

Korir, Lilian; Rizov, Marian; Ruto, Eric

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# Food security in Kenya: Insights from a household food demand model

Lilian Korir<sup>\*</sup>, Marian Rizov, Eric Ruto

Lincoln International Business School, University of Lincoln, Brayford Wharf East, Lincoln, LN5 7AT, UK



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## ABSTRACT

This paper evaluates the household food security situation in Kenya in terms of access to food. We apply a quadratic almost ideal demand system (QUAIDS) model to nationally representative household survey data from Kenya, and estimate and interpret price and expenditure elasticities as indicators of household sensitivity to market shocks. Our estimation results show positive expenditure elasticities, close to unity, while all compensated and uncompensated own-price elasticities are negative and smaller in magnitude. A complementary welfare analysis shows high compensated variations in the long run, ranging between 34% and 131% across food groups. This suggests that rising relative food costs have led to deterioration of the food security situation in Kenya, and the most severely affected households seem to be those that rely on informal markets and reside in rural areas. To improve food security, targeted income support could be a more effective policy than price support, given the much higher estimated expenditure elasticities.

## 1. Introduction

More than 10 million Kenyans (approximately 25% of the country's population) lack access to sufficient food in terms of quantity and quality, and are predominantly reliant on food aid at any given time of year (Sibhatu et al., 2015; FSIN, 2017). This inaccessibility of food is closely linked to loss of welfare and an increase in poverty incidences (WBG, 2018). The 2015/16 Kenya Integrated Household and Budget Survey (KIHBS) report demonstrates that a significant proportion of Kenyans are food insecure. The report also shows that the national food poverty headcount rate for individuals was 32%, which implies that around 14.5 million individuals were below the food poverty line.<sup>1</sup> Food poverty incidences are highest in rural areas, and represent 64.2% of those living below the food poverty line. Similarly, estimates from the Global Report on Food Crises (FSIN, 2017) show that the number of food-insecure people in Kenya increased significantly over a 10-year period, from 1.3 million in 2007 to 2.2 million in 2017. These figures justify why food security should be a priority when it comes to public policy.

Food availability has long received greater emphasis compared with other food security dimensions, such as access, stability, and utilization

(Pinstrup-Andersen, 2014). Moreover, numerous studies have focused on the supply capacity of food systems (for example Graham et al., 2007; Godfray and Garnett, 2014). Substantial efforts and resources have been spent on improving agricultural productivity and stimulating market access for smallholder producers (Khush et al., 2012; SDSN, 2013). However, less effort has been directed at investigating and attempting to remedy the challenges of demand, especially for populations vulnerable to food insecurity (the poor and rural). These challenges are associated with access and entitlement to food. Nobel laureate Amartya Sen (1981) famously wrote, "Starvation is the characteristic of some people not having enough food to eat. It is not the characteristic of there being not enough food to eat." Therefore, our paper's main contribution is in generating evidence from the demand side of the food system and providing policy-relevant insights into the household food security situation in Kenya and the African context overall.

Having a stable supply of and economic access to food is the most significant food security problem (Upton et al., 2016; Sibhatu et al., 2015). Concerns about inadequate food access have resulted in policies that focus on the income (expenditure) and prices that affect market demand by improving food access and food security, respectively (Yu

<sup>\*</sup> Corresponding author.

E-mail addresses: [likorir@lincoln.ac.uk](mailto:likorir@lincoln.ac.uk) (L. Korir), [mrizov@lincoln.ac.uk](mailto:mrizov@lincoln.ac.uk) (M. Rizov), [eruto@lincoln.ac.uk](mailto:eruto@lincoln.ac.uk) (E. Ruto).

<sup>1</sup> In practice, computing the poverty line involves several steps, starting with determining a caloric requirement, creating a food basket, and evaluating the cost of meeting the caloric requirement using that food basket. The cost of the basket is the food poverty line, which is used to determine the proportion of the population (i.e., the food poor) that is unable to meet their minimum basic food consumption needs (Greer and Thorbecke, 1986).

et al., 2004; Pinstrip-Andersen, 2014). Rizov et al. (2014) and Cupak et al. (2015) recognize that there is a close link between all dimensions of food security and indicators such as food price and expenditure elasticities, which contain information on the market equilibrium of supply and demand. Income influences the distribution of expenditure (Pieters et al., 2013) and food expenditure patterns (Kearney, 2010; Rizov et al., 2014). A report by the Food and Agriculture Organization of the United Nations (FAO, 2012) shows that higher food prices lead to higher levels of undernourishment. Assessing the sensitivity of a household to changes in prices and income, while taking into account the role played by policies and household demographics, is therefore important when analysing food security.

This paper contributes to the growing literature that examines how food security relates to households' consumption decisions and how prices, income, and demographics affect spending patterns.<sup>2</sup> Our analysis of food consumption pattern enables us to establish a population's food needs, along with the effects of income and prices. Furthermore, the measurement of food consumption and expenditure is a fundamental component of any analysis of welfare. However, an increase in household income does not necessarily mean that more of that income is spent on nutritious, health-enhancing food items. This is due, for example, to the persistence of lifestyle patterns, which are associated with heterogeneity in household characteristics (Alexandri et al., 2015; Bett et al., 2012; Ciaian et al., 2018; Regmi and Meade, 2013; Rischke et al., 2015). If the aim is to improve food security and promote a shift toward the consumption of more beneficial foods, such as those with higher nutritional value, controlling for household characteristics in food demand analysis can provide highly useful information that goes beyond the accessibility dimension.

In this paper, we focus on food demand in Kenya and apply a quadratic almost ideal demand system (QUAIDS) model to data from the Kenya Integrated Household Budget Survey (KIHBS), which is a nationally representative household survey. Price and income elasticity are estimated for five food groups to characterize heterogeneous households' demand behaviour. Price and income elasticity values are important, because they can inform relevant policies that seek to improve food security. Furthermore, the (Hicksian) price elasticity is an input in our welfare analysis. Since food pricing and income-related policies have the potential to improve the population's access to an adequate diet, our findings can directly inform government policies in developing an integrated strategy aimed at boosting both production (supply) and tackling food demand-oriented challenges associated with access to food.

The rest of the paper is organized as follows: Section 2 outlines the QUAIDS estimation framework; Section 3 describes the survey data and estimation strategy; Section 4 describes and discusses the empirical results, including welfare analysis of price changes; and Section 5 concludes.

## 2. Estimation framework: quadratic almost ideal demand system (QUAIDS)

Policy studies have identified that access to food is determined by the cost of food, willingness to pay, and household income (e.g., Westengen and Banik, 2016). These are the main components in the theoretical food demand function. Therefore, the demand system approach provides an effective method through which to consistently estimate demand characteristics by imposing and testing economic restrictions on individual behaviour. Several demand models have been applied in empirical studies. These include the Linear Expenditure System (LES) (Stone, 1954), the Rotterdam model (Barten, 1969), the Indirect Translog System (ITS) (Christensen et al., 1975), and the Almost Ideal Demand System

(AIDS) (Deaton and Muellbauer, 1980).<sup>3</sup> LES is unable to describe demand behaviour consistent with the Engel's law which states that as income increases a good's behaviour can change from normal to inferior. The Rotterdam model is consistent with demand theory; however, since it is not derived from specific utility or expenditure function, the model is inconsistent with utility maximising behaviour. It has the advantage of a flexible functional form but poses a major estimation problem due to a relatively large number of independent parameters. AIDS satisfies the restrictions of demand theory and its estimation is relatively more tractable.

Following Attanasio et al. (2013), we use the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997) which is an extension of AIDS. QUAIDS can approximate non-linear Engel curves often found in empirical estimations while AIDS only permits linearity. Thus, the flexible functional form feature of QUAIDS is an important advantage when analysing aggregate commodity groups often characterised by non-linear Engel curves.<sup>4</sup> For example, as household incomes rise, consumers demand not only more food, but also clothing, durables, recreation, and transportation. Differing income responses in terms of the quantity and quality demanded generate non-linear Engel curves.<sup>5</sup> Besides income, demographic characteristics, and prices are significant factors that impact upon the Engel curves of a household (Kumar et al., 2009; Li et al., 2015). Demographic variables can be specified and incorporated in QUAIDS using Ray (1983) method.

