

# Food consumption in urban Mozambique: A Censored demand system approach

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Comments very welcome and highly appreciated.

## Abstract:

We use a new nationwide household survey for Mozambique (IAF 2002/03) to estimate a large censored food demand system for the sample of urban households. Estimating the Almost Ideal demand system, the censored nature of the data set is taken into account by using a recently suggested quasi maximum likelihood estimator. Augmenting the system with demographic variables in a theoretical consistent way, focus is, in particular, on differences in elasticities with respect to geographic location. We find a large fraction of parameters estimated with high precision (small standard errors), implying significant elasticity estimates for a large number of goods. Elasticities differ markedly between regions, and we propose a new method of decomposing elasticities to identify the sources of regional differences. We stress that our approach is likely to be useful, and can yield insights into consumption patterns in a number of developing countries with varied geography – or between demographic groups in general. To facilitate such studies we have implemented the method used here as an ‘off the shelf’ Stata routine.

*Keywords* – censored demand system, Mozambique, quasi maximum likelihood, elasticities.

*JEL classification*: .....

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## ***Introduction***

Detailed knowledge of household's preference structure is a powerful tool for improving policy advice and evaluating the effects of existing policies. Important policy areas where such knowledge can greatly improve policy advice span a range from tax reform to public goods provision. In poor developing countries, such as Mozambique with per capita income of 1,300 dollars (PPP) in 2005, where the bulk of expenditures are directed towards food consumption, studying food demand is of particular importance both as a goal in itself to allow policy makers to study the effect of policies directly effecting food demand (i.e. price subsidies) and as an essential building block in economy wide models, such as general equilibrium models.

Not surprisingly, given the importance of price and income response parameters, identifying and estimating these has a long tradition in applied economics. Because price variation is inherently necessary for any successful attempt at identifying consumers' responses to price changes, estimation of price and income elasticities in developed countries have usually relied on aggregate time series data for the price variation, since prices normally vary little within developed countries at any given point in time. However, in developing countries where markets are less integrated and transportation is often burdensome in terms of both costs and time consumed, prices can be expected to vary considerably between locations. If national representative (or regional representative but dispersed) cross sectional household survey data is available the price differences between distant locations can be exploited to obtain estimates of price response parameters. This was first exploited by Deaton (Deaton 1987), however, with a different emphasis than the one we pursue here. An additional benefit from using household survey data is the availability of demographic variables at the household level which enable us to control (to some extent) for household heterogeneity in the parameters. In addition household surveys usually have a sample size which permits estimation of a large number of parameters.

Using survey data at the household level has challenges as well as benefits. A recurring problem when estimating demand systems using micro data is the likely wide presence of households reporting zero consumption of one or more of the commodities analyzed. As will be evident, the problem of censoring is severe in the sample of urban Mozambican households we consider here, and ignoring it would bias our estimates. Thus, in order to account for censoring we implement a recently suggested quasi maximum likelihood (QML) estimator following Yen, Lin and Smallwood (2003).

Although national representative household budget surveys are becoming increasingly more common for countries in Sub-Saharan Africa, only few studies exist where the focus is on estimating price and income elasticities (see Kedir 2005 for an exception). By making the estimation technique employed here available as an ‘off the shelf’ Stata routine we hope to make a contribution towards changing this.

In addition to this, the contributions of the present paper are threefold. First, we use a new national representative household survey conducted in Mozambique in 2002/03 (IAF02) to estimate a large complete demand system for food products augmented with demographic variables using the urban household sample. Estimated elasticities with associated standard errors are presented. Second, utilizing the location dummy variables in the system augmented with demographic variables we focus on differences in elasticities between regions. Given the geography of Mozambique, location is likely to an important determinant of demand patterns and elasticities. This constitutes a valuable input into regional applied general equilibrium models which are becoming increasingly widespread. Finally, we propose a method of decomposing elasticity differences into what we term a ‘level effect’, a ‘behavioral effect’ and a residual term. The decomposition is useful to assess the source of elasticity differences. Here we apply it to geographical differences, but the method can be used to compare elasticities between any demographic groups.

The remainder of the paper is structured as follows: in section two we outline the methodology used followed by a description of the data in section three. Section four presents the results. Finally, section five concludes.

## Methodology

The theoretical point of departure is the  $n$ -good Almost Ideal (AI) demand system proposed by Deaton and Muellbauer (1980). The share equations have the form

$$w_i = \alpha_i + \sum_{j=1}^n \gamma_{ij} \log p_j + \beta_i (\log x - \log a(p)), \quad i = 1, \dots, n \quad (1)$$

where  $x$ ,  $p_j$  is total expenditure and the price of good  $j$ , respectively. The unknown parameters are  $\alpha_i, \gamma_{ij}$  and  $\beta_i, i, j = 1, \dots, n$ . The price index  $\log a(p)$  is specified as

$$\log a(p) = \alpha_0 + \sum_{j=1}^n \alpha_j \log p_j + 1/2 \sum_{i=1}^n \sum_{j=1}^n \gamma_{ij} \log p_i \log p_j$$

The restrictions from demand theory, homogeneity, symmetry and adding-up, can be imposed by simple parametric restrictions. Homogeneity implies  $\sum_{j=1}^n \gamma_{ij} = 0$  and adding

up (shares summing to one) is ensured by letting  $\sum_{i=1}^n \alpha_i = 1, \sum_{i=1}^n \gamma_{ij} = 0$  and  $\sum_{i=1}^n \beta_i = 0$ .

