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Cereal Price Shocks and Volatility in Sub-Saharan Africa: what does really matter for Farmers' Welfare?

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Abstract

After the 2007-08 food crisis, addressing high and volatile cereal prices became a priority for national governments in Sub-Saharan Africa because of their key role in determining consumption and income of poor smallholders. Nevertheless, the lack of information and some misperceptions on the distinction between the welfare consequences of *higher* versus *more volatile* cereal prices limited the effectiveness of policy interventions. Using household-level data, this paper empirically investigates the different effects of the two phenomena and provides an estimate of their magnitude and distributional consequences in four SSA countries over the period 2011-2012. The results show that the impacts of higher and more volatile prices on welfare heavily depend on the domestic structure of the economy. The most important factors to consider are the different weight of food consumption over total expenditure, the shares of the food budget devoted to cereals, the substitution effect among food items, and the relative number of net sellers versus net buyers accessing the market. We also find that the impact of higher substantially outweigh the effects of more volatile prices on farmers' welfare across the entire income distribution in all four countries. As a consequence, farmers are likely to benefit more from policy interventions preventing or limiting cereal price increases than (untargeted and extremely expensive) price stabilization policies. Nevertheless, our results also suggest that some targeted policy interventions aimed at reducing the exposure to cereal price volatility of the poorest quintile of the population is still required to protect them from substantial welfare losses.

Keywords: cereal price; price volatility; welfare; household survey; Sub-Saharan Africa

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1. Introduction

In the past decade, major price fluctuations have interrupted nearly four decades of relatively stable global food prices and have turned to be a priority topic in the international agenda (FAO et al., 2011; HLPE, 2011; Tangermann, 2011, Dawe and Timmer, 2012). Major changes in the world food economy over the past few years may explain this recent shift in international market behaviour: strong discrepancy between the positive trend in global demand for food and the sluggish growth in agricultural production and productivity; an upsurge in oil prices during the 2008-2013 period; rising global demand for biofuels; increasing frequency and intensity of weather-related disasters in different parts of the world; and, the growing interest of financial traders in commodity markets (Von Braun and Tadesse, 2012).

The consequences of extreme international food price fluctuations on the economies of least developed countries have been extensively commented and studied, especially after the major cereal price spikes observed in 2007–2008, 2010 and again in 2012. While the first two spikes took place when the rest of food prices were also raising, in 2012 cereals prices rose almost independently from the rest of the food basket. As reported by the IMF, the main cause of this spike is the supply disruption caused by weather shocks in major international markets such as United States, Russia, China and India. While its global consequences remain limited compared to the 2007-08 crisis, it aggravated the food security of the most vulnerable subsets of the population in Sub-Saharan countries (IMF, 2012). The main risks are associated with i) the vital importance of cereals in the daily diets (on average 20-25% of the total expenditure in SSA); ii) the low substitution between cereals and the rest of the food groups and iii) the fact that high cereal prices crowd out expenditures from other nutritious foods (Anderson and Roumasset, 1996; Ivanic and Martin, 2008; Cohen et al., 2009; De Hoyos and Medvedev, 2011; de Brauw, 2011; Anriquez et al, 2013). Considering the production side, price spikes and volatility may harm smallholders, especially in SSA. In principle, farmers who are net food producers are expected to benefit from higher prices, whereby, all things being equal, their incomes will tend to increase. The benefit increases for those expanding their investment and taking advantage of market price signals. However, if higher prices are accompanied by higher volatility, then associated production risks may lower supply even when price incentives are good. Moreover, with little or no supply response to high and volatile prices, the food supply may remain tight along with the welfare gains for net producers (Magrini et al, 2016). Analysing the various impacts of price changes and volatility requires an intense and sustained monitoring of international and domestic food price fluctuations as well as a clearer understanding of their consequences on local markets and on fiscal and external balances (Benson et al., 2013).

Considering the evident relevance of the topic, it is not surprising that policymakers focus their attention on the welfare effects of high and volatile prices for smallholders. Nevertheless, national governments in developing countries – especially in SSA – cannot always implement appropriate policy interventions to respond to price crises because of the lack of information and some misperceptions on the precise relationship between food prices and household's welfare. For example, one source of ambiguity results from the often difficult distinction between the impact of higher price *level* and higher price *volatility* (Bellemare, 2015). Since high and volatile prices are two different phenomena with distinct implications for consumers and producers, policymakers' responses should be calibrated to address the most urgent priority, i.e. the welfare consequences of either change in price level or increased price volatility on the most vulnerable groups. These interventions necessarily imply trade-offs and each government should be able to carefully weigh their benefits and costs to determine which ones can contribute more effectively or more rapidly to the short-run objectives (Torero, 2016). In SSA countries, most governments adopted a series of policies in an attempt of reducing and stabilising food prices, with special attention to cereals because of their importance in the food basket of the population and political value. The most common policies included the expansion of social protection programmes, the increase of food reserves, the direct involvement in market operations through state-owned companies, the market insulation based on restrictive trade measures and the consequent pursue of self-sufficiency (Minot, 2014 and Torero, 2016).

Against this background, analysing and comparing the different effects of high and volatile prices on household welfare can provide valuable information on those policies that could most adequately help stakeholders to cope with the consequences of food price crises. On the one hand, the empirical literature on the impact of price changes on household welfare in developing countries is quite extensive (for example Ivanic and Martin, 2008; De Janvry and Sadoulet, 2009; De Hoyos and Medvedev, 2011; Vu and Gleewe, 2011; Minot and Dewina, 2013; Anriquez et al 2013). Relying on the concept of compensating variation, most studies are based on the methodology proposed by Singh et al. (1986) and Deaton (1989, 1997) which measures the welfare impacts imputing changes in relative food prices to the household's production and consumption of the corresponding food crops (De Janvry and Sadoulet, 2008). On the other hand, Bellemare et al. (2013) are the first ones to assess the consequences of price volatility on welfare at household level measuring the willingness to pay for price stabilization.

To our knowledge, there are no attempts to bring these two strands of the literature together. In this paper, we try to bridge this gap focusing our attention on comparing the welfare effects of price changes and price volatility using nationally representative household surveys for four countries in SSA, i.e. Ethiopia, Tanzania, Malawi, and Niger. Our analysis serves at least three purposes. Firstly, we carry out a rigorous analysis on the different effects of the two phenomena, providing an estimate of their magnitude and distributional effects. Secondly, we identify those factors determining the intensity of these welfare gains and losses. Thirdly, we present the welfare consequences of changes in price levels as opposed to price volatility across different segments of the population.

Our results show that the impact of price changes and price volatility on welfare (measured in terms of money metric utility) are heavily determined by the country-specific structure of the economy. The observed heterogeneity depends on differences in the share of food expenditure over total consumption, the specific budget shares devoted to cereals, the substitution effect among food items and the relative number of net sellers and net buyers accessing the market. Secondly, we find that the impact of price changes – at least in the short-run – substantially outweigh the effects of price volatility on household welfare across the entire income distribution. More specifically, households are likely to benefit more from policies preventing or limiting cereal price increases than (untargeted) price stabilization policies. Nevertheless, our results also suggest that targeted policy interventions aimed at reducing the exposure of the poorest quintiles to volatile cereal prices could effectively help these vulnerable households to cope with the adverse effects of risks associated with high food price volatility.

The remainder of the paper is organized as follows. Section two describes the methodological approach followed to estimate the welfare impact of price changes and price volatility. Section three describes the data used for the analysis and provides descriptive statistics. Section four presents the empirical strategy. Section five reports the results of the econometric exercise. Finally, section six summarizes the main conclusions.

2. Methodological Approach

Following a standard approach, we estimate the impact of price changes on household welfare relying on the concept of compensating variation (CV) as originally defined by Hicks (1942). The CV is the amount of money that has to be given to the household after a price change to make it as well-off as it was before. Let $e(p_c^0, u^0)$ be the expenditure function before the price change, i.e. the minimum expenditure needed to achieve the initial utility level u^0 with a price vector p_c^0, and $e(p_c^1, u^0)$ the same expenditure function with the new vector of prices p_c^1 after the price change. Then, the CV is calculated as:

$$CV = e(p_c^1, u^0) - e(p_c^0, u^0) \qquad [1]$$

Not surprisingly, CV will be positive for positive price increases and negative otherwise. To account for the fact that in most developing countries and especially in Sub-Saharan Africa, a large proportion of households are not just consumers but also producers of food, we need to capture both the price and incomes effects and therefore the impact of the price changes on households' implicit profits (Vu and Glewwe, 2011). For that, we augment equation [1] including a profit function $y(p_c^1, u^0)$ after the change in the producer prices p_c^1:

$$CV = e(p_c^1, u^0) - e(p_c^0, u^0) - y(p_c^1, u^0) \qquad [2]$$

As shown by Friedman and Levinsohn (2002), a first order Taylor's expansion of the expenditure function would lead to a closed form for equation [2] but it would be an upper bound because it would not consider the possibility for a consumer of switching from expensive food items to cheaper ones. Friedman and Levinsohn (2002) and Vu and Glewwe (2011) show that the "substitution effect" can be captured through a second order Taylor's expansion of the expenditure function, i.e.:

$$\Delta lne \approx \sum_{i=1}^{k} w_i \, \Delta lnp_{ci} - \left(\frac{p_{pi} q_i}{y}\right) \Delta lnp_{pi} + \frac{1}{2} \sum_{i=1}^{k} \sum_{j=1}^{k} w_i \, \epsilon_{ij} \Delta lnp_{ci} \Delta lnp_{cj} \qquad [3]$$

where ϵ_{ij} is the compensated price elasticity, $\frac{p_{pi}q_i}{y}$ is the sales of product i as share of the income y (proxied by total consumption expenditure), Δlnp_{ci} and Δlnp_{pi} consumer and producer price changes. The first two terms of Equation [3] measure the first-order effect due to the direct impact of the price changes on welfare while the last term captures the second-order effect due to the substitution of relatively more expensive items with cheaper ones[1].