Based on Banks et al. (1997) and Attanasio et al. (2013), we specify our QUAIDS model as follows. Household preferences follow the indirect utility function:

$$\ln V = \left\{ \left[ \frac{\ln m - \ln a(p)}{b(p)} \right] + \lambda(p) \right\}^{-1}, \quad (1)$$

where the term  $[\ln m - \ln a(p)]/b(p)$  is the indirect utility function of the PIGLOG<sup>6</sup> demand system,  $m$  is household income, and  $a(p)$ ,  $b(p)$  and  $\lambda(p)$  are functions of the vector of prices  $p$ . To ensure the homogeneity property of the indirect utility function, it is required that  $a(p)$  is homogenous of degree one in  $p$ , and  $b(p)$  and  $\lambda(p)$  are homogenous of degree zero in  $p$ . The price index  $\ln a(p)$  has the usual translog form

$$\ln a(p) = \alpha_0 + \sum_j \alpha_j \ln p_j + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j,$$

$b(p)$  is a simple Cobb-Douglas price aggregator defined as

$$b(p) = \prod_i p_i^{\beta_i},$$

where  $\lambda(p)$  is defined as

<sup>3</sup> Examples of more recent applications of demand models are Duffy (2003), Cranfield et al. (2004), Cranfield and Pellow (2004), Yu et al. (2004), Filippini et al. (2009), and Clements and Gao (2015).

<sup>4</sup> A good alternative to QUAIDS is the EASI (Exact Affine Stone Index) demand system (Lewbel and Pendakur, 2009). EASI can be seen as a generalisation of the QUAIDS allowing for more flexibility in the relationship between income and consumption shares. Nevertheless, EASI has some limitations; theoretically, it relies on an affine transformation of the log of Stone-index deflated expenditures. Furthermore, the transformed expenditure are endogenous to the consumption shares which requires in estimations to resort to instrumental variables techniques, with all associated complications.

<sup>5</sup> It worth noting that analyses of (separable) food demand systems have often found non-linearity of Engel curves which however can usually be well approximated with quadratic function (e.g., Attanasio et al., 2013; Cupak et al., 2015; Li et al., 2015). Implementing the weak separability in EASI as an alternative approach in estimating a food demand system could be problematic considering the limitations outlined in the previous footnote.

<sup>6</sup> Demand with expenditure shares that are linear in log total expenditure alone is referred to as Price-Independent Generalised Logarithmic (PIGLOG).

<sup>2</sup> The analysis is particularly relevant to low income countries where food makes up the largest share of total household expenditure, accounting for, on average, around 50% of the household budget (e.g., Kumar et al., 2009).

$$\lambda(p) = \sum_i \lambda_i \ln p_i, \text{ Where } \sum_i \lambda_i = 0.$$

By applying Roy's identity to the indirect utility function, Equation (1), the budget shares in QUAIDS are derived as

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln \left[ \frac{m}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[ \frac{m}{a(p)} \right] \right\}^2. \quad (2)$$

For theoretical consistency and to reduce the number of parameters to be estimated adding-up, homogeneity and symmetry restrictions are commonly imposed. The fact that  $\sum_i \omega_i = 1$ , called the adding-up condition, requires that  $\sum_i \alpha_i = 1$ ,  $\sum_i \beta_i = 0$ ,  $\sum_i \lambda_i = 0$  and  $\sum_i \gamma_{ij} = 0 \forall j$ . Moreover, since demand functions are homogeneous of degree zero in  $(p, m)$ ,  $\sum_j \gamma_{ij} = 0 \forall j$ . And Slutsky symmetry implies that  $\gamma_{ij} = \gamma_{ji} \forall i \neq j$ . These conditions are trivially satisfied for a model with  $n$  goods when the estimation is carried out on a subset of  $n - 1$  independent equations. The parameters of the excluded equation are then computed from the restrictions and the estimated parameters of the  $n - 1$  expenditure shares.

Majority of previous studies extend the system with demographic variables following Pollak and Wales (1981) where the demographic effects shift the intercept  $\alpha_i$  in equation (2). However, we follow the scaling approach introduced by Ray (1983) which has been implemented by Poi (2012) into *quaid*s and by Lecocq and Robin (2015) into *aids*ills. This approach has the advantage of having strong theoretical foundations and generating expenditure share equations that closely mimic their counterparts without demographics. For each household the expenditure function  $e(p, z, u)$ , underlying the budget shares is written as expenditure function of a reference household  $e^R(p, u)$ , scaled by the function  $m_0(p, z, u) = \bar{m}_0(z)\phi(p, z, u)$  to account for the household characteristics where  $z$  represents a vector of  $s$  characteristics and  $u$  is direct utility. The first term of  $m_0$ ,  $(\bar{m}_0(z))$  measures the increase in a household's expenditures as a function of  $z$ , not controlling for any differences in consumption patterns. The second term  $(\phi(p, z, u))$  controls for differences in relative prices and the actual goods consumed. For example, a household with two adults and two infants will consume different goods than one comprising four adults.

Furthermore, we extend vector  $z$  with a food expenditure control, the rationale for which is the following. In estimating a (weakly separable) food demand system the assumption is that the consumer's utility maximisation decision can be decomposed into two separate stages where in the first stage, the allocation of total expenditure between food and other commodity groups (housing, transport, entertainment, etc.) is decided. In the second stage, the food expenditure is allocated among different food groups.<sup>7</sup> The price and expenditure elasticities obtained from such a two-stage budgeting process are conditional elasticities in the sense that a second-stage conditional demand system is estimated. To obtain

<sup>7</sup> As in Attanasio et al. (2013) we assume separability of demand for food considering that in the context of Kenya food represents more than 50% of total household expenditure. Assumptions of (weak) separability are a common feature of analyses of food demand; as noted in Edgerton (1997), many studies of components of food demand assume separability with other types of food. Furthermore, the assumption about (weak) separability of the food expenditure decision from other expenditure choices can be motivated by Maslow (1943) hierarchy of needs theory where substitutability between goods in different groups is limited (Rizov et al., 2014). Thus, we note that assuming separability leads to modelling the demand for food commodities as a function of food expenditure, rather than total expenditure (Okrent and Alston, 2011).

<sup>8</sup> There are problems with the first stage allocation since it is not possible to replace the prices of the goods in a group with a single price index without imposing restrictive conditions (Gorman, 1959). Edgerton (1997) shows that under weak separability of preferences and price index for each group that is not too sensitive to changes in the utility function, the two-stage budgeting process leads to approximately correct budget allocation.

unconditional elasticity estimates correction for the first stage budgeting decision is needed.<sup>8</sup> Given data limitation and the fact that structured two-stage budget allocation offers only an approximation under restrictive conditions, we opt for a reduced form single-stage specification, where besides standard demographic variables, the share of food expenditure in the total household budget is also added to vector  $z$ . The addition of the share of food expenditure in the total budget as a control in the budget share equation offers an alternative approximation of the budgeting process that is consistent with the weak separability assumption and its implications for the Slutsky substitution term (Okrent and Alston, 2011, p.12).

The budget share equation (2) augmented with vector  $z$  becomes:

$$\omega_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + (\beta_i + \eta'_j z) \ln \left[ \frac{m}{\bar{m}_0(z)a(p)} \right] + \frac{\lambda_i}{b(p)c(p, z)} \left\{ \ln \left[ \frac{m}{\bar{m}_0(z)a(p)} \right] \right\}^2, \quad (3)$$

where  $c(p, z) = \prod_j p_j^{\eta_{ij}^z}$ ,  $\eta_{ij}^z$  represents the  $j$ th column of parameter matrix  $\eta$ .

The adding-up condition requires that  $\sum_j \eta_{sj} = 0 \forall s$ .

