International Food and Agribusiness Management Review
Volume 23, Issue 1, 2020; DOI: 10.22434/IFAMR2019.0140

Received: 29 August 2019 / Accepted: 23 September 2019

Should traders be blamed for soaring food prices in Ethiopia? Evidence from wholesale maize markets

RESEARCH ARTICLE

Mesay Yami[a], Ferdi Meyer[b] and Rashid Hassan[c]

[a] *PhD, Department of Agricultural Economics, Extension & Rural Development, University of Pretoria, Private Bag X20, Hatfield, Pretoria 0028, South Africa*

[b] *Associate Professor, Bureau for Food and Agricultural Policy (BFAP), University of Pretoria, Private Bag X20, Hatfield, Pretoria 0028, South Africa*

[c] *Professor, Centre for Environmental Economics and Policy Analysis (CEEPA), University of Pretoria, Private Bag X20, Hatfield, Pretoria 0028, South Africa*

Abstract

The prevalence of imperfect price transmission in the agricultural food markets continues to be an important policy concern for most countries in Africa. Motivated by the coexistence of soaring food prices and high domestic food production, this article investigates the performance of wholesale white maize markets in Ethiopia during the post-agricultural market liberalization period. The presence of price manipulation in the grain market structure has important welfare implications as it impedes the full transmission of price reductions and increases among marketing intermediaries. Results indicate that regional maize markets adjusted more quickly to price decreases than price increases to the central Addis Ababa wholesale maize market prices, suggesting the absence of positive asymmetric price transmission. Our findings are in contrast with existing studies conducted in southern, western and eastern Africa major food commodity markets.

Keywords: asymmetry, cointegration, food prices, maize, smallholder
JEL code: C54, D18, D4

Corresponding author: mesay44@gmail.com

1. Introduction

Ethiopia is an agrarian country, and the efficiency and effectiveness of the agricultural commodity markets are listed as a top priority for the government. The efficiency of an agricultural market affects how price signals transmit from surplus production to consumer markets. In doing so, integrated markets enable consumers in a deficit market to pay a reasonable price for a commodity, which thereby contributes to food security. At the same time, producers in surplus markets receive market prices that reflect consumer demand across the country. Thus, market integration contributes to regional production specializations, which can be an engine of economic growth in agriculture-based developing countries. Therefore, a better understanding of the degree of spatial grain market integration is important for designing relevant policy responses for improving the functioning of grain markets.

In recent years, food price inflation has become an important policy issue for the Ethiopian government, as it poses a significant economic threat for net food buyers. Since 2003, food price inflation has exceeded 20% on five occasions. The year-on-year change in food price inflation reached an all-time high level of 60% in 2008 (FAO, 2015). Ironically, food price inflation often exists in periods when there is high domestic crop production. Cereal production has been increasing in Ethiopia since 2004. During the periods between 1995 to 2003 and 2004 to 2015, the growth rate in domestic production of food crops was somewhat higher than the growth in total consumption as Table 1 is showing. The coexistence of high crop prices with a drastic increase in domestic crop production raises a key question about grain market pricing practices.

By overlooking the important role of grain traders in providing marketing services to smallholder farmers and in grain price stabilization, policy makers have since 2008 consistently blamed traders for the persistence of soaring food prices in Ethiopia. They claim that traders are manipulating market prices by keeping prices high for a longer period. This is said to contribute to the persistence of soaring food prices in spite of the observed growth in food production in Ethiopia. This perception of policy decision makers has also been shared by consumers. Resultantly, price fixing and market allocation have become important policy issues, with the pricing practices of grain traders being called into question by the Ethiopian government in 2011. This resulted in a new policy in food market regulation and became a justification for direct government intervention in commercial grain imports and distribution at subsidized prices for selected crops.

In an effort to control price manipulation or predatory trading practices, the Ethiopian government in 2011 imposed price caps on 17 basic food items. However, this intervention worsened the problem and resulted in a reduction in the availability of some food items in the market. Because of that, the government reversed the price cap decision for most crops in June 2011 (Minten *et al*., 2012).

The coexistence of high food crop production and soaring food prices in Ethiopia makes it necessary to empirically investigate traders' grain market price adjustment. In this article, we investigate the widely held perception that traders' inappropriate price adjustment contributes to the persistence of soaring food prices

Table 1. Average change in production and consumption of major food crops in Ethiopia (1995-2003 to 2004-2015) (Yami *et al*. 2017).

Crops	Average production (×1000 tons)			Average total consumption (×1000 tons)			Trade regimes
	1995-2003	2004-2015	%	1995-2003	2004-2015	%	
Wheat	1,629	3,056	88	2,224	3,857	73	IPP[1]
Maize	2,637	4,886	85	2,632	4,849	84	autarky
Sorghum	1,572	3,157	101	1,601	3,160	97	autarky
Millet	359	595	66	359	592	65	autarky

[1] IPP = Import Parity Price.

in Ethiopia by taking the case of maize commodity. Since maize is a major food crop grown and consumed in Ethiopia, the findings of this study will have important policy implications.

This article has two main objectives. Firstly, we examine spatial wholesale maize markets integration in Ethiopia during the post-agricultural market liberalization period from July 2004 to March 2016. Secondly, we test for the presence of Asymmetric Price Transmission (APT) among integrated wholesale maize markets. Evidence on how traders adjust market prices to grain price shocks will provide valuable information to policymakers for redressing the soaring food prices and combating unlawful tendencies and inequitable welfare distribution among grain market actors. Furthermore, the results will provide insight into the Ethiopian maize market structure and make clearer the roles and additional objectives, if any, to be incorporated by the Ethiopian government in maize market price stabilization policy.

