AN ERROR CORRECTED ALMOST IDEAL DEMAND SYSTEM FOR MAJOR CEREALS IN KENYA

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ABSTRACT

Despite significant progress in theory and empirical methods, the analysis of food consumption patterns in developing countries, particularly those in Sub Saharan Africa (SSA), has received very limited attention. An attempt is made in this article to estimate an Error Corrected Almost Ideal Demand System (ECAIDS) for four major cereals consumed in Kenya employing annual data from 1963 to 2005. The ECAIDS formulation performs well on both theoretical and empirical ground. The symmetry and homogeneity conditions are supported by the data and the *LeChatelier* principle holds. Empirically, all own-price elasticities are negative and significant at 5% level and irrespective of the time horizon, maize, wheat, rice and sorghum may be considered as necessities in Kenya. While the expenditure elasticities of all four cereals are positive, they are inelastic both in the short-run and long-run. Finally, wheat and rice compliment maize consumption in Kenya while sorghum acts as a substitute. Since cereal consumers have price and income inelastic responses, a combination of income and price oriented policies could improving cereal consumption in Kenya.

Keywords: Error Correction Model, AIDS, Cereal Consumption, Kenya.

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Introduction:

The availability of a set of reliable price and income elasticities is central to the analysis of food consumption behaviour. A good understanding of the food demand elasticities in any particular country is of interest to policy-makers for designing effective price and income support policies as well as for various other public interventions. These estimates are also essential for planned investments and future prosperity of business ventures in a country (Sadoulet and de Janvry, 1995). Despite significant progress in economic theory and estimation methods during last three decades, the analysis of food consumption patterns in developing countries especially those in Sub Saharan Africa (SSA) has received very limited attention and thus remains poorly understood.

While the number of studies on the subject which have recently been published in developing countries seems to suggest that there is a sustained increase in efforts to develop a better understanding of food consumption patterns in these countries, much less effort has been devoted to foster a good understanding of the food consumption patterns in SSA. A few studies published on SSA have relied on small survey data to generate short-run estimates (Munyi, 2000; Seale et al., 2003; Waliweta et al., 2003). While these estimates are informative, they are site-specific and not reliable for policy analysis. To the best of our knowledge, no published times series estimates of food demand elasticities exist for Kenya. An attempt is made in this study to bridge this gap by employing an error corrected almost ideal demand system (ECAIDS) for four major cereal grains consumed in Kenya.

The main cereal grains consumed in Kenya are maize, wheat, rice and sorghum. While maize is the most important staple in Kenya, the consumption of wheat and rice has gained prominence in recent years particularly in urban areas. The consumption of sorghum has traditionally been centred in the draught-prone agricultural areas of Kenya where it is predominately produced. In Kenya, spending on food accounts for about 46 percent of the total household expenditure and spending on cereal grains constitutes over one-third of the total food expenditure (Seale et al, 2003).

The Almost Ideal Demand System (AIDS) introduced by Deaton and Muelbauer (1980) has been the model of choice for many applied demand analysts for almost three decades. The enormous popularity of this model among applied demand analysts originate from the fact that it is grounded in a coherent analytical framework, it is easy to estimate and it permits empirical testing of standard restrictions of neoclassical demand theory. While the model is inherently nonlinear, the linearized version of the AIDS using the Stone share weighted price index has been used to simplify the estimation process (Green and Alston, 1990; Buse, 1994). Despite the phenomenal empirical success of this model, the issues related to data nonstationarity and cointegration have been side-stepped in applied demand analysis and it has been estimated with conventional econometric techniques such as OLS, SUR and MLE. A few studies attempted to modify AIDS to incorporate dynamics and address issues arising from data nostationarity since the mid 1990s (Ng, 1995; Karagiannis et al. 2000). This paper employs the "Paasche index" or what Moschini (1995) refers to as the "corrected" Stone price index to linearize the AIDS specification and incorporates the dynamic elements into the linearized AIDS to reflect the statistical properties of the data. The objectives of this paper are threefold: (i) to develop a theoretically consistent empirical framework for estimating demand for major cereal grains in Kenya; (ii) to generate reliable estimates of short-run as well as long-run demand elasticities for selected cereal grains and (iii) to discuss policy implications of the results. The paper makes an important empirical contribution by reporting for the first time a set of reliable, policy relevant estimates of the elasticities of demand for major cereal grains consumed in Kenya.

Section two presents the analytical framework used in this study. It also highlights the key features of the AIDS model and the correction to the Stone price index suggested by Moschini (1995). Section three deals with pertinent econometric issues and highlights the basic features of the empirical model used in this study. The estimated results from the error-corrected AIDS model are discussed next. The final section discusses policy implications and concludes the paper.