Slutsky symmetry is equivalent to the restriction  $\gamma_{ij} = \gamma_{ji}$ , for all  $i, j = 1, \dots, n$ . Note that the parameter  $\alpha_0$  is not identified when estimating (1). We follow Moschini (1998) and set  $\alpha_0$  equal to zero. This implies  $\log a(p)$  is zero when all logarithmic prices are zero.<sup>1</sup>

Each set of unknown parameters can be augmented with demographic variables. For the level parameter,  $\alpha_i$ , demographic variables can be incorporated by a re-parameterization

of  $\alpha_i$  such that  $\alpha_i = \alpha_{0i} + \sum_{k=1}^{K^\alpha} \alpha_{ki} d_k^\alpha$  for  $K^\alpha$  demographic variables denoted  $d_k^\alpha$ . The

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<sup>1</sup> Because the elements in the Slutsky matrix depend on both prices and income no parametric restriction can ensure semi-definiteness of the Slutsky matrix for all observations (global integrability). Moschini (1998) devise a method that guarantees that the Slutsky matrix is negative semi-definite for a normalized point in the sample. However, since our scope is different, we do not pursue this method here.

superscript  $\alpha$  indicates that the number and nature of demographic variables augmenting  $\alpha_i$  need not be the same as those augmenting either  $\gamma_{ij}$  or  $\beta_i$ . Both  $\gamma_{ij}$  and  $\beta_i$  can be augmented in a similar fashion such that  $\beta_i = \beta_{0i} + \sum_{k=1}^{K^\beta} \beta_{ki} d_k^\beta$  and  $\gamma_{ij} = \gamma_{0ij} + \sum_{k=1}^{K^\gamma} \gamma_{kij} d_k^\gamma$ . To maintain the adding up condition let  $\sum_{i=1}^n \alpha_{0i} = 1, \sum_{i=1}^n \alpha_{ki} = 0, k = 1, \dots, K^\alpha$ ,  $\sum_{i=1}^n \beta_{0i} = 0, \sum_{i=1}^n \beta_{ki} = 0, k = 1, \dots, K^\beta$  and  $\sum_{i=1}^n \gamma_{0ij} = 0, \sum_{i=1}^n \gamma_{kij} = 0, k = 1, \dots, K^\gamma$ . Symmetry requires  $\gamma_{kij} = \gamma_{kji}, k = 0, \dots, K^\gamma$ . Finally, homogeneity is satisfied with the restrictions  $\sum_{j=1}^n \gamma_{0ij} = 0$  and  $\sum_{j=1}^n \gamma_{kij} = 0, k = 1, \dots, K^\gamma$ .

Denote by  $\Lambda$  the set of all parameters, thus,

$$\Lambda = \left\{ \alpha_{ki}, \beta_{li}, \gamma_{mij}; k \in \{1, \dots, K^\alpha\}, l \in \{1, \dots, K^\beta\}, m \in \{1, \dots, K^\gamma\}; i, j \in \{1, \dots, n\} \right\},$$

then the system of latent share equations can be written as

$$\bar{w}_i = w_i(p, x; \Lambda) + \varepsilon_i, \quad i = 1, \dots, n \quad (3)$$

where  $\varepsilon_i$  is an error term.

## Accounting for censoring

Without restrictions on the error terms the system of latent share equations can not be a valid representation of observed behavior since nothing constrains the shares to be non-negative. In particular, if a substantial number of household have zero consumption of some goods, the distribution of the error terms should allow for a positive probability of observing zero consumption. A number of methods have been proposed to deal with the issue of censoring. Wales and Woodland (1983) suggest a Kuhn-Tucker approach, whereby a utility function is maximized subject to non-negativity constraints on quantities. Lee and Pitt (1986) starts from a random indirect utility function and use a dual approach related to the literature on rationing based on reservation prices, where demand for all goods depends on market prices for positively consumed goods and

reservation prices for non consumed goods. Because the rationed quantity is zero it is (in some cases) possible to solve for reservation prices explicitly. While theoretically appealing these approaches suffer from the drawbacks that in the case of many non-consumed goods for some household, evaluation of multiple integrals are necessary. Further, as illustrated by Van Soest and Kooreman (1990), the issue of coherency of the solution also has to be addressed since the set of reservation (and market) prices that supports the observed behavior may not be unique. Also, for some flexible forms neither the Wales and Woodland nor the Lee and Pitt approaches are feasible.<sup>2</sup>

An alternative solution, known as the Amemiya-Tobin approach in the literature, is inspired by Amemiya's (1974) multivariate regression with truncated normal distributions. Here the consumer is implicitly seen as maximizing a deterministic utility function and deviation from the corresponding deterministic shares are interpreted as random errors in the optimization process, measurement errors in the shares or random disturbances which influence the consumption decision (Wales and Woodland 1983). However, like the Kuhn-Tucker approach the implementation of Amemiya-Tobin type estimators are complicated by the need for evaluating multiple integrals in cases where censoring is severe. To circumvent the computational difficulties involved in the procedures described above, Shonkwiler and Yen (1999) suggested a two-step estimation procedure, where in the first step a probit regression is run for each equation to determine the pattern of censoring.<sup>3</sup> Using the estimated parameters in the second step, each latent share equation is augmented so as to take into account the censored nature of the data. The augmented system can then be estimated consistently with the (transformed) errors being normally distributed. The two-step nature of the estimator makes inference complicated by the need to adjust the covariance matrix as devised by Murphy and Topel (1985). The technique has been widely used in empirical applications (e.g. Yen, Kan and Su 2002).<sup>4</sup>

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<sup>2</sup> This is the case for the Almost Ideal demand system.

<sup>3</sup> Alternatively, a multivariate probit can be run to facilitate cross equation correlation between the errors in the censoring mechanism, however, multivariate probit estimation requires evaluation of multiple integrals (or simulations hereof).

<sup>4</sup> The three approaches considered here have received much attention, however, other methods have recently been suggested in the literature, see Golan, Perloff and Shen (2001) and Perali and Chavas (2000).

A number of papers have recently employed variations of the Amemiya-Tobin approach (see Yen, Lin and Smallwood 2003, Dong, Gould and Kaiser 2004, Yen and Lin 2002), and here we follow the quasi maximum likelihood estimation of an Amemiya-Tobin system used by Yen, Lin and Smallwood.

