(0.124)	(0.0322)	(0.0403)	(0.0451)	(0.0757)
Rainfall,	-0.372***	-0.348***	-0.102***	-0.0609	-0.159***	-0.162**
1 year lag (thousand mm)	(0.103)	(0.132)	(0.0233)	(0.0487)	(0.0428)	(0.0758)
Hansen test (p-value)	0.735	0.217	0.219	0.117	0.630	0.101
AR(1) (p-value)	0.000	0.006	0.000	0.142	0.000	0.130
AR(2) (p-value)	0.714	0.910	0.475	0.617	0.204	0.426
Observations	617	552	616	617	552	616
No. of *woredas*	195	181	197	195	181	197

Note: Standard errors in parentheses. Single, double and triple asterisks represent statistical significance at the 10%, 5% and 1% test levels, respectively. All regressions include year dummies.

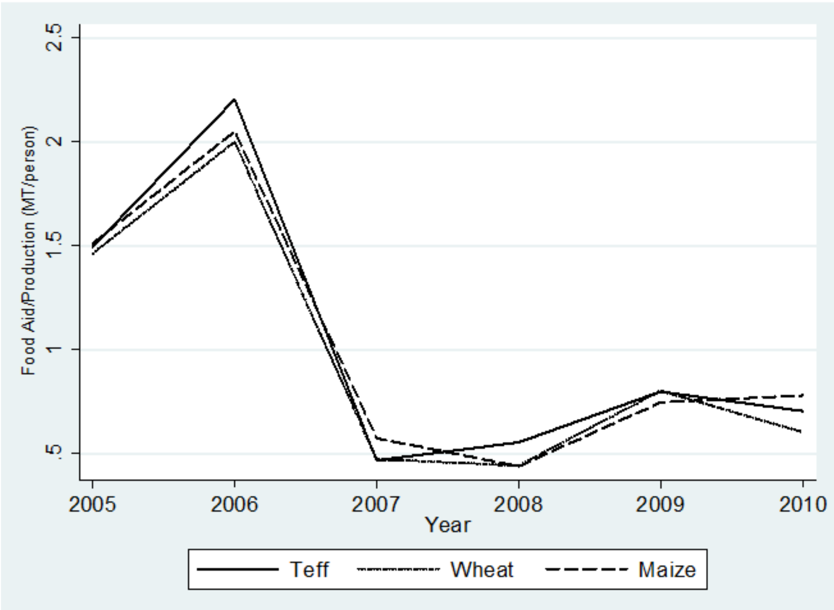

Figure 1 Share of Food Aid in Production in PSNP *Woreda's*, by Commodity (2005-2010)

PAPER 3

Cross-border Maize Market Integration: The Case of Malawi and its Neighboring Countries

Meron Assefa Arega
meron.arega@nmbu.no

Atle Guttormsen
atle.guttormsen@nmbu.no

NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), P.O.Box 5003, 1432 Ås, Norway
+47 64965700 (phone); +47 64965701(fax)

ABSTRACT. The increasing importance of informal cross-border trade (CBT) between Malawi and its neighboring countries, Mozambique, Tanzania and Zambia motivates us to examine whether markets in border districts of Malawi are more integrated with border markets in the neighboring countries than with other local markets within the country. We investigate this issue using monthly maize price series from January 2004 to December 2012 in conjunction with Johansen likelihood-based cointegration test. Results suggest intra-regional market integration among border and other-local markets in Malawi. As well, significant cross-border integration between markets along the border of Malawi and the neighboring countries is evidenced, mainly with that of Mozambique. An important implication of the findings is that CBT increases the size of maize markets for traders along border districts of Malawi. Thus, CBT potentially plays an important role in Malawi from perspective of food price stabilization, and thus food security.

JEL classification: C32, D40, Q11, Q13
Keywords: cross-border trade, cointegration, Johansen likelihood, maize, Malawi

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1. Introduction

In southern Africa, potential for maize cross-border trade (CBT) stems from prevailing comparative advantages in the region. First, there are differences in maize production risks and instability among the countries in the region, thus regional trade can mitigate local production shocks (Haggblade et al., 2008; Tschirley & Jayne, 2010; Valdés & Muir-Leresche, 1993). Maize production data in the region reveal low production covariance across countries, at least in recent years, 2006 to 2012 (results not reported). This suggests that the surplus maize producing area in the region may cross countries and supply deficit areas. Second, maize is a primary food staple in southern Africa, but there is a high potential for substitution among food staples, for instance with cassava (Haggblade et al., 2008; Tschirley & Jayne, 2010; Valdés & Muir-Leresche, 1993). Thus, two staple food zones of the region that consume both cassava and maize may choose to consume more cassava and sell more maize and potentially supply maize to deficit areas in poor harvest years (Haggblade et al., 2008; Valdés & Muir-Leresche, 1993). Third, in spite of the fact that most of the colonially inherited boundaries in the region are arbitrary, informal cross-border movements of goods are based on existing natural economic and strong cultural linkages that enhance the potential for trade in the region (Haggblade et al., 2008). In general, existing comparative advantages for regional trade suggest food security role that CBT can play by moving maize across countries in the region.

Achieving food security has been a fundamental policy priority of the Malawi government. Maize remains the most important food crop underlying to food security policies and strategies in the country. It is a major consumption (172 KG per person per year and 60 to 70 percent of dietary calorie intake) and production (90 percent of farm households and 60 percent of total cultivated land), as well as a dominant staple food crop in the country (Ellis & Manda, 2012; Makombe et al., 2010). There is a pronounced maize production shortfall and volatility that mainly result from heavy reliance on rainfall production in Malawi (Makombe et al., 2010). Maize production in Malawi declined sporadically in early 2000s, reaching a lowest level of 1.2 million tons in the 2004/05 production seasons, mainly due to poor rainfall (Figure 1). However, from 2005 to 2011, maize harvest has improved tremendously, almost doubling the past recorded level. This is attributed to a combination of favorable weather conditions and the introduction of a large-scale agricultural subsidy on the cost of seeds and fertilizer under the program called the Agricultural Input Support Program since 2005. The program has increased the affordability and profitability of modern input applications to smallholder farmers by selling fertilizer at about one-fifth of the market price (Dorward & Chirwa, 2011; Minot, 2010). It has helped to increase maize production and productivity, as well as improved food security through increased real wages and reduced food price to some extent (Dorward & Chirwa, 2011).

Overall, despite surplus maize production in the past few years in Malawi, it experiences substantial maize price instability, even higher than international prices and other SSA countries (Minot, 2010). Maize market in Malawi is known to be highly influenced by the government operating through its parastatal, Agricultural Development and Marketing Corporation (ADMARC) and relatively recently the National Food Reserve Agency (NFRA). The role of ADMARC in Malawi's maize econonomy has declined with the private sector increasing in its importance in the past few decades. However, ADMARC still is a key instituion in maize trade and in the delivery of subsidized fertilizers to farmers, whilst NFRA manages a strategic grain reserve (SGR) and provides a social safety net. There is a noticable remergence of direct parastatal operation in maize market in Malawi since early 2000s. In fact, unlike price spikes in 2002 and 2006 that correspond to domestic maize production shortfalls, high prices in 2008 and 2009, as well as low prices in 2003, 2008 and 2010 are arguably due to unintended consequences of government policy interventions in maize market in Malawi (Figure 2). This includes, banning external trade, unpredictable change in import trariffs, direct government importation and domestic purchase and slaes of grain at susidized prices, restrictions on private maize traders, and setting price floor and ceilings.[1]

Most important, maize imports and exports are also constrained by the government's legislation, licensing, and trade policies (Ellis & Manda, 2012). Besides, as a land locked country, external trade involves high cost of transportation in Malawi (Minot, 2010). Thus, import and export could not adquately help to stabilize prices. External maize trade requires export and import licensing in Malawi. The government regularly bans export of maize if prices are high or anticipates production shortfall (Tschirley & Jayne, 2010). As a result, maize exports are usually carried out either by the government or in the form of informal CBT. On the other hand, bans on maize imports are rare, but the uncertainty concerning government legislations on imports makes private traders not attracted to import maize (Minot, 2010). Typical situation could be that the government controls all formal maize imports and usually NFRA imports maize for food security reserve and later sells it to ADMARC (Tschirley & Jayne, 2010). This makes it risky for large formal traders to consider importing maize even during the times of no import bans.

Similarly, in neighboring country, Zambia, large-scale fertilizer subsidies were reintroduced since 2002/03, which has partly contributed to the recent bumper harvests (Ricker-Gilbert, 2013). At the same time, Zambia has often used export bans and restricts maize outflows to ensure food security. Both imports and exports require government permits that stipulate quantitative restrictions (Chapoto & Jayne, 2009). Food reserve agency of the government obtains the largest quantity of the maize import and export allowed, and

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[1]Detailed discussions of this issue is avialable in: Chapoto & Jayne (2009); Ellis &Manda, (2012); Minot (2010) and Tschirley & Jayne (2010).

sometimes holds a monopoly to maize export even during good production seasons. In Tanzania[2], the government parastatal, Food Security Department is mandated to directly compete with private traders and to determine the country's import and export requirements (Chapoto & Jayne, 2009). The government allows maize export only when all regions of the country are food secure, which practically imposes export bans continuously (Minot, 2010). On the other hand, there are no government grain marketing parastatals in Mozambique, and trade policy is relatively open and stable, with no apparent external trade bans (Chapoto & Jayne, 2009; Minot, 2010).

Despite the consequences, informal smaller-scale traders manage to overcome restrictions through informal maize border trades in southern Africa (Tschirley & Jayne, 2010). For instance, Famine Early Warning System (FEWSNET) has recorded a significant volume of informal maize traded across 30 borders it monitors in the southern Africa in the past decade (Table 1). Average annual informal inflow of maize to Malawi is 67,354 tons, whilst informal maize outflow from Malawi is 19,499 tons, with total net maize inflow to Malawi amounting to 47,855 tons over the past 8 years (Table 1). As these data is only from FEWSNET monitored areas, it may still underestimate total informal trade flows between these countries (Tschirley & Jayne, 2010).

Against this backdrop, the objective of this study is to examine whether markets in border districts of Malawi are integrated with border markets of the neighboring countries. In fact, the extent to which the benefits from CBT can be exploited depends on how well integrated local border markets are with neighboring border markets. Understanding spatial price relationship guides policy interventions that help to reduce transaction costs associated with trade barriers, and to develop more stable and reliable trading networks.

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[2]Tanzania has recently started subsidizing fertilizer and seed to a significant share of producers. However, little evidence is available on the agricultural production and market impact of the program.

In this study we extend the analysis of food market integration by examining spatial maize price relationships between border markets in Malawi and neighboring countries, Mozambique, Zambia, and Tanzania. First, we measure intra-regional maize market integration, mainly between regional major cities and border markets of Malawi. And second, we extend the same analysis to examine integration between maize markets situated along the border of Malawi and the neighboring countries. This gives us the opportunity to compare spatial price relationships between major and border markets within Malawi, and between border markets of Malawi and neighboring countries.

Below we analyze market integration using the Johansen Full Information Maximum Likelihood procedure based on maize price series from different markets in Malawi, Mozambique, Tanzania and Zambia over the period from January 2004 to 2012. Our main findings suggest that for the time covered by our data, integration of border markets of Malawi with other local markets, as well as with neighboring markets have taken place. This implies the food security role CBT can play in Malawi and bordering countries.

2. Background

Past studies of market integration in SSA have mainly focused on analyzing market integration at an intra-country level, with very few studies evaluating how well integrated or efficient the maize markets are at regional levels. Mutambatsere et al. (2006) show significant frequency of maize market integration among five southern African countries: Botswana (Gaborone), South Africa (Gauteng), Malawi (Blantyre), northern Mozambique (Mocuba) and southern Mozambique (Maputo). However, market efficiency among these countries holds less frequently and appears to be weakened by insufficient arbitrage, possibly a result of barriers to trade (infrastructural or regulatory), imperfect information, or supply side constraints. For these markets, positive trade is also occasionally observed when arbitrage returns are negative, possibly due to contracting lags, and exchange rate fluctuations. On a relatively recent study, Ihle et al. (2011) show that consistent with policies and infrastructural situation of the countries, maize markets in Tanzania are isolated and internally fragmented in Eastern Africa Community (EAC), in contrast to Kenya and Uganda that are well integrated with high rates of price transmission both internally and across borders.

Similarly, many market integration studies in Malawi are limited to examining the domestic maize markets. In earlier studies, Goletti & Babu (1994) and Chirwa (2001) examine the effect of market liberalization on market integration in Malawi and conclude that market liberalization enhances the degree of market integration in the country. Other studies also show that markets in major town in Malawi are integrated with relatively rapid adjustment (Chirwa, 2001; Goletti & Babu, 1994; Myers, 2013; Zant, 2013), while smaller and more remote towns remain disconnected from national markets (Chirwa, 2001; Myers, 2013). Given the existing litreature, a contribution of this study could be that it deals with a policy relevant issue in Malawi that has not been adequately addressed before to our knowledge.

3. Informal maize CBT between Malawi and neighboring countries

After market reforms of the 1990's, regional trade integration among SSA countries has received an increasing attention. Most countries joined multilateral trading systems, whilst sub-regional initiatives that promote trade in eastern and southern Africa, such as the Southern Africa Development Community (SADC), the Common Market for East and Southern Africa (COMESA) and EAC have emerged (Ackello-Ogutu, 1996; Mutambatsere et al., 2006). Subsequently, there was a growing interest in CBT with a popular notion that it overcomes regulatory trade barriers and price distortions, thus enhances intra-regional trade, potentially stabilizes food supplies and prices, and ultimately ensures food security (Little, 2007).

A number of regional efforts have taken place towards promoting CBT in SSA over the past few decades. This includes the Cross-Border Initiative in 1993 which comprises of a common policy framework to facilitate CBT by eliminating trade barriers between fourteen participating countries in eastern and southern Africa (IMF, 1999). In Regional Grain Trade Summit organized by COMESA in 2005 major suggestions include increasing regional trade through implementation of "maize without borders" policy and facilitating CBT in COMESA/EAC/SADC regions (FEWSNET, 2005). Recently, CBT project started in eastern and southern Africa in 2009 as part of Regional Food and Risk Management Programme that aims to contribute to sustainable reduction of vulnerability to food insecurity and poverty. This project works towards liberalizing food CBT in order to improve the food security in the region. A CBT desk is set up in COMESA to help governments to implement Simplified Trade Regime (STR) and to strengthen the capacity of regional Cross-border Trade Associations (CBTA), which are still in ongoing processes. STR helps to facilitate CBT by simplifying the cumbersome customs processes, particularly it produces certificate of origin, common list of tradable goods and customs documents at the borders. Thus, overall the on-going regional efforts suggest that countries identify CBT as a component of their food security strategies and food price stabilization efforts. Yet, how much these different policies and strategies enhance CBT is debatable given that a large volume of CBT in SSA is still conducted informally.

CBT between Malawi and neighboring countries are influenced by various factors. One, the volume of CBT is mainly determined by harvest situation in the region. It is usually the case that trade flows from food surplus to deficit bordering countries to relieve food production shortfalls. In all maize shortage episodes of the 2000s[3], CBT significantly helped

[3]In 2000s, Malawi experienced three maize price spikes (as much as 354%, 218%, and 395% increases experienced in 2001/2002, 2004/2005, and 2007 to 2009, respectively) causing the highest

cope with shortage of domestic supply in Malawi (Ellis & Manda, 2012). Figure 1 shows informal maize imports to Malawi correspondingly tend to be relatively higher in low production years as compared to higher recent production years. In 2004/05 to 2007/08, Figure 1 further shows that informal maize imports to Malawi are more significant subsequent to low production, peaking to 156,499 MT in 2005/06. At the same time, the volume of informal imports to Malawi still depends on the harvest situation in the bordering northern Mozambique, southern Tanzania, or eastern Zambia. In cases when its neighboring countries are in deficit, a typical response by Malawi government is formal imports from South Africa and food aid (Tschirley & Jayne, 2010).

Two, informal maize trade flow is influenced by production and marketing seasonality among trading countries. It is noted that all the four countries examined share similar maize production and marketing calendar. As shown in Figure 3, informal net maize inflow from Mozambique to Malawi is high following the harvest seasons of April to June, and the pick market season of July to September. During the planting season, from October to December, the net maize inflow from Mozambique to Malawi starts to decline and hits the lowest level during the lean seasons, January to March. The volume of Maize inflow from Tanzania to Mozambique follows different trend, showing the highest net inflow from January to March.

Three, CBT is also influenced by the quality of road transport and communications infrastructure between the bordering countries. Informal traders use vehicles, bicycles, portage, and canoes depending on the type of commodity being transported, the surrounding terrain and other conditions along the border in southern Africa (Minde & Nakhumwa, 1998).

