

Effects of Agricultural Policy Change on Maize Supply in Developing Countries: A Comparative Study of Kenya and Zambia

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Abstract

The impact of agricultural market liberalization on maize output in Kenya and Zambia and its effect on food security in these countries is evaluated in this paper. The findings suggest a weak policy influence on maize output, but the precipitation and acreage variables stand out as core determinants of maize output. Overall, the obtained results, agricultural markets in general, and the maize sub-sector in particular, responded more positively to implemented policies in Kenya, than in Zambia. Pre-existing economic structures would have contributed to the outcome. Effective policy implementation would have to be tailored to meet regional needs and local conditions. Region and sector dynamics were not considered when formulating and implementing structural adjustment policies in the 1980s. It can be inferred from the study that countries with strong economic institutions performed better than those which had weak ones.

Keywords: *agricultural policies; food security; maize; Kenya; Zambia.*

Introduction

Food security is a major challenge in Kenya and Zambia. It is further compounded by an unsustainable increase in agricultural productivity, poor price and cost incentives, and incoherent agricultural policies. Ironically, the agricultural sector fulfills an important role in the economy. The challenge of raising agricultural productivity to meet the food security dilemma echoes Theodore Schultz's Nobel Prize acceptance speech in 1979 which underlined the potential of agriculture in low-income countries, to produce enough food for the then growing population, and to improve their incomes and welfare (Schultz, 1979).

In many sub-Saharan African (SSA) countries the pre-reform period was mostly rife with government intervention in markets, and strict controls over the pricing and agricultural marketing. The restriction

of domestic and external markets and activities contributed to economic challenges in many developing economies (Thomas, 2006). Economic growth rates stagnated or weakened by the 1980s (Mohan et. al., 2000). The reform of economic and political policies chocking growth was necessary in reversing the rapid economic decline (Mohan et al., 2000). In part, the ineffective national economic policies and institutional weaknesses are assumed to lead to the witnessed decline (Mohan et al., 2000; Binswanger and Deininger, 1997).

The World Bank (WB) initiated structural adjustment¹ programs (SAP) at the beginning of the 1980

¹ Structural adjustment was the process by which the IMF and the World Bank based their lending to

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so as to deal with the economic decline. The policies were in favor of functional liberal markets and institutional reforms as the main approaches of leading to stronger growth. The unfolding market era was preceded by barriers to a functional exchange rate system, interest rates and an economic system managed by the state. The reform of the agricultural sector had the potential to affect the entire economy given its important contribution to the gross domestic product (GDP). Publicly financed marketing enterprises² participated in the procurement of inputs and the purchasing of agricultural outputs. Liberation of domestic and cross-border economic activities was presumed to lead to economy-wide gains (Edwards, 1993; Mohan et al., 2000).

The maize cereal is an important food crop for both urban and rural consumers in eastern and southern Africa. The crop's yield potential and ease of processing and marketing is of significant value. Its consumption is comparable to rice and wheat in Asia (Byerlee and Eicher, 1997). Improvement in production systems has been accompanied by changes in maize processing and marketing. In Kenya and Zambia, the crop has shown improvements in total agricultural production (Seshamani, 1998; Mosley, 1986; Jayne, 1997; 2002). The structural and institutional reforms sanctioned governments to adhere to the Berg Report³. Reforms were anchored on the notion that deregulation and unfettered market competition would guarantee the 'right' input prices and higher producer prices for farmers (Havnevik et al., 2007). The specific reforms required the liberalization of input and output prices through the elimination of subsidies on agricultural inputs such as fertilizer and credits. The goal was to align domestic prices to international ones and to bring to an end pan-territorial pricing. The encouragement of the private sector was deemed crucial.

underdeveloped economies, on certain conditions, pre-determined by these institutions (Mohan et al., 2000).

² These publicly financed enterprises are here referred to as parastatals. They were mandated by the government to administer services which favored government policies pertaining to the functioning of the agricultural sector and pertinent markets.

³ The Berg report refers to the report published by the World Bank in 1981 and written by Eliot Berg. The report was entitled "Accelerated Development in Sub-Saharan Africa"

Trade-prohibitive measures such as delivery quotas, licensing arrangements, restrictions, and other regulatory arrangements had proven costly.

