Price Change and Households' Welfare in Ghana (1991-2013)

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Abstract

Given the growing world population and income in emerging economies, increased demand for food and feed crops for the production of bio-fuels, and greater frequency and intensity of weather-related disasters in different parts of the world due to climate change, global food prices are expected to increase. Food importing developing countries are vulnerable to these price increases and associated price volatility as poor households would be the most severely affected. While there are extensive empirical studies on the effect of food price increases and volatility on household welfare in developed and developing countries, little is known about African countries. This thesis contributes to the literature on Africa, specifically Ghana using three waves of the Ghana Living Standard Survey (GLSS) to measure the effect of food price increases on household welfare between 1991 and 2013 and addressing the effect of price volatility with a measure of households' willingness to pay for price stability.

A number of contributions are made in this thesis. First, an application of both a parametric and non-parametric analysis to the GLSS shows that budget share equations require including a higher expenditure term to appropriately explain consumer behaviour; the non-linear Quadratic Almost Ideal Demand System expenditure model is the best fit for the GLSS data. Second, an analysis of the consumption patterns of cereal and cereal products shows variation in consumption patterns across time and different groups of households. For example, bread is considered a necessity while maize was a luxury in 1991/92 and 1998/99 but a necessity in 2012/13, showing a case of where a commodity is a luxury at some point and a necessity at another time. Commodity groups such as root, tubers & plantain, meat, fish and oil & fat products are considered luxuries while bread & cereals are considered necessities.

Third, welfare effects calculated for three periods of price changes show there are differences in magnitude for each period, and in all periods a higher proportion of poorer household food expenditure is needed to compensate for observed price increases than for non-poor households. However, within poorer households, we find that rural poor households suffered more from price increases than urban poor households. There are also significant regional differences in welfare effects across periods, with households in the Savannah zone suffering more from observed price changes in all periods. Finally, while the average rural household is a net producer of maize and millet but a net purchaser of rice, rural households are more price risk averse with respect to the price of rice. If substitution between the prices of maize, rice and millet are ignored, 13 per cent of income of the average rural household is required to stabilise prices of all three commodities. However, if substitution is allowed for, the average rural household will be willing to pay 9 per cent of income to stabilise the price of all three commodities at the same time. This suggests that ignoring substitution between prices lead to overestimation of household Willingness-To-Pay (WTP) to stabilise prices of maize, rice and millet in Ghana.

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Dedication

I dedicate this thesis to my wife – Fatima Abdulai Issah, and my parents– Rahaman Abdul Rahaman and Latifatu Abdul Rahaman

Words cannot express how much I love you all.

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List of Acronyms

Acronym	Meaning
AIDS	Almost Ideal Demand System
CDF	Cumulative Density Function
CREDIT	Centre for Research in Economic Development and International Trade
FAO	Food and Agricultural Organisation
GETFUND	Ghana Education Trust Fund
GLSS	Ghana Living Standard Survey
GSS	Ghana Statistical Service
MOFA	Ministry of Food and Agriculture
NAFCO	National Food Buffer Stock Company
OECD	Organisation for Economic Co-operation and Development
PDF	Probability Density Function
QUAIDS	Quadratic Almost Ideal Demand System
USDA	United States Department of Agriculture
WTP	Willingness to Pay

Chapter 1 : Context, Overview and Motivation

1.1 Context and Overview

Recent international food price increases and volatility, driven by factors such as rapidly rising demand but sluggish growth in agricultural production and productivity, resuscitated the debate on the impact of food price increases and volatility on household welfare in developing countries (Ferreira et al., 2011; Dimova, 2015; Magrini et al., 2015). Food price increases not only resulted in exacerbating poverty in developing countries, but led to increased food insecurity as well as income inequality in low income countries (Dimova, 2015). Indeed, estimates in 2009 suggest that rising international food prices had pushed an additional 24 million people into hunger, increasing the number of undernourished to a record 265 million people (Dimova, 2015).

International food price increases and volatility affect countries in various ways; we are concerned with how they may affect developing countries like Ghana. At the macro-level, net-food exporting countries gain while net-food importing economies suffer as the cost of food imports increases. At the micro-level, the welfare effects of food price increases and volatility depend on whether the household is a net-food consumer or net-food producer. Poor net-food consuming households are hit the most by food price increases and volatility because relatively more of their income goes on food (typically between 60 to 80 per cent of expenditure in countries like Ghana) than richer households. Higher food prices may reduce the number and quality of meals consumed by low income households; they consume less nutritious food (which may have negative health implications for household members, particularly children) and spend less on other things such as education, shelter and health. Net-food producing agricultural households would expect to benefit from food price increases. However, if such increases are associated with high price volatility, uncertainties are created and these act as a disincentive to produce more to take advantage of high food prices.

While there is a large literature on the welfare effects of price changes on households in developed and many developing countries (see Garcia-German, et al., 2013 for an extensive review for developed countries), there is little consensus for African countries[1]. Notable studies on this subject for Africa are Ackah and Appleton (2007), Leyaro et al (2010), Minot and Dewina (2013), Osei-Asare and Eghan (2013), Tefera et al., (2012) and Magrini et al. (2015). Ackah and Appleton (2007) analyse the effect of food price changes on household consumption in Ghana during the 1990s and assess the extent to which changes can be explained by trade and agricultural policy reforms. Both first and second order effects of price changes were estimated and their conclusion is that the distributional burden of observed price changes in the 1990s fell mainly on the urban poor. Osei-Asare and Eghan (2013) also analysed the effects of food price inflation on Ghanaian households and found that food price inflation between 2005 and 2011 eroded real household food purchasing power by almost half. Minot and Dewina (2013), also for Ghana, found that higher maize and rice prices have a relatively modest short-term impact on national poverty but significant effects on specific groups of households; urban households lose from higher grain prices and a surprisingly large share of rural households also lose because they are net buyers.

[1] The studies that have examined this issue for African countries show a diversity of results so there is a lack of consistent information about the welfare effects of commodity price changes on households, hence little guidance on effective policy responses. This is a worrisome situation when international food prices are expected to rise again; according to the OECD and FAO, all food prices will increase above average in 2020 compared to the previous decade. Thus, knowing the effect of food price increases and volatility on household welfare will be essential for nutritional improvement programs, poverty reduction, demand planning, macroeconomic policy analysis, and food security (Haq et al., 2011; Dubihlela and Sekhampu, 2014).

Leyaro et al. (2010) analysed the effect of food price changes on household consumption (welfare) in Tanzania during the 1990s and 2000s, simulating the welfare effect attributable to tax reforms and concluding that the distributional burden of food price increases fell mainly on the rural poor. Mbegalo and Yu (2016) also analysed the impact of food prices on household welfare and poverty in rural Tanzania and found that net sellers do benefit but net buyers tend to show a loss in welfare due to food price increases. The effect of rising food prices varies across household characteristics and by region. Tefera et al. (2012) examined the welfare impact in rural Ethiopia and concluded that rising food prices increased welfare of rural households by about ten per cent in aggregate terms.

A more recent study of five countries (Ethiopia, Tanzania, Malawi, Niger and Bangladesh) by Magrini et al. (2015) found key variations across countries for the same price shocks. They found that the effect of price shocks depend on the share of food expenditure in 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. Countries with high food expenditure share, less substitution effects and more net-buyers suffer more from price shocks. For all countries, Magrini et al. (2015) found that the impact of price changes substantially outweigh the effects of price volatility on household welfare across the entire income distribution of households. Furthermore, households are likely to benefit more from policies preventing or limiting cereal price increases than untargeted stabilization policies. Lastly, their results also suggest that targeted policy interventions for reducing the exposure of the poorest quintiles to volatile cereal prices could still be an effective tool to cope with the adverse effects of risk.