2. Asymmetric price transmission: theoretical and empirical considerations

Depending on the structure of spatially integrated markets, the price transmission process can be complete or partial, or linear or non-linear (Ihle *et al*., 2009; Meyer and Von Cramon-Taubadel, 2004). Perfect price transmission assumes that a price decrease or increase in one market leads to the same price change in another integrated market. The idea of perfect price transmission is analogous to a standard competition model, where a seller charges a price close to the marginal cost. Different factors constrain the complete pass-through of price signals movement among integrated spatial markets. Among the most-cited factors include the status of market fundamentals, especially the three I's: infrastructure, information communication service development, and market institutions. Government trade policy interventions and imperfect competition also obstruct price signal transmission from one market to other (Abdulai, 2000; Rapsomanikis *et al*., 2003).

Recent empirical market integration studies have given more attention to assessing the performance of agricultural commodity markets. The extension of standard cointegration approaches by examining the nature of adjustment to the previous year long-run deviation as symmetric or asymmetric has improved the policy use of agricultural market integration studies. The early and pioneering work on testing APT by modifying the error correction representation was done by Von Cramon-Taubadel and Fahulbusch (1996).

The prevalence of imperfect price transmission in the agricultural food markets continues to be an important policy concern for most countries in Africa. The underdeveloped infrastructural service, information asymmetry, and exercise of market power are believed to be the possible causes of APT. In rural agricultural markets, imperfect competition allows oligopolists to react collusively more quickly to shocks that squeeze their marketing margins than to shocks that raise them, resulting in positive APT (Ngare *et al*., 2013).

The presence of APT in the grain market structure has important welfare implications as it impedes the full transmission of price reductions and increases among marketing intermediaries. If traders respond homogenously to positive and negative price deviations from a long-run equilibrium position, then grain markets are doing well. In this case, it is believed that market actors would benefit equally from a price decrease or increase. As a result, government intervention is not required.

On the other hand, positive APT exists if economic agents tend to respond more quickly to an increase than decrease price deviations from a previous year disequilibrium state. In this case, market actors are not benefitting equally from a price reduction and increase. This kind of domination in a grain market structure could create price 'stickiness' (what goes up does not come down). This will disrupt agricultural policies that aimed at increasing agricultural production and promoting regional production specialization, which is considered a source of economic development for many developing countries. Of course, the asymmetry in price transmission may also be reflected in commodity value chain stages such as the retail market and at different processing stages. Therefore, the presence of positive APT calls for strong regulations in the food market to prevent inequitable welfare distribution in grain markets. Despite good reasons for the possible presence of imperfect price transmission in the agricultural commodity markets, the empirical analysis of testing APT is not extensive in Africa. Very few studies have attempted to test for the presence of APT in the African commodity markets (Abdulai, 2000; Acosta, 2012; Acquah and Dadzi, 2010; Alemu and Ogundeji, 2010; Cutts and Kirsten, 2006; Fiamohe *et al*., 2013; Ngare *et al*., 2013; Usman and Haile, 2017; Wondemu, 2015).

In the Ethiopian grain market context, previous studies on spatial grain market integration addressed the issue of market integration, market structure and performance (Getnet *et al*., 2005; Jaleta and Gebremedhin, 2012; Negassa and Myers, 2007; Rashid, 2011; Tamru, 2013; Ulimwengu *et al*., 2009). These studies offer useful information on the performance of grain markets in the post-liberalization period and confirm improvement in inter-regional grain market integration. However, the majority of the studies failed to test the possible presence of asymmetric price adjustment that could be induced by a particular market structure.

The coexistence of persistent soaring food prices with food crop production growth could be an indication of collusion among grain traders in Ethiopia as the relevant literature attributes this to imperfect price transmission. In this instance, traders are reluctant to fully respond to market price movements, and the speed of price transmission depends on the direction of the price change (Alemu and Ogundeji, 2010; Cutts and Kirsten, 2006). This represents a structural market phenomenon known as APT.

Worako *et al*. (2008), Wondemu (2015), and Usman and Haile (2017) are the only authors who have attempted to examine the influence of traders' market power in Ethiopia, by using the spatial price asymmetry approach. The analysis by Worako *et al*. (2008) was, however, limited to the coffee sub-sector, while Wondemu (2015) only used three wholesale grain market locations, so this limited scope makes the generalization of their results difficult. More recently, Usman and Haile (2017) tested the issue of asymmetry across regional grain markets and found no convincing asymmetry in major grain producing markets of Ethiopia. However, the study did not take into account the effect of structural breaks. Following the soaring food price situations of 2008, the Ethiopian government implemented various policy instruments to contain grain price hikes in the domestic market. These policy reforms are expected to shift the properties of the grain prices, abruptly or gradually. It has been well documented that ignoring a break when there is switch in the parameter value distorts the validity of cointegration tests (Perron, 1989; Rafailidis and Katrakilidis, 2014). In the present study, we investigate maize grain traders' price adjustment behavior with large datasets by accounting the presence of structural breaks.

3. Data

The study used the Ethiopian Grain Trade Enterprise (EGTE) monthly wholesale maize price data. The dataset incorporates fifteen maize market locations in Ethiopia: central market (Addis Ababa Ehel-Berenda market) and regional maize markets (Ambo, Bahir-Dar, Debre-Birhan, Dese, Debre-Markos, Gondar, Hosaena, Jimma, Mek'ele, Nazareth, Nekemete, Shashemene, Woliso, and Ziway). The study's maize markets are selected based on their representativeness of production of the crop, major consumption areas, importance to the national grain trade flow, and data availability. The price series is from July 2004 to March 2016 (141 months). The descriptive results for the wholesale maize prices are presented in Table 2. All the prices are expressed in Ethiopian Birr (ETB) per kg.

Major regional surplus and deficit maize markets price trends are plotted in Figure 1. Domestic wholesale maize markets showed upward swings in 2008 and at the end of 2013. Given the geographical dispersion of maize production in Ethiopia, some regional maize markets, such as Mek'ele and Gondar, are quite far from the central market. Road infrastructural development would therefore play a crucial role for maize production reallocations from major producing regions to deficit consumption areas. In the past, poor infrastructure facilities contributed to market segmentation between grain production and consumption regions in Ethiopia. It is believed that the inadequate physical infrastructure had contributed to the famines of the mid-1980s by limiting the reallocations of food in times of drought, from surplus-producing regions to drought-affected

Table 2. Descriptive results of the nominal wholesale maize market prices, July 2004 to March 2016 (ETB[1]/100 kg).