Following Banks et al. (1997) the expenditure and price elasticities are obtained by partially differentiating Equation (3) with respect to  $\ln m$  and  $\ln p_j$  respectively:

$$\mu_i \equiv \frac{\partial \omega_i}{\partial \ln m} = \beta_i + \eta'_i z + \frac{2\lambda_i}{b(p)c(p, z)} \ln \left[ \frac{m}{\bar{m}_0(z)a(p)} \right] \text{ and} \quad (4)$$

$$\mu_{ij} \equiv \frac{\partial \omega_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left( \alpha_j + \sum_k \gamma_{jk} \ln p_k \right) - \frac{\lambda_i (\beta_j + \eta'_j z)}{b(p)c(p, z)} \left\{ \ln \left[ \frac{m}{\bar{m}_0(z)a(p)} \right] \right\}^2. \quad (5)$$

Then the expenditure and the uncompensated price elasticities are computed as  $e_i = \mu_i / \omega_i + 1$  and  $e_{ij}^u = \mu_{ij} / \omega_i - \delta_{ij}$  respectively;  $\delta_{ij}$  represents Kronecker delta taking value 1 if  $i=j$  and 0 otherwise. Using the Slutsky equation, we can finally compute the compensated price elasticities:  $e_{ij}^c = e_{ij}^u + e_i \omega_j$ .

### 3. Data and estimation strategy

We use data from the Kenya Integrated Household Budget Survey (KIHBS), a Kenya government funded household survey implemented by the Kenya National Bureau of Statistics (KNBS). The KIHBS is a comprehensive household survey implemented every ten years in Kenya, covering a nationally representative sample of 13,430 households in 2005/06 and 24,000 households in 2015/16. The key objectives of KIHBS are to update measures of living standards, the Consumer Price Index (CPI), and the System of National Accounts (SNA). The KIHBS samples are drawn from the National Sample Survey and Evaluation Programme (NASSEP) household sampling frame. The frame consists of clusters split into four equal sub-samples. The frame is stratified into urban and rural areas within each of the 47 administrative counties (formally referred to as districts in 2005/6), resulting in 92 sampling strata as the counties of Nairobi City and Mombasa are wholly urban. The sample size is determined independently for each county, resulting in a national sample.

The KIHBS questionnaire collects recalled information on the quantities consumed for each of the food components over a one-week period. The food quantities consumed are valued using reported unit prices from purchases, along with locally representative prices obtained from the daily purchase diaries, completed by each household over a week period. As discussed in Attanasio et al. (2013), two issues arise while using reported unit prices - endogeneity and measurement errors - and this has been tackled by calculating aggregate prices adjusting for measurement



units (Capéau and Dercon, 1998) and adjusting for price variations due to quality differences (Cox and Wohlgemant, 1986). Details on the procedures are available on request. Another issue pertaining to the variation of prices due to inflation was addressed using CPI as the price deflator to generate real prices.<sup>9</sup> Overall the KIHBS data comprise over 276,000 observations of over 140 distinct food items that were reportedly consumed.

For the current analysis, the food items were grouped into five food groups: 1. Cereal, bread, and pulses, 2. Dairy products, 3. Meat and fish, 4. Fruit and vegetables, bananas, and tuber, and 5. Essential condiments.<sup>10</sup> Details on the food group composition are available on request. Unfortunately, economic theory does not provide any guidance on the number or composition of aggregated food groups. The construction of the food groups used in this analysis was influenced partially by previous studies on food demand (e.g., Attanasio et al., 2013) and by a classification reflecting the similarity (substitutability) of food items from a consumer's viewpoint.<sup>11</sup>

The demographic variables used in the estimations include household size, ratio of food expenditure, the ratio of own consumption from self-production (auto-consumption) for each food group, and dummy variable for rural and urban location, in order to capture factors that were not explained by both changes in prices and income and other factors that could contribute to heterogeneity in food demand elasticities. Household expenditure is commonly used as a proxy of income because household-reported income is generally regarded as unreliable, particularly in developing countries where self-employment is prevalent (Deaton, 1997; Jones et al., 2013). We address the endogeneity of expenditure concerns (Dhar et al., 2003) using Lecocq and Robin (2015) *aidsills* estimator, which utilises augmented regression technique proposed by Blundell and Robin (1999). As an instrument we use the total household income alongside demographic variables.

We aim to estimate the price and expenditure elasticities at a household level, characterising the sensitivity of households to market shocks and thus establishing the degree of a households' constraint to access food. Furthermore, we use the compensated (Hicksian) own-price elasticity in our welfare analysis of price changes. In this paper, we start by estimating Engel curves for the five food groups using non-parametric Kernel regression following Fan (1992) and Banks et al. (1997). Analysis of the shapes of the Engel curves is available on request. They are non-linear (approximately quadratic) and depict a positive relationship for the majority of the staple food items, suggesting that they are normal goods. However, essential condiments and meat and fish show a pattern, suggesting that these food groups are perceived as luxury items. Goods are considered to be luxury items when a 1% change in income results in demand change greater than 1% (Regmi and Meade, 2013). This preliminary analysis suggests that our choice of QUAIDS for estimating food demand behaviours in Kenya is justified. It is important first to examine the expenditure share equations before imposing functional forms on the empirical analysis (Abdulai and Aubert, 2004; Rizov et al., 2014).<sup>12</sup>

Next, a propensity score matching (PSM) exercise was performed to

**Table 1**

Summary table of sample characteristics for datasets 2005/06 and 2015/16.

Variable	2005/06		2015/2016	
	Mean	SE	Mean	SE
Female headed household	0.29	[0.00]	0.33	[0.00]
Age of household head in years	44.88	[0.14]	44.64	[0.29]
Christian households	0.86	[0.00]	0.90	[0.00]
Married household head	0.26	[0.00]	0.30	[0.00]
Rural	0.76	[0.00]	0.56	[0.00]
Household size	5.02	[0.02]	3.91	[0.01]
Ratio of food expenditure	0.53	[0.00]	0.64	[0.00]
Ratio of auto-consumption (subsistence)	0.19	[0.00]	0.24	[0.00]
Total food expenditure	1133.51	[4.92]	1016.85	[3.29]
Price of cereal & bread	46.56	[0.16]	53.12	[0.15]
Price of dairy products	24.33	[0.19]	51.99	[0.37]
Price of meat & fish	94.19	[0.73]	193.54	[0.64]
Price of fruit & vegetables	18.63	[0.15]	42.95	[0.16]
Price of essential condiments	57.96	[0.33]	117.36	[0.30]
Expenditure share on cereal & bread	0.34	[0.00]	0.35	[0.00]
Expenditure share on dairy products	0.11	[0.00]	0.13	[0.00]
Expenditure share on meat & fish	0.08	[0.00]	0.10	[0.00]
Expenditure share on fruit & vegetables	0.26	[0.00]	0.25	[0.00]
Expenditure share on essential condiments	0.21	[0.00]	0.18	[0.00]
No	12,208		21,155	

ensure that the characteristics of the households from the two cross sectional data sets are comparable. The basic idea behind the PSM is to match each participant of the 2005/6 dataset with an identical participant from the 2015/16 data. Following previous studies (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002; Heckman et al., 1998; Caliendo and Kopeing, 2005; Smith and Todd, 2005), we employed PSM procedure. This is important in order to reduce bias by matching households based on observable covariates. Rosenbaum and Rubin (1983), Dehejia and Wahba (2002), and Diprete and Gangl (2004) emphasise that the crucial issue is to ensure that the balancing condition is satisfied because it reduces the influence of confounding variables.

The summary statistics in Table 1 indicate that the datasets from the two matched waves are not (statistically) different, in terms of structural characteristics, and hence they can be compared. The households have an average of five family members. Around 35% of the households are in urban areas and 65% in the rural areas. The nominal food consumption aggregate for each household is computed from sources listed in KIHBS data as follows: purchases (i03), consumption from purchases (i04), consumption from own production (i05), consumption from own stock (i05A), and consumption from gifts (i06). For each food item, as in Attanasio et al. (2013), the quantity of consumption from purchases, is valued using the inferred (unit) prices by taking the ratio of the reported value of purchases over the quantity of purchases.