## Quasi maximum likelihood estimation

Write the observed shares,  $w_i^*$ , as

$$w_i^* = \max(w_i(p, x; \Lambda) + \varepsilon_i, 0), \quad i = 1, \dots, n$$

Even if the adding up condition is imposed on the deterministic shares, it may not hold for the observed shares in the model. To overcome this Pudney (1989) suggests treating the  $n$ 'th good as a residual good and then obtain the elasticities from the identity<sup>5</sup>

$$w_n^* = 1 - \sum_{i=1}^{n-1} w_i^*$$

To construct the likelihood function for the  $n-1$  estimated share equations, let the first  $k$  goods be the ones which are consumed in positive quantities by household  $h$ , and partition the  $(n-1) \times 1$  error vector into

$$[e_1 | e_2] \equiv [\varepsilon_1, \varepsilon_2, \dots, \varepsilon_k | \varepsilon_{k+1}, \varepsilon_{k+2}, \dots, \varepsilon_{n-1}]$$

and assume they are normally distributed with covariance matrix

$$\Sigma = \begin{bmatrix} \Sigma_{11} & \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}$$

where  $\Sigma_{11}$  is a  $k \times k$  matrix,  $\Sigma_{21}$  is a  $(n-1-k) \times k$  matrix and  $\Sigma_{22}$  is a  $(n-1-k) \times (n-1-k)$  matrix.

The joint pdf of the errors can be written in terms of the joint marginal pdf for the first  $k$  errors and the pdf of the last  $n-1-k$  errors conditional on the first  $k$  errors, i.e.,

$$f(e_1, e_2) = g(e_1) \cdot h(e_2 | e_1).$$

where  $g(e_1)$  is the joint marginal pdf for the first  $k$  errors, distributed  $k$ -dimensional normal with zero mean and covariance matrix  $\Sigma_{11}$ . The joint pdf of  $e_2$  conditional on  $e_1$ ,

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<sup>5</sup> This has the consequence that the estimated parameters are not invariant to which good is excluded.

$h(e_2 | e_1)$ , can be shown to be  $(n-1-k)$ -dimensional normal with mean and covariance matrix given by (Kotz et al. 2000)

$$\begin{aligned}\mu_{2,1} &= \Sigma_{21}\Sigma_{11}^{-1}e_1 \\ \Sigma_{22,1} &= \Sigma_{22} - \Sigma_{21}\Sigma_{11}^{-1}\Sigma_{21}'\end{aligned}$$

The likelihood contribution of household  $h$ , being in consumption regime,  $c$ , i.e. where the first  $k$  goods are consumed, can be stated as

$$L_c = g(e_1) \int_{-\infty}^{-w_{n-1}(\Lambda)} \dots \int_{-\infty}^{-w_{k+2}(\Lambda) - w_{k+1}(\Lambda)} h(u_{k+1}, u_{k+2}, \dots, u_{n-1} | e_1) du_{k+1} du_{k+2} \dots du_{n-1}$$

Using the expressions for the mean and covariance matrix given above, it is possible to evaluate the multiple integral as a standard  $(n-k-1)$ -dimensional normal pdf. Define the indicator function  $I_c$  as being one if household  $h$  is in consumption regime  $c$  and zero otherwise. We can now write the likelihood function for the sample of  $N$  household as

$$L = \prod_{h=1}^N \prod_c L_c(w_h(\Lambda))^{I_h(c)} \quad (4)$$

Where  $w_h(\Lambda)$  denotes the  $(n-1) \times 1$  vector of deterministic shares for household  $h$ .

While methods exist to simulate the likelihood function derived above (see Yen, Lin & Smallwood (2003) for a simulated maximum likelihood approach), they are computational intensive when the number of non-consumed goods are large for a sizable part of the sample, as is the case for our sample. Instead we adopt their quasi maximum likelihood (QML) procedure where the true likelihood function is approximated by linking bivariate Tobit models across the equations. More explicit, the likelihood function given by (4) is approximated by multiplying all possible pair-wise combinations of bivariate Tobit likelihood functions. Define for household  $h$  and equation  $i$  and  $j$  the normalized errors;  $u_{ih} = (w_{ih}^* - w_i(\Lambda)) / \sigma_i$  and  $u_{jh} = (w_{jh}^* - w_j(\Lambda)) / \sigma_j$  where  $\sigma_i$  is the standard deviation of the  $i$ 'th error term. The contribution of household  $h$  to the bivariate Tobit likelihood is then given by

$$L_{ijh} = \left[ \Psi(u_{ih}, u_{jh}, \rho_{ij}) \right]^{1(w_{ih}^* = 0, w_{jh}^* = 0)} \cdot \left[ \sigma_j^{-1} \sigma_i^{-1} \psi(u_{ih}, u_{jh}, \rho_{ij}) \right]^{1(w_{ih}^* > 0, w_{jh}^* > 0)} \cdot \\ \left[ \sigma_j^{-1} \phi(u_{jh}) \Phi((u_{ih} - \rho_{ij} u_{jh}) / (1 - \rho_{ij}^2)^{1/2}) \right]^{1(w_{ih}^* = 0, w_{jh}^* > 0)} \cdot \\ \left[ \sigma_i^{-1} \phi(u_{ih}) \Phi((u_{jh} - \rho_{ij} u_{ih}) / (1 - \rho_{ij}^2)^{1/2}) \right]^{1(w_{ih}^* > 0, w_{jh}^* = 0)}$$

1(.) is an indicator function taking the value one if it evaluates to true,  $\phi, \Phi$ , are the standard normal probability density function and standard normal cumulative probability function, respectively. Similar, the bivariate standard normal density function and cumulative function are denoted  $\psi, \Psi$ , respectively. The quasi likelihood function for the  $N$  households over all pair wise bivariate Tobits is given by

$$L = \prod_{h=1}^N \prod_{i=1}^{n-2} \prod_{j=i+1}^{n-1} L_{ijh} \quad (5)$$

Cross equation parametric restrictions on the demand system are easily accommodated via the linking of the pair wise Tobit likelihoods. Estimation proceeds by maximizing (5). The parameters obtained are consistent but will be less efficient than full information maximum likelihood estimation.<sup>6</sup>