And last, CBT is further motivated by the long standing indigenous relationships among the communities residing in the territorial boundaries which often predate the colonial

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level of maize price instability in the region and adversely affecting the food security situation in the country (Ellis & Manda, 2012; Minot, 2010).

and post colonial boundaries (Little, 2005). The people share common culture and languages. They are well integrated through marriage and people own land on either side of the borders. All these factors provide incentives to trade in order to exploit available opportunities on both sides of the border (Minde & Nakhumwa, 1998).

4. Empirical strategy

The first step before testing for shared stochastic trends is to check for unit roots in the autoregressive representation of each individual time series and determine the degree of integration of each series. We use two unit root tests namely, the Augmented Dickey–Fuller test (ADF) and Phillips–Perron test (PP), which are based on the null hypothesis of non-stationarity of the tested time series. We then examine maize market integration by applying the Johansen Full Information Maximum Likelihood co-integration framework that is fully described in (Johansen, 1995). This approach allows us to test for the number of cointegrating relations, to identify co-integrating vectors, as well as to make inference on the estimated co-integrating relations in maximum likelihood framework.

The Johansen procedure is based on the unrestricted $VAR(k)$ model transformed into the error correction form as follows:

$$\Delta P_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \prod{}_k P_{t-k} + \varepsilon_t \,, \tag{1}$$

where, P_t denotes n x1 vector of prices; Δ is a first difference operator, such that $\Delta P_t = P_t - P_{t-1}$ shows the change in the vector P_t from time $t-1$ to time t (short term price changes); Γ_i with $i = 1,...,k-1$ is the short-run coefficient; $\prod$ is a long-run impact matrix summarizing all the long-run information in P_t process, such that its rank determines the number of cointegration vectors in the system; ε_t represents an i.i.d multivariate Gaussian process; and μ is an intercept.

When all variables, P_t in equation (1) are $I(1)$, the presence of r linearly independent cointegrating vectors implies that the long-run impact matrix can be represented as, $\prod = \alpha\beta'$, where, α and β are $n \times r$ matrices of full column rank. The matrix β contains cointegrating vectors that represent long run equilibrium and the matrix α is the matrix of the adjustment coefficients to the long-run disequilibrium errors represented by the cointegrating relations. The speed of adjustment parameter, α indicates how long it takes for the long run equilibrium to re-establish itself after a shock. The absence of cointegration amongst the variables, P_t implies that the rank of $\prod$ is zero ($r = 0$), thus equation (1) becomes a $VAR(k-1)$ model in first differences of the original variables, ΔP_t.

Thus, we identify the number of cointegrating relationships in both multivariate and bivariate cases by applying trace and eigenvalue tests to determine if long-run relationships between maize prices exist. The Law of One Price (LOP) is tested using Likelihood Ratio (LR) tests on whether $\beta = (1, -1)'$.

5. Data and sources

We use monthly nominal retail maize prices from major and border markets of Malawi, as well as from border markets of Zambia and Mozambique and nominal wholesale prices from Tanzania[4]. The data spans from January 2004 to December 2012, providing 108 observations. We consider 19 urban center and border markets from Malawi, as well as 2 markets from

[4]We could not get retail maize prices for Tanzania for the time period of our analysis. However, for earlier periods that we get both wholesale and retail prices, we observe that both price series from different markets have the same trends. Thus, we assume using wholesale prices is the best available alternative.

Tanzania, 3 from Mozambique and 2 from Zambia that are close to borders of Malawi. Figure 4 provides the map of Malawi and neighboring countries with the study markets.

We select markets based on their importance to border trading, their proximity to urban city centers and data availability. Since some price series start too late or end too early, we use the time period where we find all series have the same length. A few remaining missing values in the data are linearly interpolated. To ensure the compatibility between different prices, all prices are converted to USD per kg. All prices are transformed into natural logarithms that induce linearity and avoid hetroskedasticity and non-normality. Particularly, as data covers the period of general food price spikes, using logarithm transormation help to straighten the trend out and stabilize variance of the nominal price series. All maize price data are obtained from FEWSNET and exchange rates are from IMF's International Financial Statistics database.

6. Results and discussion

Table 2 presents descriptive statistics of price series from different markets used in our analysis. Average maize prices range from 0.16 to 0.24 USD/kg. On average, we do not observe high range between prices from different border markets of the countries examined. Maize price volatility measured by coefficient of variation (CV) is high, mostly above 40 percent. Figure 5 shows monthly prices in USD/kg from all markets considered in our study. The graphs depict prices from different markets follow the same seasonal pattern of movements during the data period and are very volatile as also evidenced by the CV.

We carry out ADF and PP unit root tests with a constant and a trend for the levels and a constant for the first differences. Table 3 presents the results of these tests in levels and differences. When addressing the order of integration of the price series in levels, the null hypothesis that the corresponding time series are $I(1)$ is accepted by both the ADF and PP tests. For the difference of the time series, the unit root results suggest that they are $I(0)$. Thus, we find that all prices in level are $I(1)$ and the cointegration analysis is appropriate to investigate their joint properties.

6.1. Domestic market integration in Malawi

Given the large number of markets we examine, the bivariate and multivariate cointegration analyses are carried out intra-regionally between local markets in Malawi. For the cointegration tests, lag lengths that whiten the error term are chosen. We conduct a multivariate cointegration test in system containing 4 markets from the northern region (Chitipa, Karonga, Embangweni and Muzuzu), 8 markets from the central region (Chimbiya, Kasungu, Lilongwe, Mitundu, Lizulu, Mchinji, Ntcheu and Nsundwe) and 7 markets from the southern region (Luchenze, Lunzu, Mwanza, Nchalo, Ngabu, Nsanje and Zomba) of Malawi.

Results from multivariate cointegration tests and VECM tests are reported in Table 4. The trace tests suggest three cointegration vectors in the system in the northern, and six in the central and in the southern regions of Malawi. This implies intra-regional market integration in Malawi, suggesting maize prices among the markets in each group move together and maintain long-run equilibrium. Test for the LOP supports the conclusion that the four markets examined in the northern region are highly cointegrated. However, the null hypothesis that the LOP holds for the whole system is rejected for the central and southern regional markets.

Subsequently, we carry out intra-regional pair-wise cointegration tests, between regional major city markets and markets located along the borders. Mzuzu in the northern, Lilongwe and Mitundu in the central, and Lunzu (in Blantyre) in the southern regions represent markets in regional capital cities. Overall, results from trace and LOP tests in Table 5.1 show that for most of the market pairs, we reject the null hypothesis that there is no cointegration, indicating maize markets in Malawi are well integrated regionally.

In the northern region of Malawi, all markets are found to be spatially integrated with Muzuzu. The LOP is rejected for all market pairs examined in the northern region, except Embangweni. In the central region, Mitundu is located in the outskirt of Lillongwe district and is well integrated with all the border and city markets in the region. However, Lilongwe is not integrated with some of the markets situated in the border of Malawi, including Chimbiya, and Ntcheu. However, the LOP holds for all market pairs in the central region, thus some of the LOP test results conflict with the trace tests. Furthermore, in the southern region of Malawi, all the six bivariate cointegration tests strongly reject the absence of cointegration, but do not reject the existence of one cointegrating relationship. This is also confirmed by LOP tests.

Table 5.2 reports the speed of adjustment between prices among the different markets that are found cointegrated. The degree and statistical significance of the coefficients of the speed of adjustment vary across the pairs. The coefficients of speed of adjustment associated with major markets (Muzuzu, Lilongwe, Mitundu and Lunzu) are statistically significant in most cases, whilst the reverse holds for the majority of the rest of the markets considered. For those coefficients that are statistically significant, the speed of adjustment ranges between 19% and 48%, with most of them showing below 40% of disequilibrium error is corrected in one month. The negative values of the adjustment parameter imply that positive deviations from the long-run equilibrium are corrected by decreases in prices in a particular market. Furthermore, the long-run adjustment parameters are statistically different from zero at the 1% level for almost all cases.The long-run elasticity of price transmission is close to 1.0 in most cases, indicating a high degree of intra-regional transmission of price changes between local markets in Malawi in the long-run.

6.2. Spatial integration between maize border markets of Malawi and neighbors

Table 6.1 and Table 6.2 summarize results from cointegration tests and VECM estimates between maize border markets in Malawi and neighboring countries.

Malawi-Mozambique border

Comparison across bordering countries show that trade between Malawi and Mozambique is more significant, accounting for about 80 percent of informal maize import to Malawi over the past decade[5] (see Table 1). The Malawi-Mozambique CBT is enhanced by various particulars. One, most part of southern Malawi is practically surrounded by Mozambique and thus, trade links with Mozambique are well-established. Two, while the southern part of Malawi is highly populated, major consumption and food deficit area, northern Mozambique on the other hand have good harvest, yet located far from the major consumption areas of central and southern Mozambique (Bata et al., 2005). Thus, southern Malawi provides market to northern Mozambique. Third, the porous nature of the borders between the two countries creates relative ease for maize to cross-borders (Bata et al., 2005). Most of the maize is transported across the border to the Malawi by cyclists, in which during the peak marketing season for maize, July to September, the frequency and number of cyclists crossing the border increases (FEWSNET, 2005).

This motivates us to empirically test maize market integration between Malawi and Mozambique border markets. We consider three markets from Mozambique that border Malawi namely, Mutarara, Angonia and Milange to examine their maize price linkages with

[5]However, in the last two years 2010/11-2011/12, Table 1 shows reversed trends in maize flows between Malawi and Mozambique, with Malawi which was a net importer of Mozambican maize now becoming the net exporter into Mozambique. This is as a result of strict controls on informal trade on the Mozambique border of Milange that maize from Malawi that is destined for Zimbabwe transits through Mozambique was captured by the monitors as imports into Mozambique (FEWSNET, 2011).

Malawi's central region markets (Chimbiya, Lizulu, Mchinji, Mitundu, Nsundwe and Ntcheu), and southern region markets (Luchenaza, Lunzu, Mwanza, Nchalo, Ngabu ,Nsanje, and Zomba). Trace and LOP test results reported in Table 6.1 show all market pairs examined between Malawi and Mozambique indicate long-run equilibrium. Angonia (Mozambique) shows a long-run price relationship with Chimbiya, Mitundu, Lizulu, Nsundwe and Ntcheu (Malawi). Also maize prices in Mutarara (Mozambique) maintain a long-run equilibrium with Nchalo and Nsanje (Malawi). Further, results show maize market integration between Millange (Mozambique) and Lunzu, Luchenza and Zomba (Malawi).

VECM results in Table 6.2 further show that the estimated correction parameters for border markets in Malawi mostly exhibit statistically significant adjustment process to the long-run price relationship, the values ranging between 16% and 40%. Thus, there appears to be relatively fast adjustments toward the border maize prices between Malawi and Mozambique. The coefficients for long-run relationships are statistically significant and negative at the 1% level for all market pairs.

Malawi-Tanzania border

Malawi-Tanzania CBT becomes a major supplier to Malawi in certain years over the past decade. Table 1 shows about 84,862 MT flow to Malawi during the 2005/06 crisis, which is a substantial share of total imports. Since 2009/11, the direction is reversed that more maize trade flows from Malawi to Tanzania is observed. Thus, informal CBT plays a crucial role in alleviating food shortages and high prices in these countries.

We examine market integration between two markets from northern region of Malawi (Chitipa and Karonga), and Mbeya and Songea from Tanzania. Both trace and LOP test results reported in Table 6.1 show Mbeya is not integrated with Karonga. This probably can be due to controlled border and other natural communication barriers. However, the trace test statistics rejects the null hypothesis of no cointegration between Mbeya (Tanzania) and Chitipa (Malawi). Maize prices in Songea (Tanzania) are also linked with both Karonga and Chitipa (Malawi). Our expectations are that most of the trades between Songea and Chitipa, as well as Songea and Karonga are conducted using boats on the river.

As shown in Table 6.2, the speed of adjustment coefficient of Chitipa and Karonga are mostly statistically different from zero and suggest that about 16% to 33% of the divergence of border price pairs examined between Malawi and Tanzania are corrected each month. The coefficients for long-run relationships are statistically significant for all of the market pairs examined.

Malawi-Zambia border

Data in Table 1 shows that Malawi-Zambia CBT is insignificant in spite of tremendous potential. Both countries adopt STR to facilitate CBT, yet there are a number of cumbersome regulatory barriers that still increase transaction costs and discourage trade. Additionally, these two countries frequently impose maize export bans during crisis years, which can greatly affect the trade performances (Tschirley & Jayne, 2010).

We examine two important markets from Zambia, Chipata and Lundazi that border northern Malawi (Embangweni) and central Malawi (Kasungu and Mchinji) markets. The trace test statistics in Table 6.1 show the overall significant maize price linkages between Zambia and Malawi, except an unexpected result of no market integration between Mchinji (Malawi) and Chipata (Zambia). However, the LOP is not rejected between these two markets. We expect to find high spatial integration between these two markets since they have very close proximity and important road network between them. Despite natural potential for CBT, maize price in Mchinji are rather quite better linked with markets in central Malawi (as shown in Table 5.1) as compared to border markets of Zambia. This could be plausible because of the possibility of CBT barrier between Mchinji and Zambia. Besides, Mchinji is indeed well connected with the rest of markets in central region of Malawi, through good road networks to its eastern neighboring district of Lilongwe, and another good all-season road to Kasungu to the north.

Table 6.2 further reports that the estimated speed of adjustment coefficients of Kasungu are statistically different from zero. As well, the coefficients for long-run relationships are statistically significant for all market pairs considered.

Overall, results show maize price linkages between border markets of Malawi and its neighboring countries, especially with those in Mozambique. However, despite integration between these markets is mainly triggered by CBT, we cannot entirely eliminate other potential causes, such as change in global or regional economic activities. This is of particular concern given our analysis covers the period of the global food price crisis. Accordingly, we test contegration of maize prices between world, border markets of Malawi and its neighbors. The trace test statistics in Table 7 reports evidences of one cointegrating vector for eight out of twelve tests between world, Malawi and Mozambique, whilst two out of four tests between world, Malawi and Tanzania maize markets studied. However, all tests strongly reject the existence of cointegrating relationship between world, Malawi and Zambia markets examined. This result leaves us with the impression that CBT is possibly the major factor that triggers the co-movement of prices among the border maize markets we studied.

7. Conclusions and policy implications

Spatially integrated markets are linked by a process of arbitrage that potentially decreases price differences between markets to the level of transfer costs. Thus, a high degree of market integration is desirable ensuring smooth transmission of price signals and information, and enabling efficient product movements between spatially separated markets. In Malawi, maize imports and exports are constrained by government's legislation and unpredictable trade policies. Since the government regularly bans maize exports, it is mainly carried out by the government or through informal CBT. Maize import bans are not common; however, the subsided government parastatal import maize and operates in competition with private traders. This coupled with uncertainties concerning import licensing discourages most large private traders to import maize. However, informal smaller-scale traders manage to overcome trade restrictions and operate in informal CBT. FEWSNET has recorded a large volume of informal maize traded across borders in southern Africa in the past decade.

In this paper we examined to what extent maize markets are linked across borders to exploit the benefits from regional trade. In particular, we measured intra-regional maize market integration within Malawi, and between markets along the borders of Malawi and its neighboring countries, Mozambique, Tanzania, and Zambia. We used monthly maize price series from 2004 to 2012 and applied the Johansen cointegration test. Overall, results showed maize market integration intra-regionally in Malawi, and also between markets along the borders of Malawi and its neighboring countries, especially with those in Mozambique.

Thus, findings imply the potentials for cross-border maize trade between Malawi and the bordering countries. Given that border markets of Malawi are well linked both within the country and across border, our results suggest CBT has enlarged markets for maize traders along the border of the country, facilitating inflows during shortage and outflows during surplus times. Accordingly, this study underlines the role CBT potentially plays from perspective of food price stabilization and food security. Although existing trade barriers have not stopped informal CBT in the countries we studied, they potentially increase transaction costs and undermine incentives for private traders. Reducing trade barriers facilitates regional maize markets to become more integrated and to enhance their role in stabilizing food production and prices by ensuring commodity movements at lower transfer costs. Maize price spikes and volatility rather continued to be a major threat to food security in Malawi and surrounding countries. This is despite the observed increase in maize production that is partly attributed to on-going input subsidy programs in most of the countries we studied. After all, resulting gains from such costly government interventions in terms of maize production and productivity growth can be exploited only if they are accompanied by adequate food policies and market infrastructure. From the perspective of our analysis, encouraging regional maize CBT potentially expands markets and effectively reduces price instability, by linking together areas with covariate production. In view of that, government should respond with adequate trade policies that encourage the development of regional trade.

Most important, government maize market interventions should be rule-based, transparent, and predictable to allow private traders understand market conditions that drive the direction in government's role and operation, and to promote a viable environment for trade. Continued government investment in physical infrastructure, such as roads, communication and storage, as well as in provision of credits are also important to improve the capacity of private traders to absorb domestic surplus, or source produces from abroad during shortage.