This study adds to the above literature by analysing the distributional impact of observed food price increases and price volatility in Ghana between 1991 and 2013 using Ghana Living Standard Surveys (GLSS) data. This study is different from and extends previous studies on Ghana in four main respects. First, instead of assuming a household demand model to estimate price and income responses for welfare analysis, the data were analysed to identify which model best fits the data testing between the Almost Ideal Demand System (AIDS) and the Quadratic Almost Ideal Demand System (QUAIDS) models. Second, the effect of observed food price changes is studied over three periods noting differences in each period. Third, this study explicitly accounts for zero household consumption in the demand estimation. Fourth, all studies have focus on price increases without emphasis on price volatility. However, as noted in Magrini et al (2014), if higher food prices are accompanied by higher volatility, the associated production risks may lower supply even when price incentives are high. Hence, welfare analysis should capture the effect of price volatility.

1.2 Motivation

With a per capita GDP of $1,326 in 2010, Ghana is among the lower middle income countries in the world. Its national poverty rate, which stood at 52 per cent in 1991/1992, is down to 24.2 per cent in 2012/2013 (GSS, 2014). The rural population has always accounted for over 75 per cent of those in poverty with food expenditure forming the larger proportion of household expenditure in rural areas. In the early 2000s, on average 44% and 60% of household expenditure was on food in urban and rural Ghana respectively (GSS, 2008).

In the 2007/2008 fiscal year, as a result of the global food crises, the country saw a high rate of food price increases: the price of cereals increased by 20% to 30% between 2007 and 2008 (Osei-Asare and Eghan, 2013), while the food component of the consumer price index rose from 193.9 to 246.7 indicating 27% food inflation in the same period (Ghana Statistical Service (GSS), 2009). Due to the growing world population and expected rising incomes in emerging and developing countries, [2] increased demand for food and feed crops for the production of biofuels (and the broader co-movement of agricultural commodity prices and oil prices), and increasing frequency and intensity of weather-related disaster in different parts of the world, food prices are expected to rise again and households in Ghana (particularly poor households) like any other developing countries will be affected.

The motivation of the study stems from the fact that knowledge on how price increases and volatility affect households, particularly poor households, will put policy makers in a better position to implement policies that mitigate the impact of food price increases and volatility on households (e.g., where appropriate reductions in import tariffs may be beneficial). The objective of this thesis, therefore, is to provide an analysis of the welfare effect of observed price increases on households in Ghana as well as the effect of price volatility and price risk on agricultural households. Three periods of observed price changes for food are considered: between 1991/92 and 2012/13; between 1991/92 and 1998/99; and between 1998/99 and 2012/13. In the case of price volatility we focus on three cereal items (maize, rice and millet) and consider only the period 2012 to 2013.

[2] For instance, by 2050 the world's population is expected to have reached about 9 billion people and the demand for food to have increased by between 70% and 100%.

1.3 Research questions

Three main research questions are addressed. First, as noted in Katchova and Chern (2004) and Banks et al. (1997) for welfare analysis, the demand model employed has significant implications on the welfare estimates. Previous studies on food demand and welfare effect of price changes in Ghana employed prior specification of the demand system (i.e., assumed a particular model was appropriate). Prior specification of the demand system can lead to a bias in the estimates for welfare if the structure of the actual data deviates from that assumed for the selected functional form. Therefore, the data should be used to select the model that best fits the data. As the two most commonly used models are the AIDS and QUAIDS, Chapter 2 tests which of these two demand models is most appropriate for GLSS data.

Second, Ackah and Appleton (2007), Minot and Dewina (2013), and Osei-Asare & Eghan (2013) all focussed on one period of price change and concluded that the burden of observed price changes fell mainly on the urban poor. This conclusion, however, was reached by assuming a linear budget share-total expenditure relationship (using linear approximate AIDS) and focussing on fewer than seven commodity groups. Chapter 3 addresses the question of how results are affected by using a non-linear budget share - total expenditure relationship (the QUAIDS model supported by the analysis in Chapter 2) and extends the analysis to nine commodity groups. We investigate which types of Ghanaian households bear more of the burden of price increases, has this pattern of effects changed over time, and what accounts for any differences discovered?

Third, although price increases are welfare enhancing for agricultural households, there may be lower a supply response when accompanied by price volatility (which may be exacerbated by price increases). Chapter 4 investigates how price volatility and risk affect rural agricultural households in Ghana.

1.4 Outline of thesis

The research questions asked above are clearly an empirical exercise. To answer them, the rest of the thesis is organized as follows: Estimating welfare effects requires a rigorous methodological approach for relating consumer behaviour to price changes (Magrini et al., 2015). Such a methodological approach often starts with estimating a household demand model which has adequate functional form capable of respecting the basic theoretical properties of consumer behaviour (Magrini et al., 2015). There are many such demand systems including the Generalised Leontief (Diewert, 1971), the Almost Ideal Demand System (Deaton and Muellbauer, 1980) and the Quadratic Almost Ideal Demand System (Banks et al., 1997).

The Almost Ideal Demand System (AIDS) and the Quadratic Almost Ideal Demand System (QUAIDS) models have been frequently applied in welfare analysis because of their attractive properties. However, as noted in Katchova and Chern (2004), the choice of a model for welfare analysis should be based on how well they fit the data. In Chapter two we test for which of the models, AIDS or QUAIDS, best fits our data. Both parametric and non-parametric methods are applied in this selection process. For the parametric method, we estimate both models for five commodity groups (bread & cereal, root, tuber & plantain, pulses, nut & seeds, oil & fat products and other food expenditure) using three rounds of the GLSS data (GLSS 3, 4 and 6) and applied the test proposed by Bapape (2006), Poi (2012) and Attanasio et al (2013) to select the model that best fits the data.

For the non-parametric method, we employ kernel and quadratic polynomial regressions to describe the relationship between budget share and total food expenditure.

Cereal and cereal products are major staples in Ghana. They are consumed by almost every household and form about 20% of total food expenditure of a typical Ghanaian household. Knowledge about how households respond to price and income changes with respect to cereal and cereal products will therefore benefit discussion on food policy in Ghana. Having ascertained the model that best fits the data, we analyse household consumption patterns of cereal and cereal products in Ghana using three rounds of the GLSS (3, 4 and 6). Wassiuw and Ibrahim (2015) estimated cereal consumption patterns using GLSS 3 & 4 and a linear approximation AIDS. Chapter two goes further by using the data to determine the best model (and ensure that household consumption patterns are captured accurately), and adding GLSS 6 (with a sample size of 16,772 households) to the analysis.

Chapter three focuses on the welfare effects of observed price changes. While it would be appropriate to analyse both producer and consumer welfare effects at the same time, we focus on the consumer effect in this chapter. We estimate price and income responses of households for nine commodity groups (Ackah and Appleton (2007) did it for six), using the QUAIDS demand model supported by the data, and then use the elasticities to evaluate the effect of observed price changes on welfare. Welfare is measured using the standard approach of compensating variation (CV).

Chapter four focuses on measuring the effect of price volatility on rural households in Ghana using the recent methodology proposed by Bellemare et al., (2013). Bellemare et al., (2013) address the relationship between price risk aversion and volatility by deriving a measure of willingness to pay (WTP) for price stabilization as a proportion of income. This methodology is employed to estimate the impact of price volatility on rural households in Ghana using the GLSS 6. The emphasis is placed on only cereals (ie maize, rice and millet). Finally, in Chapter five, we provide the contribution of the thesis, outline its limitations as well as areas for future research.

