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Local measures, quality effects and the estimation of demand elasticities in urban Ethiopia

by

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Abstract

Several household expenditure surveys in less developed countries collect data on quantities purchased as well as expenditures. This allows unit values to be calculated, which may be treated as prices if corrected for quality variation and measurement error. Often, however, quantities are reported in local units of measurement, the interpretation of which may differ across household types. Using household expenditure data for a sample of Ethiopian urban households in 1994, we provide estimated price elasticities of demand for a range of basic commodities adjusted for quality effects, measurement error and non-random reporting of local units of measurement. We show that estimates of price elasticities that utilise average conversion factors for quantities reported in local units and that ignore measurement error are likely to be inaccurate.

Key words Consumer expenditure price elasticity quality unit of measurement

JEL classification D12 O12 O55

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Local measures, quality effects and the estimation of demand elasticities in urban Ethiopia

"I swapped my mother for Taba of beans,
I swapped my daughter for a Taba of beans,
I swapped my wife for a Taba of beans,
In order to fill my belly,
Thinking the bad days will not pass".

F.Azeze *Unheard Voices: Drought, Famine and God in Ethiopian Oral Poetry* (1998)[1]

"Not with fond shekels of the tested gold
Or stones whose rate are either rich or poor
As fancy values them."

William Shakespeare *Measure for Measure*, Act 2, Scene 2

1. Introduction

Accurate price information is required for the analysis of household welfare – to construct cost of living indices and standard of living measures, to derive poverty lines and to investigate behavioural responses such as own-price elasticities of demand in order to design tax policies. Household expenditure surveys are generally used as the basis of these analyses, and surveys undertaken as a result of the World Bank's Living Standard Measurement Study (LSMS) initiative have contributed much to our understanding of these policy issues in developing countries (Deaton, 1997).

Household expenditure surveys rarely collect price data as such, focussing instead on household expenditures, sources of incomes, demographics and background variables and obtaining price data from separate surveys. However, some of the LSMS surveys, as well as a few other surveys, extend the collection of data to information on quantities purchased, as well as expenditure values. This contrasts with the 'traditional' household expenditure surveys in the Western industrialised countries, such as the long running Consumer Expenditure Survey (CES) in the US and Family Expenditure Survey (FES) in the UK, which do not collect information on quantities purchased.

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[1] *Taba* is a small earthenware container used to measure grain.

Often, in developing countries, the range of basic commodities purchased is fairly limited, which makes collection of quantity data feasible.

With information on the value of expenditure on a given item, and quantity purchased, it is in principle possible to divide the former by the latter to obtain a unit value. The present paper follows a growing literature that focuses on the issue of whether this calculated 'unit value' can be treated as a 'price'. This literature, stemming from the seminal work of Prais and Houthakker (1955) and developed in particular by Deaton (for example, 1988, 1997) suggests that great care must be taken in justifying such a step. However, with certain assumptions concerning spatial price variation, differences in unit values attributable to prices, as opposed to say, quality differences, can be identified. A number of other methodological and empirical issues also arise in calculations of prices from unit values, and these are discussed in greater detail below.

However, the primary contribution of the present paper, other than utilising a new data set for the analysis, the 1994 Ethiopian Urban Household Survey (EUHS), is to raise another issue that arises in the construction of unit values: the measure of quantity itself. Many households report quantities purchased in local units rather than metric units such as kilograms and litres. These local units will often be the utensil used for measuring out or carrying quantities, such as a cup or can, or indeed described as 'heaps' (for vegetables) or 'bundles' (for herbs), rather than by weight. Capéau and Dercon (1998) report identifying at least 70 different units in the Ethiopian rural household survey. The issue is pertinent in many low income countries.

Box 1 gives some definitions of various local units utilised by respondents to the EUHS. Table A1 provides sample distributions for respondents' use of these units of measurement for various commonly purchased commodities. Whilst for some commodities, such as cereals, kilograms do indeed appear to be the dominant unit of measurement in urban Ethiopia, this is not true for other commodities such as vegetables, liquids and herbs and spices.

To the Western observer, measures in local units such as cups, cans and heaps convey little information as to actual quantities and therefore provide an additional hurdle in deriving price information from unit values. However, it is perfectly possible that the urban consumer in Ethiopia is far more likely to be able to judge the quantity and quality of a 'heap' of vegetables than he or she is able to judge whether the scales are truly weighing 500 grams of onions.[2] Nevertheless, to the external researcher, the 'local units' issue raises a considerable hurdle in the construction of consistent unit values.

Box 1 Some common units of measurement in urban Ethiopia	
Medeb:	literally a 'heap', can be large or small, often used for vegetables.
Tassa:	A large serving can, often used for cereals, pulses and liquids.
Sini:	A small ceramic cup, often used for coffee, pulses (e.g. oilseeds) and spices. Also used to serve coffee in households.
Birchiko:	A glass, often used for pulses and liquids.
Kubaya:	A mug, often used for cereals, pulses and liquids.
Esir:	A 'bundle', often used for cabbage and *chat* (a mild stimulant)
Tikil:	A wrap, often used for sugar and coffee.
	Other units include *number* (e.g. bread and fruits), *pieces* (fruits) and *bottles* (milk and oil)

A simple trick in resolving this issue is to apply an average 'conversion factor' to convert local units into identifiable metric units (perhaps by an interviewer weighing items directly), and then to adopt standard procedures to adjust for the other sources of measurement error in order to transform unit values into prices. But any variation in these implicit conversion factors across households will be ignored and, if this variation is in any way systematically linked to, say, household income level or location, the resulting use of an average conversion factor may distort poverty indices, calculated price elasticities, and so on. Capéau and Dercon (1998) therefore use spatial variation to identify different conversion factors for different households. The difficulty with this approach is that several units of measure may be used in the same locality, especially in urban areas. Moreover, the authors thereby have to reject the use of spatial variation as a means of identifying other factors involved in converting unit values into prices. In particular, their approach is not reconcilable with that of Deaton (1988), who relies on the use of within and between-spatial cluster variation to identify separately the price and quality components of unit values across households.

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[2] Just as many money lenders in, for example, middle Eastern markets can instantly provide rates of exchange between current and often obsolete and locally traded currencies and coinage.