Theoretical Approach to Cereal Production

The theoretical model used encapsulates the Leontief (fixed proportions) technology approach by taking into account the combination of land and other non-land factor inputs. Eckstein (1984) adopted the same model in another study. Maize production is made dynamic by allowing past land allocation to affect current levels of output. The price of maize during the preceding year is assumed to influence current year's acreage and output.

The following definitions are considered: X_{it} is the production of crop i at time t ; P_{it} is the producer price of crop i at time t ; A_{it} is the land allocated at time $t-1$ for the production of crop i at time t ; $\bar{A}$ is the total available cultivated land at time t ; $0 < \beta < 1$ is the objective discount factor equivalent to $\left(\frac{1}{1+r}\right)$, and E is the expectations operator, where $E_t(X) = E(X|\Omega_t)$, and Ω_t is the information set available for farmers at time t ; and L is the lag operator defined by the property $L^k X_t = X_{t-k}$. Crop 1 represents maize and Crop 2 is tea or some other cash crop.

A two period production cycle is assumed for the production of a staple cereal (maize) crop and competing cash crops such that maize planted in period $t-1$ is sold or consumed in period t . As a result of the fixed proportions production technology between land and non-land factors, the output of each activity can be related to the size of land utilized for that activity. This property is expressed as:

$$A_{1t} + A_{2t} = \bar{A} \quad [1]$$

A_1 is maize acreage, A_2 is acreage of competing crops, and $\bar{A}$ is total acreage. The output of maize and other crops in land use during time t is expressed as follows:

$$X_{1t} = \left[d_0 - \frac{d_1}{2} \bar{A}_{t-1} + (\bar{A}_{t-1} - A_{1t-2}) + e_{1t-1} \right] A_{1t} \quad [2]$$

$$X_{2t+1} = [d_2 + e_{2t}]A_{2t} \quad [3]$$

X_{1t} = output of maize in period t ; X_{2t} = output of alternative crop in period t ; e_{1t} = zero mean random disturbance term for maize; e_{2t} = zero mean random disturbance term for the other crop; $d_2(\bar{A}_t - A_{1t-1})$ = dynamic trend in land utilization

The average yields per unit of maize in period t increases (decreases) when less (more) of other crops are harvested from the land during period $t - 1$. The production parameter d_2 is positive if raising maize successively from the same land decreases its average yield.

Following [1] through [3] and assuming the production of crop 1 is subject to dynamic production constraints, its production can be expressed as follows:

$$X_{1t} = F^1(A_{1t}, A_{1t-1}, A_{1t-2}, \dots, K, \bar{A}, precipitation), \quad [4]$$

where $F_1^1 > 0$, $F_2^1 > 0$, $F_j^1 \leq 0$, K is a vector of other inputs applied to land. The production function for Crop 2 is given simply by

$$X_{2t} = F^2(A_{2t}, K, \bar{A}, Precipitation), \quad [5]$$

where $F_1^2 > 0$, $F_2^2 > 0$

The producer is expected to maximize his expected discounted profit in terms of the price of crop 1 (maize) by choosing a contingency plan at each period t for allocating his given area for the time $t + 1$ production of crops. Therefore the producer's objective is to maximize profit under the following:

$$E_{-1} \lim_{N \rightarrow \infty} \sum_{t=0}^N \beta^t \left(X_{1t} + \frac{P_{2t}}{P_{1t}} X_{2t} \right) \quad [6]$$

Equation [6]'s expectation is subject to the land constraint stated in [1] and the production functions in [4] and [5].

Agricultural policies enter equations [4] and [5] through variables associated with vector K , representing fertilizer, hybrid seeds, extension services, or other production inputs. Agricultural policies are associated with the vector K through the

elimination of subsidies or institutional efficiency. These inputs serve as policy pathways and carry the potential policy effects.

The following equation constitute the expectations operator conditional on information at $t - 1$.

$$J = \max_{(A_{it})_{t=0}^{\infty}} E \sum_{t=0}^{\infty} \beta^t \left\{ (d_0 + e_{1t} - c_{1t} + c_{2t})A_{1t} - \frac{d_1}{2} A_{1t}^2 + d_2 \bar{A} A_{1t} - d_2 \bar{A}_{1t-1} A_{1t} + P_{t+1} \bar{A}_t - P_{t+1} A_{1t} - c_{2t} \bar{A}_t \right\} \quad [7]$$

P_{it} is the nominal price received from output X_{it} , $i = 1, 2$ and c_1 and c_2 are the non-land costs of producing maize and other crops. The farmer's objective is to choose the A_{it+j} in order to maximize output for production.

