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ESSP II Working Paper 22

# Intercommodity Price Transmission and Food Price Policies

## An Analysis of Ethiopian Cereal Markets

Shahidur Rashid

Development Strategy and Governance Division, International Food Policy Research Institute – Ethiopia Strategy Support Program II, Ethiopia

Ethiopia Strategy Support Program II (ESSP II)

ESSP II Working Paper No. 22

May 2011

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**Keywords:** Ethiopia, food price stabilization, common trend, cointegration

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## Abstract

Cereal price variability in Ethiopia has worsened in recent years, and some of the earlier liberalizations are being reversed due to the unacceptable economic and political costs of increased price variability. The challenge now is to achieve price stability in a cost-effective way. This paper examines intercommodity price relationships to assess the relative importance of each of the three major cereals in generating price volatility. Based on the estimates from a dynamic econometric model, the paper concludes that maize is the most significant in exacerbating price variability with respect to the persistence of shocks to itself and the two other cereals. This implies that focusing on maize, instead of wheat, will not only help better stabilize prices but also reduce costs of stabilization. The results are also discussed in the context of ongoing policy discussions.

## Acknowledgements

The original version of this paper was written for the Ethiopia Strategy Support Program (ESSP), a collaborative research project of the Ethiopian Development Research Institute (EDRI) and the International Food Policy Research Institute (IFPRI). I am thankful to the donors that funded the ESSP, to Sara Gustafson for her excellent copy editing, Solomon Lemma for research assistance, and to Ethiopian Grain Trading Enterprise (EGTE) officials, especially Ato Berhane and Ato Gabre-Ekziabre, for answering many data-related questions. I have also benefited from helpful discussions with Mulat Demeke, Asfaw Negassa, Berhanu Gebremedhin, and Paul Dorosh.

## 1. Introduction

The staple food basket of households in developing countries typically consists of more than one substitutable cereal. Substitutability essentially implies that the prices of the cereals have a long-run relationship and shocks to one of the markets will get transmitted to the rest, across space and time, if markets are integrated. However, not all cereals entail the same degree of risk exposure, nor are they equally liked by the consumers in a given country. For instance, production of modern-variety cereals is riskier than that of traditional varieties; and one of the cereals in a household's food basket can often be preferred to the others. In such conditions, the persistence of a shock would be different for different commodities, with clear implications for technology adoptions, crop portfolio choices, and eventually supply responses.[1]

From a policy standpoint, an understanding of inter-commodity price relationships and shock transmissions becomes particularly important for developing countries, where cereals account for a large share of agricultural value-added, prices are volatile, social safety net programs are large,[2] and modern and traditional technologies coexist. In such economies, farmers will have to be self-sufficient in basic staples to protect themselves against price risks (de Janvry, Fafchamps, and Sadoulet 1991), are not likely to diversify toward cash crops if cereal prices are volatile (Fafchamps 1992), and will make less risky crop choices (Dercon 1996; Murdoch 1995). These results hold in the presence of market failures (such as inadequate infrastructure, incomplete credit and insurance markets, and information asymmetry), a fact that formed the basis for public interventions in the cereal markets (Timmer 1989).

While parastatals or marketing board-centric policies of cereal price stabilization proved expensive and led to rent seeking and inequitable distribution of benefits (Bates 1981; Newbery and Stiglitz 1981; Sahn, Dorosh, and Younger 1997), market liberalization has not proved to be fully effective either, implying that the fundamental rationales for cereal price stabilization remain valid in many countries. In fact, contrary to common expectation, there is now a growing perception that reforms have led to increased food price volatility and that risk is a major factor constraining deeper reforms, leading to reversals of the reform processes in a number of countries (World Bank 2005). While few dispute the importance of developing better-functioning markets as the long-term solution, there is a need for short-term intervention to address price instability—particularly if complete liberalization exposes countries to levels of volatility that are unacceptable in terms of economic, human, and political costs.

Thus, managing cereal price instability continues to receive policy attention in many developing countries. Ethiopia is such a country, where all cereals are non tradable, price volatility is high, and both food aid and food-based intervention programs are large. Monthly cereal price variability in the country is not only among the highest in the world but has even worsened since 2000 (Gabre-Madhin and Mezgebou 2006). Both import and local procurement of food aid in the country are substantial, and their effects on cereal markets

[1] The literature on risks and crop choices is large; see Dercon (1996) for a review.
[2] Note that success of the cash-based social safety net programs, which are being increasingly recommended, also critically depends on cereal price stability. As Rashid and Lemma (2010) illustrates, the value of cash transfers declined drastically at the time of food price hike and hence all Productive Safety Net Program (PSNP) beneficiaries preferred food over cash.

are hotly debated.[3] From 1993 to 2004, food aid imports and domestic procurement averaged about 700,000 tons and 83,000 tons, respectively. Finally, the country launched one of the largest social safety net programs in Africa in 2005, called the Productive Safety Net Programs (PSNP), which combines food aid with cash transfers to the beneficiaries. In 2006/07, the program disbursed 1.3 billion ETB (Ethiopian birr) in cash, equivalent to about US$150 million, and distributed 326,000 tons of cereals.

Using monthly price data for three major cereals in Ethiopia (teff, maize, and wheat),[4] this paper conducts a set of analyses to better understand the intercommodity price relationships and shock transmissions. The analysis builds on the idea proposed by Alderman (1993), who examined intercommodity price transmittal across two commodities in two separate market locations in Ghana. We adopt the methodologies proposed by Gonzalo and Granger (1995) to analyze the long-run price relationships among the commodities and by Pesaran and Shin (1998) to examine the significance and persistence of shocks to a given commodity on the dynamics of both itself and other commodities. The implementation of the methods involves estimating common long-run memories for each cereal across market locations, examining cointegration among the common long-run memories, and finally conducting impulse response analyses to study shock transmission.