From the summary statistics in Table 1, households headed by females are slightly more in 2015/16, increasing by 4% compared to 2005/06. Rural households decreased from 76% in 2005/06 to 66% in 2015/16, while household size was down by 1%. The ratio of food expenditure increased from 53% to 64% in 2015/16, while ratio of auto-consumption increased from 19% to 24%. The prices were very different for some food products and this may explain the results of the elasticities. For example, the price of cereals and bread increased from KES46.56 to KES53.12. The other food groups had even higher increases. Meat and fish had the highest ten-year increase, from KES94.19 in 2005/06 to KES193.54 in 2015/16, while fruit and vegetables rose from KES18.63 to KES42.95 which constituted the highest rate of increase. The large increase in prices can be attributed to the rise in global food prices (e.g., Attanasio

<sup>9</sup> CPI is the most appropriate aggregate deflator for demand analysis. Disaggregated food groups CPIs could be a better alternative if available but these are not available to us. Producer price deflators are less relevant to analysis of consumption and demand.

<sup>10</sup> Food consumed away from home is excluded. Although food away from home consumption has gain importance, it is widely recognized that food away from home is subject to considerable measurement error.

<sup>11</sup> One advantageous feature of our food group structure is that we do not face the problem of non-negligible censoring levels (Yen and Lin, 2006). In our study the zero observations did not exceed 2% for each individual food group.

<sup>12</sup> Furthermore, at the demand system estimation stage, we use the Engel curves to test the robustness and reliability of our demand analysis: we compare the actual and estimated consumption share Engel curves by the means of Kolmogorov-Smirnov stochastic dominance test and find that the two sets of curves are not statistically different.

et al., 2013) and the prolonged drought locally which affected agricultural output and led to severe famine in some parts of the country.<sup>13</sup> Expenditure shares on the other hand remained stable, apart from a few differences. Consumption shares in the basket were as follows: cereals and bread increased slightly from 34% to 35%, dairy products increased from 11% to 13%, meat and fish increased from 8% to 10%, fruit and vegetables decreased from 26% to 25%, and lastly essential condiments decreased from 21% to 18%.

#### 4. Estimation results and welfare analysis

The principal goal of the paper is to analyse the effects of income and prices on household food consumption behaviour and welfare. The analysis uses two cross-sectional datasets - 2005/06 and 2015/16. The idea behind such a comparative study is to establish if there are any major changes in demand over the ten-year period between the two survey waves. We use the price and expenditure elasticity matrix to compare the magnitudes between the two cross-sections as well as the change in household welfare. We find that in the ten-year period elasticities have generally increased. Therefore, the population appears to have become more sensitive to income and price changes which could be taken as evidence of deteriorating food security status of the households. A further evidence in support of our conclusion is the loss of welfare due to price increases over the period of analysis. However, our findings could not be attributed directly to any one policy but rather to the general food policy approach. Therefore, we review key policies implemented in Kenya during the period to provide a basis for evaluation and rethinking of those policies.

In the next two subsections we report the elasticities for (i) the whole sample (Tables 2 and 3) and (ii) by subsamples of rural and urban households, while considering low subsistence-dependant households vs. high subsistence-dependant households (Tables 4–9). These are followed by welfare analysis of price changes for the rural and urban subsamples, and by food group. The demand (and welfare) analysis results are obtained while controlling for household demographic and other characteristics; the details concerning this aspect of the analysis are available on request.

##### 4.1. Whole sample elasticities

Tables 2 and 3 report expenditure elasticity and compensated and uncompensated price elasticity estimates from the QUAIDS analysis for the 2005/06 and 2015/16 KIBHS data respectively. The expenditure elasticities of all food groups are positive, with magnitudes ranging between 0.90 to 1.13 and 0.87 to 1.34 in 2005/06 and 2015/16 respectively. The estimates show that meat and fish, and fruit and vegetables groups are expenditure (income) elastic and are therefore considered to be luxuries. This means that the change in income has a higher effect on the quantities consumed of meat and fish and fruit and vegetables. For example, if income decreases, households are likely to reduce more consumption of the items in these food groups. It may be expected that Kenyan households would be meat and fish elastic, but somewhat unexpected when it comes to fruit and vegetables. This is because vegetables are mostly consumed alongside the staple food items found in the cereals and bread group, unless the impact is due to the fruits. Since fruits tend to be expensive during a part of the year.<sup>14</sup> Cereals and bread, dairy products, and essential condiments are expenditure inelastic, and

<sup>13</sup> In Kenya the agriculture sector growth has suffered from high input prices and mixed weather conditions. In particular, the production of major cereals, maize and wheat, as well as the export commodities coffee and tea, have been adversely affected (WBG, 2018).

<sup>14</sup> Fruit and vegetables are typically considered high value products. Studies have indicated that consumer expenditures on fresh fruits and vegetables tend to rise when income levels rise (Regmi and Meade, 2013).

**Table 2**

Summary of elasticities for the whole sample, 2005/06.

Whole sample	Cereal & bread	Dairy products	Meat & fish	Fruit & vegetables	Essential condiments
Expenditure Elasticity	0.94	0.97	<b>1.13</b>	<b>1.12</b>	0.90
Compensated					
Cereal & bread	<b>−0.44</b>	0.05	0.05	0.17	0.18
Dairy products	0.16	<b>−0.58</b>	0.06	0.17	0.19
Meat & fish	0.20	0.08	<b>−0.66</b>	0.23	0.16
Fruit & vegetables	0.24	0.08	0.08	<b>−0.57</b>	0.18
Essential condiments	0.28	0.09	0.06	0.19	<b>−0.62</b>
Uncompensated					
Cereal & bread	<b>−0.76</b>	−0.05	−0.03	−0.06	−0.03
Dairy products	−0.18	<b>−0.69</b>	−0.02	−0.06	−0.02
Meat & fish	−0.19	−0.04	<b>−0.76</b>	−0.04	−0.09
Fruit & vegetables	−0.16	−0.05	−0.02	<b>−0.85</b>	−0.08
Essential condiments	−0.04	0.00	−0.02	−0.02	<b>−0.82</b>

Note: In bold, are the compensated and uncompensated own-price elasticities.

**Table 3**

Summary of elasticities for the whole sample, 2015/16.

Whole sample	Cereal & bread	Dairy products	Meat & fish	Fruit & vegetables	Essential condiments
Expenditure Elasticity	0.97	0.96	<b>1.34</b>	<b>1.14</b>	0.87
Compensated					
Cereal & bread	<b>−0.47</b>	0.08	0.00	0.17	0.22
Dairy products	0.25	<b>−0.69</b>	0.12	0.19	0.13
Meat & fish	0.01	0.17	<b>−0.70</b>	0.25	0.06
Fruit & vegetables	0.27	0.10	0.10	<b>−0.58</b>	0.11
Essential condiments	0.40	0.08	0.03	0.14	<b>−0.65</b>
Uncompensated					
Cereal & bread	<b>−0.83</b>	−0.04	−0.08	−0.05	0.03
Dairy products	−0.10	<b>−0.81</b>	0.04	−0.03	−0.05
Meat & fish	−0.48	0.00	<b>−0.81</b>	−0.06	−0.20
Fruit & vegetables	−0.14	−0.04	0.00	<b>−0.84</b>	−0.10
Essential condiments	0.12	−0.01	−0.04	−0.04	<b>−0.82</b>

Note: In bold, are the compensated and uncompensated own-price elasticities.

