Spatial price transmission under different policy regimes: A case of maize markets in Kenya

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Abstract

Kenya, like most countries in the Eastern and Southern Africa region, has continued to be overwhelmed by high and volatile food prices. In an effort to mitigate this problem, the government has implemented various trade and marketing policy instruments. The aim of this study is to examine whether the policies implemented have achieved their desired effects. The results of the study demonstrate a significant difference across the different policy regimes. Higher price transmission and faster dissipation of price shocks are observed under the regime with minimal or no policy interventions. Under policy regimes implemented to mitigate against high food prices, the reverse is true. Policies implemented to mitigate against price hikes resulted in market distortion. For these policies to achieve their desired effects, there is a need for proper consultation and coordination between government institutions, a review of the import ban on GMO foodstuffs, and distribution of the subsidised fertiliser through the private sector.

Key words: price transmission; policy regime; high food prices

1. Introduction

The international markets witnessed high food prices in 2008, triggered by global market instability and high energy prices. These two factors are instrumental in international price formation. Kenya, like most countries in Eastern and Southern Africa region (ESA), is a net importer of inputs. Hence, the shocks from the international markets were transmitted domestically through high input costs, resulting in high food prices. In the subsequent years, a downward trend in international food prices has been observed. In contrast, the ESA region has continued to be plagued by persistently high and volatile food prices since 2008 (Minot 2014). Several factors are identified in the literature as having contributed to this phenomenon in the region. These factors include macroeconomic and market-specific determinants, a lack of, or minimal, price transmission from the world markets, insulation of domestic markets, price formation, discovery and self-sufficiency in staple foods in most countries in the region (Cudjoe *et al*. 2010; Gilbert & Morgan 2010; Minot 2011; Baltzer 2013; Bryan 2015).

Stable and affordable food prices play a critical role in many developing economies. Welfare gains are associated with stable and affordable food prices. Food prices have a strong multiplier effect on non-farm rural enterprise, labour and other interlinked sectors. The majority of rural and urban poor households spend a large proportion of their expenditure on food. Studies have shown that households are willing to forgo a portion of their income to stabilise food prices. High and unstable food prices threaten to reverse the gains achieved through poverty-reduction strategies (Diao *et al*. 2008; Haggblade *et al*. 2008; World Bank 2009; Bellemare *et al*. 2013). In an effort to mitigate against high food prices, most governments in the ESA region have implemented a wide range of marketing and trade policy instruments. The participation of the governments in a liberalised economy raises the question of how successful these efforts are in stabilising food prices. Chapoto and Sitiko (2014) note most government interventions in the ESA region are highly discretionary and unpredictable. This is also a view held by Bryan (2015), in his study of government responses to the 2008 world food crisis. Policy analysts and economists have queried whether government intervention is the optimal solution to stabilise food prices, as studies have shown high price volatility in regions where the government intervened the most (Chapoto & Jayne 2009; Jayne 2012).

In Kenya, high and volatile food prices pose major challenges to food security. Approximately 36% of the population lives below the poverty line, and 32% are food poor (Kenya National Bureau of Statistics [KNBS] 2018). Persistent high and volatile food prices pose a risk by reverting milestones achieved in alleviating poverty and unemployment and addressing food insecurity in Kenya. Maize plays a significant role in the Kenyan economy with respect to food security and the feed industry at the national level, and as a source of food and income at the household level. Despite the decline in maize consumption amongst the wealthiest households, its contribution to the staple food expenditure amongst the urban and rural poor is quite significant (Kamau *et al*. 2011).

Well-functioning domestic markets will allow for price signals to act as allocators of scare resources, leading to stable prices. Studies testing for spatial price transmission and market integration either have focused mainly on vertical or spatial price dynamics. There has been little or no focus on the significant effects of policies on price transmission and market integration. This paper attempts to address this gap by understanding the effects of different policy regimes on domestic spatial price transmission. The paper also attempts to answer whether policies implemented to mitigate against high and volatile food prices have achieved their intended goals. The rest of the paper is organised as follows. Section 2 reviews the literature on market integration and price transmission. Section 3 discusses the different policies implemented to mitigate against price hikes. Section 4 discusses how these policies are supposed to mitigate against high food prices. A brief description of the maize sector, the data used and the econometric framework is provided in Section 5. The results and discussions are presented in Section 6, while Section 7 presents the conclusion and policy recommendations.

2. Literature review

Market integration is defined as the transfer of the Walrasian excess demand from one market to another. The transfer may be either as physical commodities or the transmission of price shocks, or both (Barret 1996). Market efficiency is a price-based concept that refers to the speed at which the system is restored to equilibrium after the transmission of shocks. As observed by Barret (2001), although the physical flow of goods between two markets is sufficient, it does not necessarily demonstrate tradability. Price transmission across markets is interpreted as a measurement of how well markets are integrated (Fackler & Goodwin 2001). Prohibitive transaction costs, impediments to efficient arbitrage (e.g. trade barriers) and imperfect competition are the main obstacles to market integration (Sexton *et al*. 1991).