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Table 1 Informal Cross-border Maize Trade Flows in MT, by Source and Destination Country

Source	Destination	2004/05[1]	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	Total	Average
Malawi	Mozambique	0	133	591	3,755	203	71,45	27,210	59,389	98,426	14,061
Malawi	Tanzania	637	944	2,928	1,581	239	7,719	7,073	17,252	38,373	4,797
Malawi	Zambia	34	81	202	1,779	1,293	310	443	990	5,132	642
Mozambique	Malawi	71,229	71,218	77,394	56,081	54,223	49,138	23,557	30,356	433,196	54,150
Tanzania	Malawi	2,656	84,862	1,888	1,073	2,910	89	261	9	93,748	11,719
Zambia	Malawi	2,157	419	378	2,500	5,388	533	516	0	11,891	1,486
Total outflow from Malawi		671	1158	3721	7115	1,735	15,174	34,726	77,631	141,931	19,498
Total inflow to Malawi		76,042	156,499	79,660	59,654	62,521	49,760	24,334	30,365	538,835	67,354
Total net inflow to Malawi		75,371	155,341	75,939	52,539	60,786	34,586	-10,392	-47,266	39,6904	47,855

Source: Various publications of FEWSNET (2005, 2009, 2012)

Note: [1]2004/05 starts from July, 2004

Table 2 Descriptive Statistics for Maize Prices in USD/kg, January 2004 to December 2012

Country	Market	Mean	Std. Dev.	CV	Min	Max
Malawi (North)	Chitipa	0.21	0.09	0.43	0.09	0.48
Malawi (North)	Embangweni	0.20	0.09	0.44	0.08	0.39
Malawi (North)	Karonga	0.23	0.10	0.43	0.09	0.46
Malawi (North)	Mzuzu	0.23	0.08	0.35	0.11	0.43
Malawi (Central)	Chimbiya	0.21	0.09	0.44	0.09	0.49
Malawi (Central)	Kasungu	0.24	0.10	0.42	0.07	0.50
Malawi (Central)	Lilongwe	0.22	0.09	0.41	0.11	0.51
Malawi (Central)	Lizulu	0.22	0.10	0.47	0.10	0.54
Malawi (Central)	Mchinji	0.22	0.09	0.39	0.12	0.45
Malawi (Central)	Mitundu	0.20	0.09	0.47	0.09	0.49
Malawi (Central)	Nsundwe	0.20	0.09	0.43	0.10	0.47
Malawi (Central)	Ntcheu	0.22	0.11	0.50	0.09	0.63
Malawi (South)	Luchenza	0.23	0.11	0.49	0.09	0.67
Malawi (South)	Lunzu	0.24	0.10	0.43	0.07	0.57
Malawi (South)	Mwanza	0.24	0.11	0.48	0.10	0.58
Malawi (South)	Nchalo	0.24	0.10	0.43	0.10	0.56
Malawi (South)	Ngabu	0.24	0.11	0.44	0.10	0.55
Malawi (South)	Nsanje	0.24	0.11	0.46	0.09	0.65
Malawi (South)	Zomba	0.22	0.10	0.46	0.10	0.56
Mozambique	Mutarara	0.24	0.12	0.50	0.05	0.73
Mozambique	Angonia	0.21	0.09	0.45	0.08	0.57
Mozambique	Milange	0.22	0.09	0.46	0.07	0.48
Tanzania	Mbeya	0.19	0.07	0.54	0.08	0.36
Tanzania	Songea	0.16	0.06	0.37	0.07	0.31
Zambia	Chipata	0.22	0.06	0.27	0.12	0.38
Zambia	Lundazi	0.21	0.06	0.27	0.11	0.42

Table 3 Unit Root Tests

Country/Region	Markets	Level (with trend)			First difference (without trend)		
		ADF	PP	Lags	ADF	PP	Lags
Malawi (North)	Chitipa	-2.69**	-3.38	6	-5.70	-9.31**	5
Malawi (North)	Embangweni	-2.58**	-3.12	10	-3.43	-11.92**	9
Malawi (North)	Karonga	-2.54**	-3.14	6	-5.11	-9.06**	5
Malawi (North)	Mzuzu	-2.60**	-3.15	6	-5.65	-9.32**	5
Malawi (Central)	Chimbiya	-1.95**	-2.65	11	-3.65	-9.21**	10
Malawi (Central)	Kasungu	-1.81**	-2.98	10	-4.13	-12.41**	9
Malawi (Central)	Lilongwe	-1.78**	-2.86	3	-7.87	-13.98**	2
Malawi (Central)	Lizulu	-2.87**	-2.70	3	-5.80	-7.93**	2
Malawi (Central)	Mchinji	-2.98**	-2.94	3	-5.94	-9.27**	2
Malawi (Central)	Mitundu	-2.90**	-3.23	3	-6.74	-10.52**	2
Malawi (Central)	Nsundwe	-2.43**	-2.94	3	-6.58	-10.51**	2
Malawi (Central)	Ntcheu	-3.05**	-2.27	12	-7.70	-8.68**	11
Malawi (South)	Luchenza	-2.80**	-2.75	3	-5.73	-10.75**	2
Malawi (South)	Lunzu	-3.09**	-3.12	2	-7.71	-8.78**	1
Malawi (South)	Mwanza	-2.65**	-2.97	3	-7.19	-7.49**	2
Malawi (South)	Nchalo	-2.84**	-3.29	2	-8.61	-10.48**	1
Malawi (South)	Ngabu	-2.25**	-2.98	5	-5.70	-9.63**	4
Malawi (South)	Nsanje	-2.33**	-3.18	8	-5.00	-8.54**	7
Malawi (South)	Zomba	-2.63**	-2.76	4	-5.25	-11.16**	3
Mozambique	Mutarara	-3.14**	-2.86	12	-5.83	-8.55**	11
Mozambique	Angonia	-3.14**	-2.93	2	-7.03	-10.12**	1
Mozambique	Milange	-1.87**	-2.65	6	-5.99	-6.44**	5
Tanzania	Mbeya	-3.39**	-2.90	12	-3.98	-8.52**	11
Tanzania	Songea	-2.87**	-3.29	12	-6.87	-10.40**	11
Zambia	Chipata	-2.50**	-2.34	11	-8.45	-11.00**	10
Zambia	Lundazi	-3.20**	-3.21	9	-4.94	-9.42**	8

Note: ** and * indicate statistical significance at the 1% and 5% level respectively.

Table 4 Multivariate Cointegration Result between Maize Markets in Malawi

Region/Market	H_0: Rank= P	Trace Test[1]	LOP[2]
Northern region			
Chitipa	$P=0$	72.81**	3.452(0.063)
Embangweni	$P\leq 1$	41.65**	
Karonga	$P\leq 2$	21.75*	
Mzuzu	$P\leq 3$	7.70	
Central region			
Chimbiya	$P=0$	353.35**	9.557**(0.008)
Kasungu	$P\leq 1$	239.19**	
Lilongwe	$P\leq 2$	171.93**	
Lizulu	$P\leq 3$	120.26**	
Mchinji	$P\leq 4$	78.68**	
Mitundu	$P\leq 5$	41.86**	
Nsundwe	$P\leq 6$	16.19	
Ntcheu	$P\leq 7$	5.93	
Southern region			
Luchenza	$P=0$	255.93**	10.60**(0.001)
Lunzu	$P\leq 1$	184.37**	
Mwanza	$P\leq 2$	124.33**	
Nchalo	$P\leq 3$	83.43**	
Ngabu	$P\leq 4$	50.48**	
Nsanje	$P\leq 5$	23.38*	
Zomba	$P\leq 6$	6.30	

Note: ** and * indicate statistical significance at the 1% and 5% level respectively. [1] Critical values for the cointegration tests can be found in Johansen & Juselius (1990). [2]The test is distributed as Chi-square.

Table 5.1 Bivariate Cointegration Test Results: Maize Markets in Malawi

Region/Markets		Trace test[1] (H_0: Rank= P) H_o: P=0	H_o: P<1	LOP[2]
Northern region				
Chitipa	Mzuzu	37.89**	7.25	4.43* (0.035)
Embangweni	Mzuzu	33.13**	6.63	3.44 (0.065)
Karonga	Mzuzu	51.06**	7.34	5.24* (0.022)
Central region				
Chimbiya	Lilongwe	12.16	4.69	3.31 (0.069)
	Mitundu	46.31**	5.99	0.19 (0.659)
Kasungu	Lilongwe	37.61**	5.58	2.61(0.106)
	Mitundu	58.54**	7.36	0.12 (0.725)
Mitundu	Lilongwe	45.84**	7.87	2.21(0.137)
Lizulu	Lilongwe	28.35**	4.56	5.20 (0.023)
	Mitundu	39.10**	4.63	1.46 (0.023)
Mchinji	Lilongwe	27.67**	5.67	1.04(0.308)
	Mitundu	50.96**	7.38	1.37(0.242)
Nsundwe	Lilongwe	43.45**	8.32	1.55(0.212)
	Mitundu	39.62**	7.20	0.41(0.520)
Ntcheu	Lilongwe	12.83	4.61	1.35(0.245)
	Mitundu	23.51*	4.61	2.57(0.109)
Southern region				
Luchenza	Lunzu	32.80**	5.82	0.02 (0.886)
Ngabu	Lunzu	33.67**	9.06	0.31(0.576)
Mwanza	Lunzu	29.49**	8.66	0.31(0.578)
Nchalo	Lunzu	43.02**	10.19	1.04(0.309)
Nsanje	Lunzu	27.55**	9.79	0.31(0.575)
Zomba	Lunzu	52.62**	5.10	1.43(0.232)

Note: ** and * indicate statistical significance at the 1% and 5% level respectively. [1] Critical values for the cointegration tests can be found in Johansen & Juselius (1990). [2]The test is distributed as Chi-square and p-values are in parenthesis.

Table 5.2 VECM Results: Maize Markets in Malawi[1]

Region/Markets		Speed of adjustment[2]		Long-run adjustment[4]	Speed of adjustment[3]		Long-run adjustment[4]
i	j	α_{ii}	α_{ij}	β_i	α_{ji}	α_{jj}	β_j
Northern region							
Chitipa	Mzuzu	-0.05	0.29**	-1.29**	-0.37**	0.06	-0.78**
Embangweni	Mzuzu	-0.26**	0.13**	-1.31**	-0.17**	0.34**	-0.76**
Karonga	Mzuzu	-0.09	0.36**	-1.25**	-0.46**	0.11	-0.80**
Central region							
Chimbiya	Mitundu	-0.17	0.44**	-1.04**	-0.46**	0.17	-0.97**
Kasungu	Lilongwe	-0.24**	0.20**	-1.30**	-0.26**	0.32**	-0.77**
	Mitundu	-0.48**	0.18*	-1.03**	-0.18*	0.50**	-0.97**
Mitundu	Lilongwe	-0.15	0.34**	-1.24**	-0.42**	0.18	-0.80**
Lizulu	Lilongwe	-0.02	0.26**	-1.48**	-0.39**	0.03	-0.67**
	Mitundu	-0.07	0.42**	-1.11**	-0.47**	0.08	-0.90**
Mchinji	Lilongwe	-0.10	0.23**	-1.22**	-0.28**	0.12	-0.82**
	Mitundu	-0.34**	0.23	-0.91**	-0.21	0.31**	-1.10**
Nsundwe	Lilongwe	-0.04	0.41**	-1.15**	-0.48**	0.05	-0.87**
	Mitundu	-0.19*	0.36**	-0.93**	-0.33**	0.17*	-1.08**
Ntcheu	Mitundu	0.10	0.46**	-1.16**	-0.54**	-0.12	-0.87**
Southern region							
Luchenza	Lunzu	-0.10	0.31**	-0.98**	-0.30**	0.10	-1.02**
Ngabu	Lunzu	-0.09	0.38**	-1.06**	-0.40**	0.10	-0.94**
Mwanza	Lunzu	-0.32**	0.18	-0.94**	-0.17	0.30**	-1.06**
Nchalo	Lunzu	-0.28	0.43**	-0.92**	-0.40**	0.26	-1.08**
Nsanje	Lunzu	-0.09	0.27*	-1.09**	-0.29**	0.09	-0.92**
Zomba	Lunzu	-0.40**	0.14	-1.10**	-0.16	0.44**	-0.91**

Note: [1]Only for cointegrated market pairs as reported in Table 5.1. [2] Price in column i is a dependent variable, and α_{ii} and α_{ij} report coefficients of prices in column i and j, respectively (normalizing the long-run coefficient of prices in column i to unity). [3]Price in column j is a dependent variable, and α_{ji} and α_{jj} report coefficients of prices in column j and i, respectively (normalizing the long-run coefficient of prices in column j to unity). [4] β_i and β_j report estimates with long-run coefficients of price in column i and j normalized to unity, respectively.

Table 6.1 Bivariate Cointegration Test Result: Border Markets in Malawi and Neighboring Countries

Markets		Trace test[1] (H_0: Rank= P)		LOP[2]
		Ho: P=0	H_1: p<1	
Malawi-Mozambique				
Chimbiya	Angonia	29.70**	4.81	0.000(0.990)
Lizulu	Angonia	21.44*	8.22	0.038(0.845)
Mitundu	Angonia	25.10**	6.60	0.876(0.349)
Nsundwe	Angonia	30.09**	5.15	0.966(0.326)
Ntcheu	Angonia	23.94**	4.61	0.946(0.331)
Mwanza	Angonia	26.15**	7.32	1.571(0.210)
Nchalo	Mutarara	23.98*	4.74	5.485*(0.019)
Nsanje	Mutarara	25.46**	7.93	4.470*(0.034)
Luchenza	Milange	22.04*	5.97	3.128(0.077)
Lunzu	Milange	23.96*	5.69	0.394(0.530)
Zomba	Milange	44.18**	6.64	2.013(0.156)
Malawi-Tanzania				
Chitipa	Mbeya	20.07*	2.36	3.022(0.082)
Chitipa	Songea	24.21*	7.93	0.085(0.770)
Karonga	Mbeya	19.17	2.78	5.598*(0.018)
Karonga	Songea	26.07**	6.04	0.002(0.969)
Malawi-Zambia				
Kasungu	Chipata	21.84*	5.95	0.932(0.334)
Kasungu	Lundazi	22.98*	7.80	6.059*(0.014)
Mchinji	Chipata	14.68	6.19	0.657(0.418)
Mchinji	Lundazi	20.35*	6.73	2.618(0.106)

Note: ** and * indicate statistical significance at the 1% and 5% level respectively. [1]Critical values for the cointegration test can be found in Johansen & Juselius (1990). [2]The test is distributed as Chi-square (1) and p-values are in parenthesis.

Table 6.2 VECM Results: Border Markets in Malawi and Neighboring Countries[1]

Region/Markets		Speed of[2] adjustment		Long-run[4] adjustment	Speed of[3] adjustment		Long-run[4] adjustment
i	j	α_{ii}	α_{ij}	β_i	α_{ji}	α_{jj}	β_j
Malawi-Mozambique							
Chimbiya	Angonia	-0.21**	0.20*	-1.00**	-0.20*	0.21**	-1.00**
Lizulu	Angonia	-0.16*	0.15	-1.05**	-0.16	0.16*	-0.96**
Mitundu	Angonia	-0.35**	-0.02	-0.84**	0.02	0.30**	-1.19**
Nsundwe	Angonia	-0.25**	0.18*	-0.86**	-0.16*	0.22**	-1.16**
Ntcheu	Angonia	-0.04	0.31**	-1.13**	-0.35	0.04**	-0.89**
Mwanza	Angonia	-0.24**	0.12	-0.79**	-0.10	0.19**	-1.26**
Nchalo	Mutarara	-0.30**	0.07	-0.63**	-0.05	0.19**	-1.58**
Nsanje	Mutarara	-0.40**	-0.11	-0.71**	0.08	0.28**	-1.42**
Luchenza	Milange	-0.03	0.15**	-1.78**	-0.26	0.05**	-0.56**
Lunzu	Milange	-0.29**	0.10	-1.10**	-0.11	0.32**	-0.91**
Zomba	Milange	-0.24**	0.16*	-1.19**	-0.20	0.29**	-0.84**
Malawi-Tanzania							
Chitipa	Mbeya	-0.33**	-0.06	-0.71**	0.04	0.24**	-1.41**
Chitipa	Songea	-0.28**	0.10	-0.94**	-0.09	0.26**	-1.07**
Karonga	Songea	-0.12	0.20**	-1.01**	-0.21	0.12**	-0.99**
Malawi-Zambia							
Kasungu	Chipata	-0.21**	0.04	-1.44**	-0.06	0.30**	-0.70**
Kasungu	Lundazi	-0.02**	0.09	-2.91**	-0.26**	0.05	-0.34**
Mchinji	Lundazi	-0.06	0.09*	-1.80**	-0.17*	0.10	-0.56**

Note: [1]Only for cointegrated market pairs as reported in Table 6.1. [2] Price in column i is a dependent variable, and α_{ii} and α_{ij} report coefficients of prices in column i and j, respectively (normalizing the long-run coefficient of prices in column i to unity). [3]Price in column j is a dependent variable, and α_{ji} and α_{jj} report coefficients of prices in column j and i, respectively (normalizing the long-run coefficient of prices in column j to unity). [4] β_i and β_j report estimates with long-run coefficients of price in column i and j normalized to unity, respectively.