An essential first step in implementing these methods is an analysis of market integration, which is a precondition for the transmission of price signals and shocks among commodities and over time. A substantial body of literature exists on methods of analyzing market integration, with more recent applications relying on variants of parity bound models (PBMs) and multivariate cointegration. However, neither method is free from criticisms. For instance, PBMs are criticized as being bivariate analyses of variables that emerge from a multivariate context (Gonzalez-Rivera and Helfand 2001; Fackler 2004), their results as being sensitive to underlying distributional assumptions (Fackler 1996; Barrett and Li 2002), and their methods as assuming shocks to be serially independent and hence failing to explain dynamic adjustments (Fackler 2004). On the other hand, the cointegration methods are criticized as being neither necessary nor sufficient for spatial market efficiency (McNew and Fackler 1997; Fackler and Goodwin 2001) and as being unable to explicitly account for transfer costs (Barrett 1996; Barrett and Li 2002).[5]

For analyzing the issues that this paper attempts to address, the multivariate cointegration method has some distinct advantages. In particular, the Gonzalo and Granger (1995) method allows

1. analyzing price relationships among multiple commodities across multiple spatial locations;
2. testing for the significances of commodities in terms of their importance in driving long-run variability, and
3. system reduction that enables modeling a larger number of variables without running into degrees-of-freedom problems.

[3] There are many studies, with mixed conclusions, on the effects of food aid in Ethiopia, some of which are discussed in a later section. For details, see Gilligan and Hoddinott 2006; World Bank 2006; Abdulai, Barrett, and Hoddinott 2005; Yamano, Christiansen, and Alderman 2005; and Jayne et al. 2002.
[4] These three cereals account for more than 67 percent of cereal production in the country.
[5] To some extent the transfer costs problem can be addressed through threshold autoregression methods (Goodwin and Piggott 2001; Goodwin and Harper 2000).

The generalized impulse response of Pesaran and Shin (1998), on the other hand, is invariant to ordering and therefore has distinct advantages in innovation accounting and in being conclusive about the persistence of shocks.

## 2. Methodological framework

### 2.1. Characterization of integrated markets

Consider a market of a homogeneous commodity that is traded in $n$ spatially separated locations with a corresponding price vector of $\{P_{1t}, P_{2t}, ............P_{nt}\}$. If trade exists among all locations, then these locations are said to be integrated if[6]

1. $\{P_{1t}, P_{2t}, ............P_{nt}\}$ can be decomposed as $P_{it} = a_i f_t + \widetilde{P}_{it}, \quad i = 1......n,$ where $f_t = \alpha_{\perp} P_t$ is the common long-run memory representing the integrating vector and $\widetilde{P}_{it}$ is the transitory component for each location;
2. for all $i$, $a_i \neq 0$; and
3. $P_i's$ are cointegrated with exactly $n-1$ cointegrating vectors.

Conditions 1and 2 are standard, but 3 is a stricter condition, which ensures that there is one and only one common long-run memory (common stochastic trend) in a set of nonstationary price variables.[7] The underlying idea of this characterization, particularly of imposing condition 3, is that if there were more than one common trend, it would be difficult to identify how long-run movements of prices are generated. As Gonzalez-Rivera and Helfand (2001) point out, if there were two common trends, some prices could be generated by the first trend, some by the second trend, and some by a combination of the two. In such a situation, market locations cannot be considered integrated.

### 2.2. Estimating $f_t$ and generalized impulse response

Given the characterization of market integration, both the estimation of $f_t$ (Gonzalo and Granger 1995) and the generalized impulse response (Pesaran and Shin 1998) can be carried out within Johansen's (1988) and Johansen and Juselius's (1990) multivariate cointegration framework. Formally, let $P_t = \{P_{1t}, P_{2t}, ............P_{nt}\}$ be an $n \times 1$ non-stationary vector of prices, where $P_{it}$ is the log price of a homogeneous commodity at time $t$ in market location $i$. The price relationship across locations can be represented as an unrestricted vector autoregression (VAR) with *k* lags of $P_t$, as follows:

[6] This is the same characterization used by Gonzalez-Rivera and Helfand (2001) and Rashid (2004).
[7] This follows from the fact that there is a complete duality between vector autoregression (VAR) representation, used in analyzing cointegrating relations, and vector moving average (VMA) representation, which analyzes the structure of common trends (Johansen 1991; Juselius 1994).

$$P_t = \mu + A_1 P_{t-1} + \ldots + A_k P_{t-k} + \Phi D_t + \varepsilon_t \qquad (1)$$

where $P_t$ is $(n \times 1)$ and each of the $A_i$ is an $(n \times n)$ matrix of parameters, $D_t$ is a vector of deterministic variables, and $\varepsilon_t$ is a vector of identically and independently distributed residuals. According to Granger's representation theorem, the vector $P_t$ has a vector autoregressive error correction representation,

$$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \mu + \delta t + \varepsilon_t \qquad (t = 1, \cdots, T) \qquad (2)$$

where $\Pi = \sum_{i=1}^{k} A_i - I_n$, $\Gamma_i = \sum_{i=i+1}^{k} A_i$, $\Delta = (I - L)$, $L$ is the lag operator, $k$ is the lag length, and $\mu$ and $\delta$ are a vector of a constant and a trend coefficient respectively.
The hypothesis of cointegration in the error correction model depends on the properties of the characteristic polynomial of the process, expressed as follows:

$$A(z) = (1-z)I_n - \Pi_z - \sum_{i=1}^{k-1} \Gamma_i (1-z) \qquad (3)$$

For this process, $P_t$ is stationary if all roots of A have modulus greater than one, but $P_t$ is *I(1)* if *A* has unit roots. If $z=1$ is a root, $\Pi$ has a reduced rank of $r \prec n$ and the hypothesis of cointegration is formulated as $\mathrm{H}(r): \Pi = \alpha\beta'$, where $\alpha$ and $\beta$ are $n \times r$ matrices of full column rank and $r$ is the rank of $\Pi$ that determines how many linear combinations of $P_t$ are stationary. Given the characterization of integrated markets, searching for market locations that share a common trend is equivalent to testing for $r = n - 1$.

