AGRICULTURAL ECONOMICS

Agricultural Economics 38 (2008) 313–325

The effects of NCPB marketing policies on maize market prices in Kenya

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Received 20 January 2007; received in revised form 18 September 2007; accepted 15 December 2007

Abstract

The Government of Kenya pursues maize marketing policy objectives through the National Cereals and Produce Board (NCPB), which procures and sells maize at administratively determined prices, and stores maize as a contingency against future shortages. A private sector marketing channel competes with the NCPB. This article estimates the effects of NCPB activities on the historical path of private sector prices in Kenyan maize markets between 1989 and 2004. The analysis is carried out using a reduced form vector autoregression model (VAR) estimated with sparse data and imposing only minimal identification restrictions. Results show that NCPB activities have stabilized maize market prices in Kenya, reduced price levels in the early 1990s, and raised average price levels by roughly 20% between 1995 and 2004. Over the past decade, the price-raising activities of the NCPB have transferred income from urban consumers and a majority of small-scale farm households that are net buyers of maize to a relatively small number of large- and small-scale farmers who are sellers of maize.

JEL classification: Q11, Q18

Keywords: Kenya; Maize policy; Price effects; Vector autoregression

1. Introduction

As in many countries, 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, it is desirable to keep food prices low to promote the food security interests of a growing urban population, and of the many rural households who are net buyers of maize. Policy makers in Kenya 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 legally 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 prices in the private sector channel are controversial and not well understood. Conventional wisdom in Kenya is that the NCPB's operations serve to raise prices, mainly for the benefit of large and politically well-connected maize farmers, but there is little rigorous analysis to support this. 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 an appropriate future role for the NCPB.

Previous empirical research on the impacts of food marketing policies on the level and variability of food prices in developing countries has typically taken a reduced form time-series approach. For example, autoregressive conditional heteroskedasticity (ARCH) models were used by Shively (1996) and Barrett (1997) to investigate the effects of policy reforms on the conditional means and variances of food prices. Shively found that food market liberalization reduced food price variability in Ghana, while Barrett concluded the opposite for Madagascar. Shively et al. (2002) specify time trends, seasonal terms, and deviations from trend output variables to represent

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Data Appendix Available Online

A data appendix to replicate main results is available as part of the online article from: www.blackwell-synergy.com (this link will take you to the article abstract).

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the influence of nonpolicy factors on rice price changes in the Philippines, concluding that the Filipino buffer stock program had little influence on rice prices. Others have investigated the effects of food market reform on spatial market efficiency in developing countries using a parity bounds approach (e.g., Negassa and Myers, 2007). The reason that full structural econometric models of supply and demand are not often used in such studies is that this approach is very data intensive, and the required data are simply not available in many developing countries.

The objective of this article is to estimate the historical effects of NCPB maize marketing activities on private sector maize price levels and variability in Kenya, using monthly data from January 1989 through October 2004. We also discuss some of the income transfer effects of the NCPB's maize marketing operations. As in most developing country studies, it was not possible to use a fully structural econometric model because of data limitations in Kenya. But, unlike previous studies of the effects of price policies on food prices in developing countries, we use a vector autoregression model (VAR). The VAR allows for a set of underlying supply, demand, and policy shocks that influence market prices, and we show how policy simulation can be used to estimate the historical effects of NCPB policies on market prices using minimal identification restrictions.

2. Government policy and the Kenyan maize market

Private maize trade has existed in Kenya throughout much of its history, despite government attempts to suppress it prior to the policy liberalization, which began in the late 1980s. Since 1988 a private market channel has operated legally side by side with the NCPB channel. In the private channel prices are set by supply and demand forces while the NCPB continued to purchase and sell maize at administratively determined prices. The two marketing channels are interrelated in the sense that assemblers buying maize from farmers sell to the NCPB, to wholesalers engaged in long-distance trade, and to buying agents of the major millers operating in urban areas (Nyoro et al., 1999). Large millers source maize from both private buyers and from the NCPB, depending on price relatives. A relatively small informal milling and retailing system also competes with the large millers for market share among consumers.

After the liberalization in 1988 private maize trade was regulated initially by restrictions on grain transportation across district boundaries.[1] These restrictions raised the transaction costs of private cross-district trade, and contributed to the NCPB remaining the primary market channel for maize. From 1988 through 1995, the NCPB purchased roughly 50% to 70% of the estimated total maize surplus marketed from domestic production (Nyoro et al., 1999). Restrictions on cross-district private maize trade were eliminated in 1995. However, the government has continued to influence private market prices by buying and selling maize at administratively determined prices that are sometime above and sometimes below market prices.[2]

Since 1995, the NCPB has often, but not always, offered prices at above-market levels in order to acquire maize from a private sector that had become more competitive and developed (Nyoro et al., 1999). NCPB buy prices were set below market prices in drought years, such as 1997, 2000, and 2003 when supplies in domestic markets were limited and market prices were high. But in normal production years since 1995 the NCPB has typically set prices above market levels. By absorbing maize out of the private sector channel over this period, it is likely that the NCPB's operations raised parallel market prices. Mean wholesale market prices in the major surplus zone of Kitale and the capital city, Nairobi, between January 1989 and December 2004 have been \$160 and \$197 per metric ton, respectively, considerably higher than world market levels.