Table 7 Cointegration Test Results: Markets in Malawi, Neighboring Countries and World

Region/Markets			Trace test[1] P=0	P≤1	P≤2
Malawi-Mozambique-World					
Chimbiya	Angonia	World	37.88*	9.43	2.05
Lizulu	Angonia	World	36.94*	8.03	1.89
Mitundu	Angonia	World	34.18	11.32	2.00
Nsundwe	Angonia	World	45.32**	10.39	1.62
Ntcheu	Angonia	World	33.01	8.28	1.51
Mwanza	Angonia	World	35.45*	7.98	1.90
Nchalo	Mutarara	World	36.29*	10.15	1.76
Ngabu	Mutarara	World	24.69	10.21	2.22
Nsanje	Mutarara	World	33.77	10.00	2.06
Luchenza	Milange	World	39.22*	17.13	5.24
Lunzu	Milange	World	46.47**	17.60	6.36
Zomba	Milange	World	55.41**	18.73	6.49
Malawi-Tanzania-World					
Chitipa	Mbeya	World	39.23**	8.39	1.95
Chitipa	Songea	World	41.96**	9.42	1.84
Karonga	Mbeya	World	28.59	9.47	2.08
Karonga	Songea	World	34.25	10.08	1.96
Malawi-Zambia-World					
Kasungu	Chipata	World	25.63	8.69	2.31
Kasungu	Lundazi	World	34.52	10.13	2.45
Mchinji	Chipata	World	25.55	8.61	2.12
Mchinji	Lundazi	World	34.78	9.75	1.83

Note: ** and * indicate statistical significance at the 1% and 5% level respectively. [1]Critical values for the cointegration test can be found in Johansen & Juselius (1990).

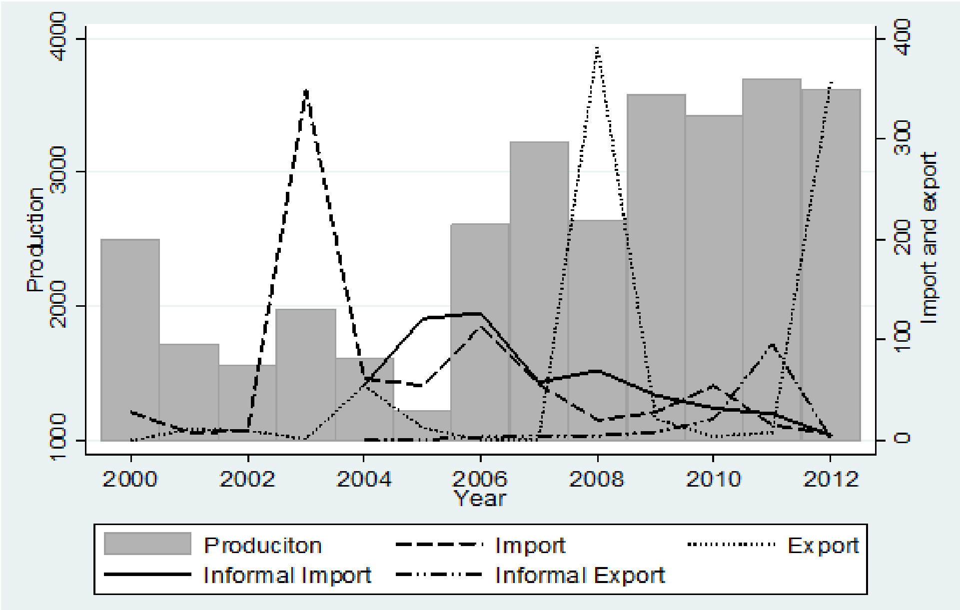

Figure 1 Maize Production, Import and Export in Malawi, in thousands MT (2000 to 2012)
Note: Informal import and export data are only from 2005-2011. Source: Production, import and export data from FAOSTAT (2014) and informal import and export data from the FEWSNET.

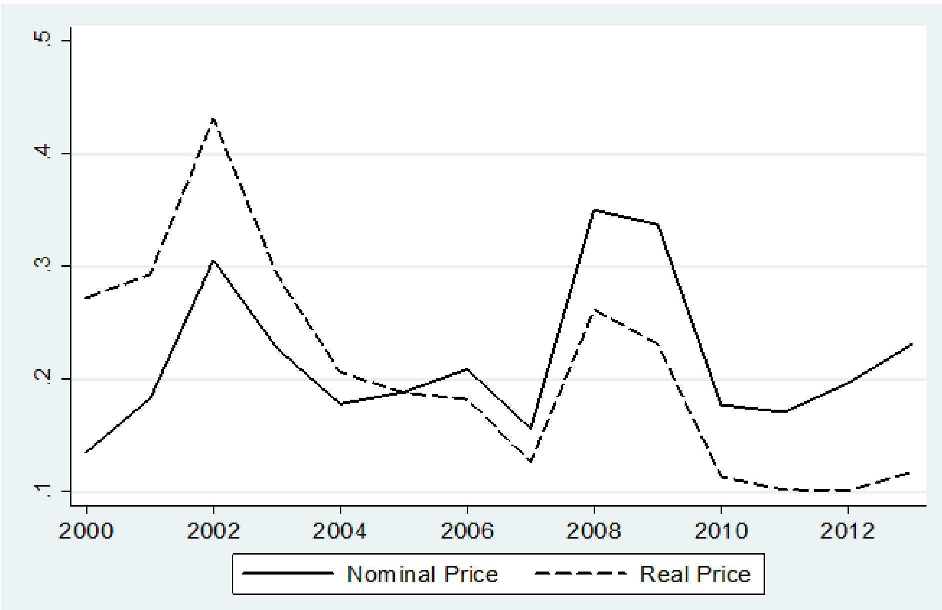

Figure 2 Annual Average Maize Price in Lilongwe, Malawi in USD/KG (2000 to 2012)

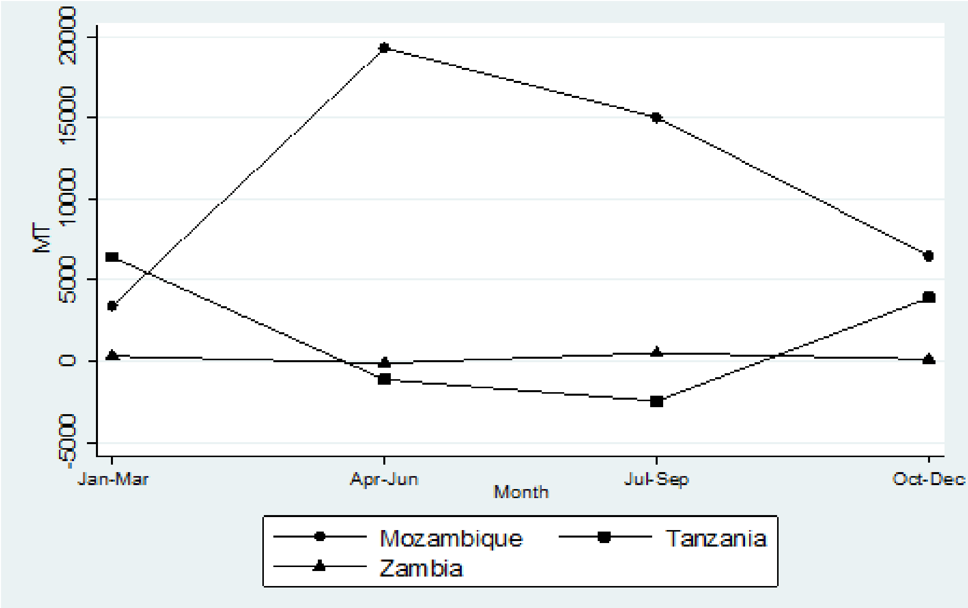

Figure 3 Average Informal Maize Net CBT Inflows to Malawi from Neighboring Countries, in MT, by Country (April 2005 to March 2012).
Source: Own calculation based on data from FEWSNET

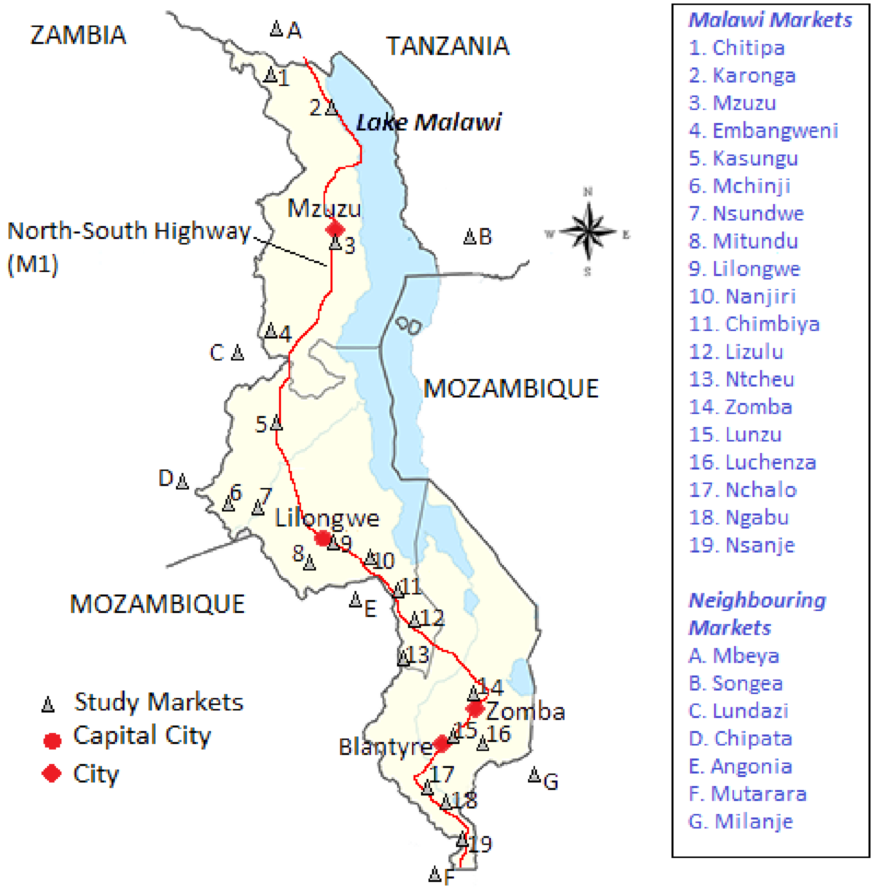

Figure 4 Map of Malawi and Neighbouring Countries

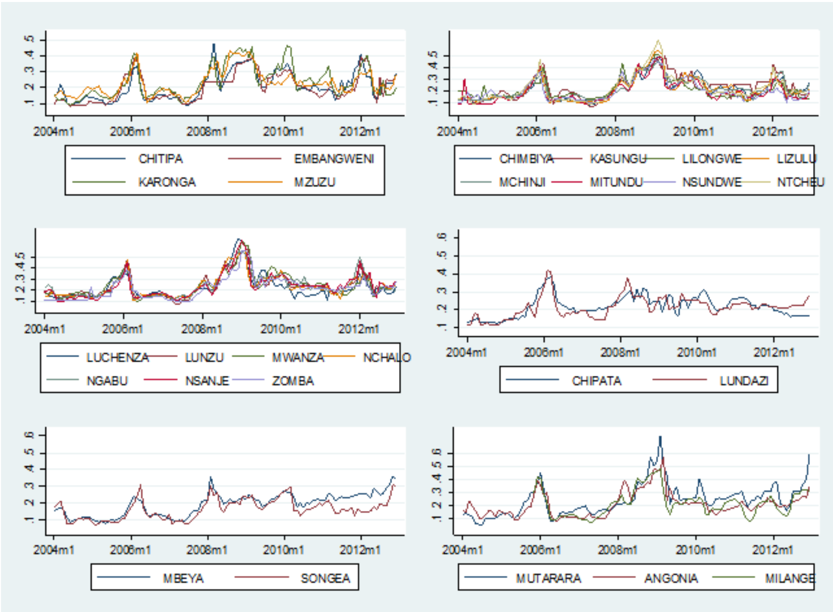

Figure 5 Maize prices from markets in Malawi, Tanzania, Mozambique and Zambia, in USD/kg (January 2004 to December 2012)

PAPER 4

Relationship between Fuel and Grain Prices: The Case of Ethiopia

Meron Assefa Arega
NMBU School of Economics and Business
Norwegian University of Life Sciences (NMBU), Ås, Norway
+47 46268785 (phone); +47 64965701(fax); meron.arega@nmbu.no

ABSTRACT. This paper examines whether food grain (*teff*, wheat and maize) prices respond to fuel price shocks through effect on transportation cost, using evidence from Ethiopia. Monthly price series from July 2001 to June 2013 is analyzed with vector error correction model and constant conditional correlation, a class of multivariate generalized autoregressive conditional heteroskedasticity model. Price transmissions are evidenced from world crude oil to Addis Ababa (AA) fuel (benzene and diesel) markets, and also from AA to other-local fuel markets. There is no observed volatility correlation between world crude oil and AA fuel prices, whilst it is high and strong between local fuel prices in Ethiopia. Most important, results show that change in world crude oil price transmits to AA maize and wheat prices, but there is no observed effect on *teff* prices. The volatility of world crude oil is correlated only with the volatility of maize prices among the three crops examined. Conversely, no discernible linkages are found between local fuel and local staple prices in Ethiopia. This may be attributed to the effect of government fuel subsidy program that was undergoing until late 2008 in the country. Thus, policymakers should recognize world oil price as one of the drivers of maize and wheat prices in Ethiopia.

JEL classification: C22, Q11, Q13
Keywords: CCC-MGARCH, crude-oil, fuel, grain price, price transmission, VECM, volatility

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1. Introduction

Managing agricultural price instability is a key policy challenge for most developing countries. The two recent price spikes in international commodity markets, in 2007/08 and 2010/11 have renewed interest on the dynamic relationship between commodity prices. It is well-known that high food price and extreme price instability aggravate poverty and food insecurity in developing countries. Unpredictable and soaring food prices adversely affect consumers that typically spend a very high share of their total budget on food and lack diet diversity. Producers do not in fact gain from high prices as they often appear as net buyers of agricultural food crops. Instead producers are threatened by price instability to make any optimal decision in investments on agricultural production. At the national level, increasing agricultural prices stimulate inflation and increase food import bills that threaten foreign exchange reserves and exacerbate balance of payment imbalances. Thus, it causes macroeconomic instabilities and adversely affect overall economic growth. Political instability and social unrest are observed to be additional consequences of recent food price spikes and variability in some countries (Wodon & Zaman, 2010).

This study focuses on how staple food prices in developing countries respond to fuel price shocks in the international and domestic markets. Recent literature identifies various channels through which oil prices can transmit to food prices (Baffes, 2007; Harri & Hudson, 2009). From supply side, energy and agricultural production are linked through the use of energy intensive or chemical and petroleum driven inputs, such as fertilizers, and fuel use for mechanized agriculture and transportation. Thus, higher oil prices increase costs of production and marketing through their effect on fertilizer and fuel prices, which in turn leads to higher agricultural commodity prices. From demand side, a relationship between energy and agricultural commodity markets is developed through increasing use of agricultural commodities to produce biofuel. That is, increase in crude oil price induces development of ethanol and biodiesel production that in turn stimulate demand for some agricultural commodities, such as sugar, maize, cassava, oilseeds and palm oil used as feedstock. Increase in demand for these agricultural commodities leads to higher global food prices that can be transmitted to domestic food markets.

Several studies examine whether oil markets can be used to explain the recent upward and instable movements in agricultural commodity prices. Some studies show increase in oil prices is the main factor behind the recent major demand shock experienced by agricultural markets (Abbott, 2013; Baffes, 2007; Chang & Su, 2010; Mitchell, 2008; Rosegrant et al., 2008). Some others conclude that there are no direct relationship between oil and agricultural commodities (Gilbert, 2010; Zhang et al., 2010). In particular, some examine the relationship between oil and agricultural prices in terms of the effect of oil prices as a production cost in agriculture, such as fertilizer and fuel use in mechanized agriculture (Alghalith, 2010; Alom et al., 2011; Baffes, 2007; Baffes, 2010; Chang & Su, 2010; Du et al., 2012; Harri & Hudson, 2009; Kaltalioglu & Soytas, 2011; Ott, 2012). Rather larger literature examines the link between oil and agricultural prices in terms of biofuel production (Balcombe & Rapsomanikis, 2008; Busse et al., 2012; Chen et al., 2010; Gardebroek & Hernandez, 2013; Hassouneh et al., 2012; Serra, 2011; Serra et al., 2011; Wu et al., 2011; Zhang et al., 2010; Zilberman et al., 2013).

