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Cereal Price Transmission in Somalia: Do Nominal and Real Prices Tell the Same Story?

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Abstract

This article assesses the degree of market functioning in Somalia through an analysis of cereal price transmission and finds a varied degree of market functioning and interconnection. This reflects the difficult environment, characterized by poor infrastructure and a high degree of insecurity and uncertainty, in which local markets operate. A comparison of the results of the analysis conducted using nominal and real data highlights the discrepancy in the findings. The use of nominal prices was found to introduce a bias in the analysis of market functioning. In particular, the use of nominal prices gives the biased impression of a) faster-than-actual transmission of sorghum prices, and b) less-substantial-than-actual price transmission of rice prices.

Keywords: Price transmission, Market integration, Consumer Price Index, Nominal and real prices

JEL Classifications: E31, F15

1. Introduction

Decades of civil war have ravaged the Somali context, severely affecting the national productive capacity and wiping out its basic infrastructure. In addition, the absence of a national government has led to a proliferation of autonomous regions, which have pursued often questionable local economic policies. Besides other critical aspects of such a process of socio-economic and political disintegration, our focus here is on the functioning of the cereal market. Access to food through markets in Somalia is a crucial determinant of food security. Over time some reviews were made of the structure, conduct and performance (WFP 2009) of the cereal market and some attempts were made as well to provide a basic assessment of its integration (FEWSNET 2011a, 2011b; Sanogo 2011).[3]

A major limitation of the analysis conducted so far is its use of nominal prices. Considering that the available price dataset spans almost two decades, and in view of the high inflation rates estimated in Somalia, it is reasonable to expect that analysis conducted on nominal prices may be misleading. Following the above, the purpose of this study is to assess the degree of cereal market integration in Somalia. In particular, it makes use of the recently-developed Consumer Price Index (CPI) to deflate nominal market prices. The analysis of nominal and real data highlights wide discrepancies in the findings. This article is organized as follows. Section 2 provides a review of the new CPI and a background to previous studies of market integration in Somalia. Section 3 presents the methodology applied in this study. Results and findings are discussed in section 4 and section 5 provides concluding considerations.

2. Current knowledge about market integration in Somalia

Very limited knowledge is available about market integration in Somalia. An assessment of market integration in southern Somalia has been conducted by FEWSNET (2011a, 2011b). The general finding is one of a reasonable degree of integration. In more detail:

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[3] The assumption that the Somali market system is robust (Longley *et al.* 2012) and therefore able to handle the increased demand generated through a demand-based strategy has led to the drastic scaling up of market-based intervention strategies during the humanitarian crisis in 2011.

a) Prices of white maize are found to be historically well correlated within southern Somalia, with the exception of a few isolated areas.
b) Sorghum prices are relatively well correlated across most of the sorghum belt (Bay, Bakool, Gedo and Hiran regions).
c) Strong integration is found between imported red rice prices across monitored reference markets in southern Somalia.
d) A good degree of correlation between the evolution of rice prices in Somalia and those in international export markets is also reported.

The findings listed above from the FEWSNET study are reflected in the analysis conducted by Sanogo (2011), which highlights how a good degree of integration between markets in southern Somalia and global and regional markets coexists with weaker cereal market integration at the domestic level. Additional insight into market integration in Somalia is provided by Brenton *et al.* (2014) who conducted a comparative study on the relevance of road infrastructure to the food trade. They find that in a sample of thirteen African countries, Somalia has one of the lowest degrees of market integration. The major determinants of such poor performance are envisaged to be poor infrastructure, long distances between markets and poor security conditions.

Finally, De Matteis (2015a) has highlighted a varied degree of price transmission throughout Somalia: better interconnected and poorly interconnected markets coexist. Interestingly, the analysis has revealed different features of the process of price transmission for the two main staples considered – rice and sorghum – mainly dictated by local supply and demand patterns. The transmission of sorghum price signals gets weaker when moving away from the main production areas in the sorghum belt, where markets play the role of price makers. This is also justified by the consideration that sorghum is the main staple in the South but not in the North. On the contrary, the degree of rice price transmission is slightly larger in the North than in the South. Again, this was somehow expected since rice is one of the food staples in the North but not in the South. Along the imported nature of rice, the main price-making markets are major ports – i.e. Bosasso and Merka. And therefore, while sorghum price signals tend to spread generally from the sorghum belt to neighbouring regions in the South and to the North, in the case of rice, instead, price signals tend to spread mainly from the two main entry points on the coast towards different directions in the hinterland.

3. Methodology

This section provides background information on the methodological approach followed for the analysis of market integration in the literature and presents the methodology applied to the data preparation and analysis for this study.

3.1 Spatial market integration and its measurement in the literature

Spatial price transmission has been widely analyzed in the context of the 'law of one price', which assumes that if two markets are linked by trade in an efficient market, the movement of prices in one market will be equalized with the movement in the other in the long run, while allowing for deviations in the short run (Margarido *et al.* 2007). An increase in price will therefore lead to an equally proportional increase, at all points in time, assuming that the markets are perfectly integrated (Mundlak & Larson 1992). In this context, 'spatial price transmission' means the process and degree to which markets for homogeneous commodities at spatially separated locations share long-run market information (McNew 1996; Amikuzuno 2009). The fact that price analysis tells us little or nothing about actual trading behaviour and market efficiency has been pointed out (Baulch 1997; Barrett & Li 2002). Nevertheless, it is common practice to analyse price transmission to assess market integration, with the implicit or explicit assumption that lack of market integration implies market inefficiency (Rashid & Minot 2010). This is done with the understanding that price transmission is not the same as market integration, and that one can occur without the other. In fact, there may be market integration without price transmission if transaction costs are non-stationary, and there may be price transmission between two markets without market integration if there is a third market explaining the price-making in the other two. Cointegration has been extensively discussed and applied in the literature, and therefore a presentation of the methodological framework is beyond the scope of the present study. The concept of cointegration (Granger 1981) and the methods for estimating a cointegrated system (Engle & Granger 1987; Johansen 1995, 1991, 1988) provide a framework for estimating and testing equilibrium relationships between non-stationary integrated variables. Cointegration methods are not immune to limitations (Barrett & Li 2002; Rapsomanikis *et al.* 2003); however they are currently considered the most appropriate approach for analysing spatial market relationship (Rapsomanikis *et al.* 2003). A comprehensive analytical framework for this econometrics approach can be found in Balcombe and Morrison (2002), and Rapsomanikis *et al.* (2003).

Cointegration methods take into account the fact that prices be non-stationary, which otherwise would cause standard regression analysis to give misleading results.[4] Cointegration between the price series analyzed implies that two prices may behave in a different way in the short run, but that they will converge toward a common behaviour in the long run. If this property is verified, the characteristics of the dynamic relationship between the prices can be described by an Error Correction Model (ECM). The short-run adjustment parameter of this type of model can be interpreted as a measure of the speed of price transmission, while the long-run multiplier can be interpreted as a measure of the degree of price transmission from one price to the other (Prakash 1999). The properties of cointegrated series also imply the existence of a causality relation, as defined by Granger, which can be tested by assessing whether the evolution of one of the two price series predicts that of the other. The analysis of spatial market integration can be applied to virtually any commodity or group of commodities. However, one of its most common applications is to the agricultural commodities market, and, in particular, to the case of staple food.[5]

3.2 Analytical approach followed in this study

In this study the analysis of market integration makes use of price time series data. The basic principle is the assumption that the closer the changes in prices experienced in two markets, the more integrated the two markets can be seen to be. In order to study the interdependence of price time series between any pair of markets *i* and *j*, we can refer to a linear relationship of the type:

$$p_{it} = \theta_1 + \theta_2 \, p_{jt} + u_t \tag{1}$$

where:

p_{it} represents the retail price prevalent on market *i* at time *t*;

p_{jt} represents the retail price prevalent on market *j* at time *t*;

u_t represents the error term;

θ_1 and θ_2 represent the coefficients to be estimated.