An Analytical Overview of the AIDS:

A two-stage budgeting procedure, which assumes that consumer preferences are weakly separable with respect to food is used in this study to estimate the demand for cereal grains in Kenya. In the first stage, consumers decide on the share of their total expenditure to be allocated to cereal grains and other consumption goods. In the second stage, the demand for each cereal item is determined by the prices of the individual cereals and the total expenditure on cereals. The demand for cereals is estimated at the second stage of the two-stage budgeting process as an AIDS.

The AIDS is compatible with the step-wise budgeting procedure as it perfectly aggregates across goods. Unlike other models, the resulting demand equations of the AIDS model generates nonlinear Engel curves and allows for exact aggregation across consumers (Moschini, 1998). Moreover, the properties of homogeneity and symmetry of the AIDS model can be explored with simple parametric restriction. The model has been widely applied in demand analysis. It yields elasticities that are consistent with consumer theory and are more flexible than those obtained from other commonly used demand systems.

The AIDS model is derived from a utility function specified as a second-order approximation of any utility function. Deaton and Muellbauer (1980) start with the specification of an expenditure function which is of the PIGLOG class of preferences that satisfies the necessary conditions for consistent aggregation across consumers. These conditions ensure that the functional forms of the market demand equations are consistent with the behaviour of a rational representative economic agent (Deaton and Muellbauer, 1980). The AIDS in budget share can be written as:

$$S_i = \alpha_i + \beta_i \ln\left(\frac{M}{P*}\right) + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \varepsilon_i \tag{1}$$

Where S_i is the i'th budget share estimated as $S_i = P_jX_j/M$, P_j are normalized nominal retail prices while γ_{ij} are price coefficients and M is the total expenditure on all goods. $P*$ is an aggregate price index defined in the nonlinear AIDS specification as:

$$\ln P* = \alpha_0 + \sum_{i=1}^{n} \alpha_i P_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j \tag{2}$$

Adding-up and homogeneity hold if $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0$ and the symmetry conditions are $\sum_i \gamma_{ij} = \sum_j \gamma_{ji}$. While adding-up is automatically imposed since budget shares must sum up to unity, homogeneity and symmetry are parametrically imposed.

The use of a non-linear price index $P*$ in equation (2) raises some empirical difficulties, especially when aggregate annual time-series data are used. Deaton and Muellbauer (1980) suggest the use of the Stone Geometric Price Index $\overline{P*}$ instead of $P*$ to overcome the difficulties. This index can be formulated as follows:

$$\ln \overline{P^*} = \sum_{i=1}^{n} S_{it} \ln P_{it} \tag{3}$$

The linear-approximate AIDS model (LAIDS) with the Stone index has been used extensively in applied demand analysis (Green and Alston, 1990). However, Moschini (1995) points out that the Stone's index fails to satisfy the "commensurability" property, in the sense that it is not invariant to the units of measurement of prices. He proposes three alternative indices to solve this problem. The first is the Tornqvist index ($P^T{}_t$) which is a discrete approximation of the Divisia index.

$$\ln P_t^T = \frac{1}{2} \sum_{t=1}^{n} (S_{it} + S_t^0) \ln \left[\frac{P_{it}}{P_t^0} \right] \tag{4}$$

The variables S_t^o and P_t^o denote the budget shares and prices in the base period. The second alternative index is the log-linear analogue to the Paasche index ($P^S{}_t$), which Moschini (1995) refers to as the "corrected" Stone price index.

$$\ln P_t^S = \sum_{t=1}^{n} S_{it} \ln \left[\frac{P_{it}}{P_t^0} \right] \tag{5}$$

If prices are normalized to one before the index is computed, Stone's price index is equal to the Paasche index. The final alternative proposed by Moschini (1995) is the log-linear version of the Laspeyres index ($P^L{}_t$) which may be written as:

$$\ln P_t^L = \sum_{t=1}^{n} S_i^0 \ln \left[\frac{P_{it}}{P_t^0} \right] \tag{6}$$

When all prices are normalized to unity, the elasticities derived from the LAIDS and the AIDS are identical at the point of normalization (Asche and Wessells, 1997). Consequently, the elasticity formula proposed by Chalfant (1987) correctly evaluates the elasticities of the LAIDS to equal those of the AIDS at the point of normalization.

The Marshallian price and expenditure elasticities are then computed at the point of normalization following Chalfant's (1987) formula on the LAIDS model as:

$$\varepsilon_{ij}^{M} = -\delta_{ij} + \left(\frac{\gamma_{ij}}{S_i}\right) - \left(\frac{\beta_i}{S_i}\right) S_j, \; \eta_i = 1 + \left(\frac{\beta_i}{S_i}\right) \text{ and } \varepsilon_{ij}^{H} = -\delta_{ij} + \left(\frac{\gamma_{ij}}{S_i}\right) + S_j \qquad (7)$$

Where δ is the Kronecker delta ($\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = 0$ if $i \neq j$). The Hicksian elasticities for good *i* with respect to *j* can be derived from the Marshallian price elasticities using the Slutsky equation as: $\varepsilon^{H}_{ij} = \varepsilon^{M}_{ij} + \eta_i w_j$ or $\varepsilon^{H}_{ij} = - \delta + (\gamma_{ij}/S_i) + S_j$.

