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Abstract

This paper investigates the integration of the Ethiopian grain market to the world market; and within country grain markets integration. To this end, two cereal crop markets: wheat and maize, have been investigated. For maize the integration into the world market is analyzed using the US and SAFEX exchange markets as a world market; for wheat Paris and Chicago exchange markets are considered a wheat world market. The analysis has been conducted using a cointegration method: Johansen (1988) procedure. The results show that the Ethiopian grain market is integrated into the world market, albeit to the once geographically proximate to it. And further, we found that the elasticity of the price pass through between the world and domestic markets has appeared to be more than unitary when evaluated at the mean prices of the two food crops.

The analysis of domestic market integration is conducted using principal component analysis (PCA). The result shows that both wheat and maize markets are fairly integrated. However, the results demonstrate that in wheat market, of the traditionally known deficit markets Mekelle has shown an improvement in integration as its mean prices and price variability appear to be in line with the central market, but the maize market result has preserved the deficit market status. In the other deficit market, Dire Dawa, the mean prices of wheat and maize appear to be higher and more volatile than the central market. The other most striking result is that despite huge infrastructural improvement markets further from the central market exhibit higher level of price volatility than markets within a 300km distance from the central market, Addis Ababa. It has also been observed that the price differential between the central market and other local markets has shown a declining trend over time, and found to be stationary. This implies that the markets are more likely to converge in the long run, provided the market infrastructure continues to develop so as to reduce market information asymmetry that we believe has contributed to differences in price differentials and price volatility across markets

Key words: world market, domestic market, Price transmission, market integration , cointegration, PCA

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1. Background

Global food prices increased sharply in recent years. However, there is no consensus on whether the recent global food price volatilities are new phenomenon. Gilbert and Morgan (2010) argue that the increased volatility of recent years is lower than it was three decades ago. Be that as it may, the increased food prices of recent years posed significant policy challenges for developing countries where households spend a larger share of their income on food. The world has witnessed large fluctuations in food prices which is attributable to many factors. The increasing risk and uncertainty that volatility poses in production and investment decisions would have substantial implications for the food insecure and/or the poor in developing countries. However, it has been observed that global food price volatility would also have an impact on those who spend a fraction of their income on food.

Thus, understanding the food price dynamics and its volatility is essential in designing policy responses. Transmission of food price shocks to domestic markets depends on the importance of the commodity in the country`s food staple, food status of the country, domestic factors, and policies. These factors confounding in many different ways limit the pass through of global food price inflation to domestic markets.

The evidence on the degree of world price transmission to domestic markets has been mixed. Hazel et al (1990), using data from 22 developing countries over the 1961-87 period, found that while the variability in world prices has been almost entirely transmitted to developing countries in the dollar value of their export unit values, it has not been fully transmitted to average producer prices, thus concluding that in addition to trade restrictions, exchange rate misalignments or domestic distortions have been responsible for the discrepancy between domestic and world prices. Dawe (2008) has also shown that exchange rate appreciation has insulated complete price pass through in Asian countries. He used data spanning from 2003 to 2007 and examined the extent to which increases in international cereal prices have been transmitted to domestic prices in Asian countries. His findings concluded that the international food price transmission was generally incomplete in the Asian countries owing to the real appreciation of their currencies against the US dollar during the sample period which neutralized a considerable portion of the global price increases when these cereals were imported into domestic markets.

Mudlak and Larson (1992) in a study covering 58 countries for the 1968-78 period concluded that most of the variation in world prices is transmitted and that they constitute the dominant

component in the variation of domestic prices. Quiroz and Soto (1993), on the other hand, using a sample for 60 countries during 1966-91, concluded that in an overwhelming majority of cases, transmission of international price signals in agriculture is either very low or non existent. Morriset (1998) examined the gap between domestic and world prices for major markets for industrial countries during 1975-94 and found that while upward movement in world prices were clearly passed through in domestic prices, downward movements were not. It has also been shown that considerable differences exist between advanced and emerging countries. The findings indicate that the pass-through tends to be larger in emerging and developing countries (IMF, 2011). Conforti (2004) has shown that price pass through has been different in developing countries, for instance, incomplete in African countries, relatively more complete among Asian countries, and more mixed in Latin America.

The price pass through has also been indicated to be heterogeneous across commodity types. Dawe (2008) shows rice has a weaker pass through in developing Asia compared to wheat. Local policies on specific agricultural commodities, particularly rice from these Asian countries, seemed to have further stabilized and shielded domestic prices from the change in world prices. Having investigated the transmission of global price shocks to domestic prices in 11 sub-Saharan Africa countries for eight food items during 2007-2008, Minot (2011) finds that there is a transmission of global food prices to domestic prices for rice and (to a lesser extent) maize. By studying the price transmission of global agricultural commodities to domestic food prices in India and the People`s Republic of China (PRC), Imai et al (2008) also finds that domestic prices for wheat, maize and rice tend to adjust faster to the international prices than those of fruits and vegetables.

In general, various studies pointed the importance of domestic factors and policies in limiting the pass-through of food prices. The factors and possible limiting policy regimes highlighted include exchange rate movements, transaction costs, and subsidies for agricultural commodities among others (Quroz and Soto, 1995; Rapsomanikis et al., 2004; Timmer, 2008; Baffes and Gardner, 2003; Imai et al., 2008; Keats et al., 2010; Ianchovichina, et al., 2012; IMF, 2011).

In addition to the above studies, some studies particularly dealt with African countries and examined price pass through from world to domestic markets and also within price ass through among local markets in a country. For instance, Abdulai (2000) for Ghana, Rashid (2004) for Uganda, Lutz Kuiper and Van Tilburg (2006) for Benin, Negassa and Myers (2007) for Ethiopia, Van Campenhout (2007) for Tanzania. Myers (2008) for Malawi, Moser, Barret, and Minten (2009) for Madagascar, Rashid (2011) for Ethiopia.

This study particularly seeks to address two issues. Firstly, it investigates whether the domestic grain market prices read the international grain market prices. Secondly, it examines the within country integration of grain markets located in different regions across the country. To answer the first question, unlike previous studies that use US prices as the world price for both wheat and maize, we use two exchange market prices for each commodity against which we analyze the integration of Ethiopian grain market to the world market. That is, we use US maize and SAFEX maize prices as two world prices against which we examine the relationship of the Ethiopian maize market price; and for wheat, we use Paris milling wheat price and Chicago Board of Trade (CBOT) soft wheat price to investigate the relationship of the Ethiopian wheat market to these exchange markets. The national prices for both food items considered here are computed as an average of 11 and 10 local markets of wheat and maize, respectively.

The integration of these domestic markets is also analyzed. With regard to domestic market integration, previous studies use similar methods explained above. However, except Gilbert (2011) we have not seen studies that use principal component analysis to investigate the pattern of market integration in the form of the average prices that the different local markets have and the magnitude of variability exhibited across markets. In this study, we use principal component analysis on the price series that are found to be I (1) to demonstrate the long run characteristic of the markets. And further, we employ the principal component analysis of the monthly price changes which are found to be I (0), stationary, to explain the short run level of market integration.

The remaining sections of the paper are organized as follows: Section 2 data source and methodology used for the analysis of world to domestic market price pass through; section 3 results and discussion of world to domestic price pass through; section 4 intra-regional market integration; and section 5 concludes.

2. Data Source and Methodology

The data used for the analysis is obtained from various sources. The time series monthly price data of maize and wheat for 10 to 12 local markets are obtained from the Ethiopian Grain Trade Enterprise (EGTE) for the period from July 2001 to December 2011. The national prices of the two food crops considered here are computed from the price data of local markets. The descriptive statistics of the domestic prices are given in section (5.4.1).

The corresponding international market prices for maize and wheat are taken from the historical data of Johannesburg Stock Exchange (JSEX), Chicago Board of Trade (CBOT), Paris *Matif* and the International Financial Statistics (IFS) database. The descriptive statistics of national and international market prices are discussed below.

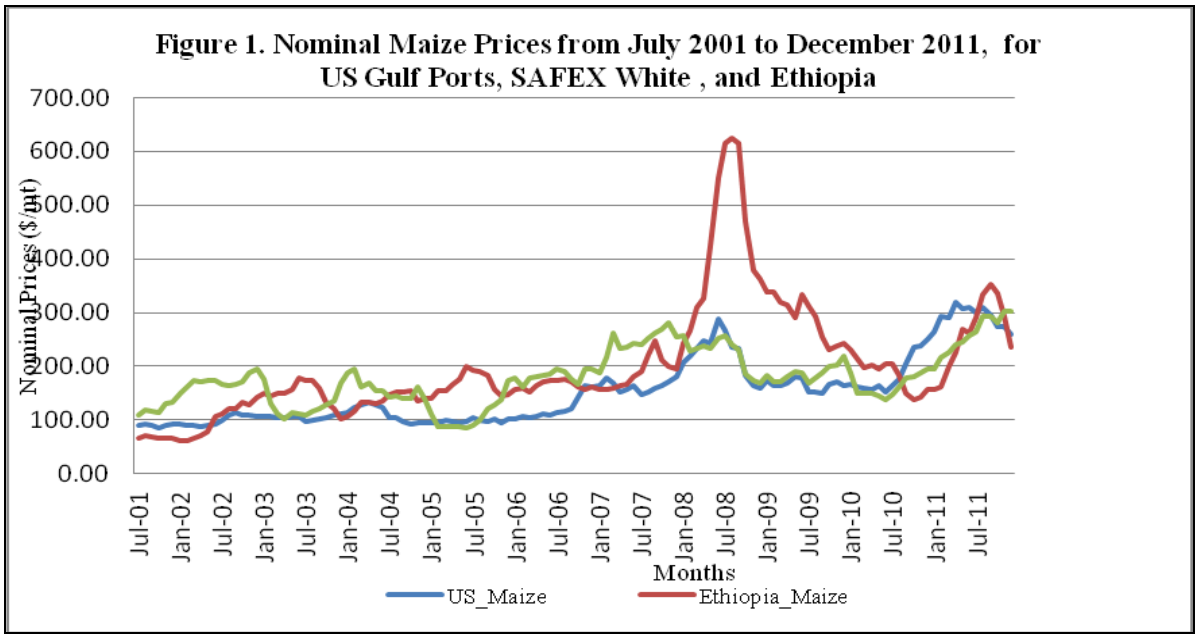
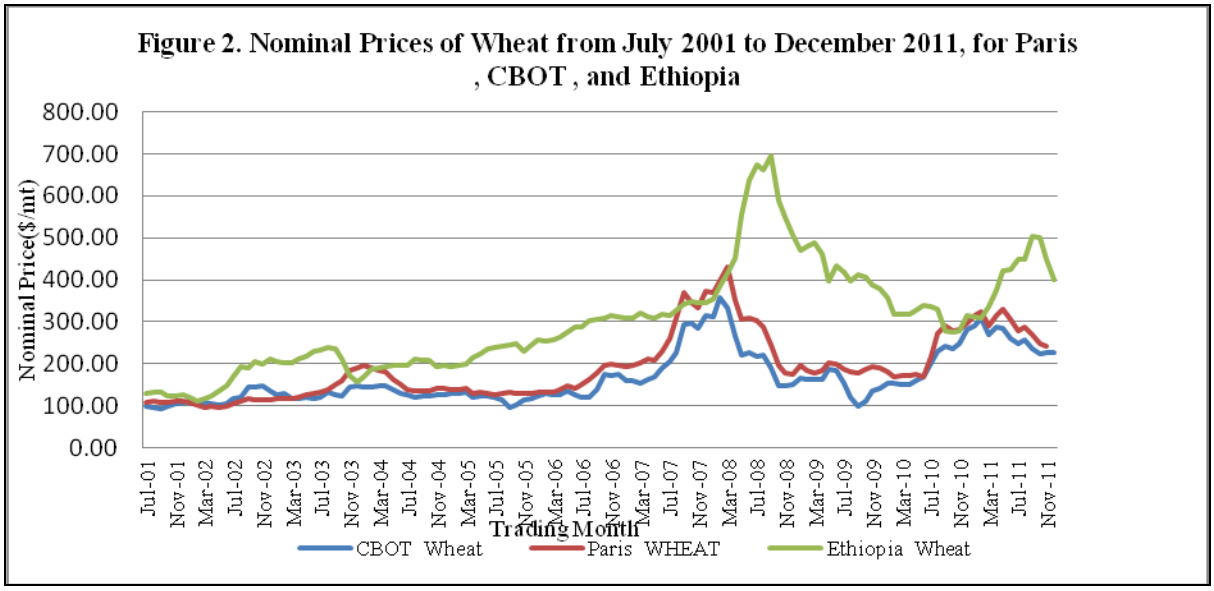


Figure 1 indicates that the Ethiopian maize prices were in tandem with the international price movements up until the beginning of 2008. However, the nominal maize prices rose sharply and exceeded all the international market prices between January 2008 and August 2010. Since August 2010 national prices, though rose up gradually, remained well below the US and the SAFEX maize prices.

When we examine the quarterly changes of maize prices (not reported here), we observe that national prices in the second quarter of 2002 have sharply increased up until the last quarter of 2003. The price increases had been occurring despite the decreasing trends in the international maize market. Mainly because, in 2002 *meher* rain did not come on time and hence grain prices went up following the drought that occurred in 2002/2003. Again since the first quarter of 2008 national maize price increased consistently and registered the highest increase in the second quarter of 2008, showing an increase of about 60 percent of the already high prices experienced at the end of 2007. The price levels in the last quarter of 2011 have remained well above the last quarter of 2007 by as much as 43 percent, 57 percent, and 10 percent, for national, US Gulf port , and SAFEX maize, respectively.



With regard to the wheat price, we observe that the national wheat price has been consistently above the international market prices. The sharp increase in national prices has followed the 2007 and 2008 food price hikes, and spiked to an unprecedented level as high as USD 646 per metric ton. Since then the national price has exceeded the international market prices by far up until it converges for a brief period in 2010 and start diverging once again.

The national price hikes, though they coincide with the international boom and bust of grain prices in the world market that occurred in 2007-2008 and later in 2011, could also be attributed to the overall macroeconomic performance of the country. Because the country has registered a consecutive double digit growth since 2006, and inflation has also risen to the level as high as 64 percent, in July 2008, and in particular the food price inflation peaked at 92 percent. For this reason, we remove such a bias from the national prices deflating the nominal prices by the CPI over the entire period considered in the study. The international prices are deflated using the unit value of exports for advanced countries. The unit value of exports is used as a deflator since it measures inflation in the international market. We have not opted for deflating all prices converted to their dollar equivalent using the CPI of USA (as in Minot, 2011), for the consumption basket considered in calculating the CPI for US consumers is considerably different from the consumption basket considered in calculating the Ethiopian consumers.

