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EFFECTS OF GOVERNMENT MAIZE MARKETING POLICIES ON MAIZE MARKET PRICES IN KENYA

1. Introduction

Kenyan policy makers are confronted with a classic "food price dilemma" surrounding their most important food crop, maize. On one hand there is pressure to ensure that maize farmers receive adequate price incentives to produce and market their crop. On the other hand, the food security of a growing urban population, and of many rural households who are buyers of maize, requires keeping maize prices low. For many years policy makers have attempted to strike a balance between these two competing objectives, primarily through the operations of the National Cereals and Produce Board (NCPB) which procures and sells maize at administratively determined prices. Since 1988 a private sector marketing channel has competed with the NCPB with prices in the private sector being set by supply and demand forces. The effects of the NCPB's marketing activities on the level and variability of maize market prices in the private sector channel are controversial and not well understood. Given the importance of maize in the Kenyan economy, empirical research on the historical effects of NCPB activities will provide a better understanding of the past impact of these policies, and also inform the debate about the appropriate future role for the NCPB.

The objective of this paper is to estimate the historical effects of NCPB maize trading activities on private sector maize price levels and variability. We also discuss the probable income transfer effects of the NCPB's maize trading operations. The analysis uses monthly data covering the period January 1989 through October 2004. It was not possible to use a fully structural econometric model to estimate the historical policy effects because of data limitations in Kenya, which are typical of many developing countries. Instead we use a vector autoregression model (VAR) and show how policy simulation results can be obtained from a fairly parsimonious VAR estimated with sparse data and imposing only minimal identification restrictions.

2. Methodology

Estimating the effects of NCPB marketing activities on private sector maize prices in Kenya over a historical period is a difficult task. Data are limited, the objectives of government policy have probably changed over time, and a traditional structural econometric approach is not feasible in the current context because prices are the only reliable market data available.

Faced with these problems we take a VAR approach (Sims, 1980, Fackler, 1988, Myers, Piggott, and Tomek, 1990). VAR models have proven to be useful for estimating policy effects in the presence of limited data and/or uncertainty about the correct structural model that is generating observed data. The approach has been applied mainly to macroeconomic policy but has also been applied successfully to study the effects of commodity marketing policies (e.g. Myers, Piggott, and Tomek, 1990).

To outline the VAR approach, suppose we observe a vector of market variables $\boldsymbol{y_t}$ we want to simulate under alternative policy scenarios. We also observe a vector of policy variables $\boldsymbol{p_t}$ that the government uses to attempt to influence $\boldsymbol{y_t}$. A general dynamic model of the relationship between the variables can be written as:

(1) $$\boldsymbol{By_t} = \sum_{i=1}^{k} \boldsymbol{B_i y_{t-i}} + \sum_{i=0}^{k} \boldsymbol{C_i p_{t-i}} + \boldsymbol{A^y u_t^y}$$

(2) $$\boldsymbol{Dp_t} = \sum_{i=0}^{k} \boldsymbol{G_i y_{t-i}} + \sum_{i=1}^{k} \boldsymbol{D_i p_{t-i}} + \boldsymbol{A^p u_t^p}$$

where the $\boldsymbol{B}$, $\boldsymbol{B_i}$, $\boldsymbol{C_i}$, $\boldsymbol{A^y}$ and $\boldsymbol{D}$, $\boldsymbol{D_i}$, $\boldsymbol{G_i}$, $\boldsymbol{A^p}$ are matrices of unknown parameters, k is the maximum number of lags allowed in any equation, and $\boldsymbol{u_t^y}$ and $\boldsymbol{u_t^p}$ are vectors of mutually uncorrelated "structural" innovations representing random shocks to the fundamental supply, demand, and policy processes that are generating data for $\boldsymbol{y_t}$ and $\boldsymbol{p_t}$.[1]

[1] The assumption that each structural error vector contains mutually uncorrelated errors is not restrictive because the $\boldsymbol{A^y}$ and $\boldsymbol{A^p}$ matrices allow each shock to enter every equation in the block. The assumption that $\boldsymbol{u_t^p}$ is also uncorrelated with $\boldsymbol{u_t^y}$ is also not restrictive because independence from current market conditions is part of the definition of an exogenous policy shock (see Bernanke and Mihov, 1998).