Markets	Mean	Std.dev.	Min.	Max.	Driving distance from Addis Ababa (km)
Addis Ababa	347	157	123	631	–
Ambo	330	155	110	696	119
Bahir Dar	344	170	112	770	559
Debre-Birhan	356	165	123	663	132
Debre-Markos[1]	362	181	116	774	306
Gondar	370	171	141	791	731
Hosaena	377	182	127	801	228
Jimma	317	158	100	718	352
Nazareth	349	163	120	680	89
Nekemete	312	156	96	635	318
Shashemene	358	181	107	770	250
Woliso	345	163	107	718	111
Ziway	345	168	106	718	163
Dese	358	160	129	690	387
Mek'ele	385	179	99	904	761

[1] ETB = Ethiopian Birr.

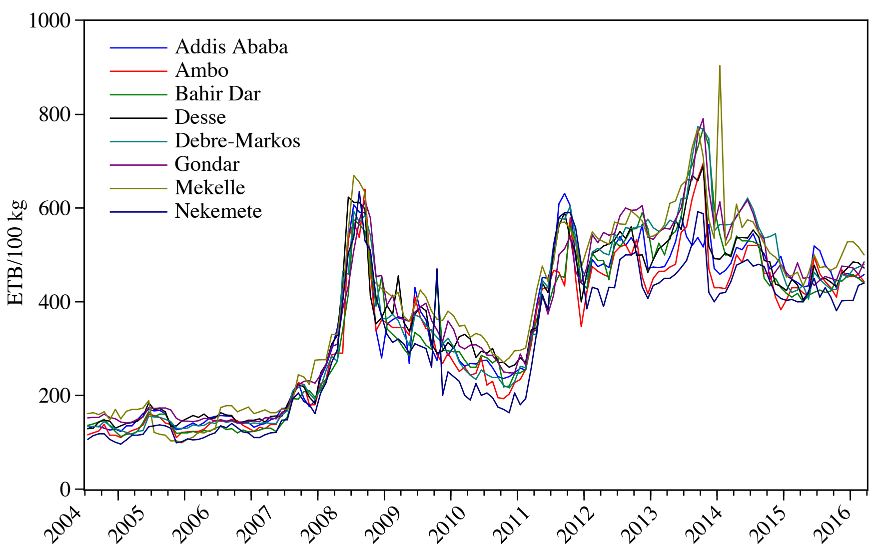

Figure 1. Nominal monthly wholesale maize prices in major surplus and deficit maize markets in Ethiopia, July 2004 to March 2016 (ETB/100 kg) EGTE (2016). ETB = Ethiopian Birr.

deficit areas (WFP, 1989). To address this problem, the current Ethiopian government has shifted its focus on road infrastructure development.

The progress in rural road development has been encouraging. The length of rural roads increased from 16,480 km in 2000 to 30,641 km by 2014. In 2014, the total road network reached 110,414 km, which showed an annual expansion of 11% as compared with 2013 (ERA, 2015). The expansion in road infrastructure development is expected to contribute to timely mobility of agricultural products from surplus to consumption areas.

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

4. Econometric models

This section starts by testing time series properties using unit root tests. We then proceed to the estimation of cointegration test. However, conventional cointegration techniques, such as the Johansen's approach (1988), may lead to misleading inferences if structural breaks persist in the data series. Given the fact that domestic commodity prices rose sharply following the global commodity price crises of 2008 and 2013, dealing with structural breaks seems to be a necessary condition. Beyond the output price fluctuations, the policy reforms made by the Ethiopian government to stabilize the domestic grain prices are expected to shift the properties of grain prices. Against this backdrop, this study investigated the presence of structural breaks in wholesale maize market prices using the Bai and Perron (1998) multiple structural break test. Following Rafailidis and Katrakilidis (2014), we estimated the Dynamic Ordinary Least Square approach (DOLS) to investigate cointegration tests by incorporating the identified structural breaks in the form of dummy variables. Finally, we used an Asymmetric Error Correction Model (AECM) to test for asymmetry in price adjustment.

4.1 Unit root and structural break tests

The estimation of a standard regression model using Ordinary Least Squares (OLS) is based on the assumption that the mean and variance of variables are time invariant. Variables their mean and variance change over time are known as non-stationary variables. Therefore, the results generated from non-stationary variables using the OLS method lead to spurious regression or nonsense regression. For non-stationary variables, the estimation of a long-run relationship among variables should be based on cointegration methods. Cointegration methods require variables to have the same order of integration. Thus, this study starts by testing the order of integration using Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979), Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and the Elliott, Rothenberg and Stock (ERS) unit root tests. The Elliott *et al.* (1996) unit root test has more power for small sample-size than its counterparts.

The Bai and Perron (1998) multiple structural break test is also employed to detect the presence of structural breaks in wholesale maize market prices. The use of Bai and Perron test is motivated by the possible presence of structural breaks created by the Ethiopian government intervention in attempt to curb the crisis of food price surge in 2008 and 2013. Testing cointegration by considering the possible presence of a structural break has at least two advantages. First, it avoids the bias towards the non-rejection of the null hypothesis of no cointegration (Leybourne and Newbold, 2003). Second, since this procedure can identify when the structural breaks occurred, it would then provide valuable information for analyzing whether a structural break on a certain variable is associated with a particular government policy, economic crisis, war, regime shift, or other factors.

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

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

Where Z_t is the dependent variable in period t, X_t' and φ_t' are vectors of covariates, while β and η_j ($j = 1, \ldots m + 1$) are the corresponding vectors of coefficients, and u_t is the disturbance term. $T_1, \ldots T_m$ are indices that represent the breakpoints. m is the maximum number of breaks used for the test and is set to five. A test, which we call the $supF$ $(\imath + 1/\imath)$ test determines the optimum structural breaks (Bai and Perron, 1998).

The null hypothesis is that the optimum number of breaks is ι, while the alternative hypothesis states that the number of breaks is $\iota + 1$.