1.5 Data Source

The data sets employed in this thesis are the Ghana Living Standard Surveys (GLSS). The GLSS, conducted by the Ghana Statistical Service (GSS) with support from the World Bank, serves as a source of information on household and individual level variables in Ghana. It is conducted through a personal household interview and usually spans a period of twelve months. The sample is nationally representative, selected through a multi-sampling procedure, and spread across all ten administrative regions in Ghana (see Appendix A Table A2.1 for the sample regional distribution for four rounds of this survey). Ghana currently has six rounds of this survey (GLSS 1 to 6). The first (GLSS 1) was in 1986/1987 and the most recent (GLSS 6) in 2012/2013. Three rounds are utilized in this thesis: GLSS 3 (1991/92, with 4,523 households), GLSS 4 (1998/99, with 5,998 households) and 6 (2012/13, with 16,722 households). The decision to use these three is based on the fact that two (i.e. GLSS 3 and 6) were undertaken at the extreme ends of the analysis period for the thesis.[3] This gives us the opportunity to study the relationship between budget share and total food expenditure over

[3] We didn't use GLSS 1 or 2 as the starting period of the analysis because they are not fully comparable with the later GLSS.

the entire period of analysis. In all data sets, two stage purposive sampling procedure was used to select households. Clusters are selected in the first stage while households are selected in the second stage. Like the sample size, the number of clusters is different for each data set. GLSS 3 has 365 clusters while GLSS 4 and 6 have 300 and 1200 clusters respectively.

The GLSS use three main questionnaires - household, community and price. The household questionnaire consists of two parts (A and B) with each part divided into sections including an expenditure section (contained in part B) as well as other sections such as agriculture, household income transfers and household credit and savings. Apart from changes in the number of visits made to households, the expenditure section has remained largely the same for GLSS 3, 4, and 6. In GLSS 3, eleven visits were made in urban areas with a 3-day interval, while eight were made in rural areas with a 2-day interval. For GLSS 4, the number of visits was reduced to seven with a 5-day interval and was the same for both urban and rural households, while seven visits (with a 3-day interval) were made to all households in GLSS 6.[4]

Amongst other things, the expenditure section provides a source of data to evaluate and monitor expenditure and price policies, poverty and the welfare consequences of observed price changes on households in Ghana. Actual household purchases on over 200 food and non-food items as well as consumption of home produce are captured in this section. The data are collected through a personal household interview, supported by the diary method where a

[4] The differences in the number of visits imply a different expenditure recall period, which has implications for how we compare poverty rates across the rounds of the GLSS. A future research is to explore how these differences in recall periods have affected poverty estimates in Ghana over the years.

literate member of the household is asked to record daily expenditure and hand the diary to the interviewer on his/her next visit to the household. For households without a literate member, the interviewer makes a daily visit to the household and records all expenditures in the diary.

Although the expenditure data collection is supposed to take place within a pre-specified number of visits to the household, by design the data collection does not start on the first visit of the interviewer, but rather on the second visit. On the first visit, the interviewer becomes familiar with the household, identifies a literate person tasked to record all expenditures made by the household and informs the household of the next visit. On the second visit, the respondent (the person responsible for the household purchase) is asked to provide information (using the diary) on the amount spend on each expenditure item (this includes both actual purchases and own consumption) since the interviewer's first visit to the household. The information is immediately recorded in the expenditure section of the household questionnaire. This procedure and process is repeated any time the interviewer visits the household until the final visit.

1.5.1 Missing data

Like other large household surveys, household with non-reported expenditure data/missing data[5] is a common problem in the analysis of the expenditure data of the GLSS. Many reasons may account for this including error during data entry and cleaning, deletion of inconsistent answers, and the household's inability to recall expenditure due to longer recall periods. As noted in Ghosh and Pahwa

[5] Table A2.2 (in Appendix A) shows the extent of non-reported/missing data for expenditure on items captured under cereals and root, tuber & plantain commodity groups. As seen from the table, non-reported/missing data is quite significant for GLSS 3 and 4, but almost zero for GLSS 6 for all items; an indication of an improvement in the data collection process for GLSS 6. Non-reported/missing data for purchase expenditure on rice were 40% and 23% for GLSS 3 and 4 respectively, quite high considering the fact that rice is a staple in Ghana. Millet and guinea corn have a high proportion of households with non-reported/missing data in both GLSS 3 and 4 but this is not so surprising because these two items are cultivated and consumed largely in the Northern, Upper East and Upper West Regions of Ghana.

(2008), if an appropriate method is not used to handle non-reported/missing data it has the potential to bias results.

Researchers who use the GLSS expenditure data for welfare analysis are silent on the method adopted to handle non-reported/missing data, but a careful examination reveals they either analyze complete data or replace non-reported/missing expenditure with zero (see, for example, Ackah & Appleton (2012) and Osei-Asare & Eghan (2014; 2013)). Complete data analysis, which discards all households with non-reported/missing data, implicitly assumes that households with and without non-reported/missing expenditure data are not different from each other so that non-reported/missing expenditure is not associated with any variable in the data (i.e., expenditure is missing completely at random) and can be omitted without biasing results.

However, for some expenditure items in the GLSS, a logistic regression of an indicator[6] variable for non-reported/missing expenditure on variables such as region, locality, poverty status of the household and sex of the household head gives evidence that non-reported/missingness of household expenditure is not completely at random in the GLSS. For example, in the case of non-reported/missing data on maize, rice and yam, in GLSS 3 and GLSS 4, rural households are more likely to have non-reported/missing data than urban households, while female headed households are less likely to have non-reported data than male headed households and non-poor households are less likely to have non-reported data than poor households (See Table A2.3 in appendix A for

[6] An indicator for non-reported expenditure for an expenditure item was generated by creating a dummy variable which takes the value of 0 if the expenditure is non-reported and 1 otherwise.

the logistic regression results for maize, rice and yam for survey periods 1991/92 and 1998/99).

These findings suggest that non-reported/missing expenditure data do not occur completely at random and therefore any study that treats households (in the GLSS) without non-reported/missing data as a random subset of the original sample will most certainly generate biased results. Hence, complete data analysis is best avoided.[7] Furthermore, complete data analysis would reduce sample sizes (for chapter 2 and 3) by up to 65%, implying a significant loss of information.

The standard approach is to assume or impute a value of zero when expenditure is not reported or missing (Coulombe & McKay, 2008) justified on the basis that zero is the modal (most frequent) value reported in expenditure surveys (Nur, et al., 2009). The implicit assumption that the true value of the non-reported/ missing expenditure is zero with certainty understates the variance, overstates precision, and results in confidence intervals and significance levels being too optimistic (Little & Rubin, 2002).

However, this approach may be legitimate for GLSS: although, the survey spans one year, expenditure data for each household is collected over a period of not more than 21 days. It is therefore possible that a household genuinely did not consume an expenditure item during the survey period due to factors such as permanent non-consumption (e.g., Muslim households do not consume pork), non-consumption during the survey period (i.e. within the 21 days) or non-consumption because households cannot afford the items given prices and

[7] For the detail analysis of the bias associated with complete case method, see Schafer (1997), Allison (2002), Little & Rubin (2002) and Langkamp et al. (2010).

household incomes (Tefera et al., 2012). For these households, replacing non-reported/ missing expenditure with zero will therefore be legitimate. Hence, for all households with non-reported/missing data, we replaced it with zero.