This system is currently underidentfied but Bernanke and Mihov (1998) suggest that a natural identification restriction in this context is to set $\boldsymbol{C_0} = 0$, which excludes policy shocks from influencing market variables within the current period. Bernanke and Blinder (1992) have shown that if $\boldsymbol{C_0} = 0$ then the effect of a policy shock on market variables is independent of the $\boldsymbol{B}$ and $\boldsymbol{A}^y$ parameter matrices, which implies that estimates of policy effects on market variables will be robust to any alternative identification scheme that might be used for the market variables block. However, policy effects will still be sensitive to the restrictions used to identify $\boldsymbol{D}$, $\boldsymbol{G_0}$, and $\boldsymbol{A}^p$ in the policy block. The most common identification scheme used in VAR models is the Choleski factorization which imposes a recursive ordering among variables (Sims, 1980).[2] In our context this would imply $\boldsymbol{A}^p$ is restricted to be diagonal and $\boldsymbol{D}$ to be lower triangular with ones on the diagonal (with $\boldsymbol{G_0}$ left unrestricted). Alternative orderings for the policy variables then imply alternative identifications.

Once an identification scheme has been chosen the model can be estimated in two steps. First, estimate the reduced form of the system using ordinary least squares. Second take the reduced form residual covariance matrix and solve for the unknown contemporaneous structural parameters. These estimation procedures are explained in detail elsewhere (e.g. Fackler, 1988; Myers, Piggott and Tomek, 1990).

Having estimated the model then impulse response analysis can be used to trace out the dynamic response of all variables in the system to a typical innovation in a particular policy variable (see Hamilton, 1994). Furthermore, if we set all structural innovations except the policy innovations to their historical values, and then control the sequence of policy innovations in order to generate specific historical paths for the policy variables, we can simulate what the effects of alternative policies would have been over the sample period.

[2] It is important to note that this restriction only applies to contemporaneous interactions between the variables. Dynamic interactions in the model remain unrestricted.

3. Application to Kenyan Maize Prices

The first step in applying the VAR methodology to estimate policy effects on Kenyan maize prices is to choose variables to include in the $\boldsymbol{y_t}$ and $\boldsymbol{p_t}$ vectors. Two regional wholesale prices in Kenya are included in the $\boldsymbol{y_t}$ vector—the wholesale price in the maize breadbasket district of Kitale and the wholesale price in the main consumption region of Nairobi. In most years there is potential for significant cross-border maize trade between Kenya, Uganda, and Tanzania, usually in the form of imports into Kenya. Mbale is a major market in Eastern Uganda that is important in cross-border trade with Kenya, and interactions are expected between Mbale and Kenyan prices. Hence, wholesale price in Mbale is also included in the $\boldsymbol{y_t}$ vector.

For the $\boldsymbol{p_t}$ vector we want variables that represent the operation of Kenyan maize price policy. The NCPB manages domestic maize prices by buying maize in surplus producing regions at an administratively determined purchase price, transporting it to major consumption regions, and selling it at an administratively determined sell price. Hence, the NCPB influences prices in two main ways—by changing the size of the buy price premium (the difference between the NCPB buy price and the market price in surplus producing regions); and by changing the size of the sell price premium (the difference between the NCPB sell price and the market price in consuming regions). Hence, we included two variables in the $\boldsymbol{p_t}$ vector: (a) the buy price premium (measured as the difference between the administered NCPB purchase price and the wholesale market price in the major production area of Kitale); and (b) the sell price premium (measured as the difference between the administered NCPB sell price and the wholesale market price in the major consumption region of Nairobi).