Our approach in this paper handles the issues of local units of measurement, quality effects, and other sources of measurement error in order to derive price elasticities from unit values for a range of basic commodities reported in the EUHS. We follow Deaton (1988, 1997) in using the between and within cluster spatial variation in unit values in order to obtain prices differences purged of quality effects and measurement error. We regress quantities on prices to obtain reduced form own-price elasticities of demand for various commodities. We undertake these calculations separately for different local units of measurement. However, we assume that the decision to report in local units is non-random. Thus the two-stage Deaton procedure, described in more detail in the next section, is based on a selection model that conditions the relationship between expenditures, quantities, total spending and demographics on the choice of unit of measurement.

Our methodology utilises a multi-choice first stage model of units of measurement by households, differentiating between three options: kilograms, the commonest local unit, and other local units, for a number of commodities. We then estimate quantity and unit value equations allowing for self-selection of reported units of measurement. The third stage of our procedure calculates price elasticities of demand with adjustments for quality variations and measurement error. Our main findings are that:

i) Decisions to report in various units of measurement are non-random across households, so that the selectivity correction terms for unit value and quantity equations, defined separately over units of measurement, are highly significant;

ii) Price elasticities for given commodities differ across different units of measurement. We show that aggregate elasticities calculated using average conversion factors may even lie outside those estimated for separate units of measurement, suggesting the possibility of aggregation bias as well as losing valuable information if choice of units is not modelled explicitly;

iii) While adopting the two stage selectivity approach is important in estimating unit value and quantity equations, it tends to weaken the precision of the estimates of price elasticities, although coefficients do not change a good deal;

iv) Adjustments for units of measurement and general measurement error using the Deaton (1988) approach seem to be important for the calculated price elasticities for commodities purchased in metric units, and tend to increase the elasticity values;

v) In contrast, these various adjustments for commodities measured in local units do not improve the own price elasticity estimates, which indeed lose precision. We infer that ‘quantities’ purchased in local units already incorporate quality adjustments as buyers bargain with sellers jointly over price, quantity and quality when purchasing in non-metric units.

The general structure of the paper is straightforward. Section 2 describes the theory, Section 3 the data set and Section 4 the empirical results. There is a short conclusion.

2. Basic theory

General model

Our basic equations describe the reported quantities and unit values for a given commodity bought by household *i* in geographical area (cluster) *c* with quantity unit of measurement *m*, described by:

(1) $$\ln q_{icm} = a_{0m} + e_{xm} \ln x_{icm} + e_{pm} \ln p^{*}_{icm} + q D_{icm} + f_{cm} + m_{0\,icm}$$

(2) $$\ln v_{icm} = a_{1m} + b_{1m} \ln x_{icm} + p_{m} \ln p^{*}_{icm} + q D_{icm} + m_{1\,icm}$$

where *q* is the quantity of the good purchased (in whatever unit), *v* is the unit value of the good purchased (in Ethiopian *birr*,[3] obtained from total expenditure on the commodity, *e*, divided by *q*), *x* is total household expenditure (in Ethiopian *birr*), *p** is the (unobserved) price of the good, and *D* is a vector of household (demographic) characteristics. *b*, e_x , e_p , *p* and *q* are parameters to be estimated, directly or indirectly. The error term in equation (1) has two components: a cluster specific fixed effect f_{cm} and a household specific error component m_{icm} , which is assumed to be uncorrelated with all other regressors, including fixed effects.

[3] 1 US $ is approximately 9 Ethiopian *birr*.

Units of measurement

We model the choice of an individual household as to whether to report quantities in kilograms or some form of local units, prior to estimating household-specific quantity and unit value equations for each reporting unit of measurement. Consider the set of possible measurement units $s = (k, m \ldots m_{s-1})$ where k is kilograms and m_1 to m_{s-1} are a variety of other (local) units of measurement. Denote the general choice model for units of measurement as:

$$(3) \qquad U_{im} = z_i' g + m_{im}$$

where we think of the individual choosing to report in kilograms, for example, if the welfare from reporting in kilograms is greater than that of reporting in any alternative measure, i.e.: *prob* $(U_{ik} > U_{im})$ for all other $m \neq k$.

To implement this two-stage procedure with multiple units of measurement, we utilise the multinomial logit (MNL) with selection (what Lee, 1983, terms a multinomial logit-OLS two stage estimate model). In the MNL, the disturbance terms are assumed to be iid with Gumbel distribution. Hence the probability that individual *i* chooses to report in kilograms *k* can be written as:

$$(4) \qquad Prob_{ik} = \frac{\exp(z_{ik}' g)}{1 + \sum_{s \neq k} \exp(z_i' g)}$$

The two stage method is used to estimate equations (1) to (2) where individual households select their units of measurement on the basis of some criteria and then quantity and unit value equations are estimated separately for each unit of measurement. The computed selectivity correction $\hat{l}_{ik}$, for *k* in (1) and (2) is:

$$(5) \qquad \hat{l}_{ik}(x_{ik}' g) = r_k s_k \frac{\hat{f}_k(z_i' g)}{\hat{\Phi}_k(z_i' g)}$$

where $\hat{f}(.)$ is the computed density function and $\hat{\Phi}(.)$ is the computed distribution function of the standard normal distribution, r_k is the correlation between the residuals in the selection equation (4) and the primary equations (1) and (2), and s_k is the standard deviation of the residuals in the primary equations (see Heckman (1979), McFadden (1973) or Maddala, 1983). Identification of course relies on there being elements in the z vector in equation (3) that are not present in the D vector of characteristics in the quantity and unit value regressions. We return to the issue of identification in the empirical section of the paper.

Quality adjustments

Having controlled for selection of units of measurement in our quantity and unit value equations, we follow the methodology of Deaton (1988) in order to adjust unit values for quality differences. The ‘commodity’ used in our analysis is therefore a composite commodity, with the assumption that each composite commodity contains a hierarchy of commodity varieties arranged by quality differences. We assume that each composite commodity constitutes a separable branch of preferences. To maintain tractability, we rule out any cross price elasticities across composites.

Within each geographical cluster, it is assumed that consumers face homogenous prices for a given commodity quality within each composite, whereas there is price variability across clusters. This permits us to explain the variation in unit values *within* clusters by quality variation, whereas explained variation in quality-adjusted unit values *across* clusters reflects price variation.