As previously mentioned, to estimate the impact of price volatility on household welfare, we refer to Bellemare et al. (2013) who made the first attempt to theoretically and empirically address the relationship between price risk aversion and volatility. Relying on the previous theoretical insights of Turnovsky et al. (1980), Schmitz et al. (1981) and Barrett (1996), the authors derive a measure of the willingness to pay (WTP) for price stabilization as a proportion of income which considers both consumption and production choices in a model with multiple goods. Let $EV(p, y)$ indicate the indirect utility function of a maximising household subject to a budget constraint that incorporates production decisions and uncertainty over the price vector p for the next period. The WTP to eliminate the price uncertainty is defined as the amount of money which makes the household indifferent to the random set of prices p and income y, i.e.:

$$E[V[E(p), y - WTP)] = E[V(p, y)] \qquad [4]$$

Bellemare et al. (2013) proceed approximating equation [4] using a first-order Taylor expansion in direction of certainty around the mean price and income for the left-hand side, and applying a second-order Taylor expansion around mean price and income in all dimensions involving

[1] Similar methods have been applied also by Minot and Goletti (2000), Alem and Söderbom (2012) and Tefera et al. (2012). However, Equation [3] has several limits. It does not take into consideration the second order effect in production, i.e. the possibility to switch from the production of one crop to another as result of an increase/decrease in price (de Janvry and Sadoulet, 2009).

risk for the right-hand side. If we assume that income is uncorrelated with prices, the WTP to stabilize the prices of *k* commodities can be written as:

$$WTP = \frac{1}{2}\left[\sum_{j=1}^{k}\sum_{i=1}^{k}\sigma_{ij}A_{ij}\right] \qquad [5]$$

where σ_{ij} is the covariance of prices *i* and *j* while A_{ij} is the *i-j* element of the matrix A which contains the price risk aversion coefficients. As shown by Barrett (1996), in this framework the concept of price risk aversion is analogous to Pratt's (1964) coefficient of absolute income risk aversion and it can be defined as $-V_{p_i p_j}/V_y$, where $V_{p_i p_j}$ is the second derivative of the indirect utility function with respect to price *i* and price *j* while V_y is the first derivative of the indirect utility function with respect to income. Bellemare et al. (2013) show that in case of multiple commodities, the matrix A takes the following form:

$$A = -\frac{1}{V_y}\cdot V_{pp} = -\frac{1}{V_y}\cdot\begin{bmatrix} V_{p_1p_1} & \cdots & V_{p_1p_k} \\ \vdots & \ddots & \vdots \\ V_{p_kp_1} & \cdots & V_{p_kp_k} \end{bmatrix} = \begin{bmatrix} A_{11} & \cdots & A_{1k} \\ \vdots & \ddots & \vdots \\ A_{k1} & \cdots & A_{kk} \end{bmatrix} \qquad [6]$$

where

$$A_{ij} = -\frac{M_i}{p_j}\left[\beta_j\left(n_j - R\right) + \varepsilon_{ij}\right] \qquad [7]$$

with M_i indicating the marketable surplus of commodity *i*, β_j the budget share of the marketable surplus of commodity *j*, n_j the income elasticity of marketable surplus of commodity *j*, R is the Arrow-Pratt coefficient of relative risk aversion and ε_{ij} the price elasticity of marketable surplus of *i* with respect to *j*. As Bellemare et al. (2013) specify, the sign of [5] depends on multiple factors and it cannot be pre-determined by theory but it relates to the relative position of the household (if it is net buyer or seller of goods *i* and *j*) as well as to the magnitude of the income elasticity and the coefficient R. It is also worth noting that for the diagonal elements of the matrix A (i=j) the interpretation of the coefficients is analogous to the income risk aversion coefficients, meaning that when 1) $A_{ij} > 0$ the household is price risk averse and welfare decreases with volatility; 2) $A_{ij} = 0$ the household is price risk neutral and welfare is unaffected by volatility; 3) $A_{ij} < 0$ the household is price risk lover and welfare increases with volatility.

Therefore, equations [3] and [5] are the two measures we use to compare the different effects of the price changes and price volatility on the household welfare. Someone may argue that they are not comparable because of the different derivations based on the approximation of the expenditure function, in the first case, and the indirect utility function, in the second one. However, since we rely on the assumption that price stabilization is associated with a potential gain for the households, the concepts of willingness to pay and compensating variation are indeed equivalent, as confirmed by the literature on empirical welfare analysis (Zhao and Kling, 2004). Moreover, both the CV and WTP are calculated as ratio of the total consumption expenditure, resulting in two measures respecting the same metrics, i.e. the percentage of welfare the households are giving up due to price changes and/or price volatility.

3. Data and Descriptive Statistics

The methodology presented in Section 2 is applied to household surveys for four Sub-Saharan countries : Ethiopia, Malawi, Niger and Tanzania,. The first reason to focus on these selected countries is that they all belong to the list of least developed countries (UN, 2014), allowing an assessment on the effects of price changes and volatility in countries of the world where the households' average food budget share accounts for more than 70% of the total consumption expenditure (see Table 1).

< INSERT TABLE 1 HERE >

Secondly, these four African countries cover different regional realities of the sub-Saharan Africa, from the West (Niger) to the East (Ethiopia and Tanzania) and Southern (Malawi) Africa, and illustrate different consumption patterns and heterogeneity in the household behaviour. Finally, recent reliable and suitable Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) of The World Bank can be exploited. They offer new multi-topic of nationally representative panel household surveys primarily focusing on agriculture. More specifically, we use the following cross-sections: the 2011/12 Rural Socioeconomic Survey (ERSS) for Ethiopia; the 2010/2011 National Panel Survey for Tanzania (TZNPS); the 2010/2011 Third Integrated Household Survey for Malawi (IHS3); and the 2011 Enquête Nationale sur les Conditions de Vie des Ménages et l'Agriculture for Niger (ECVMA)[2]. The sample sizes are 3969 households for Ethiopia; 3924 for Tanzania; 3247 for Malawi and 3968 for Niger[3].

The main feature making the LSMS-ISA particularly appealing for this analysis is that their modules on consumption and agricultural production are extensively developed and allow obtaining all the information needed to estimate the welfare impact of price changes and volatility. The consumption module records data on consumption of (home) food with a recall period of 7 days, differentiating between multiple items as well as origin, i.e. purchases, own-

[2] For more information on the LSMS-ISA, please refer to http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:23512006~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

[3] Actually, for Malawi the total number of sampled households is 12,288 but we prefer using only those designated as panel households who will be re-visited in the following years.

production and in-kind[4]. In case of food purchases, the surveys collect data on both quantities and monetary value while for own-production and in-kind food consumption only quantities are recorded. In this respect, data on purchases become important because they allow to calculate the unit values of the different food items used to construct the price indexes for estimating price elasticities (see Appendix B) [5]. The unit values are computed by dividing the expenditure on the food item by the purchased quantity[6]. These unit values are also used to impute a monetary value to own-production and in-kind food consumption to calculate the total food expenditure and the different food budget shares. In particular, the latter are constructed dividing the (imputed) expenditure on one single item by the (imputed) total food expenditure. In order to match the timing of the monetary aggregates calculated for food consumption and the other information in the surveys, total food consumption and total consumption expenditure are annualized. Besides data on food expenditure, the surveys also record data on non-food expenditures. They are recorded over different and generally longer recall periods (from one month to one year) and they are used to complement food expenditure to calculate total consumption expenditure. Again, all the constructed variables are annualized in order to have a common reference period with other modules, such as those on agricultural production.

LSMS-ISAs developed a core module including information on the quantity harvested, the quantity sold on the market and the monetary value obtained from the sell for each crop. We use these data to calculate the relative position of the household (net buyer/net seller) as well

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[4] The number of items significantly differs between surveys and goes from 25 in Ethiopia to 59 in Tanzania, 125 in Malawi and Niger. Appendix A reports some of the most important items per country.

[5] The use of unit values in this framework has been criticized due to measurement errors, quality effects and household compositional effects (Majumder et al. 2012). An alternative would be to use specific community level price surveys which – unfortunately – are not available for all our countries.

[6] Following a standard procedure for this literature, when the information is not available because data on purchases are missing (either because the item is not consumed or it is only own-produced/in-kind), we impute the median price of the lower administrative unit where the household lives. Further missing values are filled using higher administrative unit until, in the worst case, national median price is applied.

as to estimate the impact of price changes and volatility on household welfare, as described by equation [3] and equation [5] respectively.

Before data on consumption and agricultural production can be used, two other steps are required. Firstly, the list of food items contained in the consumption module does not match the list of crops included in the agricultural production module, because in the first case, some of the items are already processed while in the second case, we have data only on raw harvested quantity. We address this issue following the standard approach to match only those food items/crops which have the same level of processing[7]. Secondly, we adjust the number of food items to be investigated in our analysis. Indeed, if each item contained in the consumption module were considered as a separate element in the demand systems, the model would become too complex and almost impossible to estimate (Ecker and Qaim, 2011). Therefore, food items need to be aggregated into broader groups. A low-level of aggregation still guarantees a high quality and precision in the results but also low empirical tractability while a high-level of aggregation implies lower quality but more tractability. We also have to consider that we are performing a cross-country comparison. Therefore, the complexity of the estimation and the necessity to compare fairly balanced groups between surveys force us to choose a quite high-level of aggregation. Hence, we decide to build the same six food groups for each country: cereals; livestock and livestock products; fruits and vegetables; tubers and plantains; pulses and oils; and other food. For data on consumption and production, the aggregation process results simply in the sum of the quantities by food group while for the price index, we use the standard approach to calculate a weighted average of the single item prices, using the consumption shares as weights (i.e. Stone Index). Finally, we insert data on the age of the household head, his/her completed level of education (no education, primary education, secondary or above education),

[7] For example, the maize production in Tanzania is matched with the consumption of green/cob maize and not with maize flour

the number of children as additional variables to control for the impact of other socio-demographics characteristics. We also control if the household lives in rural or urban areas. Table 1 reports some descriptive statistics.

The key role played by (recent) price spikes and volatility in influencing the daily business of the agricultural households appears clearly in these figures. We can see that price movements contributed to exacerbate households' vulnerability to sudden shocks and increased uncertainty. In Table 1 we report the budget share for each of the food groups we created. Not surprisingly, the most important food category is cereals - mainly composed by maize, rice, wheat, sorghum and millet (see Appendix A) –which cover from 30% of the total food expenditure in Tanzania to 47% in Ethiopia. The livestock and livestock product group represents the second group after cereals in terms of food consumption expenditure. For what concerns fruits and vegetables, the situation is quite different between Tanzania, and Malawi, where the budget shares range between 13%-15%, and Ethiopia and Niger, which show substantially lower shares, i.e. 4% and 5% respectively. For tubers and plantains – mainly consisting of cassava, but also to a lesser extend potatoes and cooking bananas – we observe a range which goes from 5% in Ethiopia to 9% in Tanzania while for pulses and oils (e.g. beans, peas and cooking oil) the share is close to 10% for all the countries. Finally, the aggregate "other food" is a residual category which contains all the home consumed items in the surveys which are not included in the other food groups. Usually, they are processed or imported food not directly produced by the households and – as consequence – bought on the market. The share goes from 12% in Niger to 20% in Ethiopia.