Besides the expenditure data, GLSS 3, 4 and 6 also collect data on prevailing cluster prices of over 120 food items and non-food items in a local market (usually the biggest market in the locality). For each commodity, three prices are collected at different locations in the market. The median price of the three prices is used to construct a price index for each commodity group.[8] However, like the expenditure data, the price data also have some clusters with missing price information. Dropping such observations from the analysis may bias our results. Consequently, a single imputation method was employed to impute values of missing cluster prices for such items.

The single imputation method adopted follows Niimi (2005) and Ackah and Appleton (2007) approach of replacing missing price with the mean price for the locality (i.e. Accra, urban-coastal, urban-forest, urban-savannah, rural-coastal, rural-forest or rural-savannah) and the region in which the cluster is located. For example, if there are five clusters located in an urban coastal area in the greater Accra region and the price of an item is missing for one cluster, we replace it with the mean price for the item in the other four clusters. This is conditional on having at least one cluster price of the item being reported. If after this correction the cluster price remains missing, it is then replaced with the mean price for urban/rural for each region. If the cluster price is still missing it is replaced with

[8] We also experimented with the mean of the three prices and the results were not significantly different from using the median price.

the mean regional price; this was required only in the case of millet and guinea corn in the bread & cereal group in 1991/92.

Each chapter in the thesis is written so as to be self-contained, with the exception that Chapter 3 uses the results from Chapter 2. Detailed material and supplementary analyses are reported in appendices at the end of the thesis.

Chapter 2 : Almost Ideal Demand System or Quadratic Almost Ideal Demand System: An application to the Ghana Living Standard Survey (GLSS)

2.1 Introduction

In developing countries detailed knowledge of household consumption patterns plays a significant role in food policy advice and the evaluation of existing food policies. Food and nutritional programs, poverty reduction strategies as well as tax reforms, all require information on the consumption patterns of households for effective formulation and implementation. Welfare analysis of price increases on households also hinges largely on having the knowledge of household consumption patterns. Detailed knowledge of household consumption patterns, however, is often ascertained through the estimation of household responses to price and income changes (i.e. price and income elasticities) and this estimation often requires a specification of a household demand system that can model household demand behaviour by respecting the basic theoretical properties of consumer behaviour (Magrini et al, 2015).

There are many such demand models. The notable ones are the linear expenditure model developed by Stone (1954), the Rotterdam model introduced by Theil (1965), the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) and the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al (1997). In particular, the Almost Ideal Demand System (AIDS) and the Quadratic Almost Ideal Demand System (QUAIDS) have been widely applied in demand analysis because of their many useful properties. The AIDS model is said to be simple to estimate and free from the restrictive assumption of homotheticity; it treats zero and non-zero consumption in the same way; and is tractable and flexible, thus allowing researchers to overcome the problem of aggregation. It, however, does not allow for a non-linear relationship between budget shares and total expenditure as all commodities are assumed to have budget shares that are linear functions of total expenditure (Bapape and Myers, 2007).

In the last two decades, however, there has been a growth in the empirical literature which underscores the need to model household demand using a demand system that allows for non-linearity in budget shares and total expenditure. This was initiated in Banks et al. (1997), which examined the Engel curve[9] specification for five commodity groups (food, fuel, clothing, alcohol and other goods) using data from the UK Family Expenditure Survey and found that the Engel curve for commodity groups such as clothing, alcohol and "other goods" required a non-linear relationship between budget share and total expenditure to accurately explain consumer behaviour.[10]

To capture this non-linear relationship between budget share and total expenditure, Banks et al. (1997) proposed the Quadratic Almost Ideal Demand System (QUAIDS) which has budget shares that are quadratic in the logarithm of total expenditure but also retains the desirable properties of the AIDS model. Most recent studies on consumption patterns in developing countries have applied this model to estimate price and income responses of households (see, for example, Magrini et al. (2015), Tefera et al. (2012), Bopape (2007), Abdulai & Aubert (2004) and Meenkashi & Ray (1999)). A major advantage of having the quadratic term is that it allows the testing of situations where an increase in a household's income would alter the classification of an expenditure item from a luxury to a necessity.

[9] An Engel curve relates expenditure on a given commodity to total expenditure by a household.
[10] Thus, a linear Engel curve specification for these commodity groups will not provide an accurate description of the household's response to expenditure changes.

Despite their many attractive properties, for welfare analysis of price changes on households, as argued by Katchova and Chern (2004), the choice between the AIDS and QUAIDS models should be dependent on the available data. This is because welfare results are likely to be misleading when the data suggest a non-linear relationship between budget shares and total expenditure, and a linear relationship is assumed. For instance, the welfare impact of price increases on households with low income will be underestimated if a linear relationship between expenditure share and total expenditure is assumed when the actual relationship is a non-linear relationship (Hasan 2012). To avoid such misleading outcomes one should employ a model that best fits the data to estimate price and income responses for welfare analysis.

In the next chapter, the Ghana Living Standard Survey (GLSS) 3, 4 and 6 are used to estimate the welfare effect of observed price changes in Ghana between 1991 and 2013. The standard approach of compensating variation (CV) is employed, which requires that we estimate price and income responses of households in Ghana. Rather than choosing arbitrarily either the AIDS model or the QUAIDS demand model to estimate these price and income responses, the data are used to select which of the two demand systems fit the available data. Both parametric and non-parametric analyses are employed and this chapter explains in detail how the model selection was done. As far as welfare analysis of price changes in Ghana is concerned, this is the first time where the available data are used to determine the model choice; previous studies assume a linear relationship by employing restrictive functional forms such as the LA/AIDS model to estimate price and income responses of households in Ghana (see, for example, Ackah & Appleton (2007) and Osei-Asare & Eghan (2014; 2013)).

As noted in chapter 1, over 200 food items are captured in the GLSS. However, for practical and computational reasons, we aggregated them into five commodity groups: bread & cereals; root, tuber & plantain; pulses, nut & seeds; oil & fat products; and a residual group "other food". Since these five groups include all food items captured in the GLSS, we can fairly generalize the results to any other food groups generated out of the food items captured in the GLSS.

In addition to the model selection, we also provide an analysis of consumption patterns of household demand for cereal and cereal products between 1991 and 2013 by estimating price and expenditure elasticities for seven cereal items using the selected model. Cereals (particularly grains) are a staple food in Ghana and form over 20 percent of household total food expenditure in 2012/13 (GLSS 6; GSS, 2013). Detailed knowledge of the heterogeneity of household consumption patterns and how these patterns are changing over time will help policy makers to implement the right policies to mitigate the impact of price increases of cereal and cereal products in Ghana.

Wassiuw and Ibrahim (2015) provide a similar analysis for Ghana for the period 1991 to 1998 using GLSS 3 and 4. Price and expenditure elasticities for five cereal items were estimated with a linear approximate AIDS model (assuming a linear relationship between budget shares and total expenditure) and compared over the two periods. The linear assumption is tested in this chapter, adding more recent data (GLSS 6) and price and expenditure elasticities for seven cereal items are estimated with a demand model determined by the data. The elasticities are estimated by locality, quintile of national welfare and poverty status of household to ascertain the urban/rural and poverty status differences in consumption patterns of cereals in Ghana. We also test whether an increase in expenditure could change a luxury item to a necessity as noted in Banks et al (1997).

The rest of the chapter is organized as follows; section 2.2 presents a detailed discussion of both the parametric and non-parametric approaches employed, while section 2.3 discusses the data sets used in this chapter. Section 2.4 provides a detailed explanation of how we addressed the usual empirical issues that often arises with the adopted parametric approach while estimation techniques employed are discussed in section 2.5. Estimation results and household consumption patterns of cereal and cereal products are discussed in section 2.6 while Section 2.7 concludes the chapter.

