PRESAO

Programme de Renforcement et de Recherche sur la Sécurité Alimentaire en Afrique de l'Ouest
West Africa Food Security Capacity Strengthening and Research Program

MICHIGAN STATE UNIVERSITY

Working Paper 2016-01 November 2016

SRAI 2 Component

Strengthening Regional Agricultural Integration in West Africa: Phase II

Household-Level Evidence of Cereals Demand and the Welfare Implications of Cereals Price Shocks in Rural and Urban Mali

by

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The research presented in this paper was made possible by generous funding from The Syngenta Foundation for Sustainable Agriculture. While gratefully acknowledging this support, the authors take sole responsibility for any errors of fact or interpretation in this paper. Comments are welcome. Corresponding author is Nathalie M. Me-Nsope (mensopen@msu.edu).

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Abstract

Food demand parameters are necessary for informed food policy making. In this paper we specify a Quadratic Almost Ideal Demand System and estimate a complete demand system for rice, sorghum, millet and maize in rural and urban Mali using Mali's 2006 household budget survey data. Elasticities are estimated by per capita income groups and by rural and urban residence. We use these estimates to measure the welfare effects of cereals price shocks observed from 2008 to 2011 by means of a proportional compensating variation that allows for second-order demand responses to price changes. Our results suggest that substitution occurs between rice and coarse grains in both the rural and the urban areas and across income groups. Across income groups and place of residence, the second-order effect on welfare of cereals price shocks are only slightly lower than the first-order effect, reflecting a limited scope for substitution to "cheaper" cereals when all cereals prices are rising sharply. In both rural and urban areas, the relative income loss from observed price changes was greater for poorer than richer households, but the absolute income loss was greater for the higher income groups. The findings suggest a scope to encourage ongoing diversification of staple food sources to give consumers more opportunity for substitution and choice. Price transmission across cereals suggests a need for a cereals policy rather than just, for example, a rice policy. The results suggest strong future growth in demand and a need to focus on driving down unit costs throughout the food system.

Key words: food demand, expenditure elasticity, price elasticity, Mali

Paper submitted for presentation at the African Agricultural Economics Conference, Addis Ababa, Ethiopia, 23-26 September 2016

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1. Introduction

Structural parameters of food demand are key inputs into informed food policy making. Analyzing food demand using household-level data enables identification of households that are most vulnerable to inadequate food intake and their geographic location as well as their likely behavioral responses to changes in prices and incomes. Such information is needed for and evaluating the effect of various food and trade policies.Historically, cereals have represented a large share of total household consumption in the Sahelian countries of West Africa (WA). Approximately 20% of domestic cereal supply in WA originates from imports, making regional and international trade and hence changes in international grain prices major considerations in food security strategies in the region (Hollinger and Staatz, 2015). For example, a leading research agenda in the early 1980s and 1990s focused on understanding whether rapid growth in the consumption of imported rice and wheat in the region resulted from low world rice and wheat prices relative to those of locally produced millet and sorghum. A key finding was that the rising consumption of imported grains was not driven primarily by changes in relative cereal prices but rather by the greater convenience in the preparation and consumption of the imported goods (Reardon et al. 1988; Delgado, 1989; and Rogers and Lowdermilk, 1991). Following the 1994 devaluation of the CFA franc, research also examined whether, as intended, the resulting higher price of imported rice relative to traditional coarse grains stimulated substitution away from the former. Evidence from studies in urban Mali, Burkina Faso, Senegal and Cote d'Ivoire suggested low rates of substitution of local coarse grains for imported rice and instead a reduction in total cereal intake (Diagana et al. 1999).

The 2007-2008 global food crisis brought renewed attention to food consumption patterns. The main symptom of the crisis was an upsurge in international prices for staple foods such as maize, wheat, rice, and soybeans. In WA, a major concern was the possible reduction of consumption levels and resulting social unrest.

The lack of reliable estimates of demand parameters in much of WA has severely limited the analysis of how food consumption is likely to respond to price spikes like those of 2008. In Mali, existing estimates are few and limited mainly to urban areas. Rogers and Lowdermilk, (1991) used household-level data and a single equation model to investigate the food consumption patterns of different income classes in urban areas of Mali. Camara (2004) used an Almost Ideal Demand Systems (AIDS) model to investigate the impact of seasonal changes in real incomes and relative prices on households' consumption patterns. Like Rogers and Lowdermilk, Camara's work uses data only from urban Mali, specifically Bamako. Taondyandé and Yade (2012) using the ELIM[2]-2006 dataset, estimated the marginal propensity

[2] ELIM is an acronym for "Enquête Légère Intégrée auprès des Ménages", a household-level budget survey that was conducted in urban and rural Mali in 2006. The survey was administered on a nationally representative sample of 4,494 households.

to consume different foods from an increase in per capita income as well as income elasticities, for both urban and rural areas, but they did not control for price variation across the sample.

Changes in food prices can affect household welfare by affecting the affordability of an important component of the consumption basket. The welfare consequences of food price changes can be measured using first or second order approximations. First-order approximations focus only on the direct effects on consumption of a good resulting from a change in its price. First-order approximations have been criticized for being too restrictive for evaluating the welfare effect of a large discrete price change because supply and demand responses to a major price change may be substantial (Mghenyi et al. 2011). For example, when the price of a food item increases, consumers can switch to more affordable items or producers can respond to the increase by expanding supply or reallocating inputs to capture the increase in price. Second-order approximations take into account substitution in consumption across commodities that result from a price change, as well as the price-induced effects on production and other linkage effects. Estimating the production and linkage effects, however, requires very detailed input and production data for the whole economy, so we limit our attention in this paper to the second-order substitution-in-consumption effects.

The lack of data and empirical estimates on household-level food demand in urban and rural Mali has circumscribed the approaches considered in estimating the welfare effects of food price changes. Joseph and Wodon (2008), using food consumption expenditures data for Mali (ELIM-2006), provide an assessment of the short-term impact on poverty of the increase in the price of cereals. However, their estimates of the impact on poverty of higher food prices are based on a number of key assumptions. First, they assume that an increase in the price of a food translates into an equivalent reduction of its consumption in real terms, meaning that they do not take into account the own-price or cross-price elasticities of demand that may lead to substitution effects. Second, they assume constant relative prices and argue that the substitution of millet, sorghum, and maize for rice and wheat is likely to be low because all these products are important in the Malian diet and that the prices of the various food items seem to increase in parallel at least in the medium term. Third, they assume that changes in prices do not affect households when food is home-produced and consumed.