To show this, denote for commodity group g the quantity purchased as:

$$q_{gc} = mq^{n}_{gc} \tag{7}$$

where there are n quality varieties of good g in cluster c (cuts or types of meat, qualities of coffee, etc.). As before, m is the unit in which the commodity is measured, such as kilograms, local units, etc., and q^n is the vector of n qualities purchased, aggregated in those units. Of course, we cannot aggregate over different units of measurement, so that any quality adjustments must be done separately for each unit of measurement once we have controlled for selection in the unit of measurement as described above.

In similar vein, write:

$$p^{*}_{gc} = c_{gc}\, p^{0}_{gc} \tag{8}$$

where the (unobserved) average price of commodity grouping g is the product of a scalar measure of prices, χ, and a reference price vector p^0 , of the various varieties of the commodity contained in the grouping (Deaton, 1997, p.297).

Accordingly, following Deaton, we can write:

(9) $$v_{gc} = e_{gc} / q_{gc} = c_{gc}(p^0_{gc} \bullet q^n_{gc} / m \bullet q^n_{gc})$$

where the unit value *v* of a composite commodity *g* in cluster *c*, which is total expenditure *e* divided by quantity *q*, is a price-index weighted average cost of the bundle of 'qualities' of the commodity purchased in that cluster (the quantities measured in some unit of measurement, *m*). A rise in this unit value at fixed relative prices of different varieties reflects consumers choosing a higher quality of the composite good.

A change in the *average* price p* will affect this average quality. By assuming separability (see above), we can write the vector of demands for the composite commodity as:

(10) $$q_{gc} = g_c(e_{gc}, p_{gc}) = g_c(e_{gc} / c_{c,} p^*_{gc})$$

where the quantity purchased of composite commodity *g* in cluster *c* is a function of total expenditure on the commodity and the vector of prices of the various qualities. The second equality arises because, with separability, the demand function for the composite good is homogeneous in total expenditure and prices (Deaton and Muellbauer, 1980). This links the price elasticity of quality to the income elasticity of quality. As shown formally by Deaton (1988), variation in unit value purchases of composite commodities across households within clusters therefore reflects quality differences driven by total expenditure on the composite commodity. This idea of an 'income responsiveness of quality' is discussed by Prais and Houthakker (1955).

Measurement error in unit values

A familiar problem in this field arises from measurement error in the calculation of the dependent variable. As in labour supply, where hourly wage rates are often constructed by dividing weekly wages by weekly hours, raising the possibility of spurious correlation between hours and wage rates, so obtaining unit values by dividing expenditure by quantity may induce spurious correlation of quantities and unit values.

Denoting the 'true' quantities and unit values with an asterisk, write:

(11) $$\ln q_{icm} = \ln q^*_{icm} + m_{00}$$

and

(12) $$\ln v_{icm} = \ln v^*_{icm} + m_{11}$$

Write the variances of the errors m_{00} and m_{11} as $\tilde{s}_{00}$ and $\tilde{s}_{11}$ respectively. There is no presumption that the covariance $\tilde{s}_{01}$ is zero. We return to this shortly.

Estimation methods

To adjust for quality effects and measurement error, there are two estimation stages. First, cluster means are subtracted from all variables. Removing cluster means removes the prices and fixed effects and allows consistent estimation of the relevant regressors, in both equations. We write equations (1) and (2) as:

$$(13) \qquad (\ln q_{icm} - \ln \bar{q}_{cm}) = e_{xm}(\ln x_{icm} - \ln \bar{x}_{cm}) + q\,(D_{icm} - \bar{D}_{cm}) + (m_{0\,icm} - \bar{m}_{0\,cm})$$

$$(14) \qquad (\ln v_{icm} - \ln \bar{v}_{cm}) = b_1(\ln x_{icm} - \ln \bar{x}_{cm}) + q\,(D_{icm} - \bar{D}_{cm}) + (m_{1\,icm} - \bar{m}_{1\,cm})$$

where the bar over the variable indicates the mean over all households reporting quantities and expenditures in cluster *c*. Then the selectivity-corrected quantity and value equations (1) and (2) respectively are estimated for each unit of measurement (including the term in equation (5)).[4] Since within period prices are assumed to be constant, the coefficient b_1 in equation in (2) should be interpreted as reflecting both the direct impact of household income on quality and the indirect impact of price on quality via its effect on total expenditure within the cluster.

The equations (1) and (2) could have been estimated by adding dummy variables for each cluster. However, by the Frisch-Waugh (1933) theorem, the regression of deviations from cluster means gives identical parameter estimates to those that would have been obtained from the regression containing the cluster dummies. However, we cannot of course then utilise cluster dummies to identify other features of the model: for example, conversion factors for local units into kilograms.[5]

'Corrected' quantity and unit values can then be defined using the parameter estimates from the first stage. The estimates of the e_x's, b_1's and q's from the within cluster estimates are the final estimates of these parameters. Define the 'corrected' quantities and unit values by:

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[4] For consistency, the selection equation concerning choice of units of measurement must also either by estimated with cluster dummies or with variables as deviations from means, as in (13) and (14). This should make no difference, although we actually adopt the later procedure here.

[5] As is done by Capéau and Dercon (1998) to calculate these factors for Ethiopian rural budget surveys. However, these authors rule out quality effects.

(16) $\tilde{q}_{icm} = \ln q_{icm} - \tilde{e}_{xm} \ln x_{icm} - \tilde{q} D_{icm}$

(17) $\tilde{v}_{icm} = \ln v_{icm} - \tilde{b}_{1m} \ln x_{icm} - \tilde{q} D_{icm}$

These results strip out the quality effects, and the price information contained in the cluster dummies is retained. The basic second stage equations are therefore the between cluster regressions of quantities and values on the across-cluster price variations.

To allow for the possibility of measurement error in the unit value equation, we define an error-in-variables estimator (see Deaton, 1988).