This study estimates a LAIDS for cereals in Kenya using a "corrected" stone price index. The model is normalized to unity at the base period (1963) and all elasticities are evaluated at this point. At the point of normalization, there are no differences in the formulae used to compute elasticities for the AIDS and LAIDS (Asche and Wessels, 1997). Prior to the specification of the most appropriate dynamic form of the AIDS, it is necessary to investigate the time series properties of the data to determine whether the long-run relationships are economically meaningful or not.

Econometric Issues and the Empirical Model:

The estimation begins by investigating the time-series properties of the data since it is now widely acknowledged that many economic time-series are nonstationary. A number of empirical tests have been proposed in the literature to test for the existence of unit roots. The most frequently used test for unit roots are the *t*-like tests proposed by Dickey and Fuller (1979) and the alternative test proposed by Phillips and Perron (1988). An Augmented Dickey-Fuller (ADF) test can be specified as:

$$\Delta Y_t = \mu + \eta t + \tau * Y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta Y_{t-j} + e_t \qquad (8)$$

Where Y_t is a random variable possibly with non zero mean, μ is a constant, *t* is a time trend and e_t is the error term that is independent and identically distributed, thus iid~ (0, σ^2). The null hypothesis of a unit root ($\tau^* = 1$) is tested against the alternative of stationarity. However, the estimated τ***** does not have a standard *t*-distribution and hence the critical values provided by Dickey and Fuller (1979) have to be used. If a unit root is identified, the data is differenced to determine the order of integration.

Once the order of integration of the variables is established, the system is tested for cointegration. This can be implemented by use of either static cointrgration tests (ADF and PP tests) or the Johansen's maximum likelihood cointegration analysis. Although Johansen's approach is suitable in multivariate cases, it may not be appropriate in applied demand analysis. A major limitation of the MLE approach in applied demand analysis is that there is no *a priori* information to exclude some vectors as theoretically inconsistent whenever more than one cointegrated vectors is found (Karagiannis *et al*, 2000).

Given the low power of static cointegration tests to discriminate against alternative hypothesis, a dynamic modelling procedure proposed by Banerjee *et al*, (1986) and Kremers *et al*, (1992) is used in this study. This procedure uses the lagged residuals from the OLS regression of equation (1) to test for cointegration in the ECM. According to this test, the hypothesis that the coefficient of the EC term is not statistically different from zero is tested using a conventional *t*-test. If the null hypothesis is rejected, the series concerned is cointegrated. Once it is ensured that all the variables are cointegrated, an ECM version of the AIDS is formulated.

The ECM is a restricted form of a vector autoregression (VAR) that produces efficient estimates in small samples. The estimated ECM form of the AIDS is specified as:

$$\Delta S_i = \vartheta \Delta S_{it-1} + \beta_i \Delta \ln\left(\frac{M}{P^*}\right) + \sum_{i=1}^{n} \gamma_{ij} \Delta \ln P_j + \lambda_i \mu_{it-1} + \varepsilon_i \qquad (9)$$

Where Δ is the difference operator and μ_{it-1} are the estimated residuals from the cointegration equations (the EC component) and λ is expected to be negative. Equation (9) is estimated using the two-step method of Engle and Granger (1987) where the estimated residuals of equation (1) are substituted into the ECM (equation 9) and used as a regressor that represents the error correction (EC) term.

In this estimation, the short-run elasticity estimates are obtained by using the formulas in equation (7) and the estimated ECM parameters from equation (9). The short-run ECM parameter estimates are also used to compute their long-run counterparts using the partial adjustment formulation proposed by Johnson *et al*, (1992). Thus, the long-run estimates equal the negative of the short-run estimates divided by the EC term's parameter ($- \beta_0/\lambda_i$). Similarly, the long-run elasticities are measured using the formulae in equation (7) and the long-run parameter estimates.

The ECM version of the AIDS for cereal grains in Kenya is estimated using an iterated seemingly unrelated regression (ITSUR) procedure in the econometrics statistical software SHAZAM 9.0. Iteration ensures that the obtained estimates asymptotically approach the maximum likelihood estimates (MLE) (Judge *et al*, 1980). To avoid singularity of the estimated variance-covariance matrix, the demand equation for rice is dropped from the system while homogeneity and symmetry are parametrically imposed *a priori*.