Table 1. Maize and Wheat Price Changes 2001 to 2011

	Percentage change Jul- 2001 to Dec-2011		Percentage Range over the same Period		Standard Deviation of Monthly changes	
	Nominal	**Real**	**Nominal**	**Real**	**Nominal**	**Real**
Maize						
US Gulf Ports	184.8%	83.2%	269.4%	165.2%	6.42%	6.04%
SAFEX White	174.5%	76.6%	250.3%	185.0%	8.86%	8.48%
Ethiopia	258.8%	-23.2%	924.7%	378.6%	9.96%	8.72%
Wheat						
CBOT	132.1%	49.32%	278.5%	242.7%	8.86%	8.90%
Paris	121.8%	42.71%	345.4%	186.9%	7.20%	6.83%
Ethiopia	207.6%	-34.19%	519.7%	170.0%	6.51%	5.54%

Table 1 provides price changes, range, and standard deviation over the entire period considered in this study. Maize prices have substantially increased over the entire period both in the national and international markets. However, the increase in the national nominal price exceeds the increase in international markets nearly by 40 percent. Despite the huge increase in the nominal price, the Ehiopian real maize price dropped by around 23 percent, while the Safex and US real maize prices showed an increase of 77 percent and 83 percent, respectively. The range measures the extent of the price spike while the change in range measures the long run impact. The nominal price range of Ethiopian maize appears to be more than three times as large as the world market price range, implying that Ethiopia experiences huge price hikes due to local factors such as the high inflation rate, which has already been in a double digit mark before the onset of the crisis and later reached the unprecedentedly high level, confounded with the global food crisis that occurred between 2005 and 2008, and later in 2011.

Maize price variability in Ethiopia has not been much different from the world market price variability. Both nominal and real prices considered, price variability in Ethiopia is closer to the Safex price variability than the US gulf port maize price.

Nominal wheat prices have also increased over time in all markets. The increase in domestic nominal price appeared to be twice as large as the increase in the nominal world market prices. As has been the case for Maize, real wheat prices increased in he international market by 49 percent for CBOT and 43 percent for Paris milling wheat, while the Ethiopian real wheat price dropped by 34 percent.

The nominal price hikes appear to be higher both at the international and national markets; however, the nominal price of the Ethiopian wheat has shown a change in the price range that is 87 percent and 50 percent higher than CBOT and Paris, respectively. This implies that in nominal terms the domestic price spikes in wheat market are higher when compared to the price hikes in the international market. Nonetheless, the price spikes in the domestic wheat market appear to be lower than that of the maize market. This is because the price stabilization interventions of the government largely focus on wheat than maize. The government has imported wheat and supplied at a subsidized price which is below the market price by about 50 percent.

The price variability provided by the monthly changes shows that both nominal real prices are less variable in domestic market than the international markets indicating that the price stabilization interventions have effectively insulated the wheat market from the international market fluctuations.

2.1. Methodology

The study of price transmission for homogeneous commodities in space, or for a product as it is transformed along the stages of the marketing chain has attracted the interests of agricultural economists for many decades.

Fackler and Goodwin (2001) provides a review of methods and empirical studies of price transmission and indicate that at the beginning empirical studies of price transmission used simple regression and correlation analyses (Isard, 1977; Monke and Petzel, 1984; Mudlak and Larson, 1992; Gardner and Brooks, 1994) that did not account for the dynamics and lead/lag relationships in price data. Throughout the 1980s these methods were replaced by dynamic regression models that incorporated lagged prices (Ravallion, 1986; Timmer, 1987) and studies based on the concept of Granger Causality (Mendoza and Rosegrant, 1995).

Simple correlation and regression analyses have been found implausible as they result in spurious results. This is because with the non-stationary nature of price data using simple regression and correlation violates the basic assumptions that an unbiased regression analysis must conform to. The fundamental theses in the co-integration approach, thus, cautions that before undertaking a regression analysis one must test whether the non-stationary price data are not only correlated with one another but are *co-integrated*. If two non-stationary price series are co-integrated, it means that there exists a linear combination of the non- stationary

series that is stationary and that the series share a common form of non-stationarity, and hence cannot drift apart indefinitely.

After Ardeni`s (1989) paper on price transmission on agricultural markets, the entire literature, except the few that use parity bounds model, literature on price transmission uses cointegration methods. In this study we use the Johansen (1988) method as it provides an efficient estimate of the cointegrating vectors (β) and adjustment parameters (α). The Johansen procedure is advantageous over the traditional techniques such as like Engle and Granger (1987), Engle and Yoo (1991), in the following points (Gilbert, 2011):

i) It enables one to determine the number of existing cointegrating relationships among the variables based on the data;
ii) It distinguishes short run adjustment parameters from long-run (equilibrium) outcomes;
iii) It doesn`t restrict the equilibrium outcome to be unity
iv) It provides a possibility of symmetrical adjustment of national to world prices using reverse pass-through from former to the later.

Thus due to these merits, we use the Johansen procedure to identify whether the Ethiopian maize and wheat markets are integrated into the world market. Before proceeding with the test for cointegration we investigate the time series properties of the price series to verify that the price variables are non-stationary with the same order, I (1). The non-stationarity of the price series is detected using Augmented Dicky-Fuller (ADF) method (Dickey and Fuller, 1981)[2]. The ADF is conducted with and without trend. Table 2 reports the test results.

[2] The ADF is based on the following regression: $(x_t - x_{t-1}) = \mu + \beta x_{t-1} + lags(x_t - x_{t-1}) + \varepsilon_t$, where x_t denotes the price series under consideration. A negative and significantly different from zero value of β indicates x_t is *I(0)*.

Table 2. Time series properties of nominal and real prices of maize and wheat

		ADF Statistics without Trend		ADF Statistics with Trend	
Markets	**Lag**	**Nominal**	**Real**	**Nominal**	**Real**
Maize US	3	-1.798	-1.664	-3.407	-2.845
	2	-1.440	-1.365	-2.856	-2.478
	1	-1.060	-1.138	-2.320	-2.202
	0	**-0.694**	**-0.9161**	**-1.864**	**-1.946**
SAFEX	3	-1.667	-2.623	-2.380	-2.673
	2	-1.605	-2.486	-2.285	-2.538
	1	-1.651	-2.494	-2.316	-2.546
	0	**-1.104**	**-1.768**	**-1.715**	**-1.833**
MAIZE ETH	3	-2.455	-2.129	-2.689	-2.544
	2	-2.871	-2.466	-3.179	-2.877
	1	-3.059	-2.319	-3.365	-2.738
	0	-1.732	-1.451	-1.687	-1.958
WHEAT ETH	3	-2.149	-1.216	-2.711	-1.931
	2	-2.224	-1.194	-2.776	-1.933
	1	-1.975	-1.09	-2.405	-1.862
	0	**-1.441**	**-0.7884**	**-1.548**	**-1.651**
PARIS	3	-1.959	-2.178	-2.375	-2.369
	2	-1.572	-1.731	-1.782	-1.839
	1	-1.802	-2.034	-2.112	-2.189
	0	-1.281	-1.341	-1.315	-1.365
CBOT	3	-1.977	-2.563	-2.652	-2.888
	2	-2.004	-2.604	-2.653	-2.912
	1	-2.106	-2.704	-2.757	-3.003
	0	**-1.593**	**-2.096**	**-2.021**	**-2.29**

* The Critical value of the ADF test without trend and with trend at 5% is -2.89 and -3.45, respectively.

The results show that all prices non-stationary both in their nominal and real forms. After identifying that the price series are non-stationary, I (1), we run a cointegration test to learn that whether a linear combination of any two or three non stationary price series for each commodities exist. If it exists, the prices are said to be cointegrated and are likely that the two price series share common forms of non-stationarity implying that the pair cannot drift apart indefinitely. We used the Johansen procedure due to the merits mentioned above and the results are reported in table 3.

Table 3. Statistical Properties of Wheat and Maize Price Series, July 2001 to December 2011

	Trace Statistics of Cointegrated rank			Implied # of Cointegrating Vectors
	r=0	***r≤1***	***r≤2***	
Wheat				
CBOT &Paris	12.77 (0.124)	4.56 (0.033)		1
CBOT&Ethiopia	7.18 (0.563)	1.07 (0.302)		No
Paris &Ethiopia	12.48 (0.136)	4.02 (0.045)		1
CBOT, Paris, &Ethiopia	24.0 (0.026)	12.47 (0.137)	3.21 (0.073)	2*
Maize				
US &SAFEX	10.98 (0.217)	1.13 (0.288)		No
US&Ethiopia	13.26 (0.105)	0.379 (0.538)		No
SAFEX & Ethiopia	14.22 (0.076)	4.62 (0.032)		1
US, SAFEX, & Ethiopia	25.64 (0.144)	10.66 (0.237)	0.691 (0.406)	No

*Cointegration is tested using Johansen procedure. The reported statistics are test of $\Gamma(\alpha\beta^{`}) \le r$, $(r = 0,1,2)$. Tail probabilities are provided in "(..)" parentheses.

A bivariate cointegration test is conducted for the two exchange prices, US and SAFEX, for maize; and Chicago and Paris for wheat. We also conducted a bivariate cointegration test of the exchange prices with the domestic prices (US Maize price with Ethiopian Maize, SAFEX maize with Ethiopian Maize; and similar combinations of Wheat Exchange prices with Domestic price). The result provided in Table 3 shows that the two wheat world prices (exchange prices) are cointegrated with one cointegrating vector; Chicago and Ethiopian not cointegrated; and Paris and Ethiopian with one cointegrating vector. The trivariate cointegration test for wheat prices implied cointegration among the world and domestic prices with two cointegrating vectors at a significance level of 10 percent?.

Unlike the wheat market, the exchange prices of maize, US and SAFEX, have shown no sign of cointegration. This result is contrary to Gilbert (2011). The difference between our result and Gilbert (2011) might be due to the difference in the sample period considered, as he tested cointegration for a period from January 2005 to December 2009 while in this study we considered an extended period that ranges from July 2001 to December 2011.

The cointegration test between US and Ethiopian maize prices has also shown no cointegration; but SAFEX and Ethiopian maize prices appear to be cointegrated. We failed to identify any form of cointegration among the three maize prices in trivariate VAR (3) setting.

3. World Market Price Transmission to Domestic Market

The results of the cointegration test of the Paris and Chicago wheat prices in a bivariate VAR (2) setting signify that the two markets are cointegrated. That is, we reject the no cointegration hypothesis, but failed to reject the hypothesis $\Gamma(\alpha\beta^{`}) \leq 1$ (see table 3), implying that there is one cointegrating vector. The estimated coefficients of the cointegrating vector are $\begin{pmatrix} \hat{\alpha}_{paris} \\ \hat{\alpha}_{chicago} \end{pmatrix} = \begin{pmatrix} 0.0036 \\ -0.0113 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.0038 \\ 0.0041 \end{pmatrix}$. The coefficient for Paris is not significantly different from zero; however, the coefficient for Chicago is three times higher than that of the Paris reaction coefficient and statistically significant implying that Chicago reacts to the price developments in Paris market. This may indicate that Chicago plays a leadership role in the wheat market. Normalizing the cointegrating vector, we fail to reject the hypothesis that this is a unit cointegrating vector ($\chi^2 = 2.62$ with *p-value*=11%) implying that in the long term the two exchange prices move together. The α-matrix of the unit cointegrating vector is given as follows: $\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Chicago} \end{pmatrix} = \begin{pmatrix} -0.0344 \\ 0.0184 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.0157 \\ 0.0173 \end{pmatrix}$.

In the case where a unit pass through is assumed Paris appears to react more to the changes in Chicago prices than that Chicago does to changes in a Paris price, and the reaction of Paris is nearly twice as large as that of Chicago and it is statistically significant.

In a bivariate setting we test the Chicago and Ethiopian wheat market cointegration and we have found that Chicago and Ethiopian Wheat markets are not cointegrated.

The cointegration test in a bivariate VAR(2) setting for Paris and Ethiopian wheat markets shows that the two markets are cointegrated. That is, we fail to reject the hypothesis that $\Gamma(\alpha\beta^{`}) \leq 1$ indicating that there is one cointegrating vector (See table 3).

The estimated coefficients of the cointegrating vector with no restrictions imposed are provided as follows:

$\beta = \begin{pmatrix} 1 \\ -0.027 \end{pmatrix}$, $\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.049 \\ -0.035 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.021 \\ 0.081 \end{pmatrix}$. The estimated coefficients indicate that the reaction of Paris to changes in the Ethiopian wheat market is greater than the reaction of the Ethiopian market to developments in Paris, and it is statistically significant.

We then imposed a unit pass through restriction and tested for its validity. The likelihood ratio test failed to reject the restriction that the cointegrating vector is a unit cointegrating vector ($\chi^2_{(1)} = 1.4$, with *p-value=24%*). The corresponding β and α matrix is

$\beta = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$, $\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.04 \\ -0.01 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.015 \\ 0.014 \end{pmatrix}$. The reaction from the Paris exchange market to disequilibrium is 4 times as large as the reaction from the Ethiopian market and implying that errors are corrected rapidly in Paris market than Ethiopia, and the coefficient is statistically significant. Subsequently, we tested whether the two markets individually react to the disequilibrium (weak exogeneity). Firstly, we assumed that the Ethiopian market does not react to changes in the Paris exchange prices, i.e., $\alpha_{Eth} = 0$. Secondly, we suppose the Paris exchange market does not react to the changes in the Ethiopian domestic wheat prices, $\alpha_{Paris} = 0$. We failed to reject the restriction that the Ethiopian wheat market does not react to the changes in Paris exchange prices ($\chi^2_{(1)} = 2$, with *p-value=16%*).

$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.047 \\ 0.000 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.018 \\ 0.000 \end{pmatrix}$

However, we reject the hypothesis that Paris exchange prices don`t react to changes in Ethiopia wheat prices ($\chi^2_{(1)} = 3$, with *p-value=8%*).

$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.031 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.000 \\ 0.013 \end{pmatrix}$.

The weak exogeneity restrictions applied together with the unit pass through assumption also produce an identical relationship with the above results.

$\chi^2_{(2)} = 8.3$, $\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.04 \\ 0.00 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.015 \\ 0.000 \end{pmatrix}$, LR test: $\chi^2_{(2)} = 2$, *p-value=36%*

$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ -0.006 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.000 \\ 0.013 \end{pmatrix}$, LR test: $\chi^2_{(2)} = 8.3$, *p-value=1.5%*

The implications of the weak exogeneity test are that the Ethiopian wheat market does not react to changes in the prices of Paris milling wheat whereas the Paris milling wheat prices react to changes in the Ethiopian wheat market. This seems to be against the conventional " small country" assumption that would characterize the Ethiopian wheat market in an international context. However, we could argue that the contrary results can be attributed to two possible reasons. Firstly, when we look at the trend of wheat import to Ethiopia, we see that the wheat import has shown a significant growth in the period between 2001 to 2011 than between 1991 to 2000, 10 percent and 17 percent, respectively. The average annual import has been 688 thousand and 662 thousand metric tonnes per annum during the two periods, respectively, showing a 4 percent difference between the periods on per annum average import and a 14 percent increase in the total amount of wheat imported[3].