(18) $$f = e_{p\ icm} / p_{icm} = \frac{\operatorname{cov}(q_{icm}, v_{icm}) - s_{01}/n}{\operatorname{var} v_{icm} - s_{11}/n}$$

where e_p and p are the price elasticities defined in equations (1) and (2) and n is the number of households per cluster. The theoretical magnitudes in (18) can be replaced by their first stage estimates from equations (16) and (17), to obtain a consistent estimate of f. Hence:

(19) $$\tilde{f} = \frac{\operatorname{cov}(\tilde{q}_{icm}, \tilde{v}_{icm}) - \tilde{s}_{01}/n}{\operatorname{var} \tilde{v}_{icm} - \tilde{s}_{11}/n}$$

The correction terms in (19), $\tilde{s}_{01}/n$ and $\tilde{s}_{11}/n$, are designed to correct the usual OLS estimator for the between-cluster variances and co-variances that come from measurement and econometric error in the underlying first stage equations. After some rearrangement (Deaton, 1997, p.299), we can write (19) as:

(20) $$\tilde{f} = \tilde{e}_{p\ icm} / \tilde{p}_{icm} = \frac{\tilde{e}_p}{(1 + \tilde{b}_1 \tilde{e}_p / \tilde{e}_x)}$$

and

(21) $$\tilde{e}_{\mathrm{p}} = \frac{\tilde{f}}{1 - \tilde{f}\tilde{b}_1 / \tilde{e}_x}$$

Since we know $\tilde{f}$, and the quality elasticities $\tilde{b}_1$ and $\tilde{e}_x$, we can estimate the price elasticity $\tilde{e}_p$ for a given composite commodity and measurement unit, normalised for the effects of selection of measurement unit, quality and spurious correlation.

3. Data

The analysis is based on the Ethiopian Urban Households Survey (EUHS), which was collected by the Department of Economics at the University of Addis Ababa, Ethiopia, in collaboration with the Department of Economics at the University of Göteborg, Sweden, during 1994. Total sample size is 1500 households, distributed over the seven main urban centres in Ethiopia (of 100,000+ inhabitants) in proportion to their respective populations. These centres were Addis Ababa, Mekele, Dessie, Bahar Dar, Awassa, Dire Dawa and Jimma, representing a geographical cross section of the country.

Data collected include household expenditures on numerous food and other items, obtained by keeping a diary for periods of varying length, according to the nature of the commodity. By varying the period according to the item, the problem of extensive zero expenditures for many commodities over relatively short periods is by-passed – the commodities chosen here generally report positive purchases over the diary periods. In addition, quantities of these purchases are noted, with households responding in metric or non-metric units. This core information is supplemented by background data on demographics, economic status, ethnic and religious affiliation and so on.

Households are classified into clusters (i.e. geographical areas of various sizes). Three types of geographical cluster can be identified. The first is the urban centre, reflecting the classification of the country into administrative regions loosely based on these centres. At this level of aggregation, Addis Ababa in particular is a large, heterogeneous, unit. The second level of disaggregation is the division of urban centres into *weredas*, totalling 42 in all and the lowest administrative units are *kebeles*, which number 212 in total.[6] If the cluster is used to define price differentiation across markets, there is clearly a trade-off between excessive aggregation, which conceals potential market heterogeneity, and excess disaggregation, which fragments single spatial markets and reduces cell size. Here we use the *wereda* as the unit of analysis. Kedir (2001) examines the sensitivity of results using cluster methods to the level of disaggregation of this data set.

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[6] *Wereda* and *kebele* are administrative units with legal authority (courts). The *wereda* may also be involved in, for example, government distribution of food relief.

4. Empirical results

This section focuses on the econometric results. The estimates are presented in three stages: the initial stage at which the probabilities of reporting in metric or local units are calculated; a second stage in which selectivity-corrected quantity and unit value equations are estimated, and a third stage in which price elasticities are recovered, once the second stage estimates are purged of quality effects and measurement error using the cluster approach suggested by Deaton.

We examine a model that allows for a limited choice of reported local units as well as metric units. There is clearly a trade-off between precision arising from complete specification of all units of measurement on the one hand, and sample size considerations on the other. Our first stage estimates therefore differentiate between three options: kilograms, the most frequently named local unit for each commodity, and a residual category of other local units for which we do not quote results.

First stage estimates: Reporting units

Table 1a and 1b report the marginal effects, for reporting in metric units and in the most common specified local unit respectively, evaluated at mean values for some selected food commodities, as in equation (3) above (the default is residual 'other local units'). In general log per capita household expenditure, household size, ethnic and religion dummies are the only regressors where we find statistically significant coefficients.

The positive coefficient on household expenditure in kilograms, conditioned on household size in Table 1a, reflects the likelihood that richer households are more likely to buy foodstuffs from standardised stores that measure in metric units. In contrast, poorer households may suffer from liquidity constraints and irregular income and be forced to purchase in local markets in small, individual units, such as a single item. Indeed it is common in many parts of Ethiopia that, for basic consumption goods, there are weight limits below which traders (who sell in metric units) are not willing to sell to buyers, forcing low income households to trade in other markets.

Table 1a also shows that household size is positively related to the probability of reporting in kilograms in 4 of the 7 commodities. Again, this may reflect bulk purchases by larger households, reported in kilograms rather than local units. Education variables mostly have the expected positive signs but are mostly not statistically significant, perhaps reflecting collinearity with household expenditure per capita. Age and gender of the household head are not significant. There are varying results for religious and ethnic group affiliation, with significant coefficients for several commodities on individual coefficients, notably Tigre (coffee and vegetables at 5% and spices at 10%) and Gurage (pulses).

For the most commonly specified local units, it is harder to find significant coefficients in Table 1b. It is interesting that the link between household expenditure and use of local units observed for kilograms is not observed for local units – the coefficients are either negative or insignificant, confirming the selection mechanisms in markets described above. Nevertheless, there is some significance on the ethnic and religious variables, as might be expected: coefficients on Catholic and on several ethnic groups are significant at the 5% and 10% level.

Although there are differences in reported units of measurement by household size and expenditure, these variables are central to the second stage estimates, especially in the calculation of quality effects, so we cannot use them as identifying restrictions. Instead we use the religious and ethnic variables for identification. The last column of Table 1 shows the joint significance of these variables in the respective first stage equations. The test statistic shows that these variables are significant for 4 of the 7 commodity groupings. While not as robust as we would wish, we will show that these variables are largely *not* significant in the second stage quantity and unit value equations, justifying their exclusion at that stage. Moreover there is strong evidence of a selection mechanism in the second stage equations. However, as a check, when deriving the third stage estimates (price elasticities), we provide a variety of results including estimates both with and without selectivity corrections.