In the above considerable body of research, the topic on transport cost effect of oil price shocks on agricultural commodity prices has not attracted sufficient attention. A recent working paper by Dillon & Barrett (2014) is the only to my knowledge that has empirically tested relationship between fuel and food prices. They study transmission of global crude oil and maize prices to local maize prices in four countries in eastern Africa, including Ethiopia. By examining the relationship between global oil price, global maize price and port of entry maize price, they show both global oil and global maize prices exert considerable influence on port-of-entry maize prices. Similarly, they investigate the relationship between port-of-entry maize price, other-local market maize prices, and corresponding local market petrol prices and find that fuel price increases put greater upward pressure on local maize prices than do port-of-entry maize prices.

I extend the same line of analysis using evidence from Ethiopia. Despite the country enjoys steady food grain production and productivity growth in recent years, it is observed that high and instable staple prices exacerbate food insecurity. Thus, identifying potential factors contributing to food price spikes and volatility is central to policy markers toward reducing adverse consequences of commodity price shocks. This is also particularly important given the recent widespread and high-level concerns about the impact of international commodity market price shocks. At the same time, there are no sufficient rigorous empirical studies that investigate food grain price movements in Ethiopia. This paper aims to contribute to the literature by studying relationship between world oil prices and domestic food grain prices, mainly through transportation fuel cost effect in Ethiopia. In particular, the empirical investigation in this paper addresses two issues. First, I examine price transmission from both world crude oil and domestic fuel prices (benzene and diesel) to major food grain prices (*teff,* wheat, maize) in Ethiopia. And second, I measure volatility correlation between the same prices.

Although one cannot entirely disregard other mechanisms, it is fair to assume transportation fuel cost as a primary factor that link oil and food grain prices in Ethiopia. Other channels, such as agricultural input costs (chemical fertilizer and fuel use in mechanized agriculture) and biofuel demand are not notably important to establish this linkage in the context of the country. I follow the same argument as Dillon & Barrett (2014). First, chemical fertilizer application in food crop production is very small in Ethiopia. For instance, Urea and DAP fertilized area account 16.1% in 2003/04, 18.9% in 2007/08 and

23.8% in 2010/11 of total cereal area planted in the country (Rashid et al., 2013). Thus, changes in fertilizer prices that are associated with higher oil prices may not likely exert important influence on staple prices in Ethiopia. Secondly, mechanized food crop production is almost non-existent in Ethiopia. And third, recent empirical evidence on the link between global oil prices and global food prices mostly show no effects (Dillon & Barrett, 2014). Consequently, any effect that arises from global food grain price shocks because of changes in global oil prices should be negligible to influence local staple prices in Ethiopia. In addition, sugarcane is currently used as a feedstock for ethanol production in the country. Thus, there are no identified links between local fuel and food grain prices because of ethanol production. Accordingly, the focus of this study is on the link through transportation costs.

I use monthly price series from July 2001 to June 2013, covering nine major consumption and production grain markets in Ethiopia, as well as world market. Johansen procedure is used to examine cointegration relationship between prices. I determine their adjustment processes toward long-term cointegration relationship and long-run price transmission elasticity, using a vector error correction model (VECM). For non-cointegrated prices, vector autoregressive model (VAR) is fitted. I examine volatility correlation between prices, using constant conditional correlation, a class of multivariate generalized autoregressive conditional heteroskedasticity (CCC-MGARCH) model.

It is worth noting that, this study differs from the above contemporaneous working paper at least in two respects. One, focusing on Ethiopia, I analyze prices of three major food crops and two major fuel prices in the country, based on data from three markets in major consumption and six markets in major production areas. This enables me to investigate inter-commodity and spatial differences in the effects of fuel prices on food prices in Ethiopia. Two, I examine linkages between volatilities of food and fuel prices. This allows me to test the hypothesis that volatile food prices in Ethiopia are linked to global oil price shocks.

Results suggest change in world crude oil price transmits to Addis Ababa (AA) maize and wheat prices, with no observed effects on *teff* prices. Furthermore, the volatility of world crude oil prices is correlated with the volatility of maize prices in AA, whilst it has no effect on AA wheat prices. However, there is no price transmission from local fuel to local grain prices. Similarly, there is no linkage between volatility of local fuel and grain prices during the study period.

2. Background

Grain production and marketing are important in Ethiopia, accounting for 60% of rural employment, 80% of cultivated land, 70% of total production , 40% of household's food expenditure, and 60% of caloric intake (Rashid, 2010; Admassie, 2013). Figure 1 depicts that nominal staple food prices start to increase in 2004, and peaked first in 2008. Prices followed a decreasing trend afterwards, with another peak observed in 2010/2011. The gap between the nominal and real[1] prices reflects sharp increase in food price inflation since 2008 (Figure 1). Furthermore, Figure 2 shows inter-annual staple food crop price variability is remarkably high and has even worsen in 2007/2008 and 2011. Overall, these figures illustrate that Ethiopia is one of the countries that have been affected by price spikes following the global economic crisis.

Historically, food price inflation was mainly attributed to production shortfalls as a result of bad weather conditions in the country (Durevall et al., 2013). In fact, food grain prices rise in spite of observed increases in production of major food grain recorded in the last several years. There is no consensus on the causes of current food price spikes and variability, as well as food price inflation in the country. The government claims transmission of world commodity price to domestic food prices as a major driver of the current food price trend in

[1]Real prices are calculated based on food consumer price index with December, 2006 as a base year.

the country. On the other hand, researchers and other stakeholder indicate the observed current price trend rather is mainly due to expansionary monetary and fiscal policies in the country (Rashid, 2010; Admase, 2013) They argue food import is limited in size (only 5% of agricultural GDP) and mostly was in the form of food aid, as well as major food crops in Ethiopia are internationally non-tradable , thus there is no evidence for strong link from world to domestic commodity prices (Durevall et al., 2013; Admase, 2013, Rashid, 2010). In fact, using wholesale price series of maize, wheat and sorghum from June 2007 to June 2008 in Ethiopia, Minot (2011) shows only wheat price in AA is linked with its corresponding global price.

Transport cost constitutes a considerable share of transaction costs in food marketing. Poor road networks, high fuel prices and administrative hurdles lead to higher cost of transportation in sub-Saharan Africa as compared to other developing countries (Rashid & Minot, 2010). In Ethiopia, grain production largely concentrates in only Amhara and Oromia regions, which account for 87% of *teff* and wheat, and 82% of maize productions (Rashid, 2010). Thus, grain marketing immensely entails transporting surplus to deficit areas and city centers in the country. Rashid (2010) indicates that transportation costs associated with grain marketing in the country decline from 31% of total transaction costs in 1996 to 15% in 2008. This decline can be attributed to improvements in rural road infrastructure in the country. Despite the fact that roads and transport system are arguably improving, there is still a large fraction of areas that are poorly served by road networks in the country. For instance, given that most rural roads are not modern all-weather, the cost of operating trucks on gravel and rural roads is high (Rashid, 2010).

In order to ease the impact of world oil price shocks on domestic commodity prices, the government subsidized gasoline through Oil Stabilization Fund (OSF). This subsidy resulted in accumulated debt amounted to 1.5% of GDP by 2008, ultimately causing balance of payment crisis (IMF, 2009). Consequently, the government was compelled to eliminate the fuel subsidy in October 2008, and began to adjust the domestic fuel prices to import parity level. Afterwards, domestic fuel prices are reviewed monthly, and adjusted at a margin even above world prices in order to repay the debt from the OSF. Figure 3 depicts increasing trend of world crude oil and domestic benzene and diesel prices. As expected, the gap between domestic fuel and world crude oil prices starts to increase in 2008. The graph further exhibits before the subsidy was abolished that the regulated fuel prices follow much less variability, even showing constant price changes over some consecutive months. Around the same time (2009), the government also started blending ethanol from sugarcane in gasoline, among others, to smooth the fluctuations in domestic fuel prices. The amount of ethanol used for blending changed from 5% to the current level of 10%, and there is also a plan to increase it to 25% by the end of 2015 (allAfrica, 2013).

3. Empirical strategy

I specify the mean and the variance of crude oil/fuel and food grain price series to examine price and volatility relationships. Four scenarios address these two objectives. One, I examine the direct price linkages between world crude oil and AA fuel (benzene and diesel). Two, bivariate price relationships between world crude oil and AA grain markets is studied. Three, I examine fuel price linkages between AA and other-local markets in Ethiopia. Fourth, I study local fuel and food grain price linkages. Thus, the first two scenarios study price and volatility relationships between world and domestic price, whilst the last two approaches deal with domestic markets in Ethiopia. It is worth noting that AA is a capital city and serves as the main port-of- entry and exit for Ethiopia's international trade.

I use unit root tests namely, the Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP), which are based on the null hypothesis of non-stationary of the tested time series. Subsequently, cointegration test is conducted based on the Johansen Full Information

Maximum Likelihood cointegration framework that is fully described in Johansen (1995). This approach allows me to test for the number of cointegrating relations, to identify cointegrating vectors, as well as to make inference on the estimated cointegrating relations in maximum likelihood framework.

In particular, I adopt a two-stage estimation procedure that simplifies the computational process for the conditional variance-covariance equations. In the first stage, I estimate conditional mean equations specified with VECM. Thereby, I filter the price series from comovements in their conditional mean. In the second stage, CCC-MGARCH model is fitted to the estimated residuals from VECM, using the maximum likelihood estimation method. However, for price pairs that I found no cointegration, I estimate conditional mean equations specified with VAR, and subsequently CCC-MGARCH model is based on VAR estimates. Below these models are described in detail.

For a k variable, VAR with n lags can be written as,

$$P_t = v + A_1 P_{t-1} + \ldots + A_p P_{t-n} + \varepsilon_t \tag{1}$$

where, P_t denotes n x1 vector of prices; v is a constant; A represents estimated parameters and μ_t is an i.i.d. error term which may capture potential GARCH effect.

The unrestricted $VAR(k)$ model can be transformed into error correction models. In VECM, changes in the vector P_t depend on deviations from a long-run equilibrium relationship, as well as on short term dynamics. The VECM is defined as,

$$\Delta P_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \prod P_{t-1} + \varepsilon_t \tag{2}$$

$$= \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \alpha\beta' P_{t-1} + \varepsilon_t' \tag{2'}$$

where , Δ is a first difference operator, such that $\Delta P_t = P_t - P_{t-1}$ shows the change in the vector P_t from time $t-1$; μ is a constant and $\prod$ is a long-run impact matrix summarizing all the long-run information in P_t; Γ measures reactions to short term price changes; and $\varepsilon_t^{'}$ is an error term which also captures potential GARCH effects.

When all variables in P_t are $I(1)$, the matrix $\prod$ has rank $0 \leq r \leq k$, such that its rank determines the number of cointegration vectors in the system. If the variables are cointegrated ($r > 0$), the VAR in the first difference is misspecified since it excludes the error correction term. Rather the presence of r linearly independent cointegrating vectors implies that the long-run impact matrix can be represented as, $\prod = \alpha\beta^{'}$, where $\beta^{'}$ is the cointegration relation and represents a long run equilibrium and α gives the speed of adjustment with which prices return to the long run equilibrium. On the other hand, the absence of cointegration amongst the variables in P_t implies that the rank of $\prod$ is zero ($r = 0$) and then VAR in first difference is consistent.

I further apply a class of multivariate GARCH model. Let ε_t be an n-variate vector of T observations with $\mathrm{E}(\varepsilon_t \mid \psi_{t-1}) = 0$, where ψ_{t-1} is a sigma field generated by the past information until time $t-1$. Here, ε_t is a vector of residuals from equation (1) or (2). The estimation of the dynamics of the conditional covariance matrix of ε_t is carried out within the framework of the MGARCH model of the following,

$$\varepsilon_t = H_t^{1/2} v_t, \ \ t = 1, 2, \ldots, T \qquad (3)$$

where, $H_t^{1/2}$ is the Cholesky factor of the time-varying conditional covariance matrix H_t and v_t is a m-vector of zero-mean, unit-variance i.i.d. innovations.

Several specifications for H_t are proposed in the literature, which differ in terms of flexibility, allowing for more complex H_t processes and parsimony, allowing the model to be specified with fewer parameters. The well-known MGARCH type models such as, vector error correlation (VEC), dynamic conditional correlation (DCC) and the Baba–Engle–Kraft–Kroner (BEKK) models do not guarantee the requirement of positive definiteness in the variance-covariance matrix and thus, the estimates may not converge. Moreover, the relatively shorter price series used in this study (144 observations) could also cause the divergence in estimation. Thus, I use the CCC-MGARCH model of Bollerslev (1990) that is found computationally efficient in the estimation. In the CCC-MGARCH model, H_t is decomposed into a matrix of conditional correlations (R) and a diagonal matrix of conditional variances (D_t),

$$H_t = D_t^{1/2} R D_t^{1/2} \tag{4}$$

The diagonal elements of H_t are modeled as univariate GARCH models, whereas the off-diagonal elements are modeled as nonlinear functions of the diagonal terms. Thus,

$$h_{ij,t} = \rho_{ij} \sqrt{h_{ii,t} h_{jj,t}} \tag{5}$$

where, the diagonal elements, $h_{ii,t}$ and $h_{jj,t}$ follow univariate GARCH processes and ρ_{ij} is a time invariant weight interpreted as conditional correlation. Apparently, a major limitation of the CCC MGARCH model is the conditional correlations are constant over time. Furthermore, a univariate GARCH (*p, q*) model with p lagged terms of the squared error and q terms of the lagged conditional variances can be written as:

$$h_{it} = c_i + \sum_{j=1}^{p} \phi_i \varepsilon^2_{i,t-j} + \sum_{j=1}^{q} \gamma_i h_{i,t-j} \tag{6}$$

4. Data and sources

I use monthly prices from July 2001 to June 2013, which amounts to a total of 144 observations. A few missing data points are linearly interpolated. The relative difference in price levels, termed as return from month to month is denoted as, $r = {P_t}/{P_{t-1}}$, where P is price at time $t = \{1, ..., T\}$. I apply a logarithmic transformation of the price difference, $r = \ln P_t - \ln P_{t-1}$, that accounts for proportional changes in returns.

Domestic nominal retail prices comprise of three major food crops, *teff*, wheat and maize (Birr/KG) and two fuel prices, benzene and diesel (Birr/Lit) from Ethiopia. These data come from Central Statistics Authority of Ethiopia. Domestic prices cover three markets from the largest cities in the country including, AA, Dire Dawa (DD) and Mekelle (MK), and two more additional markets per crop that are near to major production areas of the specific crops. Thus, in addition to the three deficit markets, I consider Ambo (AB) and Debre Markos (DM) for *teff* prices, Bahir Dar (BD) and Jimma (JM) for maize prices and Asela (AS) and Hossana (HS) for wheat prices. Table 1 provides a summary profile of these selected domestic markets. When necessary, the domestic prices are converted to USD using the US exchange rates and the source of data is the International Financial Statistics database of International Monetary Fund (IMF).

The corresponding international prices include crude oil price (USD/ barrel) that are the equally weighted average of Brent, Dubai, and West Texas Intermediate spot prices; maize price (USD/MT) for number 2 yellow maize f.o.b. at US Gulf ports; and wheat price (USD/MT) for number 2 soft red winter export price delivered at the US Gulf port for prompt or 30 days shipment. All international prices are obtained from World Bank Global Economic Monitor (GEM) commodity price database.

5. Results and discussion

ADF and PP tests of stationarity for log prices account for a trend and a constant, whereas first difference log prices (log returns) are with only constants. The numbers of lags in these tests is chosen by the Akaike information criterion (AIC) and Bayesian information criterion (BIC) and are reported in Table 2. Unit root test results suggest that log prices are non-stationary in their levels, whilst their first differences (log returns) reject the null of non-stationarity at the conventional significance levels in all cases. Having shown that the series is $I(1)$ process, I move to cointegrtion tests to examine if a long-run relationship exists between the markets under study (Table 2).

The summary of descriptive statics for differenced log prices (log returns) is reported in Table 3. Log returns have means of 0 to 1% and standard deviations mostly lie between 5% and 11%. Zero excess kurtosis is rejected for all series suggesting leptokurtic distributions with heavy tails. For some of the commodities, log returns are negatively skewed, whereas most of them are positively skewed. The Jarque–Bera statistics are significant at the 1% level, strongly rejecting the null of normality for almost all of the commodities examined. Figure A1 to A3 in the appendix further depict log prices and log returns to visualize price trends and variability over time. In particular, Figures A2 exhibits that fuel prices in Ethiopia show insignificant level of variability over time, even with fixed values over some consecutive months. As mentioned above, this can be due to the government fuel price subsidy program that was undergoing until late 2008 in Ethiopia.