For identification we follow Bernanke and Blinder (1992) and Bernanke and Mihov (1998) and set $\boldsymbol{C_0} = 0$. As indicated above, this assumes market variables respond to policy changes with a lag but there is no contemporaneous response. This may seem like a strong restriction because it implies maize sellers and buyers respond to a change in the NCPB buy and sell price premiums, but it takes a full period (in our case a month) before they become fully aware of the change and start altering their behavior. However, there are a number of frictions that might preclude immediate adjustment.

First, in developing countries like Kenya access to market information tends to be sporadic and incomplete. Hence, it may take some time before buyers and sellers even become aware that the premiums have changed. Second, even when market participants become aware of the premium changes it may be costly and time consuming to alter their marketing channel because of adjustment costs and inertia. Therefore, the assumption that there is a least a one month delay in any market response to changes in NCPB buy and sell price premiums seems like a reasonable restriction in this context.

Given that $\boldsymbol{C_0} = 0$ is imposed there is no need for any identification restrictions on the market variables block (i.e. no need to restrict $\boldsymbol{B}$ or $\boldsymbol{A}^y$), as explained above. For the policy block we use a Choleski factorization with the buy price premium ordered first and the sell price premium ordered second.

4. Data and Preliminary Results

4.1 Data

The study uses monthly data from January 1989 through October 2004. Wholesale maize prices for Kitale and Nairobi were obtained from the Ministry of Agriculture's Market Information Bureau. Wholesale maize prices for Mbale in eastern Uganda were obtained from the Ministry of Agriculture in Uganda. All prices are expressed in Kenyan Shillings per 90kg bag. Ugandan prices were converted to Kenyan shillings using the official exchange rate and then adjusted upward by the official tariff rate in order to make then directly comparable to Kenyan prices.

4.2 Diagnostic tests

Preliminary investigations focused on testing for seasonality and unit roots. Correlograms for both the price and policy variables displayed no strong evidence of seasonality and results provided later confirm that residuals from the VAR regressions without seasonal variables show no significant evidence of autocorrelation. This is not unexpected because of the staggered harvest periods in different areas of Kenya, Uganda and Tanzania.

Next, augmented Dickey–Fuller regressions were run for each price and policy variable to test for unit roots. One lagged dependent variable was sufficient to eliminate autocorrelation in the residuals in all of the Dickey-Fuller regressions, and a constant and time trend were also included to account for any systematic deterministic components. Phillips-Perron tests were also applied as a consistency check. A constant and a time trend were also allowed for in the Phillips-Perron tests, and the number of Newey-West lags was set to 4. Results from both tests are shown in Table 1 and support stationarity in all variables, except perhaps the Nairobi maize price which has p-values of 0.083 under Dickey-Fuller and 0.154 under Phillips-Perron. Even in this case, however, a unit root can be rejected using a 10% significance level under Dickey-Fuller (see Table 1). Given the general support for stationarity in the Kenyan maize price and policy variables, and the fact that estimation will still be consistent even if unit roots exist,[3] we estimate the VAR without imposing any unit root or cointegration restrictions.

5. Results

5.1 VAR estimation results

Given the preceding preliminary results, the VAR was specified in levels of the variables with no seasonality or trend terms. Standard VAR order selection criteria such as the Akaike information criterion and Schwartz Bayesian criterion (see Enders, 1995) all suggested a first-order model. However, these criteria are known to underestimate lag-length in some circumstances and likelihood ratio statistics suggested higher-order lags were needed. Hence, we tested the residuals for autocorrelation using Ljung-Box Q statistics and found that both first- and second-order models had statistically significant autocorrelation in at least one set of residuals. We therefore expanded the model to third-order lag and residuals from this model are well behaved in all cases.