Once the condition of stationarity of the series and their cointegration are verified through *ad hoc* tests as the Augmented Dickey-Fuller test or the Phillips-Perron tests, the Error-Correction Model is adopted:

$$\Delta p_{it} = \alpha_1 + \alpha_2 \, \Delta p_{jt} + \alpha_3 \left(p_i - \theta_1 - \theta_2 \, p_j\right)_{t-1} + u_t \tag{2}$$

where Δp indicates the change in price between one period and the previous one (*t* and *t-1*) in market *i* or *j*.

This model can be interpreted by considering how traders adjust the price of their merchandise (Δp_{it}) from one period to the next in response to changes in concurrent prices on other relevant markets (Δp_{jt}) as well as to the previous disequilibrium between the price prevalent on their market *i* and on market *j*. From this perspective α_2 measures the short-run effect in the process of price change and α_3 measures the speed of price adjustment on market *i* to a discrepancy between p_i and the price prevalent on the reference market (p_j) in the previous period. The greater the value of α_3, the more integrated the two markets are.

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[4] Non-stationary variables do not have a constant mean or variance over time, one example being the 'random walk' which has no tendency to return to a central value. This violates one of the assumptions behind regression analysis. The result is that regression analysis of non-stationary variables will often show a 'relationship' where none exists.

[5] To cite just a few studies on the integration of agricultural markets: Goletti & Babu (1994), Chirwa (2000) and Meyers (2008) focus on maize prices in Malawi; Lutz *et al.* (1995) analyzes maize prices in Benin; Ilhe *et al.* (2009) analyzes price transmission between Kenya and Tanzania; Dercon (1995), Negassa (1998) and Jaleta & Gebremedhin (2009) focus on teff, maize and wheat in Ethiopia; Badiane & Shively (1998), Rashid (2004), Tostao & Brorsen (2005), and van Campenhout (2008) focus on maize prices in Ghana, Uganda, Mozambique and Tanzania; Moser *et al.* (2009) analyzes rice prices in Madagascar; Rapsomanikis *et al.* (2003) and Conforti (2004) compare the evolution of prices of food commodities and cash crops in a few countries against those on the international market.

The error-correction term $\left(p_i - \theta_1 - \theta_2\, p_j\right)_{t-1}$ can be interpreted as the deviation from the long-term equilibrium between the prices on two markets, where the coefficient θ_2 measures the long-term effect in the process of adjustment – i.e. how much change in one price is determined by the change in the other. The greater the value of θ_2 the more integrated the two markets are, and on a larger scale, the more functional the local market is expected to be. The use of vector autoregression models allows us to move from bivariate to multivariate cointegration to analyse the interaction of several time series. In this case the ECM becomes:

$$\Delta p_t = \mu + \alpha\theta^{'} p_{t-1} + \sum_{i=1}^{n-1} \Gamma_i \Delta p_{t-i} + u_t \qquad (3)$$

where:

p_t is a multi-dimensional vector whose components are the market prices at time *t*;

Δp_t is the difference between p_t and p_{t-1};

α is the speed-of-adjustment matrix;

θ is a matrix whose columns are linearly independent cointegrating vectors, with $\theta^{'} p_{t-1}$ representing the long-run equilibrium errors. The number of linearly co integrating relationships, *r*, lies between 0 and K-1, where K is the number of dependent variables in p_t. Furthermore, *r* is the rank of $\alpha\theta^{'}$.

3.3 The data and its preparation

3.3.1 Selection of commodities

This study covers two commodities: red rice and red sorghum. The rationale for considering two commodities is that in our case consumption patterns seem to be strongly diversified due to a strong difference in consumers' preference: while there is higher consumption of red rice in the north and central regions, more red sorghum is consumed in the south.

3.3.2 Selection of markets

The dataset managed by the Food Security and Nutrition Analysis Unit (FSNAU) includes time series of the prices of a multitude of commodities that have been monitored across 48 urban markets and 51 rural trading centres, mostly since 1995. In order to optimize the use of available data, markets where data collection was started after 2007 are not included in this analysis. Therefore this study focuses on a reduced sample of 25 markets: Abudwak, Adanyabal, Baidoa, Beletwein, Boroma, Bosasso, Dusamared, El Der, Erigavo, Galkayo, Garowe, Hara Dhere, Hargeisa, Hudur, Jowhar, Kismayo, Lasanod, Lugh, Merka, Mogadishu Bakara, Qansah Dere, Qorioley, Togwajiale, Wanle Weyne and Zeilac Lawayacado.[6] Figure A.1 helps to visualize the spatial distribution of our sample of market centers.

3.3.3 Deflation of prices

This study covers a time span of almost two decades. The length of the time span covered, as well as the persistent conditions of financial and economic – not to mention political, institutional, military – turmoil, which characterizes the Somali context since the early 1990s require an appropriate system of accounting for the evident commodity inflation periods, which have occurred throughout the past two decades. The problem has become particularly evident since 2008-09, when Somalia experienced hyperinflation due to a combination of excessive illegal printing of the Somali Shilling and the impact of the global food price crisis. The recently-developed CPI has been used to deflate the market prices of the two commodities (De Matteis 2015b). Rather than using the national CPI, market prices were deflated using the zonal – i.e. northern, central and southern, Mogadishu – CPIs because they reflect local market exchanges and inflationary processes better, in view of the different demand and supply patterns for each commodity in different zones, as well as the different monetary policies implemented autonomously by local authorities.

[6] See De Matteis (2015a) for the analysis of a sample of 38 market centers.

Furthermore, to take into account local peculiarities due to the use of different currencies, markets in the northern zone were diversified according to the currency used – either Somali Shilling (SoSh) or Somaliland Shilling (SlSh) – and prices were deflated through the respective CPIs. Overall, the following four deflators were utilized: northern SlSh, northern SoSh, central and southern, Mogadishu. Their evolution is reported in Figure 1.

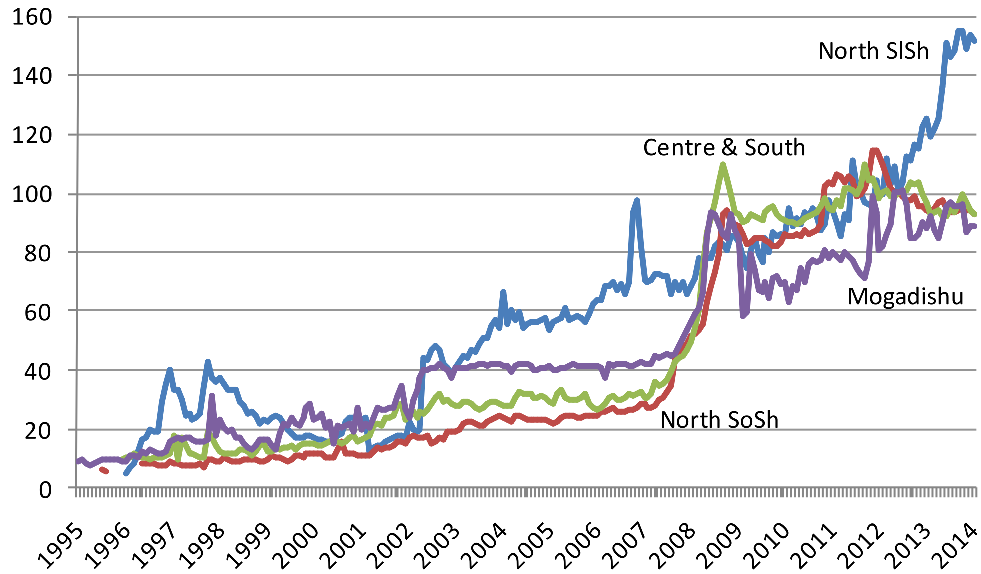

Figure 1 CPIs utilized as deflators

Source: De Matteis, 2015b

In general, volatility is a common feature of prices in Somalia. However, price movements show a different pattern whether their evolution is considered in real or in nominal terms. The general and structural process of price rises that has been going on since the global financial crisis occurred in 2007-08, which is the main striking feature of nominal price evolution, is also reflected in the evolution of real prices. However, in the latter case its relevance is reduced and balanced by a rather stable long-term trend. In some cases, this trend is even decreasing, revealing that often real prices have not increased – or have rather decreased – in the long run, contrary to the misleading impression given by the evolution of nominal prices. The following section of the analysis makes use of deflated price data. It is followed by a comparison of the results of the analysis conducted using real and nominal prices.