Table 4 reports the Chi-square statistics from the Ljung-Box Q test for serial correlation to log returns and squared log returns (for 1 and 2 months lag) and ARCH-LM test on log returns (for 1 month lag). There are some cases where Ljung-Box statistics associated with domestic prices are not significant even at a 10% level, which indicates the absence of autocorrelation in the variance. LM test for ARCH is applied on residual estimates obtained from regression of own lags. Results show that there are also cases where there is no evidence of ARCH effects or volatility clustering. However, most of the commodities show either autocorrelations or ARCH effects, and some of them show both. For those log returns with no autocorrelation or ARCH effect, there is still a support for high kurtosis and the rejection of the null hypothesis of normal distribution by the Jarque-Bera tests that may indicate the presence of conditional heteroscedasticity (Table 3). Therefore, I proceed to further analyze the volatility of all the prices considered.

5.1. Market integrations

Table 5a and 5b report the results of Johansen cointegraton trace test statistics[2] for price relationships examined. Before applying the tests, I determine the lag length based on the the AIC, Schwarz's Bayesian information criterion (SBIC) and the Hannan-Quinn information criterion (HQIC). Different lag lengths are obtained for different price relationships examined.

5.1.1. Market integrations between domestic and international markets

Table 5a presents parameter estimates of world and domestic market integration for the commodities examined. In Model 1a, the trace test statistics rejects the null hypothesis of no cointegration between world crude oil and AA benzene/diesel prices. This implies long-run equilibrium relationship between world crude oil and AA fuel prices during the study period. Most important, the trace test statistics in Model 1b further shows evidences of one cointegrating vector between world crude oil and AA maize/wheat prices. Thus, AA wheat and maize price show long-run relationship with world crude oil prices. However, world crude oil price is not cointergrated with *teff* prices that are internationally non-tradable and

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[2] Maximum eigenvalue statistics are not reported since results are similar to trace statistics.

endogenous to Ethiopia. Trace test results in Model 1c further indicate world maize/wheat prices and AA maize/wheat prices maintain long-run relationships.

5.1.2. Domestic market integration

In Table 5b, the trace test statistics show domestic market integration for the commodities studied. As expected, fuel prices in AA are well integrated with other-local markets (Model 1d). Most interesting, the trace test statistics at conventional levels of significance indicate that there is no long-run relationship between local fuel and grain prices in Ethiopia (Model 1e). At the same time, it is indicated above that world crude oil price is cointegrated with AA grain prices (maize and wheat) and with AA fuel prices (benzene and diesel). This can make it obscure to identify the linkage between world crude oil and local grain prices as a result of the effect on transportation fuel costs. However, this is not surprising given the government fuel price subsidy through OSF likely muted the potential price co-movement between local fuel and local food prices. As discussed above, Figure A2 also suggests the same that local benzene and diesel prices do not show significant variability over time. Furthermore, I find that all local grain markets examined except *teff* in DD and AB are well integrated with their corresponding AA markets (Model 1f).

Overall, for those price relationships that trace and maximum eigenvalue statistics from Johansen cointegration tests strongly reject the absence of cointegration, but do not reject the existence of cointegrating relationship, I formulate VECMs in the next step to assess the dynamics and speed of adjustment. However, I model the co-movement between local fuel and grain markets using the reduced form VAR in first difference since these tests strongly reject cointegration.

5.2. Price transmissions or mean spillover

Table 6a, 6b and 6c present the coefficient estimates for the conditional mean return equations that examine price transmissions between commodities considered.

5.2.1. Price transmission from world and domestic markets

Results of international price transmission are reported in Table 6a. I make a small country assumption in all models, given that Ethiopia is a small fuel and cereal importing country. Results also confirm that coefficient of the world prices ECMs are not statistically significant (results not reported). This implies world crude oil and world cereal prices are weakly exogenous, identifying a causal relationship which runs from the world to the domestic markets.

Considering the relationship between world crude oil and AA fuel prices, the estimated ECMs reported in Model 2a suggest that on average about 27% and 14% of the divergence of AA benzene and AA diesel prices from world crude oil price is corrected each month, respectively. This reflects that benzene and diesel prices in AA adjust fully to price changes in crude oil in international market in over about 4 and 7 months, respectively. The speed of adjustment for benzene prices is higher than diesel prices. The slow adjustments toward the world oil price can be because of the fuel price subsidy that was undergoing until 2008. The long-run transmission elasticity coefficients are much higher for diesel price as compared with benzene. It shows that 54% and 80% of the proportional change in the world oil price change is transmitted to AA benzene and diesel prices, respectively.

Most important, Model 2b reports the price transmission from world crude oil to AA grain markets. The adjustment parameters indicate that each month about 11% and 12% of divergence of AA wheat and maize prices from their long-run equilibrium is corrected, respectively. The associated long-run coefficients show about 75% and 69% of world crude oil price changes are transmitted to the AA wheat and maize prices, respectively. I further investigate price transmission from world to local grain prices in Ethiopia (Model 2c). The estimated VECM suggests that the world wheat and maize prices are the long-run drivers of their corresponding AA grain prices. However, the domestic prices adjust to changes in the world prices quite slowly. About 9% and 11% of divergences from the long-run path are corrected during the period of one month for wheat and maize, respectively. Results imply long-run transmission elasticity from world to AA grain prices is higher than that from world crude oil to AA grain prices.

5.2.2. Price transmission between domestic markets

Results of domestic market price transmissions are reported in Table 6b. It is plausible to assume no price transmission from grain to fuel, thus fuel prices are treated as weakly exogenous to grain prices. Furthermore, since Addis Ababa is a port-of-entry, I assume any price transmission from global to the local markets pass through AA prices. Thus, the focus here is rather on price transmission from AA to other-local markets, but not vice versa.

For fuel price transmission from AA to other-local markets in Ethiopia, the associated ECM coefficients are negative and statistically significant (Model 2d). In most of the price pairs, diesel prices adjust more rapidly to the previous period's deviation from long-run equilibrium than benzene price series. As expected, both fuel prices show close to 100% long-run transmission elasticity from AA to all other-local markets. In Model 2e, I measure the bivariate relationship between grain prices in AA and other-local markets. The speed of adjustment coefficients range between 16% to 48% for those coefficients that are statistically significant, whilst the long-run transmission elasticity is close to 100% in almost all cases.

Most important, results in Table 6c further show the VAR estimates for the relationship between changes in grain and fuel prices in the local markets. I find that coefficient estimates do not show statistically significant response to lagged changes in fuel prices almost in all price pairs examined. Local grain prices are not auotocorrelated in most of the cases. Thus, I surmise that AA grain prices exert influence on other-local markets corresponding grain prices, while there is no discernible effect of local fuel prices on the same local market grain prices.

5.3. Price volatility

Table 7a and 7b report the estimated results from the CCC-MGARCH models, including the coefficients of ARCH (1), GARCH (1) and constant conditional correlations.

5.3.1. Price volatility on world and domestic markets

Table 7a reports the CCC-GARCH estimated parameters of the world and domestic markets. The ARCH coefficients in all models (Model 3a to 3c) are not statistically different from zero. Thus, there is no enough evidence of ARCH effects that suggest the most recent price shock significantly affect the current conditional variance in all cases, except for AA maize prices. On the other hand, the estimates reported in all models in Table 7a show that GARCH components are statistically significant at a 1% level, except for AA maize prices in Model 3c. GARCH coefficients indicate a memory in conditional variance in most cases, that is, current conditional variance depends on past conditional variance. AA benzene and wheat prices have relatively higher GARCH effects with the magnitude of coefficients of about 0.69 to 0.76, implying that current conditional variance tends to remain close to its most recent value rather than at its basis level. The sum of the ARCH and GARCH coefficients indicates the degree of persistence in the conditional variance. However, only AA maize price shows statistically significant ARCH and GARCH effects. Thus, it exhibits high volatility persistence with the sum of the coefficients being greater than one.

The constant conditional parameter estimates suggest statistically insignificant coefficients for all the price series reported in Table 7a, except for AA maize in Model 3b. This implies price variability arising from world crude oil and world grain markets may not be associated with the corresponding domestic markets in Ethiopia. An exception is AA maize price that have shown a statistically significant volatility association with world crude oil.

5.3.2. Price volatility in domestic markets

Table 7b reports the CCC-GARCH estimated parameters of the local prices. Results in Model 3d show 4 out of 8 coefficients associated with benzene prices show statistically significant estimated ARCH coefficients. Local diesel prices show no ARCH effect. On the other hand, the GARCH component associated with most of the benzene prices is significant at a 1% level. The same as the ARCH effect, the coefficient for the GARCH terms associated with diesel prices are not statistically different from zero, except diesel prices of HS and BD that show a significant and relatively long lasting effect of the random shocks.

Looking at the conditional correlation coefficients, the pattern and the magnitude do not differ between the models with benzene and diesel prices (Model 3d). As expected, all of the estimated conditional pair-wise correlation coefficients reported are significant at a 1% level, with values of over 45% and 62% for benzene and diesel prices, respectively. This confirms correlations of the volatility among AA and other-local markets fuel prices.

Furthermore, in Model 3e estimated constant conditional correlations between local market benzene/diesel prices and corresponding market grain prices are not mostly important, both in statistical significance and magnitude. Rather, significant and relatively high conditional covariance coefficients confirm volatility linkages between grain prices in AA and all other-local markets (Model 3f). All of the associated conditional correlation coefficients are statistically significant at 1% level, values lying between 6% and 66%. The highest correlation is observed between maize prices, followed by *teff* and wheat (Model 3f).

6. Conclusions and policy implications

This study contributes to current research on the potential sources of food price spikes and volatility, by examining whether fuel prices are linked to staple food prices, mainly through effect on transportation cost. In particular, I examined fuel price transmission and strength of volatility correlation between world crude oil and AA fuel (benzene and diesel) prices, and three major grains (*teff*, maize and wheat) in Ethiopia. I used monthly prices from July 2001 to June 2013, in conjunction with VECM (or VAR) and CCC-MGARCH models. Results showed strong price transmission and volatility association between world crude oil and AA benzene/ diesel prices, as well as AA and other-local market fuel prices. Most important, AA maize and wheat prices do respond to world crude oil price and the corresponding world grain prices. However, *teff* prices do not adjust to world commodity prices examined. For both wheat and maize, results indicated higher long-run transmission elasticity from world grain prices than from world crude oil prices. However, results implied that price volatility arising from world crude oil and world wheat/maize markets are not associated with the corresponding local markets in Ethiopia. Exception is maize price in AA, which showed volatility association with world crude oil.

Turning to domestic markets, there is a strong price transmission from AA to all other-local fuel markets considered, which was also evidenced by high volatility association among these prices. On the other hand, I found that local fuel price shocks do not transmit to local grain prices. The transmission from AA to other local *teff*, wheat and maize prices is rather significantly important, approaching close to unity in long-run equilibrium. Similarly, the volatility of *teff*, wheat and maize prices in the local markets are strongly linked with the volatility of *teff*, wheat and maize prices in AA, but not with the volatility of benzene (diesel) prices of the same markets. Overall, findings vary among crops examined, but there are no apparent spatial differences between consumption and production markets. Crop-wise, I found that maize and wheat prices are linked with international commodity markets, while *teff is* not.

Findings underscored world oil price shocks exert influences on staple food prices, especially of the internationally tradable grains, wheat and maize in Ethiopia. Not surprisingly, no empirical support was found for the hypothesis that fuel price changes transmit to food grain prices in local markets in Ethiopia. The government fuel price subsidy program likely muted transmission from local fuel to staple prices. In fact, this policy intervention aimed at reducing potential adverse consequences of oil price shocks on commodity prices in the country, mainly through the link on transportation costs. This leaves one with the impression that the major policy shift with elimination of this costly government intervention may possibly exacerbate the impact of oil price shocks on staple prices. Thus, policy makers should identify international oil shocks as one of the drivers of food grain prices in Ethiopia. In view of that, government can influence marketing costs related to transportation fuel costs with continued development in road infrastructure and market institutions.

Additionally, it appeared that the performances of major staple food markets in Ethiopia have enhanced in terms of internal and external price transmissions, which can be partly attributed to accelerated government investments in rural road and communication networks. Yet, the same indicates that markets are more exposed to external commodity price shocks. This should be of a particular concern to policymakers in Ethiopia, especially considering the current high and instable global commodity price trends. Last, it is worth noting that more future work should explore emerging drivers and triggers of staple price movements in the country. This possibly stimulates policymakers to recognize and take action on the threat posed by commodity price shocks.

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Table 1 Domestic Markets Profile

Markets	Region	Grain production	Distance from AA (KM)
Addis Ababa (AA)	Addis Ababa	Deficit/Consumer	0
Dire Dawa (DD)	Dire Dawa	Deficit/Consumer	515
Mekelle (MK)	Tigray	Deficit/Consumer	783
Ambo (AB)	Oromia	*Teff* surplus	125
Debre Markos (DM)	Amhara	*Teff* surplus	295
Asela (AS)	Oromia	Wheat surplus	175
Hossana (HS)	SNNP[1]	Wheat surplus	232
Barhir Dar (BD)	Amhara	Maize surplus	575
Jimma (JM)	Oromia	Maize surplus	346

Note: [1]Southern Nations and Nationalities People.

Table 2 Unit Root Tests of Log Prices

Commodities	Markets	Level			First difference		
		ADF	PP	Lags	ADF	PP	Lags
Crude Oil	World	-3.27	-2.55	2	-6.45**	-8.36**	1
Wheat	World	-2.75	-2.59	2	-7.83**	-9.12**	1
Maize	World	-2.89	-2.54	2	-7.01**	-9.98**	1
Benzene	Addis Ababa	-2.75	-2.89	2	-8.73**	-14.08**	1
	Dire Dawa	-2.55	-2.48	2	-7.95**	-9.90**	1
	Mekelle	-2.67	-2.57	2	-7.86**	-10.08**	1
	Ambo	-2.67	-2.50	2	-7.41**	-10.81**	1
	Debre Markos	-3.06	-2.80	5	-4.90**	-10.12**	4
	Asela	-2.84	-2.80	2	-8.11**	-12.10**	1
	Hossana	-2.90	-2.95	6	-5.24**	-11.19**	5
	Barhir Dar	-2.82	-2.66	2	-7.56**	-11.70**	1
	Jimma	-2.57	-2.57	2	-8.34**	-11.57**	1
Diesel	Addis Ababa	-2.90	-3.00	9	-3.88*	-12.01**	8
	Dire Dawa	-3.36	-3.23	3	-8.13**	-16.47**	2
	Mekelle	-2.80	-2.83	6	-4.81**	-11.36**	5
	Ambo	-2.67	-3.00	11	-4.35**	-15.26**	10
	Debre Markos	-3.03	-3.23	6	-4.74**	-16.48**	5
	Asela	-2.89	-3.00	6	-5.22**	-11.01**	5
	Hossana	-2.95	-2.56	2	-13.99**	-21.31**	1
	Barhir Dar	-2.84	-2.90	6	-5.09**	-11.35**	5
	Jimma	-2.06	-2.62	2	-8.09**	-14.67**	1
Teff	Addis Ababa	-2.09	-2.28	9	-3.91*	-9.97**	8
	Dire Dawa	-2.64	-2.09	12	-3.54*	-9.75**	11
	Mekelle	-2.75	-3.31	5	-5.66**	-13.94**	4
	Ambo	-3.11	-3.38	3	-7.24**	-13.09**	2
	Debre Markos	-2.76	-2.88	9	-4.73**	-11.36**	8
Wheat	Addis Ababa	-3.20	-2.44	3	-5.23**	-9.31**	2
	Dire Dawa	-2.33	-2.11	2	-6.84**	-12.34**	1
	Mekelle	-3.04	-3.40	3	-7.28**	-12.96**	2
	Asela	-2.91	-2.77	3	-6.50**	-13.51**	2
	Hossana	-2.41	-3.07	10	-5.34**	-15.95**	9
Maize	Addis Ababa	-3.31	-3.01	10	-4.00*	-12.12**	9
	Dire Dawa	-2.82	-2.78	9	-4.20**	-11.32**	8
	Mekelle	-3.29	-3.14	12	-3.55*	-12.33**	11
	Barhir Dar	-3.12	-314	10	-4.64**	-17.61**	9
	Jimma	-2.92	-2.49	10	-4.53**	-12.87**	9

Note: * and ** denote significance at the 5% and 1% levels, respectively.