The involvement of private traders on wheat import business is virtually nil, despite the liberalization measures adopted by the incumbent government after its coming into power in 1991. As a result, the import of wheat apart from wheat imported in the form of food aid has been entirely procured by the Ethiopian government. Government procurement deals over the years have shown that almost all the purchases have been made from suppliers in Europe and supplied at the Black sea port. Since the Ethiopian government announces wheat procurement bids based on local developments such as production and supply to the local market, it is reasonable to think that international suppliers who aim at taking part in the procurement bids may closely observe developments in the domestic market and foresee potential purchases that would be made by the Ethiopian government, whether it is panic or planned purchase. Hence, international wheat suppliers may reflect such signals from local developments in the exchange markets. Further, we can argue that based on drought situations and local emergency food requirements donor agencies and/or countries appear in the exchange markets or make purchases from international suppliers who are believed to be market players in the exchange market. Both purchase needs to occur either together or separately

[3] The result calculated from FAOSTAT wheat import data provides slightly different results. It shows on average Ethiopia has imported 0.5 million meteric tonnes of wheat between the years 1993-2000 and more than double of this figure (1.03 million metric tonnes) between the years 2001-2010. The share of the total quantity imported is 4 percent out o the total imported to Africa, and 28 percent out of the total imported to East Africa between the years 2001-2010 (Here East Africa according FAO`s regional mapping constituted 19 countries). The result, however, does show no significant difference when the share is computed considering Burundi, Djbouti, Eriteria, Ethiopia, Kenya, Uganda, and Tanzania as an East African group. The share only jumped to 29 percent.

may imply that developments in local wheat market situations are likely to be read by international wheat suppliers and hence we hardly rule out the possibility that Ethiopian wheat market situations could indirectly influence exchange market prices.

On the contrary, the second reason dwells upon explaining the absence of reaction from the side of local markets to international wheat market developments. Lack of market information infrastructure and system is one of the culprits that immediately come to one`s mind in an effort to justify why Ethiopian markets are isolated from international markets. However, it is crystal clear that Ethiopia is a net importer of wheat and other grains and the local marketable surplus out of total production is not more than 30 percent. Therefore, it is counter intuitive to anticipate a supply response from the Ethiopian wheat market to international market price developments, even with the assumption of complete access for international market information.

Besides this, even if they understand that the import parity prices is below domestic prices implying the profitability of importing wheat and selling at the domestic market, local traders cannot import and sale wheat on the domestic market due to several problems that include lack of access for foreign exchange; however, there is no legal restriction put in place preventing importing wheat. As a result, local traders merely closely watch the actions of the government, for it either uses its stock reserve or import and sale at a subsidized price with an objective of local price stabilization. This compels local traders to focus on domestic developments per se than keep abreast of international market developments. And further, we argue that the introduction of local food aid purchase scheme since 1996[4] may have changed the price formation in the Ethiopian grain market. Local food aid purchase between 1996 and 2004 has accounted for on average nearly 12 percent of the total marketed surplus of cereals, which ranges from 28 to 30 percent Walker and Wandschneider (2005). Therefore, it is reasonable to believe that such local food aid purchases by different aid and humanitarian agencies including WFP, EURONAID, GTZ, Save the Children, and other agencies working in the humanitarian aid program possibly influence local price levels and draw the attention

[4] In 1996, in response to Government appeals to donors, the European Commission initiated a local procurement program. In subsequent years a more widespread program has been introduced with the following objectives: a) to procure food aid locally/ regionally as part of a more general policy support linking food aid with market development; b) to improve food aid targeting through diversifying grain types; c) to support domestic prices during years of good harvest in order to provide production incentives to farmers; d) to encourage entry and expansion of the domestic grain trade by familiarizing farmers with more formal contract arrangements and help food aid activities into the broader domestic grain marketing. However, Walker ad Wandschneider (2005) question the contribution of the procurement scheme with regard to its objective of helping the development of agricultural markets to be more formal.

of local traders to follow their actions and procurement needs than adhering to the developments of the international market for which they are incapable to react[5].

Next we add the Ethiopian prices to the world market prices and test for cointegration in trivariate setting VAR (3). The result shows that there are two cointegrating vectors, $\Gamma(\alpha\beta^{`}) = 2$, at the 10 percent level of significance. As explained above the integration of the Ethiopian market is established indirectly in contrast to its limited openness to the world market.

From the study of the Paris and Chicago wheat prices we have seen that they are cointegrated with a unit cointegrating vector, and hence we can proceed with the restriction that

$\beta_1 = \begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$ and we further consider that the two markets will have an equal effect on the Ethiopian wheat market, we restrict $\beta_2 = \begin{pmatrix} \frac{1}{2} \\ \frac{1}{2} \\ -1 \end{pmatrix}$, here Chicago is allowed to have an equal impact as that of Paris prices on the Ethiopian market. However, as we have indicated above the bivariate cointegration test of Chicago and Ethiopian wheat market indicated the two markets are not cointegrated. For this reason, we relax the equal impact assumption in a subsequent discussion.

We further impose a "small country" assumptions on the α-matrix showing that Ethiopia may not affect the world market prices in both exchange markets. That is, we restrict $\alpha_{21} = 0$ and $\alpha_{22} = 0$ hypothesizing that the Ethiopian price does not impact the Paris and Chicago wheat exchange prices. The estimated α-matrix is

$\begin{pmatrix} \hat{\alpha}_{Paris} \\ \hat{\alpha}_{Chicago} \\ \hat{\alpha}_{Ethiopia} \end{pmatrix} = \begin{pmatrix} -0.037 & 0.000 \\ 0.016 & 0.000 \\ 0.000 & 0.005 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.016 & 0.000 \\ 0.018 & 0.000 \\ 0.000 & 0.017 \end{pmatrix}$. However, the log likelihood ratio test rejected the restrictions ($\chi^2_{(5)} = 14.87$ with p-value=1%). Though we observe that Paris reacts more than Chicago to deviations from equilibrium, we reject the hypothesis that the two markets are independent of one another. The result in here confirms

[5] Over the years between 1996 and 2004 locally procured food aid (proxied by local purchases of cereals for food aid purpose) accounted for 25 percent of total relief food aid imported.

our result that we established in a bivariate cointegration test of the Ethiopian and Paris prices as we rejected the hypothesis that exchange markets do not react to the developments in the Ethiopian wheat market.

For the maize market we analyze US maize price, SAFEX white maize spot price and Ethiopian maize price. First we check the cointegration of the two exchange markets: US and SAFEX. The bivariate cointegration VAR (2) shows that the two markets are not cointegrated, as we fail to reject $\Gamma(\alpha\beta^{`}) = 0$ (see table 2).

We also conducted a bivariate cointegration test on each of the two exchange prices with the Ethiopian maize prices. The results show that the US maize price is not cointegrated with the Ethiopian price whereas SAFEX price does. Thus in the following we look in detail the cointegration relation between the SAFEX and the Ethiopian maize prices. As we can see from the table (2), that the two markets are cointegrated with one cointegrating vector, $\Gamma(\alpha\beta') = 1$ providing a one dimensional space where the cointegrating vector is positioned. The coefficients estimated with no restriction are as follows:

$\begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.065 \\ -0.023 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.023 \\ 0.021 \end{pmatrix}$. The SAFEX coefficient is significantly different from zero implying that only SAFEX reacts to changes in price disequilibrium, and the coefficient of the SAFEX is three times as large as the Ethiopian.

We have also tested whether the cointegrating vector is a unit cointegrating vector, but we reject the unit cointegrating vector hypothesis ($\chi^2_{(1)} = 4.8$, with *p-value=3%*) implying that in the long run the prices are not likely to read one another.

Next we investigated the weak exogeneity assumption imposed on the two markets. First, we employ the weak exogeneity test on both prices leaving the adjustment coefficients unrestricted. We first impose $\beta_1 = 0$, assuming that changes in SAFEX price does not depend on the price difference between SAFEX and the Ethiopian price. We failed to reject the hypothesis ($\chi^2_{(1)} = 2.15$ with *p-value=14%*) implying that SAFEX prices do not rely on the lagged difference between Ethiopian and SAFEX prices. In other words, much of the information that cause changes in the SAFEX prices emanate from its own previous year prices, and hence SAFEX tends to become an autoregressive series. We further added a restriction that SAFEX does not react to any price differences between its own and Ethiopian maize prices, i.e, $\alpha_{12} = 0$, and the hypothesis is weakly rejected ($\chi^2_{(2)} = 4.8$ with *p-value=9%*).

Nonetheless, we strongly reject the hypothesis ($\chi^2_{(2)} = 4.3$, with *p-value=4%*) when we leave out the restriction ($\beta_1 = 0$) and test the restriction on α separately. Thus we could confirm that SAFEX prices react to Ethiopian market prices when cointegration is any other than unitary.

Now we investigated the reaction of the Ethiopian maize market to the price differences between itself and SAFEX prices. The unit cointegrating vector hypothesis is rejected above. So let us suppose that $\beta_2 = 0$, implying the Ethiopian maize price changes does not carry any information from the price differences between itself and SAFEX prices. The test on the restriction is rejected ($\chi^2_{(1)} = 3.34$ with *p-value=7%*) implying that in the long term there is a possibility that the two prices relate and changes in Ethiopian maize market price consider the discrepancy between it and the SAFEX prices. Further, we impose the restriction that Ethiopian prices don`t react to changes in SAFEX prices, $\alpha_{12} = 0$. The result is that, we failed to reject the hypothesis ($\chi^2_{(2)} = 4.3$ with *p-value=12%*) implying that the Ethiopian market does react to price differences between itself and the SAFEX maize prices. This hypothesis ($\alpha_{12} = 0$) is also rejected when we leave out the restriction on the cointegrating vector ($\chi^2_{(1)} = 0.66$ with *p-value=42%*) implying that the Ethiopian market does respond to the developments in SAFEX maize prices. The α coefficients and their standard errors for restrictions discussed above are given as follows :

1. For restrictions on the Ethiopian market

$$\beta_2 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.08 \\ 0.03 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.035 \\ 0.032 \end{pmatrix}$$

$$\beta_2 = 0,\ \alpha_2 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} -0.08 \\ 0.00 \end{pmatrix} \text{with standard errors } \begin{pmatrix} 0.035 \\ 0.000 \end{pmatrix}$$

$$\beta \text{-no restriction},\ \alpha_2 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.094 \\ 0.000 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.03 \\ 0.00 \end{pmatrix}$$

2. For restrictions on SAFEX

$$\beta_1 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.065 \\ 0.075 \end{pmatrix} \text{ with standard errors } \begin{pmatrix} 0.041 \\ 0.036 \end{pmatrix}$$

$\beta_1 = 0,\ \alpha_1 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.078 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.000 \\ 0.035 \end{pmatrix}$

β -no restriction, $\alpha_1 = 0,\ \begin{pmatrix} \hat{\alpha}_{Safex} \\ \hat{\alpha}_{Eth} \end{pmatrix} = \begin{pmatrix} 0.000 \\ 0.035 \end{pmatrix}$ with standard errors $\begin{pmatrix} 0.000 \\ 0.015 \end{pmatrix}$

Adding the Ethiopian maize price to the cointegration test, we obtain no cointegration among the prices in trivariate VAR (3) setting (see table 2).

Summary of the Results

In this part we examined whether the Ethiopian wheat and maize markets are integrated into the world market. To this end, we investigated cointegration relations between the Ethiopian wheat market and two exchange wheat markets (Chicago and Paris); and the Ethiopian maize market and two exchange maize markets (US and SAFEX).

We summarize the main results that emerge from the analysis as follows:

- We found out that the Ethiopian wheat market is integrated into the world market as implied by its cointegration with the Paris wheat market; albeit this cointegration could not be directly evidenced by the reaction of the Ethiopian market to developments in Paris wheat market.

- Chicago exchange and Ethiopian wheat market have shown no cointegration. This may imply that the geographical proximity of Paris to Ethiopia than Chicago may have influenced the relation of the two markets. As provided in the discussion, Ethiopia imports most of its wheat from the Black sea and Mediterranean ports, thus, Ethiopia may prefer to look at Paris prices than Chicago.

- With regard to maize, the Ethiopian maize market is found to be integrated into the world market. As it is the case of wheat, geographically the nearest exchange market (SAFEX) appeared to be cointegrated with the Ethiopian maize market. While the US maize market does show no cointegration.

- Exchange markets in the case of wheat, Paris and Chicago, appear to be cointegrated while maize exchange markets, US and SAFEX, found to be not cointegrated.

4. Intra-Regional Food Market Analysis

4.1. Evolution of Cereal Marketing Policy

Since the Imperial regime cereal marketing policy has been put in place. The policies that have been adopted during the last three regimes, including the incumbent, fundamentally tailored to their ideological inclination.

During the Imperial regime, cereal markets were characterized by a high share of marketable surplus out of the total production, and very high transport costs due mainly to the minimal road networks and telecommunication services. The marketed surplus, which is indicated to be around 25-30 percent of the total production, however, is hardly a result of increased productivity. But it was sourced from the in kind rent and revenue paid by the renters to the church and the state. Government intervention during this period was through the Ethiopian Grain Board (EGB) established in 1950, later reformed and renamed the Ethiopian Grain Council (EGC) in 1960. Initially, the EGB was mandated to export licensing for oilseeds and pulses, quality control, supervision of marketing intelligence, and regulation of domestic sales.

The Grain Board reformed and renamed to Ethiopian Grain Council in 1960 as the Grain Board failed to achieve its objectives. The Grain Council was provided new roles and mandated to hold stocks, stabilize grain prices in urban areas, and improve the production of cereals, oilseeds and pulses for export. Yet again the Grain Council also ended up ineffective in achieving the objectives it was established for. Holemberg (1977) indicated that the policy interventions through the Grain Council did not contribute to the improvement in market integration, because the Grain Council focused its interventions in a limited number of production regions and urban areas, while disregarding larger parts of the country.

The Socialist regime that came to power in 1974, established Agricultural Marketing Corporation (AMC) in 1976, with the support from the World Bank. Through the corporation, it directly involved in wholesale and retail trade. The corporation was tasked with a range of activities which include handling almost all agricultural input and output markets. The corporation determines annual quotas that farmers and traders had to supply to the corporation at a fixed price which is far below market prices in most areas. It had put restrictions on private grain trade and interregional grain trade. As a result of these restrictions, rural incomes depressed; resources had transferred from rural households to a small group of urban households through artificially cheap prices; and consequently

depressed cereal production in Ethiopia over the years the restrictions were in place(Lirenso, 1995; Dercon, 1994; Franzel et al., 1989).

Cognizant of the setbacks that stem from the misguided cereal policy adhered, the Socialist government undertook major grain market policy reforms over the years since 1987 due mainly to increasing pressure from donors, worsening economic conditions, and political and economic policy changes in the great socialist blocks such as the USSR, and Eastern Europe. Hence as of March 1990, quota requirements abolished and movement restrictions lifted. Private traders were allowed to move grain across regions as long as they agreed to sell half of their supply to AMC again at a specified price (Franzel et al., 1989). These measures eliminated the AMC`s monopoly power and the socialist regime collapsed a year after.

Following the downfall of the socialist regime, the Agricultural Marketing Corporation has bee reorganized as a public enterprise known as the Ethiopian Grain Trade Enterprise (EGTE)The Transitional government instituted policies reorienting the country towards a market economy. For this reason, the EGTE allowed to operate in the market and compete with the private sector. In line with this, it has been given new roles: to stabilize prices both to encourage production and protect consumers from price shocks; to earn foreign exchange through grain exports to the world market; and to maintain strategic food reserves for disaster response and emergency food security operations.