For what concerns the demographic characteristics, we observe the bigger average size of households in Malawi (6.35 persons) while the lowest is in Ethiopia (4.82 persons). The age of the household head is always more than 40 years, with Tanzania reporting the highest figure

(45.96 years). The number of children is on average 2.2 for Ethiopia, Tanzania and Malawi and the highest in Niger at 3.2, which contributes to explain why Nigerien households are – on average - larger than the others. In terms of education, Tanzania stands out as more than 50% of the household head completed the primary school and about 11% also achieved a secondary or above cycle. In Ethiopia, only 6% of the household head completed the primary school and 5% the secondary one. Finally, the geographical distribution of the households is quite different between surveys, with a high concentration into rural areas for Ethiopia (88%) and a lower one for Tanzania (68%), and Niger (61%) and to some extent Malawi (74%).

4. Empirical Strategy

For calculating equations [3] and [5], we need to estimate income and price elasticities from our four country datasets. To do that, we rely on the Almost Ideal Demand System (AIDS) originally proposed by Deaton and Muellbauer (1980). The AIDS model has been largely applied because of its analytical simplicity and consistency with theory. Demand functions can be easily generated and the system can be estimated over broadly defined groups of commodities (Seale, 2003). In this paper, we use a generalised version of the AIDS model, which takes into consideration the non-linearity of the Engel curves. Specifically, we use the quadratic version of the AIDS model proposed by Banks, Blundell and Lewbel (1997) which allows the budget shares to react more flexibly to the log expenditure while respecting the standard restrictions imposed by demand theory[8]. Following Ray (1983) and Poi (2012), we introduce some demographic characteristics of the households to control for any changes in the consumption patterns not related to prices or total expenditure. For example, bigger households behave differently than smaller ones. Likewise, households with children have different consumption preferences compared to those composed exclusively by adults. Therefore, the functional form of the QUAIDS we estimate is:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} lnp_j + (\beta_i + \eta_i' z) ln\left\{\frac{m}{\overline{m}_o(z)a(p)}\right\} + \frac{\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{m}{\overline{m}_o(z)a(p)}\right\}\right]^2 \quad [8]$$

where w_i is the share of the total food expenditure m allocated to the ith item while p_j is the price of jth commodity, z is the set of household characteristics we want to consider, η a vector

[8] The restrictions are adding-up, homogeneity and Slutsky symmetry. For sake of brevity, we do not report here the derivation of the demand functions while more details are reported in Appendix B

of associated parameters to be estimated, $\overline{m_0}\,(z)$ and $c(p,z)$ two functions which measure the change in household's expenditure as a function z and p as:

$$\overline{m_0}\,(z) = 1 + \boldsymbol{\rho}'\boldsymbol{z} \quad \text{and} \quad c(p,z) = \prod_{j=1}^{k} p^{\eta_j' z} \qquad [9]$$

Finally, we address the issue related to the high proportion of zero expenditure shares for some food groups that are not consumed during the recall period, relying on a consistent two-step procedure. Table 2 reports the percentage of these zeros and the case of Ethiopia is challenging because almost all the food groups - with the obvious exception of cereals and other foods - display a considerably high proportion of zeros. For the other countries, the problem is less important, even if for some groups, such as livestock and livestock products and tubers and plantains, there are still significant proportions of zero budget shares. This situation requires some correction.

< INSERT HERE TABLE 2>

Following Shonkwiler and Yen (1999), Zheng and Henneberry (2009) and Tefera et al. (2012), we first estimate a multivariate probit regression (MPR) to calculate the probability for a given household of consuming a food group. The choice of using a multivariate probit - instead of multiple univariate probit (one for each group) - allows accounting for possible correlation among the different food groups under analysis. The covariates used in the estimation are the same demographic characteristics used to correct the QUAIDS model, the logarithm of the price indexes and the logarithm of the food consumption expenditure. Second, from the MPR we calculate for each food group the standard normal Cumulative Distribution Function (CDF) and the standard normal Probability Density Function (PDF) in order to augment the QUAIDS specification as follow:

$$w_i^* = \Phi(\hat{\tau}_i' z) w_i + \delta_i \varphi(\hat{\tau}_i' z) + \xi_i \qquad [10]$$

where w_i^* is the observed share of food item i, $\Phi(\cdot)$ and $\varphi(\cdot)$ are the CDF and PDF, respectively, $\hat{\tau}_i'$ is the vector of associated parameters from the multivariate probit and δ_i is the covariance between the error terms in the QUAIDS model and the multivariate probit (Shonkwiler and Yen, 1999). Since the budget shares in equation [10] do not respect anymore the adding-up condition (see Appendix B), we follow the Yen, Lin and Smallwood (2003) correction, treating the k^{th} food group as residual with no specific demand and imposing the following identity:

$$w_k^* = 1 - \sum_{i=1}^{k-1} w_i^* \qquad [11]$$

The choice of the k^{th} food group is arbitrary but in this framework the natural candidate is the "other foods" category, considering that it is already built as a residual group. The parameters of the QUAIDS system are estimated using an iterated feasible generalized non-linear least-square which – in this case - is equivalent to a multivariate normal maximum-likelihood estimator (Poi, 2012). Once we obtain the QUAIDS parameters, we can calculate food expenditure (μ_i) and price (ϵ_{ij}) elasticities of demand - for each food group – as follows:

$$\mu_i = \frac{\partial w_i^*}{\partial lnm} = 1 + \frac{1}{w_i}\left[\beta_i + \boldsymbol{\eta}_i' \boldsymbol{z} + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{m}{\overline{m_0}\,(z)\alpha(p)}\right\}\right]\Phi(\hat{\tau}_i' z) \qquad [12]$$

$$\epsilon_{ij} = \frac{\partial w_i^*}{\partial lnp_j} = \frac{1}{w_i}\Bigg(\gamma_{ij} - \left[\beta_i + \boldsymbol{\eta}_i'\boldsymbol{z} + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{m}{\overline{m_0}\,(z)\alpha(p)}\right\}\right] \times \left(\alpha_j + \sum_k \gamma_{jk}\, lnp_k\right) - \frac{(\beta_j + \boldsymbol{\eta}_j'\boldsymbol{z})\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{m}{\overline{m_0}\,(z)\alpha(p)}\right\}\right]^2\Bigg)\Phi(\hat{\tau}_i'z) + \varphi_i\tau_{ij}\left(1 - \frac{\delta_i}{w_i}\right) - \delta_{ij} \quad [13]$$

where τ_{ij} indicates the coefficient for the price j for good i in the first-step multivariate estimation and δ_{ij} is the Kronecker delta, meaning that it takes the value of one if $j = i$ and zero otherwise. Expenditure and price elasticities for the residual category, "Other Foods", are calculated using the adding-up restrictions proposed by Zheng and Henneberry (2009):

$$\sum_{i=1}^{K} w_i\,\mu_i = 1, \quad \sum_{i=1}^{K} w_i\,\epsilon_{ij} = -w_j, \quad \sum_{j=1}^{K} \epsilon_{ij} + \mu_i = 0 \quad [14]$$

Finally, we calculate the compensated price elasticities of demand - which capture only the substitution effect of a price change – as $\epsilon_{ij}^c = \epsilon_{ij} + w_j\mu_i$.

While the elasticities obtained from equations [12]-[14] can be directly plugged into equation [3] to calculate the impact of price changes on household welfare, they cannot be used in equation [5] since the elasticities needed to calculate the matrix A are expressed in terms of marketable surplus. In their empirical exercise, Bellemare et al. (2013) estimate a system of marketable surplus functions to retrieve those income and price elasticities. We prefer to use a different strategy which consist in adapting the matrix A to the elasticities estimated with the QUAIDS system. Doing so allows to estimate the impact of both price changes and price volatility on household welfare using the same set of elasticities and ensure consistency with consumer demand theory for the entire exercise. Using the censored QUAIDS elasticities offers several additional advantages including: i) the possibility to respect the restrictions imposed by consumption theory (adding-up, homogeneity and Slutsky symmetry); ii) the flexibility to control for the high proportion of zero expenditure that characterizes data in SSA countries; iii) the possibility to avoid the inverse hyperbolic sine (IHS) transformation on the dependent variable of the estimated system, which makes the interpretation of the income and price elasticities less straightforward with respect to the QUAIDS system[9].

Following Strauss (1984) and Singh et al. (1986), the price elasticity of marketable surplus of commodity *i* with respect to commodity *j* can be re-written as:

$$\varepsilon_{ij} = \frac{p_j}{|M_i|} \cdot \frac{\partial M_i}{\partial p_j} = \frac{Q_i}{|M_i|} \cdot \frac{p_j \partial Q_i}{Q_i \partial p_j} - \frac{X_i}{|M_i|} \cdot \frac{p_j \partial X_i}{X_i \partial p_j} = s_{ij} \frac{Q_i}{|M_i|} - \epsilon_{ij} \frac{X_i}{|M_i|} \qquad [15]$$

which is a weighted difference of supply elasticity (s_{ij}) of quantity produced Q_i and (uncompensated) price elasticity (ϵ_{ij}) of quantity consumed X_i where the weights are the ratio between production and surplus in the first case and consumption and surplus in the second case. According to Singh et al. (1986) the same applies to the income elasticity of marketable surplus of commodity *j* which can be re-written as:

$$\eta_j = \frac{y}{|M_j|} \cdot \frac{\partial M_j}{\partial y} = \frac{Q_j}{|M_j|} \cdot \frac{y \partial Q_j}{Q_j \partial y} - \frac{X_j}{|M_j|} \cdot \frac{y_j \partial X_i}{X_i \partial y} = s_y \frac{Q_j}{|M_j|} - \mu_i \frac{X_j}{|M_j|} \qquad [16]$$

where s_y captures the income elasticity of supply, i.e. the "cash effect" according to which additional wealth finances productivity-enhancing inputs, relaxes liquidity constraints and

[9] Bellemare et al. (2013) interpret the coefficients of the marketable surplus system on prices and income as elasticities, but this is a risky approximation considering the importance of the magnitude of η_i and ε_{ij} in calculating the welfare impact of price volatility. In fact - as suggested by Burbidge et al. (1988) - the IHS of M is equal to $IHS(M,\theta) = \ln(\theta M + (\theta^2 M^2 + 1)^{\frac{1}{2}}/\theta$. Assuming $\theta = 1$, the elasticity of M with respect an independent variable x (such as income or prices) is equal to $\left(\frac{\partial M}{\partial x}\right)\left(\frac{x}{M}\right) = \left(\frac{\partial IHS[M]}{\partial x}\right)\left(\frac{\partial M}{\partial IHS[M]}\right) * \left(\frac{x}{M}\right) = \beta_x x\sqrt{\left(1 + \frac{1}{M^2}\right)}$ with the elasticity being decreasing in M and increasing in x (for derivation see Carroll et al. 2003 and Pence, 2006). Therefore using β_x as the price (or income) elasticity – without any adjustment as in Bellemare et al. (2013) - could potentially generate inconsistent estimates of η_i and ε_{ij}.

favour a higher level of output (Dercon and Christiansen, 2011 and Bellemare et al., 2013) and μ_i the income elasticity. Substituting equation [15] and [16] into equation [7], we obtain a new matrix A, i.e. A^*, where each element has the following form:

$$A_{ij}^* = -\frac{M_i}{p_j}\left[\beta_j\left(s_y\frac{Q_j}{|M_j|} - \mu_i\frac{X_j}{|M_j|} - R\right) + \left(s_{ij}\frac{Q_i}{|M_i|} - \epsilon_{ij}\frac{X_i}{|M_i|}\right)\right] \qquad [17]$$

Hence, the WTP to stabilize the prices can be calculated as:

$$WTP = \frac{1}{2}\left[\sum_{j=1}^{k}\sum_{i=1}^{k}\sigma_{ij}A_{ij}^*\right] \qquad [18a]$$

while the WTP for a single commodity *i* is calculated as:

$$WTP_i = \frac{1}{2}\sigma_{ij}A_{ii}^* - \sum_{i\neq i}^{k}\sigma_{ji}A_{ji}^* \qquad [18b]$$

The main advantage of equations [17]-[18] is that they can be estimated without using the elasticities related to the marketable surplus as in Bellemare et al. (2013) and can incorporate the results of the QUAIDS model presented above. Nevertheless, the limitation of this approach is that it introduces two new parameters (s_y and s_{ij}) which are not directly estimated by the QUAIDS model. To solve this problem, we exogenously input them using other empirical works on the same topic and test the robustness of our choice showing that they do not influence the final estimates of the WTP.