2.2 Methodology

Two approaches are employed to decide on the model that best fits the available data - parametric and non-parametric. For the non-parametric approach we follow Banks et al (1997) by estimating for each of the commodity groups, kernel and polynomial kernel regressions of the relationship between budget share and total food expenditure. The parametric approach follows Bapape (2006), Poi (2012) and Attanasio et al (2013). Our objective in both approaches is to find out if for some commodity groups a non-linear relationship exists between budget share and total food expenditure. If this is the case, then as noted in Banks et al (1997) the appropriate demand model to estimate price and income responses should be the QUAIDS model. A detailed explanation of these two approaches is provided below. We start with the parametric approach.

2.2.1 Parametric Approach

In welfare analyses of price changes, there are many parametric tests for choosing between two or more demand models. Notable among them are the J test and Cox test. However, for simplicity and ease of implementation, we employ the test proposed by Banks et al (1997) based on noting that the statistical significance of the coefficient of the quadratic expenditure term in the QUAIDS model is a model specification test. The quadratic expenditure term in the QUAIDS model captures the non-linear relationship between budget share and total expenditure and distinguishes it from the AIDS model. This test constitutes our parametric approach. For us to favour the QUAIDS model over the AIDS model, the coefficient of the quadratic expenditure term should be significantly (statistically) different from zero for all share equations in the demand system. To provide further explanation of the parametric test, we need to discuss the theoretical specifications of both demand models. We start with the AIDS model.

AIDS Specification

The Almost Ideal Demand system (AIDS) of Deaton and Muellbauer (1980) assumes an indirect utility function of the form:

$$\ln V = \frac{\ln X - \ln a(p)}{b(p)} \qquad (1)$$

where X is nominal total expenditure while both $a(p)$ and $b(p)$ are price indices given as $ln\, a(p) = \alpha_0 + \sum \alpha_i\, lnp_i + \frac{1}{2}\sum\sum \gamma_{ij}\, lnp_i lnp_j$ and $ln\, b(p) = \sum \beta_i\, ln\, p_i$ respectively. By applying Roy's identity to equation 1 above, Deaton and Muellbauer (1980) obtained the budget share equations for an N-good system as a function of total expenditure and prices as:

$$w_i = \alpha_i + \beta_i ln\left(\frac{X}{a(p)}\right) + \sum_{J=1}^{N} \gamma_{ij}\, lnp_j \qquad (2)$$

where w_i is the budget share of commodity i, X is the total nominal expenditure on all commodities under consideration, p_j is the j^{th} commodity price and $a(p)$ is the price index given as:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{N} \alpha_i lnp_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} lnp_i lnp_j \quad (3)$$

Equation 2 is referred to as the Almost Ideal Demand System of Deaton and Muellbauer (1980). For demand analysis, the theoretical restrictions of adding-up, symmetry and homogeneity can be imposed respectively as:

$$\sum \alpha_i = 1; \sum \beta_i = 0; \sum_i \gamma_{ij} = 0$$

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

$$\sum_j \gamma_{ji} = 0$$

QUAIDS Specification

The Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997) assumes an indirect utility function of the form:

$$\ln V = \left\{ \left[\frac{\ln X - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1} \quad (4)$$

where X again is total nominal expenditure while $\ln a(p)$, $b(p)$ and $\lambda(p)$ are price indices given respectively as:

$$ln\ a(p) = \alpha_0 + \sum \alpha_i\ lnp_i + \frac{1}{2}\sum\sum \gamma_{ij}\ lnp_i lnp_j \quad (4a)$$

$$b(p) = \prod_{i=1} p_i^{\beta_i}$$

$$\lambda(p) = \sum_{i=1} \lambda_i\ lnp_i$$

As in the case of the AIDS model, applying Roy's identity to equation 4 above results in the budget share equation for N-good system as:

$$w_i = \alpha_i + \beta_i ln\left(\frac{X}{a(p)}\right) + \sum_{J=1}^{N} \gamma_{ij}\ lnp_j \quad + \frac{\lambda_i}{b(p)}\left[ln\left\{\frac{X}{a(p)}\right\}\right]^2 \quad (5)$$

where w_i is the budget share for commodity i and p_j is the price of the j^{th} commodity. Equation 5 is also referred to as the Quadratic Almost Ideal Demand system of Banks et al (1997). Again, adding-up, symmetry and homogeneity restrictions can be imposed respectively as:

$$\sum \alpha_i = 1; \sum \beta_i = 0; \sum_i \gamma_{ij} = 0\,; \sum_i \lambda_i = 0$$

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

$$\sum_j \gamma_{ij} = 0$$

As seen from equation 2 and 5, the difference between the AIDS and QUAIDS specifications is the inclusion of the quadratic term $\left[ln\left\{\frac{X}{a(p)}\right\}\right]^2$ in the QUAIDS model. The QUAIDS model thus reduces to the AIDS model when the statistical test of the significance of the coefficient of this term in each share equation shows that the coefficient is not significantly different from zero for all share equations. If for some share equations, the coefficient is significantly different from zero, then as noted in Banks et al. (1997) and Bapape (2007), the AIDS model should be rejected in favour of the QUAIDS model.

To perform the test, both equations 2 and 5 are estimated using the five commodity groups we have generated and the Wald test is applied to test the hypothesis that the coefficients of the quadratic expenditure term in equation 5 are jointly equal to zero for all five share equations. A rejection of this hypothesis will mean that the appropriate demand model to estimate price and income elasticities for the welfare analysis in chapter 3 will be the QUAIDS model. In addition, the resulting parameter estimates of the two equations are compared to ascertain which are more plausible for Ghana.

In household demand estimation four empirical issues arise: (a) setting an appropriate value for α_0 in equation 4a; (b) capturing demographic effects on budget shares; (c) correcting for endogeneity of total expenditure in the demand system; and (d) accounting for zero household consumption. How we deal with these empirical issues and the estimation technique adopted are discussed in sections 2.4 and 2.5 respectively.

2.2.2 Non-parametric Approach

Before the parametric approach was implemented we employed two non-parametric regressions (i.e. kernel and polynomial kernel regressions) to examine the relationship between the budget share of each of the five commodity groups and the logarithm of total food expenditure. Following Hardle (1990) and Banks et al (1997), the bivariate linear regression is employed in these non-parametric regressions with the linear kernel estimator defined as:

$$\widehat{m}(X_i) = \frac{1}{N}\sum w(X)Y \qquad (6)$$

where X_i is the budgte share of the commodity group i, Y is the household total expenditure (i.e. food expenditure in our case), and $w(X)$ is the weighting system which is obtained as:

$$w(X) = \frac{K\left(\frac{x - X_i}{h}\right)}{\sum_{j=1}^{n} K\left(\frac{x - X_i}{h}\right)} \qquad (7)$$

where *K(.)* is the kernel function and *h* is the bandwidth parameter.