The long-run memory $(f_t = \alpha_\perp P_t)$ and the generalized impulse response functions can be estimated by a vector moving average (VMA) model. There is a complete duality between VAR, used to analyze cointegrating relationships, and VMA, used to analyze the common long-run memory structure. If the root of equation (3) is equal to one or has moduli $\leq 1$, and if $\alpha'_\perp \Gamma \beta_\perp$ has a full rank of $n-r$, the VMA representation of equation (1) can be written as

$$X_t = C \sum_{i=1}^{t} (\varepsilon_i + \psi D_i) + C*(L)(\varepsilon_t + \Phi D_t) + A, \qquad (4)$$

where $C = \beta_\perp \left( \alpha'_\perp \left( I_p - \sum_{i=1}^{k-1} \Gamma_i \right) \beta_\perp \right)^{-1} \alpha'_\perp$.

The common long-run memory ( $f_t = \alpha_\perp P_t$ ) is derived from equation (4); Pesaran and Shin (1998) show that the generalized impulse response function can be derived as

$$\varphi^{g}_{z,j}(n) = \sigma_{jj}^{-1/2} \beta' B_n \sum e_j \quad \ldots \ldots \ldots \ldots \ldots , \tag{5}$$

where $\sigma_{jj}$ is the $JJ^{th}$ element of the residual variance–covariance matrix Σ of the vector $Z_t$, $e_t$ is an $m \times 1$ vector with unity at the $J^{th}$ row and zeros elsewhere, and $n$ is the number of periods ahead.

## 3. Notes on data

The data for this analysis were provided by the Ethiopian Grain Trading Enterprise (EGTE), the country's grain marketing parastatal, which has been collecting monthly price data for selected grains since the 1980s. The agency collects data from 24 market locations, but time series are incomplete with a very large number of missing values. For example, in Bahirdhar, one of the important market centers, there are a total of 63 missing values, with about 36 consecutive missing values starting from 2004. Reasonably complete series are available for six market locations—Addis Ababa (AA) and Nazareth (NZ) in the center, Mekelle (MK) in the north, Dire Dawa (DD) in the east, Jimma (JM) in the southwest, and Shashameni (SM) in the central south—from January 1996 to December 2007. A few remaining missing values in this data set were interpolated.

Although a larger number of market locations would have added value to the analysis, the sampled locations provide a good representation of the key production and populated regions of Ethiopia. Only two regions in the country, Amhara and Oromya, account for 87 percent of Teff and wheat production and about 82 percent of maize production of the country. Except for wheat, for which annual imports (mainly food aid) averaged 31 percent of productions, international trade of cereals has been practically zero since early 2000s (Rashid, 2010). Addis Ababa connects both of these production regions, with Dire Dawa in the east and Mekelle in the north being the other two main consumption regions. Nazreth and Shashemene serve as two main surplus areas market locations.

A standard first step in cointegration analysis is conducting tests to check if the variables are non-stationary. Given our characterization of market integration, these tests are particularly important, since there is a one-to-one relationship between the number of stationary variables and the number of cointegrating relationships (Hansen and Juselius 1995). More specifically, if $x$ numbers of stationary variables are included, the number of cointegrating vectors will also increase by $x$. This means, given our definition of market integration (finding exactly n - 1 cointegrating vectors), inclusion of stationary variables can potentially change the conclusions. We have applied the augmented Dickey-Fuller test (ADF) and a test from Kwiatkowski and others (1992) to examine the stationarity of the individual series. Both tests suggest that all series are I(1). For the sake of brevity, the results of these tests are not included, but they are available from the author upon request.

# 4. Empirical results

## 4.1. General note on estimation

A key element of implementing the methodology is the determination of cointegration rank (that is, the rank of $\Pi$), which critically depends on appropriate lag length and deterministic components (constant, time trend, and so onF) in the cointegration space (Johansen 1992; Johansen and Juselius 1992). Information criterion and lag reduction tests[8] are performed to determine the lag length, and the appropriate deterministic components are decided based on a Pantula method, as proposed by Johansen (1992). Three alternative models are considered to implement the Pantula method: (1) restricting all deterministic components to a constant, (2) allowing a constant and a deterministic trend in levels, and (3) allowing a constant in the cointegrating relation, a trend in level, and a trend in cointegrating relations.[9]

The extent of market integration is examined as follows. For each of the three cereals, analysis begins with three major locations, Addis Ababa, Nazareth, and Jimma. If cointegration rank is found to be *n* - 1 with appropriate lag and other diagnostics, another location is added and the procedure is repeated. This is done until each minor location, in turn, has been added to the three major locations.[10] Once the extent of integration is determined, the common long-run memories are estimated using a VMA model. For any given cereal, the coefficients of the long-run memories provide some indications of the importance of market locations in the long run. However, they do not explain how shocks to one of the cereals get transmitted to the rest. Following Gonzalo and Granger (1995), this is done by examining the relationships among the common long-run memories of the three cereals, which are *I(1)* variables by definition.

## 4.2. The extent of integration

The results of the sequential procedure of determining *n* - 1 cointegrating vectors are presented in Table 4.1. The first column shows the sequence in which market locations are analyzed for the three commodities. We began with three main locations (AA, NZ, and JM), which the tests suggest share a common long-run memory. For each addition of market location, the null hypothesis of $H_o$: $r = n-1$ is tested against the alternative, $H_1$: $r = n-2$, with Johansen's $\lambda_{Trace}$ tests. As an illustration, consider the results for wheat. For the three main market locations, $r = n-2$ is clearly rejected at the five percent level of significance.[11] The same conclusion holds when SM is included. However, when DD or MK is added, the hypothesis Ho: $r = n-1$ is rejected in favor of the alternative, H1: $r = n-2$, implying that these market locations share different common long-run memories. The test results are similar for the other two cereals. Thus, we conclude that only the market locations in the center (AA and NZ), southwest (JM), and south central (SM) areas are integrated, and the rest (in the north and east) are not.