Nouve and Wodon (2008) extend the work done by Joseph and Wodon (2008) and in a dynamic general equilibrium framework estimate the medium-term impact of higher rice prices in Mali on poverty. They compare a base scenario to six different scenarios that combine rice price changes and policy responses (import tax cuts on rice and measures to increase productivity of domestic rice production). They find that considering either an 80% or a 110% increase in international rice prices from the level in 2006, a 15% an increase in productivity will have a larger impact than a 100% reduction in taxes.

In this paper, we use household budget survey data to estimate cereals demand parameters for urban and rural Mali. Our study contributes to the literature in three ways. First, we use a large nationwide dataset (N=4494) and provide first-time estimates of price and income elasticities of demand for cereals by rural Malian households (in addition to urban estimates). Second, we specify a Quadratic Almost Ideal Demand System (QUAIDS) model for cereals in Mali. The QUAIDS model, originally proposed by Banks et al. (1997), unlike its counterpart — the AIDS model — allows for non-linearity in household expenditure shares. The final specification of our QUAIDS model deals with the problems of non-consumption and endogeneity in the expenditure variable common in demand systems estimation, using the approaches outlined in Shonkwiler and Yen (1999) and Bopape (2006), respectively. Using this model, we estimate demand elasticities by low-, middle- and high-income groups within the rural and urban sub-samples. Third, using the estimated own- and cross-price demand elasticities, we measure the welfare effects of cereals price changes observed in the period 2008-2011 by means of a proportional compensating variation that allows for second-order demand responses (direct and substitution effects).

The remainder of the paper is organized as follows. Section 2 presents a description of the household budget survey data and the supplemental price data used in the estimation. Section 3 considers empirical formulation of the cereals demand model, presenting results from the model specification test as well as the approach used in dealing with non-consumption and endogeneity in the expenditure variable. Section 4 describes the estimation procedure and the formulation of the welfare measure. Section 5 presents and discusses the empirical results for the cereal demand model and the estimated effects on welfare of changes in cereal prices. Section 6 presents concluding remarks and policy implications of the findings.

2, Data

We use Mali's 2006 household budget survey (HBS), also known as the "Enquête Légère Intégrée auprès des Ménages (ELIM)-2006". The ELIM-2006 data covered a total of 4494 Malian households (urban=1566 and rural=2888), and 9 regions (Koulikoro, Segou, Sikasso, Gao, Kayes, Kidal, Mopti, Tombouctou, and the district of Bamako). Data were collected on household socio-demographic characteristics and food and non-food expenditures. Total consumption expenditure on each food type is the sum of the value of consumption from own-production, purchases, and net gifts received. Total expenditure on all household expenditure categories is used as a proxy for household income.

The ELIM-2006 dataset contains no information on the prices paid by individual households for most goods. As a result, cereals prices were imputed from an external source, the Observatoire du Marche Agricole (OMA), which is the office responsible for collecting agricultural price data. The regions surveyed for the ELIM-2006 data are comprised of a total of 48 districts ("cercles"). For 33 of the 48 districts, OMA monitors at least one market within each district. In districts that lacked an OMA price monitoring, we used regional-average prices. Details on the correspondence between the ELIM data and the OMA data collection sites are available in Me-Nsope (2013).

A question that often emerges in the analyses of household food demand using cross-sectional survey data is whether cross-sectional variations in prices can be used to derive a complete system of own- and cross- price elasticities. Cross-sectional variations in prices could be due to reasons such as region, price discrimination, seasonality and quality effects (Prais and Houthakker, 1955). Since we deal with primary commodities, we expect relatively little quality variation. Deaton (1988) and Cox and Wohlgenant (1988) observe that price variations from regional and seasonal differences allow accurate estimation of price elasticities, and are thus desirable for demand analysis. Friedman (1976) suggests that constructing a demand curve from spatial data is similar to that from time-series data when conditions of supply vary considerably while conditions of demand vary little. Deaton (1997) notes that it is often desirable to allow for the effects of regional and seasonal taste variation in the pattern of demand by entering regional and seasonal dummies into the regression, so that the price effects on demand are only identified to the degree that there are multiple observations within regions or that regional prices do not move in parallel across seasons. We therefore use regional dummy variables to isolate changes in demand from differences in taste and preference from changes in demand from changes in prices.

Further, according to Deaton (1988), under appropriate separability conditions, it is possible to exploit the spatial nature of data to back out true price elasticities. The idea is that within a geographic unit (say a district) the prices will be the same, and controlling for district-level fixed effects allows one to back out the true price elasticities because the real price variation occurs only through the spatial dimension. Thus, even though the ELIM-2006 survey is a one shot survey, multiple observations of prices at the district level within a region allow us to capture some temporal variability in prices, which when combined with regional dummy variables permits us to obtain estimates of price elasticities by income group.

Table 1 presents summary statistics of the data used in the estimation. Average household size is 8 individuals in the urban sub-sample and 10 individuals in the rural sub-sample. Using the adult equivalent (AE) scale in Duncan (1994) (male>14 years=1.0; female>14=0.8; child=0.5), the average household AE is 6.2 and 7.0 in the urban and rural sub-samples, respectively. Average total consumption expenditures are higher for the urban than for the rural sub-sample. Irrespective of place of residence, there is a decline in food share as we move from the low-income group to the high-income group (Engel's law). The share of cereals in the food budget also decreases from the low- to the high-income group within each place of residence. An examination of shares by cereal types, by income group and place of residence reveals that in both rural and urban areas the share of the cereal expenditures going to rice increases with income level while that going to millet and sorghum falls.

3. Empirical formulation of the cereals demand model

As observed by Deaton and Muelbauer (1980), the consumer's optimization problem is intractable if the demand for every commodity is a function of the prices of all other commodities. Therefore, we assume weak separability of consumer preferences in order to simplify the modeling of consumption decisions. Under this assumption, the consumer's decision-making process is viewed as involving three stages. In Stage I, households allocate total budget between food and non-food items. Conditional on the first stage allocations, in

Stage II, households allocate food expenditure between cereals and non-cereals items. In Stage III, conditional on the second stage allocations, households allocate cereal expenditures to rice, maize, millet and sorghum. We focus our analysis on Stage III because of our interest in understanding demand for different types of cereals.