Model evaluation tests were conducted on the estimated VAR and results are provided in Table 2. Ljung-Box Q tests support residuals from each equation having the white noise property. The same test applied to the squared residuals supports no autoregressive conditional heteroscedasticity (ARCH) in any residual series, except for the Kitale price equation which does show evidence of ARCH effects. ARCH effects are

[3] The reason is that least squares estimation of the VAR parameters remains consistent, even in the presence of unit roots and cointegration (Davidson and MacKinnon, 1993). It is only distribution theory (and therefore hypothesis testing) that is altered drastically. But the VAR analyses of impulse response functions and policy simulation do not require formal hypothesis testing.

not modeled explicitly because they only appear in one equation and because parameter estimates remain consistent in the presence of conditional heteroscedasticity (Enders, 1995). We also tested for a linear trend term in each equation and this term was statistically insignificant at conventional significance levels in all equations except the Nairobi price equation. Trend terms were not modeled explicitly because they are only statistically significant in one equation and because it is often recommended not to include trend terms in VARs so that the dynamic interrelationships between variables remains as unrestricted as possible (Enders, 1995).

5.2 Impulse response results

The economics underlying dynamic interrelationships between Kenyan maize price and policy variables is that buyers and sellers of maize have two alternative marketing channels to choose from—they can sell to or buy from the NCPB at administratively determined NCPB prices, or they can sell or buy through the private sector wholesale market channel at prices set by forces of supply and demand. Clearly, relative prices in the two channels will be a major determinant of volume moving along each channel, and changing volumes in the market channel should influence market prices. For example, if the NCPB raises its buy price above the market price in Kitale then we might expect more supply entering the NCPB channel and less supply entering the market channel. And as supply contracts in the marketing channel this should put upward pressure on market prices in Kitale. Similarly, if the NCPB raises its sell price above the market price in Nairobi then we might expect less demand for NCPB maize and more demand for market sourced maize.

Nevertheless, volumes moving through the different marketing channels are not expected to depend solely on the price premiums, nor would we expect all of the adjustment to changes in price premiums to occur instantaneously. There are many reasons besides price alone why sellers and buyers might choose a particular marketing channel over another. These would include information gathering, learning, transaction costs and payment modalities associated with different channels, and the benefits of long-term relationships (e.g. you might be excluded from participating later when the price differentials return to being favorable). For these reasons we would expect a dynamic aggregate response to changing price premiums.

The dynamic response of market prices to changes in NCPB buy and sell price premiums can be investigated using impulse response analysis which uses the moving average representation of the VAR to trace out the dynamic effect of shocks to the system on each of the variables in the system. Here we are interested in the dynamic response of market prices to shocks to the NCPB buy and sell price premiums. Based on the economic reasoning above we would expect positive shocks to the premiums to have positive effects on market prices, with the effect being spread over time as a result of adjustment costs from moving between marketing channels.

The response of Kitale and Nairobi maize prices to a one-time random shock in NCPB buy and sell price premiums are shown in Figure 1. As expected, a positive shock to the buy price premium increases Kitale market prices, with the effect starting out small, getting gradually stronger over a seven month period, and then diminishing (but still positive) after that (see the top panel of Figure 1). The second panel of Figure 1 shows that the response of the Nairobi price to a positive shock in the buy price premium mirrors the positive effect on the Kitale price. The third panel of Figure 1 shows the response of the Nairobi price to a positive shock to the NCPB sell price premium. In this case, demand for product through the market channel should increase because this channel has become relatively cheaper, leading to the observed positive response in the Nairobi market price. The fourth and final panel of Figure 1 shows the effect of a shock to the sell price premium on the Kitale price.

Overall, the impulse response results are quite consistent with economic logic and provide support for moving forward and using the VAR to estimate the historical effects of NCPB marketing activities.

5.3 The estimated effects of NCPB marketing activities

Prices in the absence of the NCPB marketing channel were simulated by: (a) recursively constructing a set of counterfactual policy shocks that generate zero values for NCPB buy and sell price premiums over the entire sample period; (b) assuming that the shocks to the market variables remain at their estimated values over the sample period; and (c) constructing dynamic forecasts of the Kitale and Nairobi maize price paths under the counterfactual policy shocks and actual market shocks. The resulting estimated NCPB price effects are tabulated in Table 3 and graphed in Figure 2.