The restructured enterprise has reduced grain marketing networks, fewer purchase and sales centres than the AMC. These factors juxtaposed to shortage of working capital that the EGTE encountered and under utilization of available resources made the enterprise fell short of expectations, especially in price stabilization (Lirenso, 1994).

In later years, an attempt has been made through a series of proclamations and regulations which gradually withdraw the EGTE from the price stabilization role and redirect its efforts towards export promotion, facilitating emergency food security reserves, and helping national disaster prevention and preparedness programs.

In the face of a series of regulations which require the EGTE to concentrate on issues other than price stabilization, the EGTE has been called on back to its price stabilization roles in two occasions. Firstly, following the 2000/1 and 2001/2 bumper produce of grain; secondly, to stabilize the food price spikes between 2005 to 2008, because, regardless of consecutive years of reported good harvest, prices of major cereals began rising sharply in late 2005 (Rashid and Lemma, 2010). The challenges that the enterprise has been dealing with were diametrically opposite. In the first instance, it was supposed to deal with the decline of maize prices by an unprecedented amount as large as 80 percent in early 2002, that occurred as a

result of increased maize productivity. Maize farming, thus, has become highly unprofitable, for the ratio of input to the producers` price has climbed from 1.7 in 2000 to about 9.0 in 2002, leading to a a fall in fertilizer application by about 22 percent in the following crop year. The implication of the incident was that the increase in productivity cannot simply translate into improvements in farmers` well-being.

The return to its stabilization role enabled the EGTE to procure 18000 metric tonnes of maize, of which it exported 11000 metric tonnes. Unfortunately, the bumper harvest could not be extended to the 2002 crop year due to both the delay in the 2002 *meher (main growing season)* rainfall, and decline in the application of modern inputs because of higher input-output price ratio which made using modern inputs unprofitable. Unsurprisingly, in the next year the country has faced a food security crisis which was averted through generous donor support and about 1 million metric tonnes of maize imported as food aid.

The incident of the 2000/1 and 2001/2 has been a showcase in that agricultural policy measures that aim to increase productivity and promote technology adoption can be sustained only when the marketing infrastructure is developed hand in hand with the improvement in productivity. As market infrastructure by itself can not result in desired outcomes, systems that aim to bring efficient marketing outcomes need to be put in place. This, in turn, may increase the share of the producers` price both in the wholesale and retail prices, and hence improve the welfare of the smallholder farmers that contribute more than 90 percent the food supply. In the following section, we explore the extent of physical infrastructure and market infrastructure development in terms of its impetus to food market integration in the country.

4.2. Infrastructure Development

The market mechanism works where the necessary and sufficient conditions for its operation are satisfied. That is, market functioning towards the desired objectives depends on the adequacy of both physical, informational , and institutional infrastructure. In a place where at least the physical infrastructure is virtually non-existent, as it was in the 1980s and early 1990s Ethiopia, there are likely to have been different prices across the country characterized by inter-regional price differentials, differing variability, and inefficient price formation. Poor infrastructure may also have contributed to the famines that occurred in mid 1980s and before. Since in times of drought, it was not possible to transport the surplus produce available in an unaffected area to the drought stricken areas due mainly to lack of infrastructure connecting the two places. For example, in the 1980s, more than 90 percent of

the country's population lived more than a 48 hour walk from a paved road (WFP, 1989); the government largely controlled transportation, telecommunication was thin, and mobile phone technology was non-existent. Up until 1991, the country had about 4109 kms of asphalt road, 9298 kms of gravel road, and about 5601kms of rural roads. The construction of all types of roads, especially rural roads, has been given due attention by the new government that came into power in 1991. As a result, total road networks increased by 29 percent before 2000. The rural road network grew by around 68 percent, gravel roads by around 23 percent, while asphalt road network fell by about 10 percent. During the later years, the construction new rural and gravel roads, upgrading existing gravel roads to asphalt roads, continued consistently. Between the years 2000 and 2011, total road network grew by about 39 percent. Of these asphalt roads increased by 6 percent, gravel roads by 14 percent, and rural roads by 21 percent showing that due attention has been given to connect rural areas to main all weather and asphalt roads thereby reducing the number of hours that someone has to walk to reach the main roads connecting towns or cities. The focus provided for the construction of rural roads is reasonable on account of the fact that Ethiopia is largely a rural country, where more than 80 percent of the population resides.

Information flow plays a significant role in the performance of markets. For this reason, increasing means of information flow and hence enhancing access for it is fundamental to achieve market efficiency or integration of markets across regions. Telecommunication service is one of the means by which market information could be transmitted between buyers and sellers, and prices possibly negotiated between trading partners. In the Ethiopian context, the virtue of telecommunication service with regard to market information flow has not been exploited until recently. For example, in 1991 the penetration rate of fixed lines in 1991 was 0.27 per 100 individuals, showing that telecommunication services were largely inaccessible during the Socialist regime. Mobile telephone service was not available until 1999.

Table 4. Road Network, Telephone Subscription, and Penetration Rate

	Road Network(km)				Telephone Subscription and Penetration Rate			
Year	Gravel	Asphalt	Rural	Total	Fixed Line	Fixed Line*	Mobile	Mobile*
Average 1993-1999	11.41	3.68	9.40	24.49	153.80	0.26	6.74	0.01
2000	12.25	3.82	15.48	31.55	231.95	0.35	17.76	0.03
2001	12.47	3.92	16.48	32.87	283.68	0.42	27.50	0.04
2002	12.56	4.05	16.68	33.29	353.82	0.51	50.37	0.07
2003	12.34	4.36	17.15	33.85	404.79	0.57	51.32	0.07
2004	13.91	4.64	17.96	36.51	484.37	0.67	155.53	0.21
2005	13.64	4.97	18.41	37.02	610.35	0.82	410.63	0.55
2006	14.31	5.00	20.16	39.47	725.05	0.95	866.70	1.14
2007	14.63	5.45	22.35	42.43	880.09	1.13	1208.50	1.55
2008	14.36	6.07	23.93	44.36	897.29	1.13	1954.53	2.46
2009	14.23	6.94	25.64	46.81	915.06	1.13	4051.70	4.99
2010	14.37	7.48	26.94	48.79	908.88	1.10	6854.00	8.26
2011	13.61	8.82	29.61	52.04	829.01	0.98	14126.66	16.67
Average 2000-2011	13.56	5.46	20.90	39.92	627.03	0.81	2481.27	3.01
Average 1993-2011	13.39	5.32	20.01	38.73	590.62	0.77	2290.92	2.77
Average Annual Growth (%)	1.59	7.66	11.00	6.69	16.05	12.38	97.10	92.50

Source: Data on Road Network (1993-2008) is taken from Shahidur and Asfaw (2011), and for the years 2009 to 2011 compiled from CSA Statistical Abstracts various years. Data on telephone subscription and penetration rate are obtained from UN Data/World Telecommunications/ICT database.

* The penetration rate is calculated by dividing the number of telephone subscriptions by the population and multiplying by 100

4.3. Analytical Approach

The integration of the domestic food markets is analyzed using a principal component analysis (PCA). PCA is fundamentally a dimension reduction technique. It may be used to estimate factor structure on the assumption that factors are uncorrelated and "specific" variances (i.e., those of the unexplained components are equal for all items considered. This is an exploratory statistical technique which specifies a linear factor structure between variables, and especially useful when the data under consideration are correlated. If the underlying data are un-correlated PCA will have little utility. In the sense of this paper, PCA is used to analyze the integration of regional market prices taking 10 to 12 cereal markets in Ethiopia. We consider two crops, maize and wheat.

The procedure for PCA begins with the raw price data of the above-mentioned cereals on *m* markets for *n* months. As we need all markets to have equal importance, we calculate the eigenvalues and eigenvectors using a correlation matrix. The size of the eigenvalues reflects

the percentage of the variance explained by each component. To calculate the amount that it explains, we sum up the value of all of the eigenvalues, and then divide each eigenvalue by the sum. Since we do the principal component analysis based on the correlation matrix, essentially the eigenvalues on the diagonal will sum up to 1 and hence we would expect any major factor would at least be able to generate its share of variance. The eigenvectors, on the other hand, are weights (regression coefficients) attached to each variable in the computation of each principal component.

The first principal component is a linear combination of the original variables $(m_1, m_2, ..., m_n)$:

$$PC_1 = \varphi_{11} m_1 + \varphi_{12} m_2 + ... + \varphi_{1n} m_n$$

that varies as much as possible for the individual markets, subject to the condition that the weights of the PC coefficient, *eigenvectors*, add up to one, i.e.,

$$\varphi_{11} + \varphi_{12} + ... + \varphi_{1n} = 1$$

Thus the variance of $PC_1, Var(PC_1)$, is as large as possible, provided the constraint on the constants. Likewise, for m-markets we will have *m*-principal components, where each consecutive component accounts for as much variation in the underlying data as possible, i.e.,

$$Var(PC_1) \geq Var(PC_2) \geq ..... \geq Var(PC_m)$$

Each principal component is uncorrelated with every other component. The lack of the correlation means that the indices are measuring different dimensions of the data, and hence the above principal component variance ordering, i.e., the eigenvalues of the principal components in descending order. The idea in the principal component analysis is that the variance of every new variable will be so low that most of the variation in the data will be explained by the first few *PC* variables. The number of the principal components to be retained in the analysis can be determined in two ways. Firstly, based on some theoretical knowledge of the subject of the study and desired objectives to be met, only a few of principal components that explain the majority of the variation underlying the data can be retained. This is done by observing the cumulative percentage explained. Secondly, using the time plot of eigenvalues ordered from the largest to the smallest, we examine the *scree plot* of eigenvalues. It helps in visually demonstrating the proportion of total variance each principal component accounts for, and that we can throw away the lower principal components without losing much explanatory power. That is, we look at for a point on the *scree plot* where the value of the eigenvalue drops dramatically and from that point on the remaining values have

nearly about the same size. That turning point will serve as a *cut-off* point to consider those principal components up till the kink.

Market integration analysis using PCA differs from the conventional cointegration analysis in that cointegration looks for long run relationships between different prices, while PCA, applied to price changes looks for short run co-movement between different prices. There can be considerable co-movement without cointegration but also cointegration with only limited short run co-movement. Applied to price levels PCA is closer to cointegration analysis but can give very different results if one price has much larger trend than another; this can dominate the first PCA without explaining much of the other series. For that reason, we conduct a PCA analysis on price changes so that we reduce the impact of the market price with larger trend, if any, and to demonstrate the short run co-movement of market prices.

The results from the principal component analysis are corroborated by examining the stationarity of the price spreads between the central market, Addis Ababa and other regional markets. This is because the stationarity of price spreads can be used to suggest that markets are efficient and integrated. The intuition behind the price spread stationarity is that price spread stationarity implies a market in which locations are, in the long run, both efficient and fully integrated. This means that the market equilibrates in the long run, as arbitrage opportunities exploited, and that shocks originating in one location are eventually transmitted fully to the other location. However, more contentious is the explanation that would emerge from non-stationarity of price spreads. It may imply that markets are in a long run disequilibrium situation. More likely it may imply integration is less than complete, either because markets are isolated or marginal adjustments occur. Thus, drawing conclusions about the extent of integration are difficult to justify using linear dynamic regression per se, either because a switching regime regression (before and after a certain factors which likely improve market integration have been introduced) is more appropriate. In brief, other tests such as like cointegration tests of spatial integration are heavily dependent upon assumptions which may, in most cases, be quite strong. These assumptions may pertain to transaction costs, which are assumed to be stationary or represented in an ad hoc simplistic manner.

For this reason, the investigation of market integration should not simply dwell upon analysis of whether prices are integrated. Exploratory results from the analysis of market integration based on price data provide an insight of revealed patterns of integration. This opens up an agenda for inferential analysis so that we examine what factors possibly impacted the observed market integration. Though we are well aware of the importance of analyzing the factors that contributed to the revealed market integration, we have not been able to go

beyond uncovering the patterns due mainly to lack of data on market infrastructure tailored to the market locations.

4.4. Results and Discussion

In the following we discuss the results obtained from the principal component analysis.

4.4.1. Wheat Market

In the analysis of wheat market integration, we use wholesale crop price data obtained from the Ethiopian Grain Trade Enterprise (EGTE) for the period July 2001 to December 2011 across 11 local markets namely: Addis Ababa, Ambo, Assela, Dire Dawa, Dessie, Gonder, Jimma, Mekelle, Nazereth, Robe, and Shashemene. Addis Ababa, the capital city of the country, is treated as a central market and all the other market prices compare against the central market.

Table 5. Summary Statistics of Nominal and Real Prices of Wheat in 11 Markets

Markets	Percentage Change July 2001 to December 2007		Percentage Range Over the same period		Standard Deviations of Monthly Changes		Mean		Standard Deviation	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
AA	313%	-37%	546%	184%	25%	21%	30.69	22.01	1297%	1660%
Ambo	395%	60%	684%	665%	27%	186%	27.03	16.83	1263%	1871%
Assela	416%	-24%	670%	187%	28%	29%	28.05	19.79	1280%	1598%
DD	202%	-44%	327%	372%	26%	73%	35.87	24.16	1349%	1961%
Dessie	173%	-39%	461%	335%	27%	45%	31.27	22.90	1287%	1753%
Gonder	320%	-39%	524%	476%	28%	136%	32.27	23.08	1386%	2077%
Jimma	165%	-35%	338%	168%	30%	20%	34.91	21.56	1332%	1639%
Mekelle	309%	-5%	530%	240%	23%	30%	30.16	17.11	1281%	1598%
Nazereth	440%	-27%	959%	226%	35%	75%	24.86	20.18	1257%	1691%
Robe	383%	-34%	607%	171%	26%	19%	28.73	21.50	1277%	1636%
Shash	309%	-34%	527%	171%	23%	19%	30.15	21.50	1279%	1636%
National	308%	-34%	520%	168%	23%	19%	30.12	21.47	1269%	1636%

Table 5 provides price changes, percentage range, standard deviation of monthly changes, average prices, and standard deviation of the monthly price series over the entire period considered in this study.

The nominal wheat prices have increased substantially in all markets. The increase in most of the markets, except Dire Dawa, Dessie, and Jimma, was well above the increase in the national price. The real wheat prices have fallen in all the markets over the period July, 2001 to December, 2011; however, Ambo exceptionally has shown an increase of about 60 percent. The range measures the the extent of price spikes, while the change in range

measures the long run impact. The percentage range in Ambo, Dire Dawa, Dessie, and Gonder have been above 300 percent, the largest being in Ambo. These markets have experienced a price spike that is 2 to 3 times as large as the price spikes of the rest of the markets. The price variability provided by the standard deviation of the monthly changes espouses the difference in price fluctuations across markets. Price variability in Ambo, Dire Dawa, Gonder, and Nazereth is more than twice as large as the variability in other markets. However, the average price over the entire period across markets has not shown substantial difference. Markets in Ambo and Dire Dawa have shown the smallest and largest average price, respectively. This is commensurate with the fact that traditionally Ambo is a surplus market and hence it is more likely to have lower average prices than other places whereas Dire Dawa is deficit market where prices , unless there exist interventions from the government, would be higher than the surplus markets and the central market by a substantial amount.