## Elasticities and decomposition of demographic effects

As pointed out by Lazaridis (2004), in a system of censored demand equations, price and expenditure elasticities should take into account not only the direct effect on the latent share but also the indirect effect from a possible change in the nature of censoring. The unconditional mean of observed shares are given by (Wooldridge 2002)

$$E(w_i^*) = \Phi[w_i(\Lambda) / \sigma_i] w_i(\Lambda) + \sigma_i \phi[w_i(\Lambda) / \sigma_i]$$

Income and uncompensated price elasticities for the system of equations can be written as

$$\eta_i = \hat{\Phi}_i \frac{\hat{\beta}_i}{E w_i^*} + 1 \text{ and } \varepsilon_{ij} = \hat{\Phi}_i \frac{1}{E w_i^*} \left[ \hat{\gamma}_{ij} - \hat{\beta}_i \left( \hat{\alpha}_j + \sum_{k=1}^n \hat{\gamma}_{ik} \log p_k \right) \right] - \delta_{ij}$$

<sup>6</sup> The performance of the QML estimator relative to a simulated maximum likelihood estimator has – as far as we are aware - not been investigated systematically, however, in a three equation application Yen and Lin (2002) state that for their application the “...QML estimator performs as well as the FIML estimator ...” (p. 100)

where a hat denotes estimated parameters and  $\hat{\Phi}_i = \Phi[w_i(\hat{\Lambda})/\hat{\sigma}_i]$ . Compensated price elasticities,  $\varepsilon_{ij}^C$ , are calculated using the Slutsky equation  $\varepsilon_{ij}^C = \varepsilon_{ij} + \eta_i Ew_i^*$ , for all  $i, j = 1, \dots, n$ .

We now propose a method to decompose the difference in income and price elasticities between two demographic groups into three terms: level effect, behavioral effect and a residual.<sup>7</sup> First, let the logarithm of prices and incomes and the vector of demographic variables be scaled such that they are all zero for a reference household (or mean values zero for a group of reference households). Denote by superscript  $r$  an estimated parameter or a term evaluated at estimated parameters for the reference household. With superscript  $a$  we indicate an estimated parameter belonging to the comparison group of households. Finally, superscript  $ap(r)$ , will be applied to a term evaluated at the demographic vector for the alternative household but at prices for the reference household. The difference in the income elasticity for good  $i$  between the reference household and another demographic group can be expressed as

$$d\eta_i = \eta_i^r - \eta_i^a = \beta_i^r \left( \frac{\Phi_i^r}{Ew_i^{*,r}} - \frac{\Phi_i^{ar(p)}}{Ew_i^{*,ar(p)}} \right) + \frac{\Phi_i^{ar(p)}}{Ew_i^{*,ar(p)}} (\beta_i^r - \beta_i^a) + residual_i \quad (6)$$

The first term is the level effect. We evaluate both terms within the parenthesis at the zero logarithmic prices and income vector, thus, differences in income elasticities are due only to differences in the level parameter ( $\alpha_i$  in equation (1)).<sup>8</sup> The second term is the behavioral effect; if the real income response parameter, beta, does not differ across demographic groups the behavioral effect is zero. In the case where the price and income vectors do not differ between groups (i.e. the logarithm of prices and income is zero for the comparison demographic group) the first two terms capture the total difference in the elasticities; hence the residual will be zero. In general, the price vectors will differ between demographic groups and the residual term will capture interactions between prices, income, level and behavioral effects. The level and behavioral effects can be

<sup>7</sup> This is similar in spirit to Moro and Sckokai (2000), although the method employed here is different.

<sup>8</sup> Note that the assumption of  $\alpha_0 = 0$  is not innocent here. It allows us to disregard the parameter beta in the level effect.

thought of as ‘pure’ effects, in the sense that they would persist even if relative price were to change so that they would be equal in the reference and comparison demographic group.

Differences in price elasticities can be decomposed in a similar way. In particular we can write the difference in own price elasticities for good  $i$  as<sup>9</sup>

$$d\varepsilon_{ii} = \left[ \left( \gamma_{ii}^r - \beta_i^a \alpha_i^a \right) \left( \frac{\Phi_i^r}{Ew_{i,*}^r} - \frac{\Phi_i^{ar(p)}}{Ew_{i,*}^{ar(p)}} \right) + \frac{\Phi_i^r}{Ew_{i,*}^r} \beta_i^r (\alpha_i^a - \alpha_i^r) \right] + \left( \frac{\Phi_i^{ar(p)}}{Ew_{i,*}^{ar(p)}} (\gamma_{ii}^r - \gamma_{ii}^a) + \frac{\Phi_i^r}{Ew_{i,*}^r} \alpha_i^a (\beta_i^a - \beta_i^r) \right) + residual_i \quad (7)$$

The square bracket on the first line is equivalent to the level effect term in (6). In absence of differences in the level parameters this term will evaluate to zero. The behavioral effect is the term in brackets on the second line. This can further be decomposed into an effect from differences in price response parameters,  $\gamma_{ij}$ ’s, and an effect from differences in the real expenditure parameter,  $\beta_i$ ’s. Again, these are pure effects which will add up to the total difference in own price elasticities if no price differences are present. In practice, especially when looking at regional differences, prices will differ and the residual will capture the effects from interactions between prices, level and behavioral effects. Confidence interval around the estimated effects can be obtained by the delta method.

Our main interest here is to see if regional differences are due entirely to differences in prices experienced by households or if regional taste differences are present as well. Thus, we will focus on the size of the combined level and behavioral effect.

### ***Data and descriptive statistics***

We use the 2002/03 national representative household survey of Mozambican household (IAF). It contains detailed information on food consumption for a random sample of 8700 households in Mozambique, as well as information on general characteristics of the household, daily expenses and home consumption, possession of durable goods, gifts and

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<sup>9</sup> A similar decomposition can be made for cross price effects. We choose to focus on income and own price effects.

transfers received. All aspects of survey implementation and a set of summary statistics are available from the National Institute of Statistics (INE 2004). The interviewers were in the enumeration area for a week, in which three household visits were programmed in order to administer questionnaires and assist household in keeping track of daily consumption etc. Thus, to the extent it is possible food consumption should be very well covered within the survey period.