One of the side effects of absorbing surplus maize off the market is stock accumulation. Indeed, based on the data provided by the NCPB, the board cumulatively purchased 16.8% more maize than it sold domestically between the 1990/91 and 2003/04 marketing years. To ease the stock accumulation problem, the NCPB has exported maize, often at a loss, and also distributed maize for drought relief operations mainly in the pastoral areas of the country.[3]

Trade policy is another important aspect of maize price determination in Kenya. In order to support domestic maize prices, the government has imposed variable tariffs on maize imports, both at the port of Mombasa (to restrict imports from the world market) and at border crossings along the Ugandan and Tanzanian borders. Evidence indicates that the costs of maize production in eastern Uganda is typically lower than in most areas of Kenya (Nyoro et al., 2004), and import tariffs were deemed necessary to stem the inflow of imported maize from Uganda. However, since the border is relatively porous unrecorded cross-border trade occurred regularly, and it is alleged that the NCPB support price policy encouraged maize imports from Uganda at the same time that official trade policy attempted to suppress it (Ackello-Ogutu, 1997). Illegal cross-border trade is impeded somewhat by transaction costs, including bribery payments to police, extra handling charges associated with offloading maize

[1] Movement controls took the form of a maximum quantity of maize that could be transported in a single truckload. There were no restrictions on the number of truckloads that a trader could transport across district boundaries. So the movement controls acted to increase transactions costs rather than as a strict quota on maize movement. Moreover, the existing rules were often not enforced due to bribery payments, which again raise transaction costs without strictly limiting the amount of maize transported.

[2] The NCPB is still able to buy some maize when its purchase price is below the private market channel price, and the private market channel still receives some throughput when the official NCPB price is above the market price. The reason is that price is not the only determinant of channel choice. Switching channels requires information gathering and learning, and therefore incurs adjustment costs. There may also be benefits from establishing long-term channel relationships (e.g., if a farmer declines to sell to the NCPB they might be excluded from participating later when the price differentials return to being favorable).

[3] Most of the food aid distributed in Kenya is in the pastoral northern and eastern parts of the country. High transport costs from these regions to the major maize producing and consuming areas segment these markets to a large extent.

at the border, smuggling it across, and onloading maize onto trucks on the Kenya side.

In summary, we hypothesize that the Kenyan government influenced wholesale maize market prices in Kenya through four main processes: (1) the official price setting process of the NCPB, with the difference between its purchase and sale prices relative to private sector market prices being the major determinant; (2) the restrictions on interdistrict maize trade that were in operation prior to 1995; (3) stockholding policies of the NCPB as indicated by net inflows and outflows from NCPB stocks; and (4) tariff and trade policy, including informal transaction costs of illegal cross-border trade. In this article we focus on the effects of the official price setting process of the NCPB.

3. 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 may have changed over time, and a traditional structural econometric approach is not feasible because prices are the only reliable market data available.

Faced with these problems, we take a VAR approach (Fackler, 1988; Myers et al., 1990; Sims, 1980). VAR models have proven 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 used to investigate the effects of commodity marketing policies (e.g., Myers et al., 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

$$\boldsymbol{B}\boldsymbol{y}_t = \sum_{i=1}^{k} \boldsymbol{B}_i \boldsymbol{y}_{t-i} + \sum_{i=0}^{k} \boldsymbol{C}_i \boldsymbol{p}_{t-i} + \boldsymbol{A}^y \boldsymbol{u}_t^y \tag{1}$$

$$\boldsymbol{D}\boldsymbol{p}_t = \sum_{i=0}^{k} \boldsymbol{G}_i \boldsymbol{y}_{t-i} + \sum_{i=1}^{k} \boldsymbol{D}_i \boldsymbol{p}_{t-i} + \boldsymbol{A}^p \boldsymbol{u}_t^p, \tag{2}$$

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 $\boldsymbol{p}_t$.[4]

This system is underidentified as specified 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).[5] 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 et al., 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 any policy variable (see Hamilton, 1994). Furthermore, if we set all of the market innovations $\boldsymbol{u}_t^y$ to their estimated historical values, and then control the sequence of policy innovations to generate specific historical paths for the policy variables, we can simulate the impacts of alternative policy decisions on the path of each market variable over the sample period (see Myers et al., 1990).

4. Application to Kenyan maize prices

The first step in applying the VAR methodology is to choose variables to include in the $\boldsymbol{y}_t$ and $\boldsymbol{p}_t$ vectors. We want to evaluate the effect of NCPB policy decisions on private sector market prices, which suggests that $\boldsymbol{y}_t$ must contain the market prices of interest. We include two regional wholesale prices in Kenya 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

[4] 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).

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

Kenyan prices. Hence, wholesale price in Mbale is also included in the $\boldsymbol{y_t}$ vector, resulting in a system with three market variables (Kitale wholesale price, Nairobi wholesale price, and Mbale price).

Other variables were also considered for inclusion in the market variable vector. Maize prices in Tanzania might be relevant but a suitable maize price series for Tanzania could not be found and so could not be included. Kenya also occasionally imports maize from South Africa or related world markets so South African prices are also candidates for inclusion in the $\boldsymbol{y_t}$ vector. However, internationally sourced maize is only rarely competitive in Kenya because of the import tariff and so South African prices are unlikely to have a major influence on Kenyan prices in normal years. Furthermore, estimated NCPB policy effects on Kenyan maize prices were very similar irrespective of whether or not the South African price was included in $\boldsymbol{y_t}$ (results available on request). Hence, South African prices were not included in the final model specification. Including other market variables such as trade flows, consumption levels, private storage levels, etc., might provide additional information but data on these variables for maize in Kenya are not available. Hence, the $\boldsymbol{y_t}$ vector in the final model specification includes three variables—Kitale price, Nairobi price, and Mbale price.