**Table 4**

Expenditure elasticities for rural-urban and level of subsistence, 2005/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit & Vegetables	Essential condiments
Rural & high subsistence level	0.93	0.95	<b>1.17</b>	<b>1.14</b>	0.91
Urban & high subsistence level	0.94	0.90	<b>1.10</b>	<b>1.08</b>	0.92
Rural & low subsistence level	0.94	<b>1.03</b>	<b>1.19</b>	<b>1.25</b>	0.91
Urban & low subsistence level	0.95	0.97	<b>1.13</b>	<b>1.12</b>	0.92

**Table 5**

Compensated price elasticities for rural-urban and high subsistence level, 2005/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit &Vegetables	Essential condiments
Rural					
Cereal & bread	<b>−0.42</b>	0.03	0.03	0.09	0.26
Dairy products	0.16	<b>−0.51</b>	0.03	0.04	0.28
Meat & fish	0.21	0.04	<b>−0.61</b>	0.12	0.24
Fruit &Vegetables	0.24	0.03	0.05	<b>−0.57</b>	0.26
Essential condiments	0.34	0.07	0.05	0.13	<b>−0.59</b>
Urban					
Cereal & bread	<b>−0.45</b>	0.05	0.05	0.18	0.17
Dairy products	0.14	<b>−0.60</b>	0.07	0.20	0.19
Meat & fish	0.17	0.09	<b>−0.67</b>	0.26	0.16
Fruit &Vegetables	0.21	0.09	0.09	<b>−0.60</b>	0.18
Essential condiments	0.25	0.10	0.06	0.21	<b>−0.62</b>

**Table 6**

Compensated price elasticities for rural-urban and low subsistence level, 2005/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit &Vegetables	Essential condiments
Rural					
Cereal & bread	<b>−0.44</b>	0.08	0.04	0.16	0.16
Dairy products	0.19	<b>−0.53</b>	0.06	0.19	0.19
Meat & fish	0.17	0.12	<b>−0.64</b>	0.22	0.14
Fruit &Vegetables	0.23	0.12	0.07	<b>−0.57</b>	0.16
Essential condiments	0.27	0.13	0.05	0.19	<b>−0.62</b>
Urban					
Cereal & bread	<b>−0.45</b>	0.06	0.05	0.23	0.11
Dairy products	0.12	<b>−0.62</b>	0.08	0.28	0.13
Meat & fish	0.15	0.11	<b>−0.68</b>	0.32	0.10
Fruit &Vegetables	0.20	0.11	0.09	<b>−0.62</b>	0.12
Essential condiments	0.21	0.11	0.06	0.25	<b>−0.62</b>

**Table 7**

Expenditure elasticities for rural-urban and level on subsistence, 2015/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit &Vegetables	Essential condiments
Rural & high subsistence level	0.97	0.95	<b>1.40</b>	<b>1.12</b>	0.77
Urban & high subsistence level	0.98	0.92	<b>1.23</b>	<b>1.08</b>	0.78
Rural & low subsistence level	0.97	0.98	<b>1.47</b>	<b>1.20</b>	0.82
Urban & low subsistence level	0.98	0.97	<b>1.40</b>	<b>1.12</b>	0.80

considered to be normal goods with positive elasticities of less than one.

All compensated (Hicksian) own-price elasticities show the expected negative signs and are below unity, thus showing that household

responses are price inelastic i.e., households are less affected by price changes. Compensated own price elasticity estimates range from  $-0.44$  to  $-0.66$  in 2005/06 period, and between  $-0.47$  and  $-0.70$  in 2015/16 period. The 2015/16 data seems to show higher elasticities than 2005/06. This could be attributed to the increase in food prices over time, while incomes have not increased in equal measure. Uncompensated (Marshallian) own-price elasticity estimates are generally larger; with values ranging between  $-0.69$  and  $-0.85$  and  $-0.81$  to  $-0.84$  in 2005/06 and 2015/16 period.

The lower magnitude of the own-price elasticities may also be related to the relative importance of the food items. Cereal and bread are staple foods and are frequently consumed by majority of households; grains represent on average 35% of household food expenditure. Our estimates show that this group has the lowest Hicksian elasticity values: 0.44 and 0.47 in 2005/6 and 2015/16 respectively. Meat and fish could be regarded as high-value foods and therefore could be unaffordable for the majority of households. Our estimates show that this group has the highest Hicksian elasticity - 0.66 in 2005/6 and 0.70 in 2015/16.

The compensated cross-price elasticities provide information on substitutions between commodity groups, as they are a measure of the

**Table 8**

Compensated price elasticities for rural-urban and high subsistence level, 2015/6.

	Cereal & bread	Dairy products	Meat & Fish	Fruit &Vegetables	Essential condiments
Rural					
Cereal & bread	<b>−0.47</b>	0.12	$-0.01$	0.18	0.19
Dairy products	0.28	<b>−0.60</b>	0.10	0.20	0.12
Meat & fish	$-0.08$	0.23	<b>−0.61</b>	0.26	0.00
Fruit &Vegetables	0.28	0.14	0.08	<b>−0.58</b>	0.09
Essential condiments	0.41	0.11	0.00	0.12	<b>−0.63</b>
Urban					
Cereal & bread	<b>−0.48</b>	0.09	$-0.01$	0.20	0.19
Dairy products	0.25	<b>−0.69</b>	0.11	0.23	0.10
Meat & fish	$-0.05$	0.18	<b>−0.65</b>	0.31	0.01
Fruit &Vegetables	0.27	0.11	0.09	<b>−0.66</b>	0.09
Essential condiments	0.41	0.09	0.00	0.14	<b>−0.64</b>

**Table 9**

Compensated price elasticities for rural-urban and low subsistence level, 2015/6.

	Cereal & bread	Dairy products	Meat & Fish	Fruit &Vegetables	Essential condiments
Rural					
Cereal & bread	−0.47	0.05	−0.01	0.11	0.30
Dairy products	0.24	−0.64	0.10	0.10	0.20
Meat & fish	−0.07	0.13	−0.67	0.17	0.14
Fruit &Vegetables	0.28	0.05	0.07	−0.59	0.19
Essential condiments	0.43	0.06	0.03	0.11	−0.63
Urban					
Cereal & bread	−0.49	0.08	0.02	0.16	0.22
Dairy products	0.22	−0.69	0.14	0.19	0.14
Meat & fish	0.05	0.16	−0.70	0.25	0.09
Fruit &Vegetables	0.23	0.11	0.12	−0.68	0.12
Essential condiments	0.38	0.09	0.05	0.14	−0.66

substitution effects net of income. The fact that the signs of some compensated elasticities are different from those of uncompensated elasticities suggests that income effects are significant in affecting consumer demand decisions.

#### 4.2. Subsample elasticities

The food consumption of rural and urban households in Kenya differs and it is further significantly affected by the level of subsistence. Therefore, we discuss findings for four types of household: (i) rural with high subsistence level, (ii) rural with low subsistence level (iii) urban with high subsistence level, and (iv) urban with low subsistence level.<sup>15</sup> Thus, the four types represent households that differ by their location as well as by their reliance on formal/informal market for their food purchase. These groupings highlight systematic differences between the rural and urban households; results for only rural versus urban household type demonstrate similar but less pronounced patterns and are available on request. Generally, those households that are heavily reliant on subsistent consumption (and production) are expected to be less affected by changes in market prices as compared to those actively involved in the formal market. These results could inform policy of building capacity in the informal economy (Sibhatu et al., 2015).

Tables 4–6 present expenditure and Hicksian elasticities for 2005/06 samples; the results for Marshallian elasticities are available on request. The results show that rural households are more responsive to income (expenditure) changes and less sensitive to price changes when compared to urban households. The systematic differences in expenditure elasticities are most pronounced for the dairy products, meat and fish, and fruit and vegetables food groups with expenditure elasticity ranging between 0.91 and 1.25 for rural households and between 0.90 and 1.13 for urban households. When considering the level of subsistence, and reliance on formal/informal markets, as expected, high-subsistence households are less sensitive to price changes than the less-subsistence households. The Hicksian elasticities are the highest in magnitude for urban, low-subsistence households and range between −0.45 and −0.68, while they are the lowest in magnitude for rural high-subsistence household and range between −0.42 and −0.61. The cross-price elasticities are generally positive, indicating that the food groups are correctly defined.