The IAF was designed with an explicit view to be representative in time as well as space. Data collection was done over the space of one year divided into quarters. For each subgroup of the population that the survey was designed to represent, one quarter of households were interviewed in each period.

The geography of Mozambique and the fact that we have ‘around the year’ price information mean that we should have sufficient price variation to be able to identify price elasticities with some precision; an exercise which is often difficult when only cross section data is available.

Our food demand system includes all expenditures on food products; vegetables, maize flour, fish, bread, rice, meat, oil & fats and the residual group other foods. Maize, bread and rice together with a broad group of vegetables are the main staples of Mozambican households in urban areas. As an artifact of the geography of Mozambique fish is also widely consumed. Meat is composed of beef, pork and chicken meat. A big component of oil and fats is cooking oil, however, a limited number of households also consume butter.

To avoid the problems inherent in evaluating the value of home produced goods we limit ourselves to the urban part of the sample. The sample consist of 4,005 urban households, however, we removed households where the unit price and expenditure information looked dubious and very large households. Also, for estimation purposes we removed household which had purchased only one good (no household had zero consumption for all goods). Specifically, we deleted households with more than 10 members, households with log income and log unit prices more than 4 standard deviations from the mean

sample value. For households not consuming a specific good we used as unit price the average over consuming households in the enumeration area. Unit prices for bundles of goods are obtained by weighting individual good prices with the expenditure share. Our final sample includes 3,041 households.

[Table 1 around here]

Table 1 illustrates the need for a censored approach to estimating demand for urban Mozambican households. While a few goods (vegetables, fish and the residual other food) is consumed by more than 90 percent of the household, the other five goods have a substantial number of households with zero-purchases. Looking at the second half of table 1 reveals that only around 9 percent of the households consume all 8 goods; again highlighting the relevance of taking zero consumption explicitly into account.

In estimating the system we augment the level parameter ( $\alpha_i$ 's) with five demographic variables; two dummy variables for location in the south and north respectively (the central part is reference), a dummy for location at the sea (at sea is base), household size normalized by the mode of the distribution (reference household has five members) and a dummy for possession of a fridge or freezer (no fridge/freezer is base). To keep the number of estimated parameters manageable the real expenditure coefficient ( $\beta_i$ 's) and the price response coefficient, ( $\gamma_{ij}$ 's), are augmented with location dummies (north and south) only. Table 2 present summary statistics for the demographic variables.

[Table 2 around here]

The sample is roughly equally divided between the three geographical areas and between households located at the shore. Around one in seven households have a fridge, a freezer or both. Thus, the reference household (i.e. when all demographic variables are zero) consists of five persons, is at the sea in the central part of the country, and is without a fridge and freezer. Income and all prices are normalised such that the average over the

reference households is one (i.e. the logarithm of income, prices and prices over income are zero).

All estimations are carried out using household weights provided by the Statistical Office in Mozambique (INE). Standard errors are robust to clustering at the enumeration area, and stratification of the sample.<sup>10</sup> In total, 175 parameters were estimated.<sup>11</sup>

## **Results**

As a first check on how well the model performs, we compare the estimated expected expenditure share with weighted sample means of each good for the reference households and for similar households in the North and South locations. Table 3 shows estimated mean shares together with sample means and their associated 95 percent confidence interval.

[Table 3 about here]

For the reference households in Central Mozambique all estimated shares are close to sample means and all are within the 95 percentage confidence interval. The same holds for the northern equivalent except for vegetables where the estimated mean is just outside the confidence interval. However, since the northern sample of households equivalent to the reference household is small (8 households) the confidence intervals are fairly wide. In the south, maize flour and rice are somewhat overestimated compared to their sample means, whereas oil and fats is underestimated. The estimated mean for the other food groups are close to their sample counterparts.

Before turning to the estimated price and expenditure elasticities, table 4 gives a summary of estimated parameters and the degree to which they are significantly estimated.

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<sup>10</sup> All estimations were done in the software package Stata 8.2 using the command `qmldemand.ado` obtainable from the author.

<sup>11</sup> A full list of estimated coefficients can be obtained from the author.

[Table 4 about here]

In total 79 of the 175 estimated coefficients (45 percent) are significantly different from zero at the 5 percent level. A further seven coefficients pass the significance test at 10 percent. None of the demographic variables seem to be superfluous. Almost 25 percent of the price response coefficients ( $\gamma_{ij}$ 's) are significant, confirming the advantage of the price variation resulting from 'around the year' collection of data. All but six (71 percent) of the estimated error correlation terms are significant, confirming the merits of estimating food demand as a system – apart from the need to impose cross equation restrictions.

The precision with which the coefficients are estimated is expected to carry over to the standard errors around the estimated elasticities. Table 5 confirms this.

[Table 5 about here]

Of the 49 estimated price elasticities 22 are significant at the 5 percent level.<sup>12</sup> All seven expenditure elasticities are significantly different from zero, however, more interestingly; five of these are different from one.

Looking at the uncompensated price elasticities, bread, oil and fats and meat are price elastic – although none are significantly different from minus one – while fish. Vegetables, maize flour, fish and rice are price inelastic and vegetables, maize flour and rice all significantly so. The cross price elasticities are generally smaller than own price elasticities in absolute value, however, for some goods there are sizeable cross price effects. This is especially valid for vegetables, bread, rice and meat, which all have relative large and significant cross price effects. A majority of food groups are gross complements as is often found in food demand studies (see Yen, Lin & Smallwood 2003, Dong, Gould & Kaiser 2004) and the absolute size also conforms well with these studies.

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<sup>12</sup> Since we focus exclusively on food consumption all elasticities are conditional elasticities and, thus, expenditure elasticities are measured with respect to total food expenditures.

Gross substitutes are found between vegetables and bread, rice and fish (for rice the cross price elasticity is not significant), reflecting the nature of these goods as important ingredients in urban Mozambican food consumption, however, this is not so for maize flour as might be expected. Interestingly, bread and fish are also (insignificantly) gross substitutes. Also note that an increase in the price of maize flour affects all estimated food groups significant negatively except for fish and oil and fats. The same goes for vegetables with the exception of rice and meat.