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 market 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 sale price and the market price in consuming regions). Hence, we included two variables in the $\boldsymbol{p_t}$ vector: (1) 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 (2) 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). Notice that both of these policy variables can be positive, zero, or negative and if both of them were set to zero then the market would be operating without NCPB influence.

There are other potential variables that might have been included in the $\boldsymbol{p_t}$ vector. As well as the price premiums we might have included a measure of how much maize the NCPB was actually selling and buying at its administratively determined prices. Positive net NCPB purchases would indicate they are adding to their stocks while negative net purchases would indicate they are running down stocks. However, it was found that estimated NCPB effects on maize market prices were very similar irrespective of whether the third policy variable (net NCPB purchases) was included or not (results available on request). This suggests that the effects of the NCPB on market prices is well captured by the price premium variables alone, probably because the extent to which the NCPB is building or reducing stocks is tied so closely to the size of their buy and sell price premiums and discounts. For this reason the final model specification reported below only includes the buy price premium and the sell price premium in the policy vector $\boldsymbol{p_t}$.

There are two other policy variables that might be sensibly included in the model. The first is a variable representing the restrictions on interdistrict maize trade that were in place in Kenya prior to 1995. It is possible that these restrictions influenced private markets in ways that stretch beyond the effects of the buy and sell price premiums offered by the NCPB. This means that the effects of NCPB activities might be substantively different before and after the restrictions on interdistrict trade were abolished in 1995. We investigate this possibility by testing for structural change in the VAR model before and after the 1995 policy change, and find no evidence of structural change (see the discussion below). We also estimated separate VARs for the two subsamples before and after the restrictions on interdistrict trade were lifted in 1995. It was found that results on the effects of NCPB policies were very similar, irrespective of whether the full sample model or the two split-sample models were used. Hence, results reported below are for the full sample model assuming constant parameters across the entire sample period.

The second variable we might want to include in the policy vector would be a measure of the formal tariff rate the government imposes on maize imports. However, the tariff is an administratively determined rate that is changed very infrequently and therefore not well suited to being modeled in a linear VAR framework. Furthermore, the tariff rate is already included implicitly in the model because the Ugandan maize price data are converted to Kenyan shillings and adjusted by the historical tariff rate in order to make the Ugandan prices directly comparable to Kenyan prices. This suggests that the effects of NCPB marketing activities can be evaluated assuming no change in the tariff (i.e., assuming the tariff was set at its historical level) without including a separate tariff variable directly in the $\boldsymbol{p_t}$ vector.[6]

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 that maize sellers and buyers respond to a change in the NCPB buy and sell price premiums, but that 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

[6] One way of simulating the tariff effect separately would be to extract the tariff effect from the Ugandan prices, and then recursively compute the resulting dynamic price path of the Kenyan maize price variables using the VAR. Undertaking this analysis suggested that the tariff effects on domestic Kenyan maize prices are considerably smaller than the influence of NCPB marketing activities (results available on request).

Table 1
Unit root test results

Test	Uganda price	Kitale price	Nairobi price	NCPB buy price premium	NCPB sell price premium
Dickey-Fuller					
-With trend	−4.126	−3.294	−3.206	−4.344	−4.183
	(0.006)	(0.067)	(0.083)	(0.003)	(0.005)
-Without trend	−3.885	−2.400	−2.008	−4.191	−4.111
	(0.002)	(0.142)	(0.283)	(0.001)	(0.001)
Phillips-Perron					
-With trend	−3.665	−3.480	−2.926	−4.730	−3.999
	(0.025)	(0.042)	(0.154)	(0.001)	(0.009)
-Without trend	−3.505	−2.507	−1.799	−4.561	−3.937
	(0.008)	(0.114)	(0.381)	(0.000)	(0.002)

Notes: Dickey-Fuller and Phillips-Perron values are $Z(t)$ statistics with Davidson and MacKinnon (1993) approximate P-values for testing the null hypothesis of a unit root given in parentheses 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.

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 at 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.

Furthermore, the only real alternative to setting $\boldsymbol{C_0} = 0$ is to set $\boldsymbol{G_0} = 0$, which implies that policy variables do not respond contemporaneously to changes in market prices. This is an untenable assumption because it implies that the NCPB is not monitoring closely what is going on in the markets. We estimated the model under the $\boldsymbol{G_0} = 0$ restriction and found that impulse responses were illogical and inconsistent. Hence, $\boldsymbol{C_0} = 0$ appears to be the most appropriate identification restriction for this application.

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. This implies the NCPB determines its buy price premium first and evaluates how much maize is being delivered, then it sets the sell price premium based on results being obtained. This seems logical and the results are very similar using the reverse order.[7]

5. Data and preliminary results

5.1. Data

The study uses monthly data from January 1989 through October 2004. Wholesale maize prices for Kitale and Nairobi are collected weekly and averaged into monthly prices by the Ministry of Agriculture's Market Information Bureau (MIB). Only monthly prices are disseminated by the MIB. 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 90 kg 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 them directly comparable to Kenyan prices. The NCPB price, sales, and purchase data were acquired directly from the NCPB. Over the sample period, NCPB purchase and sale prices were pan-territorial and pan-seasonal (i.e., they are uniform at all depots throughout the country and remain fixed within the marketing season, except for several years when they were revised more than once in the year as a response to changes in crop forecasts). Therefore, it was straightforward to match up NCPB prices with specific Kitale and Nairobi market prices to compute price premia for any given month.