In the initial part of the sample period from April 1989 through May of 1992, prior to serious cereal market reform, NCPB marketing activities are estimated to have lowered average maize prices in both Kitale and Nairobi by approximately 17%, and also stabilized prices by reducing both the standard deviation and the coefficient of variation (CV) of prices over this period (see Table 3 and Figure 2). During this initial period the NCPB set both their buy and sell prices persistently below market prices in Kitale and Nairobi, respectively. Hence, over this initial period the NCPB added stability to the market and lowered average market prices significantly in both Kitale and Nairobi.

The next part of the sample period from June 1992 through June 1995 contains two consecutive seasons of drought that pressured maize supplies in Kenya. During most of this period the NCPB set administered prices at steep discounts to market price levels, at least until mid-1994 when a good incoming harvest depressed market prices and turned the NCPB price from being at a discount to the market to being at a premium. The steep discounts had the effect of keeping average market price in Kitale (Nairobi) approximately 27% (24%) lower over this period than it would have been in the absence of the NCPB channel (see Table 3 and Figure 2).

The final part of the sample period from July of 1995 through October of 2004 corresponds to a period in which grain markets in Kenya were ostensibly liberalized and the NCPB was forced to take a more commercial stance in its operations. Yet Figure 2 shows that the NCPB continued to buy and sell maize at substantial premiums to the market over most of this period. The net effect was to raise mean market prices in Kitale and Nairobi by approximately 21% over the period, and at the same time to reduce both the standard deviation and CV of prices (see Table 3 and Figure 2). These estimated effects suggest that the NCPB has maintained a major influence on maize prices, despite the general perception that the market had been liberalized and despite the fact that the quantities traded by the NCPB are lower than in the pre-liberalization period.

The effect of the NCPB over the entire sample period was to raise both average Kitale and average Nairobi prices (by approximately 5%) and also to stabilize prices by reducing their standard deviation and coefficient of variation over the sample period (see Table 3).

This information can be combined with data on the pattern of maize purchases and sales from household-level surveys to draw inferences about the distributional consequences of government maize price policy. Nationwide farm household surveys implemented during the 1990s and early 2000s consistently indicate that the majority of rural farm households in Kenya are net buyers of maize (which tend to be the relatively smaller and poorer farms) while roughly 10 percent of farms (generally larger) account for the majority of the maize marketed (see Nyoro, Jayne, and Kirimi, 2004). This survey evidence indicates that the market price-raising effects of NCPB operations over the past decade have generally transferred income from (mostly poorer) maize purchasing rural households and urban consumers to larger maize-selling farms.

6. Conclusions

The objective of this paper was to estimate the historical effects of NCPB maize marketing activities on wholesale maize market price levels and variability in Kenya. The analysis uses monthly maize price data covering the period January 1989 through October 2004. Results are based on a VAR approach that allows estimation of a counterfactual set of maize prices that would have occurred over the 1989-2004 period had the NCPB marketing channel been eliminated.

Results from counterfactual model simulations indicate that the NCPB's activities have indeed had a marked impact on both maize price levels and variability. The NCPB's administered prices have, on average, raised wholesale market prices in Kitale (a major surplus production area) and Nairobi (the main urban center) by 4.6 and 5.2 percent, respectively, over the entire sample period. However, the NCPB's impact on the market varied considerably between periods. The estimated effect was large and negative during the 1992/93 drought and 1993/94 when the NCPB was both buying and selling maize at major discounts to market prices. Since the 1995/96 season, however, NCPB prices were mainly set at premiums to the market and their operations are estimated to have raised average Kitale and Nairobi maize prices by around 20%, implying a significant transfer of income from maize purchasing rural and urban households to relatively large farmers who account for roughly half of the country's domestically marketed maize surplus. The NCPB's activities have also reduced the standard deviation and coefficient of variation of prices, consistent with its stated mandate of price stabilization.