Table 1. Summary Statistics of the Data

Variable	**Urban**			**Rural**		
	Income Tercile#			Income Tercile#		
	Low	Middle	High	Low	Middle	High
Annual Average Total consumption Expenditure CFAF						
Per household	1,375,659 (41,759)	2,624,424 (72,556)	5,119,698 (160,300)	803,385 (16,050)	1,235,347 (23,403)	1,948,274 (53,820)
Per Adult Equivalent	197,931 (66,633)	423,478 (91,306)	1,089,084 (647,004)	99,421 (28,915)	177,400 (28,529)	362,015 (235,838)
Average Annual Expenditure Per Household CFAF						
Food	723,552	1,039,077	1,218,093	480,024	729,176	906,493
Non food	652,107	1,585,347	3,901,605	323,361	506,172	1,041,782
food shares	0.53	0.41	0.26	0.60	0.59	0.47
Average Annual Expenditure CFAF Per Household						
Cereals	286,519	368,221	306,188	221,952	341,857	377,647
Non-cereals	437,032	670,856	911,905	258,073	387,319	528,845
Average Annual Expenditure CFAF Per Adult Equivalent						
Cereals	42,209	59,842	63,021	27,997	49,809	70,574
Non-cereals	64,643	113,756	192,009	32,455	58,405	101,147
Cereals share	0.4	0.35	0.25	0.47	0.48	0.43
Average Annual* Expenditures CFAF/AE						
Rice	24,491	39,866	42,734	7,890	18,134	32,166
Millet	10,255	11,858	12,705	11,557	17,321	20,580
Sorghum	4,325	4,778	4,202	5,523	8,751	10,958
Maize	3,137	3,339	3,380	3,027	5,603	6,870
Shares in cereal budget						
Rice	0.57	0.64	0.65	0.27	0.36	0.46
Millet	0.24	0.19	0.19	0.43	0.35	0.29
Sorghum	0.11	0.1	0.08	0.18	0.17	0.16
Maize	0.09	0.07	0.08	0.11	0.12	0.1
Average Household size	8.2			9.6		
Average HH AE	6.2			7.0		
Household Head						
Percent Male-	88.8			95.5		
Percent Female	11.2			4.5		

"Income terciles" are calculated based on total per capita expenditures (the proxy used here for per capita income) and are calculated separately for urban and rural areas. Exchange rate: 540.5 CFAF = US $1,00.
(*) includes the value of consumption from own-production.
Source: Authors' computation using ELIM-2006.
Note: The figures in parenthesis are the standard errors of the mean.

Most rural households in the dataset produce one or more types of cereals. However, comparing aggregate expenditure on cereals to the revenue from cereals sales, most of these rural households are categorized as net cereals buyers. We argue that while cereals are major staples in Mali, a household's consumption of a specific cereal from its own-production is responsive to changes in the market prices. For example, in the event of a price hike, a cereal-producing household could sell one type of cereal – e.g., rice—and buy back a cheaper cereal, such as maize. In this paper, we present the findings from our estimation of cereals demand using total cereals expenditure (purchased and value of consumption from own production). Results from the estimation using only purchased cereals expenditures and aggregating expenditures across purchased cereals are available upon request.

The choice between a Quadratic Almost Ideal Demand System (QUAIDS) model proposed Banks et al. (1997) and the AIDS model of Deaton and Muelbauer (1980) rests on the shape of the Engel curves. Bopape (2006) developed a parametric quadratic expenditure specification test for whether the QUAIDS or the AIDS is appropriate for the demand analysis. Applying that test to our data led us to adopt the QUAIDS model, which allows for non-linearity in the budget shares, while maintaining all the relevant properties of the AIDS model (exact aggregation over households and satisfaction of all the axioms of choice). As a complete demand system, the QUAIDS specification allows us to consistently account for the interdependence in the choices made by households among different cereals. In addition, this specification allows more flexibility—expenditure elasticities differ with expenditure levels, which could be a significant advantage in welfare analysis; and the possibility of normal goods becoming inferior or vice versa as one moves along the expenditure spectrum of households (Bopape, 2006).

The augmented QUAIDS share equations are specified as follows:

$$w_{ih} = \alpha_i + \delta_{ih} lnAE_h + \theta_i M_h + \sum_{n=1}^{8} \rho_{in} RD_h + \sum_{j=1}^{k} \gamma_{ij} lnp_{jh} + \beta_i ln\left[\frac{CX_h}{a(p_h)}\right] +$$

$$\frac{\lambda_i}{b(p_h)}\left\{ln\left[\frac{CX_h}{a(p_h)}\right]\right\}^2 + u_{ih} \quad (1)$$

where w_{ih} is the household budget share for cereal type i. The budget shares are calculated using food expenditures. p_{ih} is the retail price of each cereal type i. CX_h is household cereal expenditure. Dummy variables capture the effect of a household's geographic location on expenditures. RD_h, are regional dummies and M_h represents a dummy for urban or rural residence. The translog price aggregator, $a(p_h)$, and the price aggregator function, $b(p_h)$, are functions homogeneous of degree 1 and 0, respectively, in prices. ln $a(p_h)$ and $lnb(p_h)$ and are specified as translog and Cobb-Douglas equations.

$$\ln a(p_h) = \alpha_0 + \sum_{i=1}^{k} \alpha_i lnp_{ih} + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \gamma_{ij}\, lnp_{ih} lnp_{jh} \quad (2)$$

$$b(p_h) = \prod_{i=1}^{k} p_{ih}^{\beta_i} \quad (3)$$

For commodities i=1,…k.

The theoretical restrictions of homogeneity, adding up and symmetry are imposed on the parameters to ensure integrability of the demand system. Adding-up requires that expenditure shares sum to one (i.e., $\sum_{i=1}^{n} w_i = 1$), and can be expressed in terms of model parameters as:

$$\sum_{i=1}^{n} \alpha_i = 0, \quad \sum_{i=1}^{n} \beta_i = 0, \quad \sum_{i=1}^{n} \gamma_{ij} = 0, \quad \forall j \;, \sum_{i=1}^{n} \lambda_i = 0 \quad \forall i \quad \text{and} \quad \sum_{i=1}^{n} \theta_i = 0$$

Hicksian demands are homogenous of degree zero in prices, which implies

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \qquad \forall j$$

The Slutsky symmetry restriction requires that

$$\gamma_{ij} = \gamma_{ji} = 0 \qquad \forall \text{ i, j,}$$

These restrictions are imposed during estimation. Negativity of own-price elasticity is not automatically introduced, but by estimating all the compensated own-price elasticities one can test for their negativity.