5. Results

We first discuss the estimates of the expenditure and price elasticities obtained from the parameters of the QUAIDS model and then proceed with the simulations of the welfare effects generated by price changes and price volatility. The results of the multivariate probit for each country are reported in Appendix C.

Expenditure and Price Elasticities

Table 3 reports the expenditure elasticities calculated at mean values of the population for the four countries analysed. They measure the percentage change in the consumption of a food group when the food expenditure changes by 1%. An expenditure elasticity above 1 indicates that consumption over-reacts to changes - a luxury good - while an elasticity between 0 and 1 indicates that the good is a necessity for the household. All the expenditure elasticities are found to be positive and significant at 1% level, indicating that the food groups are considered normal goods in all the circumstances.

< INSERT HERE TABLE 3>

As expected, cereals turn out to be a necessity good in all cases and this is easily explained by the fact that they are the main staple food consumed by the households, especially by the poorest quintiles. The estimates are around 0.6 for all the countries except for Ethiopia where the expenditure elasticity is equal to 0.785. This is partly explained by the fact that some cereals – especially teff in rural areas – are considered luxuries and consumed only in special occasions (Tefera et al., 2012). On the contrary, the livestock and livestock products are always considered as luxury goods with the highest estimate recorded for Niger. Not surprisingly products like meat, milk and eggs are not affordable for a large share of the population in these countries and a substantial proportion of livestock is kept for other uses than food such as, for example, draught power or capital assets to be sold in case of emergency (FAO, 2006). For fruits and vegetables the elasticities are always below but close to 1 except for Niger where it is equal to 1.134. The results indicate that while fruits and vegetables are generally found to be necessity goods, they do not compare to cereals for most households who cannot afford to consume in a similar fashion.

Expenditure elasticities for tubers and plantains are quite heterogeneous, with values below 1 for Ethiopia (0.781) and Malawi (0.841) and above 1 for Niger (1.479) and Tanzania (1.200). Explaining such an heterogeneity is quite challenging but several factors can be isolated: the difference in importance of the root and tuber crops in the dietary patterns; the difference in weights of the individual items composing the food groups; and the shifts from fresh to processed products which changed the status of some crops - such as cassava – from inferior to normal and even luxury goods (Scott et al., 2000). Finally, the expenditure elasticities for pulses and oils are below 1 for Tanzania (0.628), Ethiopia (0.787) and close to or above unity for Niger (0.947)and Malawi (1.383) while for the residual category "other foods" the elasticity is always above one except for Niger where it is 0.693. The fact that the residual category appears as a luxury good is not surprising if we consider that it mainly includes processed, less-affordable and not essential items for the household daily diet (see Table A.1).

Table 4 shows the Marshallian (uncompensated) and Hicksian (compensated) price elasticities calculated applying equation [12] and the restrictions in equation [14]. For the sake of simplicity, we only report the own-price elasticities while the full set of estimates including the cross-price elasticities is available in Appendix D. The own-price elasticities measure the percentage change in the consumption of a food group when its own price changes by 1%. The demand for a food group is price-elastic if the absolute value of the elasticity is greater than one, and inelastic if it is between zero and one. Consistent with consumption theory, both

Marshallian and Hicksian elasticities are negative and significant, meaning that an increase in the price leads to a reduction of the quantity demanded for each food groups.

As a general comment, we observe that all the food groups - with the exception of pulses and oils - appear to be price inelastic. In particular, Table 4 shows that cereals are inelastic in all the cases with the lowest intensity of response for both uncompensated and compensated estimates. Except for Tanzania, livestock and livestock products also show an inelastic demand to price changes even if in some cases the response is not too far from being unit-elastic (Niger and Malawi).

< INSERT HERE TABLE 4>

Similarly, for fruits and vegetables, the demand is inelastic for all the countries except for Malawi but the estimates are quite close to one also for Ethiopia, Niger and Tanzania.

Tubers and plantains are price-inelastic in all the cases with the higher responses registered in Ethiopia and Tanzania. As already mentioned, the responsiveness of pulses and oils is the highest with three countries reporting elasticity above one - Tanzania, and Niger while Ethiopia and Malawi are very close to be unit-elastic. Finally, the residual group shows that the demand is price inelastic for Ethiopia, Tanzania and Niger while it is elastic for Malawi.

Simulated scenarios for price changes and price volatility

The literature provides several alternatives on how price changes should be simulated and the appropriate choice depends on the purpose of the research. As suggested by de Janvry and Sadoulet (2008), the most common approach is to look at a vector of observed prices and its path through time to determine the magnitude of the price changes to be simulated.

< INSERT HERE FIGURE 1>

This approach is quite convenient for this paper because we want to compare the impact of the real price shock on cereals over the period 2011-2012 against the impact of price volatility over the same period. Figure 1 reports the path of the real cereal price index we calculate using the deflated retail monthly prices provided by the WFP.

For each country, we build the index: 1) calculating the national average of each item composing the cereal group in the QUAIDS system (see Appendix A); 2) combining them in a single index using a weighted average based on the consumption share obtained from the LSMS-ISA; 3) deflating the series using the domestic Consumption Price Index, and 4) using January 2010 as numeraire. It is worth noting that in 3 of 4 the countries studied, the real cereal prices reached their highest level during 2012. The only exception is Ethiopia which – nevertheless - experienced a substantial price changes over the period 2011-2012. Therefore, we simulate the impact of the real cereal price change observed between January 2011 and December 2012 which correspond to 21% for Ethiopia, 29% for Tanzania, 20% for Niger and 100% for Malawi. In the last case, such big increase has been driven mainly by the serious maize shortage over the year.

To simulate the welfare impact of price volatility, we need to calculate the variance of the cereal price and fix the values of those parameters in equation [17] that are not estimated by the QUAIDS, i.e. the relative (income) risk aversion (R), the income elasticity of production (s_y) and the supply elasticity (s_{ij}). In the first case, we calculate the cereal price variance and its covariance with other food group prices exploiting the cross-sectional dimension of the surveys as in Bellemare et al. (2013) (Table 5).

< INSERT HERE TABLE 5>

For the other parameters, we first impose R to be equal to 1, which the literature considers a credible value. For the price elasticity of supply, we use a common approach to set it equal to 0.3 (Dorosh et al., 2010; and Minot and Dewina, 2013). Indeed, numerous empirical studies demonstrate at aggregate and micro-level that production response to higher food prices in developing countries is quite limited with price elasticities of supply close of 0.3 (e.g. Scandizzo and Bruce, 1980; Khiem and Pingali, 1995; Yu and Fan, 2011; Vu and Glewwe, 2011; Aksoy, 2012). Lastly, for the income elasticity of production, we do not have any empirical evidence suggesting a precise estimate so we decide to set it equal to 1. We test the sensibility of our choices looking at how the willingness to pay (WTP) changes according to different values of price elasticity of supply and the income elasticity of production.

Welfare effects of price changes

Table 6 reports the welfare impact of the 2011-12 real cereal price shocks observed in the four SSA countries. Since it is measured in terms of compensating variation, a positive change - as a proportion of total expenditure – indicates a welfare loss while a negative change corresponds to a welfare gain. The mean welfare losses calculated over the full sample are equal to 8.35% for Malawi, 7.78% for Niger, 5.23% for Tanzania and 3.63% for Ethiopia. Not surprisingly, the magnitude of the price shock is fundamental in understanding its consequences but it doesn’t explain the whole variation. For example, although the cereal price (mainly maize) in Malawi doubled in only a few months, the welfare losses are similar to those experienced in Niger, where prices increased by only 20%. At the same time, whereas Niger and Ethiopia experienced a very similar shock, welfare losses in the former are more than twofold that of the latter.

What are the other factors – beyond the magnitude of the price changes - explaining the heterogeneity in the performances? The first intuitive explanation is the different weights of cereals in the food basket of the households. Malawi has a substantially lower consumption share (32%) devoted to cereal compared to Niger (0.46%) and Ethiopia (0.47%) and this reduces the negative consequences of the price increase because households are less dependent. On top of the budget share, there are two other factors that can also explain the different performances: i) a stronger substitution effect (i.e. second order effect) which allows households to better switch from cereals to other food groups; and ii) a higher share of net seller which partially offsets the welfare losses experienced by net buyers. The first explanation is difficult to verify in this analysis because the level of aggregation in six broad and highly complementary food groups reduces the possibility unveil the substitution effects. Moreover, the second order effect is always quite limited in our estimations and between 1% and 2% for all the countries[10].

< INSERT HERE TABLE 6>

On the other hand, the second factor seems to be a more plausible in our case. For example, it helps to explain why Niger and Ethiopia register such a difference in terms of welfare losses while they exhibit similar price shocks and cereal budget shares. In Ethiopia 26% of the population can be defined as net seller of cereals while in Niger 99% of the population is a net buyer[11]. This situation is due to the fact that in Niger cereal production is mainly at subsistence

[10] For sake of simplicity, we do not report the disaggregation between first and second order effects. However, results are available upon request.
[11] As suggested by WFP (2009), we use the monetary definition of net buyer/net seller, meaning that we define a household as net seller (buyer) if the value of the sold food is higher (lower) than the value of the purchased item.

level where land is cultivated by individual households and only a limited amount of millet and sorghum is marketed (Zakari & Ying, 2012). As a consequence, a very limited number of households manage to buy the rest of the consumed cereals (e.g. rice and maize) with the profit made from millet and sorghum previously sold.