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[8] The lag reduction test is formulated as $H_{ij} : H(k = i)$ against $H(k = j)$ for $j = 2, \ldots\ldots k_{\max}$ and $i = 1, \ldots\ldots, j\text{-}1$, respectively. It is an LR test that follows $\chi^2$ distribution with $(j-i)n^2$ degrees of freedom.

[9] The ordering of the models is done from most to least restrictive. Johansen (1992) discuss the rationales for using this ordering and for selecting the model using the Pantula method.

[10] The diagnostics included tests for normality, autocorrelations, and autoregressive conditional heteroskedasticity (ARCH).

[11] Although not reported, the roots of the companion matrix were calculated to double-check accuracy of rank determination. For the sake of brevity, these results are not reported, but they are available from the author upon request.

**Table 4.1. Cointegration rank tests for maize, wheat, and teff prices in various markets locations** $H_0 : r = n-1 against\ H_a : r < n-1$

| Commodity / market locations | $\Pi(r)$ | Trace test | Critical values Trace (90) | Trace (95) |
|---|---|---|---|---|
| **Tests for maize** | 0 | 76.99 | 59.14 | 62.99 |
| | 1 | 40.26 | 39.06 | 42.44 |
| Addis + Nazareth + Jimma + Shashemene | 2 | 14.62 | 22.76 | 25.32 |
| | 3 | 2.89 | 10.49 | 12.25 |
| | 0 | 107.35 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Dire Dawa | 1 | 65.63 | 59.14 | 62.99 |
| | 2 | 38.26 | 39.06 | 42.44 |
| | 3 | 15.32 | 22.76 | 25.32 |
| | 4 | 5.48 | 10.49 | 12.25 |
| | 0 | 129.32 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Mekelle | 1 | 67.97 | 59.14 | 62.99 |
| | 2 | 42.13 | 39.06 | 42.44 |
| | 3 | 16.8 | 22.76 | 25.32 |
| | 4 | 2.67 | 10.49 | 12.25 |
| **Tests for wheat** | 0 | 84.08 | 59.14 | 62.99 |
| | 1 | 55.00 | 39.06 | 42.44 |
| Addis + Nazareth + Jimma + Shashamene | 2 | 27.45 | 22.76 | 25.32 |
| | 3 | 4.53 | 10.49 | 12.25 |
| | 0 | 105.66 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Dire Dawa | 1 | 71.05 | 59.14 | 62.99 |
| | 2 | 42.55 | 39.06 | 42.44 |
| | 3 | 19.30 | 22.76 | 25.32 |
| | 4 | 5.72 | 10.49 | 12.25 |
| | 0 | 101.45 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Mekelle | 1 | 68.89 | 59.14 | 62.99 |
| | 2 | 39.21 | 39.06 | 42.44 |
| | 3 | 16.20 | 22.76 | 25.32 |
| | 4 | 4.19 | 10.49 | 12.25 |
| **Tests for teff** | 0 | 83.44 | 59.14 | 62.99 |
| | 1 | 47.90 | 39.06 | 42.44 |
| Addis + Nazareth + Jimma + Shashemene | 2 | 24.64 | 22.76 | 25.32 |
| | 3 | 12.05 | 10.49 | 12.25 |
| | 0 | 109.18 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Dire Dawa | 1 | 66.77 | 59.14 | 62.99 |
| | 2 | 36.45 | 39.06 | 42.44 |
| | 3 | 19.10 | 22.76 | 25.32 |
| | 4 | 5.44 | 10.49 | 12.25 |
| | 0 | 110.27 | 83.20 | 87.31 |
| Addis + Nazareth + Jimma + Shashemene + Mekelle | 1 | 71.26 | 59.14 | 62.99 |
| | 2 | 42.82 | 39.06 | 42.44 |
| | 3 | 15.90 | 22.76 | 25.32 |
| | 4 | 4.49 | 10.49 | 12.25 |

Source: Author's calculation.
Note: Critical values, taken from Osterwald-Lenum (1992), change depending on which of the three models is selected.

These results are (1) robust to various diagnostic tests, (2) generally in conformity with available market integration studies, and (3) consistent with the geographic distribution of production and consumption in Ethiopia. The diagnostic tests were performed at each step of the estimation. The lag length reduction tests and the residual analysis results for the final models are reported in Tables 4.2 and 4.3. For both wheat and maize, the null hypothesis $H_o$: $k$ = 2 against $H_1$: $k$ = 3 to 6 cannot be rejected (Table 4.3). However, for teff, a lag length of smaller than six is clearly rejected. Therefore, we initially specified VAR with two lags for wheat and maize and VAR with six lags for teff. However, if the LM tests indicated evidence of autocorrelations, the lag length was increased and the model re-estimated. The test results, presented in Table 4.4, suggest that there is no evidence of autocorrelation and the residuals are largely normal.