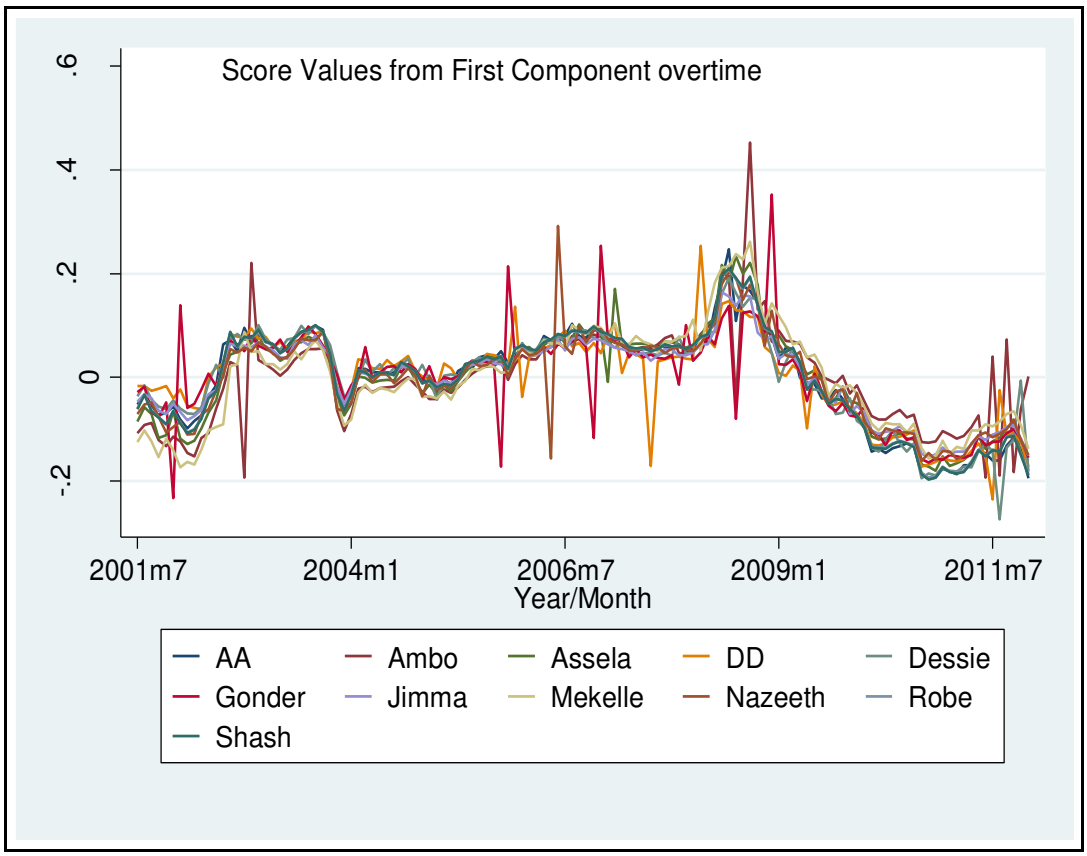
We conducted the PCA of the 11 wheat markets, and based on the scree plot and cumulative variation method, we retained two principal components. Because we found that the first two principal components explain more than 90 percent of the variation in the price data of the 11 markets.

Table 6. PCA Results of Wheat Market

Variable	**Comp1**	**Comp2**
AA	0.3139	-0.0573
Ambo	0.3084	-0.2496
Assela	0.3090	-0.2436
DD	0.2852	0.4302
Dessie	0.3023	0.2017
Gonder	0.3057	0.0397
Jimma	0.2492	0.6723
Mekelle	0.3165	-0.0386
Nazereth	0.2906	-0.4088
Robe	0.3126	-0.1605
Shash	0.3166	-0.0377
Eigenvalue	9.9264	0.7006
Proportion Explained	0.9024	0.0637
Cumulative Variation	0.9024	0.9661

The first principal component assigns nearly equal (positive) weights to all the markets. It, therefore, shows that there is a common component to price changes in all markets. We demonstrate this by plotting the score values obtained using the weights of the principal components and the standardized market prices of the markets. Figure(4) below shows that except Dire Dawa and Gonder the average prices of markets are moving together throughout the period under consideration.

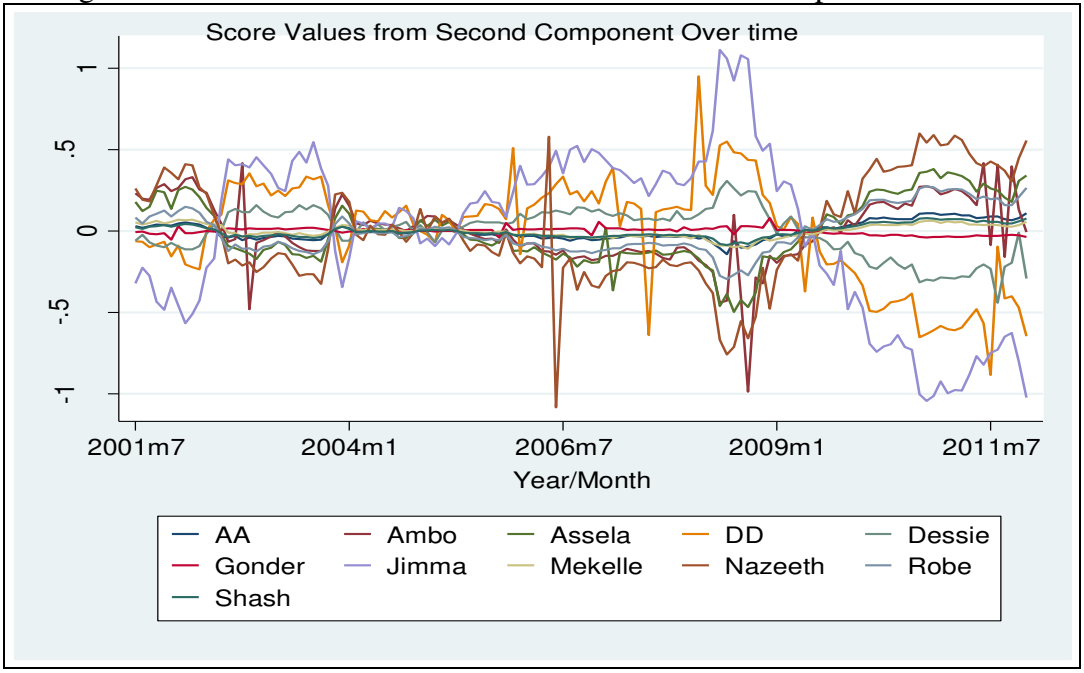
Figure 4. Score Values of Wheat Markets from First Component Overtime



The results from the second component provide more explanation on why the wheat prices of the two markets (Dire Dawa and Gonder) differ from the others. The second principal component helps us in categorizing markets in terms of the magnitude of price variability, as it provides patterns of price variability across markets. Though we find that the average price across markets is nearly the same, the second component elucidates that price variability across markets is different. We deduce from the results that there is a negative price variability correlation between markets located within the 300 km radius of the central market, Addis Ababa, and those located outside the 300km radius, except Mekelle. That is,

price variability within the 300 km radius is lower than price variability outside this radius implying that the further markets are located from the capital, or the central market, the more variable wheat prices become. Figure (5) provides the patterns of price variability over time.

Figure 5. Score Values of Wheat Market from Second Component Overtime

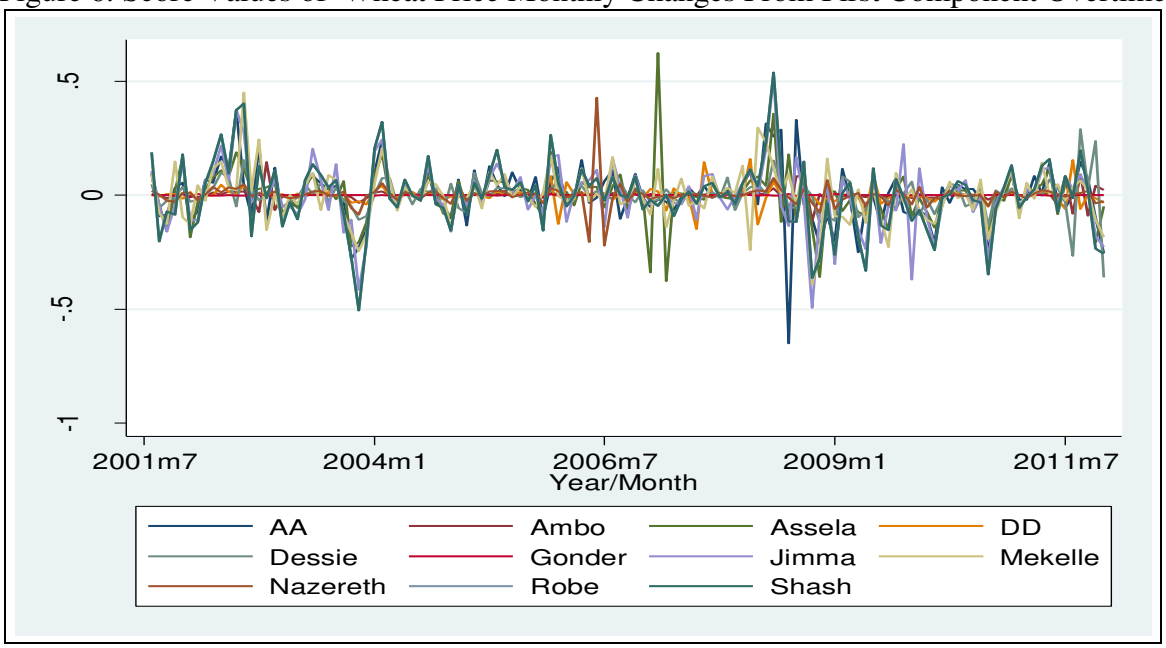


PCA on Monthly Price Changes

To demonstrate the short run dynamics of the price movements across the markets, the PCA has been conducted on the monthly changes of the wheat price.

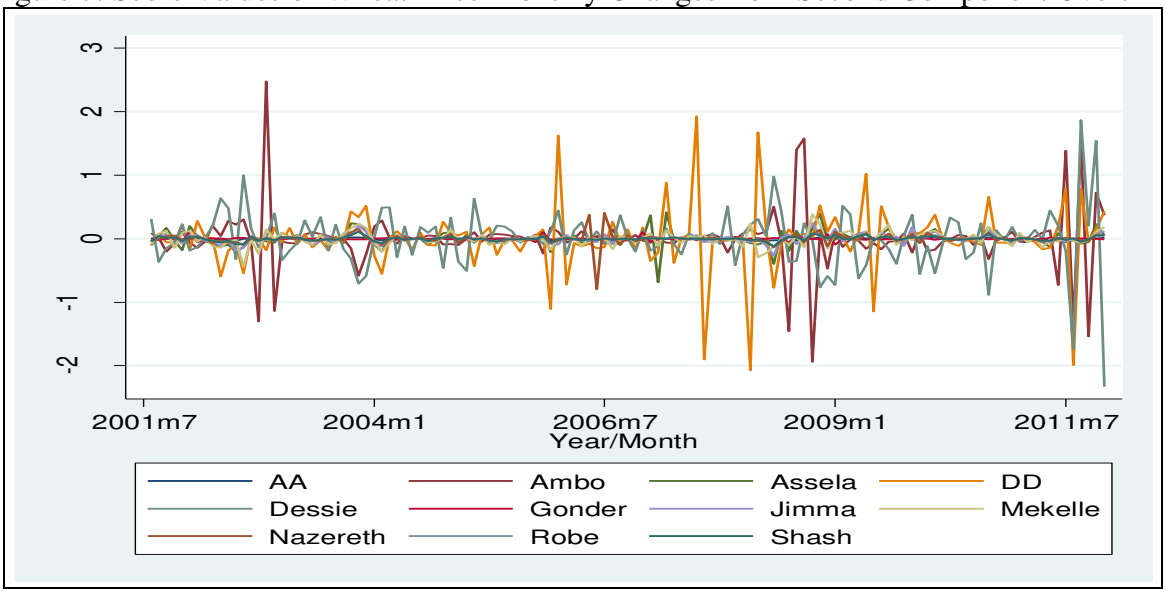
The PCA conducted on the monthly changes of the prices of wheat at different markets reveals that in the short run the average monthly change in the prices of wheat categorizes the markets under investigation into two blocks: Group 1- Ambo, Dire Dawa, Dessie, Gonder, and Nazereth; Group 2-Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene. In Group 1 we observe that the average monthly changes are less than Group 2.

Figure 6. Score Values of Wheat Price Monthly Changes From First Component Overtime



From the second score value we observe that the price variability in the short run is the highest in Ambo, Dire Dawa, and Dessie.

Figure 7. Score Values of Wheat Price Monthly Changes from Second Component Overtime



4.4.2 Maize Market

For the analysis of the maize market, we look into the maize prices of 10 local markets namely: Addis Ababa, Ambo, Dire Dawa, Dessie, Gonder, Jimma, Mekelle, Nazereth, Nekemete, and Shashemene. As for the case in the wheat market, Addis Ababa is considered the central maize market and all other local market prices compare against the Addis Ababa maize price.

The summary statistics provided in table (7) indicate that nominal prices have increased substantially between July 2001 and December 2011. The increase in Addis Ababa, Ambo, Jimma, Nekemte, and Shashemene happened to be above the increase in the national price level. In contrast, the Dire Dawa and Mekelle prices changed below the national average. As these two markets are deficit markets some kind of price stabilization intervention may have been introduced so that prices don`t change as large as the other markets. The real prices, on the other hand, have fallen in all markets except Nekemte. The percentage range of nominal prices also shows that price spikes are relatively low in the deficit markets compared with the central market and markets considered as surplus markets. However, when it comes to real prices the story is different, as we observe that even price stabilization interventions, if any, would not be able to effectively stabilize the market. Markets that appear to be benefiting from some form of price stabilization have not consistently reflect it in the real price series. For instance, the percentage range of real price in the Dire Dawa market exceeds the national percentage range by 50% showing that unlike its nominal counterpart real price in Dire Dawa has shown larger price spikes, yet below some of the markets located proximate to the central market.

With regard to price variability, the standard deviation of monthly changes shows that the nominal price variability has not shown a difference of more than one percentage point across markets including the national price, with the exception of Jimma, Nekemete, and Nazereth, which have, 12%, 13%, and 14% nominal price variability, respectively. The variability in the real prices appeared to be higher than the variability in the national price level in 6 of the 11 markets, the highest being in Nazereth. The two deficit markets, Dire Dawa and Mekelle, have higher average prices than the other markets.