Price behaviour in space and time is a central part of economic theory. Understanding price transmission and market integration have been critical in the prescriptions of the various policies. The policy prescriptions are focused on understanding the interaction between markets and prices in space and time (Von Cramon-Taubadel 2017). Integrated and well-functioning markets will determine the design of effective and successful price stabilisation policies. Methodological approaches to price transmission and market integration have undergone major developments over the past four decades as time-series data have become more available and researchers have gained an in-depth understanding of the agricultural commodity markets. Generally, the literature on the price transmission and market integration approaches has been categorised into three distinctive approaches, namely pre-cointegration, cointegration and post-cointegration (see Von Cramon-Taubadel (2017) for detailed studies using these three approaches). An in-depth understanding of the market operations and development of sophisticated methodologies has driven the transition through the three approaches. Despite the development of sophisticated methods, the complex nature of the agricultural commodity markets implies that the approaches that have been developed have limitations. The lack of availability of time-series data on observable transaction costs and trade flows, as acknowledged by Barrett (1996), continues to be a limiting factor, hence the continued reliance on price data in analysing price transmission and market integration. The lack of observable transaction costs has been addressed via estimation within the model. Instances in which trade flow data is available, such as the study by Meyer and Jayne (2012), combined the estimation of transaction costs within the model and used trade flow data as the threshold, thus allowed the estimation of price transmission under multiple regimes.

Most approaches still utilise bivariate analysis of the pairwise market prices derived from two markets (Von Cramon-Taubadel 2017). More than two markets may be interlinked, thus increasing the complexity of spatial arbitrage conditions and the non-linearity behaviour of prices. Using pairwise market prices under these conditions results in misspecification (Fackler & Tastan 2008). Market operations determine market response. The frequency of compiling price data may not reflect market operations, as the data is aggregated. Studies such as that by Von Cramon-Taubadel *et al*. (2006) show the effects of spatial aggregation on price transmission. Despite these limitations, these approaches have provided effective policy prescriptions that address challenges to price and market behaviour.

Kenya is the net maize consumer in the East African region, importing its deficit from Uganda and Tanzania. Several regional studies have been undertaken to measure price transmission and market integration in the maize markets. Marketing costs, border effects and distance between markets have been shown to affect price transmission and market integration. The four major consumption markets of Dar es Salaam, Kampala, Mombasa and Nairobi are integrated, as discussed by the World Bank (2009) and Ihle *et al*. (2011). These studies focused on the major consumption markets across the three countries, which are well connected by infrastructure. However, the studies did not focus on spatial price transmission and market integration within each country. Only one study in the region has focused on the effects of policy on price transmission, namely that of Ihle *et al*. (2009). These authors studied the effects that the maize exports ban in Tanzania had on price transmission between Kenya and Tanzania. Domestically, the limited studies on spatial price transmission and market integration have focused mainly on asymmetrical and threshold approaches (Gbegbelegbe & De Groote 2012; Ngare *et al*. 2013; Nzuma 2013; Gitau & Meyer 2018). Only one study, that by Gitau and Meyer (2018), has studied the effects of policy on pre- and post-high food prices on market integration using the extended threshold autoregression model.

3. Policy regimes

Policies in the maize sector can be categorised into four regimes described below.

Regime 1 – Fully liberalised maize sector (January 2000 to November 2008)

The National Cereal and Produce Board (NCPB), a state marketing board, was restructured and its non-core functions of selling inputs were commercialised. The board continued to maintain its core function of managing the country's strategic grain reserves (SGR). The board was expected to purchase maize from the market at the prevailing price. Market forces determined maize prices, and there were minimal or no policy interventions in the maize markets. During this era there was an increase in private sector participation within the maize value chain (Kirimi *et al*. 2011). This encouraged competition, leading to a decline in maize prices.

Regime 2 – Fertiliser subsidy (November 2008 to December 2016)

Following the global financial market and high-energy crises of 2007/2008, the Ministry of Agriculture, Livestock and Fisheries (MOALF) noted that the local fertiliser prices in 2008 were the highest in the country's history. To stabilise the fertiliser prices, the government implemented a fertiliser subsidy programme. The subsidy programme was also aimed at stimulating production and reducing consumer prices. According to the MOALF, the national annual fertiliser requirement in Kenya is 540 000 metric tons. Estimates from MOALF indicated that, in the financial period between 2008/2009 and 2015/2016, an estimated 76% of the required fertiliser was procured, and 20% of the procured fertiliser was subsidised. The amount of money allocated by the Treasury for the subsidy increased by 116% – from 17.9 million US $ to 38.8 million US $ in the same period respectively. The distribution of the subsidised fertiliser disadvantages small-scale farmers in remote areas, as most NCPB depots are located in major towns (Opiyo *et al*. 2015). The subsidised programme operates together with an already established commercial private sector. In cases where the two distribution channels operate concurrently, Ricker-Gibert *et al*. (2013) noted that the publicly managed distribution negatively affects the commercial value chain. Researchers need to clearly establish how public subsidy has affected the commercial value chain. Liverpool-Tasie (2014) argue for the need to focus on the targeting, size, timeliness and administrative efficiency of the public subsidy, which are the causes of distortions.