Table 3 Summary Statistics of Log Price Returns, July 2001 to June 2013

Commodity	Markets	Mean	Median	Max	Min	SD	CV	Skwe-ness	Kurt-osis	Jarque-Bera
Crude Oil	World	0.01	0.02	0.17	-0.32	0.08	8.6	-1.2	5.3	27.89***
Maize	World	0.01	0.00	0.23	-0.22	0.07	11.0	0.4	4.8	11.44***
Wheat	World	0.01	0.01	0.22	-0.24	0.06	7.8	-0.2	5.2	10.57***
Benzene	Addis Ababa	0.00	0.00	0.22	-0.36	0.07	14.4	-0.5	10.9	29.41***
	Dire Dawa	0.01	0.00	0.21	-0.20	0.06	10.8	0.1	7.3	17.12***
	Mekelle	0.00	0.00	0.22	-0.19	0.05	11.1	0.7	9.3	28.92***
	Ambo	0.00	0.00	0.21	-0.17	0.05	10.3	1.0	10.0	36.61***
	Debre Markos	0.00	0.00	0.21	-0.26	0.05	11.3	0.0	10.9	25.18***
	Asela	0.00	0.00	0.27	-0.28	0.07	13.2	0.1	9.4	22.48***
	Hossana	0.01	0.00	0.21	-0.23	0.06	10.1	0.1	7.2	16.52***
	Barhir Dar	0.01	0.00	0.21	-0.24	0.06	11.2	0.5	8.3	24.25***
	Jimma	0.00	0.00	0.21	-0.19	0.05	11.2	0.4	8.1	22.34***
Diesel	Addis Ababa	0.01	0.00	0.33	-0.18	0.06	7.7	1.8	12.2	56.99***
	Dire Dawa	0.01	0.00	0.41	-0.37	0.10	12.5	0.4	6.6	17.93***
	Mekelle	0.01	0.00	0.33	-0.18	0.06	7.6	1.7	13.2	57.74***
	Ambo	0.01	0.00	0.44	-0.64	0.09	12.5	-1.3	22.9	57.66***
	Debre Markos	0.01	0.00	0.38	-0.39	0.08	10.2	0.4	13.6	32.78***
	Asela	0.01	0.00	0.33	-0.23	0.06	8.1	1.2	11.2	43.19***
	Hossana	0.01	0.00	2.30	-2.38	0.29	37.7	-0.4	62.9	58.54***
	Barhir Dar	0.01	0.00	0.32	-0.23	0.06	7.8	1.6	13.2	54.27***
	Jimma	0.00	0.00	0.28	-0.65	0.08	17.1	-2.9	31.0	48.78***
Teff	Addis Ababa	0.01	0.01	0.26	-0.17	0.05	6.4	1.1	9.9	39.80***
	Dire Dawa	0.01	0.01	0.25	-0.19	0.05	6.1	0.8	9.6	32.13***
	Mekelle	0.01	0.00	0.34	-0.65	0.09	11.6	-2.3	26.8	6.78*
	Ambo	0.01	0.01	0.34	-0.35	0.11	12.2	0.1	4.1	5.44*
	Debre Markos	0.01	0.00	0.36	-0.24	0.08	7.8	0.4	5.2	12.68***
Wheat	Addis Ababa	0.01	0.00	0.25	-0.20	0.06	7.9	0.5	6.3	18.00***
	Dire Dawa	0.01	0.01	0.19	-0.23	0.06	11.3	-0.3	4.6	8.49**
	Mekelle	0.00	0.00	0.31	-0.44	0.10	22.9	-0.4	6.3	16.33***
	Asela	0.01	0.01	0.41	-0.39	0.11	11.9	-0.1	4.9	8.66**
	Hossana	0.01	0.01	0.49	-0.65	0.15	13.4	-0.2	6.5	15.20***
Maize	Addis Ababa	0.01	0.00	0.52	-0.42	0.11	10.5	0.6	10.1	28.60***
	Dire Dawa	0.01	0.00	0.34	-0.34	0.09	11.6	0.5	7.7	22.59***
	Mekelle	0.01	0.00	0.45	-0.45	0.11	18.3	0.1	6.7	15.24***
	Barhir Dar	0.01	0.01	0.66	-0.79	0.19	16.2	-0.2	6.9	16.22***
	Jimma	0.01	0.00	0.69	-0.50	0.16	11.8	0.4	6.3	16.24***

Notes:.*, ** and ** denote significance at the 10%, 5% and 1% levels, respectively. The Jarque-Bera test follows Chi-square distribution

Table 4 Test of Normality and ARCH Effects

Commodity	Markets	Ljung-Box test (Level)		Ljung-Box test (Square)		ARCH-LM test
		Lag(1)	Lag(2)	Lag(1)	Lag(2)	Lag(1)
Crude Oil	World	15.935***	19.42***	15.93***	19.42***	48.13***
Maize	World	9.573**	9.58**	9.57**	9.58**	6.09*
Wheat	World	3.937**	5.44*	3.94**	5.44	0.24
Benzene	Addis Ababa	4.955**	5.26*	20.56***	20.61***	7.29**
	Dire Dawa	1.951	2.2	8.90**	9.17**	10.22***
	Mekelle	2.034	2.09	1.82	1.9	2.53
	Ambo	0.965	1.1	0.03	0.05	0.01
	Debre Markos	4.145**	5.29*	2.54	2.79	3.20*
	Asela	0.44	0.53	10.05**	10.29**	10.74***
	Hossana	1.172	1.37	0.2	0.87	0.45
	Barhir Dar	0.068	1.23	0.66	1.2	1.18
	Jimma	0.434	0.45	0.62	0.89	0.96
Diesel	Addis Ababa	0.002	0.31	4.92**	5.36*	0.32
	Dire Dawa	12.724***	12.72**	23.21***	23.28***	24.26***
	Mekelle	0.051	1.19	0.19	1.03	0.45
	Ambo	3.090*	8.21**	3.09*	8.21**	15.80***
	Debre Markos	11.831***	11.83**	11.83**	11.83**	20.02***
	Asela	0.21	0.74	0.21	0.74	1.3
	Hossana	36.072***	36.12**	36.07***	36.12***	34.20***
	Barhir Dar	0.09	0.23	0.09	0.23	0.08
	Jimma	5.060**	5.06*	5.06**	5.06*	3.28*
Teff	Addis Ababa	8.687**	12.65**	0	4.56	12.22***
	Dire Dawa	6.184**	13.31***	8.66**	11.00**	6.17**
	Mekelle	2.255	2.57	10.37***	10.81**	8.82**
	Ambo	1.002	1.05	1	1.05	0.7
	Debre Markos	0.499	0.61	0.5	0.61	2.55
Wheat	Addis Ababa	11.256***	14.19***	9.81**	10.98**	1.33
	Dire Dawa	0.096	4.78	0.36	0.36	0.17
	Mekelle	0.235	0.37	0.04	0.55	0.04
	Asela	1.019	2.34	1.02	2.34	3.03*
	Hossana	5.615**	5.62*	5.61**	5.62*	0.21
Maize	Addis Ababa	0.011	0.54	0.36	0.56	3.53*
	Dire Dawa	0.989	7.69**	0.01	0.16	0
	Mekelle	0.018	0.03	0.31	0.31	0.34
	Barhir Dar	11.761***	14.84***	11.76***	14.84***	21.88***
	Jimma	0.28	1.69	0.28	1.69	5.75*

Notes: Ljung-Box and ARCH.LM tests follow Chi-square distribution for the given lag lengths.*, **and ** denote significance at the 10%, 5% and 1% levels, respectively.

Table 5a Johanson's Cointegration Test Results: World and Domestic Prices

Markets/Commodities	Trace test[1] (H_0: rank=P)	
	P=0	P≤1
Model 1a: Addis Ababa fuel and world crude oil prices		
Benzene AA -Crude Oil World	21.129*	3.195
Diesel AA-Crude Oil World	28.886**	4.131
Model 1b: Addis Ababa grain and world crude oil prices		
Teff AA-Crude oil World	18.443	3.530
Maize AA-Crude oil World	24.539**	2.585
Wheat AA-Crude oil World	37.460**	3.863
Model 1c: Addis Ababa grain and world grain prices		
Maize AA-Maize World	22.256*	1.427
Wheat AA-Maize World	27.981**	3.797

Note: * and ** denote significance at the 5% and 1% levels, respectively. [1]Critical values for the cointegration test can be found in Johansen and Juselius (1990).

Table 5b Johanson's Cointegration Test Results: Domestic Prices

	Trace test[1] (H_0: rank=P)			Trace test[1] (H_0: rank=P)	
Markets/Commodities	P=0	P≤1	Markets/Commodities	P=0	P≤1
Model 1d: Addis Ababa and other-local markets fuel prices					
Benzene DD-AA	48.12**	4.36	Diesel DD -AA	46.38**	8.41
Benzene MK-AA	57.59**	4.42	Diesel MK -AA	45.80**	8.53
Benzene AB-AA	62.82**	4.91	Diesel AB -AA	58.26**	8.34
Benzene DM-AA	43.22**	4.03	Diesel DM -AA	60.04**	8.6
Benzene AS-AA	38.73**	3.82	Diesel AS -AA	54.60**	7.84
Benzene HS-AA	37.20**	3.78	Diesel HS -AA	71.41**	8.25
Benzene BD-AA	30.41**	4.07	Diesel BD -AA	43.99**	8.76
Benzene JM -AA	53.22**	4.59	Diesel JM -AA	62.84**	8.01
Model 1e: Local markets fuel and grain prices					
Benzene AA-*Teff* AA	19.04	4.21	Diesel AA-*Teff* AA	16.04	4.14
Benzene DD-*Teff* DD	14.83	3.7	Diesel DD-*Teff* DD	20.69*	5.91
Benzene Mk-*Teff* MK	13.67	4.45	Diesel Mk-*Teff* MK	18.47	6.35
Benzene AB-*Teff* AB	14.08	4.26	Diesel AB-*Teff* AB	13.69	4.67
Benzene DM-*Teff* DM	16.95	3.13	Diesel DM-*Teff* DM	19.8	7.11
Benzene AA-Wheat AA	17.44	4.85	Diesel AA-Wheat AA	18.28	5.32
Benzene DD-Wheat DD	15.24	3.41	Diesel DD-Wheat DD	17.89	6.79
Benzene MK-Wheat MK	18.95	4.31	Diesel MK-Wheat MK	17.79	7.66
Benzene AS-Wheat AS	15.75	6.97	Diesel AS-Wheat AS	19.95	8.47
Benzene HS-Wheat HS	15.62	5.33	Diesel HS-Wheat HS	24.83**	4.67
Benzene AA-Maize AA	15.34	4.18	Diesel AA-Maize AA	18.6	7.63
Benzene DD-Maize DD	15.23	3.04	Diesel DD-Maize DD	12.87	5.42
Benzene MK-Maize MK	15.08	3.61	Diesel MK-Maize MK	17.38	7.36
Benzene BD-Maize BD	16.72	4.32	Diesel BD-Maize BD	24.81**	9.15
Benzene JM-Maize JM	19.23	5.32	Diesel JM-Maize JM	18.83	4.69
Model 1f: Addis Ababa and other-local markets grain prices					
Teff DD-AA	46.15**	12.38*	Maize DD-AA	42.15**	4.77
Teff MK-AA	41.08**	6.46	Maize MK- AA	48.88**	4.17
Teff AB-AA	36.09**	10.18*	Maize BD- AA	67.04**	5.28
Teff DM-AA	23.26*	5.47	Maize JM- AA	67.37**	6.14
Wheat DD-AA	27.02**	5.18			
Wheat MK- AA	27.70**	7.97			
Wheat AA-AA	41.85**	6.23			
Wheat HS-AA	62.52**	7.86			

Note: * and ** denote significance at the 5% and 1% levels, respectively. [1]Critical values for the cointegration test can be found in Johansen and Juselius (1990).

Table 6a VECM Results: World and Domestic Prices

Markets/Commodities	Speed of adjustment	Long-run adjustment
Model 2a: Addis Ababa fuel and world crude oil prices		
Benzene AA -Crude oil world	-0.27**	-0.54**
Diesel AA-Crude oil world	-0.14**	-0.80**
Model 2b: Addis Ababa grain and world crude oil prices		
Wheat AA-Crude oil world	-0.11**	-0.75**
Maize AA-Crude oil world	-0.12**	-0.69**
Model 2c: Addis Ababa grain and world grain prices		
Wheat AA-World	-0.09**	-1.23**
Maize AA-World	-0.11**	-0.76**

Note: * and ** denote significance at the 5% and 1% levels, respectively.

Table 6b VECM Results: Domestic markets

Markets/Commodities	Speed of adjustment	Long-run adjustment	Markets/Commodities	Speed of adjustment	Long-run adjustment
Model 2d: Addis Ababa and other-local markets fuel prices					
Benzene DD -AA	-0.28*	-1.06**	Diesel DD -AA	-0.56**	-0.98**
Benzene MK -AA	-0.39**	-1.03**	Diesel MK -AA	-0.35	-0.99**
Benzene AB-AA	-0.42**	-1.02**	Diesel AB -AA	-0.75**	-0.99**
Benzene DM-AA	-0.56**	-1.04**	Diesel DM -AA	-0.75**	-1.00**
Benzene AS-AA	-0.38**	-1.06**	Diesel AS -AA	-0.74**	-1.01**
Benzene HS-AA	-0.40**	-1.02**	Diesel HS -AA	-1.09**	-0.96**
Benzene BD-AA	-0.45**	-1.02**	Diesel BD -AA	-0.85**	-0.99**
Benzene JM -AA	-0.50**	-1.02**	Diesel JM -AA	-1.05**	-0.98**
Model 2e: Addis Ababa and other-local markets grain prices					
Teff DD-AA	-0.34**	-1.01*	Maize DD- AA	-0.1	-0.93*
Teff MK- AA	-0.48**	-1.02*	Maize MK-AA	-0.25**	-0.79*
Teff AB-AA	-0.18**	-1.06*	Maize BD-AA	-0.63**	-0.96*
Teff DM-AA	-0.03	-1.08*	Maize JM-AA	-0.16*	-1.07*
Wheat DD- AA	-0.32**	-0.93*			
Wheat MK- AA	-0.21**	-0.83*			
Wheat AS-AA	-0.08	-1.04*			
Wheat HS -AA	-0.39**	-1.08*			

Note: * and * denote significance at the 5% and 1% levels, respectively.

Table 6c VAR Results: Domestic Markets

Markets /Commodities	AR(1)	AR(2)	LD(1)	LD(2)	Markets /Commodities	AR(1)	AR(2)	LD(1)	LD(2)
Model 2f: Local markets grain and fuel prices									
Teff AA-Benzene AA	0.207*		0.047		*Teff* AA-Diesel AA	0.232**	0.102	0.045	-0.192**
Teff DD-Benzene DD	0.157	0.211*	0.030	0.010	*Teff* DD-Diesel DD	0.209*	0.168*	-0.070	0.052
Teff MK-Benzene MK	-0.156		0.104		*Teff* MK-Diesel MK	-0.160	-0.080	0.048	-0.002
Teff AB-Benzene AB	-0.131		0.311		*Teff* AB-Diesel AB	-0.114		0.074	
Teff DM-Benzene DM	0.010		0.346**		*Teff* DM-Diesel DM	0.065		0.267*	
Wheat AA-Benzene AA	0.229**		0.020		Wheat AA-Diesel AA	0.214**		0.097	
Wheat DD-Benzene DD	-0.229		0.209		Wheat DD-Diesel DD	-0.047		0.027	
Wheat MK-Benzene MK	-0.086		0.340		Wheat MK-Diesel MK	-0.047	0.027	0.012	-0.048
Wheat AS-Benzene AS	-0.128		0.150		Wheat AS-Diesel AS	-0.126		0.052	
Wheat HS-Benzene HS	-0.229	-0.048	0.209	0.017	Wheat HS-Diesel HS	-0.222	-0.041	0.004	0.039
Maize AA-Benzene AA	-0.024		0.019		Maize AA-Diesel AA	-0.023		-0.014	
Maize DD-Benzene DD	0.037		0.143		Maize DD-Diesel DD	0.081		-0.163*	
Maize MK-Benzene MK	0.003		-0.045		Maize MK-Diesel MK	-0.013		-0.305	
Maize BD-Benzene BD	-0.300**		-0.038		Maize BD-Diesel BD	-0.302**		-0.050	
Maize JM-Benzene JM	-0.045		0.001		Maize JM-Diesel JM	-0.045		0.020	

Note: * and ** denote significance at the 5% and 1% levels, respectively. (1) and (2) indicate log prices with 1 and 2 months lags, respectively.

Table 7a CCC-MGARCH Model Results: World and Domestic Prices

Markets/Commodities	ARCH	GARCH	CCC
Model 3a: Addis Ababa fuel and world crude oil prices			
Benzene AA -Crude oil world	0.31	0.76**	0.13
Diesel AA-Crude oil world	1.04	0.37**	-0.02
Model 3b: Addis Ababa grain and world crude oil prices			
Wheat AA-Crude oil world	0.13	0.75**	0.08
Maize AA-Crude oil world	0.66*	0.46**	0.21*
Model 3c: Addis Ababa grain and world grain prices			
Wheat AA-World	0.13	0.69**	0.06
Maize AA-World	0.61	0.05	-0.02

Note: * and ** denote significance at the 5% and 1% levels, respectively. Following the assumption that world prices are weakly exogenous, reported ARCH and GARCH coefficients are only for AA prices.