4. Findings

4.1 Findings from the analysis of real prices

The analysis conducted here makes use of multivariate cointegration techniques.[7] These were initially applied to each zone separately, and then to the three zones combined. The analysis of the aggregate sample covers eleven markets: two from each zone identified by the analysis above as the most relevant centers in the price transmission process (Baidoa, Merka, Galkayo, Hara Dhere, Bosasso and Hargeisa), plus five additional markets in the southern zone (Beletwein, Jowhar, Kismayo, Lugh and Wanle Weyne). For comparative purposes the analysis was conducted for both commodities on the same samples of markets.

First of all, a trace test was run to estimate the number of cointegrated links.[8] The results highlight the existence of a larger number of cointegrated links in the rice market than in the sorghum market. At the zonal level, this greater integration of the rice market is evident in the north, where three cointegrating equations have been identified for rice, compared to only two for sorghum. No difference is detected in either the central zone or in the south, where three and four equations have been detected respectively. However, analysis of the three zones using a combined approach finds five cointegrating equations for red rice and only one for red sorghum.

[7] Results derived from the application of bivariate cointegration can be found in De Matteis (2015a).

[8] The trace or Johansen test is applied through the analysis of multivariate cointegration to identify the number of cointegrating relationships. A larger number of cointegrating relationships signals a more structured network of cointegrated markets.

The main parameters in the analysis of multivariate cointegration – i.e. the coefficients of long-term adjustment θ_2 and speed of adjustment α_3 – are reported in Tables 1-4. Overall, the general interpretation of the results reveals a higher degree of cointegration for the rice market than for the sorghum market.

Table 1 Coefficients of multivariate cointegration of real prices: Northern zone

	Red sorghum				Red rice					
	c.e. 1		c.e. 2		c.e. 1		c.e. 2		c.e. 3	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Bosasso	1	-0.03 ***		-0.06 **	1	-0.04		0.02		-0.07
		(0.01)		(0.02)		(0.02)		(0.06)		(0.06)
Hargeisa		-0.12 ***	1	-0.20 **		0.03	1	-0.31 **		-0.04
		(0.03)		(0.04)		(0.04)		(0.11)		(0.11)
Erigavo	-34.10 ***	-0.03	21.76 ***	-0.06 *		0.05		0.07	1	-0.43 ***
	(4.23)	(0.02)	(2.68)	(0.03)		(0.04)		(0.10)		(0.10)
Boroma	12.92 ***	0.00	-9.67 ***	0.01	-2.73 ***	0.22 ***	-0.13	0.32 ***	-0.15	-0.09
	(2.84)	(0.03)	(1.80)	(0.04)	(0.40)	(0.04)	(0.13)	(0.11)	(0.13)	(0.10)
Lasanod	8.56 ***	-0.02	-5.56 ***	-0.03	0.57 *	0.02	-0.27 **	0.10	-0.07	0.00
	(2.33)	(0.02)	(1.48)	(0.03)	(0.34)	(0.03)	(0.11)	(0.07)	(0.11)	(0.07)
Togwajiale	2.30	-0.08 ***	-1.62	-0.12 **	2.29 ***	0.03	-0.97 ***	0.17 *	-0.65 ***	0.07
	(1.74)	(0.02)	(1.10)	(0.04)	(0.36)	(0.03)	(0.12)	(0.09)	(0.12)	(0.09)
Zeliac L.	6.40 **	-0.18 ***	-3.09 **	-0.26 ***	-0.54 *	0.06	0.43 ***	-0.17	-0.11	0.08
	(2.31)	(0.03)	(1.46)	(0.05)	(0.33)	(0.05)	(0.11)	(0.13)	(0.11)	(0.12)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Data source: FSNAU

Table 2 Coefficients of multivariate cointegration of real prices: Central zone

	Red sorghum						Red rice					
	c.e. 1		c.e. 2		c.e. 3		c.e. 1		c.e. 2		c.e. 3	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Galkayo	1	-0.28 ***		-0.12 **		0.03	1	-0.30 ***		0.10 **		-0.20 **
		(0.08)		(0.06)		(0.10)		(0.09)		(0.05)		(0.08)
Hara Dhere		0.01	1	-0.08 **		0.05		0.16 **	1	-0.11 **		-0.02
		(0.06)		(0.04)		(0.08)		(0.09)		(0.05)		(0.08)
Abudwak		-0.01		-0.09 **	1	-0.18 ***		0.24 ***		-0.04	1	-0.31 ***
		(0.04)		(0.03)		(0.06)		(0.08)		(0.04)		(0.07)
Dusamared	-0.07	-0.01	0.81 ***	-0.05 *	-0.55 ***	0.19 ***	0.01	0.25 ***	1.08 ***	-0.11 ***	-0.28 **	0.08 *
	(0.15)	(0.04)	(0.25)	(0.03)	(0.14)	(0.05)	(0.16)	(0.06)	(0.35)	(0.03)	(0.13)	(0.05)
El Der	-0.39 ***	0.06	-1.39 ***	0.09	-0.29 ***	-0.03	-1.10 ***	0.15 **	-2.89 ***	0.02	-0.40 **	0.10
	(0.09)	(0.08)	(0.14)	(0.06)	(0.08)	(0.10)	(0.18)	(0.07)	(0.39)	(0.04)	(0.15)	(0.06)
Garowe	-1.03 ***	0.18 ***	0.29	-0.08 **	0.01	-0.03	0.01	0.12	1.02 ***	-0.11 **	-0.21 *	0.01
	(0.14)	(0.05)	(0.23)	(0.03)	(0.13)	(0.06)	(0.13)	(0.10)	(0.30)	(0.05)	(0.11)	(0.08)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Data source: FSNAU