The food expenditure elasticities reveal three food groups, namely vegetable, fish and oil and fat, to be necessities, although the standard error on the expenditure elasticity of oil and fats is large. The remaining four estimated food groups, maize flour, bread, rice and meat are luxury food items. As noted earlier three of these pass significance tests at five percent. These findings conform reasonably well to prior expectations. The fact that maize flour and rice come out as luxuries reflect the small incomes which, despite the good economic performance of the Mozambique economy recently, many urban families still have to get by on (MPD 2004).

[Table 6 about here]

Turning to the compensated price elasticities, these are displayed in table 6. In terms of significance 19 of the 49 coefficients are significant at 5 percent and further two at 10 percent. The compensated own price effects are all negative and smaller (in absolute value) than their uncompensated counterpart as would be expected from demand theory. While most food products are gross complements table 6 shows that if households are compensated for price changes most products become net substitutes as should be expected.

### **Demographic decomposition of differences in elasticities**

We apply the method laid out in the methodology section to decompose the differences in income and own price elasticities between the central part of Mozambique and the

Southern and Northern parts. Table 7 shows the comparison between central and northern Mozambique.<sup>13</sup>

[Table 7 about here]

The first thing to note is that the differences are substantial in magnitude for some food groups. For example, the income elasticity of vegetables is around one third larger in the north compared to the centre. Oil and fats which is a necessity (although insignificant) in the centre is a luxury good in the north. For fish and rice the differences are smaller at around one standard error of the estimates for the centre. The decomposition of the income elasticity into level and behavioral effects and a residual, which is due to regional price difference, shows that the larger share of the differences cannot be accounted for by price differences. The level effect is negligible except for meat whereas the behavioral effect is large (relative to the size of the income elasticity) for most food groups, fish and rice being exceptions. Despite the large behavioral effects, only for maize flour is the combined effect (level effect plus behavioral effect) significantly different from zero at five percent. The difference in income elasticities for vegetables accounted for by the combined effect is significant at 10 percent.

Comparing own price elasticities between centre and north also reveals large differences relative to the point estimates for central Mozambique. This is especially so for maize flour and rice. The own price elasticity of maize flour is double in size in the north compared to the central part of the country. Fish and rice are price inelastic in the centre, but price elastic in the north. The opposite holds for meat. Looking at the decomposition we find the level effects to be small and the behavioral effects large – except for meat where the level effect is half the size of the behavioral effect – relative to both estimated own price elasticities and the residual effects. Clearly significant (5 percent) combined effects are found for maize flour, fish and rice, and at 10 percent for meat.

[Table 8 about here]

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<sup>13</sup> A complete set of elasticities for northern and southern Mozambique is available from the author upon request.

Table 8 shows the comparison between the reference household in the centre and a similar household located in the south. For the income elasticity we find again large combined effects for all goods except vegetables although these are generally smaller than between central and northern Mozambique. For vegetables and maize flour there are sizable level effects, but the behavioral effects have the opposite sign, such that the combined effect is smaller than the behavioral effect alone. The combined effects are significant for meat and oil and fats, and also – at 10 percent – for fish. Differences in own price elasticities are large for maize flour, rice and oil and fats. For maize flour both the level effect and the behavioral effect are large, but they work in opposite directions. Residual of any magnitude is only found for oil and fats. Maize flour is the only food group for which the combined effect is significantly different from zero.

The lack of significance of sizeable combined effect in some case – notably for bread, meat and oil and fats in the expenditure elasticity in table 7, and maize flour and oil and fats in table 8 for respectively the expenditure and own price elasticity – suggests that the decomposition methodology demands a lot of the price variation in the data. Nevertheless, we believe it is useful for assessing which sources account for differences in elasticities between demographic groups – and their magnitude relative to the total difference.

## ***Conclusion***

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## Tables

**Table 1. Food consumption for Urban Mozambican households.**

| Food group  | Households consuming (%) | Mean expenditure share (%) |
|-------------|--------------------------|----------------------------|
| Vegetables  | 99.7                     | 27.4                       |
| Maize flour | 53.5                     | 13.4                       |
| Fish        | 90.7                     | 15.7                       |
| Bread       | 66.4                     | 7.5                        |
| Rice        | 51.1                     | 8.3                        |
| Meat        | 34.7                     | 6.8                        |
| Oil & fats  | 60.5                     | 3.9                        |
| Other food  | 95.6                     | 17.0                       |

  

| Number of goods consumed | Number of household consuming | Share of household consuming (%) |
|--------------------------|-------------------------------|----------------------------------|
| 2                        | 46                            | 1.5                              |
| 3                        | 175                           | 5.8                              |
| 4                        | 461                           | 15.2                             |
| 5                        | 744                           | 24.5                             |
| 6                        | 781                           | 25.7                             |
| 7                        | 569                           | 18.7                             |
| 8                        | 265                           | 8.7                              |

**Table 2. Sample means of demographic variables.**

| Variable       | Description                                                      | Mean  | Min | Max |
|----------------|------------------------------------------------------------------|-------|-----|-----|
| Household size | Household size normalized at the mode of the sample distribution | -0.05 | -4  | 5   |
| Sea            | Town/city located at the sea (=0)                                | 0.48  | 0   | 1   |
| South          | Household located in south (omitted category)                    | 0.33  | 0   | 1   |
| Center         | Household located in center (=1)                                 | 0.29  | 0   | 1   |
| North          | Household located in North (=1)                                  | 0.38  | 0   | 1   |
| Fridge/Freezer | Household has a freezer or fridge (=1)                           | 0.16  | 0   | 1   |