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Table 1. Unit Root Test Results

Test	Uganda Price	Kitale Price	Nairobi Price	NCPB Buy Price Premium	NCPB Sell Price Premium
Dickey-Fuller	-4.126 (0.006)	-3.294 (0.067)	-3.206 (0.083)	-4.344 (0.003)	-4.183 (0.005)
Phillips-Perron	-3.665 (0.025)	-3.480 (0.042)	-2.926 (0.154)	-4.730 (0.001)	-3.999 (0.009)

Notes: Dickey-Fuller and Phillips-Perron values are *Z(t)* statistics with MacKinnon approximate *p*-values for testing the null hypothesis of a unit root given in brackets under the statistic. The number of lags included in the augmented Dickey-Fuller tests was 1 and the number of Newey-West lags used in the Phillips-Perron test was 4. Both models include a constant term and a time trend to account for deterministic components.

Table 2. VAR Model Evaluation Results

Test	Uganda Price Equation	Kitale Price Equation	Nairobi Price Equation	Buy Price Premium Equation	Sell Price Premium Equation
Evaluation of Residuals					
- AR(1)	0.045 (0.831)	0.288 (0.591)	0.005 (0.945)	0.105 (0.746)	0.007 (0.935)
- AR(6)	4.7115 (0.581)	6.225 (0.399)	7.172 (0.305)	4.405 (0.622)	2.010 (0.919)
- AR(12)	8.731 (0.726)	16.343 (0.176)	10.529 (0.570)	11.243 (0.508)	7.276 (0.839)
- ARCH(1)	2.419 (0.120)	5.411 (0.020)	1.185 (0.276)	3.069 (0.080)	2.708 (0.100)
- ARCH(6)	2.752 (0.839)	19.020 (0.004)	5.924 (0.432)	6.552 (0.364)	4.278 (0.639)
- ARCH(12)	2.971 (0.996)	28.455 (0.005)	7.407 (0.830)	12.616 (0.398)	7.275 (0.839)
Deterministic Trend	0.225 (0.704)	0.064 (0.842)	0.521 (0.030)	0.090 (0.792)	-0.303 (0.276)

Notes: The AR (ARCH) residual tests are Ljung-Box Q tests for the relevant order autocorrelation in the residuals (squared residuals) of the series. The deterministic trend statistic is a t-value for testing the null hypothesis of no linear trend in each equation, with *p*-value in parentheses under the statistic.

Table 3. Summary of NCPB Effects on Kitale and Nairobi Wholesale Maize Prices

Period	Kitale wholesale maize price (Ksh per 90kg bag)				Nairobi wholesale maize price (Ksh per 90kg bag)		
	Historical	Simulated	% difference		Historical	Simulated	% difference
April 1989 – May 1992							
Mean	305.63	367.28	-16.8%		395.37	474.50	-16.7%
Standard deviation	96.29	127.43	-24.4%		62.17	113.35	-45.2%
Coefficient of variation	31.5%	34.7%	-9.2%		15.7%	23.9%	-34.2%
June 1992 – June 1995							
Mean	780.30	1064.38	-26.7%		942.00	1236.33	-23.8%
Standard deviation	217.20	304.88	-28.8%		159.93	295.31	-45.8%
Coefficient of variation	27.8%	28.6%	-2.8%		17.0%	23.9%	-28.9%
July 1995 – October 2004							
Mean	1006.65	831.47	21.1%		1225.72	1019.25	20.3%
Standard deviation	308.07	395.64	-22.1%		281.01	425.44	-33.9%
Coefficient of variation	30.6%	47.6%	-35.7%		22.9%	41.7%	-45.1%
Overall sample period (April 1989 – October 2004)							
Mean	819.41	783.23	4.6%		1000.85	951.50	5.2%
Standard deviation	378.10	408.79	-7.5%		398.60	439.13	-9.2%
Coefficient of variation	46.1%	52.2%	-11.6%		39.8%	46.2%	-13.7%

Notes: Historical refers to the historical data and simulated refers to estimated market prices in the absence of the NCPB marketing channel. Percentage differences are the estimated effects of the NCPB policies (percentage deviation of the historical price statistics from their simulated values).