Table 3 Coefficients of multivariate cointegration of real prices: Southern zone

	Red sorghum								Red rice							
	c.e. 1		c.e. 2		c.e. 3		c.e. 4		c.e. 1		c.e. 2		c.e. 3		c.e. 4	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Merka	1	-0.23 **		0.06		-0.04		-0.28 ***	1	0.02		0.03		-0.12 *		0.08 **
		(0.10)		(0.05)		(0.05)		(0.06)		(0.15)		(0.09)		(0.07)		(0.04)
Baidoa		0.15	1	-0.14 **		0.13 **		-0.28 ***		0.42 ***	1	-0.35 ***		0.00		-0.02
		(0.11)		(0.05)		(0.06)		(0.07)		(0.15)		(0.09)		(0.07)		(0.04)
Kismayu		0.21		0.12 *	1	-0.32 ***		0.15 *		0.36 **		0.10	1	-0.28 ***		0.11 **
		(0.14)		(0.07)		(0.07)		(0.09)		(0.16)		(0.10)		(0.08)		(0.05)
Beletwein		-0.07		-0.06		0.12 **	1	-0.42 ***		0.26 *		-0.04		0.05	1	0.02
		(0.09)		(0.05)		(0.05)		(0.06)		(0.14)		(0.08)		(0.07)		(0.04)
Adanyabal	-0.20 ***	0.14 *	0.63 ***	0.01	0.44 ***	-0.10 **	0.37 ***	0.02	-0.15 ***	0.53 ***	0.18 *	0.02	-0.70 ***	0.21 ***	-0.32	-0.03
	(0.05)	(0.08)	(0.15)	(0.04)	(0.16)	(0.04)	(0.08)	(0.05)	(0.05)	(0.16)	(0.10)	(0.10)	(0.13)	(0.08)	(0.29)	(0.05)
Hudur	-0.06	0.14	-1.80 ***	0.12 **	-1.17 ***	0.04	-1.11 ***	-0.13 *	-0.17 **	0.25 **	-0.13	-0.09	-0.23	0.12 **	1.02 **	-0.06 **
	(0.11)	(0.11)	(0.31)	(0.05)	(0.33)	(0.06)	(0.17)	(0.07)	(0.08)	(0.10)	(0.17)	(0.06)	(0.22)	(0.05)	(0.49)	(0.03)
Jowhar	-0.13	0.24 **	1.15 ***	-0.04	0.13	-0.01	-0.82 ***	-0.12 *	-0.46 ***	0.36 ***	-1.20 ***	0.09	1.90 ***	-0.16 ***	4.79 ***	0.02
	(0.10)	(0.10)	(0.28)	(0.05)	(0.30)	(0.05)	(0.16)	(0.06)	(0.11)	(0.12)	(0.23)	(0.07)	(0.30)	(0.06)	(0.67)	(0.03)
Mogadishu B.	0.17 **	0.07	-1.04 ***	0.23 ***	-0.55 **	0.01	0.21 *	-0.28 ***	-0.02	0.28	0.20 ***	-0.13	0.03	0.06	0.06	-0.04
	(0.08)	(0.15)	(0.21)	(0.07)	(0.23)	(0.08)	(0.12)	(0.09)	(0.03)	(0.22)	(0.05)	(0.13)	(0.07)	(0.11)	(0.15)	(0.06)
Qansah Dere	-0.05	0.15	0.72 ***	-0.06	0.30 ***	0.06	-0.05	-0.25 ***	0.00	0.65 ***	-0.29 *	0.19 **	-0.19	0.08	-0.87 *	0.09 **
	(0.08)	(0.13)	(0.24)	(0.06)	(0.26)	(0.07)	(0.13)	(0.08)	(0.08)	(0.15)	(0.16)	(0.09)	(0.21)	(0.07)	(0.48)	(0.04)
Qorioley	-0.84 ***	0.47 ***	-0.46 **	0.07	-0.73 ***	-0.04	-0.07	-0.15 **	-0.62 ***	0.73 ***	1.45 ***	0.04	-0.65 *	-0.09 *	-5.01 ***	0.15 ***
	(0.08)	(0.12)	(0.22)	(0.06)	(0.24)	(0.06)	(0.13)	(0.07)	(0.14)	(0.11)	(0.28)	(0.06)	(0.36)	(0.05)	(0.82)	(0.03)
Wanle Weyne	0.03	0.14	-0.12	0.21 ***	0.97 ***	-0.17 ***	0.79 ***	-0.23 ***	0.26 **	0.46	-1.20 ***	0.31 ***	-1.46 ***	0.09	-0.34	0.09 ***
	(0.10)	(0.10)	(0.29)	(0.05)	(0.32)	(0.05)	(0.17)	(0.06)	(0.13)	(0.12)	(0.26)	(0.07)	(0.33)	(0.06)	(0.75)	(0.03)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Data source: FSNAU

Table 4 Coefficients of multivariate cointegration of real prices: All zones

	Red sorghum		Red rice									
	c.e. 1		c.e. 1		c.e. 2		c.e. 3		c.e. 4		c.e. 5	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Merka	1	0.08 **	1	-0.11		-0.17 *		0.12 *		0.04		0.08
		(0.04)		(0.11)		(0.09)		(0.07)		(0.12)		(0.08)
Baidoa	0.94 ***	0.00		0.10	1	-0.45 ***		0.23 ***		-0.09		0.02
	(0.22)	(0.04)		(0.12)		(0.09)		(0.07)		(0.12)		(0.08)
Beletwein	-0.52 ***	0.09 **		-0.04		0.08	1	-0.05		0.09		-0.02
	(0.20)	(0.04)		(0.11)		(0.09)		(0.07)		(0.12)		(0.08)
Jowhar	0.95 ***	0.05		0.06		-0.03		0.20 ***	1	-0.60 ***		0.27 ***
	(0.28)	(0.04)		(0.11)		(0.09)		(0.07)		(0.12)		(0.08)
Kismayu	-0.68 ***	0.13 **		0.22 **		-0.06		0.06		-0.02	1	-0.07
	(0.17)	(0.05)		(0.10)		(0.08)		(0.06)		(0.11)		(0.07)
Lugh	-0.01	0.02	-1.70 ***	0.33 ***	0.59 ***	0.03	2.04 ***	0.08	0.16	-0.17	-1.50 **	-0.01
	(0.11)	(0.06)	(0.33)	(0.10)	(0.22)	(0.08)	(0.50)	(0.06)	(0.22)	(0.10)	(0.64)	(0.07)
Wanle Weyne	-1.87 ***	0.24 ***	-0.97 ***	0.30 **	0.75 ***	-0.24 **	0.91 **	0.29 ***	-0.78 ***	0.03	-1.88 ***	0.03
	(0.21)	(0.03)	(0.23)	(0.12)	(0.15)	(0.10)	(0.36)	(0.08)	(0.16)	(0.13)	(0.45)	(0.09)
Galkayo	0.93 ***	-0.02	-0.47 **	0.14	-0.34 **	0.22 **	0.26	0.26 ***	-0.75 ***	-0.02	-1.88 ***	0.28 ***
	(0.18)	(0.05)	(0.20)	(0.12)	(0.13)	(0.10)	(0.31)	(0.07)	(0.14)	(0.13)	(0.39)	(0.09)
Hara Dhere	-0.55 ***	0.09 **	2.28 ***	0.34 ***	-2.28 ***	0.14 *	-4.73 ***	0.23 ***	0.64 **	0.01	4.60 ***	-0.04
	(0.15)	(0.04)	(0.37)	(0.09)	(0.25)	(0.07)	(0.57)	(0.05)	(0.25)	(0.10)	(0.72)	(0.06)
Bosasso	-0.60 **	0.09 ***	-0.38 **	0.12	0.17	0.11	0.96 ***	-0.05	-0.34 ***	0.15	-0.65 **	-0.06
	(0.29)	(0.02)	(0.17)	(0.12)	(0.11)	(0.10)	(0.26)	(0.07)	(0.12)	(0.13)	(0.33)	(0.08)
Hargeisa	0.12	0.16 ***	0.03	0.23	0.11 ***	-0.33 **	-0.13	0.43 ***	-0.03	-0.08	0.00	0.17
	(0.10)	(0.05)	(0.06)	(0.17)	(0.04)	(0.14)	(0.09)	(0.11)	(0.04)	(0.19)	(0.12)	(0.12)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Data source: FSNAU

Starting from the sorghum market in the northern zone, high values of the coefficient of long-term adjustment have been estimated for almost all markets. However, such high values are generally associated with very low values for adjustment speed.[9]

[9] The time required for price adjustment can be estimated as $1/\alpha_3$.