Tables 7–9 present expenditure and Hicksian elasticities for analogous 2015/16 samples as the results for Marshallian elasticities are again available on request. The results confirm that rural households are more

responsive to income (expenditure) changes and less sensitive to price changes when compared to urban households. Importantly, the magnitudes of large majority of elasticities estimated from the 2015/16 samples are higher than corresponding elasticities from 2005/06 samples, exception being the expenditure elasticities of essential condiments which have declined over the period of analysis. The systematic differences in expenditure elasticities are again most pronounced for the dairy products, meat and fish, and fruit and vegetables food groups with expenditure elasticity ranging between 0.77 and 1.47 for rural households and − between 0.78 and 1.40 for urban households. When considering the level of subsistence, and reliance on formal/informal markets, again, high-subsistence households are less sensitive to price changes than the less-subsistence households. The Hicksian elasticities are the highest in magnitude for urban, low-subsistence households and range between −0.49 and −0.70, while they are the lowest in magnitude for rural high-subsistence household and range between −0.47 and −0.63.

#### 4.3. Welfare analysis

Alongside the expenditure and price elasticities, which provide important insights for the food security situation of the Kenyan households, we next study the welfare effects due to price changes - actual and simulated - over the period of analysis. As common in the literature, our measure of the welfare effect of a price change is the compensated variation (CV): the amount of income that needs to be given to a household to make them indifferent between the old price vector (and original income) and the new price vector. Hence, the money needed to maintain the initial level of household utility given a change in prices can be expressed as:

$$CV = e(p_1, u_0) - e(p_0, u_0),$$

where  $e(\cdot)$  is the expenditure function,  $p$  is the price vector, with  $p_1$  and  $p_0$  are respectively prices after and before the price change, and  $u_0$  is the initial utility. Friedman and Levinsohn (2002) show that  $e(p_1, u_0)$  can be approximated by a second-order Taylor expansion and when only the prices of the food group of interest changes while all other food group prices are fixed, CV can be expressed as:

$$\frac{CV}{x_0} \cong CR \frac{\Delta p}{p_0} + \frac{1}{2} \varepsilon_d CR \left( \frac{\Delta p}{p_0} \right)^2, \quad (6)$$

where

$$CR = \frac{p_0 \cdot q(p_0, u_0)}{x_0}$$

is the consumption ratio defined as the proportion of the budget allocated to the food group consumption relative to the household (food) expenditure  $x_0$ ;  $p_0$ ,  $q$ , and  $\varepsilon_d$  are the price, the quantity demanded, and the Hicksian own-price elasticity for a given food group respectively. The CV

<sup>15</sup> The two sub-types, with low subsistence level and with high subsistence level, are defined as the households that are highly dependent on the formal market (high income and low subsistence dependency) and those that are highly dependent on the informal market (low income and high dependency on subsistence) respectively. In formal markets, we assume sellers can publicly advertise their prices, whereas in informal markets, sellers need to trade through mutual bargaining of prices and transactions are not always formally recognized.



in equation (6) is deflated by the initial (food) expenditure  $x_0$  so that the compensated money metric entails a constant utility when food prices change. If we ignore the last term in equation (6) which represents substitution effect, a short-term or income effect only is estimated. Hence, economic welfare changes for the consumer can be measured only by the information of price and budget shares.

The results of the welfare analysis are reported in Tables 10 and 11 for the full sample, rural-urban subsamples, and by further subsamples, considering level of subsistence. Across the five food groups the short-run welfare losses over the period of analysis, between 2005/6 and 2015/6, range from 41%, in the case of meat and fish to 177%, in the case of fruit and vegetables as the average loss is around 96%. The results suggest that the welfare losses are relatively larger in the rural areas ranging over food groups between 47% and 182% respectively. When in addition we consider the level of subsistence, there is a tendency of larger welfare losses in the high-subsistence subsamples, with the highest losses in the rural areas as high as 220%. The welfare losses decline quite substantially in the long-run, when households are allowed to substitute with relatively cheap food groups and range between 34%, in the case of meat and fish and 131%, in the case of fruit and vegetables. Our general finding that welfare losses are larger in rural areas and for high-subsistence subsamples holds also in the long-run.

Our findings for the magnitude of welfare losses are in line with previous studies, which have expressed CV as a proportion of the initial food expenditure as we do. Akbari et al. (2013) study of Iranian urban households, between 2009/10 and 2011/12 finds that the average first-order (short-run) effect as a proportion of household food expenditure is 51%. It is also noteworthy that some studies report a very high CV even when the deflation is based on initial total household expenditure. For example, Friedman and Levinsohn (2002) analysing the impact of post-1996 Indonesian economic crisis on household welfare, estimate a first-order CV between 73% and 85% with a reference to pre-crisis total expenditure.

#### 4.4. Linking estimation results to food policy in Kenya

Our demand and welfare analyses demonstrate that for food groups such as dairy, meat and fish, and fruit and vegetables which are important for the quality of diet, availability and access had declined, and thus the overall food security situation of the population has deteriorated, over the 2005/6–2015/6 period. While there are a variety of factors that could have contributed to worsening of the food security in Kenya, we argue that inconsistent food policy had played an important role.

The government of Kenya had predominantly adopted food-price response policies over the period of analysis to support food security needs. As shown in Table 12, the government has widely utilised various supply-side policies such as subsidies and price support and some demand-side policies such as food safety nets and tax reductions (Pinstrup-Andersen, 2014). Table 12 also provides a timeline of the policy interventions; importantly, some of the measures existed prior to the period of analysis but were further scaled up, intensified, and extended to a broader range of beneficiaries. For example, with the intension to support consumers, the government provided a subsidy to maize millers, bringing down the consumer retail price of maize (IFPRI, 2012; AGRA, 2018). This policy was introduced in 2009 in an attempt to mitigate the effects of staple food shortages. Although the policy bill was passed in 2009 and repeatedly reinforced in 2010, 2011, and onwards, it has never been fully implemented (MAFAP, 2013). Thus, besides the design and targeting of policies there had been also problems with implementation.

Supply-side policies that had dominated and favoured the producers are characterised by the strong presence and control of the government, which sets, among other things, the producers' input prices. A prominent example of such type of policy is the price stabilization and producer support prices for maize which is realised through four main actions: (i) imports by the National Cereals and Produce Board (NCPB) for strategic grain reserves (in 2008 the Board was authorised to import three million

**Table 10**

Short term CV due to change in food group prices, 2005/6–2015/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit & Vegetables	Essential condiments
1. Full sample	0.76	0.54	0.41	1.77	0.78
2. Rural	0.88	0.55	0.47	1.82	0.79
Urban	0.59	0.53	0.36	1.71	0.77
3. Rural, low subsistence	0.85	0.63	0.39	1.06	0.82
Urban, low subsistence	0.48	0.43	0.30	0.88	0.70
Rural, high subsistence	0.83	0.71	0.58	2.13	0.82
Urban, high subsistence	0.65	0.68	0.47	2.20	0.92

**Table 11**

Long term CV due to change in food group prices, 2005/6–2015/6.

	Cereal & Bread	Dairy products	Meat & Fish	Fruit & Vegetables	Essential condiments
1. Full sample	0.68	0.42	0.34	1.31	0.60
2. Rural	0.79	0.43	0.38	1.38	0.61
Urban	0.53	0.41	0.30	1.22	0.58
3. Rural, low subsistence	0.58	0.34	0.31	0.76	0.64
Urban, low subsistence	0.44	0.48	0.24	0.60	0.53
Rural, high subsistence	0.74	0.55	0.48	1.61	0.68
Urban, high subsistence	0.76	0.51	0.37	1.56	0.54

90 kg-bags of maize); (ii) supply of maize to millers at fixed prices (in 2008 the price was fixed at KES1,700 per bag, equivalent to a 50% subsidy); (iii) fixing the purchasing price of maize which in 2011 reached KES3,000 per bag, equivalent to double the market price; and (iv) input subsidies, mainly for fertilizer, in the form of direct payments to farmers or free distribution. Other policies include the involvement of the NCPB in the purchase of maize from farmers at above market prices to provide incentives for producers (IFPRI, 2012).