Table 1a: Probabilities of reporting in kg, by commodity

Variable	*Coffee*	*Vegetables*	*Lentils*	*Split Lentils*	*Pulses*	*Onion*	*Spices*
	Coef(s.e.)	**Coef(s.e.)**	**coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**
Log (Expenditure)	0.95(0.12)**	0.42(0.08)**	0.46(0.24)**	0.11(0.07)*	0.50(0.13)**	0.17(0.11)*	0.22(0.08)**
Log (Household size)	1.29(0.50)**	0.46(0.33)*	2.62(1.07)**	0.17(0.26)	1.38(0.53)**	0.13(0.44)	0.09(0.35)
Head completed junior secondary schooling	0.07(0.22)	0.06(0.16)	-0.58(0.46)	0.06(0.12)	0.20(0.25)	0.07(0.20)	0.05(0.16)
Head completed senior secondary and HE	0.26(0.30)	0.34(0.19)**	-0.11(0.57)	0.16(0.15)	0.66(0.30)**	0.14(0.26)	0.12(0.21)
Log (age of head)	0.29(0.38)	0.06(0.25)	-0.43(0.73)	0.06(0.20)	0.13(0.39)	0.07(0.34)	0.06(0.27)
Head is male	-0.02(0.22)	-0.05(0.14)	-0.16(0.41)	-0.03(0.11)	-0.19(0.22)	-0.04(0.19)	-0.03(0.15)
Head is Catholic	1.01(0.94)	0.69(0.46)*	0.17(1.21)	-0.05(0.45)	-0.21(0.78)	0.08(0.78)	0.38(0.62)
Head is Protestant	-0.87(0.60)	-0.07(0.33)	-0.37(1.01)	-0.01(0.25)	-0.14(0.50)	-0.51(0.46)	-0.34(0.36)
Head is Muslim	0.21(0.27)	0.02(0.18)	0.71(0.59)	0.05(0.15)	0.27(0.30)	0.10(0.23)	-0.10(0.19)
Head is Gurage	-0.01(0.29)	-0.17(0.18)	-0.33(0.60)	-0.12(0.14)	-0.60(0.29)**	0.07(0.26)	0.11(0.21)
Head is Oromo	0.16(0.22)	-0.05(0.15)	0.12(0.44)	-0.03(0.11)	-0.04(0.22)	-0.08(0.20)	0.003(0.16)
Head is Tigre	0.63(0.36)**	0.36(0.21)**	0.34(0.54)	0.05(0.17)	0.32(0.32)	0.32(0.29)	0.31(0.23)*
Reference period	Last 7 days	Last 7 days	Last 30 days	Last 30 days	Last 30 days	Last 30 days	Last 30 days
Log likelihood	-1070.74	-2484.51	-393.33	-716.51	-1113.29	-1336.61	-2084.07
No. of observations	1059	2317	370	672	1042	1235	1926
Proportion of total food expenditure	1.36	0.90	0.70	1.25	1.95	1.76	1.80
Proportion reporting in metric units	63.5	17.8	71.6	85.4	80.5	22.2	22.4
LR test (religion/ethnic) χ^2 cv =12.59	16.52**	29.16**	3.36	4.39	6.61	12.80**	17.00*

NOTES: 1) Demographic composition variables are included as controls included but not reported;
2) Variables are entered in deviation form; Marginal effects are evaluated at the mean values of the regressors and refer to the change in the probability of reporting in a metric unit(kg);
3)* =significant at 10%; **=significant at 5%..

Table 1b: Probabilities of reporting in specified local unit, by commodity

Variable	*Coffee (Sini)*	*Vegetables (Medeb)*	*Lentils (Tassa)*	*Split Lentils (Tassa)*	*Pulses (Tassa)*	*Onion (Medeb)*	*Spices (Medeb)*
	Coef(s.e.)	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**	**Coef(s.e.)**
Log (Expenditure)	-0.16(0.11)*	-0.04(0.08)	0.20(0.23)	0.12(0.16)	0.15(0.13)	-0.20(0.10)**	-0.17(0.08)**
Log (Household size)	-0.10(0.44)	-0.36(0.31)	0.52(0.84)	0.26(0.60)	0.35(0.47)	-0.10(0.43)	-0.29(0.34)
Head completed junior secondary schooling	0.04(0.20)	-0.16(0.15)	-0.35(0.44)	0.36(0.28)*	0.16(0.23)	-0.14(0.19)	-0.18(0.16)
Head completed senior secondary and HE	-0.24(0.29)	-0.11(0.19)	-0.30(0.56)	0.36(0.36)	0.11(0.29)	-0.14(0.26)	-0.19(0.20)
Log (age of head)	-0.23(0.36)	-0.38(0.24)	0.18(0.72)	0.25(0.47)	0.22(0.38)	-0.35(0.33)	-0.35(0.26)*
Head is male	-0.07(0.20)	0.01(0.14)	-0.34(0.40)	-0.08(0.26)	-0.15(0.21)	0.08(0.19)	0.10(0.15)
Head is Catholic	-0.79(1.35)	-2.57(1.02)**	-0.47(1.40)	-0.37(1.09)	-0.39(0.84)	-0.02(0.83)	0.17(0.66)
Head is Protestant	0.29(0.49)	0.10(0.32)	-0.23(0.99)	-0.04(0.62)	-0.08(0.51)	-0.18(0.42)	0.05(0.33)
Head is Muslim	0.28(0.27)	0.07(0.18)	0.43(0.60)	-0.11(0.36)	0.05(0.30)	-0.25(0.25)	-0.28(0.20)*
Head is Gurage	-0.18(0.28)	-0.39(0.19)**	-0.04(0.57)	-0.24(0.32)	-0.24(0.27)	-0.15(0.26)	-0.05(0.21)
Head is Oromo	-0.29(0.22)*	0.04(0.14)	-0.24(0.45)	-0.05(0.26)	-0.10(0.22)	-0.10(0.20)	0.003(0.16)
Head is Tigre	-0.13(0.40)	0.005(0.22)	0.16(0.54)	0.06(0.43)	0.07(0.33)	-0.55(0.34)**	-0.50(0.26)**
Reference period	Last 7 days	Last 7 days	Last 30 days	Last 30 days	Last 30 days	Last 30 days	Last 30 days
Log likelihood	-1070.74	-2484.51	-393.33	-716.51	-1113.29	-1336.61	-2084.07
No. of observations	1059	2317	370	672	1042	1235	1926
Proportion of total food expenditure	1.36	0.90	0.70	1.25	1.95	1.76	1.80
Proportion reporting in local units	36.5	82.2	28.4	14.6	19.5	77.8	77.6
LR test (religion/ethnic) χ^2 cv =12.59	16.52**	29.16**	3.36	4.39	6.61	12.80**	17.00*