Estimated Results and Discussion:

Annual time series cereal grain consumption and price data for the period 1963 to 2005 was used to estimate the AIDS-ECM. The database was obtained from Kenya's Central Bureau of Statistics (CBS) and annual reports from the Ministry of Agriculture (MOA). It was supplemented by consumption statistics from the United

Nations Food and Agriculture Organizations (FAO) online database on agriculture (FAOSTAT). The descriptive statistics of the variables used in the estimation process are shown in Table 1.

The budget share for maize was the highest, accounting for over half of the total cereal consumption expenditure (Table 1). Consequently, the combined budget shares for the other cereals in Kenya account for less than the budget share for maize (Table 1). Overall, the budget shares of wheat and sorghum were 29 and 12 percent respectively while that of rice was less than 10 percent of total cereal consumption expenditure. These budget shares closely track the actual cereals consumption pattern in Kenya, where maize is the key staple food. Moreover, the average log-transformed and normalized prices of all the cereals are within the same range as that of maize.

The data set used in estimating the AIDS-ECM was initially graphically examined for the existence of linear trends. Figure 1 presents the evolution of aggregate cereal budget shares in Kenya. The graph indicates the presence of trends in the budget shares of the four cereals. Moreover, the corresponding price graph shows that cereal retail prices appear to be upward trended (Figure 2). While these figures are informative do not tell us anything about stochastic trends in the data. Thus, formal unit root tests such as ADF tests have to be undertaken to ascertain the presence of unit roots in all the data series used in estimating the demand system. The results of formal unit root tests from a trended and a non-trended model for the variables of the demand system are summarized in Table 2. In both models, the ADF test is used to determine the existence of a unit root. The hypothesis that all cereal retail prices, total expenditures and budget shares contain a unit root cannot be rejected at the five percent significance level for both models (Table 2). However, the first differenced series reject nonstationarity in all cases. Thus, the results are consistent with the hypothesis that nonstationarity characterizes the time series of these variables.

The ADF test results imply that the level series of the variables used to estimate the demand system for grain cereals in Kenya are integrated of order one (Table 2). It can, therefore, be concluded that the time series data of all the variables used to estimate the demand system are generated by a unit root process. Thus, any time series estimation of demand for grain cereals in Kenya has to deal with the issue of non-stationarity of prices and test for cointegration between the quantity variables and the corresponding explanatory variables.

Having established that all the variables in the demand system are nonstationary, we next turn to testing the demand system for cointegration. Cointegration tests are necessary to investigate whether the budget shares are jointly determined with their respective prices. This is because the literature suggests that a linear combination of nonstationary variables might be stationary. The EG Representation Theorem posits that once budget shares are integrated of the same order with the explanatory variables, then cointegration can be established. In this study, two residual based tests and the dynamic test proposed by Banerjee *et al*, (1986) are used to test for cointegration.

Table 3 presents the results of three alternative tests for cointegration between the budget shares and the corresponding explanatory variables: ADF tests, PP tests and a dynamic test that uses the error correction term of the ECM. The ADF test fails to reject the hypothesis of no cointegration for all budget shares at the five percent significance level (Table 3). However, the PP test, considered to be a more powerful test in small samples, rejects the hypothesis of no cointegration at the same level of significance when a time trend is included in the model. This finding supports Ng's

(1995) suggestion that a deterministic time trend is sometimes needed for the identification of cointegration in a dynamic AIDS model.

The dynamic cointegration test results suggest that the budget shares are cointegrated with their explanatory variables at least at the 10 percent significance level (Table 3). Cointegration ensures that shocks affecting commodity prices will be reflected on different budget shares in a similar way. The cointegrated variables move together in the long-run and obey an equilibrium constraint. Having established the existence of long-run cointegrating relationships, an ECM form of the AIDS as specified in equation (9) was estimated. Initially, the demand system was estimated in unrestricted form to test the theoretical restrictions of homogeneity and symmetry. The hypotheses of linear homogeneity, symmetry and both linear homogeneity and symmetry are tested using the Wald test. To implement these statistical tests, the ECM form of the AIDS is estimated without imposing symmetry and homogeneity, with the budget share of rice excluded, to satisfy the adding-up property. Based on the Wald test, the maintenance of linear homogeneity and symmetry either separately or jointly, could not be rejected at the five percent significance level (Table 4). These findings suggest that the empirical results are theoretically consistent with symmetry and homogeneity and thus are valid for this functional specification.

As Attfield, (1985) suggests, the acceptance of the homogeneity property can be interpreted as an acceptance of the exogeneity of expenditures. Thus, the model does not consider the consumption of other food products and changes in income are considered to be exogenous. The estimated parameters satisfy monotonicity and concavity of the underlying (true) cost function. Monotonicity in prices requires that all budget shares are strictly positive. It is satisfied at each data point since all budget shares in this model are strictly positive. Subsequently, the AIDS-ECM was estimated with the parametric imposition of symmetry and homogeneity and used to compute elasticities.