4.2 Stock-Watson Dynamic Ordinary Least Square approach

We next test the presence of cointegration by accounting the identified structural breaks in the form of dummy variables using the DOLS approach proposed by Stock and Watson (1993). DOLS is an improvement on OLS as it copes with small samples and dynamic sources of biasness. The Johansen cointegration method, being a full information technique, is exposed to the problem that parameter estimates in one equation are affected by any misspecification in other equations. In contrast, the Stock-Watson method is a robust single-equation approach, which overcomes the simultaneity bias by incorporating leads and lags of first differences of the regressors, and for serially correlated errors, by a Generalized Least Squares procedure (Azzam and Hawdon, 1999).

We model the long-run relationship between two series P_t^L and P_t^C as:

$$P_t^L = \delta_1 + \delta_2 P_t^C + \sum_{j=-k}^{k} \beta \Delta P_{t-j}^C + u_t \quad (2)$$

Where P_t^L and P_t^C are regional and central maize market prices, and K is known as the lead-lag truncation parameter. The OLS estimator of δ_2 based on Equation 2 above is efficient in a certain class of distributions (Saikkonen, 1991).

4.3 Asymmetric Error Correction Model

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

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

$$P_t^L = \alpha_0 + \alpha_1 P_t^C + u_t \quad (3)$$

The OLS residuals from Equation 3 are a measure of disequilibrium: $\hat{u}_t = P_t^L - \hat{\alpha}_0 - \hat{\alpha}_1 P_t^C$. A test for cointegration is a test of whether $\hat{u}_t$ is stationary. This is determined by ADF tests on the residual, with the MacKinnon (1991) critical values. A long-run relationship exists when cointegration holds between the price series, P_t^L and P_t^C. Once cointegration is confirmed, then the second stage of Engle-Granger in Equation 4 is conducted to obtain the short-run dynamics and the error correction term. The second step, which estimates the error correction model, is specified as:

$$\Delta P_t^L = \varphi_0 + \sum_{k=1} \varphi_1 \Delta P_{t-k}^L + \sum_{h=0} \theta_h \Delta P_{t-h}^C) + \alpha \hat{u}_{t-1} + \varepsilon_t \quad (4)$$

Since Equation 4 has only I(0) variables, a standard hypothesis test using t-ratios and diagnostic testing of the error term is valid. The adjustment term α is the error correction term and must be negative and significant to show adjustment to the previous year departure from an equilibrium position. The lags of P_t^L and P_t^C quantify the short-run dynamics of regional and central prices on price movements of regional maize market prices. Lag length is selected using the Akaike Information Criterion and the Schwarz Bayesian Criterion.

Finally, the Von Cramon-Taubadel (1998) approach is adopted to test for asymmetry in price adjustment. An AECM is outlined in Equation 5.

$$\Delta P_t^L = \beta_0 + \beta_1 \sum_{i=1}^{k} \Delta P_{t-i}^L + \beta_2 \, \Delta P_t^c + \beta_3 \sum_{i=1}^{h} \Delta P_{t-i}^c + \beta_4^+ \, ECT_{t-1}^+ + \beta_4^- \, ECT_{t-1}^- + \varepsilon_t \quad (5)$$

where $ECT_{t-1}^+ = \begin{cases} ECT_{t-1} & ECT_{t-1} > 0 \\ 0 & otherwise \end{cases}$ and $ECT_{t-1}^- = \begin{cases} ECT_{t-1} & ECT_{t-1} < 0 \\ 0 & otherwise \end{cases}$

P_t^L and P_t^C are regional and central maize market prices. Equation 5 is obtained by decomposing the lagged error correction term ($\hat{u}_{t-1}$) from the second stage of Engle-Granger test into its positive (ECT_{t-1}^+) and negative parts (ECT_{t-1}^-). A positive error correction term (ECT_{t-1}^+) indicates that the margin is higher compared with the long-run equilibrium value (opposite for a negative error correction term). Splitting the error correction term into positive and negative parts will enable us to observe whether the speed of price adjustment of regional wholesale maize markets to upward and downward price deviations from the equilibrium position are different. In other words, whether price transmission is asymmetric.

Although Equation 5 resolves the issue of asymmetry and cointegration, it still suffers from simultaneity of prices at different spatial markets. We have addressed this problem by using the Toda and Yamamoto (1995) ('T-Y') Granger Causality approach. The advantage of the T-Y causality test is that, unlike the conventional Granger causality test, a researcher can examine causality, irrespective of the results from the order of integration and cointegration. As a result, it avoids the pre-testing bias that could potentially arise from the order of integration and cointegration tests (Clarke and Mirza, 2006; Zapata and Rambaldi, 1997). Moreover, the application of this approach can shed light on the central maize market hypothesis test in Ethiopia. To test T-Y causality, a vector autoregressive specification in level form similar to Equation 2 was estimated by augmenting it with a maximum order of integration and the true optimum lag length. In this study, all the statistical testing procedures were estimated using EViews 9 (IHS Global Inc., Irvine, CA, USA).

5. Results and discussion

5.1 Maize price leadership

The extended vector autoregressive procedure of the Toda and Yamamoto (1995) causality test analyses the lead-lag price relationships among regional wholesale maize markets. The central market hypothesis test was conducted in two stages. Firstly, the wholesale maize market price relationship between Addis Ababa and major surplus maize markets is examined. Secondly, the deficit maize markets and the leadership role of the Addis Ababa maize market price are investigated. The classification of markets as deficit and surplus maize markets is based on the USAID maize production and market flow map (Supplementary Figure S1).

Tables 3 and 4 present the results of T-Y modified Wald test of causality among deficit and surplus regional maize markets in Ethiopia. The findings from the T-Y causality test indicate that, with the exception of the Dese maize market, the Addis Ababa maize price is exogenous to the rest of the regional maize markets. Thus, Addis Ababa's wholesale maize market is behaving as the dominant maize market in Ethiopia. Similar results were obtained by Yami *et al*. (2017) and Getnet *et al*. (2005), where the central market prices have been influencing the price formation of regional wholesale grain market prices in post-market liberalization period in Ethiopia. The geographical advantage enables the Addis Ababa wholesale maize market to have large number of feeder markets, which further contributes to the unidirectional price influence.