In terms of geographical distribution of the welfare effects, we observe for Tanzania and Ethiopia losses are high in the urban area, mainly because the benefits coming from producing cereals are concentrated in the rural zones. The results are different for Niger and Malawi since the production side effects are not offsetting the consumption effects due to the fact that farmers in these countries are mainly producing for substance. We also investigate the distributional effects of the price changes, presenting the results according to the per-capita consumption expenditure quintiles. From Table 6, we observe that for Ethiopia and Tanzania the lower quintiles would experience lower welfare losses than better-off households. However, the magnitude of the difference between quintiles is limited and almost null for Malawi. Moreover, in Niger the impact of the cereal price shock affects the poorest quintile significantly more than the richer ones. In this respect, the results suggest that the consumption and production patterns may significantly influence the distributional effects of the price shocks and its relative consequences in terms of poverty and food security.

Finally, we compare the welfare effects of the price change looking at the net position of the household. Not surprisingly, cereal net buyers experience significant welfare losses while net sellers report welfare gains. More than the sign of the impact which is quite intuitive, one should focus on the magnitude of the effects and their relative difference with the total average impact. In Ethiopia and Malawi, for example, the welfare losses for net buyers would be equal to 8.69% and 18.18% respectively, more than twice the national average (3.63% and 8.35%) which also includes net sellers and self-sufficient households. This difference raises two important considerations. First, it confirms that the "production effect" could have an important role in reducing the negative impact of a cereal price shock. Second, it is likely that a sub-group of the population (e.g. net-buyers) will be heavily affected by the price change, even if the aggregate results may suggest otherwise. We observe a similar pattern in Tanzania with production effects partially offsetting the negative consequences on the consumption side. Niger stands out among the countries studied as one where the impact on net buyers corresponds to the total average because the production effect is almost inexistent and cereals are mainly bought on the market. The gains for net sellers are quite limited. They range from -0.39% for Niger to -3.58% for Tanzania. Such a result may be attributed to the high level of item aggregation in the model. Households are likely to produce one or two cereals (e.g. maize and rice) while they consume a more diversified number of them (e.g. wheat, sorghum, millet, teff, etc.). As a consequence, the welfare gains obtained from selling the cereals produced is partially offset by the price increase of the others, resulting in a limited positive net benefit. A higher level of disaggregation and a more specific price shock would probably reveal higher welfare gains for producers.

These results might be of value to policymakers interested in setting up national policies to control prices and support food security. In situation like Niger where the production effect is close to zero, price control policies might be the appropriate response to mitigate price-induced food insecurity since the negative welfare effects is homogenously distributed across the population groups of the country. On the contrary, if the negative effect of the price shocks is limited to specific subsets of the population, having nationwide price control interventions does not appear as the best strategy in support of food security. Temporary and targeted cash transfers, food vouchers and other safety net measures for protecting the most vulnerable households would be better calibrated and less expensive policies.

Welfare effects of price volatility

Before turning to the welfare impact of price volatility for the cereals, in Table 7 we report the estimated matrix of the own-price risk aversion calculated at the mean values of the sample. Households can be defined as price risk averse for all the items in all the countries because the A^*_{ii} coefficients are always positive, meaning that welfare is decreasing in case of volatility of price i (Bellemare et al, 2013). Considering that the prices are measured in local currency and the quantities in kilograms, the coefficients in Table 7 can be compared among different items in the same country but not for the same item among different countries. An interesting point is that households are always – on average – significantly own-price risk averse over cereals.

< INSERT HERE TABLE 7>

Moreover, the aversion over price volatility for cereals is the highest compared to the aversion over other items. This is less marked in Malawi where price risk aversion for cereals is only outranked by fruits and vegetables. These results might be easily explained by the fact that cereals are the food group with the highest marketed surplus compared others food items produced.

Finally, Table 8 reports average household WTP for stabilising the cereal price[12]. Results are expressed as percentage of the total consumption expenditure and presented using the same household typology adopted for the welfare impact of price changes to ease the comparison. The first interesting result is the magnitude of the WTP according to which households would be willing to give up a limited portion of their welfare in order to stabilize the real cereal prices.

[12] We also calculate the WTP for a complete price stabilization of all food groups and results are available upon request. Interestingly, for Ethiopia we obtain a total WTP equal to 15.2% which is close to the result of Bellemare et al. (2013) with an estimated WTP equal to 17.9%. It suggests that the attempt to adapt their empirical framework to our needs resulted in reasonable estimates.

In particular, the WTP is equal to 2.14% in Niger, 1.17% in Malawi, 1.15% in Ethiopia, and only 0.49% in Tanzania. If we compare these figures with those obtained in the previous exercise, we can infer that – in the short-run - households would benefit more from preventing or limiting an increase in the level of the cereal prices than from reducing their volatility. This conclusion is not too surprising if we consider that the impact of the price changes has multiple and direct effects on the daily life of the agricultural households influencing their production and consumption strategies.

< INSERT HERE TABLE 8>

On the contrary, the impact of price volatility is less evident and tangible because it is connected to the dynamic concept of risk and the unobservable household capacities to manage and cope with it. For example, on the consumption side, an increase in the cereal price for a household which is highly dependent on staple food has direct and immediate implications by limiting its access to food because of budget constraints. An increase in price volatility of cereals might influence the consumption smoothing and saving decisions of the household but those impacts are more visible in the long-run. However, such effects cannot be fully captured in this framework because we do not have the possibility to exploit the temporal dimension. Another interesting point is the heterogeneity we observe between different countries. Such differences are determined by several factors For example, we note that the coefficient of variation (CV) varies from around 0.3 for Ethiopia, Tanzania and Niger to 0.42 for Malawi[13]. It means that households in Malawi are willing to give up a higher fraction of their consumption expenditure to eliminate that residual variability still present in the cereal prices compared to Ethiopia,

[13] We refer to the concept of CV - i.e. the price standard deviation divided by its mean - because all the variances we use are measured in monetary terms and therefore they are not comparable across countries.

Tanzania, and Niger. Moreover, urban households seem to benefit more from reducing price volatility, except for the case of Niger where rural household would be willing to pay 2.75% of their consumption expenditure for full cereal price stabilization. More interestingly, the distribution of the welfare gains among different quintiles of the population gives us a clear picture across all the countries: the poorest households are those more harmed by price volatility and the inter-quintile difference between the poorest and the richest can be quite pronounced, such as for Ethiopia, Malawi and Niger. Apparently, these results diverge from those of Bellemare et al. (2013), who found an inverse relationship between welfare gains and stabilization. Nevertheless, McBride (2015) shows that Bellemare et al. (2013) results are seriously distorted in the distribution of the budget shares by the choice of the authors to replace the zero-valued observed incomes with the population mean, deflating the WTPs for poorer households and inflating those for richer ones. A different choice - such as using the minimum income instead of the mean - would easily revert the relationship between WTP and prize volatility. Since in our exercise we use the total expenditure instead of the cash income to calculate the budget shares and we don’t have the problem of zero valued observations, our results confirm the point raised by McBride (2015). In other words, the benefits derived from the reduction or the elimination of the cereal price volatility decrease with household’s wealth, suggesting to a distributional positive effect of stabilization policies.

< INSERT HERE FIGURE 2>

Finally, we test how the robustness of our WTP estimates to different choices over the income elasticity of supply and price elasticity of supply. Specifically, we simulate the change in the WTP for each possible combination of s_y and s_{ij} over the range 0.5-1.5 for the first parameter and 0.1-1.2 for the second one. As we can see from Figure 2, the impact of price stabilization on welfare is not significantly influenced by the magnitude of those two parameters because the range of the WTP is always small (around 0.1%), making us confident that the chosen values are not distorting the final estimates.

6. Conclusions

In developing economies, the welfare of agricultural households that rely on cereals-based food systems is determined by the interaction of several complex and interconnected factors including consumer and producer price dynamics, the market structure, and the policy environment. Understanding how these factors operate together is essential for policy makers engaged in delivering food security as part of their mandate. Hence, a deeper understanding of the forces influencing household responses to price shocks and price volatility at micro level is a necessary step to better support evidence-based policy interventions.

In this paper, we focus on estimating and analysing the possible welfare consequences of higher versus more volatile cereal prices using household survey data for Ethiopia, Malawi, Niger, and Tanzania. Determining in advance whether the net effects will be positive or negative is not obvious because an increase in food price tends to raise the real incomes of net food sellers, while at the same time, tends to harm net food consumers. Since relatively poorer households may potentially fall into either category, the balance between effects on net buyers and net sellers must be determined at household level. In addition, this paper also discusses the severity of the impact of price surges and/or price volatility on households' welfare so as to help decision makers to formulate better informed, targeted and ultimately more effective policy responses.

Our results lead to three main conclusions. Firstly, the impact of price changes and price volatility on welfare should be analysed at domestic level because the country-specific structure of the economy plays a fundamental role. It is likely that other factors, like geography and the institutional framework, also play a key role although we do not control for them in this paper. Indeed, our results suggest substantial variations across countries which depend on differences in the share of food expenditure over total consumption, the specific budget share devoted to cereals, the substitution effect among food items and the relative number of net sellers and net buyers accessing the market. Secondly, given the more pronounced welfare impacts resulting from a price increase compared to price volatility, it appears that poor households are likely to benefit more from policies preventing or limiting cereal price increases than untargeted stabilization policies. The greater impact of a price change should not be a surprise as it has multiple, direct and indirect effects on the daily life of agricultural households, influencing both their production and consumption strategies. Conversely, the impact pathway of price volatility is less clear and evident because it is connected to the dynamic concept of risk and the unobservable household capacities to manage it. The recommendation arising from this finding is to focus more on policies mitigating and coping with the effects of price surges. While compelling to many analysts, this result does not reflect the rationale behind some policy decisions adopted in the recent past by many developing countries, especially in Sub-Saharan Africa. Thirdly, the paper calls for systematic targeting of policy measures aimed at reducing the negative effects of price volatility. Indeed, our results suggest that policy interventions could effectively hedge the poorest quintiles which are likely to be more affected by volatile prices than other groups. This point may be particularly important for policymakers interested in targeting vulnerable households.

Future research steps on this topic could usefully address the possibilities and practicalities of adapting this type of analysis focusing on welfare impact to outcomes that would be more directly related to food security and nutrition. This could not only bridge an important gap in the literature but also, and perhaps more importantly, attract the interest of policy makers in countries where the primary concerns is chronic food insecurity and stunting.