Table 7b CCC-MGARCH Model Results: Domestic Prices

Markets/Commodities	ARCH	GARCH	CCC	Markets/Commodities	ARCH	GARCH	CCC
Model 3d: Addis Ababa and other-local markets fuel prices							
Benzene DD -AA	0.05	0.66	0.74**	Diesel DD -AA	1.35	0.34	0.62**
Benzene MK -AA	0.04*	0.68**	0.76**	Diesel MK -AA	0.01	0.45	0.89**
Benzene AB-AA	0.01	0.96**	0.74**	Diesel AB-AA	0.90	0.1	0.82**
Benzene DM-AA	0.10**	0.55**	0.75**	Diesel DM-AA	0.07	0.05	0.84**
Benzene AS-AA	0.06	0.43**	0.66**	Diesel AS-AA	0.26	0.09	0.90**
Benzene HS-AA	0.05*	0.70**	0.45**	Diesel HS-AA	0.03	0.68**	0.28
Benzene BD-AA	0.06**	0.60**	0.56**	Diesel BD-AA	0.03	0.82**	0.87**
Benzene JM -AA	0.03	0.93**	0.70**	Diesel JM -AA	0.37	0.04	0.65**
Model 3e: Local markets grain and fuel prices							
Benzene AA-*Teff* AA	0.46	0.02	0.10	Diesel AA-*Teff* AA	0.399	0.035	0.12
Benzene DD-*Teff* DD	0.21	0.16	0.03	Diesel DD-*Teff* DD	0.216	0.156	0.13
Benzene Mk-*Teff* MK	0.20	0.09	0.09	Diesel Mk-*Teff* MK	0.210	0.085	-0.08
Benzene AB-*Teff* AB	0.38	0.10	0.21*	Diesel AB-*Teff* AB	0.375	0.096	0.18
Benzene DM-*Teff* DM	0.15	0.05	0.11	Diesel DM-*Teff* DM	0.148	0.040	-0.08
Benzene AA-Wheat AA	0.17	0.62**	0.11	Diesel AA-Wheat AA	0.174	0.579*	0.16**
Benzene DD-Wheat DD	0.18	0.43*	0.16*	Diesel DD-Wheat DD	0.191	0.399*	0.10
Benzene MK-Wheat MK	0.05**	1.01**	0.04	Diesel MK-Wheat MK	0.21	0.89**	-0.01
Benzene AS-Wheat AS	0.39	0.31	-0.05	Diesel AS-Wheat AS	0.393	0.314	-0.08
Benzene HS-Wheat HS	0.09	0.44	0.04	Diesel HS-Wheat HS	0.093	0.441	-0.04
Benzene AA-Maize AA	0.88	0.40	0.12	Diesel AA-Maize AA	0.864	0.411	0.16
Benzene DD-Maize DD	1.46*	0.08	0.11	Diesel DD-Maize DD	1.484	0.055	0.16
Benzene MK-Maize MK	0.26	0.62**	0.14*	Diesel MK-Maize MK	0.184	0.689	0.10
Benzene BD-Maize BD	0.70*	0.16**	0.05	Diesel BD-Maize BD	0.672	0.149	-0.01
Benzene JM-Maize JM	0.11**	0.73**	0.09	Diesel JM-Maize JM	0.083	0.537	0.03
Model 3f: Addis Ababa and other-local markets grain prices							
Teff DD-AA	0.23*	0.75	0.53**	Maize DD- AA	0.77	0.03	0.66**
Teff MK- AA	1.73	0.17	0.55**	Maize MK-AA	0.15	0.64**	0.57**
Teff AB-AA	0.47*	0.09	0.53**	Maize BD-AA	0.06*	0.55*	0.52**
Teff DM-AA	0.16	0.1	0.41**	Maize JM-AA	0.09	0.72**	0.51**
Wheat DD- AA	0.13	0.40**	0.53**				
Wheat MK- AA	0.13	0.77**	0.36**				
Wheat AA-AA	0.27	0.44**	0.49**				
Wheat HS -AA	0.03	0.60*	0.45**				

Note: * and ** denote significance at the 5% and 1% levels, respectively. Reported ARCH and GARCH coefficients are only for local prices other than AA prices. Model 3e is based on VAR.

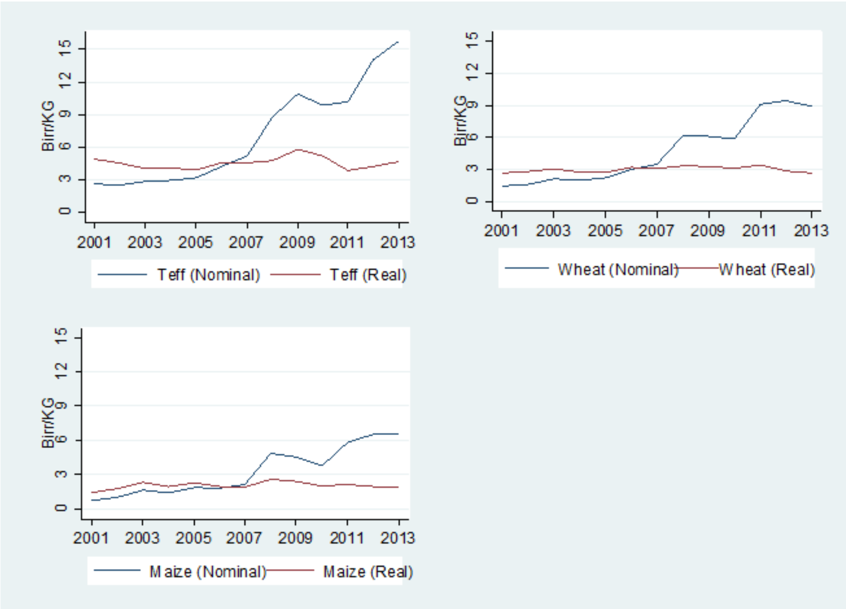

Figure 1 Nominal and Real Price, by Commodity (2001- 20013)

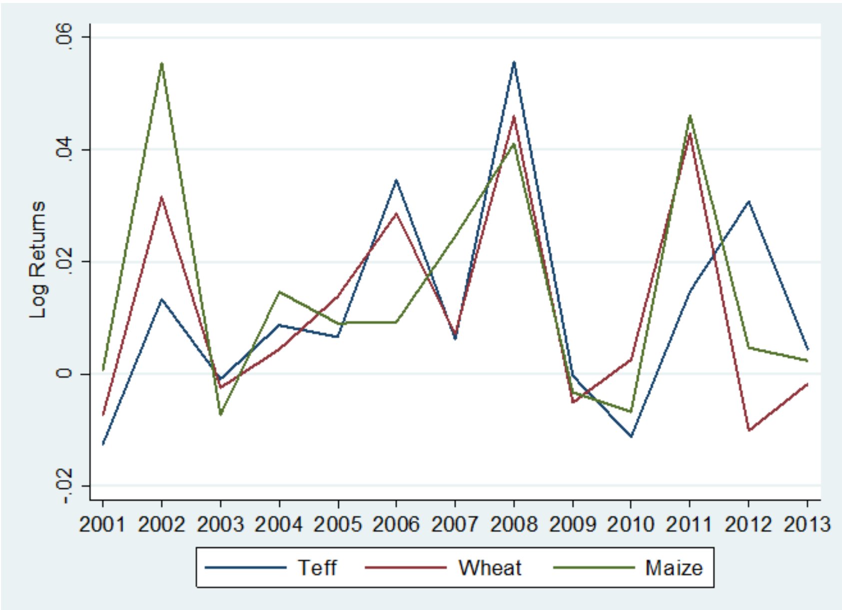

Figure 2 Price Variability, by Commodity (2001-2013)

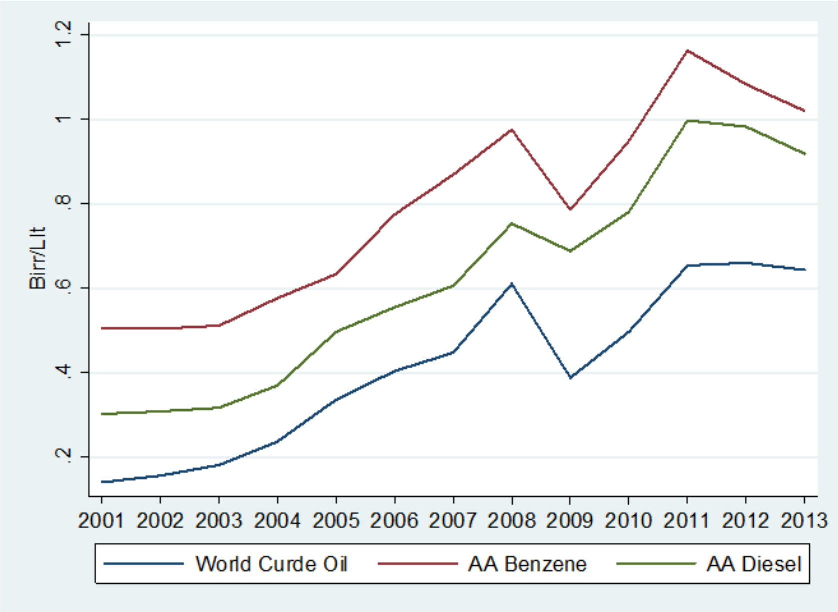

Figure 3 Nominal Prices, by Commodity (2001-2013)

Appendix

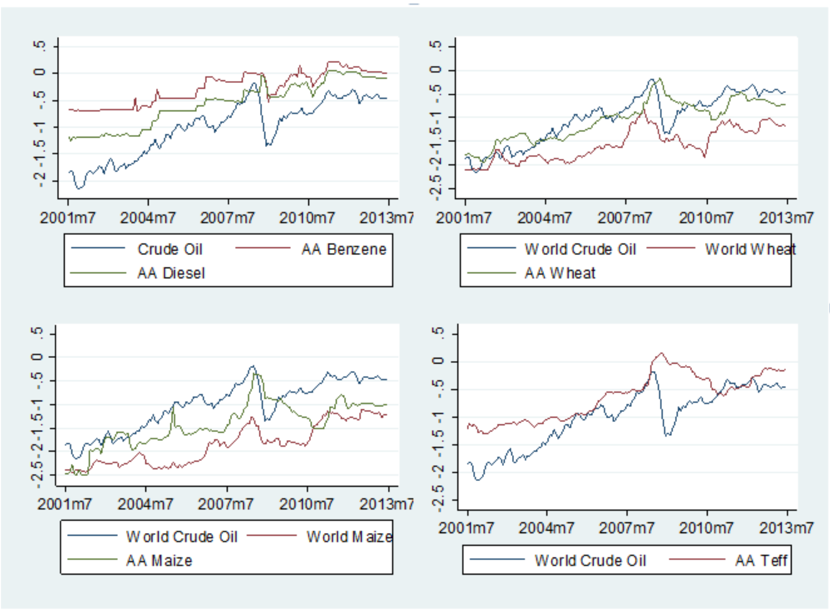

Figure A1.1 Monthly Log Prices in World and Domestic Markets, by Commodity (2001-2013)

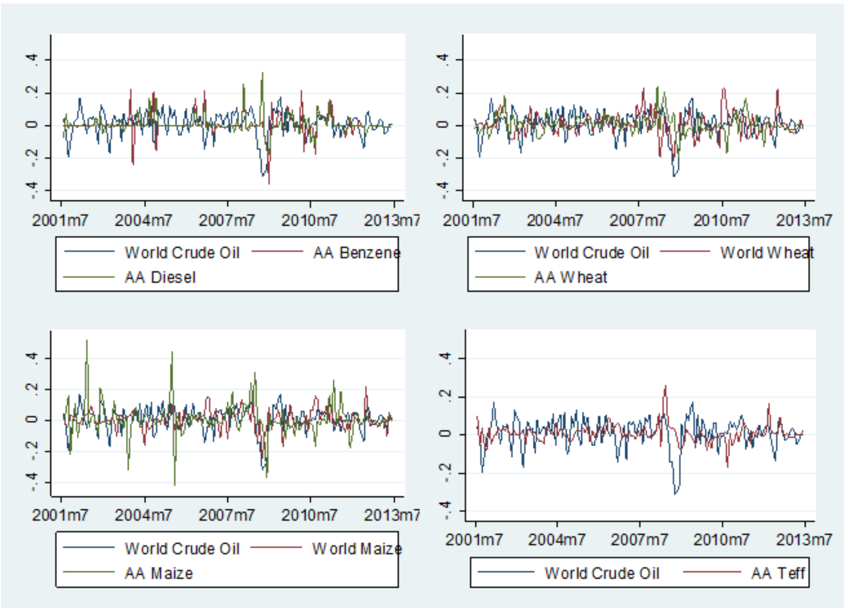

Figure A1.2 Monthly Log Returns in the World and Domestic Markets, by Commodity (2001-2013)

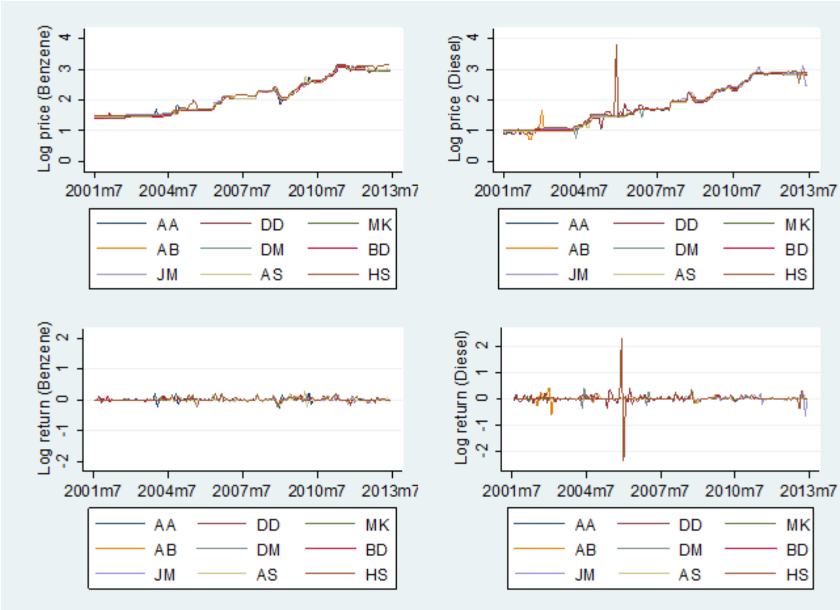

Figure A2 Monthly Fuel Log Prices and Returns in Domestic Markets, by Commodity (2001-2013)

Figure A3 Monthly Grain Log Price and Returns in Domestic Market, by Commodity (2001-2013)

Meron Assefa Arega

School of Economics and Business,
Norwegian University of Life
Sciences (NMBU),
P. O. Box 5003
N-1432 Ås, Norway

Phone: +47 46268785
Fax: +47 64965701
E-mail:
meron.arega@nmbu.no
meron_assefa@yahoo.com

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Meron Assefa Arega was born in Addis Ababa, Ethiopia in 1980. She holds a BA degree in Economics (2001) and MSc degree in Economic Policy Analysis (2003) from the Department of Economics at Addis Ababa University.

This thesis contains four independent papers, in conjunction with an introductory chapter. It contributes to growing body of methodological and empirical literature regarding food price movements in sub-Saharan Africa (SSA). The main objective is to measure how food grain prices respond to government policies, and domestic and international commodity price shocks in SSA, using evidences from Ethiopia and Malawi. Topics covered and major findings are succinctly summarized below.

Paper 1 studies the independent and joint impacts of Ethiopia's Productive Safety Net Program (PSNP) and emergency relief programs on producers' prices for *teff*, wheat and maize. Results show food aid allocated both from PSNP and emergency relief programs have either no discernible correlation with subsequent prices or a weak negative correlation. Cash transfers are found to raise prices slightly, especially those of *teff*. The magnitudes of the correlations between prices and seasonal and time trends are substantially stronger than those associated with cash and grain transfers to local markets. **Paper 2** is an extension of the first paper to directly test whether food aid discourages food production and also whether food aid responds to production shortfalls in Ethiopia. Results indicate that previous year food aid allocated from PSNP and from emergency relief programs have no evident negative correlation with subsequent *teff*, maize and wheat production and area planted. It is also shown that a low level of rainfall triggers more emergency relief and PSNP food aid. **Paper 3** measures integration of border maize markets of Malawi, with major local markets in the country, and with border markets of the neighboring countries. Results indicate intra-regional market integration within Malawi. Additionally, significant cross-border maize market integration between border markets of Malawi and its neighbors exist, mainly with that of Mozambique. **Paper 4** examines whether fuel prices are linked to food grain (*teff*, wheat and maize) prices, through effect on transportation cost, using evidence from Ethiopia. Results indicate that change in the world crude oil price does transmit to Addis Ababa (AA) maize and wheat prices, with no observed effects on *teff* price. However, local fuel (benzene and diesel) prices do not transmit to staple prices in Ethiopia. Also, volatility of world crude oil price is linked to volatility of only maize price in AA, whilst there are no volatility correlations between local fuel and food grain prices.

Supervisors were Prof. Atle Guttormsen and Prof. Gerald Shively.