5.2 Asymmetric price transmission

In this study, econometric modelling of maize market integration is undertaken to provide information on the adjustment practices of wholesale traders to price signals. Such information will be flawed if proper account is not taken of the time series properties of the variables such as unit root tests and structural breaks. To this end, unit root tests were first carried out, and the results from all unit root tests correspond with each other. Table 5 depicts the results of unit root tests based on ADF, ERS, and KPSS statistics in levels and

Table 3. T-Y causality test among deficit maize markets.[1]

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

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

Table 4. T-Y causality test among surplus maize markets.[1]

Markets	Addis	Ambo	Bahir Dar	DB[2]	DM[2]	Gondar	Hosaena	Jimma	Nazareth	Nekemete	Shashemene	Woliso	Ziway
AA[2]	–	7.01 (0.54)	8.25 (0.41)	10.21 (0.25)	9.27 (0.32)	7.35 (0.50)	17.31 (0.03)**	6.68 (0.57)	16.02 (0.04)**	21.26 (0.00)***	7.13 (0.52)	10.05 (0.26)	11.53 (0.17)
Ambo	5.88 (0.66)	–	4.55 (0.80)	4.03 (0.85)	6.04 (0.64)	6.72 (0.57)	10.88 (0.21)	4.48 (0.81)	8.92 (0.35)	16.85 (0.03)**	11.14 (0.19)	14.11 (0.08)*	19.83 (0.01)**
Bahir Dar	5.49 (0.7)	3.52 (0.89)	–	3.94 (0.86)	4.19 (0.84)	3.84 (0.87)	8.16 (0.42)	12.35 (0.14)	13.09 (0.11)	16.45 (0.04)**	9.57 (0.30)	8.80 (0.36)	12.11 (0.15)
DB[2]	9.93 (0.27)	7.14 (0.52)	6.77 (0.56)	–	9.74 (0.28)	9.35 (0.31)	15.98 (0.04)**	8.22 (0.41)	14.82 (0.06)*	12.03 (0.15)	11.29 (0.18)	13.61 (0.09)*	29.71 (0.00)***
DM[2]	9.33 (0.31)	15.00 (0.06)*	13.23 (0.10)	14.69 (0.06)*	–	9.03 (0.34)	4.92 (0.77)	3.47 (0.90)	28.88 (0.00)***	19.72 (0.01)**	11.20 (0.19)	13.87 (0.08)*	12.33 (0.14)
Gondar	9.49 (0.30)	2.81 (0.94)	8.72 (0.36)	14.72 (0.06)*	6.51 (0.59)	–	9.00 (0.34)	6.85 (0.55)	8.67 (0.37)	8.70 (0.37)	8.75 (0.36)	15.77 (0.04)**	18.51 (0.02)**
Hosaena	12.32 (0.14)	8.53 (0.38)	6.73 (0.56)	8.04 (0.43)	10.25 (0.25)	9.55 (0.30)	–	4.40 (0.82)	5.74 (0.67)	21.64 (0.00)***	14.93 (0.06)*	20.82 (0.00)***	23.00 (0.00)**
Jimma	6.28 (0.61)	8.04 (0.43)	4.27 (0.83)	2.16 (0.98)	2.28 (0.97)	5.43 (0.71)	3.87 (0.87)	–	14.00 (0.08)*	5.93 (0.65)	7.38 (0.49)	10.72 (0.22)	6.06 (0.64)
Nazareth	11.05 (0.20)	7.09 (0.53)	9.36 (0.31)	6.27 (0.62)	7.62 (0.47)	5.53 (0.70)	7.31 (0.50)	4.19 (0.84)	–	21.74 (0.00)***	21.75 (0.00)***	5.62 (0.69)	19.69 (0.01)**
Nekemete	9.79 (0.28)	12.36 (0.14)	3.40 (0.91)	4.33 (0.83)	5.77 (0.67)	9.20 (0.32)	4.47 (0.81)	4.01 (0.86)	6.13 (0.63)	–	5.06 (0.75)	9.99 (0.26)	10.04 (0.26)
Shashemene	7.73 (0.46)	17.72 (0.02)**	4.52 (0.81)	2.88 (0.94)	4.92 (0.77)	7.24 (0.51)	8.28 (0.41)	2.60 (0.96)	11.90 (0.15)	19.75 (0.01)**	–	12.68 (0.12)	17.71 (0.02)**
Woliso	4.44 (0.81)	5.63 (0.68)	5.21 (0.73)	2.85 (0.94)	4.86 (0.77)	4.96 (0.76)	5.80 (0.67)	3.41 (0.91)	5.26 (0.73)	5.69 (0.68)	3.65 (0.89)	–	4.32 (0.83)
Ziway	8.22 (0.41)	7.83 (0.45)	5.86 (0.66)	2.62 (0.96)	4.00 (0.85)	7.94 (0.44)	5.25 (0.73)	4.13 (0.84)	2.54 (0.96)	4.00 (0.86)	3.26 (0.92)	9.63 (0.29)	–

[1] Null hypothesis of non-causality: x^2 (2) statistics; Probability values in parenthesis; ***, **, * reject the null hypothesis at 1%, 5%, and 10% significance levels.

[2] DB = Debre-Birhan market; DM = Debre-Markos market; AA = Addis Ababa.

first difference of the variables. The results suggest that all variables are nonstationary at levels while they turn stationary after first difference.