Regime 3 – Import bans for all foodstuffs with genetically modified organisms (GMOs) (November 2012 to December 2016)

The Séralini *et al*. (2012) study linked cancer in rats to the consumption of GMO food. The Kenyan Medical Research Institute (KEMRI), an Institute under the Ministry of Public Health and Sanitation (MPHS), concurred with the findings of the above study and advocated for a ban on the importation of GMO foodstuffs. In November 2012, the government, through the Department of Public Health (DPH), banned the importation of GMO foodstuffs. The Department was exercising its mandate of safeguarding consumer health by ensuring that products that could harm consumers were not being imported into the country. The regulatory institution mandated with GMO affairs, the National Biosafety Authority (NBA), raised concerned over the ban. They pointed out that there had been no consultation amongst NBA stakeholders and the ban was counterproductive to the progress undertaken in the field. The ban had implications for local maize prices. During drought periods, Kenya sources maize from outside the region. Imported parity prices put pressure on local maize prices, which are usually high, resulting in lower maize prices for consumers. With the import ban in effect, the country had limited choices, as it had to import maize from GMO-free countries, and these imports could include a premium. Thus the intended goal of ensuring consumer benefits from the cheaper price of maize on the world market during the drought period was not achieved.

Regime 4 – Zero rating of import tariffs (November 2008 to December 2009 and June to December 2011)

In normal seasons, Kenya sources its maize deficit mainly from the region, especially form the Tanzanian and Ugandan markets. The country turns to the international markets during the drought period, when imports from the region are not adequate. The import tariff on maize coming from outside the Common Market for Eastern and Southern Africa (COMESA) attracts an import duty of 50%. Hence, the Treasury, on the recommendation of the MOALF, waives this duty to allow for the importation of maize. Going by past experiences, duty waiver has not been timely, nor has the period allocated for the waiver been adequate. The importation process is plagued by time lags. The MOALF estimates that the whole process – from procurement, transport from the source, clearance at the port and inland transportation – takes a minimum of 60 days.

4. Theory

When the markets are integrated, the government only has to target a few strategic markets to implement its policies, and these policies will then be transmitted to the rest of the markets. When markets operate freely, price acts as the most efficient allocator of resources when it reflects scarcity conditions. The determination of maize prices by market forces rather than by the NCPB, as under regime 1, results in competition and low maize prices, as more players participated along the maize value chain. One of the causes of high maize prices is high input costs. The lowering of input costs will stimulate production and lower maize prices. Fertiliser accounts for between 21% and 25% of the total cost of production. The policy aim of the fertiliser subsidy is to provide farmers with cheaper fertiliser. A reduced cost of production will stimulate production in the surplus region, resulting in lower maize prices that will be transmitted to the deficit regions. During the drought period, domestic maize prices are high. The timely removal of the 50% import duty and the importation of maize from world markets will result in a decline in domestic maize prices, as the imported parity prices will put downward pressure on local prices. The decline in prices is also transmitted to other markets.

5. Data and econometric framework

Kenya's maize production is mainly rain-fed. The country is a deficit maize producer, meeting 90% of its domestic requirements on average. Kenya occasionally becomes self-sufficient when it receives above-average rainfall. Geographical stratification and seasonality are the main causes of the disparity in maize production and supply. The Rift Valley region, which produces 51% of the national production and more than 60% of the national marketed surplus, is the major surplus region. The deficit regions include parts of the Western, Nyanza, Central, Eastern and North Eastern regions. These regions are characterised by a high population density and net[1] maize consumers. The three major cities of Nairobi, Mombasa and Kisumu also form part of the deficit markets. Major large- and medium-scale traders are located in the surplus region, with satellite premises in deficit regions. The maize value chain is made up of different players, and there is competition along the chain. The retail price transmission is asymmetrical, with a higher speed of price response for market pairs further apart compared to the pairs closest to each other (Ngare *et al*. 2013; Gitau & Meyer 2018).

This study utilised nominal monthly wholesale price data from nine domestic markets sourced from the agricultural commodity and market information division of the Ministry of Agriculture, Livestock and Fisheries (MOALF). The domestic markets comprise two surplus markets (Eldoret and Kitale) and seven deficit markets (Kisumu, Mombasa, Nakuru, Garissa, Machakos, Kisii and Nairobi). The data covers the period from January 2000 to December 2016. The consumer price index (CPI)[2] is used in the deflation of nominal prices.