NOTES: 1.) Demographic compositioin variables are included as controls included but not reported;
2.) Variables are entered in deviation form;
3.)* =significant at 10%; **=significant at 5%

Second Stage estimates: unit value and quantity equations

Two unit value and two quantity equations (one for each measurement unit/regime) are estimated for each commodity using OLS, as in equations (14) and (15) above, in doublelog specification. The results in relation to the unit value and quantity equations are summarised below in Table 2a and Table 2b respectively, where we focus on the expenditure and household size coefficients. Dummies on age, education and sex of head of household are additional co-variates. Ethnic and religious variables are omitted as the identifying restrictions. The interpretation of the selectivity correction term (l) is also discussed.

Table 2a Unit value equations

Food item	**Unit value Equation (kg)**			**Unit value equation(local unit†)**		
	Log of PCE	**Log of hh size**	l	**Log of PCE**	**Log of hh size**	l
Coffee	0.67** (0.044)	0.87** (0.168)	1.03** (0.023)	0.87** (0.044)	1.12** (0.353)	-0.87** (0.044)
Vegetables	0.14** (0.039)	0.19 (0.168)	0.54** (0.024)	0.04** (0.011)	0.10* (0.08)	-0.04** (0.01)
Lentils	-0.04 (0.045)	-0.02 (0.196)	0.07** (0.022)	0.08* (0.050)	0.99* (0.442)	-0.09 (0.06)
Split lentils	0.03 (0.020)	0.17** (0.080)	0.13 (0.119)	0.27* (0.193)	-0.35 (0.929)	-0.23** (0.11)
Pulses	-0.04** (0.021)	0.09 (0.080)	0.12** (0.011)	0.16** (0.06)	0.38 (0.509)	-0.15** (0.07)
Onion	0.14** (0.042)	-0.05 (0.195)	0.33** (0.026)	0.11** (0.014)	0.15 (0.108)	-0.12** (0.014)
Spices	0.18** (0.035)	0.05 (0.165)	0.37** (0.022)	0.12** (0.012)	0.15** (0.086)	-0.12** (0.011)

Notes: † Local unit is that specified in Table 1b; PEC = per capita household (hh) expenditure, λ is selectivity correction (IMR); 1) Standard errors are corrected for sample selection; 2) Included but not reported are controls representing household demographic composition; dummies for schooling completed by the household head; gender and age of the same; 3) The dependent variable is log of unit value in deviation form; 4)*=significant at 10%; **=significant at 5%.

In Table 2a, the coefficient on the log of per capita household expenditure can be interpreted as the expenditure elasticity of quality (or, simply, the quality elasticity). For 5 of the 7 commodities in kilograms, and 5 in local units, these quality effects are significant at the 5% level, and most have the expected positive sign, especially in local units. In addition, for many of the equations, the elasticity of unit value (quality) with respect to household size is positive and significant. This may imply that bulk buying allows households to trade up in quality. Of course this finding may depend on household composition, but we find that household age composition variables are not in general significant in these equations, so it is hard to pursue this specific hypothesis.

The quantity equations are described in Table 2b, also estimated separately for the 7 commodity groupings, both for the kilogram and the local units sample. We expect the quantity of food purchased to increase in line with household expenditure, although the Engel curves may be non-linear (see Girma and Kedir, 2001 for evidence from this data set). Likewise, we expect households to increase the quantity of their purchases as the number of household members increase, although there may be economies of scale in household food purchases.

Table 2b: Quantity Equation Parameters

Food item	**Quantity Equation (kg)**			**Quantity equation(local unit†)**		
	Log of PCE	**Log of hh size**	*l*	**Log of PCE**	**Log of hh size**	*l*
Coffee	-0.07* (0.045)	-0.45** (0.176)	-0.77** (0.026)	0.13** (0.070)	0.06 (0.070)	0.87** (0.049)
Vegetables	0.31** (0.058)	0.05 (0.250)	-0.36** (0.036)	0.28** (0.030)	0.40** (0.110)	0.02* (0.010)
Lentils	0.45** (0.077)	0.56** (0.330)	-0.04 (0.030)	0.44** (0.182)	1.44** (0.685)	0.08 (0.090)
Split lentils	0.47** (0.046)	0.31** (0.160)	-0.11** (0.023)	-0.03 (0.191)	1.70* (0.915)	0.18** (0.108)
Pulses	0.46** (0.040)	0.41** (0.152)	-0.10** (0.020)	0.33** (0.140)	1.41** (0.598)	0.17** (0.080)
Onion	0.62** (0.059)	0.91** (0.273)	-0.22** (0.037)	0.35** (0.038)	0.40** (0.148)	0.08** (0.022)
Spices	0.45** (0.061)	0.78** (0.283)	-0.20** (0.038)	0.24** (0.038)	0.33* (0.141)	0.08** (0.022)

Notes: † Local unit is that specified in Table 1b; PEC = per capita household (hh) expenditure, λ is selectivity correction (IMR); 1) Standard errors are corrected for sample selection; 2) Included but not reported are controls representing household demographic composition; dummies for schooling completed by the household head; gender and age of the same; 3) The dependent variable is log of unit value in deviation form; 4)*=significant at 10%; **=significant at 5%.

All but coffee show positive coefficients in quantity purchased on household expenditure and household size in kilograms, and of those, all but vegetables (which is an aggregated commodity grouping) are significant. Results in the specified local unit are similar, with only one negative coefficient and all but two significant. Coefficients on household expenditure are less than one, possibly indicating that these are staple foodstuffs (income inelastic) but we must bear in mind that these are not fully specified demand equations and that no structural interpretation can be placed on the parameters.

Coefficients on household size do not always lie between 0 and 1, especially when measured in local units, suggesting that economies of scale in household food consumption are not universal.