## 5. Conclusion

Our results from demand system and welfare analyses demonstrate that income and price changes generate significant budget responses and lead to welfare changes which vary across types of household and food groups. Previous studies have observed that these changes tend to be larger for higher valued foods (such as meat and dairy) than for staple foods such as cereals (e.g., Abdulai and Aubert, 2004; Wong et al., 2015). We find that cereals and bread, dairy products, and essential condiments are necessities, while meat and fish, and fruit and vegetables are luxuries which suggest that the later are more responsive to income shocks. Considering that fruit and vegetables are an important component of the staple Kenyan diet and with relatively low (compensated) own-price elasticities, support our result of high welfare losses, indicated by the highest compensated variation, associated with the fruit and vegetable food group. Further, our findings have implications for the general supply-side support food policies which often focus on cereals in Kenya.

Our demand and welfare analyses reveal that households have generally been less price responsive and more income responsive over the period. Furthermore, comparing the responses seen at the beginning and the end of the period, and considering the magnitude of welfare losses, we can conclude that access to food, and by implication, the state of household food security has worsened. Arguably, a major reason is that incomes have not increased in an equal measure with price rises.

**Table 12**

Major food policy measures in Kenya (2015)/6–2015/6.

Year	Policy action	Remarks
January 2008	Export ban on maize	Retaliation from neighbouring countries
February 2008	NCPB* maize importation	Arrival of imports delayed by 3 months
March 2008	NAAIP** launched; Kilimo plus (farmers input grants), Kilimo Biashara (farming as a business), Partners, Equity Bank, AGRA, FAO, IFAD	Fertilizer and seed subsidy
March 2008	Irrigation subsidy	Economic stimulus package
March 2008	NCPB procures 30% of national fertilizer requirement	Fertilizer subsidy
June 2008	Reduction of wheat import tariff from 35 to 10%	Prices rose owing to a surge in world prices
June 2008	Zero rating of maize, wheat, and milk	Prices rose owing to a surge in world prices
December 2008	Urban consumer price subsidy on maize meal (prime minister)	Poor targeting, inaccessible to the poor, food riots, flawed distribution
December 2008	NCPB producer price subsidy of KES. 200/90 kg bag	Farmers decline to release stocks
February 2008	Consumer subsidy policy reversal	Maize meal subsidy withdrawn
February 2008	Food price taskforce formed	Multi-sector task force on food prices formed
March 2009	Cash for work programme launched by the prime minister	Poor targeting
March 2009	Fertilizer price subsidy announced by the President	Poor targeting

Notes: \* The National Cereals Produce Board is a State corporation established in 1985 through an Act of Parliament (Cap, 338) as the Maize and Produce Board. It was formed by the amalgamation of The Maize and Produce Board and The Wheat Board on July 1, 1979 in order to streamline the management, handling, and marketing of all grains (National Council for Law Reporting, 2012). \*\* National Accelerated Agricultural Input Programme.

Source: Nzuma (2014)

Rising relative food costs seem to have affected more severely the food security of households relying on informal markets and residing in rural areas. For example, on average the prices of fruit and vegetables and meat and fish more than doubled over the period. On the backdrop of the significant price increases, real food expenditure had decreased, from KES1133.51 in 2005/06 to KES1016.85 in 2015/16. The studies of Abdulai and Aubert (2004) and Rizov et al. (2014) show that relative food prices are strongly linked to the quantity and quality of household consumption. Thus, considering the clear evidence provided by our analyses that food has become less affordable and accessible to households between 2005/6 and 2015/6, we can conclude that food security situation in Kenya has deteriorated.

Our findings could usefully inform food policy interventions. In order to improve the food security situation of the population, policy measures such as income support could be more effective than price support, given the much higher expenditure elasticities estimated compared to price elasticities. However, effective income support measures would require knowledge about how different types of household react to income (and price) changes as well as the magnitude of their welfare losses. Hence, if the emphasis of policy interventions is centred on improving household food security and minimising household welfare losses, then our results for expenditure and price elasticities, and the corresponding welfare estimates, by subsamples - rural-urban and according to subsistence level - will be particularly relevant.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### References

- Abdulai, A., Aubert, D., 2004. A cross-section analysis of household demand for food and nutrients in Tanzania. *Agric. Econ.* 31, 67–79.
- AGRA, 2018. Africa Agriculture Status Report: Catalyzing Government Capacity to Drive Agricultural Transformation. Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya. Issue 6.
- Akbari, A., Ziaei, M.B., Ghahremanzadeh, M., 2013. Welfare impacts of soaring food prices on Iranian urban households: evidence from survey data. *International Journal of Business and Development Studies* 5 (1), 23–38.
- Alexandri, C., Păunab, B., Luca, L., 2015. An estimation of food demand system in Romania – implications for population's food security. *Procedia Economics and Finance* 22, 577–586.
- Attanasio, O., Di Maro, V., Lechene, V., Phillips, D., 2013. Welfare consequences of food prices increases: evidence from rural Mexico. *J. Dev. Econ.* 104, 136–151.
- Banks, J., Blundell, R., Lewbel, A., 1997. Quadratic Engel curves and consumer demand. *Rev. Econ. Stat.* 79 (4), 527–539.
- Barten, A.P., 1969. Maximum likelihood estimation of a complete system of demand equations. *Eur. Econ. Rev.* 1 (1), 7–73.
- Bett, H.K., Musyoka, M.P., Peters, K.J., Bokelmann, W., 2012. Demand for meat in the rural and urban areas of Kenya: a focus on the indigenous chicken. *Economics Research International* 1, 1–10.
- Blundell, R., Robin, J.M., 1999. Estimation in large and disaggregated demand systems: an estimator for conditionally linear systems. *J. Appl. Econom.* 14, 209–232.
- Caliendo, M., Kopeing, S., 2005. Some Practical Guidance for the Implementation of Propensity Score Matching. IZA Discussion Paper, no. 1588, Bonn, Germany.
- Capéau, B., Dercon, S., 1998. Prices, Local Measurement Units and Subsistence Consumption in Rural Surveys: an Econometric Approach with an Application to Ethiopia (The Centre for the Study of African Economies Working Paper Series).
- Christensen, L., Jorgenson, D., Lau, L., 1975. Transcendental logarithmic utility functions. *Am. Econ. Rev.* 65 (3), 367–383.
- Ciaian, P., Cupák, A., Pokrivčák, J., Rizov, M., 2018. Food consumption and diet quality choices of Roma in Romania: a counterfactual analysis. *Food Security* 10 (2), 437–456.
- Clements, K.W., Gao, G., 2015. The Rotterdam demand model half a century on. *Econ. Modell.* 49, 91–103.
- Cox, T., Wohlgenant, M., 1986. Prices and quality effects in cross-sectional demand analysis. *Am. J. Agric. Econ.* 68 (4), 908–919.
- Cranfield, J.A.L., Pellow, S., 2004. The role of global vs. local negativity in functional form selection: an application to Canadian consumer demands. *Econ. Modell.* 21 (2), 345–360.
- Cranfield, J.A.L., Preckel, P.V., Eales, J.S., Hertel, T.W., 2004. Simultaneous estimation of an implicit directly additive demand system and the distribution of expenditure—an application of maximum entropy. *Econ. Modell.* 21 (2), 361–385.
- Cupák, A., Pokrivčák, J., Rizov, M., 2015. Food demand and consumption patterns in the new EU member states: the case of Slovakia. *Ekonomický časopis* 63 (4), 339–358.
- Deaton, A., 1997. The Analysis of Household Surveys: A Micro-econometric Approach to Development Policy. Johns Hopkins University Press, Baltimore: Maryland.
- Deaton, A., Muellbauer, J., 1980. An almost ideal demand system. *Am. Econ. Rev.* 70 (3), 312–326.
- Dehejia, H.R., Wahba, S., 2002. Propensity score matching methods for nonexperimental causal studies. *Rev. Econ. Stat.* 84 (1), 151–161.
- Dhar, Tirtha, Chavas, Jean-Paul, Gould, Brian W., 2003. An empirical assessment of endogeneity issues in demand analysis for differentiated products. *Am. J. Agric. Econ.* 85, 605–617.
- Diprete, T., Gangl, M., 2004. Assessing bias in the estimation of causal effects: rosenbaum bounds on matching estimators and instrumental variables estimation with imperfect instruments. *Socio. Methodol.* 34, 271–310.
- Duffy, M., 2003. On the estimation of an advertising-augmented, cointegrating demand system. *Econ. Modell.* 20 (1), 181–206.
- Edgerton, D., 1997. Weak separability and estimation of elasticities in multistage demand system. *Am. J. Agric. Econ.* 79, 62–79.
- Fan, J., 1992. Design-adaptive non-parametric regression. *J. Am. Stat. Assoc.* 87, 998–1004.
- FAO, 2012. World Food Programme, IFAD. *The State of Food Insecurity in the World 2012*. FAO, Rome.
- Filippini, M., Masiero, G., Moschetti, K., 2009. Regional consumption of antibiotics: a demand system approach. *Econ. Modell.* 26 (6), 1389–1397.
- Friedman, J., Levinsohn, J., 2002. The distributional impacts of Indonesia's financial crisis on household welfare: a "Rapid Response" methodology. *World Bank Econ. Rev.* 16 (3), 397–423.
- FSIN (Food Security Information Network), 2017. Global Report on Food Crises. Food Security Information Network.
- Godfray, H.C.J., Garnett, T., 2014. Food security and sustainable intensification. *Phil. Trans. Biol. Sci.* 369, 20120273.
- Gorman, W.M., 1959. Separable utility and aggregation. *Econometrica* 27 (3), 469–481.