Studies undertaken both domestically and in the region have mainly delved into the dynamics of price transmission and market integration, with little or no focus on the effects of policies on the same. In the literature, researchers have used dummy variables, splitting data into sub-sample, extended parity bound model and threshold analysis to study the effects of policy on price transmission and market integration (Negassa *et al*. 2004; Ihle *et al*. 2009; Yang *et al*. 2015; Gitau & Meyer 2018).

[1] Households that consume more maize than they produce and have to depend on the market to bridge the deficit.
[2] The CPI base year used was February 2009.

For our study, we split the data into four sub-samples representing the different policy regimes. A vector error-correction model (VECM) was applied to analyse different policy effects. To complement this approach, an econometric analysis of the price variation across the different policy regimes was also undertaken. Time-series data is often non-stationary. Hence, prices will drift randomly rather than return to a mean value. Prices are cointegrated when they integrate to the order of one and the linear combination of one of them is zero. Johansen's maximum likelihood vector auto-regression (VAR) approach was used to determine the co-integration between the market pair (Johansen & Juselius 1990). From a standard VAR model, a VECM can be derived as follows:

$$P_t = A_0 + A_1P_{t-1} + A_2P_{t-2} + \ \ldots\ldots + A_kP_{t-k} + \varepsilon_t \tag{1}$$

P_t represents a vector of endogenous prices for the deficit and surplus market prices, $P_t = \begin{pmatrix} P_t^d \\ P_t^s \end{pmatrix}$, A_t are matrices of unknown parameters, while ε_t is the error term. Taking the first difference of equation (1), it can be rewritten as

$$\Delta P_t = \pi_0 + \pi_1\Delta P_{t-1} + \qquad + \pi_{k-1}\Delta P_{k-1} + \pi P_k + \varepsilon_t, \tag{2}$$

where $\pi_0 = A_0, \pi_i = -\left(1 - \sum_{j=1}^{k=1} A_j\right)$ and $\pi = -\left(1 - \sum_{j=1}^{k} A_j\right)$

The rank of π provides the basis of establishing the presence of cointegration. When the rank (π) = 0, prices are not cointegrated and the model is equivalent to a VAR in the first difference; if the rank (π) = 2, the prices are stationary and the model is equivalent to a VAR in level form; if (π) = 1, the prices are cointegrated. The vector π can be decomposed as $\pi = \alpha\beta'$, where α is the matrix of the speed of adjustment coefficient and β is the cointegration vectors. The long-run disequilibrium term for VECM for one lag is expressed as follows:

$$\Delta P_t = \alpha\beta' P_{t-1} + \sum_{i=1}^{k-1} \pi_i \, \Delta P_{t-1} + \varepsilon_t \tag{3}$$

Our long-run relationship will be expressed as indicated below, as P_t has two prices for the deficit and surplus markets. We can express the long-run spatial price relationship as

$$P_t^d = \lambda + \beta P_t^s + \nu_t, \tag{4}$$

where $\lambda = \beta_0/\beta_1$ *and* $\beta = \beta_2/\beta_1$. Therefore, β measures the long-run equilibrium relationship. Since our prices are expressed in logarithms, then β in our case represents long-run price transmission elasticity to the deficit market from the surplus markets. When β is close to 1, then markets are well cointegrated and price fluctuation from the surplus market is completely transmitted to the deficit markets. The VECM is expressed as follows:

$$\Delta P_t^d = \alpha\nu_{t-1} + \sum_{j=1}^{k} \vartheta_{ij}\Delta P_{t-j}^d + \sum_{j=1}^{k} \vartheta_{ij}\Delta P_{t-j}^s + \varepsilon_i \tag{5}$$

VECM takes into account that the change in price in the deficit market, P_t^d, is a factor of changes in P_t^d, P_t^s and disequilibrium in the previous period of the two prices represented by ν_{t-1} in our equation (5). Typically, -1< α < 0, and the negative value of α usually helps to revert the price back to the long-run equilibrium. When α is close to -1 we can infer that short-term disturbances quickly return to equilibrium in the long run, and the two markets are closely interlinked. The coefficient change in the surplus market, ϑ_{ij}, is the short-run elasticity of deficit price relative to surplus price. The half-life[3]

[3] Half-lives in this study are computed using $\ln(0.5)/\log(\alpha)$.

represents the time required for a given shock to return to half its initial value. For econometric analysis, we ran the following regression:

$$\gamma_i^{ds} = \alpha\lambda_i + \varepsilon_i, \quad (6)$$

where γ_i^{ds} represents the coefficient of variation (CV) of maize prices across deficit and surplus markets, while λ_i represents a matrix of independent variables (distance between the two pairs, different policy regimes). ε_i is the error term. The F-statistic is used to test for a significant difference across the policy regime.