The above weighting system (equation 7) depends on the kernel function employed and the bandwidth parameter selected. However, as noted in Yatchew (1998) and Hasan (2012), the selection of the appropriate bandwidth parameter for the weighting system is more important than the selection of the kernel function. This is because the results are more sensitive to the choice of bandwidth compared to the choice of the Kernel function. The selection of high bandwidth leads to a large bias with a small variance, while a small bandwidth generates a large variance with a small bias. In both cases the residual sum of squares and thus the mean squared error (MSE) are higher. The selection of an optimal bandwidth, however, minimizes the integrated version of the MSE. Therefore, following Hardle (1990) and Banks et al (1997) the bandwidth parameter is set to the optimal bandwidth based on the normal scale bandwidth selection approach, often called the "Rule-of-Thumb" (ROT) bandwidth selector, while the Gaussian kernel function is employed (See table A2.4a for the optimal bandwidth for each commodity group in each survey year). The resulting curves for each of the commodity groups in each survey period are discussed in section 2.6.

2.3 Data and Descriptive statistics

2.3.1 Data

As noted in chapter 1, the source of data for this chapter is the GLSS, 3, 4 and 6. All food items captured in the GLSS are aggregated into five commodity groups (only for this chapter) and Table 2.1 shows these groups and the individual expenditure items constituting each of the groups.

Table 2.1: Commodity groups and Individual items

Commodity group	Individual items
Bread & Cereals	Maize (Corn), Rice, Maize Flour, Bread, Millet and Guinea Corn/Sorghum
Roots, Tubers & Plantain	Cassava, Cocoyam, Yam, Plantain, Gari and Cassava Dough
Pulse, Nuts & Seeds	Beans, Palm Nuts and Ground Nuts
Oil & Fats Products	Groundnut Oil, Palm Kennel Oil, Palm Oil and Margarine
Other food Expenditure	All food items captured in the GLSS not included in the above four

2.3.3 Descriptive Statistics

The parametric and non-parametric approaches presented in sections 2.2.1 and 2.2.2 respectively, require the construction of three sets of variables for each household: the budget share of each of the commodity groups, total food expenditure of the household, and a price index for each of the commodity groups. How we constructed these variables for each household is discussed below.

Budget share

The budget share of a commodity group for a household is obtained by dividing the household expenditure of that group by the total food expenditure of the household. Household total food expenditure (which is generated as the sum of expenditure on all food items captured in the GLSS) has already been generated for each household in the GLSS data; hence we only needed to calculate the household expenditure for each commodity group. This was done in two stages. In the first stage, the household expenditure for each individual item in each commodity group is calculated. This is done by summing the actual purchase and own-consumption expenditure[11] of each item in the group. Second, having done this, the household expenditure on each commodity group is obtained by summing the expenditure on all individual items in the group. Since the "other food" commodity group contains all expenditure items captured in the GLSS but not included in the other four commodity groups, the expenditure on "other food" is obtained by subtracting the total expenditure on the four groups from household total food expenditure.

Table 2.2 presents the average budget shares of the commodity groups by entire sample, locality (urban/rural) and poverty status of the household. The average budget share clearly differs between urban and rural households as well as poor and non-poor households. Excluding the "other food" group for convenience, on

[11] In the GLSS, own-consumption expenditure of items are captured as quantity, however, their values have already been generated using cluster prices collected during the survey.

average nationally, roots, tubers & plantain constitutes the largest share of household's total food budget in all periods (25% in 1991/92, 20% in 1998/99 and 19% in 2012/13). The national average budget share of bread & cereals group has risen considerably since 1991/92 (from 13% in 1991/92 to 18% in 2012/13). Given that the consumption of rice which constitutes over 30% of expenditure on bread & cereal group, generally has been rising over the last three decades, this result is not surprising. Indeed, data from the Ministry of Food and Agriculture (MoFA) shows that rice consumption has almost doubled since 1985 and demand was expected to rise to 850,000 metric tonnes in 2013/2014 (USDA, Grain Report, 2013).

The average budget shares on bread & cereal, roots, tubers & plantain and pulses, nuts & seeds are higher for rural households than urban households, while poor households average budget share on bread & cereal and pulses, nut & seeds is higher (they spend more) than non-poor households. Poor households' share of bread & cereal has also risen considerably since 1991/92 (from 14% in 1991/92 to 26% in 2012/13) while their share for roots, tuber & plantain has reduced considerably from 28% in 1991/92 to 18% in 2012/13.

Table 2.2: Average expenditure share by Entire sample, locality and poverty status

Group	Locality and Entire sample									Poverty Status					
	1991/92			1998/99			2012/13			1991/92		1998/99		2012/13	
	Urban	**Rural**	**Entire sample**	**Urban**	**Rural**	**Entire sample**	**Urban**	**Rural**	**Entire sample**	**Poor**	**Non-poor**	**Poor**	**Non-poor**	**Poor**	**Non-poor**
BC	0.13	0.14	0.13	0.13	0.15	0.14	0.14	0.21	0.18	0.14	0.13	0.17	0.13	0.26	0.16
RT	0.19	0.28	0.25	0.15	0.23	0.20	0.16	0.21	0.19	0.28	0.23	0.20	0.21	0.18	0.18
PNS	0.03	0.05	0.04	0.03	0.04	0.03	0.02	0.05	0.04	0.05	0.04	0.04	0.03	0.06	0.03
OF	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
OthFood	0.63	0.51	0.55	0.67	0.56	0.60	0.66	0.51	0.58	0.51	0.58	0.58	0.62	0.49	0.60
Sample Size	1,578	2,945	4,523	2,199	3,799	5,998	7,445	9,327	16,772	1,803	2,720	1,897	4,101	4,014	12,758

Source: Author's calculation from GLSS 3, 4 and 6

Note:

The budget share may not sum to 1 or 100 due to rounding. BC, bread and cereals; RT, roots and tubers; PNS, pulses nuts and seeds; OF, oil and fat products; OthFood, other food expenditure.

Price Index

With the aggregation of expenditure into groups, there is the need to find commodity group price indices. Following Attanasio et al (2013) the Stone price index for each commodity group is constructed using the price of the individual expenditure items in each commodity group and the cluster budget share of the individual expenditure items in each commodity group where the cluster budget shares are used as weights. The Stone price index is therefore given as:

$$PI = \sum_{i=1}^{M} w_{ci} p_{ci} \qquad (8)$$

where w_{ci} and p_{ci} are the cluster budget share and cluster price for commodity i respectively. The cluster budget share is obtained by summing the expenditure on each individual item within a commodity group for a cluster and dividing by the total cluster expenditure for that commodity group. In cases where there is no expenditure on a commodity group in a cluster, regional-level data are used instead.

Because the "other food" group includes a large number of items which complicates the calculation of a price index, we follow Ackah & Appleton (2007) by treating it as a numeraire and setting its price to unity. Table 2.3 shows the average real Stone price index for bread & cereal, roots, tubers & plantain, pulses, nuts & seeds and oil & fat products. Based on the real Stone price index, in 2012/13 bread & cereal was the most expensive commodity group among the four groups. This is not surprising, particularly when one of its components, imported rice, saw a rise in demand as well as a rise in import cost due to exchange rate depreciation and increases in international food prices. The most expensive commodity group in 1991/92 was the oil & fat group, while pulses, nut & seed group was the most expensive commodity group in 1998/99.