**Table 4.2. Test for lag length determination**

| Ho: $k=i=j-1$ against $H_1$: $k=j$ | Test for maize LR test | | Test for wheat LR test | | Test for teff LR test | |
|---|---|---|---|---|---|---|
| | $\chi^2(j-i)n^2$ | p-value | $\chi^2(j-i)n^2$ | p-value | $\chi^2(j-i)n^2$ | p-value |
| K=5 against K=6 | $\chi^2_{16}$ = 15.082 | 0.519 | $\chi^2_{16}$ = 25.842 | 0.056 | $\chi^2_{16}$ = 51.532 | 0.000 |
| K=4 against K=6 | $\chi^2_{32}$ = 30.464 | 0.544 | $\chi^2_{32}$ = 64.059 | 0.001 | $\chi^2_{32}$ = 67.572 | 0.000 |
| K=4 against K=5 | $\chi^2_{16}$ = 15.381 | 0.497 | $\chi^2_{16}$ = 38.216 | 0.001 | $\chi^2_{16}$ = 16.040 | 0.450 |
| K=3 against K=6 | $\chi^2_{48}$ = 44.322 | 0.624 | $\chi^2_{48}$ = 80.080 | 0.003 | $\chi^2_{48}$ = 96.858 | 0.000 |
| K=3 against K=5 | $\chi^2_{32}$ = 29.240 | 0.607 | $\chi^2_{32}$ = 54.238 | 0.008 | $\chi^2_{32}$ = 45.325 | 0.059 |
| K=3 against K=4 | $\chi^2_{16}$ = 13.858 | 0.609 | $\chi^2_{16}$ = 16.022 | 0.451 | $\chi^2_{16}$ = 29.286 | 0.022 |
| K=2 against K=6 | $\chi^2_{64}$ = 64.423 | 0.462 | $\chi^2_{64}$ = 97.863 | 0.004 | $\chi^2_{64}$ = 119.045 | 0.000 |
| K=2 against K=5 | $\chi^2_{48}$ = 49.341 | 0.419 | $\chi^2_{48}$ = 72.021 | 0.014 | $\chi^2_{48}$ = 67.512 | 0.033 |
| K=2 against K=4 | $\chi^2_{32}$ = 33.959 | 0.373 | $\chi^2_{32}$ = 33.805 | 0.380 | $\chi^2_{32}$ = 51.473 | 0.016 |
| K=2 against K=3 | $\chi^2_{16}$ = 20.101 | 0.216 | $\chi^2_{16}$ = 17.783 | 0.337 | $\chi^2_{16}$ = 22.187 | 0.137 |
| K=1 against K=6 | $\chi^2_{80}$ = 10.498 | 0.014 | $\chi^2_{80}$ = 26.711 | 0.001 | $\chi^2_{80}$ = 144.755 | 0.000 |
| K=1against K=5 | $\chi^2_{64}$ = 95.416 | 0.007 | $\chi^2_{64}$ = 100.868 | 0.002 | $\chi^2_{64}$ = 93.223 | 0.010 |
| K=1 against K=4 | $\chi^2_{48}$ = 80.035 | 0.003 | $\chi^2_{48}$ = 62.652 | 0.076 | $\chi^2_{48}$ = 77.183 | 0.005 |
| K=1 against K=3 | $\chi^2_{32}$ = 66.176 | 0.000 | $\chi^2_{32}$ = 46.630 | 0.046 | $\chi^2_{32}$ = 47.898 | 0.035 |
| K=1 against K=2 | $\chi^2_{32}$ = 46.075 | 0.000 | $\chi^2_{32}$ = 28.847 | 0.025 | $\chi^2_{32}$ = 25.711 | 0.058 |

Source: Author's calculations.

**Table 4.3. Mis-specification tests on the final model for each cereal**

| Grains/ equations | Univariate tests | | | | Multivariate tests | |
|---|---|---|---|---|---|---|
| | ARCH | | Normality | | Autocorrelation | |
| | $\chi^2(j-i)n^2$ | p-value | $\chi^2(j-i)n^2$ | p-value | LM test stats | p-value |
| **Maize** | | | | | | |
| 1 | 1.90 | 0.59 | 10.27 | 0.01 | LM(1) $= \chi^2_9$ :7.71 | 0.56 |
| 2 | 3.81 | 0.28 | 2.05 | 0.37 | | |
| 3 | 1.68 | 0..64 | 4.27 | 0.12 | LM(2) $= \chi^2_9$ : 8.55 | 0.48 |
| 4 | 0.66 | 0.88 | 4.07 | 0.13 | | |
| **Wheat** | | | | | | |
| 1 | 0.23 | 0.89 | 3.60 | 0.17 | LM(1) $= \chi^2_{16}$ :12.68 | 0.70 |
| 2 | 1.84 | 0.40 | 9.35 | 0.02 | | |
| 3 | 1.02 | 0.60 | 1.03 | 0.60 | LM(2) $= \chi^2_{16}$ : 5.11 | 0.52 |
| 4 | 13.23 | 0.00 | 13.21 | 0.00 | | |
| **Teff** | | | | | | |
| 1 | 9.21 | 0.24 | 2.13 | 0.35 | LM(2) $= \chi^2_{16}$ : 5.11 | 0.23 |
| 2 | 4.72 | 0.70 | 2.59 | 0.28 | | |
| 3 | 6.92 | 0.44 | 3.48 | 0.18 | LM(2) $= \chi^2_{16}$ : 3.98 | 0.90 |
| 4 | 4.69 | 0.70 | 34.02 | 0.00 | | |

Source: Author's calculations.

**Table 4.4. Cointegration rank tests and diagnostics on $f_{ti}$**

| Cointegration rank tests | | |
|---|---|---|
| $\Pi(r)$ | **Trace test** | **Trace (95)** |
| 0 | 36.78 | 35.07 |
| 1 | 20.34 | 20.16 |
| 2 | 6.46 | 9.14 |

| Mis-specification tests results | | | | |
|---|---|---|---|---|
| | ARCH (4) | | Normality | |
| **Eqns** | **Test stats** | **p-value** | **Test stats** | **p-value** |
| 1 | 6.54 | 0.16 | 1.94 | 0.38 |
| 2 | 6.73 | 0.15 | 1.56 | 0.45 |
| 3 | 2.95 | 0.57 | 4.49 | 0.11 |

Source: Author's calculations.