6. Results and discussion

Figure 1 illustrates the trend in the real wholesale prices across the different policy regimes and markets. The trend in real maize prices exhibits volatility across the different policy regimes. Under regime 1, the price volatility appears smoother compared to the other regimes. There is evidence of a decline in the maize prices with the removal of the import duty (regime 4), and a subsequent increase after the duty is reinstated. Under regime 2 (fertiliser subsidy), the real price volatility has shorter kinks compared to regime 1. The provision of subsidised fertiliser was expected to lower prices. The price spread between the deficit and surplus markets across the different policy regime is summarised in Figure 2. Under regime 1, the price spread is low compared to that in regime 2. The price spread is lower in regime 3 compared to that in regime 4. Garissa and the surplus markets account for the highest price spread across the different regimes. The price spread is highest under regime 1.

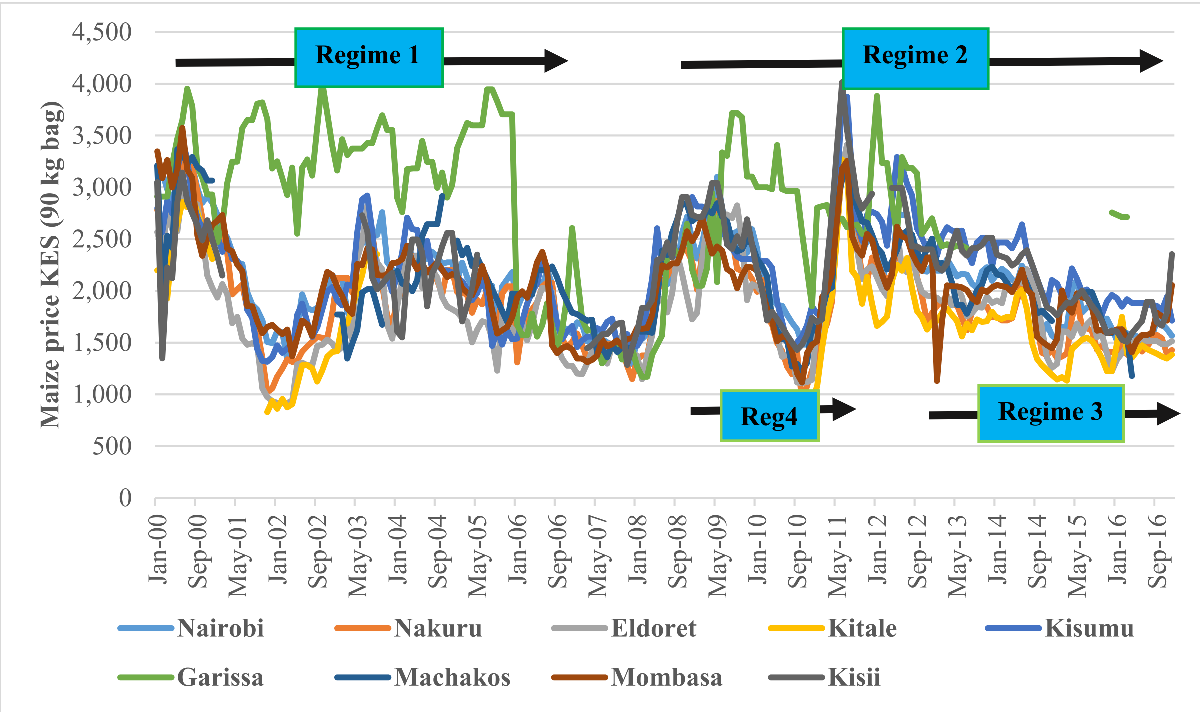

Figure 1: Real maize prices across the surplus and deficit markets under different policy regimes