**Table 3. Observed vs. estimated shares for reference households.**

| Variable                  | Reference household (central) |                    |                          |       | North               |                   |                          |       | South               |                    |                          |       |
|---------------------------|-------------------------------|--------------------|--------------------------|-------|---------------------|-------------------|--------------------------|-------|---------------------|--------------------|--------------------------|-------|
|                           | Estimated mean                | Sample mean (N=41) | 95 % confidence interval |       | Estimated mean      | Sample mean (N=8) | 95 % confidence interval |       | Estimated mean      | Sample mean (N=85) | 95 % confidence interval |       |
| Vegetables                | 0.213                         | 0.197              | 0.159                    | 0.234 | 0.408 <sup>b)</sup> | 0.273             | 0.148                    | 0.399 | 0.250               | 0.268              | 0.242                    | 0.295 |
| Maize flour               | 0.150                         | 0.124              | 0.075                    | 0.173 | 0.134               | 0.154             | 0.072                    | 0.235 | 0.066 <sup>b)</sup> | 0.022              | 0.011                    | 0.034 |
| Fish                      | 0.150                         | 0.144              | 0.120                    | 0.167 | 0.224               | 0.236             | 0.084                    | 0.387 | 0.095               | 0.114              | 0.095                    | 0.133 |
| Bread                     | 0.070                         | 0.067              | 0.047                    | 0.086 | 0.020               | 0.018             | -0.004                   | 0.040 | 0.123               | 0.140              | 0.120                    | 0.159 |
| Rice                      | 0.138                         | 0.172              | 0.124                    | 0.220 | 0.067               | 0.095             | 0.024                    | 0.165 | 0.139 <sup>b)</sup> | 0.090              | 0.066                    | 0.115 |
| Meat                      | 0.042                         | 0.073              | 0.033                    | 0.114 | 0.025               | 0.031             | -0.017                   | 0.079 | 0.081               | 0.072              | 0.046                    | 0.098 |
| Oil & Fats                | 0.060                         | 0.052              | 0.041                    | 0.063 | 0.012               | 0.028             | -0.003                   | 0.059 | 0.023 <sup>b)</sup> | 0.052              | 0.041                    | 0.063 |
| Other foods <sup>a)</sup> | 0.177                         | 0.172              | 0.127                    | 0.216 | 0.110               | 0.166             | 0.097                    | 0.235 | 0.222               | 0.241              | 0.216                    | 0.266 |

Notes:

<sup>a)</sup> Residual, <sup>b)</sup> Estimate is outside the 95 percentage confidence interval of the sample mean

**Table 4. Summary of estimated coefficients**

| Significant coefficients / number of estimated coefficients |                        |        |        |                |       |                  |
|-------------------------------------------------------------|------------------------|--------|--------|----------------|-------|------------------|
| Coefficients                                                | Reference coefficients | North  | South  | Household size | Sea   | Fridge / Freezer |
| <b>Gamma</b>                                                | 7 / 28                 | 7 / 28 | 4 / 28 | ..             | ..    | ..               |
| <b>Alpha</b>                                                | 7 / 7                  | 3 / 7  | 5 / 7  | 4 / 7          | 4 / 7 | 5 / 7            |
| <b>Beta</b>                                                 | 5 / 7                  | 2 / 7  | 4 / 7  | ..             | ..    | ..               |
| <b>Sigma</b>                                                | 7 / 7                  | ..     | ..     | ..             | ..    | ..               |
| <b>Rho</b>                                                  | 15 / 21                | ..     | ..     | ..             | ..    | ..               |

Note:

Significance refers to significant different from zero at the 5 percent level.

**Table 5. Uncompensated Elasticities (reference household).**

|                                 | <b>Vegetables</b> | <b>Maize flour</b> | <b>Fish</b> | <b>Bread</b> | <b>Rice</b> | <b>Meat</b> | <b>Oil &amp; Fats</b> | <b>Other foods</b> |
|---------------------------------|-------------------|--------------------|-------------|--------------|-------------|-------------|-----------------------|--------------------|
| <b>Vegetables</b>               | -0.85***          | -0.21***           | 0.13***     | 0.14***      | 0.08        | -0.01       | 0.12***               | -0.02              |
| <b>Maize flour</b>              | -0.38***          | -0.36***           | -0.13**     | -0.15***     | -0.19***    | -0.10       | -0.07                 | -0.29*             |
| <b>Fish</b>                     | 0.14***           | -0.03              | -0.93***    | 0.03         | -0.01       | 0.00        | -0.02                 | 0.04               |
| <b>Bread</b>                    | 0.26***           | -0.27***           | 0.03        | -1.02***     | -0.19*      | -0.04       | 0.01                  | 0.20               |
| <b>Rice</b>                     | -0.02             | -0.17***           | -0.08       | -0.11**      | -0.89***    | 0.04        | -0.05                 | -0.04              |
| <b>Meat</b>                     | -0.10             | -0.37**            | -0.09       | -0.07        | -0.09       | -1.07***    | -0.06                 | 0.05               |
| <b>Oil &amp; Fats</b>           | 0.31***           | -0.09              | -0.04       | 0.02         | -0.07       | -0.04       | -1.13***              | 0.16               |
| <b>Other foods</b>              | -0.15             | 0.10               | -0.01       | 0.04         | 0.10        | 0.11        | 0.02                  | -0.88              |
| <b>Expenditure elasticities</b> | 0.62***           | 1.67***            | 0.79***     | 1.01         | 1.32***     | 1.79***     | 0.89                  | 0.67               |

Notes:

\*, \*\*, \*\*\* denotes significance at 10, 5 and 1 percent level. Standard errors are calculated by the delta method. For price elasticities the significance levels concern differences from zero. For expenditure elasticities the significance is with respect to differences from 1. All expenditure elasticities are significantly different from zero at any conventional level.