Although obtained through different methodology, the above results do not diverge much from those of the available studies. For example, the two most recent studies—by Negassa and Myers (2007) and by World Bank (2006)—draw very similar conclusions. Using an extended PBM, Negassa and Myers examined whether cereal market efficiency improved following the 1999 reforms and concluded that the policy change generally had little effect in improving spatial market efficiency. In particular, the study found that, for both maize and wheat, DD in the east and Desse in the north were not integrated and MK showed an insignificant improvement. The World Bank (2006) study, on the other hand, used a bivariate error correction model but drew a similar conclusion—that is, the northern and eastern deficit regions were not integrated. A much older study (Dercon 1995) also found the eastern region (DD) not to be integrated in the long run, but this study did not include the northern market, MK. Finally, the regional production estimates of the Central Statistical Authority (CSA) of Ethiopia over the last five years indicate that more than 80 percent of the cereals in the country are produced in the regions where markets are integrated.

### 4.3. The relationship among the $f_{ti} = \alpha_{\perp} P_{ti}$ for each cereal

The main focus of this paper is to examine how shocks to one cereal market get transmitted to the markets for other cereals. We do this by (1) estimating long-run memories, $f_{ti} = \alpha_{\perp} P_{ti}$, for each cereal and (2) examining the relationships among the $f_t$'s of the three cereals. The estimated $f_t$ for each cereal is presented below:[12]

$$
\begin{aligned}
f_t\_Wheat &= AA - 0.08\,NZ + 0.28\,JM + 0.61\,SM \\
f_t\_Maize &= AA - 0.35\,NZ + 0.36\,JM + 0.61\,SM \quad \cdots\cdots\cdots \\
f_t\_Teff &= AA + 0.38\,NZ - 0.01\,JM + 0.12\,SM
\end{aligned} \tag{6}
$$

Following the method proposed by Gonzalo and Granger (1995), we now analyze the relationships among these three equations. The underlying idea is that since ft's are I(1) variables by definition, they are cointegrated and have common long-run memories. The cointegration test results, along with diagnostics, are presented in Table 4.5. The numbers suggest that there are two cointegrating vectors and hence a unique long-run memory.

**Table 4.5. Relationships and hypothesis tests on $Fti's$**

| $f_t's$ | Estimates of $\alpha_{\perp}$ | Hypothesis tests<br>Ho: ***shocks to*** $f_{ti}$ ***have no permanent effect***<br>Test stat | <br><br>p-value |
|---|---|---|---|
| Maize | 0.83 | $\chi^2_1 = 7.26$ | 0.007 |
| Wheat | -0.52 | $\chi^2_1 = 3.24$ | 0.072 |
| Teff | 0.21 | $\chi^2_1 = 0.13$ | 0.720 |

Source: Author's calculations.

The test for whether shocks to a given variable have long-term impacts on the variables in the system is a test for unit vector, where the null hypothesis is that shocks to a given

[12]As Gonzalez-Rivera and Helfand (2001) have discussed, these estimates provide some insights into the relative importance of the market locations. For example, consider the case of maize, which is dominated by the AA price, with JM and SM being two other important locations. Teff is largely influenced by AA, followed by NZ, with the other two locations having very small influence. For wheat, on the other hand, JM and SM appear to be the most dominant, followed by AA. Being the largest city and consumption location, it is no surprise that AA has the largest influence on price formation. However, note that the production locations are also important, such as NZ for teff and SM and JM for maize and wheat.

variable do not have long-term impacts on the variables in the system. Table 4.5 presents these test results, which include hypothesis test results along with estimated $\alpha_{i\perp}$. As discussed in Gonzalez-Rivera and Helfand (2001), the estimates of $\alpha_{i\perp}$ indicate the relative importance of each commodity in driving the long-run prices. The hypothesis test results, on the other hand, determine the significance of a shock to a given commodity on the dynamics of itself and other cereals. Notice that the hypothesis is strongly rejected for maize and wheat but accepted for teff. Thus, it can be concluded that shocks to either the maize or the wheat market will influence each other, but the teff market will have insignificant effects on the other two.

### 4.4. Generalized impulse response analysis

The generalized impulse responses to a shock of one standard error to long-run memories of maize and wheat are presented in Figures 5.1 and 5.2. The results are consistent with the results of the previous section but provide further details in terms of persistence and transmission of shocks across commodity and over a three-year time horizon. Three findings are obvious from these figures:

1. Shocks to both maize and wheat have very little impact on teff.
2. Shocks to maize have a relatively higher impact on wheat than do shocks to wheat on maize.
3. Shocks to either maize or wheat do not die down within a three-year time horizon.

Given that teff is the most cherished cereal among Ethiopians, this finding might seem a little counterintuitive at first sight. However, the finding is very consistent with the market structure. Teff is more resilient to climatic shocks and its production has not experienced as much technological change as has that of maize and wheat. Simple measures of variability, such as coefficient of variations, show that both yield and price are more stable for teff than for any other cereal in the country. By contrast, in the time period considered for this analysis, maize and wheat have shown more growth and experienced more shocks, such as the collapse in 2002.

## 5. Discussion of results

The analysis in the previous section presents evidence on the extent of markets and the significance and persistence of shock transmission over time. Although obtained through different methodology, the results on market integration are largely in conformity with those of earlier studies. The analysis of the inter-commodity price relationships and shock transmission is new. The results suggest that shocks to both maize and wheat markets have significant long-run impacts, although shocks to maize markets have relatively larger impacts on wheat than shocks to wheat markets on maize. These findings have important policy messages for managing cereal price instability and for planning food aid imports and distribution as well as other food-based intervention programs.

### 5.1. Implications for grain price stabilization

The relative importance of maize in the long-run relationships and its significance in shock transmission imply that price stabilization schemes, in whatever form, are likely to be more effective if they focus on maize. The collapse of grain markets in 2002 and price hikes in 2006/07 can provide further insights about this inference. With help from international nongovernmental organizations (NGOs), farmers began to adopt improved maize technology on a large scale in the late 1990s. As farmers adopted the new technology in favorable weather conditions, the country harvested two consecutive years of bumper crops in 2001 and 2002. However, the blessings of the technology did not translate into improvements in farm households' well-being. A few years earlier, the government had suspended minimum price support policies, and therefore when production boomed, maize prices collapsed—so much so that maize farmers allegedly did not find it profitable to harvest their maize crops.