In order to obtain unbiased and efficient price elasticities, our specification of the QUAIDS model also handles the two most common econometric issues that arise when cross-sectional data are used to estimate elasticities–expenditure endogeneity and zero-expenditure.

The problem of expenditure endogeneity arises when total expenditures are determined jointly with the expenditure shares of the individual commodities that enter the demand model, making it endogenous in the expenditure share equations (Blundell and Robin, 1999). This problem may also arise whenever the household expenditure allocation process is correlated with other unobserved behavior not captured by the explanatory variables in the budget share equations, because these unobserved effects would be bundled in the error term. We use the augmented regression technique of Hausman (1978) and Blundell and Robin (1999) to deal with the problem of expenditure endogeneity. This technique is suitable in a system of non-linear equations (see also Barslund, 2011; Bopape, 2006; and Tafera et al. 2010). To perform the test, we use the number of wives to the household head and its square as our instruments. The choice of the instruments was based on a formal test of the relevance[3] of the instrumental variable (IV). The technique assumes that the error terms have an orthogonal decomposition:

$$u_{si} = \rho_s \tau_{si} + \varepsilon_{si} \tag{4}$$

τ_{si} are the residuals from the regression of total cereal expenditure on the set of instruments[4] and explanatory variables. ε_{si} is normally distributed. The parameter ρ_s provides a test of exogeneity of total cereal expenditure for each consumption share and should be equal to zero if the cereal expenditure is exogenous.

Zero-expenditure arises when a large number of households report zero consumption for some goods for which demand is being estimated. Rice, millet and sorghum are the mainstays of the Malian diet. Non-consumption could be the result of the reference period used in reporting consumption failing to capture any expenditures on any of these commodities. Non-consumption in the data causes a censored dependent variable problem that leads to biased results if not dealt with (Alfonzo et al. 2006). Considering the total cereals expenditures (purchased plus the value of own-consumption), 5.1% of the total sample reported non-consumption for rice, 45.2% reported non-consumption for sorghum, 18.9% reported non-consumption for millet, and 49.8% reported non-consumption for maize. Dropping all these households would dramatically reduce the sample size) and still give inconsistent estimates. To address this problem, we use Shonkwiler and Yen (1999)'s approach.

Consider the dichotomous variable

$$d_{ih} = 1 \ \ if \ \sigma_i z_{ih} + v_{ih} > 0 \ ; \ and \ \ d_{ih} = 0 \ otherwise \tag{5}$$

Where σ_i is a vector of coefficients, z_{ih} a vector of explanatory variables and v_{ih} is the equation-specific error term, which is distributed normally (0,1).

The observed expenditure shares for the h[th] household are given by:

$$w_{ih}^{obs} = (w_{ih} + \ \rho_s \tau_{si}) \cdot d_{ih} \tag{6}$$

τ_{si} are the residuals from the regression of total cereal expenditure on the set of instruments and explanatory variables, and it is equals to zero if total cereals expenditure is exogenous.

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[3] A good instrumental variable must satisfy the i) the relevance condition – sufficiently correlated with the potentially endogenous variable; and ii) the exogeneity condition – not correlated with the error term in the demand model. While the exogeneity condition of IVs is most often assumed, the relevance condition must be tested.

[4] The number of wives to the household head and the square of number of wives to the household head.

Consistent parameters in equation (1) can be obtained by estimating

$$w_{ih}^{obs} = \Phi(\hat{\sigma}_i z_{ih})(w_{ih} + \rho_s \tau_{si}) + \pi_i \phi(\hat{\sigma}_i z_{ih}) + \xi_{ih} \quad (7)$$

Where $\hat{\sigma}_i z_{ih}$ are predicted indices from the first-step probit estimation of the equation in (5) and Φ and ϕ are respectively the standard normal cumulative distribution function (cdf) and probability density function (pdf). Unlike in the conventional system specification without censoring, the deterministic components on the right hand side of equation (7) do not add up to unity across all equations of the system, and so the error terms in the estimation form do not add up to zero (Yen et al., 2002). As a result, the usual procedure of imposing the adding-up restriction on the system and dropping one equation is not valid. Therefore, with censoring, equation (7) is estimated correctly when using the entire set of n equations (Yen et al., 2002).

The expressions for the elasticities, following Banks et al. (1997), are simplified as follows:

$$\mu_i \equiv \frac{\partial w_{ih}^{obs}}{\partial lnCX_h} = \Phi(\hat{\sigma}_i z_{ih}) \left[\beta_i + \frac{2\lambda_i}{b(p_h)} \left\{ln\left[\frac{CX_h}{a(p_h)}\right]\right\}\right] \quad (8)$$

$$\mu_{ii} \equiv \frac{\partial w_{ih}^{obs}}{\partial lnp_i} = \Phi(\hat{\sigma}_i z_{ih}) \left[\gamma_{ij} - \mu_i \left(\alpha_i + \sum_{l=1}^{K} \gamma_{jl}\, lnp_{lh}\right) - \frac{\lambda_i \beta_j}{b(p_h)} \left\{ln\left[\frac{CX_h}{a(p_h)}\right]\right\}^2\right] \quad (9)$$

Expressing the formula for expenditure elasticities in terms of μ_i:

$$e_i = \frac{\mu_i}{w_i} + 1 \quad (10)$$

Similarly, the Marshallian or uncompensated elasticities of demand can be expressed as follows:

$$e_{ij}^{u} = \frac{\mu_{ij}}{w_i} - \delta_{ij} \quad (11)$$

Where δ_{ij} is the Kronecker delta, which equals1 if i=j and 0 otherwise. The Hicksian or compensated elasticities can be derived using Slutsky equation:

e_{ij}^{c}

$$= e_{ij}^{u} + w_i e_i \tag{12}$$

4. Estimation Procedure

The complete estimation procedure for equation (7) is as follows. We first conduct the test for endogeneity of the total cereal expenditure using the Hausman technique. Next, we apply the test for model specification to determine the appropriateness of the AIDS versus QUAIDS model. In step 3, the system in equation (5) is estimated by multivariate probit, and the pdfs and cdfs are computed. In step 4, the system in equation (7) is estimated using Non-linear, Seemingly Unrelated Regression (NLSUR) in STATA. To capture differences in expenditure patterns across income groups, we rank households within each place of residence (urban and rural) from lowest to highest based on per capita income levels and divide them into per capita income terciles and analyze consumption behavior separately for each group. We use the formulas in equation (8) to (12) to compute elasticities for the different cereals by place of residence and income group.