The Bai and Perron (1998) breakpoint test was used to detect the presence of structural breaks in the wholesale maize market prices and the results are presented in Table 6. The sequential Bai and Perron test results identified 15 breakpoints. Structural breaks were identified in the Gondar, Bahir-Dar, Mek'ele, Hosaena, Debre-Markos, Dese, Nazareth, Nekemete, Shashemene, and Ziway wholesale maize markets. The 2008 M07, M10, M11, and M12 structural breaks are likely associated with the Ethiopian government's

Table 5. Unit root tests.[1]

Market	**ADF**[2]	**ERS**[2]	**KPSS**[2]
	Test statistics		
Level (constant, no trend)			
Addis Ababa	-1.63	-0.55	0.95***
Ambo	-1.82	-0.76	0.93***
Bahir Dar	-1.53	-0.62	0.91***
Debre-Birhan	-1.53	-0.40	0.96***
Debre-Markos	-1.62	-0.68	0.90***
Dese	-1.66	-0.56	0.92***
Gondar	-1.69	-0.75	0.91***
Hosaena	-1.42	-0.34	1.00***
Mek'ele	-1.64	-0.61	0.92***
Nazareth	-1.47	-0.43	0.98***
Nekemte	-1.93	-0.87	0.88***
Shashemene	-1.42	-0.37	0.99***
Woliso	-1.69	-0.63	0.93***
Ziway	-1.39	-0.35	0.99***
Jimma	-1.75	-0.81	0.86***
First difference (constant, no trend)			
Addis Ababa	-2.88*	-2.83***	0.072
Ambo	-3.12**	-3.14***	0.069
Bahir Dar	-3.08**	-3.09***	0.082
Debre-Birhan	-2.95**	-2.30**	0.046
Debre-Markos	-2.81**	-2.79***	0.073
Dese	-2.93**	-2.91***	0.074
Gondar	-3.01**	-3.03***	0.076
Hosaena	-3.14**	-2.66***	0.061
Mek'ele	-3.33**	-3.32***	0.074
Nazareth	-3.25**	-3.07***	0.084
Nekemete	-3.36**	-3.17***	0.055
Shashemene	-3.45**	-3.35***	0.058
Woliso	-3.35**	-3.24***	0.066
Ziway	-2.93**	-2.82***	0.071
Jimma	-3.08**	-3.09***	0.058

[1] ***, **, * reject the null hypothesis at 1%, 5%, and 10% significance levels, respectively.

[2] ADF = Augmented Dickey-Fuller unit root test; ERS = Elliott, Rothenberg and Stock unit root test; KPSS = Kwiatkowski-Phillips-Schmidt-Shin unit root test.

macroeconomic intervention. In March 2008, the government restricted foreign exchange access for private traders. This intervention is expected to hinder private traders' involvement in international grain trade. Because of the restriction, although imports have become profitable, traders' do not freely get involved in international grain trade to exploit profitable import opportunities. As a result, the domestic grain prices for tradable commodities would drift over the upper threshold Import Parity Price (IPP). For instance, between June and July 2008, the domestic wheat grain price exceeded the IPP by US$ 200 (Rashid and Minot, 2010). Through substitution effects between maize and wheat, this might have contributed to the domestic maize price surge.

After that, we estimated the DOLS to investigate cointegration tests by incorporating the identified structural breaks in the form of dummy variables. A similar approach has been followed by Rafailidis and Katrakilidis

Table 6. Bai-Perron test results and break dates for regional and Addis Ababa maize market pairs.

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

[1] ** denotes rejection of the null hypothesis at 5% significance level.

[2] BD = Bahir Dar market; DM = Debre Markos market.

(2014) to examine the relationship between oil prices and stock prices. Estimates of cointegration and APT tests for regional maize markets are presented in Table 7.

Analyzing cointegration by taking into account breaks shows that all regional maize markets are found to have long-run relationships with the Addis Ababa maize market. The cointegration of all maize market pairs considered in this study is a reflection of better spatial maize market linkages in Ethiopia after the introduction of a Structural Adjustment Program.

Table 7. Estimates of long run equilibrium and asymmetric price transmission.[1]

Market pairs	Cointegration test	Asymmetric price transmission			
	DOLS[2] (U_t)	ECT_{t-1}^{+}	ECT_{t-1}^{-}	Wald test ($ECT_{t-1}^{+} = ECT_{t-1}^{-}$)	LM test[3]
Nazareth-Addis	-2.47**	0.069	-0.25*	2.70	0.28
Dese-Addis	-2.97***	-0.39***	-0.38**	0.003	0.25
Jimma-Addis	-2.35**	-0.75***	-0.42*	0.14	0.25
Ambo-Addis	-3.32***	-0.66***	-0.71***	0.069	0.52
Mek'ele-Addis	-3.59***	-0.54***	0.03	7.17***	0.29
DM[4]-Addis	-2.79***	-0.16**	-0.36***	1.75	0.11
Ziway-Addis	-2.46**	-0.53***	-0.53***	0.0003	0.88
SAHS[4]-Addis	2.74**	-0.23**	-0.41***	1.20	0.38
Woliso-Addis	-2.27**	-0.63***	-0.56***	0.12	0.25
Hosaena-Addis	-2.25**	-0.72***	-0.77***	0.08	0.22
Nekemete-Addis	-3.02***	-0.71***	-0.33**	2.89*	0.72
DB[4]-Addis	-3.49***	-0.42***	-0.43***	0.0003	0.56
Bahir Dar-Addis	-3.15***	-0.30***	-0.27**	0.84	0.80
Gondar-Addis	-2.88***	-0.22***	-0.26**	0.13	0.60

[1] Lag length is selected using Akaike Information Criterion and the Schwarz Bayesian Criterion.

[2] Is the innovation series obtained by the dynamic ordinary least squares cointegration equation; ***, **, *. denote rejection of the null hypothesis of no cointegration at 1%, 5%, and 10% significance levels, respectively.

[3] The Breusch-Godfrey (LM) test for higher-order serial correlation rejected the presence of autocorrelation in all equations. The value reported in the LM test is the probability value where the test failed to reject the null hypothesis of no serial correlation in the individual maize equations.

[4] DM = Debre-Markos market; SAHS = Shashemene market; DB = Debre-Birhan market.