5.2. Diagnostic tests

The first step was to test the data for unit roots and cointegration. Dickey-Fuller and Phillips-Perron tests for unit roots are reported in Table 1. One lagged dependent variable was sufficient to eliminate autocorrelation in the residuals in all of the Dickey-Fuller regressions, and the regressions were estimated with a time trend (the most general alternative hypothesis of stationarity around a deterministic trend) and without (the more specific alternative hypothesis of stationarity around a constant mean). Phillips-Perron tests were also applied as a consistency check, again both with and without a time trend. For the Phillips-Perron tests the number of Newey-West lags was set to 4. Enders (1995) suggests first testing for a unit root with trend included. If the null hypothesis of a unit root is rejected then stop and conclude that the series does not have a unit root. This step supports stationarity in all variables except the Nairobi maize price, which shows evidence of a unit root irrespective of whether or not a trend term is included in the model (see Table 1). However, it is very unlikely that the Nairobi price

[7] Also note that this recursive ordering only influences the impulse response analysis and has no effect on the simulated path of counterfactual prices in the absence of the NCPB (because in this case both of the NCPB policy variables become zero in every period irrespective of the recursive ordering).

would have a unit root while the Kitale and Ugandan prices are stationary. Given this, the fact that unit root tests have notoriously low power, and the fact if there are structural breaks in the series the Dickey-Fuller and Phillips-Perron tests are biased toward accepting a unit root (see Perron, 1989), we would conclude that the evidence generally supports stationarity of all variables. Since all variables are concluded to be stationary cointegration testing is unnecessary.

Nevertheless, impulse response analysis (reported later) shows that shocks to this system of variables have persistent effects that fail to die out after 24 months, suggesting that unit root, or near unit root, behavior remains a possibility. Therefore, it is prudent to investigate the potential pitfalls of proceeding with estimation under the assumption of stationarity when the system is actually characterized by unit roots and possibly cointegration. Fortunately, it is well known that OLS remains a consistent estimator of VAR parameters, even in the presence of unit roots and cointegration (Hamilton, 1994). It is true that some efficiency will be lost by not imposing valid unit root and cointegration restrictions, but this is not an important issue given the sample size in our study. Less fortunately (and somewhat surprisingly), it is also true that very long-run horizon impulse response coefficients computed from these consistent OLS VAR parameter estimates are inconsistent estimates of the true long-run impulse responses if valid unit root and cointegration restrictions are not imposed (Phillips, 1998). This suggests that the impulse response analysis in this article should be interpreted with caution. However, the impulse response analysis in this article is only used to check whether the dynamics of the model are consistent with responses we would expect based on sensible economic reasoning. The main policy conclusions come from in-sample policy simulations using the VAR parameters and do not involve any long-horizon forecasting. These in-sample policy effects should be estimated consistently by OLS even in the presence of unit roots and cointegration. Therefore, the main costs of not imposing valid unit root and cointegration restrictions in this study would remain the loss of efficiency in estimating the VAR parameters.

It is also important to remember that there will be costs involved in falsely imposing invalid unit root and cointegration restrictions. Imposing such restrictions erroneously will lead to biased estimation of VAR parameters, in much the same way that imposing any invalid restriction during estimation will do. Given these potential costs, the results of the unit root tests, and the fact that not imposing valid unit root and cointegration restrictions only entails a loss of efficiency for the estimated in-sample policy simulations, we do not impose any unit root or cointegration restrictions when estimating the VAR.

Trends terms are sometimes included in VAR models to account for deterministic trends in variables. Based on test results provided below there was no strong evidence of deterministic trends in our model and so trend terms were excluded from the VAR.

Seasonality is another potentially important influence to model in the VAR. However, 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 and Uganda.

6. Results

6.1. VAR estimation results

Given the preceding preliminary results, a five variable VAR (Ugandan price, Kitale price, Nairobi price, the buy price premium, and the sell price premium) 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 a third-order lag and residuals from this model are well behaved in all cases.

Third-order VAR estimation results are provided in Table 2. As is typically the case in VAR models, there are many parameter estimates that are not individually statistically significant. However, likelihood ratio tests and tests for residual autocorrelation suggest a third-order model is appropriate, and the usual approach is to allow the dynamic interrelationships among variables to be estimated without further exclusion restrictions based on individual *t*-statistics. Coefficients of determination shown at the bottom of the table indicate each equation has strong in-sample explanatory power.

Specification tests for the third-order VAR are reported in Table 3. 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 heteroskedasticity (ARCH) in any residual series, except for the Kitale price equation, which does show evidence of ARCH effects. ARCH effects are not modeled explicitly because they only appear in one equation and because parameter estimates remain consistent in the presence of conditional heteroskedasticity (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 (see Table 3). 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).