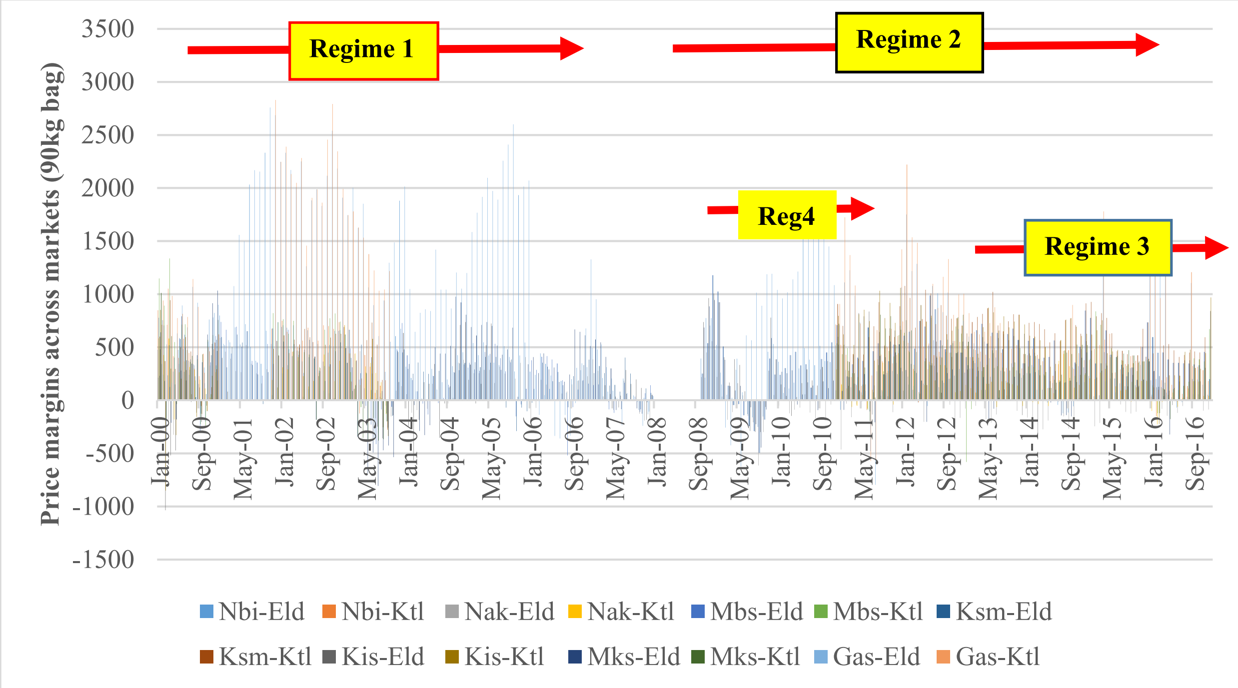

Figure 2: Price spread across the surplus and deficit markets under different policy regimes

The descriptive statistics and unit root tests are summarised in Table 1. As expected, real wholesale maize prices are lower in surplus markets than in deficit markets. The Garissa market exhibited the highest price. This market is the furthest from the surplus markets, located at a minimum distance of about 700 kilometres away. The wholesale real maize series across all the markets are non-stationary at the price level, as we fail to reject the null hypothesis of a unit root. They became stationary on first differencing, as the null hypothesis is rejected at the 1% significance level.

Table 1: Descriptive statistics and unit root test for the real maize price series

Markets	Descriptive statistics						ADF* test	
	Obs	Mean	Median	Min	Max	CV	Price level	Price difference
Eldoret	204	1 828	1 779	918	3 411	0.26	-1.169	-12.498
Garissa	170	2 805	2 937	1 170	4 020	0.26	-0.857	-13.880
Kisii	153	2 214	2 255	1 285	4 015	0.23	-1.024	-11.120
Kisumu	204	2 176	2 154	1 316	3 875	0.22	-0.248	-13.174
Kitale	108	1 721	1 698	829	3 269	0.30	-0.248	-7.611
Machakos	167	2 144	2 079	1 099	3 367	0.23	-0.074	-13.228
Mombasa	204	2 018	2 026	1 115	3 573	0.22	-1.282	-13.153
Nairobi	204	2 106	2 094	1 293	3 439	0.22	-1.214	-12.834
Nakuru	204	1 896	1 868	925	3 277	0.25	-1.212	-11.560

* Augmented Dickey-Fuller test. The ADF critical value for the null hypothesis is -1.95 for the 5% level of significance and -2.58 for the 1% level of significance

Descriptive statistics of the price spread across deficit and surplus markets is summarized in Table 2. Kitale and its respective pairwise market exhibits a higher price margin and lower CV compared to Eldoret and its respective pairwise markets. The highest price spread is between both surplus markets and Garissa markets.

Table 2: Descriptive statistics of the price margin between the surplus and deficit markets

Market pair	Obs	Mean	Median	Minimum	Maximum	Coefficient of variation
Eldoret-Nakuru	204	68	48	-613	709	3.13
Eldoret-Kisii	153	280	291	-1 036	1 006	1.17
Eldoret-Kisumu	204	348	356	-494	1 180	0.71
Eldoret-Machakos	167	231	256	-806	1 034	1.46
Eldoret-Garissa	170	950	930	-795	2 759	0.86
Eldoret-Nairobi	204	278	272	-358	824	0.81
Eldoret-Mombasa	204	189	190	-802	779	1.50
Kitale-Nakuru	108	189	176	-226	709	0.94
Kitale-Kisii	86	473	508	-850	1 060	0.73
Kitale-Kisumu	108	583	597	-275	1 079	0.42
Kitale-Machakos	80	325	377	-504	1 012	1.00
Kitale-Garissa	74	1 190	1 064	-571	2 830	0.58
Kitale-Nairobi	108	413	437	-148	1 053	0.52
Kitale-Mombasa	108	348	327	-580	1 337	0.82

We complemented the VECM with an econometric analysis that investigated the relationship between the variation in price margin across the different policy regimes between the surplus and deficit markets. A summary of the econometric analysis is illustrated in Table 3. We tested for statistical significance between the different policy regimes.[4] The results of the econometric statistics are summarised in Table 3. There is a positive relationship between the price variation between and the distance surplus and deficit markets, although the results are not statically significant. There was a decline in CV in regimes 2, 3 and 4 compared to regime 1. This decline is not statistically significant, except in the case of Kitale pairwise in regime 2 and 3, which is significant at the 10% level.