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TABLES AND FIGURES

Table 1: Descriptive Statistics

	Ethiopia	Tanzania	Niger	Malawi
Food Expenditure Share	0.79	0.71	0.72	0.78
Budget Shares				
Cereals	0.47	0.30	0.46	0.32
Livestock and Livestock Products	0.14	0.20	0.21	0.20
Fruits and Vegetables	0.04	0.13	0.05	0.14
Tubers and Plantains	0.05	0.09	0.07	0.06
Pulses and Oils	0.11	0.10	0.09	0.10
Other Foods	0.20	0.18	0.12	0.17
Demographic Characteristics				
Household Size	4.82	5.34	6.35	4.87
Age of the HH Head	43.61	45.96	45.39	42.04
Rural/Urban	0.88	0.68	0.61	0.74
Number of Children	2.24	2.23	3.23	2.26
Primary Education	0.06	0.52	0.12	0.26
Secondary or Above Education	0.05	0.11	0.14	0.13

Source: authors' calculation from LSMS-ISAs

Table 2: Percentages of zero expenditure share

	Ethiopia	Tanzania	Niger	Malawi
Cereals	0.02	0.04	0.01	0.01
Livestock and Livestock Products	0.40	0.09	0.04	0.16
Fruits and Vegetables	0.26	0.02	0.06	0.01
Tubers and Plantains	0.57	0.22	0.13	0.24
Pulses and Oils	0.25	0.08	0.01	0.15
Other Foods	0.01	0.00	0.00	0.01

Source: authors' calculation from LSMS-ISAs

Table 3: Expenditure Elasticities of food demand at population means

	Ethiopia	Tanzania	Niger	Malawi
Cereals	0.785	0.572	0.579	0.594
	(0.02)	(0.223)	(0.051)	(0.019)
Livestock and Livestock Products	1.238	1.682	2.004	1.257
	(0.051)	(0.217)	(0.083)	(0.068)
Fruits and Vegetables	0.819	0.934	1.134	0.750
	(0.059)	(0.111)	(0.065)	(0.027)
Tubers and Plantains	0.781	1.200	1.479	0.841
	(0.109)	(0.097)	(0.107)	(0.055)
Pulses and Oils	0.787	0.628	0.947	1.383
	(0.049)	(0.149)	(0.045)	(0.055)
Others	1.542	1.119	0.693	1.474
	(0.036)	(0.173)	(0.042)	(0.087)

Source: authors' calculation from LSMS-ISAs using the censored QUAIDS model. Standard errors are calculated using the delta method.

Table 4: Own-Price Elasticities of food demand at population means

	Ethiopia	Tanzania	Niger	Malawi
Marshallian (uncompensated) Own-Price Elasticities				
	Ethiopia	**Tanzania**	**Niger**	**Malawi**
Cereals	-0.696	-0.693	-0.786	-0.641
	(0.019)	(0.149)	(0.049)	(0.02)
Livestock and Livestock Products	-0.591	-1.010	-0.896	-0.943
	(0.033)	(0.022)	(0.02)	(0.029)
Fruits and Vegetables	-0.897	-0.808	-0.984	-1.074
	(0.045)	(0.034)	(0.019)	(0.026)
Tubers and Plantains	-0.957	-0.987	-0.837	-0.549
	(0.061)	(0.047)	(0.038)	(0.041)
Pulses and Oils	-0.954	-1.104	-1.314	-0.972
	(0.037)	(0.044)	(0.023)	(0.032)
Others	-0.786	-0.717	-0.778	-1.060
	(0.03)	(0.032)	(0.019)	(0.039)
Hicksian (compensated) Own-Price Elasticities				
Cereals	-0.326	-0.521	-0.518	-0.450
	(0.015)	(0.084)	(0.028)	(0.019)
Livestock and Livestock Products	-0.416	-0.677	-0.499	-0.687
	(0.03)	(0.05)	(0.028)	(0.027)
Fruits and Vegetables	-0.867	-0.683	-0.932	-0.970
	(0.045)	(0.036)	(0.019)	(0.026)
Tubers and Plantains	-0.920	-0.877	-0.728	-0.500
	(0.061)	(0.046)	(0.041)	(0.04)
Pulses and Oils	-0.870	-1.041	-1.232	-0.827
	(0.036)	(0.038)	(0.023)	(0.031)
Others	-0.481	-0.521	-0.686	-0.804
	(0.032)	(0.043)	(0.018)	(0.03)

Source: authors' calculation from LSMS-ISAs using the censored QUAIDS model. Standard errors are calculated using the delta method.

Table 5: Variance-Covariance Matrix of Food Item Prices

Ethiopia

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Other
Cereals	4.158	5.335	0.787	0.188	2.408	6.492
Liv & Prod	5.335	382.217	5.936	0.396	17.536	39.116
Fruit & Veg	0.787	5.936	9.046	1.831	2.983	10.178
Tubers	0.188	0.396	1.831	17.853	3.858	0.160
Pulses	2.408	17.536	2.983	3.858	34.571	6.565
Other	6.492	39.116	10.178	0.160	6.565	651.251

Tanzania

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Other
Cereals	57894.7	26527.4	23403.3	16540.9	19200.4	15558.2
Liv & Prod	26527.4	1309134.0	38567.4	31034.5	56892.1	44610.4
Fruit & Veg	23403.3	38567.4	64135.2	15384.7	13972.2	11220.6
Tubers	16540.9	31034.5	15384.7	50836.2	22678.3	17625.9
Pulses	19200.4	56892.1	13972.2	22678.3	268800.8	48475.0
Other	15558.2	44610.4	11220.6	17625.9	48475.0	312485.7

Malawi

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Other
Cereals	814.2	85.4	50.0	88.5	186.4	460.9
Liv & Prod	85.4	14008.8	120.4	114.1	841.0	2126.1
Fruit & Veg	50.0	120.4	413.3	49.9	315.6	572.9
Tubers	88.5	114.1	49.9	281.2	109.9	325.8
Pulses	186.4	841.0	315.6	109.9	15444.1	2429.3
Other	460.9	2126.1	572.9	325.8	2429.3	11028.2

Niger

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Other
Cereals	6907.1	29182.9	-10647.5	3748.0	6245.8	576.2
Liv & Prod	29182.9	555645.3	-121055.6	13321.4	22507.6	-33684.8
Fruit & Veg	-10647.5	-121055.6	256037.1	-2275.3	-15172.2	27352.8
Tubers	3748.0	13321.4	-2275.3	33997.7	1021.1	11503.0
Pulses	6245.8	22507.6	-15172.2	1021.1	56199.1	7314.1
Other	576.2	-33684.8	27352.8	11503.0	7314.1	177079.7

Source: authors' calculation from LSMS-ISAs

Table 6: Welfare effects of the change in the real cereal price, 2011/2012

	Ethiopia	Tanzania	Niger	Malawi
Total	3.63%	5.23%	7.78%	8.35%
Urban	6.00%	6.20%	6.38%	6.73%
Rural	3.30%	4.77%	8.67%	12.83%
1st quintile	3.21%	4.18%	8.95%	8.66%
2nd quintile	3.08%	4.89%	8.65%	6.79%
3rd quintile	3.50%	5.71%	8.33%	7.95%
4th quintile	3.74%	6.10%	7.53%	8.75%
5th quintile	4.63%	5.28%	5.44%	9.61%
Net Buyer	8.69%	7.93%	8.21%	18.18%
Net Seller	-0.86%	-2.07%	-0.39%	-3.58%

Source: authors' calculation from LSMS-ISAs.

Table 7: Mean Price Risk Aversion for the full sample

	Ethiopia	Tanzania	Niger	Malawi
Cereals	55.259	0.275	4.383	3.110
Livestock and Livestock Products	3.801	0.069	0.047	0.333
Fruits and Vegetables	5.090	0.229	0.072	4.332
Tubers and Plantains	5.421	0.148	0.131	2.104
Pulses and Oils	4.580	0.036	0.161	0.171
Others	0.991	0.079	0.054	0.988

Source: authors' calculation from LSMS-ISAs.

Table 8: Welfare effects of cereal price volatility, 2011/2012

	Ethiopia	Tanzania	Niger	Malawi
Total	1.15%	0.49%	2.14%	1.17%
Urban	1.29%	0.55%	1.22%	1.32%
Rural	1.12%	0.45%	2.75%	0.96%
1st quintile	2.24%	0.85%	3.42%	3.63%
2nd quintile	1.14%	0.56%	2.65%	1.47%
3rd quintile	1.07%	0.46%	2.22%	0.91%
4th quintile	0.79%	0.43%	1.66%	0.64%
5th quintile	0.78%	0.25%	0.87%	0.42%
Net Buyer	1.62%	0.68%	2.16%	1.51%
Net Seller	-0.16%	-0.49%	-0.23%	-0.50%

Source: authors' calculation from LSMS-ISAs.