Table 2.3: Real Stone Price Index

Aggregate	1991/92	1998/99	2012/13
Bread & Cereals	0.1134	0.3123	3.0293
Root, Tubers & Plantain	0.0905	0.1170	2.6383
Pulses, Nut & Seeds	0.2269	1.0438	2.5018
Oil & Fat Products	0.6197	0.1994	2.7773
No. of clusters	365	300	1,200

Source: Author's calculation from GLSS 3, 4 and 6
Notes:
January 1999 Accra price was used as the based to normalize prices for GLSS 3 and 4 while January 2013 price was used to normalize prices for GLSS 6. All figures are in Ghana cedis and are prices per kilos

2.4 Empirical Estimation strategy

For the parametric analysis, the empirical version of equation 2 and 5 estimated is slightly differently from the original specification. It was modified to account for four main empirical issues. First, we use the original specification of price index $a(p)$ (i.e. equation 4a) and not its linear version by Stone (1954). This requires that we set a value for α_0. We follow Deaton and Muellbauer (1980) and Banks et al. (1997) by setting it to a value slightly less than the minimum value of total household food expenditure.[12]

The second empirical issue we address is the issue of how to capture the effects of household and demographic variables in both models (i.e. AIDS and QUAIDS model). As noted in Dhar et al. (2003), Mazzocchi (2003), Akbay et al. (2007), Tefera et al. (2012) and Magrini et al. (2015), household consumption patterns are not only explained by price and income changes, but also by household and demographic characteristics such as household size, location and education of the

[12] In some cases it is set equal to the minimum level of expenditure that would be needed for subsistence if all prices were equal to one. We however experimented with different values of α_0 and the results were not significantly different from each other.

household head.[13] More often than not, such variables are captured by modifying the empirical specification of the demand model. There are two ways of doing this: the demographic transition method of Pollak and Wales, (1981) and Heien and Wessells (1990); and the scaling technique of Poi (2002) and Ray (1983).

The demographic transition method of Pollak and Wales (1981) and Heien and Wessells (1990) incorporate demographic variables by modifying the constant term α_i, in equations 2 and 5 as:

$$\alpha_i = \delta_i + \sum_{j=1}^{s} \delta_{ij} D_j, \quad and \sum_{j=1}^{s} \delta_{ij} = 0 \;\; i = 1, \dots . n$$

where δ_i and δ_{ij} are parameters to be estimated and D_j is the vector of demographic variables included in the model. Although this method is simple and easy to implement, it does not account for the effects of demographic variables on total household expenditure and the composition of goods consumed by the household. For instance, a household with five members will have a higher expenditure than one with two members. Furthermore, a household with two adults and two infants will consume different goods than one comprising four adults (Poi, 2002).

The scaling technique of Ray (1983) and Poi (2002) accounts for the effects of demographic variables on the household's total expenditure as well as the composition of goods consumed by the household. Consequently, we rely on this method to capture the effect of demographic variables in equations 2 and 5. The

[13] For example, urban households may have different consumption preferences from rural ones; households with children may have different consumption preferences compared to those composed exclusively of adults.

Ray (1983) and Poi (2002) method uses for each household an expenditure function of the form:

$$e(p,z,u) = m_o(p,z,u) \times e^r(p,u) \qquad (9)$$

where $e^r(p,u)$ is the expenditure function of a reference household, z represents a vector of *s* characteristics and $m_o(p,z,u)$ is a function that scales the expenditure function to account for the household characteristics. Ray (1983) and Poi (2002) further decomposes $m_o(p,z,u)$ into two components:

$$m_o(p,z,u) = \bar{m}_0(z) \times \emptyset(p,z,u) \qquad (10)$$

where the term $\bar{m}_0(z)$ measures the increase in the household's expenditures as a function of z, not controlling for any changes in consumption patterns while the second term $\emptyset(p,z,u)$ measures the effects of demographic variables controlling for changes in relative prices and the actual goods consumed. Ray (1983) parameterized $\bar{m}_0(z)$ and $\emptyset(p,z,u)$ as:

$$\bar{m}_0(z) = 1 + \rho' z \text{ and } \emptyset(p,z,u) = \frac{\prod_j^k p_j^{\beta j} (\prod_{j=1}^k p_j^{\eta' z} - 1)}{\frac{1}{u} - \sum_{j=1}^k \lambda_j ln p_j} \qquad (11)$$

where ρ is a vector of parameters to be estimated and η_j represents the j^{th}column of $s \times k$ parameter matrix η. After this adjustment, equation 2 takes the form:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} ln p_j + (\beta_i + \eta_i' z) ln \left\{ \frac{X}{\bar{m}_0(z) a(p)} \right\} \qquad (12a)$$

while equation 5 takes the form:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} lnp_j + (\beta_i + \eta_i' z) ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\}$$

$$+ \frac{\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\}\right]^2 \qquad (12b)$$

where $c(p,z) = \prod_{j=1}^{k} p^{\eta_j' z}$; and $\overline{m}_0(z)$ as well as η are as stated in equation (11).

The household characteristics and demographic variables included in each model are regional dummies to capture regional effects, locality (urban/rural), sex of household head, age of household head, household size, the poverty status of the household and quarter dummies to capture seasonal effects. Table A2.4 (in appendix A) shows the mean and standard deviations of the household characteristics and demographic variables, total food expenditure and household income for all periods.

As shown in Table A2.4, in all periods the sample of households is not balanced between region, localities and poverty status of households. There are more rural households than urban households (except in 2012/13), and more non-poor households than poor households. In addition, there are relatively fewer households from the three northern regions, while household size ranges from 1 to 30 with an average household size of 4.48 in 1991/92; 4.28 in 1998/99 and 3.92 in 2012/13. Furthermore, households headed by a male constitute a higher proportion of households in all three periods while the average age of household head was 44.3 in 1991/92 but went up slightly to 45.04 in 2012/13.

The third empirical issue we address relates to the presence of zero household expenditure in the GLSS. Aside from the already existing zero consumption in the GLSS, replacing missing data with zero also resulted in some households having zero consumption for some of the commodity groups. If not accounted for, zero expenditure could create sample selection problems in estimation which have tendencies to bias our results.

As noted in Tefera et al., (2012), zero consumption can be reduced greatly by aggregating over commodities. However, as shown in Table 2.4, even after the aggregation of expenditure into the five commodity groups, there are still significant proportions of zero expenditure in all data sets. It is particularly high for the oil & fat group and pulses, nut & seed group in all periods, but relatively small for bread & cereal and roots, tuber & plantain groups. Compared to 1991/92 and 1998/99 samples, the 2012/13 sample (i.e. GLSS 6), has a higher proportion of zero expenditure for all groups (except bread & cereal).

Table 2.4: Proportion of households with zero expenditure

Aggregates	1991/92	1998/99	2012/13
Bread & Cereal	7.55	1.95	5.57
Roots, Tubers & Plantain	5.91	6.67	12.34
Pulses, Nut & Seeds	20.24	16.49	32.61
Oil & Fat Products	34.21	26.31	36.19
Other food	0.00	0.00	0.00
Sample size	4,523	5,998	16,772

Source: Calculations from GLSS 3, 4 and 6
Note:
All values are expressed in percentages except the last row, which represents the sample size of each round.

If zero expenditure is observed, the dependent variable (i.e. budget share) in equations 2 and 5 will become a censored dependent variable (with a minimum of zero, but a maximum of any positive amount). As recognized by Tobin (1958) the application of ordinary least squares (OLS) in this situation will result in biased and inconsistent estimates. Different methods, however, have been proposed on how to reduce the biased and incomsistency associated with zero consumption. A two-step estimation procedure based on Heckman (1979) was introduced by Heien and Wessells (1990). In the first stage of this procedure, the household's decision to consume a particular commodity is modeled as a dichotomous choice problem,

$$w_{ihc} = f\left(p_{ic}, p_{jc}, \ldots \ldots . . p_{nc}, X_{hc,} Z_{hc}\right) \qquad 12c$$

where w_{ihc} is 1 if the h^{th} household in cluster *c* consumes the i^{th} expenditure item, (i.e. if $w_{ihc} > 0$) and 0 if the household does not consume the item in question. p , X and Z are commodity prices, household total expenditure and demographic and household characteristics that influence the household decision to consume or not consume the commodity in question. Equation 12c is estimated using the standard probit estimation technique for all expenditure groups and from the result the inverse Mills ratio for each expenditure group is estimated. For households that consume the commodity group, the inverse Mills ratio is given as:

$$\lambda_{ihc} = \frac{\phi(p, z, x)}{\Phi(p, z, x)}$$

while for those that do not consume the commodity group it is given as:

$$\lambda_{ihc} = \frac{\phi(p, z, x)}{1 - \Phi(p, z, x)}$$

where $\emptyset(p, z, x)$ is the probability density function and $\Phi(p, z, x)$ is the cumulative density function. In the second stage of estimation, the inverse Mills ratio of each expenditure group is included in equation 2 and 5 as an additional explanatory variable.