Table 2
VAR estimation results

Coefficient	Uganda price equation	Kitale price equation	Nairobi price equation	Buy price premium equation	Sell price premium equation
Constant	46.75	19.83	43.26	−34.64	−15.39
	(0.81)	(0.63)	(1.82)	(−1.03)	(−0.56)
Uganda price-lag 1	0.98	0.02	0.02	−0.02	−0.02
	(13.37)	(0.43)	(0.55)	(−0.52)	(−0.64)
Uganda price-lag 2	−0.14	0.02	−0.00	−0.00	−0.00
	(−1.42)	(0.37)	(−0.12)	(−0.01)	(−0.10)
Uganda price-lag 3	0.04	−0.03	−0.01	0.03	0.02
	(0.60)	(−0.86)	(−0.40)	(0.62)	(0.45)
Kitale price-lag 1	−0.10	1.07	0.36	−0.15	−0.22
	(−0.31)	(5.99)	(2.68)	(−0.78)	(−1.43)
Kitale price-lag 2	−0.01	−0.25	−0.19	−0.08	0.16
	(−0.02)	(−1.09)	(−1.09)	(0.33)	(0.81)
Kitale price-lag 3	0.06	−0.06	0.03	0.11	−0.10
	(0.19)	(−0.34)	(0.25)	(0.59)	(−0.66)
Nairobi price-lag 1	0.34	0.19	1.09	−0.03	−0.21
	(0.92)	(0.93)	(7.24)	(−0.15)	(−1.24)
Nairobi price-lag 2	−0.14	−0.00	−0.27	0.08	−0.31
	(−0.28)	(−0.00)	(−1.34)	(0.27)	(1.34)
Nairobi price-lag 3	−0.07	−0.01	−0.03	−0.04	0.07
	(−0.19)	(−0.05)	(−0.19)	(−0.21)	(0.43)
Buy premium-lag 1	−0.16	0.26	0.27	−0.68	−0.13
	(−0.56)	(1.69)	(2.32)	(4.19)	(−0.98)
Buy premium-lag 2	0.05	−0.37	−0.24	0.27	0.22
	(0.13)	(−1.83)	(−1.55)	(1.24)	(1.25)
Buy premium-lag 3	0.09	0.24	0.02	−0.24	−0.08
	(0.32)	(1.56)	(0.21)	(−1.49)	(−0.64)
Sell premium-lag 1	0.44	−0.04	0.11	0.03	0.73
	(1.54)	(−0.25)	(0.94)	(0.21)	(5.49)
Sell premium-lag 2	−0.23	0.06	−0.03	−0.29	0.05
	(−0.64)	(0.28)	(−0.22)	(−0.13)	(0.27)
Sell premium-lag 3	−0.13	−0.09	0.01	0.11	0.02
	(−0.47)	(−0.62)	(0.09)	(0.72)	(0.19)
R^2	0.834	0.913	0.955	0.713	0.765

Note: Numbers in parentheses under the coefficient estimates are associated *t*-statistics.

Data for the model cover a fairly extended period from January 1989 through October 2004. During this time there were two major shocks, which may have caused structural change in the VAR—the drought of 1993/94 (which also coincided with the period when the import tariff was temporarily waived) and the removal of interdistrict trade restrictions implemented in 1995. This suggests investigating structural change in the model by breaking the full sample into three periods: (1) the early "partial liberalization period" from January 1989 through May 1992; (2) the "drought period" from June 1992 through June 1995, which featured the removal of the maize import tariff and also featured a drought in 1993/94, and; (3) the "full liberalization period" from July 1995 through October of 2004, during which time interdistrict controls on private trade were completely eliminated, but the import tariff was reinstated to restrict imports. Dummy variables were constructed and used to test for structural change in the VAR over these three periods using Chi-square tests. Tests for the null hypothesis of no structural change are reported in Table 3 and support the hypothesis of no structural change. Therefore, the VAR was assumed to be stable over the entire sample period for further analysis.

It is also possible that imports have a significant effect on the dynamic interrelationships between price and policy variables in the VAR. To test this we obtained monthly data on private sector, NCPB, and food aid imports from the NCPB. These three import variables were then included as exogenous variables in the VAR and Chi-square tests conducted for whether they have additional explanatory power once all the price and policy variable lags had been included. Results reported in Table 3 support the null hypothesis that the import variables have no additional explanatory power. Therefore, imports were not included as exogenous variables in the VAR.[8]

[8] Of course, this does not necessarily mean that imports do not affect prices, only that imports do not inform the dynamic interrelationships between domestic prices and NCPB price premiums, once lags of the price and policy variables have been accounted for. Put differently, exclusion of the import variables implies that when the effects of NCPB activities on prices are evaluated it is being assumed that imports will continue to play the same *role* they have played historically in influencing market price levels (though not necessarily that imports would remain at their historical *levels*.

Table 3
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	0.288	0.005	0.105	0.007
	(0.831)	(0.591)	(0.945)	(0.746)	(0.935)
- AR(6)	4.7115	6.225	7.172	4.405	2.010
	(0.581)	(0.399)	(0.305)	(0.622)	(0.919)
- AR(12)	8.731	16.343	10.529	11.243	7.276
	(0.726)	(0.176)	(0.570)	(0.508)	(0.839)
- ARCH(1)	2.419	5.411	1.185	3.069	2.708
	(0.120)	(0.020)	(0.276)	(0.080)	(0.100)
- ARCH(6)	2.752	19.020	5.924	6.552	4.278
	(0.839)	(0.004)	(0.432)	(0.364)	(0.639)
- ARCH(12)	2.971	28.455	7.407	12.616	7.275
	(0.996)	(0.005)	(0.830)	(0.398)	(0.839)
Deterministic trend	0.225	0.064	0.521	0.090	−0.303
	(0.704)	(0.842)	(0.030)	(0.792)	(0.276)
Structural breaks	1.12	0.99	4.43	0.07	5.12
	(0.571)	(0.610)	(0.109)	(0.966)	(0.077)
Import effects	0.15	1.56	2.45	1.57	1.35
	(0.985)	(0.670)	(0.484)	(0.666)	(0.717)

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 statistics are t-values for testing the null hypothesis of no linear trend in each equation. The structural break statistics are Chi-square values for testing the null hypothesis of no structural breaks in the relevant VAR equation, and the import effects are Chi-square values for testing the null hypothesis that import variables have no explanatory power in the model. Values in parentheses under each statistic are corresponding *P*-values.