Figure 1: Monthly Real Cereal Price Index, 2007-2015

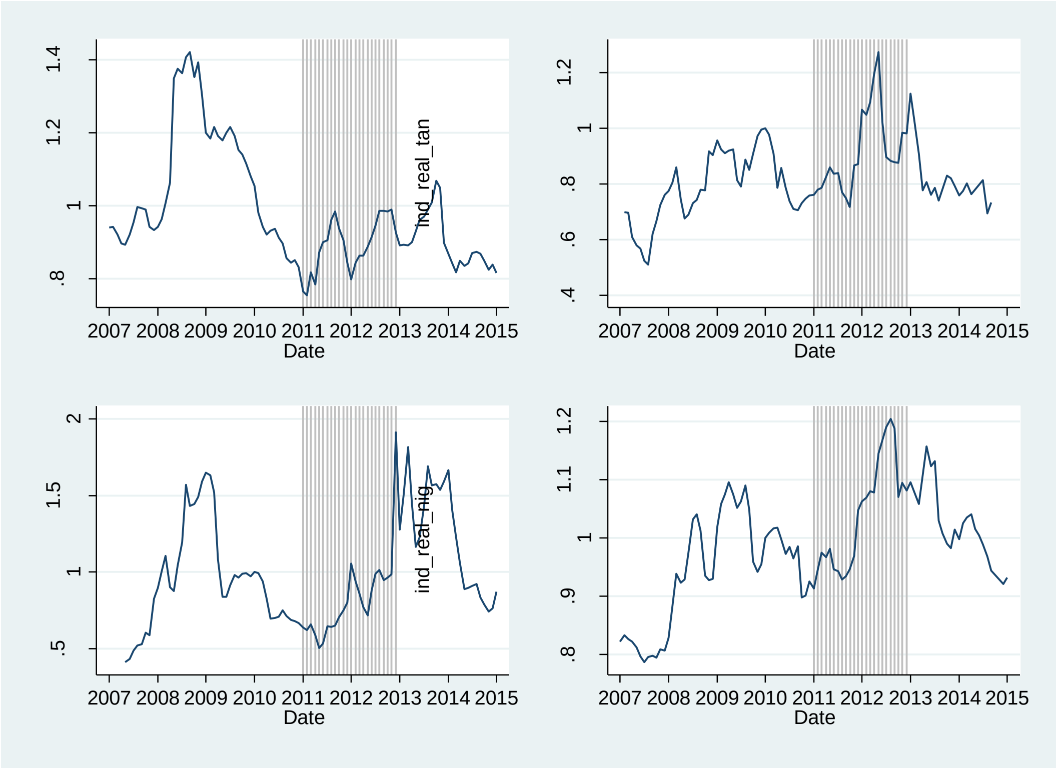
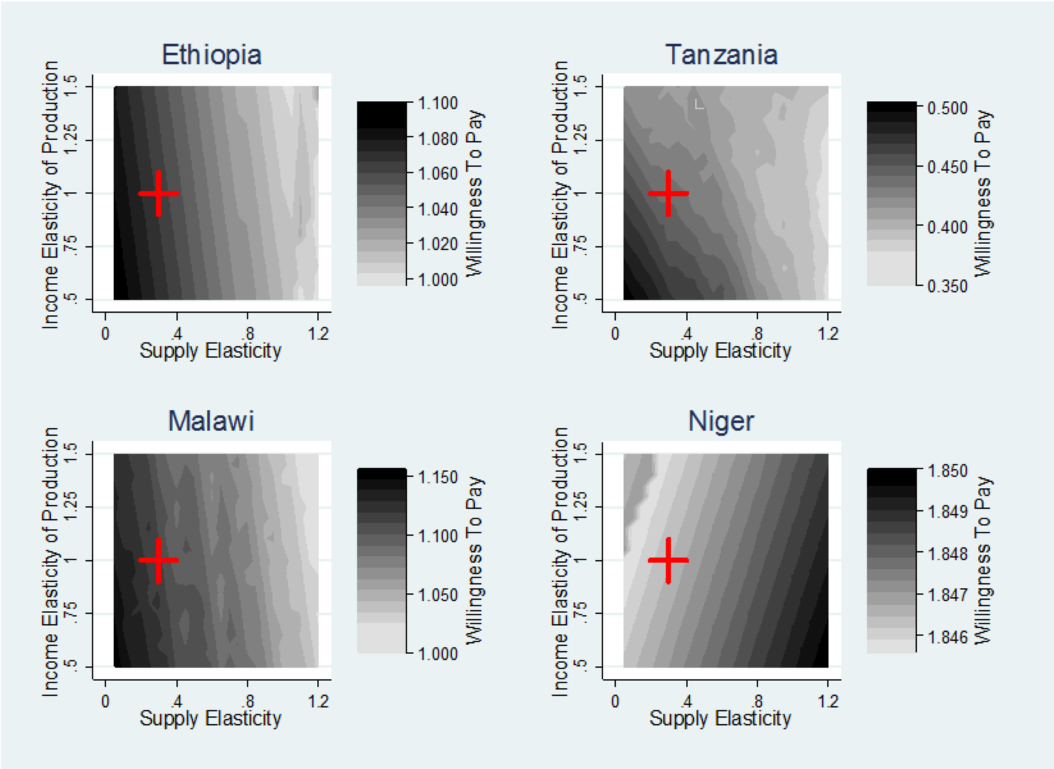


Figure 2: WTP for different values of Income and Supply Elasticities



Source: authors' calculation from LSMS-ISAs.

SUPPLEMENTAL MATERIAL

Cereal Price Shocks and Volatility in Sub-Saharan Africa: what does really matter for Farmers' Welfare?

Appendix A: Food Groups (Table A.1)

	ETHIOPIA	TANZANIA	NIGER	MALAWI
Cereals	Teff, Wheat, Barley, Maize, Sorghum, Millet	Rice, Maize, Millet, Sorghum, Wheat, Barley	Maize, Millet, Wheat, Sorghum	Maize, Rice, Millet, Sorghum, Wheat
Livestock and Livestock Products	Meat, Milk, Cheese, Eggs	Goat, Beef, Pork, Chicken, Birds, Insects, Eggs, Fresh and Dried Fish, Milk, Cheese	Beef, Mutton, Goat, Poultry, Eggs, Milk, Curd	Beef, Goat, Pork, Mutton, Chicken, Eggs, Fresh and Dried Fish, Milk, Butter, Cheese, Yoghurt
Fruits and Vegetables	Onion, Banana	Onions, Tomotoes,Carrots, Pepper, Spinach, Cabbage, Other Vegetable, Bananas, Citrus Fruits, Mango, Avocado, Sugarcane	Onion,Okra, Tomatoes, Fresh Pepper	Onion, Cabbage, Rape, Green Leaves, Tomatoes, Cucumber, Pumpkin, Mango, Banana, Critrus, Pineapple, Papaya, Guava, Avocado
Tubers and Plantains	Potato, Kocho	Cassava, Potatoes, Yams, Plantains, Others	Cassava, Yam, Potato, others	Cassava, Potato, Plantain, Cocoyam
Pulses and Oils	Horsebeans, Chick Pea, Field Pea, Lentils, Haricot beans, Niger seed, Linseed,	Peas, Beans, Lentils, Other Pulses, Cooking Oil, Margarine	Beans, Dry Pea, Palm Oil, Peanut Oil	Bean, Pigeonpea, Groundnuts, Cowpea, Others, Cooking Oil
Other Foods	Sugar, Salt, Coffee, Chat	Bread, Buns, Cakes, Macaroni, Salt, Other Spices, Sugar, Sweets, Nuts and Seeds, Tea, Coffee and other Beverages	Maggi Cube, Pastes, Soumbala, Baobab leaves, Yodo, Malahya, Salt, Pimento, Sugar, tea	Bread, Buns, Cakes, Macaroni, Sugar, Salt, Spices, Sweets, Honey, Hot Sauce, Tea, Coffee, Beverages

Appendix B: Quadratic Almost Ideal Demand System

Banks et al. (1997) show that it is possible to derive the quadratic specification for the budget shares considering a generalization of the Price-Independent Generalized Logarithmic (PIGLOG) preferences proposed by Muellbauer (1976) and assuming the following indirect utility function:

$$lnV(p,m) = \left[\left\{\frac{lnm - lna(p)}{b(p)}\right\}^{-1} + \lambda(p)\right]^{-1} \qquad [B1]$$

where m indicates the total food expenditure and p is the vector of prices. $lna(p)$, $b(p)$ and $\lambda(p)$ are price aggregator functions, i.e.:

$$lna(p) = \alpha_o + \sum_{j=1}^{N} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \gamma_{ij} lnp_i lnp_k \qquad [B2]$$

$$b(p) = \prod_{i=1}^{k} p_i^{\beta_i} \qquad [B3]$$

$$\lambda(p) = \sum_{i=1}^{k} \lambda_i lnp_i \qquad [B4]$$

with i and j indicating the food items under investigation and $\alpha_o, \alpha_i, \gamma_{ij}, \beta_i$ and λ_i parameters to be estimated. In order to make the system of equation [B1]-[B4] consistent with demand theory, some restrictions are needed. Specifically, for respecting adding-up, homogeneity and Slutsky symmetry we need to impose the following constraints:

$$\sum_{i=1}^{k} \alpha_i = 1, \quad \sum_{i=1}^{k} \beta_i = 0, \quad \sum_{j=1}^{k} \gamma_{ij} = 0, \quad \sum_{1}^{k} \lambda_i = 0 \qquad \text{adding-up}$$

$$\sum_{i=1}^{n} \gamma_{ji} = 0 \qquad \text{homogeneity} \qquad [B5]$$

$\gamma_{ij} = \gamma_{ji}$ Slutsky symmetry

As shown by Banks et al. (1997), if we apply the Roy's identity to equation [B1], we can express the food budget shares as:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} lnp_j + \beta_i ln\left\{\frac{m}{a(p)}\right\} + \frac{\lambda_i}{b(p)}\left[ln\left\{\frac{m}{a(p)}\right\}\right]^2 \qquad [B6]$$

where *w* is the share of the total food expenditure *m* allocated to the *i*th item while p_j is the price of *j*th commodity. It is interesting to note that if all λ_i are equal to zero the curves would be linear again and the QUAIDS would collapse to the AIDS model. It is also worth to point out that the empirical version of the model used in this paper to estimate the price and expenditure elasticities is based on a modified version of equation [B6] which takes into consideration the role played by socio-economic characteristics in determining the household behaviour as well as the issues related to the zero expenditure for food groups which characterize survey data in developing countries.

Appendix C: Parameter Estimates of the Multivariate Probit Models

Table C.1: Multivariate Probit for Ethiopia

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses
Prices Indexes (log)					
Cereals	**-0.570**	**-0.297**	-0.042	**0.177**	**0.225**
Livestock & Liv Product	**-0.235**	**-0.127**	**0.231**	0.019	**0.279**
Fruit & Vegetables	0.231	0.124	**-0.216**	**-0.439**	**-0.229**
Tubers and Plantains	**0.589**	**0.183**	**-0.091**	**-0.297**	**-0.255**
Pulses & Oils	-0.210	**0.270**	**0.157**	-0.080	-0.059
Other Foods	**-0.144**	-0.051	**0.079**	**0.064**	**0.124**
Total Expenditure (Log)	**0.471**	**0.777**	**0.391**	**0.253**	**0.181**
Demographic Variables					
Household Size	-0.072	-0.022	**0.062**	0.003	0.036
HH Head Age	0.004	**-0.004**	**-0.009**	**-0.003**	**-0.003**
Rural/Urban	0.114	**-0.186**	**-0.539**	**-0.507**	0.024
Nr. Children	**0.167**	0.015	**-0.090**	-0.007	**-0.063**
Primary Education	0.035	0.143	**0.281**	**0.228**	0.125
Secondary Education	**-0.617**	**0.722**	**0.654**	0.180	0.239
Constant	-0.843	**-6.689**	**-2.731**	**-0.807**	**-1.425**
Error Correlation Matrix					
Cereals	1.000	0.021	0.059	-0.048	0.052
Livestock & Liv Product		1.000	**0.128**	0.012	**-0.101**
Fruit & Vegetables			1.000	**0.111**	**0.271**
Tubers and Plantains				1.000	-0.013
Pulses & Oils					1.000