The situation warranted some form of intervention. The EGTE entered into the market to purchase maize at a preannounced price and exported 11,000 tons of maize. However, the data for subsequent years suggest that the event had already shattered farmers' confidence in the market. Gabre-Madhin (2003) estimated that farm gate prices of maize declined by an unprecedented 80 percent in early 2002, the ratio of input prices to producers' price jumped from 1.7 in 2000 to about 9.0 in 2002, and fertilizer application rates declined by more than 20 percent in the following cropping season. More importantly, data from the CSA suggest that, unlike that of other cereals, total maize production declined for four years in a row following the price collapse. This was a big blow to a crop that has the highest yield rates,[13] has shown the highest production growth over the past 10 years, and perhaps has the largest future potential for regional trade.

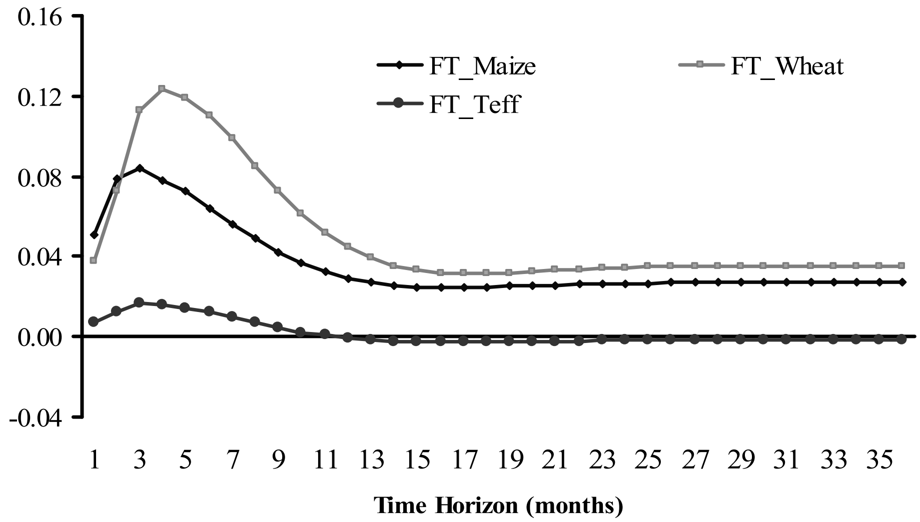
In late 2005 and early 2006, Ethiopian grain markets started exhibiting quite a different trend. Despite consecutive years of good harvests, prices of major cereals increased sharply. Between 2005 and 2006, nominal prices increased by more than 48 percent for teff, more than 27 percent for wheat, and about 10 percent for maize. This sharp rise in cereal prices was a major concern for the government and its development partners. For policymakers it was an unacceptable rise in cereal prices, and the government temporarily instituted food rationing in major urban centers.[14] The World Bank commissioned a study to analyze the

[13] Maize yield rates over the past 10 years have been 1.75 to 2.2 tons per hectare, compared to 1.4 to 1.5 tons per hectare for wheat and 0.8 to 0.9 tons per hectare for teff.

[14] The urban wheat rationing program began in April 2007 in Addis Ababa and in July 2007 in other regional cities. Beneficiary households received 25 kilograms of wheat per month. Since its inception, the rationing program has distributed more than 950,000 tons of wheat.

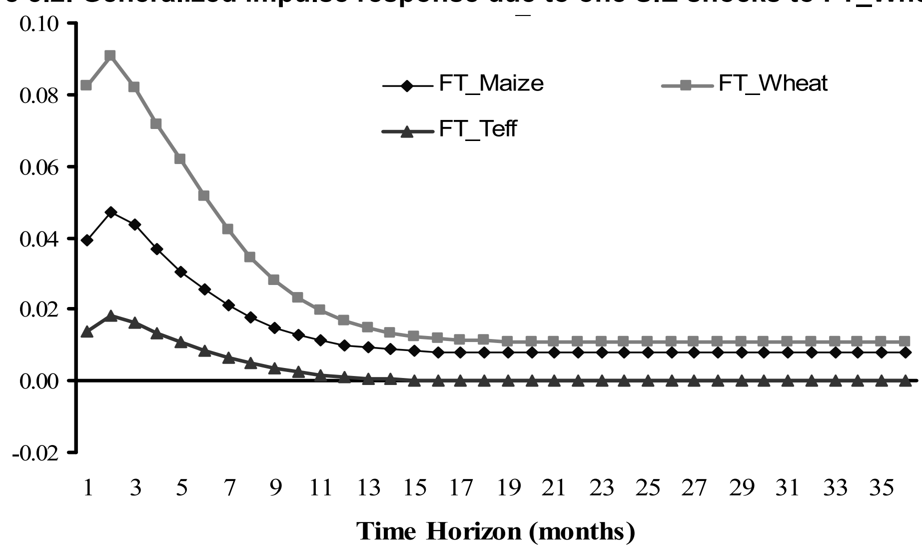
situation. It concluded that monetary policy phenomena accounted for much of the increase (about 89 percent) in cereal price (World Bank 2007). The study argued that the real price of teff had increased by about 26 percent and that of wheat by 8 percent but that maize prices had actually declined by 6.5 percent. Although they are not strictly comparable, these numbers are consistent with the results in Table 4.5 and Figure 5.1 of our analysis.

**Figure 5.1. Generalized impulse responses due to one S.E shocks for FT_Maize**




Source: Author's calculations.

**Figure 5.2. Generalized impulse response due to one S.E shocks to FT_Wheat**




Source: Author's calculations.