6.2. Impulse response results

The economics underlying dynamic interrelationships between Kenyan maize price and policy variables is that sellers and buyers of maize have two alternative marketing channels to choose from—they can sell to or buy from the NCPB at administratively determined 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 because of adjustment costs and other rigidities (see footnote 2). Hence, 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 a one-time shock 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 is shown in Fig. 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 (see the top panel of Fig. 1). The second panel of Fig. 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 Fig. 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 Fig. 1 shows the effect of a shock to the sell price premium on the Kitale price.

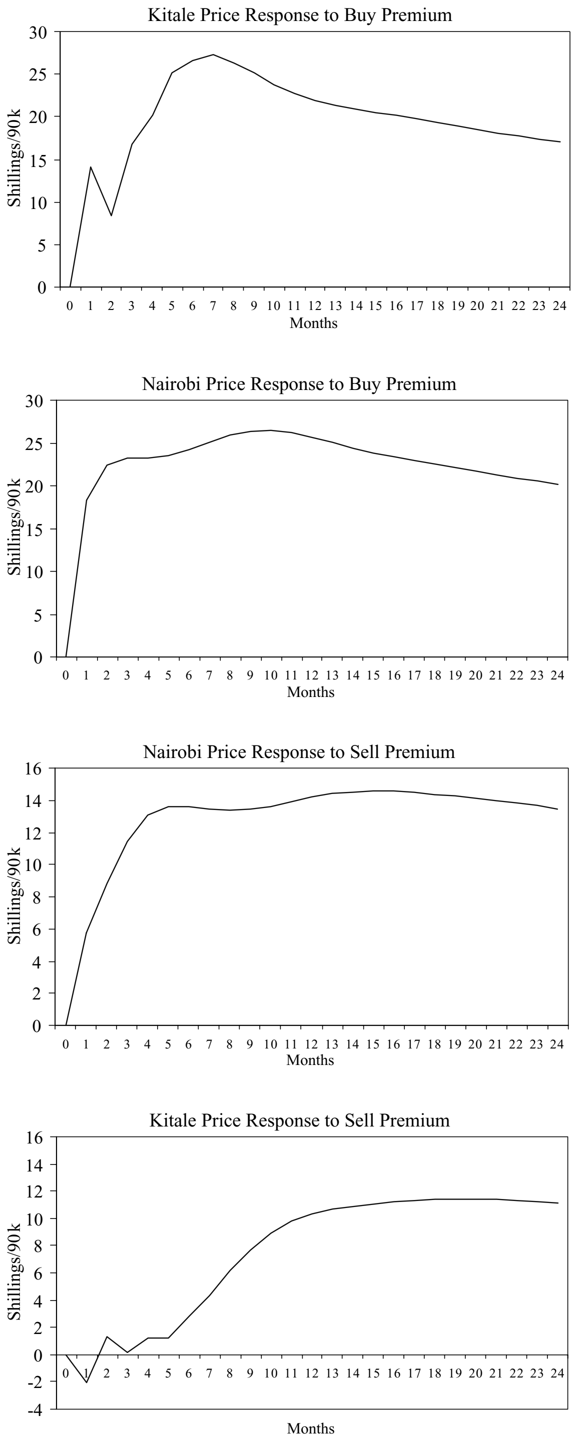

Fig. 1. Impulse response functions.

Overall, the impulse response results are quite consistent with economic logic and suggest that shocks to the NCPB price premiums have a persistent effect on market prices. Even after 24 months the marginal effect of the one-time premium shock continues to be quite substantial.

6.3. *The estimated effects of NCPB marketing activities*

Prices in the absence of the NCPB marketing channel were simulated by: (1) recursively constructing a set of counterfactual policy shocks that generate zero values for NCPB buy and sell price premiums over the entire sample period; (2) assuming that the shocks to the market variables remain at their estimated sample values over the sample period; and (3) 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 4 and graphed in Fig. 2. In addition, Fig. 3 graphs the estimated NCPB price effects against the historical NCPB price premiums to illustrate the relationship between premium choice and the resulting price effect.

In the initial period of partial maize market reform from April 1989 through May of 1992, 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 4 and Fig. 2). Figure 3 shows that during this initial period the NCPB set both their buy and sell prices persistently below market prices, thus lowering and stabilizing market prices in both Kitale and Nairobi.[9]

The next part of the sample period from June 1992 through June 1995 contains two consecutive drought seasons that exerted upward pressure on maize prices in Kenya. During most of this period the NCPB intensified its efforts by setting administered prices at steep discounts to market price levels, at least until August of 1993 when their buy price shifted from being at a discount to the market to being at a premium (see Fig. 3). 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 4 and Fig. 2).

The final and longest part of the sample period, from July of 1995 through October of 2004, corresponds to a period in which grain markets in Kenya were officially liberalized and the NCPB was forced to take a more commercial stance in its operations. Fig. 3 shows that the NCPB bought and sold maize at both premiums and discounts to the market over this period, but that periods where the NCPB prices were at a premium were longer and more pronounced than periods in which NCPB maize was priced at a discount. The net effect was to raise mean market prices in Kitale and Nairobi by approximately 20% over the period, and at the same time to reduce both the standard deviation and CV of prices (see Table 4 and Fig. 2). These estimated effects suggest that the NCPB has maintained a major influence on maize prices over the

[9] However, the budgetary costs involved in achieving this improvement in price stability are not known, and the lower prices would clearly have had a negative effect on the welfare of surplus maize producers. Hence a net welfare improvement cannot be inferred.