Table C.2: Multivariate Probit for Tanzania

	Cereals	Liv & Prod	Fruit & Veg	Starches	Pulses
Prices Indexes (log)					
Cereals	**-0.460**	0.163	**-0.575**	**0.544**	**-0.858**
Livestock & Liv Product	-0.150	**-0.304**	0.188	0.045	**0.194**
Fruit & Vegetables	0.048	0.187	-0.366	**-0.230**	-0.029
Starches	**0.349**	0.133	-0.162	**-0.325**	0.040
Pulses & Oils	**0.788**	**0.537**	**0.434**	**-0.523**	0.153
Other Foods	-0.073	0.107	0.069	-0.045	**0.251**
Total Expenditure (Log)	**1.024**	**1.175**	**0.854**	**0.714**	**0.892**
Demographic Variables					
Household Size	-0.020	-0.045	-0.033	**-0.066**	-0.009
HH Head Age	0.003	**-0.005**	0.005	**0.003**	-0.002
Rural/Urban	**-0.488**	-0.110	**-0.411**	0.059	**-0.277**
Nr. Children	-0.024	0.032	0.028	0.024	-0.018
Primary Education	-0.056	-0.048	**0.401**	0.094	**0.283**
Secondary Education	-0.070	0.297	0.064	0.147	**0.276**
Constant	**-15.448**	**-19.934**	**-7.462**	**-5.297**	**-9.463**
Error Correlation Matrix					
Cereals	1.000	-0.023	**0.307**	**-0.116**	**0.202**
Livestock & Liv Product		1.000	0.039	**0.111**	-0.050
Fruit & Vegetables			1.000	0.071	**0.229**
Starches				1.000	0.003
Pulses & Oils					1.000

Table C.3: Multivariate Probit for Niger

	Cereals	Liv & Prod	Fruit & Veg	Starches	Pulses
Prices Indexes (log)					
Cereals	0.583	**-0.507**	-0.067	**0.701**	0.166
Livestock & Liv Product	**-1.241**	-0.125	**0.211**	**0.356**	0.111
Fruit & Vegetables	0.061	0.087	-0.011	0.071	-0.139
Starches	**-1.760**	**0.631**	**0.587**	**-0.264**	0.292
Pulses & Oils	-1.283	**-0.503**	**-0.294**	**-0.497**	-0.396
Other Foods	-0.039	**0.413**	**0.392**	0.062	0.208
Total Expenditure (Log)	**1.859**	**0.979**	**1.093**	**0.616**	**0.872**
Demographic Variables					
Household Size	0.622	**-0.090**	**-0.063**	-0.037	0.039
HH Head Age	0.003	0.004	0.002	**-0.006**	0.002
Rural/Urban	**1.310**	**-0.539**	**-0.732**	**-0.828**	0.074
Nr. Children	-0.148	0.045	0.005	-0.001	-0.078
Primary Education	0.441	0.124	0.218	0.185	-0.025
Secondary Education	-0.183	**0.551**	-0.263	**0.392**	**-0.577**
Constant	3.040	**-11.107**	**-17.591**	**-8.239**	**-10.528**
Error Correlation Matrix					
Cereals	1.000	-0.094	**0.215**	0.059	0.137
Livestock & Liv Product		1.000	**0.168**	**0.107**	0.114
Fruit & Vegetables			1.000	0.088	**0.591**
Starches				1.000	0.109
Pulses & Oils					1.000

Table C.4: Multivariate Probit for Malawi

	Cereals	Liv & Prod	Fruit & Veg	Starches	Pulses
Prices Indexes (log)					
Cereals	**-0.496**	**-0.190**	-0.278	0.062	**-0.192**
Livestock & Liv Product	0.134	**-0.540**	0.179	0.058	0.071
Fruit & Vegetables	-0.191	**0.330**	-0.223	**0.243**	**0.221**
Starches	**-0.834**	0.142	-0.226	0.022	-0.132
Pulses & Oils	**0.534**	0.040	0.109	0.045	**0.147**
Other Foods	**-0.800**	**0.148**	-0.247	-0.075	0.059
Total Expenditure (Log)	**0.858**	**1.256**	**0.817**	**0.443**	**0.813**
Demographic Variables					
Household Size	-0.073	-0.048	-0.048	-0.026	**-0.083**
HH Head Age	0.000	-0.004	-0.006	-0.003	-0.001
Rural/Urban	0.100	**0.238**	0.284	0.031	0.103
Nr. Children	-0.015	-0.053	0.066	-0.014	0.053
Primary Education	**-0.442**	0.031	-0.183	0.082	-0.066
Secondary Education	**-0.549**	**0.248**	-0.198	0.118	0.073
Constant	-0.508	**-11.657**	**-4.001**	**-5.720**	**-9.081**
Error Correlation Matrix					
Cereals	1.000	-0.061	-0.067	-0.018	-0.050
Livestock & Liv Product		1.000	-0.075	**0.086**	0.068
Fruit & Vegetables			1.000	0.085	**0.131**
Starches				1.000	**0.103**
Pulses & Oils					1.000

Appendix D: Expenditure and Price Elasticities

Table D1: Expenditure and Price Elasticities for Ethiopia

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Others
Expenditure Elasticity	**0.785**	**1.238**	**0.819**	**0.781**	**0.787**	**1.542**
	Marshallian (uncompensated) Price Elasticities					
Cereals	**-0.696**	**-0.050**	-0.003	**0.054**	-0.004	**-0.086**
Livestock and Livestock Products	**-0.278**	**-0.591**	0.001	**-0.123**	**0.072**	**-0.318**
Fruits and Vegetables	**-0.145**	**0.127**	**-0.897**	0.035	**0.079**	-0.018
Tubers and Plantains	**0.269**	-0.087	**-0.587**	**-0.957**	**-0.312**	**0.893**
Pulses and Oils	0.050	**0.189**	0.027	**-0.121**	**-0.954**	0.020
Other Foods	**-0.591**	**-0.278**	**0.113**	0.006	-0.007	**-0.786**
	Hicksian (compensated) Price Elasticities					
Cereals	**-0.326**	**0.061**	**0.025**	**0.091**	**0.079**	**0.069**
Livestock and Livestock Products	**0.305**	**-0.416**	**0.046**	**-0.065**	**0.203**	**-0.074**
Fruits and Vegetables	**0.241**	**0.243**	**-0.867**	**0.073**	**0.165**	**0.144**
Tubers and Plantains	**0.637**	0.024	**-0.558**	**-0.920**	**-0.229**	**1.047**
Pulses and Oils	**0.421**	**0.301**	**0.056**	**-0.084**	**-0.870**	**0.176**
Other Foods	**0.136**	**-0.060**	**0.169**	**0.079**	**0.156**	**-0.481**

Table D2: Expenditure and Price Elasticities for Tanzania

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Others
Expenditure Elasticity	**0.572**	**1.682**	**0.934**	**1.200**	**0.628**	**1.119**
	Marshallian (uncompensated) Price Elasticities					
Cereals	**-0.693**	0.009	**-0.039**	**0.112**	-0.015	**0.054**
Livestock and Livestock Products	**-0.316**	**-1.010**	**-0.046**	-0.017	-0.027	**-0.267**
Fruits and Vegetables	**-0.178**	**0.053**	**-0.808**	**-0.091**	**0.101**	-0.011
Tubers and Plantains	-0.012	-0.043	-0.043	**-0.987**	**0.203**	**-0.317**
Pulses and Oils	-0.010	**0.105**	**0.168**	0.034	**-1.104**	**0.178**
Other Foods	-0.021	**-0.082**	**-0.100**	**-0.129**	-0.069	**-0.717**
	Hicksian (compensated) Price Elasticities					
Cereals	**-0.521**	**0.122**	0.038	**0.165**	0.042	**0.154**
Livestock and Livestock Products	**0.189**	**-0.677**	**0.181**	**0.138**	**0.140**	0.029
Fruits and Vegetables	**0.103**	**0.237**	**-0.683**	-0.005	**0.193**	**0.153**
Tubers and Plantains	**0.349**	**0.195**	**0.118**	**-0.877**	**0.322**	**-0.106**
Pulses and Oils	**0.179**	**0.229**	**0.253**	**0.092**	**-1.041**	**0.288**
Other Foods	**0.315**	**0.140**	**0.051**	-0.026	0.042	**-0.521**

Table D3: Expenditure and Price Elasticities for Niger

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Others
Expenditure Elasticity	**0.579**	**2.004**	**1.134**	**1.479**	**0.947**	**0.693**
	Marshallian (uncompensated) Price Elasticities					
Cereals	**-0.786**	-0.006	**0.046**	0.006	**0.080**	**0.081**
Livestock and Livestock Products	**-0.675**	**-0.896**	**-0.058**	**-0.054**	**-0.090**	**-0.231**
Fruits and Vegetables	**0.177**	**-0.041**	**-0.984**	-0.026	**-0.068**	**-0.192**
Tubers and Plantains	**-0.212**	0.018	**-0.062**	**-0.837**	**-0.093**	**-0.292**
Pulses and Oils	**0.274**	**-0.031**	-0.003	0.021	**-1.314**	**0.105**
Other Foods	**0.138**	**-0.109**	**-0.044**	**-0.035**	**0.135**	**-0.778**
	Hicksian (compensated) Price Elasticities					
Cereals	**-0.518**	**0.109**	**0.073**	**0.049**	**0.130**	**0.158**
Livestock and Livestock Products	**0.253**	**-0.499**	**0.034**	**0.092**	**0.084**	**0.035**
Fruits and Vegetables	**0.703**	**0.184**	**-0.932**	**0.057**	0.031	-0.041
Tubers and Plantains	**0.473**	**0.311**	0.006	**-0.728**	0.035	**-0.096**
Pulses and Oils	**0.713**	**0.157**	**0.040**	**0.091**	**-1.232**	**0.231**
Other Foods	**0.459**	**0.028**	-0.012	0.016	**0.195**	**-0.686**

Table D4: Expenditure and Price Elasticities for Malawi

	Cereals	Liv & Prod	Fruit & Veg	Tubers	Pulses	Others
Expenditure Elasticity	**0.594**	**1.257**	**0.750**	**0.841**	**1.383**	**1.474**
	Marshallian (uncompensated) Price Elasticities					
Cereals	**-0.641**	0.027	0.000	**-0.039**	0.016	**0.043**
Livestock and Livestock Products	**-0.222**	**-0.943**	**0.058**	**-0.048**	**-0.074**	-0.026
Fruits and Vegetables	-0.023	**0.110**	**-1.074**	**0.108**	**0.123**	0.007
Tubers and Plantains	-0.008	**-0.171**	**0.182**	**-0.549**	**-0.159**	**-0.137**
Pulses and Oils	**-0.187**	**-0.233**	0.010	**-0.086**	**-0.972**	**0.085**
Others	**-0.272**	-0.009	**-0.075**	**-0.055**	-0.005	**-1.060**
	Hicksian (compensated) Price Elasticities					
Cereals	**-0.450**	**0.148**	**0.083**	-0.005	**0.078**	**0.146**
Livestock and Livestock Products	**0.182**	**-0.687**	**0.232**	0.024	**0.057**	**0.192**
Fruits and Vegetables	**0.218**	**0.262**	**-0.970**	**0.151**	**0.201**	**0.137**
Tubers and Plantains	**0.263**	0.001	**0.299**	**-0.500**	**-0.071**	0.009
Pulses and Oils	**0.259**	0.048	**0.202**	-0.006	**-0.827**	**0.325**
Others	**0.203**	**0.291**	**0.130**	**0.030**	**0.149**	**-0.804**

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1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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