Three reference markets were considered in the case of rice.[10] Significant absolute values of θ_2 range between 0.26 (Lasanod) and 2.73 (Boroma). Prices in Boroma adjust quickly to price changes in the reference markets: 3.1 and 4.5 months to adjust to price changes in Hargeisa and Bosasso respectively. The equal number of cointegrating equations identified in the central zone gives the impression of a rather balanced degree of integration when comparing the two commodities. Nevertheless, the results reveal significantly higher values of θ_2 and α_3 for rice. Significant values of θ_2 range from 0.28 to 1.39 for sorghum and from 0.21 to 2.89 for rice, with 0.74 and 1.00 as respective average values. This reveals a stronger price transmission process for rice than for sorghum. At the same time, price transmission appears to be generally slow, although once again it is faster for rice than for sorghum. In the southern zone Merka, Baidoa, Kismayo and Beletwein were selected as reference markets for both commodities. The values of θ_2 are higher on average for rice than for sorghum. Among the reference markets, Baidoa has an equal number of connections for the two commodities, but on average a larger share of sorghum price changes get transmitted to connected markets: 97% against 75% for rice. This confirms Baidoa as one of the major price-makers for sorghum. The transmission of sorghum price changes between Baidoa and Mogadishu occurs at an interesting speed (corresponding to around 4.3 months) while the process is much slower in all other cases. Rice prices reveal that Baidoa is well connected to other markets, as highlighted by remarkable θ_2 values. However, in this case we assume that the price signal proceeds from coastal markets towards Baidoa, in line with the imported nature of red rice. This is supported by the results of the Granger causality test, which highlight how rice price changes in Baidoa are influenced by rice price changes in Mogadishu and Merka. For all significant market connections with Merka the transmission process is faster when dealing with rice than with sorghum. Price signals from Kismayo have a stronger impact on rice than on sorghum, although they are remarkable in both cases at 117% and 77% respectively. Nevertheless, the transmission of price signals remains slow. After considering each zone individually, multivariate analysis was conducted on market samples from the three zones in an aggregated manner. Baidoa was taken as the reference center for the sorghum market, and five centers – Baidoa, Merka, Beletwein, Galkayo and Bosasso, one for each cointegrating equation – were taken as reference centers for the rice market. Overall, southern markets reveal a good degree of integration, with the absolute value of θ_2 ranging between 0.52 and 1.98. As expected, the transmission of price changes weakens as distance increases, and the value of θ_2 tends to fall when considering price changes in central and northern markets in reaction to price changes in Baidoa. However, price adjustment in Hargeisa occurs significantly faster than in most of the other markets considered.[11]At this point, Table 5 helps to provide a comparative view of the findings presented above. Only significant values of θ_2 and α_3 are considered, and their absolute value is averaged to provide aggregate estimates. The average values indicate a similar strength of price transmission for red rice through the various zones and Somalia as a whole. The same applies for sorghum with the exception of the northern zone, where an excessively high price transmission rate was found. The speed of adjustment is higher in the south for red sorghum and slower in the central zone for red rice. The comparison of the two commodities highlights that average values of θ_2 are equal in the central and southern zones and throughout Somalia as a whole, while the speed of adjustment is higher for red rice in the north and in the country as a whole. Overall, the average values in Table 5 reflect a good level of price transmission, although they hide remarkable variation.

Between 88% and 137% of price signals are on average transmitted, and the time required for transmission is on average twice as long for red sorghum as it is for red rice (approximately eight months for the former against four months for the latter). These estimates are in line with estimates in studies of other cereals in remote areas of neighbouring countries.

[10] It is necessary to consider how this analysis is somehow incomplete due to the unavailability of data about market prices in Berbera, which is assumed to be the major entry point for rice imports into the North West.

[11] Hargeisa also records a high speed of adjustment to rice price changes in Baidoa. This speed is double than that for sorghum, requiring approximately three months rather than the six months estimated for sorghum, and the degree of price adjustment in both cases is quite similar. As for sorghum, the degree of price adjustment is smaller than in all the other markets considered. This recalls the argument for the possibility of price transmission without market integration, and therefore it is necessary to view this result with caution considering the long distance involved. It is hard to think that any exchange actually occurs between Baidoa and Hargeisa. In this case the link in price transmission is instead expected to be related to price changes on the international market that are transmitted to all the main market ports, such as Mogadishu, Merka and Kismayo in the south and Bosasso and Berbera in the north.

As a reference, De Matteis (2014) estimates θ_2 values ranging between 0.23 and 6.52 for maize prices in Kenyan districts neighbouring the Somali border, and Jaleta and Gebermedhin (2009)'s estimates range between 0.24 and 2.33 for wheat and 0.14 and 1.30 for teff in Tigray in northern Ethiopia. The speed of adjustment in the former study is estimated to range between 0.06 and 0.75, while no estimates were provided in the latter.

Table 5 Average values of coefficients of cointegration

	θ_2				α_3			
	Red sorghum		Red rice		Red sorghum		Red rice	
Zone	average	range	average	range	average	range	average	range
North	12.76	3.09 - 34.10	1.06	0.27 - 2.73	0.12	0.03 - 0.26	0.29	0.17 - 0.43
Center	0.74	0.29 - 1.39	1.00	0.21 - 2.89	0.14	0.05 - 0.28	0.18	0.08 - 0.31
South	0.75	0.17 - 1.80	1.19	0.15 - 5.01	0.21	0.10 - 0.47	0.27	0.06 - 0.73
All	0.88	0.52 - 1.87	1.37	0.11 - 4.73	0.12	0.08 - 0.24	0.28	0.12 - 0.60

Data source: Tables 1–4

4.2 Comparison of findings from the analysis of nominal and real prices

The analysis presented above has been replicated using nominal prices. In order to facilitate the comparison of results, the analysis of cointegration was conducted on the same market samples as those used above. Results related to nominal prices are reported in Tables 6–9 for comparison with results reported in Tables 1–4. A few corresponding coefficients are substantially different, and in some rare cases even show a different sign. Nevertheless, the comparison reveals how the vast majority of corresponding coefficients are not statistically different. This is indicated by the prevalence of estimates of α_3 and θ_2 in Tables 6–9 in italics. Italics are used in this case to identify coefficients for which there is an overlap of their 95% confidence intervals derived respectively from nominal (in Tables 6–9) and real (in Tables 1–4) prices.

Table 6 Coefficients of multivariate cointegration of nominal prices: Northern zone

	Red sorghum				Red rice					
	c.e. 1		c.e. 2		c.e. 1		c.e. 2		c.e. 3	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Bosasso	1	*-0.10* ***		*-0.12* ***	1	*-0.01*		*0.05*		*-0.05*
		(0.02)		*(0.03)*		*(0.03)*		*(0.07)*		*(0.05)*
Hargeisa		*-0.21* ***	1	*-0.30* ***		*0.17* ***	1	*-0.49* ***		*-0.27* ***
		(0.04)		*(0.05)*		*(0.05)*		*(0.10)*		*(0.08)*
Erigavo	-4.35 ***	*0.03*	2.97 ***	*-0.07* *		*0.17* ***		*-0.21* **	1	*-0.33* ***
	(0.50)	*(0.03)*	(0.41)	*(0.04)*		*(0.04)*		*(0.09)*		*(0.07)*
Boroma	1.27 ***	*-0.09* **	-1.87 ***	*0.02*	*-4.10* ***	*0.17* ***	*-0.44* ***	*0.08*	-1.94 ***	*-0.16* **
	(0.30)	*(0.04)*	(0.25)	*(0.05)*	*(0.58)*	*(0.05)*	*(0.13)*	*(0.10)*	(0.36)	*(0.08)*
Lasanod	1.12 ***	*-0.06* **	-1.34 ***	*-0.03*	*0.85* *	*-0.02*	*-0.40* ***	*0.09*	0.87 ***	*-0.03*
	(0.30)	*(0.03)*	(0.25)	*(0.03)*	*(0.49)*	*(0.03)*	*(0.11)*	*(0.06)*	(0.31)	*(0.05)*
Togwajiale	*-0.21*	*-0.12* ***	*-0.30* *	*-0.13* ***	*2.26* ***	*0.01*	*-0.66* ***	*0.09*	0.92 ***	*-0.03*
	(0.21)	*(0.04)*	*(0.17)*	*(0.05)*	*(0.52)*	*(0.04)*	*(0.11)*	*(0.08)*	(0.32)	*(0.06)*
Zeliac L.	0.90 ***	*-0.24* ***	*-0.22*	*-0.23* ***	*-0.28*	*-0.10* *	*0.51* ***	*-0.08*	-0.97 ***	*0.24* **
	(0.26)	*(0.06)*	*(0.22)*	*(0.07)*	*(0.42)*	*(0.06)*	*(0.09)*	*(0.12)*	(0.26)	*(0.10)*