The information set available to producers is broadly defined to include the past history of prices, as well as production trends. Current and past economic variables, which are exogenous to the producer, are among the factors which contribute to production decisions. Even the past policies affecting production, and which are likely to recur in the future are influential in the determination of the types of production that a producer engages in.

Econometric Approach

In the econometric approach domestic maize output is represented by a dynamic production function in which stated explanatory variables are presumed to affect output in current and in lagged time. This is typical in agriculture where producers exercise rationality (Tegene et al., 1988). The inclusion of production response lags is important and common in production. The assumption of a producer's rationality in production decisions is captured in the selected variables from year to year.

The use of fertilizer and hybrid seeds is assumed in the generalized production model below;

$$X_{1t} = F(A_{it}, P_{it}, K; u) \quad [8]$$

X_{1t} = maize output, A_{it} = acreage, P_{it} = price vector, K_{it} = input price vector, u = error term

In order to operate with a reasonably simple function, zero values of the u are assumed. The relation of u to the other variables may not be directly measured due to the lack of data. Variance in production decisions suggests that the factors of production are evaluated differently based upon the production environment and attending constraints or other unmeasured factors.

Econometric Specification

The following model uses simple approximations to capture the exogenous variables (prices and policies). Policies in this case range over several or most of the variables used in the econometric representations. Data sets for non-land costs for the production of cereals and other cash crops are unavailable, so they become part of the error term. The estimation procedure, which considers cross-equation correlation of disturbances in the model, minimizes the effect of the missing information on parameter estimates.

The following AR specification is used. The random disturbance term in average annual output of maize is represented by a first-order autoregressive process,

$$e_{1t} = \rho e_{1t-1} + U_t^e, |\rho| < 1 \quad [9]$$

The total acreage planted to all crops (maize and other crops) is represented by a second-order autoregressive process.

$$\bar{A}_t = \gamma_1 \bar{A}_{t-1} + \gamma_2 \bar{A}_{t-2} + U_t^a, |\gamma_2| < 1, \gamma_1 + \gamma_2 < 1, \gamma_2 - \gamma_1 < 1 \quad [10]$$

The area of land is considered fixed for all t . Farmers are often confronted with low crop productivity due to inefficient production techniques applied on the land. In addition to these productivity constraints, agricultural policies exogenously constrain the level of maize output.

The condensed variables in equation [8] are selected based on their presumed link to agricultural output. The estimation of a maize supply function is assumed to rely on the economic relationship of the explanatory variables in the maize output equation.

In rural agricultural production, acreage is a critical determinant of output and hence a source of income for rural households; in the form of food and income. A large portion of the staple food produced in rural areas is consumed as food while the surplus marketed.

$$A_{1t} = \alpha_0 + P_{1t-1} + P_{2t-1} + A_{3t} + e \quad [11]$$

Productive arable land is shared between a diverse set of commodities and producers continually change the type of commodity based upon its economic value, its productive capacity or, in some cases, its cultural value. Given that these countries are technology deficient and have abundant labor, it is economically practical to expand that resource.

$$P_{1t} = \alpha + \delta P_{1t-1} ; |\delta| < 1 \quad [12]$$

After the deletion of maize production costs and the other agricultural crop, equation [13] represents a function of variables that farmers might be aware of at time t . It is non-stochastic because it contains only variables in the farmers' information set.

$$A_{1t} = \delta A_{1t-1} + \text{III}_1 \bar{A}_t + \text{III}_2 \bar{A}_{t-1} + \text{III}_3 P_{1t-1} - \text{III}_4 P_{2t-1} + \text{III}_5 e_{1t-1} \quad [13]$$

The III s represents non-linear functions of the parameters and the stochastic processes for the exogenous variables and the discount factor.

$$A_t = \alpha_0 + \alpha_1 P_{1t-1} + \alpha_2 P_{2t-2} + \alpha_3 A_3 + e_t \quad [14]$$

$$\bar{A}_t = \gamma_1 \bar{A}_{t-1} + \gamma_2 \bar{A}_{t-2} + U_t^a \quad [15]$$

The variables entering the land allocation equation are in the reduced form. In this model the values of these coefficients will change when government policies with respect to prices change.