The formula we use to evaluate the partial equilibrium welfare effect of cereals price changes from an initial price level is adapted from de Janvry and Sadoulet (2008). The measure is known as the proportional compensating variation (CV). The idea is that using a set of reference prices, we can compute how well-off or worse-off households are as a result of the price changes, moving from their initial utility level to the new utility level in response to the changes in cereals prices. The CV is the difference between the minimum expenditure required to achieve the original utility level at the new prices and the initial total expenditure – i.e., the amount of money the household would need to be given at the new set of (higher) prices in order to attain the initial level of utility. Approximated using a second-order Taylor expansion of the minimum expenditure function, the CV is written as:

$$CV \approx \sum_{i=1} w_i^d \, dlnp_i + 0.5 \left[\sum_{i=1} \sum_{j=1} w_i^d e_{ij}^d (dlnp_i)(dlnp_j) \right] \tag{13}$$

Where e_{ii}^d is a 4x1 matrix of estimated compensated own price elasticites; e_{ij}^d is a 4x4 matrix of estimated own and cross-price elasticities of demand for rice, maize, millet and sorghum by place of residence and income group; w_i^d is the share of each cereal type in the household's food budget in the initial period (2006), calculated from the survey data; and $dlnp_i$ approximates the proportionate change in the price of commodity *i*. The first-order effect is captured by the first term in equation (13), and it implicitly assumes zero demand elasticities (i.e., household consumption behavior remains unaltered with price changes). From equation (13) we see that the second-order effect depends on the compensated price elasticities, on the magnitude of the price change, as well as the relative importance of the product in purchases in the household's budget.

5. Findings and Discussion

A formal test for endogeneity in total cereals expenditures was conducted using the augmented regression technique discussed earlier. Space limitations prevent presentation here of the application of the procedure to our data, which are available in Me-Nsope (2013). In the individual budget share equations, the test results provide statistical evidence in favor of cereals expenditure exogeneity in all four equations. Similarly, tests on the system of equations (carried out both with and without imposing demand restrictions –symmetry and homogeneity, with adding-up satisfied automatically by the data) also failed to reject the null hypothesis at the 5% level of significance. Based on these test results, it is not necessary to control for expenditure endogeneity. With total cereals expenditure exogenous, the only necessary modification to the model was to deal with the issue of zero-expenditures.

Bopape's (2006) test for model specification was implemented to choose between the AIDS and QUAIDS model. The results of the model specification test are reported in Appendix Table A-1 and clearly show that the QUAIDS (non-linear) model is the more appropriate choice. To check if any fundamental difference exists between the decisions to purchase these cereals and how much of each to purchase (selection bias), the QUAIDS model for cereals demand is estimated dealing with non-consumption (censored data) using the following procedure.

We estimate the household's decision to consume a specific cereal type (Equation 5) using a maximum likelihood probit regression to obtain household-specific probit estimates $\widehat{\sigma}_h z_{ih}$. The univariate standard normal probability density (pdf) and the cumulative distribution (cdf) to use in the QUAIDS model are later calculated for each cereal type and each household. Given the initial values of the price index a(p) and the predicted values (pdfs and cdfs) from the probit regressions, the cross-equation nature of the restrictions, and the non-linear structure of the QUAIDS model, Poi's (2008) "demand-system estimation: update, Non-Linear Seemingly Unrelated regression (NLSUR) model" written in STATA, augmented with the pdf and cdf from the first stage probit regression to account for zero expenditure and household demographics, is used to estimate the demand system in equation 7 (dropping the term $\rho_s \tau_{si}$ since we rejected expenditure endogeneity).

5.1 Expenditure Elasticities of Demand

Expenditure elasticities relative to total cereals expenditure and by income-group per place of residence are summarized in Table 2 below.[5] The full matrix of estimated elasticities and their standard errors by place of residence and income group is available upon request from the authors.

[5] In the tables and discussion that follow, the three per capita consumption expenditure terciles for both rural and urban areas are referred to, for simplicity of exposition, as "low-income", "middle-income" and "high-income". These appellations refer to the relative incomes of the three groups and not to any standards for low-, middle- or high-income status used by international agencies such as the World Bank.

Table 2. Cereals Expenditure Elasticities by Place of Residence and Income Group

	Rice	**Millet**	**Maize**	**Sorghum**
		Urban		
All	0.964*	1.038*	0.668*	1.502*
By Income Group				
Low	1.248*	0.758***	0.702*	0.673*
Middle	0.880*	1.079*	1.070*	1.454*
High	1.239*	0.415*	1.032*	1.247*
		Rural		
	Rice	**Millet**	**Maize**	**Sorghum**
All	0.728*	1.200*	1.099*	1.109*
By Income Group				
Low	0.654*	1.248*	1.030*	1.054*
Middle	1.006*	0.980*	0.867*	1.069*
High	1.001*	1.025*	1.014*	0.974*

Note: * means significant at a 1% level and ** means significant at 5% and *** means significant at 10%.

Across all income groups and by place of residence, all expenditure elasticities are positive and statistically significant at the 1% level (except for millet in the low-income urban households, which is only significant at a 10% level). For rice and sorghum, we observe higher expenditure elasticities in the urban areas than in the rural areas, while millet and maize expenditure elasticities are higher in the rural areas than in the urban areas. The higher rice expenditure elasticity in the urban area (0.964) than in the rural areas (0.728) indicates that urban households are more likely to spend any additional income on rice than are rural households despite per capita rice consumption in urban areas averaging nearly double that of rural areas. The estimated urban rice expenditure elasticity is higher than Camara's (2004) estimated income elasticity of demand for rice in Bamako (0.796) and much larger than what Rogers and Lowdermilk (1991) obtained as a rice income elasticity (0.562) for urban Mali (the cities of Kayes, Sikasso, Segou, Tombouctou, Gao, Bamako, Mopti, and Koulikoro). The apparent growing expenditure elasticity of rice over time supports Camara's comment that rice is becoming less of a necessity for urban households over time.