The results of AECM demonstrate that out of 14 maize market pairs with the central Addis Ababa market, APT was confirmed in only two wholesale maize markets of Mek'ele and Nekemete. Contrary to our expectations, negative asymmetric price adjustment exhibits in both Mek'ele and Nekemete wholesale maize markets. This suggests that the negative price deviations from the long-run equilibrium position persists for longer period than the positive price deviations do. In other words, decreases in prices in the central Addis Ababa wholesale maize market are more quickly transmitted to the regional wholesale maize markets than increases in prices are. Our AECM results are in sharp contrast with many empirical price transmission analyses conducted on African food markets, which show that price increases are corrected and transmitted more quickly and fully than price decreases (positive APT) are (Abdulai, 2000; Acosta, 2012; Acquah and Dadzi, 2010; Alemu and Ogundeji, 2010; Cutts and Kirsten, 2006; Fiamohe *et al*., 2013; Ngare *et al*., 2013; Yeboah, 2012).

Overall, from the analysis of APT, we did not find strong evidence of asymmetric price adjustments. Several factors may contribute to the absence of positive asymmetric price adjustment in wholesale maize market in Ethiopia. The active presence of the EGTE in the maize market may contribute to symmetric price transmission in the maize market in Ethiopia. The EGTE is the only parastatal organization involving in the procurement of maize from farmers, for three purposes: the national food reserve, school feeding, and the Productive Safety Net Programme. In addition to these activities, the enterprise is also involved in maize price stabilization.

Besides the EGTE, other non-governmental organizations such as the World Food Programme (WFP) are also involved in the maize market in Ethiopia. The recent launch of the Purchase for Progress Program and purchase from Africans to African programs of the WFP ought to play an important role in maize price determination by linking producers to output markets. Both programs have targeted local procurement of white maize commodity from farmers for humanitarian assistance to other neighboring countries. From 2010 to 2013, the Purchase for Progress Program of the WFP purchased 26,212 tons of maize and beans, generating nearly US$ 8 million for Ethiopian smallholders. Close to 600,000 maize farmers, excluding large-scale maize traders, have benefited from the program (Nogales and Fonseca, 2014). In general, these initiatives may contribute to stiff competition in wholesale maize markets. Hence, the active participation of these organizations in the maize market is expected to improve the competitive structure of the maize market in Ethiopia.

6. Conclusions

Motivated by the coexistence of soaring food prices and high domestic food production, this study investigates the price adjustment practices of white maize wholesale grain markets in Ethiopia during the post-agricultural market liberalization period, from July 2004 to March 2016. Notwithstanding the widely held belief by consumers and the government that the inappropriate price adjustments of traders contribute to the persistence of soaring food prices in Ethiopia, we found no evidence to support this argument. Instead, wholesale maize traders tend to adjust homogenously to increases and decreases in maize price deviations from the central Addis Ababa maize market. Surprisingly, the regional wholesale maize markets of Mek'ele and Nekemete adjust their prices more quickly for decreases in prices stemming from the central Addis Ababa wholesale maize market than they do for increases in prices. Hence, the widely held perception that considers traders as constituting the main contributor to the recent soaring food price situation in Ethiopia is simply a misconception. In this study, it is argued that the recent surge in grain price in Ethiopia has little to do with APT in maize markets. The active presence of the EGTE and involvement of non-governmental organization such as the WFP in domestic maize market may contribute to the absence of asymmetric price adjustment in wholesale maize market in Ethiopia.

Since we find that regional traders, in most cases, adjust homogenously to an increase and decrease price deviations from the long-run equilibrium state, we are inclined to believe that the absence of positive asymmetric price adjustment in the maize market is a sign that maize markets are competitive on the sellers' side but not on the buyers side. This is because in this study Addis Ababa maize market is characterized as a central market, and all regional maize markets are treated as a supplier to Addis Ababa maize market. In this context, price shocks from the central market influences the price formation of local maize markets. It is, therefore, reasonable to believe that large wholesalers from the central market may use their market power to hold down prices so that they can buy at lower prices. This would slow adjustment rates after a price fall.

Our findings are in contrast with the general consensus in the literature about traders' price manipulation in African major food commodity markets (Abdulai, 2000; Acosta, 2012; Acquah and Dadzi, 2010; Alemu and Ogundeji, 2010; Cutts and Kirsten, 2006; Fiamohe *et al*., 2013; Ngare *et al*., 2013), which show that marketing intermediaries respond more quickly when their marketing margins are squeezed, than they do when they are stretched. The findings of this study should encourage the undertaking of additional studies to investigate price transmission between surplus and deficit maize markets in Ethiopia. Owing to limited working capital, most grain traders in Ethiopia lack the necessary financial strength and storage capacity to undertake long-distance trading from production to the central market. Instead, a considerable amount of grain production has been traded between nearby surplus and deficit regional markets. Hence, future studies should examine the nature of market integration and price adjustment patterns between surplus and deficit regional maize and other grain markets in Ethiopia.

Acknowledgements

The first author is grateful to Kennedy Kalundu and Bertha Ijambo for the comprehensive discussion and comments. I would like also to acknowledge the anonymous referees for their constructive feedback and the financial support of the Bureau for Food and Agricultural Policy.

Supplementary material

Supplementary material can be found online at https://doi.org/10.22434/IFAMR2019.0140

Figure S1. Map of maize producing regions and market flow in Ethiopia.

References

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

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

Acquah, H.G. and S.K. Dadzi. 2010. An application of the Von Cramon-Taubadel and Loy error correction models in analyzing asymmetric adjustment between retail and wholesale maize prices in Ghana. *Journal of Development and Agricultural Economics* 2: 100-106.

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

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

Bai, J. and P. Perron. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica* 66: 47-78.

Clarke, J.A. and S. Mirza. 2006. A comparison of some common methods for detecting Granger non-causality. *Journal of Statistical Computation and Simulation* 76: 207-231.

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

Dickey, D.A. and W.A. Fuller. 1979. Distribution of the estimator for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74: 427-431.

Elliott, G., T.J. Rothenberg and J.H. Stock. 1996. Efficient tests for an autoregressive unit root. *Econometrica* 64: 813-836.

Engle, R.F. and C.W.J. Granger. 1987. Cointegration and error correction representation, estimation and testing. *Econometrica* 55(2): 251-276.