The modified estimated model is represented as follows:

$$X_{it} = \beta_1 A_{1t} + \beta_2 A_{2t} + \beta_3 K_{t-1} + \beta_4 P_{1t-1} + \text{precip}_t + e_t \quad [16]$$

The changing policies and their resulting effects on the agricultural sector are evaluated over the changes of the variables selected. The disruptive effects of state control over markets prior to 1985 are represented by a shift in the functional form of equation [16].

Application to the Maize Data on Kenya and Zambia

The data used in subsequent analysis is based on 41 annual observations ranging from (1962 to 2006) of acreage, prices, precipitation, and fertilizer prices as they pertain to the maize subsector. The acreage for crops competing for land with maize, in this case wheat or tea, are also included. The area of land for tea is not used as a variable for Zambia due to the fact that it is not a major crop.

Using Kenyan data, we estimate equations with the ordinary least squares (OLS) method. The Breusch-Godfrey serial correlation LM test, which is obtained by the $LM = nR^2$ of the auxiliary regression with an asymptotic χ^2 distribution under the null hypothesis of the absence of serial correlation, is applied in each estimation. A non-linear least squares (NLS) procedure (Cochrane-Orcutt iterative procedure) is also applied.

The results in Table 1 below show that the series of disturbances, e_t , may be correlated and in order to verify that the Breusch-Godfrey test for serial correlation suggests its presence. The occurrence of serial correlation, for time series data, implies that some of the dynamic properties of the data are not captured by the model (Eviews, 2010).

Table 1

OLS Maize Output estimates, 1962-2006

Variable	Coefficient	t-statistic	p-value
Maize acreage	714.04	3.27	0.003*
Wheat acreage	6.9	2.46	0.02**
Lagged maize price	-38.73	-2.26	0.03**
Tea acreage	9.67	3.16	0.004*
Precipitation	427.4	0.77	0.45
C	-632672.3	-1.25	0.22
AR (2)	-0.42	-2.27	0.03**
R-Squared	0.63		
Adj. R Sq.	0.54		
Breusch-Godfrey Serial Correlation LM test			
F-statistic	0.995729	Prob. F(2,23)	0.3848
Obs*R Sq.	2.549938	Prob. Chi-Sq.	0.2794

*, ** Signify significance at 1% and 5% levels

In the Cochrane-Orcutt iterative procedure, the coefficients of the lagged maize price and wheat acreage take the wrong sign. This outcome could be suggestive of the market conditions surrounding the period of state intervention in the agricultural economy. It is difficult to identify the effect of policies over maize production, hence overall output. In terms of the robustness of the equation results, there exists reliability. Serial correlation is absent from the equation based on the diagnostic test, the Breusch-Godfrey serial correlation LM test.

A post-liberalization era regression shows the coefficient of maize acreage at 0.11. Although there is no statistical significance, maize output increase in Kenya occurs mostly through acreage expansion. The lagged price coefficient is positive and significant. This is suggestive of the markets changes associated with liberalization. During the post-reform era, a decline in the role of the Kenya National Cereals and Produce Board (NCPB), a dominant state marketing agency, was witnessed. This allowed the entry of private marketing enterprises and more. The NCPB lost its monopoly status and the wide-ranging powers including its food security mandate accorded by the state. The vacuum resulting from the relinquishment of its cereals market influence was not fully filled by the private sector

In practice, price policies play a decisive role in maize production often through inputs and output. However, the results show that the lagged price of maize has a positive coefficient and statistically significant. In this case, prices are important in output determination. This also implies price evolution in markets that can be attributed to government intervention in the cereal markets. In practice prices serve as an intermediary between markets and producers, erstwhile announced by the NCPB. In theory, the price level serves as an incentive for markets by attracting the quantity producers are willing to supply. It would also mean that commercial maize imports and exports to and from the interior would only take place in response to sizeable shifts in the price – shifts large enough to exceed the transport costs – thereby reducing the role that external trade would play in stabilizing domestic prices (Hubbard, 2003). However, it cannot be concluded fully if the positive response of maize output to price policy

change resulted into greater access to the maize cereal.

First, the summary from Table 2 suggests that maize output responded well to price policy reform. This also affirms the role that markets, if well regulated, would play in spurring production. Farmers rationally form their planting decisions and prepare current year acreage based on their expectations as observed in the preceding year (positive or negative). Other non-policy factors such as local conditions play a role besides the policies. However, the fertilizer variable takes the right sign, but it is insignificant statistically. This may not concretely suggest that fertilizer is unimportant in contributing to maize output. Lack of statistical causality may be due to inconsistency in access to the fertilizer input. Access to fertilizer by producers was dependent on its availability.