For urban consumers, the rice expenditure elasticity decreases slightly from the low- to the high-income group, the millet expenditure elasticity drops from the low-to the high-income group, and the maize and sorghum elasticities increase from the low- to the high-income groups. Thus, we observe an increasing preference for rice and sorghum at higher per capita income levels while the preference for millet seems to decrease with income level in the urban areas. The high expenditure of elasticity of sorghum and millet in the urban area, and the increases in sorghum expenditure elasticity as income increases are intriguing findings because past studies argued that coarse grains are generally less preferred than rice in the urban areas for reasons such as the high opportunity cost of the time required for their processing and preparation. This finding suggests that future budget-consumption studies need to differentiate demand for processed versus unprocessed sorghum and by place of consumption (for example, home and away from home).

In rural areas, aggregating across all income groups, maize is also expenditure elastic. Across income groups, the expenditure elasticities also reveal that the responsiveness of rice to changes in income increases from the low- to the high-income households in the rural areas. Millet, sorghum and to a lesser extent maize expenditure elasticities tend to decline from the rural low- to the high-income rural group.

Overall, poorer households have higher expenditure elasticities than richer households for millet, sorghum and to a lesser extent maize in the rural areas, but this relationship only holds true for millet in the urban areas. This is not surprising given the clear pattern of decline in sorghum and millet budget shares from the low- to the high-income groups and a marked increase in the rice budget share from the rural low- to high-income households shown in Table 1.

5.2 Price Elasticities of Demand

5.2.1 Own-Price Elasticities of Cereals Demand

Table 3 reports estimated own-price elasticities of demand. Aggregating across income groups, all uncompensated and compensated own-price elasticities are negative and statistically significant at a 5% level. Considering only the urban sub-sample and aggregating across income groups, all uncompensated own-price elasticities are close to unity, indicating high sensitivity to own price changes. The own-price elasticity for rice obtained here for the urban area (-0.955) is about 3 times that reported by Camara (2004) using data for Bamako households only (-0.338). However, Rogers and Lowdermilk (1991) using data from 5 cities in Mali found the own-price elasticity of demand for rice to be -0.683. Given that the urban sample used by Rogers and Lowdermilk (1991) is quite comparable to that used in this study (in terms of geographical coverage), it can be noted that the sensitivity of rice demand to changes in its own-price in the urban areas appears to have increased over two decades. When only the substitution effects are considered (compensated demand), all the cereals became less elastic, as expected for normal goods. Considering total cereals expenditures, millet demand is the least sensitive to changes in its own price in the urban area. However, compared to maize and sorghum, rice demand is less responsive to changes in its own price.

Disaggregating across income groups in the urban sample, almost all our estimates of uncompensated and compensated own-price elasticities are negative and statistically significant (Table 3). The estimated own-price elasticities of cereals demand are more elastic for lower-income households than for higher-income households only for maize and sorghum. High-income urban households' demand for rice is more responsive to changes in the price of rice than that of the low-income urban households.

Aggregating across income groups in the rural sub-sample, uncompensated own-price elasticities are all statistically significant and negative as expected. Rice is the least sensitive to changes in its own price in the rural areas. The uncompensated own-price elasticities show that low-income rural households are more sensitive to a change in the price of millet and maize than are high-income households, but these findings appear to be driven by the income-effects of the price change, as the compensated elasticities are not uniformly higher in magnitude for the bottom income tercile than for the top one.

Table 3. Own-Price Elasticities of Cereal Demand – Urban and Rural Mali

	Rice	Millet	Maize	Sorghum
		URBAN		
Uncompensated				
All	-0.955*	-0.904*	-1.046*	-1.156*
Low	-0.997*	-0.243	-0.996*	-1.014*
Middle	-0.915*	-1.035*	-1.026*	-0.948*
High	-1.065*	-0.514*	-0.946*	-0.658*
Compensated				
All	-0.341*	-0.714*	-0.986*	-1.021*
Low	-0.277*	-0.089	-0.914*	-0.944*
Middle	-0.318*	-0.860*	-0.945*	-0.828
High	-0.241*	-0.439*	-0.870*	-0.557**
		RURAL		
Uncompensated				
All	-0.938*	-1.135*	-1.024*	-0.994*
Low	-0.781*	-1.010*	-1.041*	-0.894*
Middle	-0.973*	-0.963*	-0.940*	-0.945
High	-0.991*	-0.993*	-0.996*	-0.988*
Compensated				
All	-0.660*	-0.723*	-0.896*	-0.819*
Low	-0.585*	-0.513*	-0.907*	-0.713*
Middle	-0.607*	-0.622*	-0.834*	-0.768*
High	-0.516*	-0.696*	-0.897*	-0.853*

Source: Authors
Note: * = significant at 1%, ** =significant at 5% and *** = significant at 10%.

5,2,2 Cross-Price Elasticities of Cereals Demand

Table 4 reports compensated cross-price elasticities of demand by income group in the urban sub-sample. With one exception, all the estimated cross-elasticities that are statistically significant are positive, as expected. Amongst the low-income group, maize and sorghum are substitutes for rice, with elasticities of substitution of 0.567 and 0.460 respectively. In the middle-income group, millet, maize and sorghum are substitutes for rice, with elasticities of substitution of 0.674, 0.580 and 0.437 respectively. Amongst high-income urban households, a change in the price of rice does not have a statistically significant effect on the demand for millet and sorghum. Maize is a substitute for rice amongst the high-income urban group, with a high cross price elasticity of 1.299.

Comparing across urban income groups, we observe that: (i) the degree of substitution of rice for millet is similar in the low- and high-income groups; (ii) substitution of rice for sorghum is stronger in the low-income than the high-income group; (iii) rice is a substitute for maize only in the low and middle income groups, with the magnitude of substitution similar for both groups; (iv) substitution of maize for rice increases from the low- to the high-income group; (v) substitution of maize for sorghum drops from the low- to the high-income group; and (vi) the degree of substitution of sorghum for rice drops from the low- to the middle-income group.

Table 4. Compensated Cross-Price Elasticities of Cereal Demand –Urban Mali

	Low-Income			
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.277*	0.192	0.567*	0.460*
lnpmillet	0.129**	-0.089	0.145	-0.304
lnpmaize	0.098*	0.124***	-0.914*	0.300*
lnpsorghum	0.130*	-0.077	0.215**	-0.944*
	Middle-Income			
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.318*	0.674*	0.580*	0.437*
lnpmillet	0.146*	-0.860*	0.191*	0.356*
lnpmaize	0.096*	0.063*	-0.945*	0.000*
lnpsorghum	0.067*	0.128*	0.111*	-0.828*
	High-Income			
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.241*	0.305	1.299*	0.167
lnpmillet	0.128*	-0.439*	0.570***	0.089
lnpmaize	-0.097**	0.651*	-0.870*	-0.005
lnpsorghum	0.089*	-0.034	0.245	-0.557**

Source: Authors

Note: * means significant at a 1%; ** significance at 5%, and *** means significant at 10%.