Furthermore, the concavity of the cost function at the sample mean is ensured since all own-price Hicksian elasticities are negative (see Table 8) and consequently the corresponding slutsky matrix is negative semi-definite. As expected, the EC terms are all negative and significant at the five percent level (Table 5). This finding suggests that the model is stable and that any deviations from the long-run equilibrium are corrected to bring the system back to the equilibrium. Overall, the estimated parameters of consumer demand are theoretically consistent and thus the estimated elasticities are valid for policy analysis.

The parameter estimates of the restricted AIDS-ECM are presented in Table 6. The explanatory power of the model is satisfactory as indicated by the high system's R^2 of 0.98. All estimated parameters are jointly significant as indicated by the test of overall significance that rejects the null hypothesis that the slope coefficients are jointly zero. The calculated x^2_{15} of 167.26 exceeds the critical value of 25.00 at the five percent significance level (Table 5). The LR test of the diagonal covariance matrix shows that the model adequately corrects for the heteroskedasticity expected when demand systems are cointegrated. Over two thirds of the estimated coefficients are statistically significant at least at the 10 percent level (Table 5). The expenditure coefficients (β) measure the change in the i^{th} budget share with respect to a change in total expenditure and indicate whether goods are necessities ($\beta<0$) or luxuries ($\beta>0$). All expenditure coefficients for cereal grains in Kenya with the exception of that for rice are negative and significant at least at the five percent level (Table 5). The negative β coefficients for maize, wheat and sorghum suggest that these cereal grains are considered as necessities in Kenya.

Tables 6 to 9 present the estimated Marshallian and Hicksian elasticities of demand for grain cereals in Kenya. In general, all estimated elasticities are price and income inelastic. Specifically, the own-price elasticities are negative and significant at least at the five percent level. The own-price Marshallian elasticities of demand for maize, wheat, rice and sorghum in the short-run are -0.53, -0.26, -0.66 and –0.79 respectively (Table 6). The negative own-price elasticities suggest that the corresponding demand curves are downward sloping, satisfying the law of demand.

All expenditure elasticities are positive and significant at the five percent level (Tables 6 and 7). The short-run expenditure elasticities ranges from a lower estimate of 0.57 for wheat to 0.82 for maize. In the long-run, the expenditure elasticities vary from 0.62 for wheat to 0.93 for maize. The positive expenditure elasticities suggest that cereal grains are normal goods in Kenya. Moreover, all cereals grains are expenditure inelastic both in the short and long-run, implying that they can be considered as necessary goods in Kenya.

The consumer demand elasticity estimates show only minimal changes in price responses between the short-run and the long-run (Table 6 and 7). All long-run own-price Marshallian elasticities are larger in absolute terms than their short-run counterparts. Further, all the estimated long-run expenditure elasticities are positive and larger than their short-run counterparts. Given that the short-run elasticities are smaller than their long-run counterparts for the four major cereal grains in Kenya, the *LeChatelier*[1] *principle* is satisfied with regard to the price and income elasticities. In general, the Marshallian estimates suggest that the consumer demand for any particular cereal grain is more responsive to its own-price than to the cross-prices. The cross-price Marshallian elasticities posses similar signs both in the short-run and in

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[1] The LeChatelier principle states that long-run demand functions are more price and expenditure responsive than their short-run counterparts. Thus at the optimum price and expenditure elasticities are greater in long rather than short-run (Silberberg, 1992 pp. 216-222).

the long-run but are fairly low in magnitude (Tables 6 and 7). These results are consistent with the actual grain consumption patterns in Kenya where maize compliments rice and wheat but is a substitute for sorghum. However, Hicksian elasticities provide better measure of substitutability since they only capture the substitution effect and leave out the income effect.

The own-price Hicksian elasticities of demand are negative but smaller than their Marshallian counterparts both in the short-run and in the long-run (Tables 8 and 9). The Hicksian elasticities of demand for maize, wheat, rice and sorghum were estimated at -0.20, -0.12, -0.64 and -0.58 respectively in the short-run and at -0.44, -0.20, -0.61 and -0.90 in the long-run. Since all own-price Hicksian elasticities are negative, the underlying slutsky matrix is negative semi-definite. The cross-price Hickisian effects are in agreement with their Marshallian counterparts, implying that maize acts as a net substitute for sorghum but as a net compliment for rice and wheat.