Table 2

OLS Estimate of the post-liberalization maize output, 1986-2006

Variable	Coefficient	t-statistic	p-value
Lagged fertilizer price	-31.55	-1.70	0.12
Maize acreage	28685.73	1.82	0.11
Lagged maize price	107.62	2.41	0.04**
Tea acreage	-29.95	-2.14	0.06**
Precipitation	1770.23	2.29	0.05**
C	2236621	1.31	0.22
R-squared	0.56		
Adjusted R-squared	0.29		
Breusch-Godfrey Serial Correlation LM test			
F-statistic	8240133	Prob. F (2, 6)	0.0000
Obs*R Sq.	14.00000	Prob. Chi-Sq.	0.0009*

*, ** Signify significance at the 1%, and 5% levels

Structural adjustment programs supported output and input liberalization policies. However, they were not immediately implemented due to political opposition as well as public resentment towards them. In theory, markets are a clearing house for production where supply and demand converge to determine the price level. Farmers then respond to higher or lower prices in their production; by

raising their supply in response to higher prices and reducing output during low prices. In anticipation of higher prices for the next season, farmers form expectations by allocating the level of inputs and planting area to permit maximum output. In the case of inputs, and given the extent of poverty in Kenya, liberalizing input markets had the immediate response of increasing input prices, particularly fertilizers.

Domestic maize production is the most significant source of supply for food consumed by rural and urban consumers in Kenya. The alternative source of cereal supply to meet domestic food (cereal) demand is through imports from international markets. By importing maize, often viewed as a temporary food security measure, the government may generally help ease the supply deficiency in the country, but for low income households in rural regions of Kenya the reality of income poverty would not permit them to purchase the imported maize. Rural agricultural producers mostly rely on their own maize production for consumption and sell their surplus to markets. In the post-liberalization scenario, these farmers could benefit if they have enough to sell in markets for income. The policy implication of the results of Table 2 for both rural and urban consumers may be mixed as the prices are likely to be counterproductive for their consumption depending on market response to the prices.

Over the years, maize supply instabilities have been common in Kenya. The country was more than self-sufficient in maize in good crop years (1982, 1983, 1987, 1989, 1990, and 1994), but in bad crop years (1981, 1984 and 1993) a large amount of maize was imported. According to conducted research, the amount and timing of rains, poor quality fertilizer, seed maize and falling prices during supply overrun periods were responsible. Sufficient rains at any given year during land preparation and maize planting season may not be the sole reason that determines the level of output, nevertheless their amount and timing is a crucial determinant. In the regression summary of Table 2 the interpretation of precipitation, which is positive and significant, is expected. It is notable also that maize acreage is significant statistically in relation to total output and that the coefficient takes the correct positive sign. Producers rely on rains in their maize

planting decisions. Rain delays tend to affect the quantity of harvested output implying low market supply and higher market prices. Even with access to the other factors important in output, sufficient rainfall is a crucial factor; other variables depend on it for the realization of higher output. The introduction of reforms and subsequent removal of subsidies had the direct effect of weakening fertilizer demand.

When the cash prices of coffee or tea decline, farmers producing those crops suffer losses based on their production and marketing costs. There are also losses associated with the opportunity cost of producing those crops as opposed to producing maize or a more profitable crop. Unlike legumes or other horticultural products, tea does not permit intercropping. It is clear from Table 4 rather than being complementally, increasing tea acreage does not improve the income position of producers, by allowing them to purchase, for instance inputs necessary in maize growing.

The maize price coefficient in Table 2 is according to economic theory, which arguably supports the contention of policy effects on agricultural production. In the pre-liberalization era, inter-district (regional domestic trade) in Kenya was either banned or not discouraged. Maize trade was not subject to open competitive markets. As such, maize trade was mostly conducted under the supervision of a government cereals agency. These trade restrictions contributed to corruption and cross-border smuggling of maize and other cereals.

The stated hypothesis that the introduction of liberal policies negatively impacted food supply can be viewed from the response of the explanatory variables in the estimated equation. It may be concluded that maize output response was generally positive. However, it is not proven if market reforms resulted in greater access to maize for consumption by the general public. Marketed maize response was most important for those producers who had access to markets.