Table 5 reports compensated cross-price elasticities of demand by income group in the rural sub-sample. With one exception, all compensated cross-price elasticities are statistically significant and positive. The sensitivity of rice demand to changes in the price of millet, maize and sorghum increases from the low- to the middle-income rural group but drops from the middle- to the high-income rural group. Also noticeable is the increase in the sensitivity of millet, maize and sorghum demand to changes in the price of rice as per capita income increases. This means that richer rural households are more likely to substitute coarse grains for rice when the price of rice increases. With agriculture being the mainstay of rural Malian households, one would expect that richer households would own larger farms than poorer households and be producing more food than poorer households. This suggest that richer households have more options than poorer households, such that an increase in the price of one type of cereals (for example rice) would cause these household to substitute coarse grains for rice in order to satisfy household food needs.

Table 5. Compensated Cross-Price Elasticities of Cereal Demand –Rural Mali

			Low-Income	
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.585*	0.215*	0.326*	0.369*
lnpmillet	0.291*	-0.513*	0.469*	0.298*
lnpmaize	0.058*	0.202*	-0.907*	0.103*
lnpsorghum	0.148*	0.176*	0.117*	-0.713*
			Middle-Income	
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.607*	0.347*	0.338*	0.369*
lnpmillet	0.335*	-0.622*	0.363*	0.367*
lnpmaize	0.119*	0.122*	-0.834*	0.064
lnpsorghum	0.167*	0.171*	0.048	-0.768*
			High-Income	
	Rice	**Millet**	**Maize**	**Sorghum**
lnprice	-0.516*	0.457*	0.451*	0.495*
lnpmillet	0.286*	-0.696*	0.308*	0.266*
lnpmaize	0.096*	0.104*	-0.897*	0.092*
lnpsorghum	0.141*	0.136*	0.136*	-0.853*

Source: Authors
Note: * means significant at a 1%; ** significance at 5%, and *** means significant at 10%.

Compensated cross-price elasticities by income group in the urban area reveal that rice is a stronger substitute for millet than it is for sorghum across all income groups, and the magnitude of the substitution of rice for sorghum declines from the low to the high income urban groups. The cross-price elasticities do not reflect a uniform pattern in the substitution of millet and sorghum for rice across place of residence. We find that the substitution of sorghum for rice is much stronger in the low and middle income urban groups compared to their rural counterparts; while the substitution of millet for rice is much stronger in the low and high income rural groups compared to the same income groups in the urban areas. For maize, however, the cross-elasticity with respect to the rice price is uniformly higher in urban areas. This finding can be attributed to the greater availability of processed maize products in the urban areas due to better milling facilities, so that urban consumers have a much broader scope for substitution compared to rural consumers. The substitution between rice and coarse grains across income groups in both the rural and the urban groups implies some scope for dealing with price spikes for one cereal by increasing the availability of substitutes—a possibility that the earlier findings of low cross-elasticities seemed to discount.

5.3 Welfare Effects of Cereals Price Changes

The proportional compensating variation (CV) is computed jointly for rice, millet, sorghum and maize using the demand elasticities just presented and price changes observed in each of the years 2008, 2009, 2010 and 2011 compared to the 2006 baseline.[6] Price changes were

[6] Price data at the administrative unit level for 2006 to 2011 were obtained from the OMA.

computed at the district level as the natural logarithm of the ratio of the price in year t+1 to the price in year t, i.e., $dlnP_i = \ln(p_{it+1}/P_{it})$. Table 6 summarizes the average price changes for all locations covered by ELIM-2006. Average price rose rapidly for all cereals over time but maize price changes were more dramatic compared to the other cereals.

Table 6. Average Consumer Price Changes Compared to 2006 (%)

Period	Rice	Millet	Maize	Sorghum	Average
2008	21	9	17	10	14
2009	21	21	28	21	23
2010	16	15	20	14	16
2011	23	19	30	23	24

Source: Authors' computation using price data from OMA-Mali

Table 7 presents the welfare measure as a share of total household cereals expenditure in 2006 by place of residence. The table reports both the first-order and the full effect[7] considering all four cereals (rice, millet, sorghum and maize) by place of residence and per capita income group. In terms of percentage of total cereals expenditures in 2006, the welfare measure of cereals price changes does not show much difference across per capita income groups within a given place of residence. However, in absolute terms the impacts differ widely.

Table 7. Compensating Variation of Cereals Price Changes by Place of Residence and Income Group (% of Total Cereals Expenditures in 2006)

	Urban		Rural	
	First-order	Full Effect	First-order	Full Effect
	Low-Income Group			
2008	18.1	17.8	15.2	15.0
2009	22.8	22.6	23.6	23.4
2010	16.3	16.2	16.8	16.7
2011	22.9	22.7	23.5	23.3
	Middle-Income Group			
2008	18.2	18.0	15.7	15.4
2009	22.0	21.9	23.0	22.7
2010	16.8	16.7	16.6	16.3
2011	23.1	22.8	24.0	23.6
	High-Income Group			
2008	17.8	17.5	16.5	16.2
2009	21.7	21.8	22.0	21.7
2010	17.0	17.0	16.0	15.6
2011	23.2	23.1	23.7	23.3

Source: Authors' computation

[7] As a reminder, the full effect includes substitution effects through cross-elasticities, but no income effects through production or other linkages discussed in section 1

The figures reported in Table 7 illustrate that the first-order approximation of the impact of the price changes that occurred in Mali over the period 2008-11, which implicitly assumes that households are unable to change their consumption patterns when prices change, captured almost all of the impact of the price changes on welfare. It has been argued that ignoring substitution effects in consumption in the computation of welfare measures may lead to significant biases and inappropriate inferences (Friedman and Levinsohn, 2002). However, as seen from the table above, there is not much difference between the first-order and the full impacts of cereals price changes considering the urban and rural sub-samples. This reflects the fact that during this period all cereals prices were rising sharply, limiting the scope for substitution to “cheaper” cereals. Across all the years, the first-order impact was larger than the full impact by less than 1%. Thus, consistent with a priori expectations, the first-order effect overstates, albeit marginally, the welfare losses for urban and rural households.