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Italics identify those coefficients for which the 95% confidence interval estimated on real and nominal prices overlap.
Data source: FSNAU

Table 7 Coefficients of multivariate cointegration of nominal prices: Central zone

	Red sorghum						Red rice					
	c.e. 1		c.e. 2		c.e. 3		c.e. 1		c.e. 2		c.e. 3	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Galkayo	1	-0.27 ***		-0.23 **		0.13	1	-0.16 *		0.07		-0.18 **
		(0.08)		(0.09)		(0.09)		(0.09)		(0.04)		(0.08)
Hara Dhere		-0.19 ***	1	-0.16 **		0.18 **		0.35 ***	1	-0.15 ***		-0.07
		(0.06)		(0.07)		(0.07)		(0.09)		(0.04)		(0.08)
Abudwak		-0.04		-0.01	1	-0.09 *		0.23 **		-0.10 **	1	-0.33 ***
		(0.05)		(0.05)		(0.05)		(0.10)		(0.05)		(0.09)
Dusamared	0.00	-0.01	0.59 **	-0.05	0.27	0.06	-2.31 ***	0.27 ***	-4.72 ***	-0.09 ***	-0.06	0.03
	(0.17)	(0.04)	(0.25)	(0.04)	(0.24)	(0.05)	(0.52)	(0.07)	(1.10)	(0.03)	(0.18)	(0.06)
El Der	-0.09	-0.06	-1.68 ***	0.11	-1.04 ***	0.07	-0.29	0.12	-0.96	-0.03	-0.51 ***	0.11
	(0.12)	(0.08)	(0.18)	(0.09)	(0.17)	(0.09)	(0.44)	(0.09)	(0.94)	(0.04)	(0.15)	(0.08)
Garowe	-0.81 ***	0.12 **	-0.19	-0.17 ***	-0.77 ***	0.21 ***	1.75 ***	0.36 ***	5.19 ***	-0.20 ***	-0.42 **	-0.07
	(0.20)	(0.05)	(0.31)	(0.06)	(0.29)	(0.06)	(0.51)	(0.09)	(1.08)	(0.04)	(0.18)	(0.08)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets. Italics identify those coefficients for which the 95% confidence interval estimated on real and nominal prices overlap.
Data source: FSNAU

Table 8 Coefficients of multivariate cointegration of nominal prices: Southern zone

	Red sorghum								Red rice							
	c.e. 1		c.e. 2		c.e. 3		c.e. 4		c.e. 1		c.e. 2		c.e. 3		c.e. 4	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Merka	1	-0.15		-0.14 **		0.00		-0.30 ***	1	0.16		-0.05		0.04		0.13 *
		(0.11)		(0.06)		(0.07)		(0.07)		(0.17)		(0.11)		(0.05)		(0.07)
Baidoa		0.13	1	-0.27 ***		0.13 *		-0.26 ***		0.48 ***	1	-0.48 ***		-0.05		0.29 ***
		(0.11)		(0.07)		(0.07)		(0.08)		(0.15)		(0.10)		(0.04)		(0.06)
Kismayu		0.28 **		-0.04	1	-0.38 ***		0.02		0.40 **		-0.10	1	-0.01		0.17 **
		(0.13)		(0.08)		(0.08)		(0.10)		(0.18)		(0.12)		(0.05)		(0.08)
Beletwein		-0.01		-0.15 **		0.14 **	1	-0.32 ***		0.37 **		0.05		0.00	1	0.07
		(0.10)		(0.06)		(0.06)		(0.07)		(0.15)		(0.11)		(0.04)		(0.07)
Adanyabal	-0.24 ***	0.27 ***	0.29 ***	-0.01	-0.16 **	-0.08	0.15 **	0.03	-0.12	0.44 ***	0.25	0.01	-0.80	0.08 *	0.05	0.27 ***
	(0.04)	(0.08)	(0.08)	(0.05)	(0.08)	(0.05)	(0.07)	(0.06)	(0.12)	(0.16)	(0.22)	(0.11)	(0.73)	(0.05)	(0.46)	(0.07)
Hudur	0.14	0.20 *	-1.07 ***	0.12 *	0.08	0.14 **	-0.53 ***	0.02	0.43 **	0.25 **	-0.46	-0.12	1.88	0.05 *	-1.76 **	0.24 ***
	(0.11)	(0.11)	(0.19)	(0.06)	(0.20)	(0.07)	(0.18)	(0.08)	(0.21)	(0.11)	(0.36)	(0.07)	(1.23)	(0.03)	(0.77)	(0.05)
Jowhar	-0.22 *	0.30 ***	1.29 ***	-0.11 **	-0.17	0.08	-1.40 ***	0.03	2.27 ***	0.40 ***	-4.37 ***	0.08	14.74 ***	-0.03	-8.33 ***	0.09
	(0.11)	(0.09)	(0.20)	(0.06)	(0.21)	(0.06)	(0.19)	(0.07)	(0.32)	(0.13)	(0.56)	(0.09)	(1.88)	(0.04)	(1.19)	(0.06)
Mogadishu B.	0.24 ***	0.07	-0.96 ***	0.22 ***	-0.51 ***	0.13 *	0.43 ***	-0.18 *	0.26 **	0.08	-0.12	-0.23 *	1.15	0.05	-0.82 *	0.24 ***
	(0.09)	(0.13)	(0.16)	(0.08)	(0.16)	(0.08)	(0.14)	(0.09)	(0.13)	(0.20)	(0.23)	(0.14)	(0.76)	(0.06)	(0.48)	(0.08)
Qansah Dere	-0.07	0.17	0.08	-0.10	-0.46 **	0.18 **	-0.22	-0.12	-0.25	0.63 ***	-0.21	0.12	-1.02	0.13 ***	0.14	0.34 ***
	(0.09)	(0.12)	(0.17)	(0.07)	(0.18)	(0.08)	(0.15)	(0.09)	(0.23)	(0.15)	(0.41)	(0.10)	(1.37)	(0.04)	(0.86)	(0.06)
Qorioley	-0.89 ***	0.49 ***	-0.19	0.02	-0.32 **	-0.02	0.46 ***	-0.19 **	-3.58 ***	0.82 ***	3.79 ***	0.00	-12.34 ***	0.01	8.70 ***	0.24 ***
	(0.07)	(0.11)	(0.13)	(0.07)	(0.14)	(0.07)	(0.12)	(0.08)	(0.38)	(0.12)	(0.68)	(0.08)	(2.30)	(0.03)	(1.45)	(0.05)
Wanle Weyne	0.07	0.32 ***	-0.50 **	0.10	0.69 ***	-0.05	0.22	-0.14 *	-0.03	0.43 ***	0.20	0.21 **	-4.61 **	0.15 ***	0.94	0.27 ***
	(0.12)	(0.11)	(0.21)	(0.06)	(0.22)	(0.07)	(0.19)	(0.08)	(0.35)	(0.13)	(0.62)	(0.09)	(2.09)	(0.04)	(1.32)	(0.06)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Italics identify those coefficients for which the 95% confidence interval estimated on real and nominal prices overlap.
Data source: FSNAU