Table 4
Summary of NCPB effects on Kitale and Nairobi wholesale maize prices

Period	Kitale wholesale maize price (Ksh per 90 kg bag)			Nairobi wholesale maize price (Ksh per 90 kg 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).

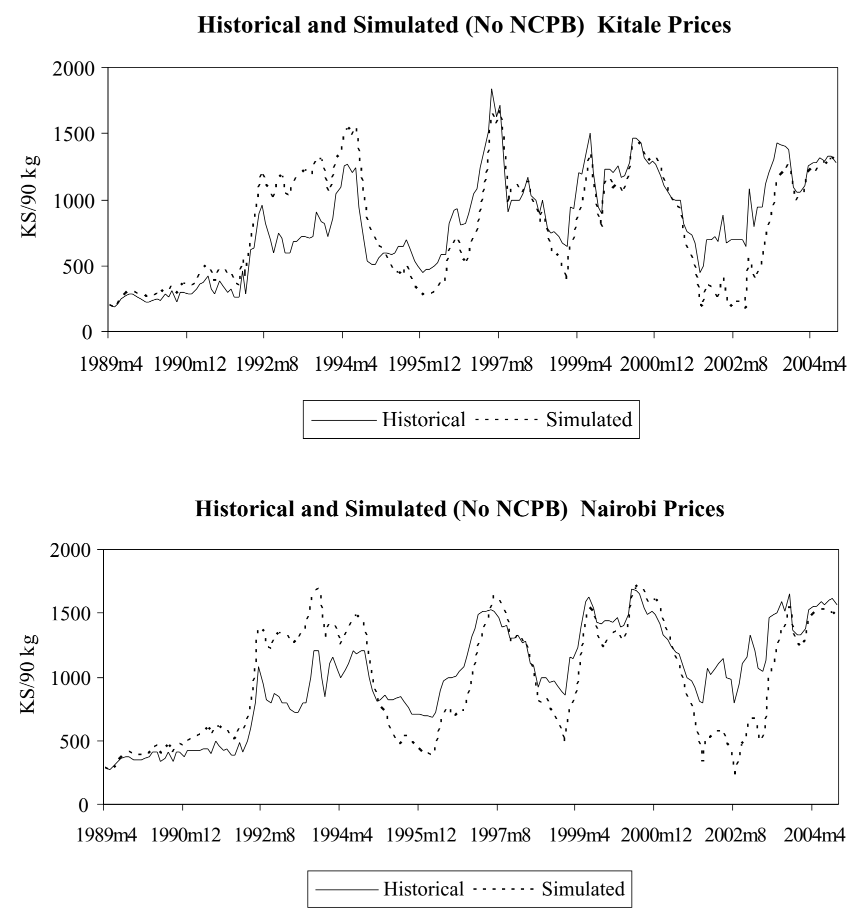

Fig. 2. Estimated effects of NCPB marketing activities.

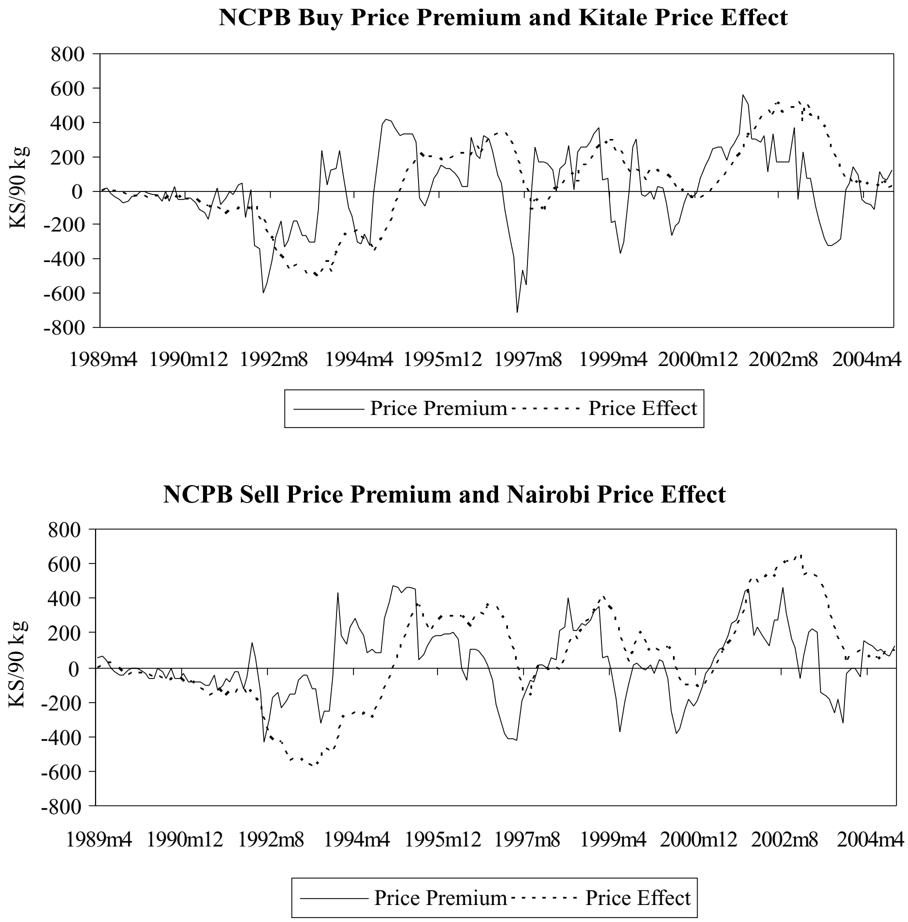

Fig. 3. NCPB premiums and price effects.

post-liberalization period, despite the general perception that the market had been liberalized.