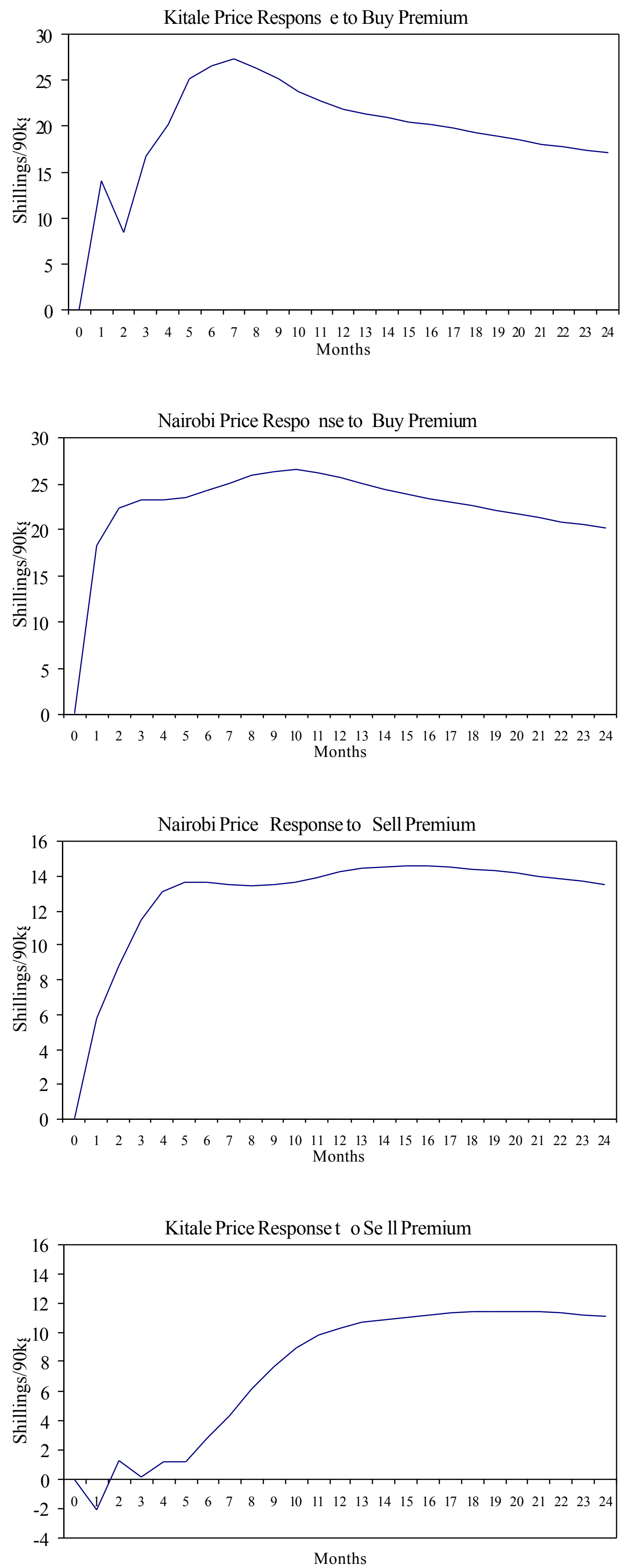
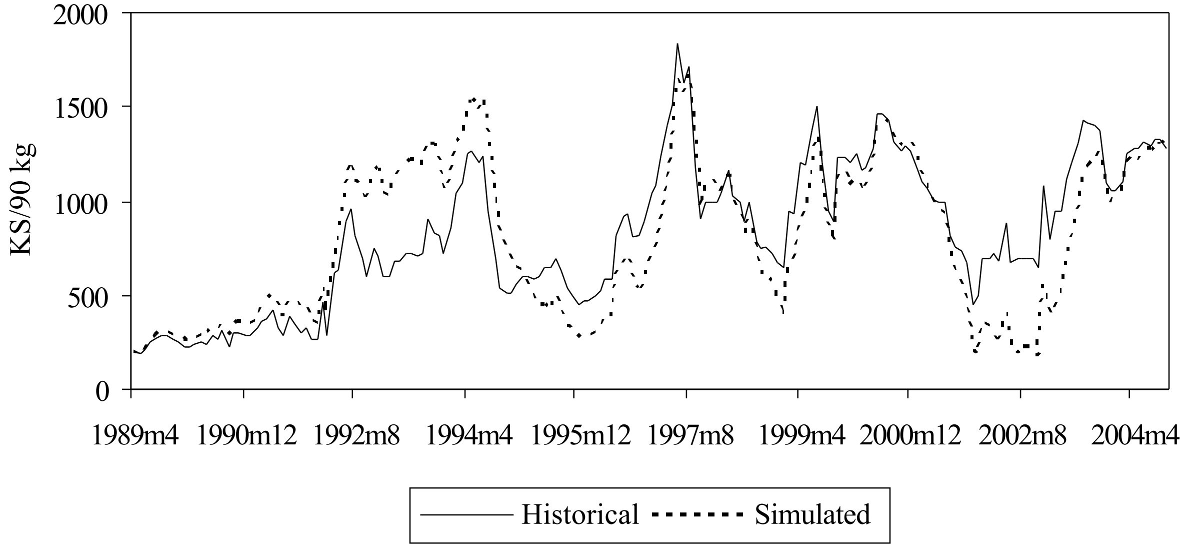