Table 9 Coefficients of multivariate cointegration of nominal prices: All zones

	Red sorghum		Red rice													
	c.e. 1		c.e. 1		c.e. 2		c.e. 3		c.e. 4		c.e. 5		c.e. 6		c.e. 7	
series	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3	θ_2	α_3
Merka	1	-0.23 ***	1	*-0.12*		*-0.07*		*0.36* **		*-0.15*		*-0.06*		0.01		-0.04
		(0.05)		*(0.16)*		*(0.13)*		*(0.16)*		*(0.15)*		*(0.12)*		(0.16)		(0.09)
Baidoa	*0.56* ***	-0.26 ***		*0.44* ***	1	*-0.61* ***		*0.20*		*-0.30* **		*-0.06*		-0.18		-0.17 **
	(0.15)	(0.06)		*(0.15)*		*(0.12)*		*(0.15)*		*(0.14)*		*(0.11)*		(0.14)		(0.08)
Beletwein	*0.14*	-0.17 ***		*0.31* **		*-0.02*	1	*-0.35* **		*0.08*		*0.13*		-0.13		-0.02
	(0.15)	(0.05)		*(0.15)*		*(0.12)*		*(0.15)*		*(0.14)*		*(0.11)*		(0.15)		(0.08)
Jowhar	-1.12 ***	*0.00*		*0.25* *		*-0.12*		*0.21*	1	*-0.51* ***		*0.20* **		-0.28 **		-0.04
	(0.23)	*(0.05)*		*(0.13)*		*(0.10)*		*(0.13)*		*(0.12)*		*(0.09)*		(0.12)		(0.07)
Kismayu	*-0.66* ***	*0.09*		*0.29* **		*-0.11*		*0.24* **		*0.02*	1	*-0.25* ***		-0.25 **		-0.07
	(0.13)	*(0.07)*		*(0.12)*		*(0.09)*		*(0.12)*		*(0.11)*		*(0.09)*		(0.11)		(0.07)
Lugh	*-0.02*	*-0.09*		*0.32* **		*0.01*		*0.20*		*-0.24* **		*0.00*	1	-0.56 ***		0.02
	(0.08)	*(0.08)*		*(0.13)*		*(0.10)*		*(0.13)*		*(0.12)*		*(0.09)*		(0.12)		(0.07)
Wanle Weyne	-0.83 ***	-0.01		*0.44* ***		*-0.26* **		*0.30* *		*-0.19*		*0.00*		-0.07	1	-0.31 ***
	(0.18)	(0.05)		*(0.16)*		*(0.13)*		*(0.16)*		*(0.16)*		*(0.12)*		(0.16)		(0.09)
Galkayo	*1.33* ***	-0.33 ***	-0.16 **	*0.38* **	*-0.52* **	*0.19*	*-0.25* *	*0.25*	*-0.26*	*-0.18*	*-0.71* ***	*0.28* **	0.00	-0.22	0.40 **	-0.27 ***
	(0.15)	(0.06)	(0.08)	*(0.16)*	*(0.13)*	*(0.12)*	*(0.13)*	*(0.15)*	*(0.19)*	*(0.15)*	*(0.21)*	*(0.11)*	(0.09)	(0.15)	(0.20)	(0.09)
Hara Dhere	*-0.24* **	*-0.03*	-0.15 ***	*0.51* ***	-0.75 ***	*0.09*	-0.20	*0.26* **	*0.23*	*-0.15*	0.38	*-0.08*	-1.23 ***	-0.12	-1.15 ***	0.07
	(0.11)	*(0.05)*	(0.10)	*(0.13)*	(0.16)	*(0.10)*	(0.16)	*(0.13)*	*(0.23)*	*(0.12)*	(0.25)	*(0.10)*	(0.11)	(0.13)	(0.25)	(0.07)
Bosasso	*-0.10*	*0.01*	0.17 **	*0.21*	-0.31 ***	*0.07*	*0.40* ***	*0.13*	0.32 *	*0.21*	0.80 ***	*-0.17* *	0.05	-0.12	0.77 ***	-0.19 **
	(0.15)	*(0.03)*	(0.07)	*(0.14)*	(0.12)	*(0.11)*	*(0.12)*	*(0.14)*	(0.17)	*(0.13)*	(0.19)	*(0.10)*	(0.08)	(0.13)	(0.18)	(0.08)
Hargeisa	*0.11*	*-0.05*	0.09	*0.21*	*0.69* ***	*-0.15*	-0.95 ***	*0.42* **	-1.36 ***	*0.03*	-1.58 ***	*0.05*	0.17 *	-0.18	-1.08 ***	-0.10
	(0.09)	*(0.06)*	(0.08)	*(0.17)*	*(0.13)*	*(0.13)*	(0.13)	*(0.17)*	(0.19)	*(0.16)*	(0.21)	*(0.12)*	(0.09)	(0.16)	(0.20)	(0.10)

Note: c.e. stands for cointegrating equation. Significance: *** = 0.01, ** = 0.05, * = 0.01. Standard errors in brackets.
Italics identify those coefficients for which the 95% confidence interval estimated on real and nominal prices overlap.
Data source: FSNAU

A comparison of the value of corresponding α_3 coefficients is easier to interpret than the case of θ_2 since the value of the former is restricted between zero and one. Figure 2 reveals how for both cereals, a unitary increase in nominal price is on average reflected at below parity in real prices, as indicated by the slope of the trend line, which in both cases is below 0.9. In other words, this suggests that the use of nominal prices tends to raise the speed of price transmission.