A striking feature of both Tables 2a and 2b is the signs of the selectivity correction terms (l), which are almost all positive and significant in the unit value equations and negative and significant in the quantity equations for kilograms, with the reverse holding true for local units.. This supports our key hypothesis that there is a correlation between the unobserved variables that influence the probability of reporting in metric units and unobserved variables affecting the unit value and quantity of a given good. The coefficients on the inverse Mills ratio suggests that the factors that cause individuals to report in metric rather than local units bias upward the unit value estimates in kilograms and downwards for local units. Since unit values are the ratio of expenditure to quantities, we should expect the signs to be opposite for the quantity equations, and this is indeed the case.

For completeness, we also examine the validity of the identifying restriction by testing whether the religious and ethnic variables can be jointly excluded from the second stage regressions, using F-tests. In the majority of cases, they are accepted at the 5% level, although the results are slightly weaker in kilograms.[7]

Table 3: Tests of exclusion restriction for multi-unit model

Commodity	*Unit value equation – kg*	*Quantity equation - kg*	*Unit value equation - most frequent local unit*	*Quantity equation - most frequent local unit*
Coffee	Reject	Reject	Accept	Accept
Vegetables	Accept	Accept	Accept	Accept
Lentils	Accept	Accept	Accept	Accept
Split Lentils	Accept	Reject	Accept	Accept
Pulses	Accept	Reject	Accept	Accept
Onion	Accept	Accept	Accept	Accept
Spices	Accept	Accept	Accept	Accept

Note: The local unit for coffee is *sini;* for vegetables, spices and onions it is *medeb* and for all lentils, it is *tassa*

[7] Note, in the rejected cases, that split lentils and pulses in kilograms are 2 of the commodities where out first and second stage results are less satisfactory.

Third Stage estimates: Own-Price Elasticity Estimates

Table 3 presents gives several alternative price elasticity estimates calculated from the second stage regressions via the various adjustment procedures described in the previous section. Column (1) calculates ‘raw’ elasticities from unrestricted estimates over the whole sample, from equations (1) and (2), separately for metric units and the specified local units over the 7 commodity groups. Column (2) allows for the sample selection in text equation 3 over choice of units of measurement by respondents. Column (3) estimates the elasticities conditioning out cluster fixed effects. Results from columns (1) to (3) therefore assume that unit values are prices and are measured without error.

Columns (4) and (5) incrementally provide the measurement error (ME) correction and the quality adjustment (QE) specified in text equations 16 to 21. The standard errors of column (4) and (5) are obtained asymptotically using the Delta method (see Greenberg and Webster, 1983). As a final test concerning the importance of specifying the unit of measurement, column (6) uses the adjustment procedures in (4) and (5) but simply uses an average conversion factor applied to all local units and estimates the whole sample in kilograms or kilogram equivalents – thus there are no separate elasticity calculations for local units. It should be emphasised that our main interest in these own price elasticity estimates lies in examining the implications of alternative procedures, and in particular how the local measurement issue is handled. The calculated elasticities may not be the ‘true’ own price elasticities in the sense that they do not take account of cross-price effects. However, it should be borne in mind that construction of estimates based on (quasi)demand systems will be highly problematic in an environment where individuals report quantities in a variety of heterogeneous measurement units.

Table 4: Own-Price Elasticity Estimates

Commodity	Unit	(1) ***No selection and clustering***	(2) ***Selection but no clustering***	(3) ***Selection and clustering***	(4) ***After ME Correction***	(5) ***After ME & QE correction***	(6) ***Converting all quantities into kg***
Coffee	Kg	-0.32*** (0.07)	-0.32*** (0.07)	-0.54*** (0.05)	-0.64*** (0.06)	0.13 (0.16)	-0.20** (0.08)
	Sini	-0.78*** (0.06)	-0.77*** (0.06)	-0.12*** (0.04)	-0.47*** (0.07)	-0.11 (0.07)	
Vegetables	Kg	-0.59*** (0.06)	-0.54*** (0.06)	-0.57*** (0.10)	-0.74*** (0.11)	-0.55*** (0.10)	-0.46*** (0.02)
	Medeb	-0.42*** .(0.04)	0.003 (0.02)	0.40 (0.28)	0.29 (0.30)	0.30 (0.31)	
Lentils	Kg	-0.93*** (0.17)	-0.94*** (0.15)	-1.67*** (0.42)	-4.66*** (1.72)	-6.57* (3.85)	-0.78*** (0.11)
	Tassa	-0.65*** (0.14)	-0.70*** (0.13)	0.97*** (0.20)	1.32*** (0.13)	2.09*** (0.29)	
Split lentils	Kg	-0.42*** (0.09)	-0.43*** (0.11)	0.41* (0.27)	-0.67 (0.47)	-0.64 (0.46)	-0.47*** (0.08)
	Tassa	-0.68*** (0.13)	-0.07 (0.23)	-2.09*** (0.54)	0.59 (0.81)	0.10 (0.60)	
Pulses	Kg	-0.60*** (0.06)	0.001 (0.001)	-1.23*** (0.27)	-1.54*** (0.28)	-1.56*** (0.29)	-0.52*** (0.04)
	Tassa	-0.68*** (0.10)	-0.64*** (0.09)	0.99*** (0.29)	0.49*** (0.17)	0.65*** (0.14)	
Onions	Kg	-0.40*** (0.10)	-0.40*** (0.09)	-1.22** (0.48)	-2.37*** (0.71)	-1.54** (0.63)	-0.83*** (0.041)
	Medeb	-0.68*** (0.04)	-0.15 (0.11)	-0.18 (0.29)	-0.57* (0.33)	-0.48 (0.32)	
Spices	Kg	-0.67*** (0.08)	-0.08 (0.13)	-0.73 (0.54)	-1.48** (0.65)	-0.93 (0.62)	-0.43*** (0.03)
	Medeb	-0.52*** (0.04)	-0.10 (0.09)	-0.26 (0.21)	-0.47 (1.72)	-0.38 (1.66)	

Notes ; Local units as specified in Table 1b; ME = measurement error, QE = quality effect (adjustment); 1.) Asymptotic Standard errors in the columns (4) to (6) have been estimated using the Delta Method. 2.) Coefficients with *** are significant at 1%; with ** at 5% and with * at 10% levels.

Examining column (1), which imposes the least structure on the estimation procedure, it will be observed that the estimated own price elasticities are all significantly negative, with plausible parameter estimates in both kilograms and local units. Equally important is that the estimated price elasticities are significantly different between purchases measured in kilograms and in local units (statistically different in all cases except pulses). Estimated price elasticities using average conversion factors (as in column 6) will ignore these variations in calculated elasticities across units and in some cases generate average elasticities that lie outside those estimated for individual units of measurement.[8] At first sight, it seems a puzzle as to why elasticities should diverge across units of measurement, and we return to this issue shortly.