The regression results illustrate the pre-reform regression equation and they suggest that maize output responded strongly to most of the selected explanatory variables. However, such response is subject to question given the absence of free market conditions. State control over agricultural market instruments impeded any incentive for the exercise of market-based price formation for inputs

and outputs. Pan-territorial pricing particularly discouraged agricultural producers from market-based production due to the fixed prices dictated by the government. Consumer prices were often lowered (as a form of subsidy) in order to guarantee increased consumption. In the unrestricted model, the p-statistic suggests no viable link between market prices (a policy measure) and maize output. The lagged price coefficient takes the wrong sign and there is absence of statistical significance and indication of no economic interpretation. The relationship between maize acreage and maize output may suggest a causal link, but the absence of free markets discredits such interpretation. There are likely to be other non-policy factors that spur output, besides the policy ones. In the face of reform, maize output is assumed to have responded to policies. Such response is indicative of the effects of policies on market instruments.

Collusion by a smaller number of powerful private entrepreneurs, often with strong political ties, brings to bear an additional cost on markets. While this was common in other agricultural commodities, the sensitivity of the maize cereal in Kenya heightened the infiltration of corruption into the maize supply chain, from production to the market. Private investors, except those with government ties, were mostly stifled out of maize markets. The introduction of reforms paved the way for efficient export marketing and this allowed farmers to keep a larger share of the export price for some products. However, maize producers faced difficulties in obtaining inputs in sufficient proportions due to ineffective fertilizer markets. Most fertilizer traders were unwilling to offer inputs on credit because of the likelihood to resell the same inputs to competitors and default on the payment.

Supply response to reforms is greater for export crops than for food crops. Farmers have often responded by reallocating land from one crop to another or by expanding overall cropped area; as opposed to increasing yields (Kherallah et al., 2002). Many of the cash crops are mostly perennial crops, unlike maize which is an annual crop with a shorter storage span. It is unclear from the estimations if the removal of fertilizer subsidies increased fertilizer use as was earlier anticipated. The statistical insignificance of the fertilizer coefficient implies an inconclusive economic link.

Summary of Maize Output Estimations for Zambia

The following regression results are based on OLS estimates and in the case of the presence of serial correlation the Cochrane-Orcutt iterative procedure is applied. In all the equations, maize output is the dependent variable. Assuming a structural change in the mid-1980s, regression results of both the period before reforms and after reforms are included for purposes of comparison.

After performing the Breusch-Godfrey serial correlation LM test, the presence of first order serial correlation is detected in the estimates in Table 3. The use of lagged variables in the equation invalidates the DW test. To remove serial correlation and to render the results more robust, we proceed to perform the Cochrane-Orcutt iterative process. The convergence is below.

Table 3

Cochrane-Orcutt Iterative Procedure for serial correlation, 1961-2006

Variable	Coefficient	t-statistic	p-value
Maize acreage	0.86	2.07	0.05**
Wheat acreage	39.25	1.89	0.07***
Maize price lag	569.12	0.35	0.73
Fertilizer price	-0.12	-0.81	0.42
Precipitation	805.03	1.9	0.06**
C	-519023	-1.15	0.25
AR (1)	0.41	2.51	0.01*
R-Squared	0.48		
Adjusted R Sq.	0.38		
DW statistic	2.11		
Inverted AR roots	0.41		
Breusch-Godfrey Serial Correlation LM test			
F-statistic	0.483	Prob. F (2,29)	0.62
Obs*R Sq.	1.227	Prob. Chi-Sq.	0.54

*, **, *** signify significance at the 1%, 5% and 10% levels

The Cochrane-Orcutt iterative process suggests that precipitation, maize acreage and wheat acreage are the only statistically significant variables at the 1 percent, 5 percent and 10 percent levels, respectively.

The presence of government intervention in agricultural and maize markets implies that markets were not allowed to flourish hence the disconnection between the policy variables and agricultural output. The introduction of the precipitation variable in the equation almost crowds out the significance of other variables. In order to test this, an estimation of the same equation is repeated without adding precipitation and to lag the price of fertilizer.

In Table 4 the maize and wheat acreage variables regress well. The wheat acreage particularly reflects the presence of competition for the area of land. This can be inferred from its negative coefficient; implying that increasing wheat acreage results correspond to a negative effect on maize output, since they compete for the same area of land. Other policy variables, such as the price of fertilizer and maize are insignificant, suggestive of the lack of functional free markets. However, the fertilizer takes the correct sign even if statistical significance lacks.