Overall, the current elasticities of demand for maize in Kenya are consistent with other studies in this region (Table 10). The current estimates compare well with the recent time series estimates by Munyi, (2000); Seale *et al*, (2003) and Renkow *et al*, 2004. However, the current estimates are lower than the estimates by Bezuneh *et al*, (1988) and Renkow *et al*, 2004 that use survey data. Previous elasticity estimates of demand for wheat, rice and sorghum in Kenya are unavailable. This thesis makes an empirical contribution by being the first study to report the elasticities of demand for wheat, rice and sorghum in Kenya.

Policy Implications and Concluding Remarks:

An attempt is made in this paper to apply time-series econometrics for estimating an error-corrected AIDS model for four major cereals in Kenya using annual data from

1963 to 2005. Assuming weak separability, the demand system is modelled at the second stage of a two-stage budgeting procedure based on a consumer cost minimization problem. On the basis of two static and a dynamic cointegration test, the hypothesis of no cointegration was rejected for all budget shares considered, thus justifying the use of an error correction augmented AIDS model in this study.

The estimated model fits the data well. In addition, all statistical tests of model adequacy were satisfactory. Specifically, the ECM version of the AIDS supported the theoretical properties of homogeneity and symmetry. Moreover, the model fulfils the conditions for monotonicity and concavity of the underlying cost function. These theoretical tests highlight the robustness of the estimated model. Thus, the estimated elasticities are theoretically consistent, reliable and valid for policy analysis. Specifically, all short-run elasticities are smaller in absolute terms than their long-run counterparts which satisfy the *Lechatlier* principle.

All own-price elasticities have the expected signs and are significant at the five percent level. On the basis of the Marshallian elasticities, cereals can be considered as necessities in Kenya. Moreover, the cross-price elasticities conform to the actual grain consumption pattern in Kenya where maize compliments rice and wheat but is a substitute for sorghum. Finally, Kenyan cereal consumers have inelastic responses to price and income changes. Thus, food subsidies alone may not be adequate to increase the consumption cereals in Kenya. A combination of price and income support policies may induce higher consumption. Since Kenya is a net importer of maize, wheat and rice, a viable option to improve cereal consumption would be to gradually reduce food subsidies and encourage higher domestic production of maize, wheat and rice through investments in research and technology and through price stabilization and agri-food safety net programs for farmers.

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Figure 1. Cereal Expenditure Shares, 1963-2005