Table 7. Summary Statistics of Nominal and Real Prices of Maize in 10 Markets

Markets	Percentage change July 2001 to December 2011		Percentage Range over the same period		Standard deviations of monthly changes		Mean		Standard Deviation	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
AA	309%	-13%	954%	383%	10%	30%	20.28	14.43	3764%	461%
Ambo	328%	-9%	1151%	438%	10%	32%	19.16	13.49	3763%	457%
DD	22%	-74%	541%	429%	11%	35%	25.27	19.19	3874%	757%
Dessie	212%	-33%	824%	375%	10%	29%	21.13	15.16	3776%	465%
Gonder	235%	-28%	801%	329%	9%	29%	21.26	15.32	3607%	467%
Jimma	387%	4%	1358%	460%	12%	36%	18.22	12.73	3782%	462%
Mekelle	177%	-41%	690%	344%	9%	28%	23.38	17.08	3749%	495%
Nazereth	209%	-34%	940%	366%	14%	45%	19.81	14.11	3600%	433%
Nekemete	443%	16%	1563%	495%	13%	39%	17.47	12.09	3775%	459%
Shash	313%	-12%	1076%	403%	11%	35%	19.45	13.73	3745%	454%
National	259%	-23%	925%	379%	10%	30%	20.08	14.26	3730%	451%

The overall price variability provided by the standard deviation of the price series over the entire period indicate that maize prices are more variable in Dire Dawa than any other market. In most markets, the nominal maize price variability is above the variability in the national nominal price, the exceptions are Nazereth and Gonder. Nazereth also has demonstrated the lowest variability in real prices, which is below the national real price variability.

As indicated in table (8) we retained only two principal components, since the first two principal components explain 98% of the variation in the price data of the 10 local maize markets. The first principal component sheds light on the pattern of average maize price across the 10 local markets. It shows that average maize prices move together across 9 of the 10 markets studied, except Dire Dawa. Because, Dire Dawa market is categorized as deficit market and located far from the central market at a distance of over 600 kms. Unlike Dire Dawa, markets such as Gonder and Mekelle both located at a distance of 600 and 783 kms, respectively, have average maize prices equivalent to the average price of other markets. This implies that the distance barrier as an obstacle to market integration has been overcome following the infrastructure developments observed in the areas where these markets are located.

The second component, on the other hand, hints the extent of price variability in the deficit and surplus markets. It projects into Dire Dawa and Mekelle and compares their price variability to the other markets. As it can be seen from the score values of the second component depicted in figure(9), prices are more variable in Dire Dawa than any other

market, followed by Mekelle. Thus from the results we observe that improving market infrastructure would help in making prices less unpredictable across regions in the country. This is because of the fact that in integrated markets shocks in one market will instantly transmit to the other market and impact the other market either proportionately or less proportionately depending on the extent of integration. For this reason, within a certain time period markets adjust to nearly the same level of average prices, resulting in one national price.

Table 8. PCA Results of Maize Market

Variables	**Comp1**	**Comp2**
AA	0.3352	-0.0375
Ambo	0.3332	-0.1037
DD	0.1344	0.9577
Dessie	0.3344	0.0373
Gonder	0.3246	-0.0528
Jimma	0.3302	-0.1366
Mekelle	0.3253	0.1222
Nazereth	0.3297	0.0137
Nekemete	0.3266	-0.1699
Shash	0.3333	-0.0618
Eigenvalue	8.8652	0.9098
Proportion Explained	0.8865	0.0910
Cumulative Variation	0.8865	0.9775

Figure 8. Score Values of Maize Markets from First Component Overtime

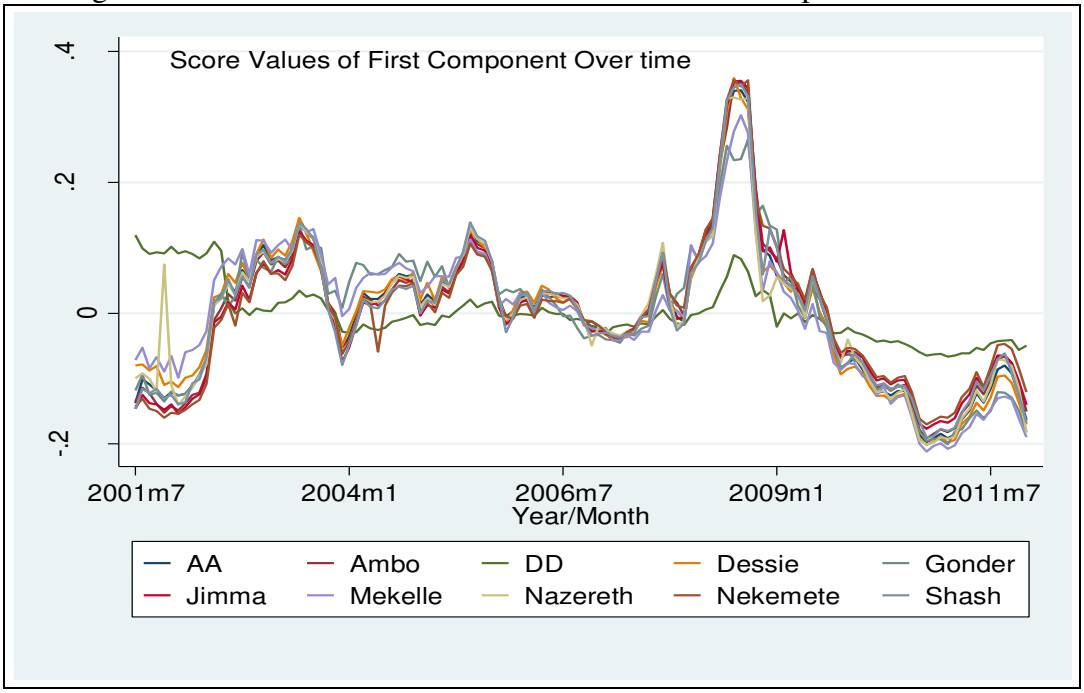
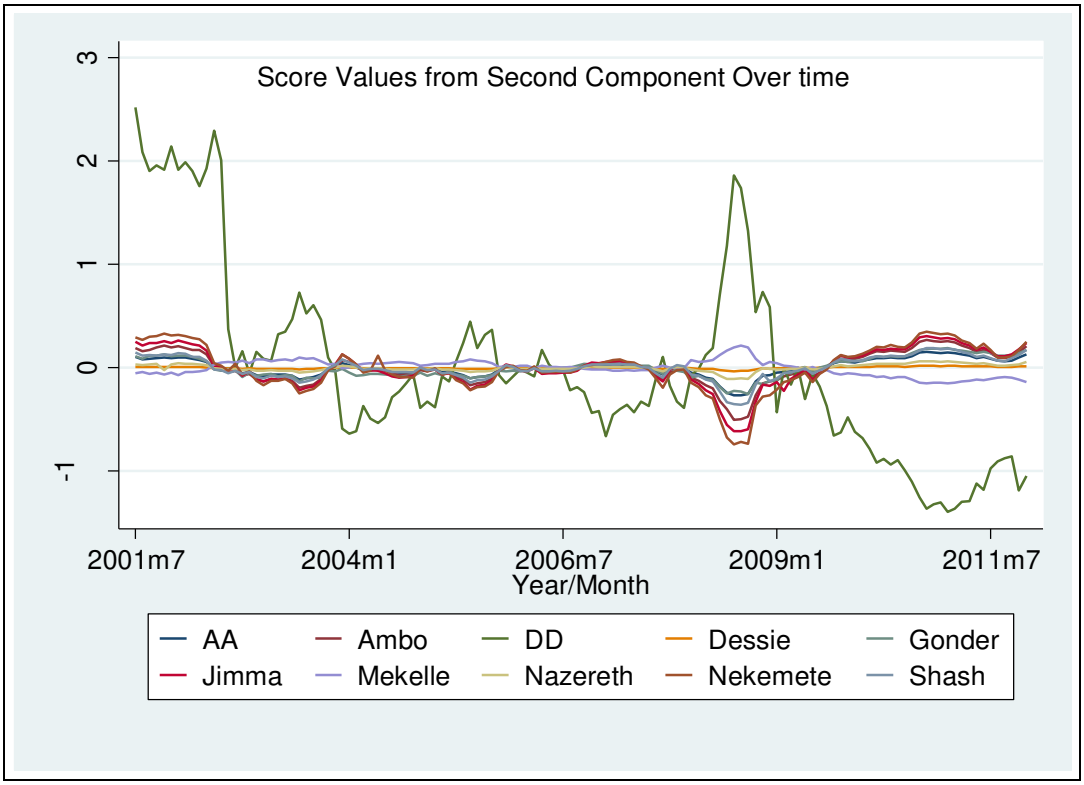


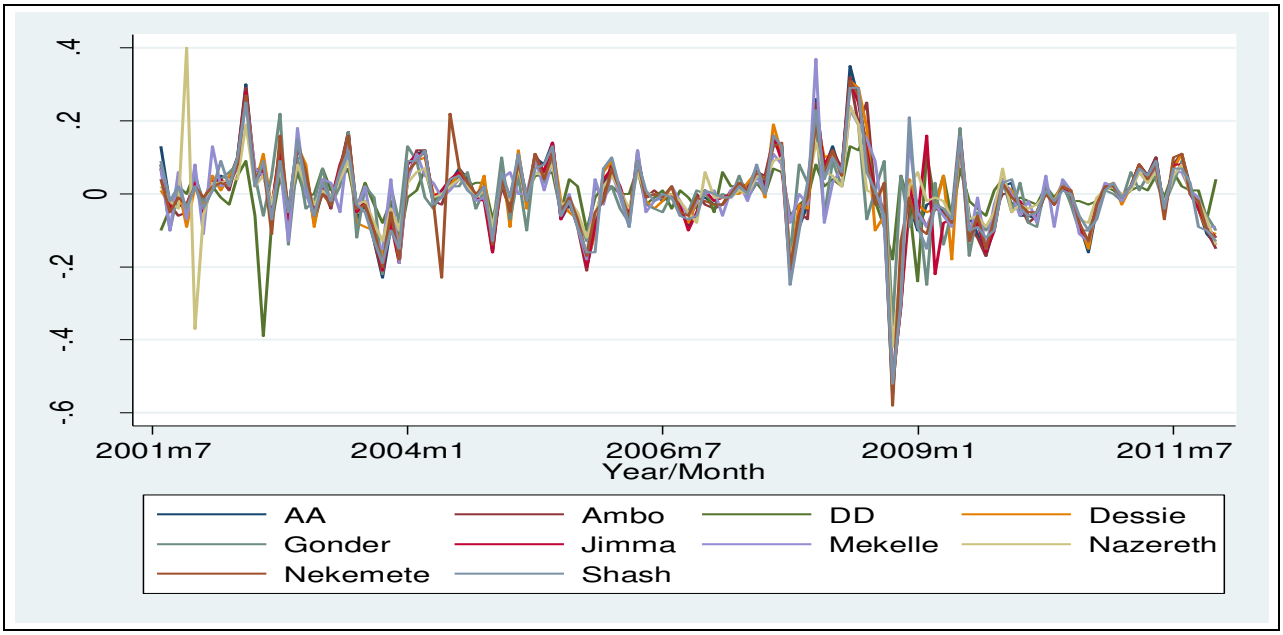
Figure 9. Score Values of Maize Markets from Second Component Overtime



PCA on Monthly Price Changes

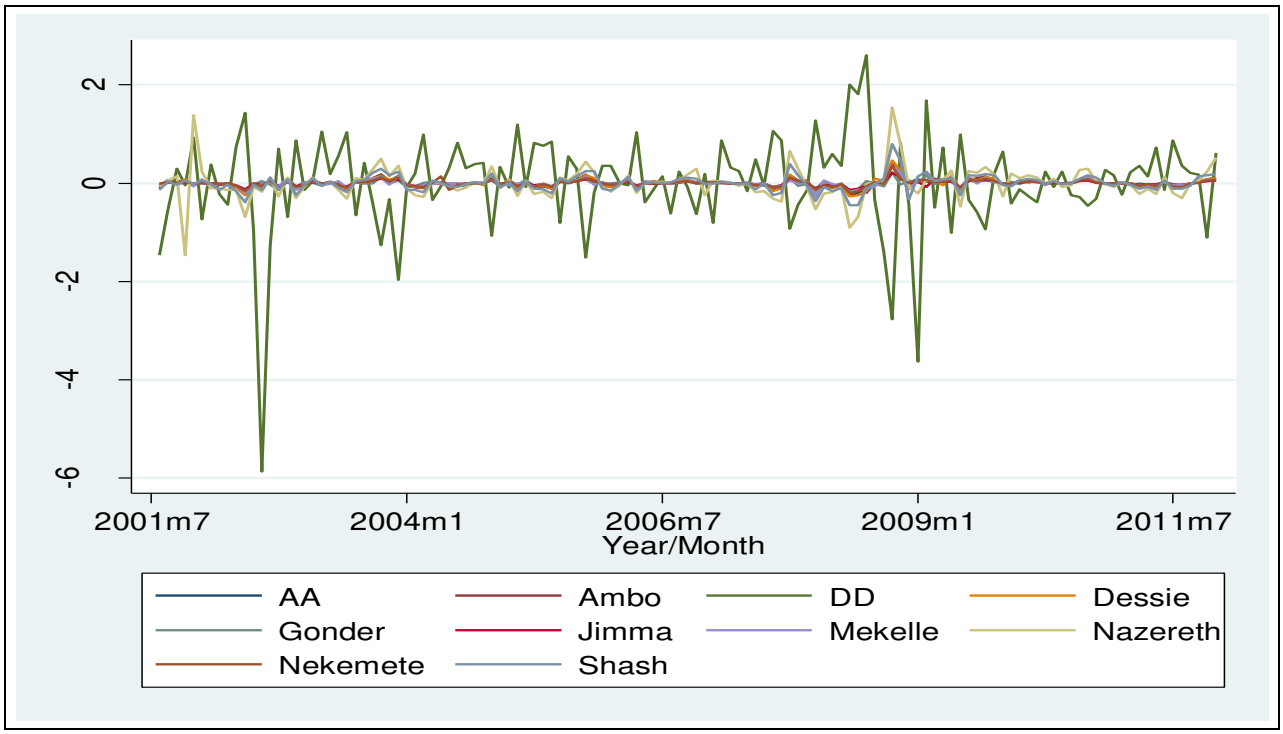
The PCA employed on monthly price changes, as discussed in section 4.3, implies the co-movement of prices in different markets in the short run. As can be seen from Figure 10, the prices in all markets follow a similar trend in the short run, except Dire Dawa. Thus, those markets known as deficit markets in maize production such as Mekelle, Gonder, and Dessie have shown improvement overtime following the development of market infrastructure. However, Dire Dawa, despite such developments remained an isolated deficit market characterized by price trends moving contrary to the markets under consideration.

Figure 10. Score Value of Wheat Price Monthly Changes from First Component Overtime



With regard to the variability of the monthly price changes across markets, the second component of the PCA on monthly price changes reveals that the prices are more variable in the short run in Dire Dawa followed by Nazereth and Shashemene.

Figure 11. Score Value of Maize Monthly Price Changes from Second Component Overtime



4.5. Price Spreads

As an exposition to the long run tendency of the integration of local markets, in this part we discuss the pattern of price spreads between the central market, Addis Ababa, and other local markets of wheat and maize.