Table 3: Econometric analysis of the variation in price margin across the different policy regimes

Variables	Eldoret pairwise	Kitale pairwise
Distance (km)	0.004	0.000
	(0.90)	(-0.33)
Regime 2	-1.336	-1.507*
	(-0.47)	(-1.75)
Regime 3	-0.970	-1.521*
	(-0.34)	(-1.77)
Regime 4	5.843	-1.257
	(2.05)	(-1.46)
Constant	0.050	2.286
	(0.02)	(2.8
Prob > F	0.093	0.3849)
R^2	0.2828	0.1593

The t-statistics are presented in parentheses. The asterisk (*) represents the 10% level of significance

The test for significant difference between the different policies regimes is illustrated in Table 4. The null hypothesis is rejected in Eldoret pairwise at the 10% level of significance, but cannot be rejected under Kitale pairwise market. There is a significant difference across the policy regimes under the Eldoret pairwise markets.

Table 4: Testing for significant differences between the policy regimes

Restriction: Null hypothesis (reg2 = reg3 = reg4 = 0)	F statistics	
	Coefficient	P-value
Eldoret pairwise	2.76*	0.07
Kitale pairwise	1.42	0.26

The asterisk * represents the rejection of the null hypothesis at the 10% level of significance

[4] The base used for comparison was policy regime 1. It was characterised by little or no policy intervention from the government and covered the period from January 2000 to December 2007.

The results of the Johansen cointegration tests on the logged wholesale maize prices between market pairs are summarised in Table 5. Regarding the full sample, all the pairwise markets are cointegrated. Differences can be observed across the different policy regimes. Eldoret and its respective pairwise markets show that, with the exception of a few markets, most of the markets are cointegrated across the four regimes, while this is not the case for Kitale and its respective pairwise markets. Eldoret is a major maize assembly point, is third in milling capacity and has a network of major traders in deficit areas. This may explain the results.

We ran the residual diagnostic test to ensure that our data does not suffer from serial correlation or heteroscedasticity. The null hypothesis for both tests was accepted, suggesting that our price data suffer from neither. To investigate the long-run relationship between our markets, a VECM was applied to the market pair. The results of the VECM are illustrated in Table 6.

The results for the full sample demonstrate a high, long-run price transmission between the surplus and deficit markets. If there was an increase in maize prices of 1% in the surplus markets, at least 0.72% of these prices were transferred to the deficit markets. There was no short-run Granger causality between the surplus market and the respective deficit markets, except for the Eldoret-Nakuru and Eldoret-Nairobi pairwise markets. The lack of short-run Granger causality implies that price shocks in the short run are not corrected and prices drift apart. The prices will drift back to the equilibrium if there is a long-run relationship. Regarding the full sample, Eldoret and its respective pairwise markets have a lower speed of adjustment (-0.17) and higher half-life, which represents the time taken before the shock can reduce to half its value (3.8 months), compared to the Kitale speed adjustment of -0.25 and 2.3 months respectively.

Across the different policy regimes, there is no short-run Granger causality between the surplus and deficit markets, except under regime 2 (Eldoret-Nairobi) and regime 4 (Eldoret-Kisii). Under regime 1, the pairwise of Eldoret-Kisii has a long-run price transmission of 0.8. Hence, a 1% increase in price in the Eldoret market will result in a 0.8% transmission to the Kisii market. The speed of adjustment to equilibrium is -0.78, with a half-life of 0.5 months. Under regime 4, the same pairwise markets have a lower long-run price transmission and speed of adjustment and a higher half-life. The Eldoret-Machakos pairwise markets show similar results when we compare results under regimes 1 and 4. Our econometric analysis shows a significant difference across the different policy regimes under the Eldoret pairwise markets. Therefore, there is better price transmission and dissipation of price shocks under regime 1, compared to the low price transmission and slower dissipation of price shocks in the other policy regimes. There was little or no policy intervention under regime 1, hence policies implemented to mitigate high food prices may have distorted the markets.