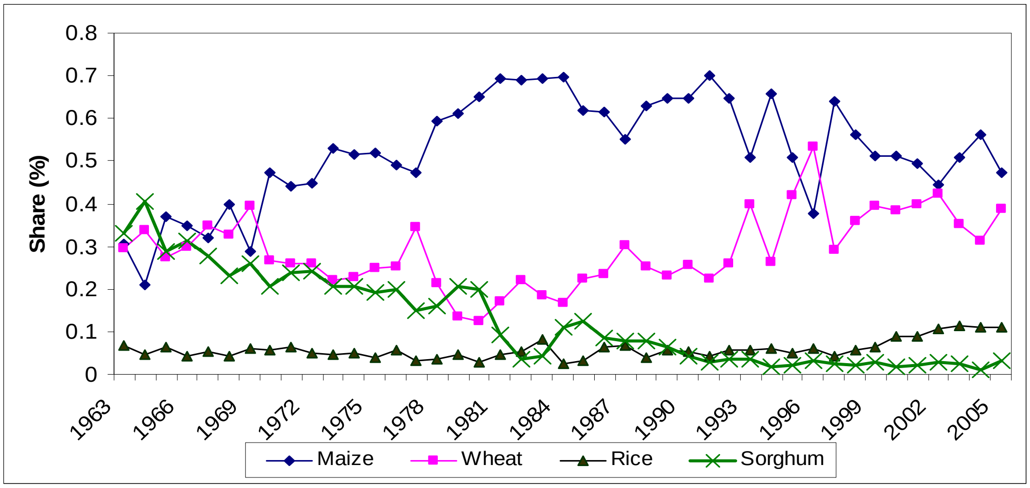

Figure 2. Log Transformed Nominal Consumer Prices, 1963-2005

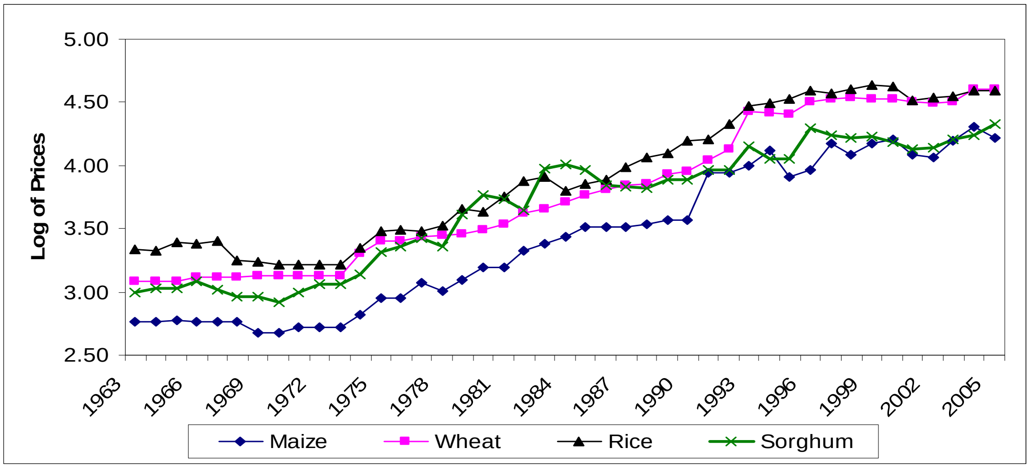

Table 1. Descriptive Statistics of the Variables used in Demand Estimation

Variable	Description	Units	Mean	*Std*	*n*
Dependent Variables					
S_1	Budget share of maize		0.525	0.124	43
S_2	Budget share of wheat		0.289	0.086	43
S_3	Budget share of sorghum		0.127	0.109	43
S_4	Budget share of rice		0.059	0.021	43
Explanatory Variables					
$\ln Pm_1$	Log retail price of maize	KES/MT	3.488	0.506	43
$\ln Pm_2$	Log retail price of wheat	KES/MT	3.744	0.727	43
$\ln Pm_3$	Log retail price of sorghum	KES/MT	3.628	0.489	43
$\ln Pm_4$	Log retail price of rice	KES/MT	3.907	0.781	43
lnM	Log of Total expenditure	KES	6.087	1.354	43

Note: *Std* and *n* denote the standard deviation and the sample size respectively.

Table 2. ADF Test Results for Retail Prices and Total Expenditure

Series	Level Series			First Differences		*I*(d)
	No Trend	Trend	Lags	No Trend	Trend	
Budget Shares (w)						
w Maize	-2.136	-1.440	3	-3.339 [c]	-4.141 [c]	*I*(1)
W wheat	-1.205	-1.618	4	-3.496 [c]	-3.584 [c]	*I*(1)
w Rice	-0.572	-1.602	3	-3.192 [c]	-3.611 [c]	*I*(1)
w Sorghum	-0.966	-1.709	3	-3.804 [c]	-3.878 [c]	*I*(1)
Logarithm of Consumer Prices (Log Pc)						
Log Pc Maize	-0.235	-2.988	2	-3.167 [c]	- 8.029 [c]	*I*(1)
Log Pc Wheat	-0.146	-2.228	2	-3.088 [c]	- 7.438 [c]	*I*(1)
Log Pc Rice	-0.094	-2.011	2	-3.448 [c]	- 6.315 [c]	*I*(1)
Log Pc Sorghum	-0.726	-2.140	2	-3.573 [c]	- 6.579 [c]	*I*(1)
Total Expenditure	-2.110	-1.694	3	-3.989 [c]	- 4.864[c]	*I*(1)
5% Critical Values	-2.93	-3.50		-2.93	-3.50	

(c) Indicates rejection of the null hypothesis of a unit root at the 5 percent level (MacKinnon, 1991).

Table 3. Cointegration Tests: Consumer Demand Series

Series	Dickey-Fuller Cointegration Test		Philips-Perron Cointegration Test		Dynamic Cointegration Test	
	No Trend	Trended	No Trend	Trended	EC term	t - value
Budget Shares (w)						
w Maize	-3.665	-3.547	-5.104 [c]	-4.986 [c]	-0.419[c]	-1.718
w wheat	-3.727	-3.415	-6.136 [c]	-6.099 [c]	-0.886 [c]	-6.273
w Rice	-2.310	-1.969	-3.552	-5.618 [c]	-0.225 [c]	-4.679
w Sorghum	-3.507	-3.448	-5.165 [c]	-5.243 [c]	-0.682 [c]	-4.659
5% Critical Values	-4.71	-5.03	-4.71	-5.03		-1.960

(c) Reject the null hypothesis of no cointegration at the 5 percent level (Phillips and Ouliaris, 1990).