Column (2) allows for self-selection of reporting units. Generally this adjustment lowers the calculated elasticities, with some exceptions such as lentils. The importance of selection therefore appears to lie in the calculation of the unit value and quantity equations, although we reiterate that, from column (1), estimates should be undertaken separately for kilograms and local units.

Columns (3) to (5) contain the extensions of the methodology suggested by Deaton (1988) in order to isolate prices, purged of quality variation and measurement error. In general, the inclusion of cluster fixed effects in column (3) has two main effects. First, it raises the elasticity effects in kilograms, albeit sometimes with loss of precision. Second, it reduces the significance of coefficients in local units (except split lentils) and in some cases reverses the sign. This pattern is broadly continued in to columns (4) and (5), with the measurement error and quality effect corrections raising the elasticities for commodities measured in kilograms, while the measures in local units generally lose significance. The results suggest that it is more important to adjust for measurement error than quality effects in the calculation of these reduced form elasticities (column (4) v. (5)), although, as we saw, there are significant quality effects in estimating unit values (Table 2a), which vindicates Deaton's (1988) approach.

In our view, a broad conclusion stems from these findings in columns (3) to (5). Where commodities are reported in an understood quantitative unit of measurement (i.e. metric units), the Deaton procedure 'works' and does indeed illustrate that we should condition calculated price elasticities on measurement and quality effects otherwise we are likely to bias the estimated coefficients. However, when commodities are reported in local units (as is common in our data set – see Table 1b), the Deaton procedure does not 'work' – quality, measurement and price effects cannot be separated out although, as column (1) of Table 4 suggests, there is a composite price elasticity that can be observed using a more simple approach. In this case of locally reported units, we infer,

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[8] Compare coffee, pulses and onions in column (6) with the estimates in column (1) but note, of course, that there are various additional adjustments obtained in arriving at the estimates in column (6).

markets operate differently. Where commodities are bought in units such as *medeb* ('heaps'), *sini* (cups), *birchiko* (glasses) and *tassa* (cans), buyers and sellers negotiate over quality *and* quantity for a discrete purchase, particularly if, as we have seen, buyers are selected into particular markets by household wealth and size. Thus the quantity bought at a given price in a cluster (which in the Deaton approach permits us to estimate quality effects) is not a fixed amount in a local market where bargaining takes place between traders – the 'price elasticities' calculated in column (1) for local units are a composite of quality and price effects. Since these local units of measurement are discrete containers and other items, it is impossible to deconstruct these separate quality and quantity effects when items are reported in local units of measurement.

5. Conclusion

This paper has focussed on the problem of estimating the parameters of reduced form demand equations in developing countries where information is provided on quantities purchased as well as expenditures. The particular issue of central concern here is where those quantities are reported in local units of measurement. We use data from a survey of urban households in Ethiopia to show that there is a wide variation in reporting units of measurement, and evidence that these reporting probabilities are non-random across household types. Therefore, we argued, quantity and unit value equations should be reported separately for different units of measurement and conditioned on self-selection of units, as should auxiliary parameter estimates, for example the reduced form own price elasticities constructed here using the Deaton (1988, 1997) procedures to condition out measurement error and quality variation. We show that these elasticities differ across reporting units. One reason that we infer for this finding is that bargaining over quality *and* quantity takes places in markets where local units of measurement predominate so that it is difficult in such markets to apply the Deaton procedure.

This suggests that a selective use of the Deaton procedure is appropriate where we are using self-reported data on units of measurement. The alternative, of course, is to suppress local information and to convert such information into identifiable units (to the researcher) before proceeding to more sophisticated estimation procedures. But this, too, induces biases (as in comparing columns (1) and (6) of Table 4) and loses information that may provide greater insight into the structure of markets that underpins reported expenditure patterns. There are trade-offs here, and our analysis suggests that retaining reported information and only using more complex modelling procedures where appropriate is a worthwhile strategy for understanding market heterogeneity and different means of price determination.

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4. Appendix

Table A1

Distribution of measurement units by commodity

Source: Compiled from *Ethiopia Urban Households Survey* (EUHS) 1994

(For definitions of these units of measurement, see Box 1, main text)

Cereals	Unit	%	No. of obs.
Teff	Kilograms	96.1	1172
	Quintals	1.2	30
	Tassa	0.6	8
	Kubaya	1.0	12
Barley	Kilograms	78.7	182
	Quintals	0.5	1
	Tassa	10.9	24
	Kubaya	4.1	12
	Birchiko	3.2	7
Wheat	Kilograms	87.2	600
	Tassa	5.2	37
	Kubaya	2.5	18
	Birchiko	2.1	15
Maize	Kilograms	81.3	325
	Tassa	9.0	36
	Kubaya	4.8	19
	Birchiko	4.9	20

Pulses, fruits and vegetables	Unit	%	No. of obs.
Lentils	Kilograms	69.8	269
	Tassa	11.9	48
	Kubaya	7.4	31
	Sini	2.1	5
	Plate	5.0	20
Onions	Kilograms	24.8	282
	Medeb	66.6	886
	Plate	2.0	26
	Tassa	2.6	31
Fruits	Kilograms	89.7	541
	Pieces	5.6	33
	Other	4.2	25
Vegetables	Kilograms	17.8	426
	Medeb	61.6	1475
	Esir	16.2	387
	Pieces	1.4	34
	Plate	0.8	18

Beverages and spices	Unit	%	No. of obs.
Salt	Kilograms	79.8	1042
	Tassa	9.0	118
	Sini	3.7	48
	Kubaya	3.1	40
	Birchiko	2.8	36
	Other	1.5	22
Coffee	Kilograms	57.0	685
	Sini	19.7	237
	Tikil	7.8	94
	Birchiko	6.0	73
	Other	9.6	116
Tea	Kilograms	8.9	47
	Packet	62.2	328
	Tikil	9.7	51
	Birchiko	7.0	37
	Sini	1.9	10
	Other	10.2	54
Sugar	Kilograms	81.2	763
	Tikil	6.6	62
	Sini	4.0	38
	Birchiko	2.7	25
	Other	5.5	41