Although the figures displayed in Table 7 do not reveal huge differences between the urban and the rural sub-samples in the first and the full effects, the actual magnitude of the welfare losses from cereals price changes are substantial and differ by place of residence and income groups. Table 8 reports the actual magnitude of the welfare loss from cereals price changes. In 2008, for instance, considering the full welfare impact, on average low-income urban households had to be compensated by 17.8% of their cereal budget in 2006, equivalent to 51,000 CFAF=95 US $, while low-income rural households had to be compensated by 15.0% of their total cereals expenditures in 2006, equivalent to 33,293CFAF = 62 US $. This is equivalent to saying that the observed price changes in 2008 require a compensation of low-income urban households of about 3.7% and low-income rural households of about 4.1% of their 2006 total household consumption expenditures (proxy for income) to avoid a fall in their welfare.

The adverse effect of the higher prices on Malian population as shown in Table 8 supports the view that essentially every group experienced an income reduction as a result of the higher cereals prices. However, the percentage reduction in total household consumption expenditure declined from the low- to the high-income groups in both the urban and the rural sub-samples. This means that in both locations, the welfare loss from observed price changes in the period 2008 to 2011 (as a proportion of total household consumption expenditures) was greater for poorer households than richer households. Furthermore, the percentage reduction in total household expenditures (proxy for income) was higher for rural income groups than for urban ones.

Table 8. Magnitude of Welfare Loss Implied by Cereals Price Changes by Place of Residence and per Capita Income Group

	Urban			Rural		
Year	**CV (Full impact) in %**	**Value of compensation based on 2006 average cereals expenditure (CFAF)**	**Percent of average total household consumption expenditure in 2006**	**CV (Full impact) in %**	**Value of compensation based on 2006 average cereals expenditure (CFAF)**	**Percent of average total household consumption expenditure in 2006**
	Low-Income			**Low-Income**		
2008	17.8	51,000 (95)	3.7%	15.0	33,293 (62)	4.1%
2009	22.6	64,753 (120)	4.7%	23.4	51,937 (96)	6.5%
2010	16.2	46,416 (86)	3.4%	16.7	37,066 (69)	4.6%
2011	22.7	65,040 (121)	4.7%	23.3	51,715 (96)	6.4%
	Middle- Income			**Middle- Income**		
2008	18.0	66,280 (123)	2.5%	15.4	52,646 (98)	4.3%
2009	21.9	80,640 (150)	3.1%	22.7	77,602 (144)	6.3%
2010	16.7	61,493 (114)	2.3%	16.3	55,723 (103)	4.5%
2011	22.8	83,954 (156)	3.2%	23.6	80,678 (150)	6.5%
	High-Income			**High-Income**		
2008	17.5	53,583 (99)	1.0%	16.2	61,179 (114)	3.1%
2009	21.8	66,749 (124)	1.3%	21.7	81,949 (152)	4.2%
2010	17.0	52,052 (97)	1.0%	15.6	58,913 (109)	3.0%
2011	23.1	70,729 (125)	1.4%	23.3	87,992 (163)	4.5%

Source: Authors
Note: The figures in parenthesis are US dollar equivalents.

Separate analyses, not shown here due to space limitations but available in Me-Nsope (2013), document that that rice accounts for a substantial part of the overall welfare effect implied by higher cereals prices. Across all income groups, the full welfare effects of rice price changes are higher in the urban area than in the rural area across all years. This result is not surprising given that the share of rice in cereals budget is much larger in the urban location than in the rural location.

6. Conclusion and Policy Implications

We found high expenditure elasticities for cereals in both urban and rural areas of Mali. The high expenditure elasticities for these staples suggest strong future growth in demand (assuming continued income growth in the country) and hence pressure on prices if supply is not increased substantially. Therefore, there is a need to both expand production while driving down unit costs throughout the food system.

For the range of prices observed in 2006, the compensated cross-price elasticities point to a relationship of substitution among the different cereals in both the urban and rural-sub-samples. This reveals not only a scope for dealing with price spikes for one cereal by increasing the availability of substitutes—a possibility that the earlier findings of low cross-price elasticities seemed to discount — but also a scope for price transmission across cereals. Efforts geared towards expanding production and driving down the unit cost of production could encourage consumption of these grains, and private sector involvement in the processing of coarse grains to reduce preparation time would give consumers more opportunity for substitution and choice. Overall, there is need for a cereals policy rather than just, for example, a rice policy.

Our findings further suggest that demand patterns for cereals may be changing over time. For example, while past findings that coarse grains are generally less preferred in the urban areas for various reasons such as the high opportunity cost of the time required for their preparation, we found a high expenditure elasticity for sorghum in the urban sub-sample. One possible explanation is that greater availability of mechanical processing of this coarse grain in urban areas is making it a more preferred staple over time.

The welfare analysis of cereals price shocks in Mali over the period 2008-2011, taking into account the first order (direct) and the second-order (substitution) responses, revealed a very limited substitution effect for the reason that all cereals prices rose together. Estimates of the full impact revealed that all households were adversely affected by cereals price changes and the adverse effect of the higher cereals prices on Malian population ranged from a 1% to 7% income reduction, without considering the possibility of producer supply response. The analysis reveals that, as expected, in both the urban and rural population, low-income households are hardest hit by cereals price increases – i.e., the percentage increase in total household expenditure required to compensate for the higher prices is lowest for the high-income group and largest for the low-income group. The decreasing expenditure elasticity of sorghum and millet as per capita income increases, particularly in the urban area, and the willingness to substitute one cereal type for another implies that expanding the availability of these cereals could help reduce some of the welfare losses from cereals price shocks, especially those emanating from the world market for rice. The welfare losses from the recent price hikes imply a need to address supply (including marketing and processing) issues due to concerns about welfare and food security.

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APPENDIX

Table A-1. Tests for Nonlinearity of the Demand System Based on Statistical Significance of the Coefficient of the Price Times Expenditure-Squared Terms

Equation-by-equation tests (t-tests)		
Commodity	t stat	p-value
Rice	13.86	0.0000
Millet	7.66	0.0000
Maize	18.33	0.0000
Sorghum	3.94	0.0000
Equation System tests (across all budget shares): SUR (χ^2) tests		
Unrestricted	142.52	0.0000
Restricted	189.36	0.0000

Source: Authors' computation using ELIM-2006.