**Table 6. Compensated price elasticities (reference household).**

|                       | <b>Vegetables</b> | <b>Maize flour</b> | <b>Fish</b> | <b>Bread</b> | <b>Rice</b> | <b>Meat</b> | <b>Oil &amp; Fats</b> | <b>Other foods</b> |
|-----------------------|-------------------|--------------------|-------------|--------------|-------------|-------------|-----------------------|--------------------|
| <b>Vegetables</b>     | -0.72***          | -0.12**            | 0.22***     | 0.18***      | 0.17**      | 0.02        | 0.16***               | 0.09               |
| <b>Maize flour</b>    | -0.02             | -0.11**            | 0.11*       | -0.03        | 0.04        | -0.03       | 0.03                  | 0.01               |
| <b>Fish</b>           | 0.31***           | 0.08               | -0.81***    | 0.08         | 0.10        | 0.03        | 0.03                  | 0.18               |
| <b>Bread</b>          | 0.48***           | -0.11*             | 0.18        | -0.95***     | -0.05       | 0.01        | 0.07                  | 0.38               |
| <b>Rice</b>           | 0.26***           | 0.03               | 0.12        | -0.02        | -0.70***    | 0.09        | 0.03                  | 0.19               |
| <b>Meat</b>           | 0.28***           | -0.10              | 0.18***     | 0.06         | 0.16        | -1.00***    | 0.05                  | 0.37               |
| <b>Oil &amp; Fats</b> | 0.50***           | 0.05               | 0.09***     | 0.08         | 0.05        | 0.00        | -1.08***              | 0.32               |
| <b>Other foods</b>    | -0.01             | 0.20               | 0.09        | 0.09         | 0.19        | 0.14        | 0.06                  | -0.76              |

Notes:

\*, \*\*, \*\*\* denotes significance at 10, 5 and 1 percent level. Standard errors are calculated by the delta method. Significance levels are with respect to differences from zero.

**Table 7. Decomposition of differences in elasticities between Central and Northern Mozambique**

|             | Income elasticity |       |       |              |                   |          |          | Own price elasticity |       |       |              |                   |          |          |
|-------------|-------------------|-------|-------|--------------|-------------------|----------|----------|----------------------|-------|-------|--------------|-------------------|----------|----------|
|             | Central           | North | Diff. | Level effect | Behavioral effect | Combined | residual | Central              | North | Diff. | Level effect | Behavioral effect | Combined | residual |
| Vegetables  | 0.62              | 0.85  | -0.23 | -0.02        | -0.11             | -0.12*   | -0.11    | -0.85                | -0.95 | 0.10  | 0.00         | 0.11              | 0.11     | 0.00     |
| Maize flour | 1.67              | 1.27  | 0.39  | 0.00         | 0.41              | 0.41**   | -0.01    | -0.36                | -0.80 | 0.43  | 0.00         | 0.44              | 0.44***  | -0.01    |
| Fish        | 0.79              | 0.83  | -0.04 | -0.05        | 0.02              | -0.03    | -0.01    | -0.93                | -1.12 | 0.19  | 0.01         | 0.19              | 0.20**   | -0.01    |
| Bread       | 1.01              | 1.32  | -0.31 | 0.00         | -0.21             | -0.21    | -0.10    | -1.02                | -1.28 | 0.26  | 0.00         | 0.18              | 0.18     | 0.08     |
| Rice        | 1.32              | 1.41  | -0.09 | 0.01         | 0.02              | 0.03     | -0.11    | -0.89                | -1.58 | 0.70  | 0.00         | 0.56              | 0.56***  | 0.13     |
| Meat        | 1.79              | 2.27  | -0.48 | -0.12        | -0.39             | -0.51    | 0.03     | -1.07                | -0.90 | -0.18 | -0.07        | -0.15             | -0.22*   | 0.04     |
| Oil & Fats  | 0.89              | 1.60  | -0.71 | 0.03         | -0.54             | -0.51    | -0.20    | -1.13                | -1.20 | 0.07  | 0.04         | -0.02             | 0.02     | 0.05     |

Notes:

\*, \*\*, \*\*\* denotes significant different from zero at 10, 5 and 1 percent level. Standard errors are calculated by the delta method. Significance only shown for the combined columns.

**Table 8. Decomposition of differences in elasticities between Central and Southern Mozambique**

|             | Income elasticity |       |       |              |                   |          |          | Own price elasticity |       |       |              |                   |          |          |
|-------------|-------------------|-------|-------|--------------|-------------------|----------|----------|----------------------|-------|-------|--------------|-------------------|----------|----------|
|             | Central           | South | Diff. | Level effect | Behavioral effect | Combined | residual | Central              | North | Diff. | Level effect | Behavioral effect | Combined | residual |
| Vegetables  | 0.62              | 0.61  | 0.01  | -0.07        | 0.06              | -0.02    | 0.03     | -0.85                | -0.80 | -0.06 | 0.01         | -0.06             | -0.05    | -0.01    |
| Maize flour | 1.67              | 1.40  | 0.27  | -0.31        | 0.55              | 0.24     | 0.03     | -0.36                | -1.13 | 0.76  | -0.47        | 1.24              | 0.77***  | 0.00     |
| Fish        | 0.79              | 0.93  | -0.14 | 0.05         | -0.20             | -0.15*   | 0.01     | -0.93                | -1.02 | 0.09  | 0.00         | 0.09              | 0.09     | 0.00     |
| Bread       | 1.01              | 0.91  | 0.11  | 0.00         | 0.11              | 0.11     | -0.01    | -1.02                | -1.05 | 0.02  | 0.00         | 0.03              | 0.03     | -0.00    |
| Rice        | 1.32              | 1.19  | 0.13  | -0.04        | 0.15              | 0.11     | 0.02     | -0.89                | -0.77 | -0.11 | -0.03        | -0.12             | -0.15    | 0.04     |
| Meat        | 1.79              | 2.07  | -0.28 | 0.05         | -0.49             | -0.44**  | 0.16     | -1.07                | -1.10 | 0.03  | 0.02         | -0.03             | 0.00     | 0.04     |
| Oil & Fats  | 0.89              | 1.28  | -0.39 | 0.03         | -0.38             | -0.35**  | -0.04    | -1.13                | -1.63 | 0.50  | 0.05         | 0.36              | 0.40     | 0.09     |

Notes:

\*, \*\*, \*\*\* denotes significant different from zero at 10, 5 and 1 percent level. Standard errors are calculated by the delta method. Significance only shown for the combined columns.