Negative values of average price spreads show that prices in Addis Ababa are lower than the corresponding local markets and vice versa. In the wheat market the highest average price spreads occurred in Ambo and Mekelle, where real wheat prices were below the Addis Ababa price by $5.16 and $4.88 per ton, respectively (see table 9 below). In markets such as Dire Dawa, Gonder and Dessie wheat prices have been on average above the Addis Ababa price by the amount $2.14, $1.06, and $0.88 per ton, respectively. Two points emerge from these results. First, even if Ambo is the market closest to Addis Ababa, the real wheat price difference between the two markets happen to be larger on average. However, the price spreads have declined over time (see appendix B1). The reason for such price difference may have been due to the intervention of intermediate market brokers who might have distorted market information despite the closeness of the market to the centre. Thus, the structure of the market organization by itself plays a significant role in price determination and transmission of price signals between markets. Second, in contrast to its wheat production

status and distance from the central market, the Mekelle market has exhibited higher positive price spread on average implying that real wheat prices in Mekelle have been lower than the central market over the period under consideration. This might be due to the food aid releases to the area and the subsequent effect of such intervention on market prices.

The stationarity test of price spreads (last column of table 9) from the central market for all markets shows that in the long run the price differences across markets tend to die out indicating that the integration of local markets has been improving through time.

Table 9. Price Spreads between the central market and other markets of Wheat from July 2001 to December 2011

Markets	Average Price Spread	Standard Deviation of Price Spreads	Distance (in Km)	are Spreads Stationary?
Ambo	5.16	1249%	125	Yes
Assela	2.21	483%	175	Yes
DD	-2.14	866%	515	Yes
Dessie	-0.88	452%	401	Yes
Gonder	-1.06	1240%	725	Yes
Jimma	0.45	247%	346	Yes
Mekelle	4.88	798%	783	Yes
Nazereth	1.82	686%	98	Yes
Robe	0.51	218%	430	Yes
Shash	0.51	218%	251	Yes

With regard to maize market**,** the price spreads as reported in table (10) indicate that markets further from the central market have the highest average price spreads, or in other words, the real maize price that prevail in the central market has been lower than other local markets located in a distance of more than 400 kms, with the exception of Nekemte. The maize market of Nekemte appears to be relatively less integrated to the central market. However, the graphical illustration of the price spreads indicates that price spreads between Nekemte and the central market has been declining owing to the development of infrastructure connecting the two market sites. Likewise, the Mekelle maize market also appears to be weakly integrated into the central market; but it has shown improvement over time.

Table 10. Price Spreads between the central market and other markets of Maize from July 2001 to December 2011

Markets	Average Price Spread	Standard Deviation of Spreads	Distance	Is Price Spread Stationary?
Ambo	0.94	1.64	125	Yes
DD	-4.76	25.22	515	Yes
Dessie	-0.73	1.77	401	Yes
Gonder	-0.89	4.45	725	Yes
Jimma	1.70	2.65	346	Yes
Mekelle	-2.65	4.74	783	Yes?
Nazereth	0.32	3.38	98	Yes
Nekemete	2.33	3.52	430	No?
Shash	0.69	1.71	251	Yes

Summary of Results of Intra-Regional Market Integration

Wheat Market

- Nominal wheat prices increased substantially in all markets. The increase in most of the markets, except Dire Dawa, Dessie, and Jimma, was well above the increase in the national prices.

- The real prices of wheat have fallen in all markets over the period from July 2001 to December 2011;howeer, Ambo exceptionally has shown an increase of about 60 per cent.

- Price variability in Ambo, Dire Dawa, Gonder and Nazereth appeared to be more than twice as large as the variability in other wheat markets. However, the average price over the entire period across markets has not shown substantial difference.

- Results from PCA of the wheat market show that except Dire Dawa and Gonder, average wheat prices across markets are moving together over the entire period under consideration.

- Further, we observe that there is a negative price variability correlation between markets located within the 300 Km radius of the central market , Addis Ababa, and those located outside the 300 Km radius, with the exception of Mekelle. This implies that the further markets are located from the capital, or the central market, the more variable wheat prices become.

- With regard to the short run characterization of the wheat market, wheat prices in Ambo, Dire Dawa, Dessie, and Nazereth tend to move together whereas prices in Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene move together. The short run price variability tends to be the highest in Ambo, Dire Dawa, and Dessie.

Maize Market

- Nominal prices of maize have increased substantially across markets between July 2001 and December 2011. The increase observed in Addis Ababa, Ambo, Jimma, Nekemte, and Shashemene happened to be above the increase in the national price level. In contrast, the Dire Dawa and Mekelle prices changed below the national average.

- The real prices of maize, on the other hand, have fallen in all markets except Nekemte. price spikes in maize market appear to be low in the deficit markets compared to the central market and markets considered as surplus markets.

- The nominal price variability has not shown a difference of more than one percentage point across markets including the national price, with the exception of Jimma, Nekemte and Nazereth, which have 12%, 13%, and 14% nominal price variability, respectively.

- The overall price variability provided by the standard deviation of the price series over the entire period indicate that maize prices are more variable in Dire Dawa than any other markets.

- The PCA results also show that the average maize prices move together in 9 out of the 10 markets studied with the exception of Dire Dawa.

- Unlike Dire Dawa, markets such as Gonder and Mekelle located at a distance of 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that the distance barrier as an obstacle to market integration has been overcome following the national infrastructure developments.

- Maize prices appear to be more variable in Dire Dawa, followed by Mekelle.

- With regard to the short run price dynamics, maize price in all markets demonstrated a similar trend, except Dire Dawa. The short run price variability happened to be more in Dire Dawa followed by Nazereth and Shashemene.

Price Spreads

- In the wheat market the highest average price spreads occurred in Ambo and Mekelle, where real prices of wheat were below the Addis Ababa price by $5.16, and $4.88 per ton, respectively.

- Looking the price spreads between the central market and other markets we observe that even if Ambo is the market closest t the central market, the difference in the real prices of wheat between the two markets happen to be larger on average, but the

spreads have been declining over time. On the other hand, Mekelle has exhibited higher positive price spread on average implying that real prices of wheat in Mekelle have been lower th the central market in the period under consideration.

- The stationarity test of the price spreads from the central market for all markets shows that in the long run the price differences across markets tend to die out indicating that the integration of local markets has been improving.
- The price spreads of the maize market reveal that the real price of maize that prevail in the central market has been lower than other local markets located at a distance of more than 400 Kms, with the exception of Nekemte.

5. Conclusion

After the 2007/08 global food price increases, the global concern has shifted towards understanding the food price dynamics and its volatility so that such an understanding helps in designing policy responses. Particularly, the increased food prices posed significant challenges for developing countries where households spend a larger share of their income on food. To this end, studying how the domestic markets are linked to the world market and the extent of the pass through of the increased food prices to domestic markets is indispensable.

Various studies have shown that transmission of food price shocks to domestic markets depends on the importance of the commodity in the country`s food staple, food status of the country, domestic factors, and policies. These factors come together in many different ways to limit the pass through of global food price inflation to domestic markets.

In this study we addressed two issues. Firstly, we have shown that the domestic grain market prices, though thought to be structurally isolated, appeared to be integrated to the international grain market. This has been demonstrated using two exchange market prices for each commodity against which we analyze the integration of Ethiopian grain market to the world market. That is, we used US maize and SAFEX maize prices as maize exchange market prices and examined the relationship with the Ethiopian maize market. For wheat, we used Paris milling wheat and Chicago Board of Trade (CBOT) soft wheat prices as exchange market prices and investigated the relationship of them with the Ethiopian wheat market.

We found out that the Ethiopian whet market is integrated into the world market as evidenced by its cointegration with the Paris wheat market. However, the cointegration happened to be uni-directional as only Paris wheat market reacts to the price developments in Ethiopia. No cointegration is observed between Ethiopian wheat market and Chicago exchange wheat market. This implies that the Ethiopian wheat market is integrated to the international wheat market which are geographically closer to it. This is evidenced by the fact that Ethiopia imports most of its wheat from the Black sea and Mediterranean ports, for it requires lower transportation cost and the wheat imported through these ports is purchased with lower price at the exchange markets located in Europe.

With regard to maize, the Ethiopian maize market is found to be integrated into the world market. As it is the case for wheat, geographically the nearest exchange market (SAFEX) appeared to be cointegrated with the Ethiopian maize market. While the US maize market does show no cointegration. However, the results must be taken with caution as the no-

cointegration relation does not necessarily guarantee that there is no price pass through between any two markets investigated. Therefore, it might be helpful to further investigate a regime switching cointegration model to see whether the co-integrations observed are due to some form of policy interventions.

In the study further we examined domestic market price integration. The Ethiopian grain market have been under the influence of policy changes that resulted from the changes in governments and hence their ideologies towards the functioning of the market. In the post 1991 period, though not full-fledged, the grain market in Ethiopia has shown improvement. This is mainly attributable to the developments in infrastructure such as road networking and telephone service expansion.

Nonetheless despite such developments, we observe that in the domestic wheat market price variability appears to be higher in the markets located in a distance outside the 300Km radius of the central market. The exception in this regard is Mekelle, which has been categorized as deficit market. With regard to the short run characterization of the wheat market, wheat prices in Ambo, Dire Dawa, Dessie, and Nazereth tend to move together whereas prices in Addis Ababa, Assela, Jimma, Mekelle, Robe, and Shashemene move together. The short run price variability tends to be the highest in Ambo, Dire Dawa, and Dessie.

In the maize market analysis we found that Gonder and Mekelle located at a distance of 600 Kms and 700Kms, respectively, have shown average maize prices equivalent to the average price of other markets. This implies that the distance barrier as an obstacle to market integration has been overcome following the national infrastructure developments.

The price spreads between the central market and other markets have shown that over time the price differences is declining. But we observe that even if Ambo is the market closest to the central market, the difference in the real prices of wheat between the two markets happen to be larger on average, but the spreads have been declining over time. On the other hand, Mekelle has exhibited higher positive price spread on average implying that real prices of wheat in Mekelle have been lower than the central market in the period under consideration.

These mixed result imply that full integration of the domestic market is an objective hat is not yet achieved. Thus further intensification of the investment in market infrastructure and development of market institutions is essential so that the differences in prices and hence the price volatility across domestic markets could be reduced.

References

Abdulai, A., 2000. Spatial price transmission and asymmetry in the Ghanaian maize market. J. Dev. Econ. 63, 327–349.

Ardeni, P. G. (1989). Does the Law of One price Really Hold for Commodity Prices? American Journal of Agricultural Economics 71: 661-669.

Baffes, J. and B. Gardner. 2003. The Transmission of World Commodity Prices to Domestic Markets under Policy Reforms in Developing Countries." Journal of Policy Reform. 6. 159-180.

Conforti, P. 2004. Price Transmission in Selected Agricultural Markets. FAO Commodity and Trade Policy Research Working Paper No. 7. Food and Agriculture Organization.

Dawe, D. 2008. Have Recent Increases in International Cereal Prices Been Transmitted to Domestic Economies?: The Experience in Seven Large Asian Countries. ESA Working Paper No. 08-03. Development Economics Divisions, Food and Agriculture Organization.

Dercon, Stefan, 1994. "Food Markets, Liberalization and Peace in Ethiopia: An Econometrics Analysis," Centre for the Study of African Economies, Oxford.

Engle, R.F. and Granger, C.W.J. (1987). Cointegration and Error Correction: Representation, Estimation and Testing. Econometrica 55: 251-276.

Fackler, P.L., and B.K. Goodwin. 2001. Spatial price transmission. In Handbook of Agricultural Economics, (ed.) B. Gardner and G. Rausser. Volume 1, Chapter 17. Elsevier Science.

Franzel, S., F. Colburn, and G. Degu. 1989. Grain marketing regulations: Impact on peasant production in Ethiopia. Food Policy14: 347-358.

Gardner, B.L. & Brooks, K.M., 1994.Food prices and market integration in Russia: 1992-93. American Journal of Agricultural Economics, 76, 641-646.

Gilbert, C. L. and C. W. Morgan. 2010. Food Price Volatility. Philosophical Transactions of the Royal Society. 365, 1554: 3023-3034.

Gilbert, C.L. 2011. Grain Price Pass,Through,2005,2009. In: Prakash, A. (ed.), Safeguarding Food Security in Volatile Global Markets. Rome, FAO.

Hazell, P. et al. 1990. The relationship between world price instability and the prices farmers receive in developing countries, Journal of Agricultural Economics, 41: 227-243

Holmbeg, J. 1977. Grain Marketing and Land Reform in Ethiopia: An Analysis of the Marketing and Pricing of Food Grains in 1976 after the Land Reform. Research Report 41. The Scandinavian Institute of African Studies.

Ianchovichina, E., J. Loening, and C. Wood. 2012. How Vulnerable Are Arab Countries to Global Food Price Shocks. World Bank Policy Research Working Paper 6018. Washington D.C.

Imai, K., R. Gaiha, and G. Thapa. 2008. Transmission of World Commodity Prices to Domestic Commodity Prices in India and China. Brook World Poverty Institute (BWPI) Working Paper No. 45.Manchester.

International Monetary Fund (IMF). 2011. "Target What You Can Hit: Commodity Price Swings and Monetary Policy" in World Economic Outlook September 2011. IMF: Washington D.C.

Isard, P. 1977. How far can we push the 'law of one price'?, American Economic Review, 67, pp. 942–948.

Johansen, S. 1988. Statistical analysis of cointegrating vectors. Journal of Economic Dynamics and Control 12: 231-254.

Keats, S., S. Wiggins, J. Compton, and M. Vigneri. 2010. Food Price Transmission: Rising International Cereals Prices and Domestic Markets. Overseas Development Institute (ODI) Project Briefing No. 48.ODI: London.

Lirenso, A. 1994. Liberalizing Ethiopian Grain Markets. In Papers of the 12th International Conference of Ethiopian Studies, ed. H. Marcus, and G. Hudson. East Lansing: Michigan State University.

Lirenso, A. 1995. "Grain Market Reform and Food Security in Ethiopia," paper presented at the World Bank Seminar, Washington, D.C., June 15, 1995.

Mendoza, M.S., and M.W. Rosegrant 1995a. Pricing Behavior in Philippine corn markets: Implications for market efficiency, Research Report 101. International Food Policy Research Institute, Washington, DC.

Minot, N. 2011. Transmission of World Food Price Changes to Markets in sub-Saharan Africa. International Food Policy Research Institute, Discussion Paper 1059.Washington D.C.

Monke, E., and T. Petzel. 1984. Market integration: An application to international trade in cotton, American Journal of Agricultural Economics 66:481-487.

Morisset, J. 1998.Unfair trade? The increasing gap between world and domestic prices in commodity markets during the past 25 years. The World Bank Economic Review, Vol. 12, No. 3, 503-26.

Mundlak, Y. and D. Larson. 1992. On the Transmission of World Agriculture Prices. World Bank Economic Review. 6, 3: 399-422.

Negassa, A. and R. Myers, 2007. Estimating Policy Effects on Spatial Market Efficiency: An Extension to the Parity Bound Model. American Journal of Agricultural Economics 89 (2): 338-352.

Quiroz, J. and Soto, R. 1993. International price signals in agricultural markets: do governments care?, mimeo, The World Bank, October

Quiroz, J. and R. Soto. 1995. International Price Signals in Agricultural Markets: Do Governments Care? World Bank Mimeo.