Ethiopian Grain Trade Enterprise (EGTE). 2016. *Wheat import trends and subsidized wheat distribution*. EGTE, Addis Ababa, Ethiopia.

Ethiopian Roads Authority (ERA). 2015. *Assessment of 17 years performance of the road sector development program*. ERA, Addis Ababa, Ethiopia.

Fiamohe, R., P.A. Seck and D.Y. Alia. 2013. Price transmission analysis using threshold models: an application to local rice markets in Benin and Mali. *Food Security* 5: 427-438.

Food and Agriculture Organisation (FAO). 2015. FAOSTAT production database. Available at: http://www.fao.org/worldfoodsituation/foodpricesindex/en/

Getnet, K., W. Verbeke and J. Viaene. 2005. Modelling spatial price transmission in the grain markets of Ethiopia with an application of ARDL approach to white teff. *Agricultural Economics* 33: 491-502.

Ihle, R., S. Von Cramon-Taubadel and S. Zorya. 2009. Markov-switching estimation of spatial maize price transmission processes between Tanzania and Kenya. *American Journal of Agricultural Economics* 91: 1432-1439.

Jaleta, M. and B. Gebermedhin. 2012. Price cointegration analyses of food crop markets: the case of wheat and teff commodities in Northern Ethiopia. *African Journal of Agricultural Research* 7: 3643-3652.

Johansen, S. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12(3): 231-254.

Leybourne, S. and P. Newbold. 2003. Spurious rejections by cointegration tests induced by structural breaks. *Applied Economics* 35(9): 1117-1121.

MacKinnon, J.G. 1991. *Critical values for cointegration tests in long-run economic relationships*. Oxford University Press, Oxford, UK, pp. 267-276.

Meyer, J. and S. Von Cramon-Taubadel. 2004. Asymmetric price transmission: a survey. *Journal of Agricultural Economics* 55: 581-611.

Minten, B., D. Stifel and S. Tamiru. 2012. S*tructural transformation in Ethiopia: evidence from cereal markets*. Ethiopia Strategy Support Program II Working paper 39, Addis Ababa, Ethiopia.

Negassa, A. and J.R. Myers. 2007. Estimating policy effects on spatial market efficiency: an extension to the Parity Bound model. *American Journal of Agricultural Economics* 89: 338-352.

Ngare, L.W., S.K. Wambugu, J.M. Nzuma and C. Shisanya. 2013. Asymmetric price transmission in food markets in the highlands of central Kenya. Paper presented at the 4th International Conference of the African Association of Agricultural Economists. September 22-25, 2013. Hammamet, Tunisia.

Nogales, E.G. and J. Fonseca. 2014. *Institutional procurement of staples from smallholders: the case of purchase for progress in Ethiopia*. FAO, Rome, Italy.

Perron, P. 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica* 57: 1361-1401.

Rafailidis, P. and C. Katrakilidis. 2014. The relationship between oil prices and stock prices: a non-linear asymmetric cointegration approach. *Applied Financial Economics* 24: 793-800.

Rashid, S. and N. Minot. 2010. Are staple food markets in Africa efficient? Spatial price analyses and beyond. Paper presented at the Comesa policy seminar ‘Food price variability: causes, consequences, and policy option’. January 25-26, 2010, Maputo, Mozambique.

Rashid, S., N. Tefera, N. Minot and G. Ayele. 2013. *Fertiliser in Ethiopia: an assessment of policies, value chain, and profitability*. IFPRI discussion paper No. 01304, International Food Policy Research Institute, Washington, DC, USA.

Rapsomanikis, G., D. Hallam and P. Conforti. 2003. *Market integration and price transmission in selected food and cash crop markets of developing countries: review and applications in commodity market review*. FAO, Rome, Italy.

Saikkonen, P. 1991. Asymptotically efficient estimation of cointegration regressions. *Econometric Theory* 7: 1-21.

Stock, J.H and M.W. Watson. 1993. A simple estimate of cointegrating vector in higher ordered integrated systems. *Econometrica* 61: 783-820.

Tamru, S. 2013. *Spatial integration of cereal markets in Ethiopia. Ethiopia Strategy Support Program II*. ESSP working paper No. 56. International Food Policy Research Institute, Washington, DC, USA

Toda, H.Y. and T. Yamamoto. 1995. Statistical inference in vector auto-regressions with partially integrated processes. *Journal of Econometrics* 66: 225-250.

Ulimwengu, J.M., S. Workneh and Z. Paulos. 2009. *Impact of soaring food price in Ethiopia: does location matter?* International Food Policy Research Institute, Washington, DC, USA.

Usman, M.A. and M.G. Haile. 2017. Producer to retail price transmission in cereal markets in Ethiopia. *Food Security* 9: 815-829.

Von Cramon-Taubadel, S. and S. Fahlbusch. 1996. *Estimating asymmetric price transmission with the error correction representation: an application to the German pork market*. University of Kiel, Department of Agricultural Economics, Kiel, Germany.

Von Cramon-Taubadel, S. 1998. Estimating asymmetric price transmission with the error correction representation: an application to the German pork market. *European Review of Agricultural Economics* 25: 1-18.

Wondemu, K. 2015. Price transmission asymmetry in spatial grain markets in Ethiopia. *African Development Review* 27: 106-116.

Worako, T.K., H.D. Van Schalkwyk, Z.G. Alemu and G. Ayele. 2008. Producer price and price transmission in a deregulated Ethiopian coffee market. *Agrekon* 47: 492-508.

World Food Programme (WFP). 1989. *Rehabilitation of forest, grazing, and agricultural lands.* World Food Programme, Addis Ababa, Ethiopia.

Yami, M., F. Meyer and R. Hassan. 2017. Testing price leadership in major regional maize markets in Ethiopia: implications for targeted market intervention. *Agrekon* 56: 97-109.

Zapata, H.O. and A.N. Rambaldi. 1997. Monte Carlo evidence on cointegration and causation. *Oxford Bulletin of Economics and Statistics* 59: 285-298.