Figure 1. Impulse Responses

Historical and Simulated (No NCPB) Kitale Prices



Historical and Simulated (No NCPB) Nairobi Prices

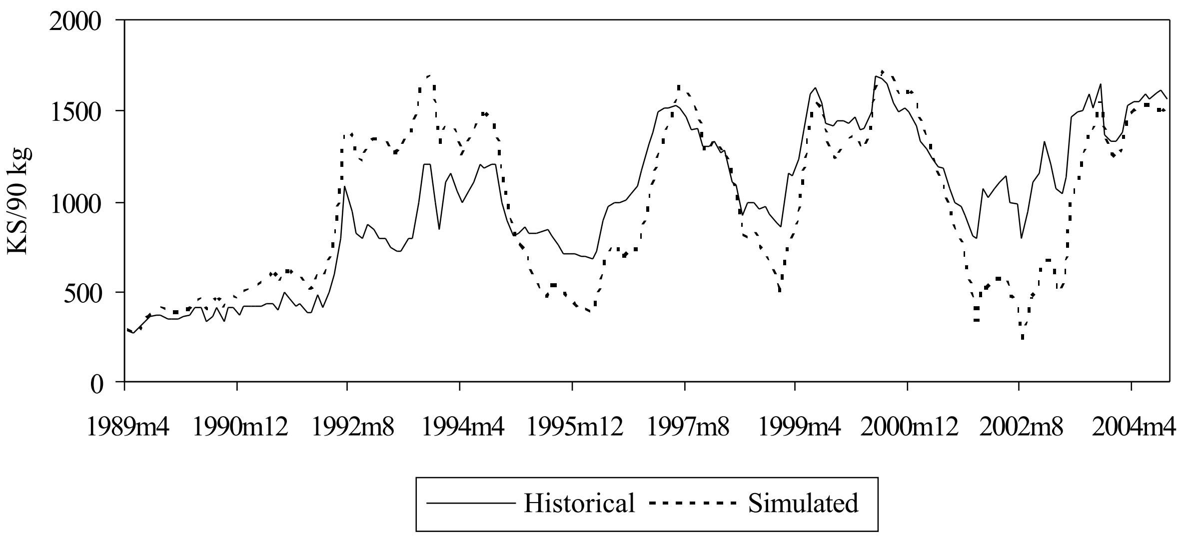


Figure 2. Estimated Effects of NCPB Marketing Activities