Table 4

Cochrane-Orcutt iterative procedure for serial correlation, 1986-2006

Variable	Coefficient	t-statistic	p-value
Maize acreage	2.42	3.30	0.01*
Wheat acreage	-44.26	-2.14	0.06**
Fertilizer price	-0.06	-0.55	0.59
Maize price lag	517.36	0.41	0.69
C	-1894.7	-0.004	0.99
AR (1)	-0.56	-1.86	0.09***
R Sq.	0.62		
Adjusted R Sq.	0.42		
AR Inverted roots	-0.56		

Breusch-Godfrey Serial Correlation LM test

F-statistic	3.384734	Prob. F(2,7)	0.0937
Obs*R Sq.	7.374433	Prob. Chi-Sq.	0.250

*, **, *** signify significance at the 1%, 5% and 10% levels

In Table 4, the results from the Cochrane-Orcutt iterative procedure suggest that both fertilizer and maize price variables are statistically insignificant. The R-squared statistic, which measures the equation's goodness of fit, is high. However, the response of maize output to changes in acreage

strengthens after the removal of serial auto-correlation from the equation. The shift in significance insinuates that while policies influenced maize output, most of the output change occurred due to acreage expansion. This is plausible argument, particularly in Zambia, which has a higher acreage ratio of land relative to the number of producers.

The results from Table 4 suggest a strong acreage influence on maize output. This phenomenon can be associated to the removal and reintroduction of fertilizer subsidies in Zambia, due to public pressure. The stop-go policy implementation experience was a common economic liberalization feature, which never allowed fertilizer prices to freely respond to market conditions. It can be inferred that the implementation of reforms policies was slow overall, and particularly in so far as it affected the maize sub-sector. A constant policy reversal by the government is the most likely cause, but other causes may be difficult to measure. Lack of price policy coherence for maize inputs and outputs is certainly evident given the documented government interference in the economy. The simulated equation lacks evidence of the direct effect of prices in boosting maize production. Farmers' exercise of rational expectations is absent in maize production and across other sectors.

Implications of Maize Output Estimates

These results present considerable variations in the maize sub-sector's response to agricultural reforms in the two countries. Even with the roughly similar approach applied in the estimations and the selection of explanatory variables based on the maize economy in each country, the outcome depicts a varied maize output response. Several conclusions may be drawn from the outcome. First, policies cannot be assumed to be the sole maize/agricultural output determinant given the nature of the agricultural sector in these countries. Additional crucial but often ignored factors would be at work.

The maize output equation [16] the core estimated supply equation, has direct implications on food security due to domestic maize production's presumed contribution to consumption and incomes. The maize cereal and derivative products

is a major diet in rural and urban households as compared to other cereals such as millet or sorghum. Previous research on food security and agriculture reiterates how agricultural productivity can enhance food security (Pletcher, 1986; Seshamani, 1998; Sitko, 2008; Muyatwa, 2001). These studies also imply that the proportion of aggregate population directly relying on agriculture continues to increase. Expansion in maize production has been generally on the rise due to maize research and the commercialization of the maize variety technology. This is indicative of the importance of maize as a single staple and cash crop. Further, the decreasing or constant production value of traditional substitute cereals (millet and sorghum) suggests that the value of maize in consumer diets on average is higher and increasing. Access to production-based endowments also strengthens access to food and other livelihood means available from markets for average households.

A policy conclusion to be drawn from the results for Kenya is that maize output faces competition from cash crops such as tea. Estimation results suggest that tea is a maize competitor through acreage. Rising maize production costs are not assuaged by the constant earning from tea sales. The two markets have parallel characteristics. Rising cost in agricultural production, particularly in maize production, does not mean that farmers with a tea plantation are better off than those who do not have even if the tea market is more vertically integrated and guarantees a constant source of earnings for farmers. Maize production inputs consist of: fertilizers, hybrid seeds and other tools.

Elaborate agricultural policies affecting inputs and outputs harness the rate of growth in food supply, a crucial partial element of food security. While the equation does not explicitly describe these important elements; they can be derived from recorded time series statistics. The food production aspect of food policy can be deducted from total maize output and its response when controlling for other explanatory variables. Consequently, policy instruments are crucial in informing policy makers on appropriate measures necessary in ensuring food self-sufficiency. The reflected long run elasticity trends for maize output are crucial in aiding policy makers to draw relevant conclusions.