Table 5: Pairwise cointegration tests for surplus and deficit markets across the different policy regimes

Markets	Full sample		Regime 1		Regime 2		Regime 3		Regime 4	
	Obs	Trace test	Obs	Trace test	Obs	Trace test	Obs	Trace test	Obs	Trace test
Eldoret-Nakuru	204	49.157***	96	20.768***	99	41.485***	50	32.578***	21	25.788***
Eldoret- Kisii	153	52.072***	48	23.533***	96	36.354***	49	16.344**	21	18.233**
Eldoret-Kisumu	204	46.853***	96	20.182***	99	24.705***	50	22.838***	21	14.136
Eldoret-Machakos	167	38.534***	73	20.289***	85	26.767***	35	8.861	21	18.817**
Eldoret-Garissa	170	19.161**	96	7.58	65	15.043	15	16.911**	21	12.666
Eldoret-Nairobi	204	42.320**	96	11.656	99	33.845***	50	18.434**	21	23.197***
Eldoret-Mombasa	204	47.276***	96	17.671**	99	37.669***	50	29.683***	21	12.686
Kitale-Nakuru	108	31.509***	35	20.786***	73	23.592***	49	16.385**		
Kitale-Kisii	89	22.566***	16	16.871**	70	18.815**	49	9.660		
Kitale-Kisumu	108	17.724**	35	14.708	73	15.755**	49	13.053		
Kitale-Machakos	80	22.646***								
Kitale-Garissa	74	17.300**	35	12.52	39	15.269**	15	11.75491		
Kitale-Nairobi	108	36.382***	35	11.97	73	26.467***	49	15.67**		
Kitale-Mombasa	108	33.060***	35	7.028	73	24.064***	49	13.304		

The asterisks *** and ** signify the rejection of the null hypothesis (no cointegration vector) at the 1% and 5% levels of significance respectively. There was not enough data under regime 4 for Kitale and its respective pairwise to run cointegration results

Table 6: Spatial price transmission of maize under the different policy regimes

Sample	Markets	Long-run relationship	Wald test (chi-square)	Speed of adjustment	Half-life
Full sample	Eldoret-Nakuru	0.95**	0.03**	-0.18***	3.5
	Eldoret-Kisii	0.97**	0.14	-0.16**	3.9
	Eldoret-Machakos	1.95**	0.98	-0.16***	4.1
	Eldoret-Nairobi	0.83**	0.04**	-0.17***	3.8
	Eldoret-Mombasa	0.79**	0.59	-0.16***	3.9
	Kitale-Kisii	1.25**	0.34	-0.22***	2.3
	Kitale-Garissa	0.14	0.84	-0.29***	2
	Kitale-Mombasa	0.72**	0.29	-0.23**	2.7
Regime 1	Eldoret-Kisii	0.8**	0.09	-0.78***	0.5
	Eldoret-Machakos	1.9**	0.25	-0.25***	2.4
	Kitale-Kisii	0.17	0.19	-0.55**	0.9
	Kitale-Garissa	0.09**	0.50	-0.57***	0.8
	Kitale-Nairobi	0.06**	0.62	-0.64**	0.8
Regime 2	Eldoret-Nakuru	1.06**	0.34	-0.30**	1.9
	Eldoret-Garissa	0.12	0.09	-0.31**	1.9
	Eldoret-Nairobi	0.90**	0.01**	-0.20**	2.9
Regime 3	Eldoret-Nakuru	0.8**	0.06	-0.74***	0.5
	Eldoret-Mombasa	0.5**	0.60	-0.82***	0.4
	Kitale-Nakuru	0.8**	0.29	-0.33**	0.6
Regime 4	Eldoret-Kisii	0.1**	0.04**	-0.11**	5.9
	Eldoret-Machakos	0.09**	0.08	-0.06**	11.2
	Eldoret-Mombasa	1.56**	0.17	-0.26***	2.3

*** and ** denote significance at the 1% and 5% level of significance respectively, with the t-values of speeds of price adjustment given in the brackets, representing the estimated adjustment speed in the outer regimes. The half-lives of price adjustment for the producer and consumer markets respectively are measured in months ($hl = \ln(0.5)/\ln(\alpha)$)

7. Conclusion and policy recommendations

Policies implemented to mitigate high food prices in this study resulted in market distortion. High price transmission, low half-life and a faster return to equilibrium were observed under the regime with little or no policy interventions compared to the other policy regimes.

Given the effects of policies on spatial market transmission, it is important for the government to implement policies appropriately to achieve their desired effects. Proper consultation and coordination among government institutions involved in policy implementation will facilitate optimal policy output. The MOALF produces food security reports that provide information on season performance, weather and available food stocks. In addition, the reports provide an outlook and forecast of food security in subsequent seasons. Consultation and coordination between the MOALF and Treasury will facilitate the timely removal of import duty, and the procurement and provision of imported maize to consumers. The government needs to review the ban on importing GMO foodstuffs. As a result, Kenya will have the choice to access cheap maize during the drought period, irrespective of the source. In terms of the fertiliser subsidy, the government should consider collaborating with the private sector, as its distribution network is nationwide. Small-scale farmers in the remote areas will be able to access the subsidised fertiliser.

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