Rapsomanikis, G., D. Hallam, and P. Conforti. 2004. "Market Integration and Price Transmission in Selected Food and Cash Crop Markets of Developing Countries: Review and Applications." in Commodity Market Review 2003-2004. Food and Agriculture Organization: Rome.

Rashid, S. 2004. "Spatial Integration of Maize Markets in Post-Liberalized Uganda." Journal of African Economies 13 (1): 103–133.

Rashid, S., and S. Lemma. 2010. Strategic Grain Reserve in Ethiopia: Institutional Design and Operational Performance. International Food Policy Research Institute, Discussion Paper 1054. Washington, D.C.

Rashid, S. 2011. Inter-commodity Price Transmission and Food Price Policies: An Analysis of Ethiopian Cereals Markets. IFPRI Discussion paper 1079. Washington, D.C.: International Food Policy Research Institute.

Ravallion, M., 1986. Testing market integration, American Journal of Agricultural Economics, 68(2), 292-307.

Timmer, C. P. 2008. Causes of High Food Prices. ADB Economics Working Paper Series No. 128.ADB: Manila.

Van Campenhout, B., 2007. Modelling trends in food market integration: Method and an application to Tanzanian maize markets. Food Policy 33 (1), 112–127.

World Food Program (WFP). 1989. Mid-term Evaluation by a WFP/FAO/ILO/UN Mission of Project Ethiopia 2488/(Exp. II): Rehabilitation of Forest, Grazing, and Agricultural Lands, Vol. 1. Addis Ababa: World Food Program.

Appendix A

Missing Value Imputation Technique

The missing values of the price series of the local markets have been interpolated using the following technique after (Gilbert, 2011).

Let the price of a commodity in market m and month t be p_{mt}, $(m=1,....,n;t=1,....,T)$. The set of months for which p_{mt} is observed for a market m is denoted by S_m. To estimate the missing prices suppose

$$\ln p_{mt} = \ln \pi_t + \delta_{mt} + \varepsilon_{mt}$$

Where π_t is the (unobserved) representative national price in month t, δ_m is the average market m differential relative to the national average and ε_{mt} is a random error. Given estimates $\hat{\pi}_t$ and $\hat{\delta}_{mt}$, a missing price, $\tilde{p}_{mt}$, can be estimated as

$$\ln \hat{p}_{mt} = \ln \hat{\pi}_t + \hat{\delta}_{mt} \qquad (t \in S_m)$$

The procedure implemented in this paper is as follows:

I. For the price series where we have at least one price observation for a month t, we estimate π_t as a median of the observed prices. Here we use median instead of the average since the median will be less affected by the pattern of missing observations and the presence of high and low price markets.

II. If no prices are reported for a particular month t, which rarely happens, we interpolate the national price of that particular month as $\ln \hat{\pi}_t = \frac{1}{2}[\ln \hat{\pi}_{t-1} + \ln \hat{\pi}_{t+1}]$. We have not faced this problem in this study, however.

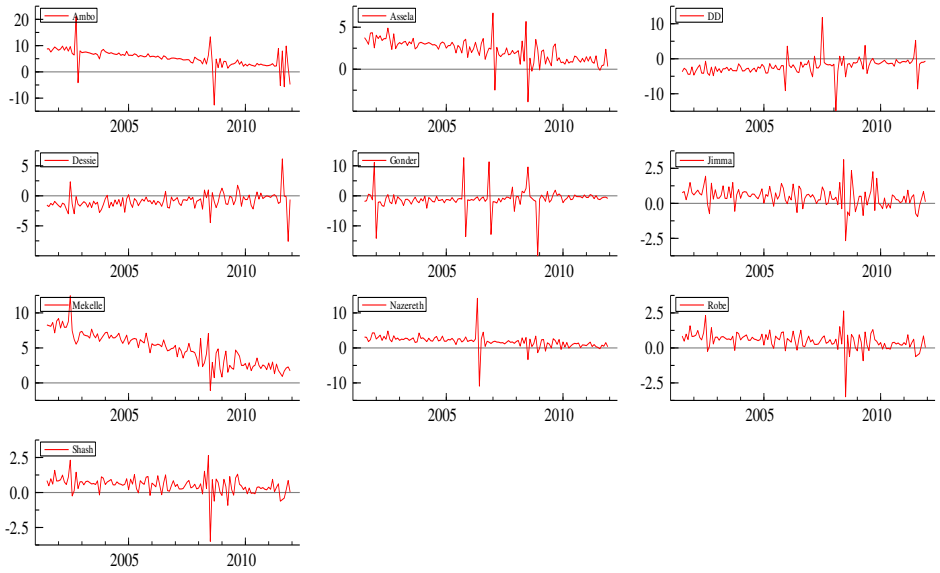
III. Then we estimate the differentials $\tilde{\delta}_{mt} = \ln p_{mt} - \ln \hat{\pi}_t \quad (t \in S_m)$. Suppose the differentials are AR(1), $\delta_{mt} = \kappa_m + \rho_m \delta_{m,t-1} + \upsilon_{mt}$. We estimate the parameters of this AR(1) by OLS over S_m, this allows interpolation of δ_{mt} as

$\hat{\delta}_{mt} = \hat{\kappa}_m + \hat{\rho}_m \hat{\delta}_{m,t-1}$, in the case that $t-1 \in S_m$ and $\hat{\delta}_{mt} = \hat{\kappa}_m + \hat{\rho}_m \hat{\delta}_{m,t+1}$, otherwise.

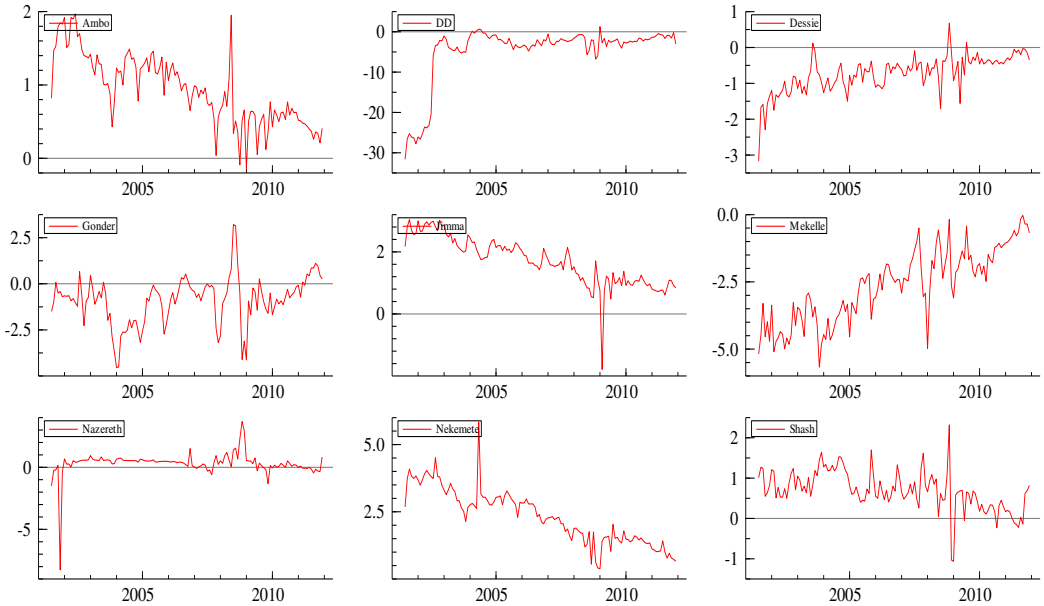
The national prices of all food crops considered in this paper are medians of the local market prices for the missing values of any particular month has been interpolated using the above technique.

Appendix B

1. Wheat Market Price Spreads Overtime



2. Maize Market Price Spreads overtime



Appendix C

Table 11. Results of Wheat Market Principal Components Analysis (Principal Components)

Principal Components	Number of observations	126
(Components/Correlation)	Number of components	4
	Trace	11
Rotation: Unrotated Principal	Rho	0.9871

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	9.9264	9.2258	0.9024	0.9024
Comp2	0.7006	0.5569	0.0637	0.9661
Comp3	0.1437	0.0568	0.0131	0.9792
Comp4	0.0869	0.0270	0.0079	0.9871
Comp5	0.0598	0.0180	0.0054	0.9925
Comp6	0.0419	0.0273	0.0038	0.9963
Comp7	0.0146	0.0033	0.0013	0.9976
Comp8	0.0113	0.0015	0.0010	0.9987
Comp9	0.0098	0.0050	0.0009	0.9995
Comp10	0.0047	0.0044	0.0004	1.0000
Comp11	0.0003		0.0000	1.0000

Table 12. Eigenvectors of the first four Wheat Market Principal Components

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
AA	0.3139	-0.0573	-0.0584	0.0404	0.0186
Ambo	0.3084	-0.2496	0.2712	0.5746	0.0031
Assela	0.3090	-0.2436	-0.1466	-0.1674	0.0213
DD	0.2852	0.4302	-0.1824	0.4130	0.0678
Dessie	0.3023	0.2017	-0.0870	0.1209	0.0541
Gonder	0.3057	0.0397	0.9011	-0.1457	0.0010
Jimma	0.2492	0.6723	-0.0683	-0.0180	0.0091
Mekelle	0.3165	-0.0386	-0.0550	-0.4358	0.0352
Nazereth	0.2906	-0.4088	-0.0750	-0.4527	0.0664
Robe	0.3126	-0.1605	-0.0972	-0.0246	0.0049
Shash	0.3166	-0.0377	-0.0972	-0.0246	0.0049

Table 13. Results of Maize Market Principal Components Analysis (Principal Components)

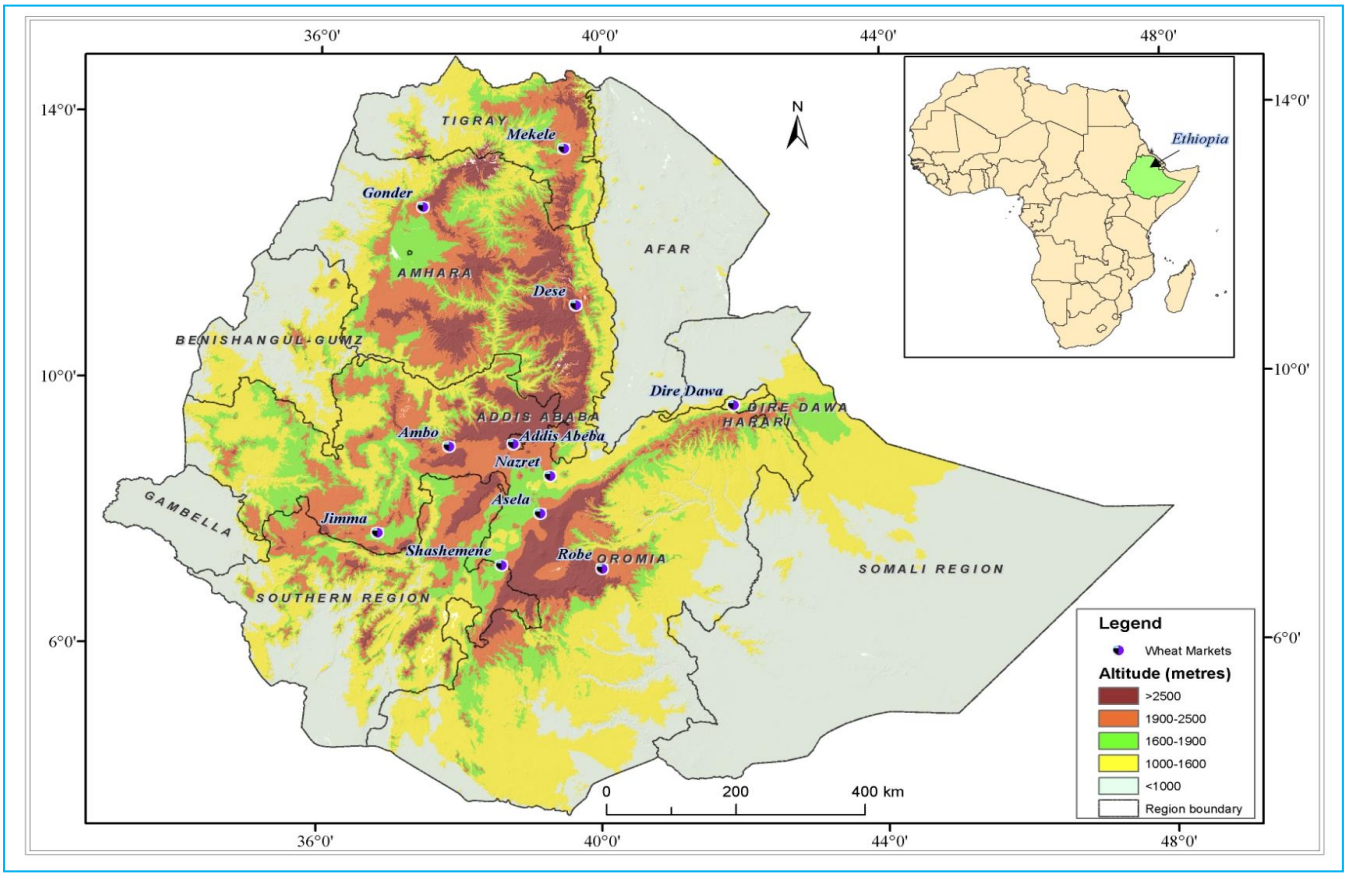
Principal components	Number of observations		126
(Components/Correlation)	Number of Components		4
		Trace	10
Rotation: Unrotated: Principal		Rho	0.9954

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	8.8652	7.9554	0.8865	0.8865
Comp2	0.9098	0.7799	0.0910	0.9775
Comp3	0.1299	0.0810	0.0130	0.9905
Comp4	0.0489	0.0262	0.0049	0.9954
Comp5	0.0227	0.0149	0.0023	0.9977
Comp6	0.0079	0.0019	0.0008	0.9984
Comp7	0.0060	0.0005	0.0006	0.9990
Comp8	0.0055	0.0026	0.0005	0.9996
Comp9	0.0028	0.0016	0.0003	0.9999
Comp10	0.0012	.	0.0001	1.0000

Table 14. Eigenvectors of the first four Maize Market Principal Components

Variables	Comp1	Comp2	Comp3	Comp4	Unexplained
AA	0.3352	-0.0375	0.0278	-0.0253	0.0025
Ambo	0.3332	-0.1037	0.1397	0.1338	0.0026
DD	0.1344	0.9577	0.1727	0.1670	0.0001
Dessie	0.3344	0.0373	-0.0703	-0.1410	0.0056
Gonder	0.3246	-0.0528	-0.6063	0.4172	0.0069
Jimma	0.3302	-0.1366	0.2889	0.1616	0.0042
Mekelle	0.3253	0.1222	-0.5532	-0.2073	0.0065
Nazereth	0.3297	0.0137	0.1339	-0.7355	0.0074
Nekemete	0.3266	-0.1699	0.3695	0.3839	0.0034
Shash	0.3333	-0.0618	0.1829	-0.0469	0.0070

Appendix D
1. Map of Wheat Markets



2. Map of Maize Markets