Maize output elasticity of acreage is positive for Zambia. This response is an indicator of the extensive nature of maize production. Investment in maize research through agricultural research institutions, access to yield enhancing technology has yet to be widespread. The diversity of farming systems and the scale of production in the country cannot be decisively assumed to converge. The maize output response to changes in acreage suggests a strong positive correlation with maize output. That confirms the extensive nature of maize production in Zambia. The acreage coefficient is positive in relation to maize output at an aggregate level, and consistent with agricultural production in Zambia. However, this does not assume a similar trend when viewed domestically due to decreasing per capita land holdings and decreasing marginal output caused by abundant labor.

Maize's growing importance for food and income highlights farmers' responsiveness to prices, as well as other market incentives. Improved price signals and efficient institutions that serve the agricultural sector emphasize the role of markets in agricultural resource allocation. Access to inputs affect the production side of agricultural markets by enabling producers to deliver desirable levels of output. Thin input markets lead to a contraction of agricultural output. The maize supply response in the foregoing equation can be interpreted both as a response of output to prices and output to the manipulation of inputs. Input access manipulation can have consequences on the quantities producers apply in a given crop year. However, other important production inputs, such as technology, extension, marketing, are not well included in the study

The results suggest that wheat is a weak maize substitute, based on Kenyan data. Wheat is a more intensive cereal and utilizes less labor and more machinery from planting to harvesting as compared to maize. Wheat productivity has not improved and its supply has remained weak in the face of a rising demand. In sub-Saharan Africa, wheat demand has been overtaken by other coarse grains such as maize and rice, which can both be grown on much smaller scale. The production of cereals, particularly wheat is also constrained by ecological factors, so that its demand is met by other cereals. It is also noted in literature that on

average the SSA region produces only about 18% of the wheat it consumes while the rest is imported (Morrison, 1984).

Conclusion

The results from these empirical estimations suggest that the introduction of agricultural policies has had varying effects in the countries studied. These results highlight the countervailing measures arising from state intervention, significantly in case of Zambia. The discussed reforms were made up of wide-ranging structural changes applied generally within the agricultural sector, with a tremendous effect on the maize sub-sector. The policy reform measures considered included the liberalization of input and output prices through the elimination of subsidies, the inclusion of the private sector, and the restructuring of public marketing enterprises.

Based on the econometric results, it is evident that the results would vary even if generally similar structural adjustment policies were followed in the countries of study. The dissimilarity in outcome may be due to existing domestic conditions, or due to the reaction of the lagged variable, multiplier effects and long-run differences. It can be concluded that the state plays a decisive role in determining certain agricultural or economic outcomes. In effect, the organization of the state can be presumed to be a function of the performance of the agricultural sector.

In both countries, acreage still remains a critical maize supply shifter. The general lack of access to the essential inputs and technologies does not give room for intensive agriculture. While reform policies may have entered the maize supply chain through acreage, it is difficult to make strong policy conclusions on acreage size choice. The decision to expand acreage may be a result of producers' direct access to subsidies enabling them to afford the basic inputs necessary for production. A specific example can be made from Zambia, which has a long history of providing subsidies for maize farmers to increase production, particularly during bad crop years. During the droughts of 2002, the government encouraged farmers to produce more maize, and even supported large-scale producers to do the same with the aim of averting a crisis in the next crop year.

The precipitation variable, whose occurrence is often unpredictable, influences maize output differently in the two countries. While the effect of precipitation is not quite as evident from Zambian results as it is from Kenyan ones, it stands to reason that rainfall is a decisive factor in agricultural output. The results suggest that the maize output in Zambia does not respond to the amount of rainfall and its inclusion in the equation distorts the other variables. Initial equation simulation indicates that its inclusion in the estimated equation made all the other variables statistically insignificant. However, it is statistically significant for the equation that applies to Kenyan data sets. In spite of the variance in outcomes, rainfall and weather in general remain a critical non-policy factor.

Differences between Kenya and Zambia with regard to the response of maize supply to policy

changes may equally be explained by the socio-political environment within which the respective markets function. The dynamic response by markets represents an important reason that may not be statistically measured. It is evident that producers' response to policy change is slightly more significant in Kenya than in Zambia based upon the coefficients of policy variables. Contrary to conventional thinking, producers in these countries do respond to market changes. This also implies that a considerable portion of the significant supply shift in maize output in Kenya would have been a result of the change in policies. However, the producers tended to be confused by the multiple signals coming from markets, such as both the implementation and withdrawal of policies.

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