- Graham, Robin D., Welch, Ross M., Saunders, David A., Ortiz-Monasterio, Ivan, Bouis, Howarth E., Bonierbale, Merideth, De Haan, Stef, Burgos, Gabriella, Thiele, Graham, Liria, Reyna, Meisner, Craig A., Beebe, Steve E., Potts, Michael J., Kadian, Mohinder, Hobbs, Peter R., Gupta, Raj K., Twomlow, Steve, 2007. Nutritious Subsistence Food SystemS. *Adv. Agronomy* 92, 1–74.
- Greer, J., Thorbecke, E., 1986. A methodology for measuring food poverty applied to Kenya. *J. Dev. Econ.* 24 (1), 59–74.
- Heckman, J., Ichimura, H., Smith, J., Todd, P., 1998. Characterising selection bias using experimental data. *Econometrica* 66 (5), 1017–1098.
- IFPRI (International Food Policy Research Institute), 2012. Policy Responses to Food Crisis in Kenya. Food security portal (IFPRI), Washington, DC.
- Jones, A.D., Ngure, F.M., Pelto, G., Young, S.L., 2013. What are we assessing when we measure food security? A compendium and review of current metrics. *Advances in Nutrition* 4, 481–505.
- Kearney, J., 2010. Food consumption trends and drivers. *Philosophical Transactions of the Royal Society B* 365, 2793–2807.
- Khush, G.S., Lee, S., Cho, J.I., Jeon, J.S., 2012. Bio-fortification of Crops for Reducing Malnutrition, vol. 6. Korean Society for Plant Biotechnology and Springer, pp. 195–202.
- Kumar, T.K., Mallick, S.K., Holla, J., 2009. Estimating consumption deprivation in India using survey data: a state-level rural–urban analysis before and during the reform period. *J. Dev. Stud.* 45 (4), 441–470.
- Lecocq, S., Robin, J.M., 2015. Estimating almost-ideal demand systems with endogenous regressors. *STATA J.* 15 (2), 554–573.
- Lewbel, A., Pendakur, K., 2009. Tricks with Hicks: the EASI demand system. *Am. Econ. Rev.* 99 (3), 827–863.
- Li, L., Song, Z., Ma, C., 2015. Engel curves and price elasticity in urban Chinese Households. *Econ. Modell.* 44, 236–242.
- MAFAP, 2013. Review of Food and Agricultural Policies in Kenya. MAFAP Country Report Series. FAO, Rome.
- Maslow, A.H., 1943. A theory of human motivation. *Psychol. Rev.* 50 (4), 370–396.
- NCPB-(National Council for Law Reporting), 2012. National Cereals and Produce Board Act Chapter 338. [http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/NationalCerealsandProduceBoardAct\\_Cap338.pdf](http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/NationalCerealsandProduceBoardAct_Cap338.pdf). (Accessed 20 November 2019).
- Nzuma, J.M., 2014. The political economy of food price policy in Kenya. In: Pinstrup-Andersen, P. (Ed.), *Food Price Policy in an Era of Market Instability: A Political Economy Analysis*. Oxford University Press, Oxford, pp. 197–214.
- Okrent, A.M., Alston, J.M., 2011. A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand [Giannini Foundation Monograph 48, April 2011.] Davis. University of California, Agricultural and Natural Resources.
- Pieters, H., Guariso, A., Vandeplas, A., 2013. Conceptual Framework for the Analysis of the Determinants of Food and Nutrition Security, pp. 1–51. Foodsecure, Working paper no.13.
- Pinstrup-Andersen, P., 2014. Contemporary food policy challenges and opportunities. *Aust. J. Agric. Resour. Econ.* 58 (4), 504–518.
- Poi, B., 2012. Easy demand-system estimation with QUAIDS. *STATA J.* 12 (3), 433–446.
- Pollak, R., Wales, T., 1981. Demographic variables in demand analysis. *Econometrica* 49 (6), 1533–1551.
- Ray, R., 1983. Measuring the costs of children: an alternative approach. *J. Publ. Econ.* 22, 89–102.
- Regmi, A., Meade, B., 2013. Demand side drivers of global food security. *Global Food Security* 2, 166–171.
- Rischke, R., Kimenju, S.C., Klasen, S., Qaim, M., 2015. Supermarkets and food consumption patterns: the case of small towns in Kenya. *Food Pol.* 52 (1), 9–21.
- Rizov, M., Cupak, A., Pokrivcak, J., 2014. Food Security and Household Consumption Patterns in Slovakia. LICOS Discussion Paper Series DP 360/2014, KU Leuven.
- Rosenbaum, P.R., Rubin, D.B., 1983. The central role of the propensity scores observational studies for causal effects. *Biometrika* 70 (1), 41–55.
- SDSN (Sustainable Development Solutions Network), 2013. Solutions for Sustainable Agriculture and Food Systems: Technical Report. Sustainable Development Solutions Network: A global Initiative for the United Nations.
- Sen, A., 1981. Poverty and Famines: an Essay on Entitlement and Deprivation. Oxford university press.
- Sibhatu, K.T., Krishna, V.V., Qaim, M., 2015. Production diversity and dietary diversity in smallholder farm households. *Proc. Natl. Acad. Sci. Unit. States Am.* 112 (34), 10657–10662.
- Smith, J., Todd, P., 2005. Does matching overcome LaLonde's critique of non-experimental estimators? *J. Econom.* 125 (1–2), 305–353.
- Stone, R., 1954. Linear Expenditure Systems and demand analysis: an application to the pattern of British demand. *Econ. J.* 64, 511–527.
- Upton, J.B., Cisse, J.D., Barret, C.B., 2016. Food security as resilience: reconciling definition and measurement. *Agric. Econ.* 47, 135–147.
- Westengen, O.T., Banik, D., 2016. The state of food security: from availability, access and rights to food systems approaches. *Forum Dev. Stud.* 43, 113–134.
- WBG (The World Bank Group), 2018. Kenya Poverty and Gender Assessment 2015/16. The World Bank, Washington DC.
- Wong, L., Selvanathan, E.A., Selvanathan, S., 2015. Modelling the meat consumption patterns in Australia. *Econ. Modell.* 49, 1–10.
- Yen, S.T., Lin, B.H., 2006. A sample selection approach to censored demand systems. *Am. J. Agric. Econ.* 88 (3), 742–749.
- Yu, W., Hertel, T.W., Preckel, P.V., Eales, J.S., 2004. Projecting world food demand using alternative demand systems. *Econ. Modell.* 21 (1), 99–129.