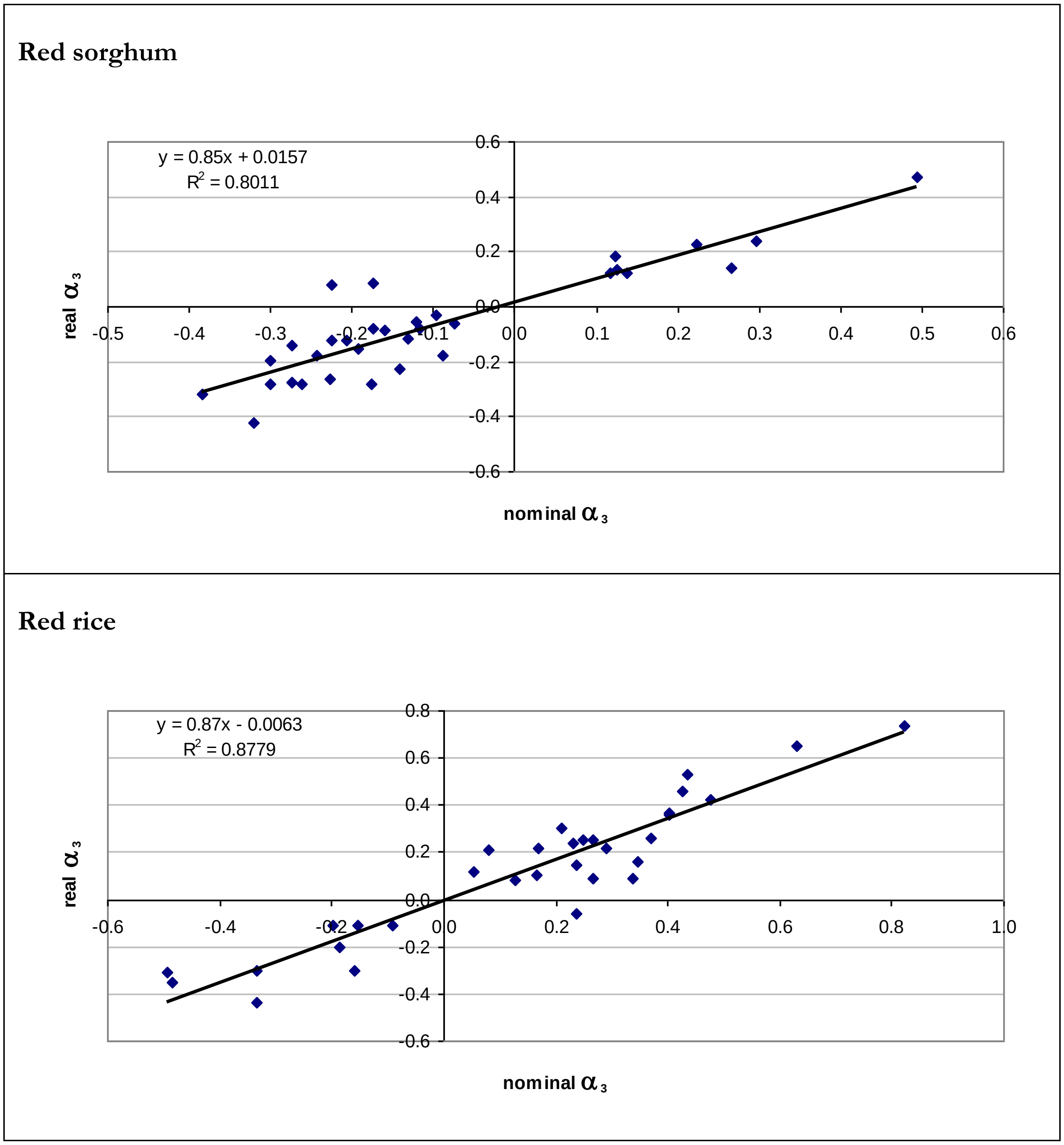

Figure 2 Speed of adjustment estimated through nominal and real prices

Data source: Tables 1–4 and Tables 6–9

For an aggregate perspective, Table 10 provides average estimates of the absolute values of θ_2 and α_3 along the lines followed in Table 5. This allows a comparison of average estimates of the process of integration at the zonal and national levels. A quick look at the two tables reveals a set of varied results. In the case of sorghum, a more substantial strength of price transmission is detected in all aggregates but one – the central zone – when the analysis is conducted on real prices. In contrast, the analysis of nominal prices yields lower θ_2 coefficients for all zones, but not for the country as a whole. In other words, for both commodities the analysis of nominal prices seems to contain the strength of price transmission at the national level and when the analysis is focused on the central zone. However, the analysis provides contrasting findings about the other two zones: the analysis of nominal prices seems to underestimate θ_2 while the use of real prices seems to lead to its overestimation. The results are less controversial regarding the speed of adjustment. In the case of red sorghum the analysis of nominal prices provides consistently higher estimates of α_3. The same occurs when dealing with red rice, with the only exception of the estimates for the northern zone.

Table 10 Average values of coefficients of cointegration

	θ_2				α_3			
	Red sorghum		Red rice		Red sorghum		Red rice	
Zone	average	range	average	range	average	range	average	range
North	1.76	0.30 - 4.35	1.26	0.40 - 4.10	0.15	0.06 - 0.30	0.23	0.10 - 0.49
Center	0.98	0.59 - 1.68	2.49	0.42 - 5.19	0.18	0.09 - 0.27	0.22	0.09 - 0.36
South	0.57	0.15 - 1.40	5.08	0.27 - 14.75	0.22	0.11 - 0.50	0.31	0.05 - 0.82
All	0.79	0.24 - 1.33	0.71	0.17 - 1.58	0.25	0.18 - 0.33	0.32	0.17 - 0.61

Data source: Tables 6–9

As just considered, the results are mixed, particularly concerning the strength of price transmission; however, they seem to be more coherent regarding the speed of price transmission. In particular, the estimates of the latter provide a clear hint towards its overestimation when the analysis is conducted on nominal prices. Nevertheless, it is also necessary to consider how the regular overlap of the range of individual estimates calls for a certain amount of caution. Therefore, a t-test was conducted to assess the significance of any difference identified between estimates of respective aggregate averages. As shown in Table 11, which reports the results of the t-test, the test rejects the hypothesis of coefficient equality in most of the cases considered.

Among the few exceptions are the strength of adjustment of red sorghum prices in the north, and the speed of adjustment of red sorghum prices at the national level. In the former case, the use of nominal prices underestimates the strength of price transmission, while in the latter case the use of nominal prices overestimates the speed of price adjustment. In this regard it is worth mentioning that, although real prices overestimate the strength of price transmission, the estimate derived in this case remains above unity, which means that both nominal and real prices inform us about a full price transmission. In contrast, the estimates of speed of adjustment inform us that the price adjustment estimated using nominal prices is double that estimated using real prices.

Going back to the results of the t-test, in the case of red rice the estimates of speed of adjustment are not significantly different whether using nominal or real prices. However, estimates of the strength of price transmission are different when the analysis is focused on the southern zone or is conducted at national level. In particular, nominal prices overestimate the strength of price transmission in the south, while they underestimate it at the national level. Although both estimates of θ_2 indicate full price transmission in the south, the estimate obtained using nominal prices indicates only a partial price transmission at national level. In this case the difference in the speed of price adjustment is not statistically significant.

Having considered all of the above, the results of the analysis tell us above all that the use of nominal prices overestimates the speed of price adjustment of red sorghum and underestimates the strength of the price transmission of red rice.

Table 11 T-test of equality of estimates of θ_2 and α_3 for nominal and real prices

	Red sorghum				Red rice			
Zone	H_a	Pr(|T| > |t|)	H_a	Pr(|T| > |t|)	H_a	Pr(|T| > |t|)	H_a	Pr(|T| > |t|)
North	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.010	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.433	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.672	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.343
Central	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.383	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.189	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.225	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.233
South	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.174	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.615	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.002	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.428
All	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.695	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.010	$\theta_{2\ real} \neq \theta_{2\ nominal}$	0.025	$\alpha_{3\ real} \neq \alpha_{3\ nominal}$	0.198

Data source: Tables 1–4 and Tables 6–9

5. Concluding remarks

This article has assessed the degree of cereal market functioning in Somalia through the analysis of price transmission. Following the expectation that the use of nominal prices would be misleading in view of the fragmentation of political and economic institutions as well as of the high inflation rates experienced in Somalia, this analysis has made use of real price data. In particular, it has used the Consumer Price Index developed to deflate nominal market prices. The comparative analysis conducted on nominal and real data has highlighted the discrepancy of findings. The analysis of price transmission among market centers has highlighted a varied degree of market functioning and interconnection throughout Somalia, indicating that functioning markets coexist with malfunctioning ones. Overall, markets appear to be reasonably integrated, particularly when taking into account the fragile and fragmented institutional set-up and the difficult environment in which they operate, characterized by poor infrastructure and a high degree of insecurity and uncertainty.

Average values of the strength of price transmission are quite similar, both geographically and when comparing the two cereals considered in this study against each other. Having said that, the coefficients of long-term adjustment for red rice seem to be generally lower than those for sorghum in the south. This hints at a less intense process of price transmission and adjustment for rice than for sorghum in the south. At the same time, the degree of price adjustment is slightly higher in the north than in the south. Both considerations were somehow expected as rice is a staple food in the north but not in the south.

The speed of transmission of price signals is significantly higher for rice than for sorghum throughout Somalia, with the exception of a few regions in the sorghum belt. From an aggregate perspective, price transmission ranges on average between 88% and 137% and the time required for transmission is on average twice as long for red sorghum as for red rice (approximately eight months for the former against four months for the latter). These values are in line with similar estimates for other basic food commodities in remote areas of neighbouring countries.

Overall, this analysis has revealed that the use of nominal prices tends to overestimate the process of red sorghum price adjustment and underestimate that of red rice. In particular, in the former case it overestimates the speed of price adjustment, while in the latter it underestimates the strength of price transmission. Both factors introduce a bias in the analysis of market functioning and, therefore, a distortion in the eventual use of nominal prices for planning purposes. In particular, the use of nominal prices gives a biased impression of a) faster-than-actual transmission of sorghum prices, and b) less-substantial-than-actual price transmission of rice prices. In this way the use of nominal prices reduces the evidence of the gap in market functioning between the two commodities, which, instead, is revealed by the analysis of real prices.

Finally, it is necessary to consider that, while this study has focused on the comparative use of nominal and real prices for the analysis of price transmission, it has also highlighted how some markets function better than others. As this study cannot do full justice to the diverse range of factors that determine market functioning in Somalia, this analysis is recommended for further research.

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Annex

Figure A.1 Spatial distribution of markets