Thus, the results of our analysis are consistent with the above experiences. This suggests that managing price instability of maize and wheat in a given price band can help promote grain-sector development. However, this does not mean reintroduction of old-style parastatal-centric stabilization policies. Instead, it means institutionalizing the policies that have been implemented on ad hoc and temporary bases, such as giving a minimum price support in 2002 and rationing food in 2007. If implemented properly, a credible price band will bring transparency to the market, promote adoption of modern technology, and boost much-needed supply responses.

### 5.2. Implications for food aid–supported programs

Most of the food aid imports to Ethiopia come as wheat and wheat flour, and a very large share of local procurement by EGTE, the World Food Programme (WFP), and other NGOs is maize. Since shocks to these two commodity markets have long-run impacts, a coordinated effort among the donors and national counterparts is needed to come up with a strategy to ensure that food aid–supported programs do not displace trade, cause production disincentives, and generate instability. In the Ethiopian context, two issues are particularly important in this regard: (1) inconsistency between food aid imports and production in terms of quantity and timing, and (2) targeting of food aid–supported programs.

Given Ethiopia's level of poverty, weaknesses in markets, and recurrence of production shocks, the role of food aid in managing emergencies is perhaps inevitable. Thus, the issue has been planning food aid imports and distribution in ways that minimize their adverse effects. A rule of thumb in food aid planning is that the higher the domestic production, the lower the imported food aid. Historical data suggest that quite the opposite has happened in Ethiopia. From 1993 to 2005, the correlation coefficient between food aid and domestic wheat production has been positive (0.13). This suggests that even in the years of good harvest, there have been large food aid inflows. This was particularly true in 2002, the year of the cereal market collapse, when food aid inflow jumped to 1.2 million tons, compared to about 300,000 tons in 2001. Such unplanned arrival and distribution of food aid can generate large variability in the cereal market, causing producing regions to face problems clearing their surpluses and often forcing farmers to sell at lower prices. If the food aid programs are driven by need, the implementing agencies should have a clear mechanism to assess the need and place the aid request accordingly. This underscores the importance of an accurate crop forecasting system. Currently, three agencies (CSA, USAID, and the FAO's WFP) carry out such forecasting, but the estimates seldom converge (World Bank 2007). Thus, if the government and the aid donors coordinate to strengthen the crop forecasting and emergency need assessment, the returns can be large in terms of improved planning of both food aid imports and local procurement.

The issue of mistargeting is often cited as the main reason for the adverse effects of food aid programs. The underlying idea is simple: If food aid goes to the households who would otherwise not have access to food, there would be little to no adverse effect on markets. In a global context, Barrett and Maxwell nicely articulate this fact by noting, "If the donor community could improve the targeting of food aid, it could improve the effectiveness of food aid in accomplishing its primary humanitarian and development aim—the maintenance of valuable human capital—and reduce many of the errors that sometimes make food aid controversial, ineffective, or both" (2002, page 2).

However, in practice, foolproof targeting has proved difficult to institute, and this has led to discussions on various ill effects of food aid. Studies argue that food aid distribution in Ethiopia is geographically biased (Jayne et al. 2002), targeting of poor households is imperfect (Dercon and Krishnan 2001), and an estimated 30 percent of food aid was mistargeted (WFP 2004). On the other hand, studies on adverse effects of food aid draw very mixed conclusions. Of the available recent studies, one finds no adverse impacts of food aid at both micro and macro levels (Abdulai, Barrett, and Hoddinott 2005) and two others find positive impacts in terms of nutritional benefits (Yamano, Christiansen, and Alderman 2005) and consumption growth (Gilligan and Hoddinott 2006). Yet others find significant negative effects, both indirect (through reduced producer prices) and direct (through reduced grain production), using both macro- and micro-level data (Demeke F. Gutu, T. Ferede 2004; World Bank 2006).

Without taking any side of the debate, one can argue that it is difficult to convince the skeptics that large food aid has no adverse effects on markets and production. Given that shocks to wheat have significant long-run impacts, that food aid flow is inconsistent with domestic production, and that crop forecast varies by sources, it is clear that careful planning of food aid imports can contribute toward improving price stability and much-needed supply responses.

## 6. Conclusion

If agricultural markets are characterized by inadequate infrastructure, information asymmetry, and incomplete markets—as is the case in many African countries—prices are bound to be volatile and some forms of intervention can be justified to address various sources of market failures. Experiences with market liberalization suggest that these policy rationales are still valid in many countries, where withdrawal of governments led to increased price variability and policy reversals. Ethiopia has had these types of experiences: Price instability has increased and government has had to intervene occasionally to address price collapse and price hikes in recent years. Thus, the challenge for the government is finding a more cost-effective price intervention strategy.

This paper has been an attempt to contribute toward that end. Using monthly prices of three major cereals in the country, it has analyzed intercommodity price relationships to examine whether targeting one of the cereals can achieve broader price stabilization objectives. Three key results emerge from the analysis:

1. Markets in the major grain-producing regions are integrated.
2. Maize is the most important of the three cereals in the common long-run memory, followed by wheat and then teff.
3. While shocks to both maize and wheat have significant long-run impacts on each other, these do not transmit to teff markets.

In light of these results, the paper argues that setting credible price bands for maize and wheat in Ethiopia can stabilize cereal prices in a more cost-effective way. Under the current policy environment, this would mean institutionalizing the policies that are being implemented on ad hoc and temporary bases, such as giving minimum price support in 2002 and providing wheat rations to urban dwellers in 2007. Given that food aid imports are largely wheat and that shocks to wheat have significant long-run impacts, the results also have implications for food aid–supported programs. The debate over targeting and adverse effects of food aid notwithstanding, historical data suggest that food aid inflow to the country has not been consistent with domestic production. This suggests that the government and its development partners should coordinate to strengthen crop forecasting and food aid planning to avoid adverse effects on cereal markets.

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