The effect of the NCPB over the entire sample period was to raise both average Kitale and Nairobi prices by approximately 5% and also to stabilize prices by reducing their standard deviation and coefficient of variation (see Table 4). However, the NCPB's average effect over the full sample period masks distinct periods of both negative and positive effects on market maize prices. In particular, and in accordance with local perceptions in Kenya, the NCPB's operations since grain markets were liberalized in 1995 have served to raise maize market prices significantly, by an average of just over 20%.

The NCPB has also had a clear stabilizing effect on maize market prices. In many months over the sample period, there are relatively small differences between the historical and the simulated prices. It is mainly when there is an unusually poor harvest, or more commonly a good harvest, that we see sizeable divergences between the actual and simulated prices. Most of the months where the NCPB had a relatively large positive effect on markets prices (e.g., 1996, 1999, 2002, and 2003) are during surplus conditions when simulated prices without the NCPB effect are relatively low. However, in other periods, usually when maize deficits occurred (e.g., 1993, 1994, and the end of 1997), NCPB operations served to push market prices lower as the simulated prices without the NCPB effects are considerably higher than actual historical prices.

6.4. *Distribution and poverty effects*

The NCPB's estimated influence on maize price levels 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 by the Tegemeo Institute of Egerton University consistently indicate that the majority of rural farm households in Kenya are net buyers of maize, who tend to be the relatively smaller and poorer farms. By contrast, roughly 20% of farms (generally larger) account for the majority of the maize marketed nationwide (see Table 5). Moreover, less than 3% of the farms in this nationwide sample account for 50% of all the maize sold from the smallholder sector (see Jayne et al., 2006). This survey evidence indicates that the effects of the NCPB price-raising operations over the past decade have been to transfer income from (mostly poorer) maize-purchasing

Table 5
Characteristics of small-scale households in Kenya using pooled data from 1997, 2000, and 2004

	Maize marketing position						
	Sell only (n = 781)	Buy only (n = 2052)	Net seller (n = 467)	Net buyer (n = 242)	Net equal (n = 18)	Neither buys nor sells (n = 412)	Total (n = 3972)
% of total sample	19.7	51.7	11.8	6.1	0.5	10.4	100
Household income (2004 Ksh per hh)	334,188	175,409	275,006	184,375	243,950	213,775	223,176
Crop income (2004 Ksh per hh)	182,093	86,702	153,616	90,908	157,080	102,893	115,580
Household wealth (2004 Ksh per hh)	273,390	58,662	118,840	61,862	31,590	110,435	113,401
Land cultivated (acres)	7.5	2.6	4.8	3.0	2.4	3.6	4.0
Household size (adult equivalents)	6.2	6.2	6.2	6.3	6.9	5.8	6.2
Female-headed households (%)	12%	49%	7%	16%	5%	11%	100%

Source: Tegemeo Rural Household Surveys, based on nationwide sample of 1,324 rural farm households surveyed in 1997, 2000, and 2004.

rural households and urban consumers to larger maize-selling farms. This conclusion is consistent with the findings of Mude and Kumar (2006) and Mghenyi (2006), who independently used different years of the same household panel data set to estimate the effects of maize price changes on rural poverty. Mghenyi's study found that a 20% increase in maize market prices increased rural headcount poverty rates and transferred income from the majority of small-scale maize purchasing farmers in rural Kenya to a much smaller number of larger maize-surplus farmers. Of course, these estimates do not account for any additional welfare effects due to the enhanced maize price stability resulting from NCPB activities.

7. Conclusions

Parastatal marketing boards continue to operate in many African countries, yet their impacts on food markets remain poorly understood. Analysis of parastatal effects on market price levels can provide insights into the distributional effects of state activities in food markets, how governments are managing the food price dilemmas they face, and possible changes needed to achieve greater congruence between government operations and stated national development objectives.

The objective of this article was to estimate the historical effects of NCPB maize marketing activities on wholesale maize market price levels and stability in Kenya. The analysis uses monthly maize price data covering the period January 1989 through October 2004. Results are based on a VAR model 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 around 5% over the entire sample period. However, the NCPB's impact on the market varied considerably between periods. Private sector maize prices were reduced in the early part of the sample period from 1989 through 1994, especially during the 1992/93 drought and in 1993/94 when the NCPB was both buying and selling maize at major discounts to market prices. Throughout this period NCPB operations were transferring income from the larger surplus-producing maize farms to consumers and small-scale maize producers who were net buyers of maize. Since the 1995/96 season, however, NCPB prices were mostly 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 a small number of 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 over the sample period, consistent with its stated mandate of price stabilization. With some notable exceptions, the NCPB's impact in raising food prices occurred primarily during surplus production years, while market prices were often lowered during years of shortage. Hence, surplus maize producers benefited from NCPB intervention primarily when market prices would have otherwise been low, while consumers and deficit producers benefited when prices would have otherwise been relatively high. This interpretation is consistent with the finding that the NCPB had a generally stabilizing effect on maize market prices in Kenya.

Acknowledgments

This study was carried out under the Tegemeo Agricultural Monitoring and Policy Analysis Project, funded by USAID/Kenya, and by USAID/Washington's Africa and Economic Growth and Agricultural Technology Bureaus. The authors also acknowledge the helpful comments and support from the poverty and Economic Management group in the African Region of the world Bank.

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