Table 4. Systems Wald Tests for Homogeneity and Symmetry

Parametric Restriction	Calculated x^2 Values	Critical Value 5%	1%	Degrees of Freedom
Homogeneity	3.443	7.82	11.35	3
Symmetry	0.735	7.82	11.35	3
Homogeneity and Symmetry	3.730	12.59	16.81	6

Table 5. Parameter Estimates of an AIDS-ECM for Cereal Demand in Kenya

Parameter	Estimated Parameters with Respect to			
	Maize	**Wheat**	**Sorghum**	**Rice**
γ_{i1}	0.159			
	(2.728)			
γ_{i2}	-0.131	0.153		
	(-4.888)	(4.417)		
γ_{i3}	0.006	-0.026	0.031	
	(0.403)	(-1.614)	(1.825)	
γ_{i4}	-0.034	0.004	-0.011	0.041
	(-0.781)	(0.157)	(-0.542)	
β_i	-0.068	-0.104	-0.114	0.286
	(-2.517)	(-8.843)	(-15.210)	
λ_i	-0.419	-0.886	-0.682	
	(-1.718)	(-6.273)	(-4.659)	
Model Diagnostics	Systems R-Square = 0.980			
	Test of the overall significance (x^2_{15}) = 167.260			
	LR test of the diagonal covariance matrix (x^2_3) = 50.360			

Note: Figures in parenthesis are *t*-values. The critical value at the 5 percent significance level is 1.960.

Table 6. Short-run Marshallian Elasticities for Cereals in Kenya, 1963-2005

Commodity	Elasticity with Respect to the Price of				Expenditure
	Maize	Wheat	Sorghum	Rice	Elasticity
Maize	-0.531	-0.432	0.101	-0.226	0.828
	(0.120)	(0.062)	(0.049)	(0.620)	(0.068)
Wheat	-0.290	-0.260	0.089	-0.045	0.568
	(0.050)	(0.132)	(0.126)	(0.483)	(0.049)
Sorghum	0.073	0.162	-0.794	-0.878	0.657
	(0.033)	(0.063)	(0.043)	(0.321)	(0.023)
Rice	-0.081	-0.096	-0.021	-0.659	0.643
	(0.106)	(0.115)	(0.058)	(0.160)	(0.032)

Note: Figures in parenthesis are standard errors

Table 7. Long-run Marshallian Elasticities for Cereals in Kenya 1963 -2005

Commodity	Elasticity with Respect to the Price of				Expenditure
	Maize	Wheat	Sorghum	Rice	Elasticity
Maize	-0.803	-0.171	0.050	-0.012	0.928
	(0.286)	(0.147)	(0.117)	(0.479)	(0.163)
Wheat	-0.118	-0.345	0.085	-0.022	0.618
	(0.119)	(0.149)	(0.142)	(0.545)	(0.055)
Sorghum	0.036	0.154	-0.860	-0.769	0.766
	(0.079)	(0.071)	(0.063)	(0.471)	(0.033)
Rice	-0.033	-0.084	-0.013	-0.923	0.920
	(0.254)	(0.130)	(0.084)	(0.712)	(0.143)

Note: Figures in parenthesis are standard errors

Table 8. Short-run Hicksian Elasticities of Demand for Cereals in Kenya

Commodity	Elasticity with Respect to the Price of			
	Maize	**Wheat**	**Sorghum**	**Rice**
Maize	-0.203	-0.149	0.415	-0.702
	(0.120)	(0.147)	(0.117)	(0.479)
Wheat	-0.090	-0.123	0.254	-0.612
	(0.050)	(0.132)	(0.142)	(0.545)
Sorghum	0.348	0.351	-0.576	0.009
	(0.033)	(0.063)	(0.043)	(0.471)
Rice	-0.055	-0.079	0.001	-0.639
	(0.106)	(0.115)	(0.058)	(0.160)

Note: Figures in parenthesis are standard errors

Table 9. Long-run Hicksian Elasticities of Demand for Cereals in Kenya

Commodity	Elasticity with Respect to the Price of			
	Maize	**Wheat**	**Sorghum**	**Rice**
Maize	-0.436	-0.168	0.404	-0.064
	(0.286)	*(0.147)*	*(0.117)*	*(0.479)*
Wheat	-0.102	-0.196	0.253	-0.515
	(0.119)	(0.149)	*(0.142)*	*(0.545)*
Sorghum	0.339	0.348	-0.605	0.099
	(0.079)	(0.071)	(0.063)	*(0.471)*
Rice	-0.005	-0.066	0.009	-0.895
	(0.254)	(0.130)	(0.084)	(0.712)

Note: Italicized figures in parenthesis are standard errors

Table 10. Comparison of own-price elasticities of demand for Maize

Study	Sample Period	Marshallian Estimate		Hicksian Estimate	
		Short-run	Long-run	Short-run	Long-run
Bezuneh *et al*,(1988)	1983 - 1984	-1.19	-	-1.11	-
Munyi, (2000)	1999	-0.45	-	-	-
Seale *et al*, (2003)	1993 - 1996	-0.46	-	-	-
Waliweta *et al*, 2003	2003	-0.90	-	-0.71	-
Renkow *et al*, (2004)	1997	-	-	-0.42	-
Current study	1963 - 2005	-0.53	-0.80	-0.20	-0.44