Although Heien and Wessells (1990) estimation procedure is simple and easy to implement, Shonkwiler and Yen (1999) found that it is inconsistent and performs poorly in Monte Carlo simulations. As a result, they suggested an alternative two-step estimation procedure. It is this alternative procedure that we apply to correct for zero expenditure in our analysis.

In the first step of Shonkwiler and Yen (1999) approach, zero expenditure is modelled in the system of equations with limited dependent variables as:

$$w_i^* = f(x_i, \mu_i) + u_i, \qquad d_i^* = z_i' \partial_i + v_i \tag{13}$$

$$d_i = \begin{cases} 1 \ if\ d_i^* > 0 \\ 0\ if d_i^* \leq 0 \end{cases} \qquad w_i = d_i w_i^*$$

where w_i is expenditure share of good i and d_i is a binary outcome that takes one if the household consumes the item, and zero otherwise; and w_i^* and d_i^* are the corresponding unobserved (latent) variables, x_i represents household expenditure and prices of commodities while z_i is a vector of household demographics and related variables; μ_i and ∂_i are vectors of parameters to be estimated while u_i and v_i are the random errors. If we assume that the error terms in equation (13), u_i and v_i, have a bivariate normal distribution with $cov(u_i, v_i) = \emptyset$, a multivariate probit model using equation (13) can be estimated and the probability density function (PDF) and cumulative distribution function (CDF) for each commodity group can be obtained.

In the second step, the PDF and CDF obtained are used to account for zero expenditure by augmenting the AIDS and QUAIDS specifications as follows:

$$w_i^* = \Phi(z_i' \partial_i) f(x_i, \mu_i) + \delta_i \varphi(z_i' \partial_i) + \varepsilon_i \tag{14}$$

where $\varphi(z_i'\partial_i)$ and $\Phi(z_i'\partial_i)$ are the probability density function and the cumulative distribution function respectively. The covariates included in the multivariate probit regression are variables that are likely to predict the probability of the household consuming the expenditure item. In particular, we included all the household characteristic and demographic variables mentioned earlier (see Table A2.4 in appendix A), the logarithm of the prices for commodity groups as well as the logarithm of total food expenditure.

After capturing the effect of demographic variables and accounting for zero expenditure, the AIDS model in its modified form becomes:

$$w_i^* = \alpha_i\Phi(z_i'\partial_i) + \sum_{j=1}^{k} \gamma_{ij}\Phi(z_i'\partial_i)lnp_j + (\beta_i + \eta_i'z)\Phi(z_i'\partial_i)ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\} + \delta_i\varphi(z_i'\partial_i) + \varepsilon_i \tag{15a}$$

while the QUAIDS model also in its modified form becomes:

$$w_i^* = \alpha_i\Phi(z_i'\partial_i) + \sum_{j=1}^{k} \gamma_{ij}\Phi(z_i'\partial_i)lnp_j + (\beta_i + \eta_i'z)\Phi(z_i'\partial_i)ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\} + \frac{\lambda_i}{b(p)c(p,z)}\Phi(z_i'\partial_i)\left[ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\}\right]^2 + \delta_i\varphi(z_i'\partial_i) + \varepsilon_i \tag{15b}$$

One main drawback of Shonkwiler and Yen's (1999) two-step estimation procedure is that, after the correction for zero expenditure, the budget share equations (15a and 15b) will not satisfy the adding-up restriction. However, as shown in Yen, Lin and Smallwood (2003), adding-up can be achieved by treating the k^{th} commodity group as a residual with no specific demand and imposing the following identity (Magrini et al 2015):

$$w_k^* = 1 - \sum_{i=1}^{k-1} w_i^* \qquad (16)$$

The parameters of the k^{th} equation are recovered from the estimates of the $k-1$ equations. As noted by Pollak and Wales (1993), the estimates are invariant to which equation is treated as the residual but in this framework the natural candidate is the "other food" category, considering it is already a residual group.

In most empirical demand analysis, total expenditure is often treated as endogenous. This is often attributed to a possible correlation of total expenditure with some unobserved characteristics (i.e., the error term) that affect demand as well as the existence of shocks that are common to total expenditure and budget shares (Blundell and Robin, 1999; Barslund, 2011). Estimation procedures that fail to account for this endogeneity may lead to inconsistent demand parameter estimates; hence the fourth empirical issue we dealt with is how to account for the endogeneity of total food expenditure in the demand system.

In this regard, the augmented regression approach of Hausman (1978) and Blundell & Robin (1999) is employed. This approach, first, requires us to identify suitable instruments for total food expenditure, after which we proceed in two steps: first, the log of the endogenous variables (total food expenditure) is regressed on the log of prices of the commodity groups, demographic and household characteristics variables included in the model, and the instruments. The resulting equation, often referred to as the reduced form, is given as:

$$lnX = \alpha + \beta y + \sum_{j=1}^{k} \gamma_{ij} lnp_j + \theta z + \varepsilon \tag{17}$$

where lnX is the log of total food expenditure, y is the vector of instruments, z is a vector of demographic variables, p_j is the j^{th}commodity group's price, $\alpha, \beta, \gamma_{ij}$ and θ are parameters to be estimated and ε is the random error term with the standard properties. Second, the residual from equation 17 is predicted and included as an additional explanatory variable in equation 15a and 15b, for equation 15a to become:

$$w_i^* = \alpha_i \Phi(z_i' \partial_i) + \sum_{j=1}^{k} \gamma_{ij} \Phi(z_i' \partial_i) lnp_j + (\beta_i + \eta_i' z) \Phi(z_i' \partial_i) ln \left\{ \frac{X}{\overline{m}_0(z) a(p)} \right\}$$
$$+ \quad \delta_i \varphi(z_i' \partial_i) + \pi_1 \acute{V}_1 + \varepsilon_i \tag{18a}$$

while equation 15b becomes:

$$w_i^* = \alpha_i \Phi(z_i' \partial_i) + \sum_{j=1}^{k} \gamma_{ij} \Phi(z_i' \partial_i) lnp_j + (\beta_i + \eta_i' z) \Phi(z_i' \partial_i) ln \left\{ \frac{X}{\overline{m}_0(z) a(p)} \right\}$$
$$+ \frac{\lambda_i}{b(p) c(p,z)} \Phi(z_i' \partial_i) \left[ln \left\{ \frac{X}{\overline{m}_0(z) a(p)} \right\} \right]^2 + \quad \delta_i \varphi(z_i' \partial_i)$$
$$+ \pi_1 \acute{V}_1 + \varepsilon_i \tag{18b}$$

where π_1 is the coefficient of the residual and everything else remains the same as in equations 15a and 15b. The augmented regression approach of Hausman (1978) and Blundell & Robin (1999) has several advantages, including the fact that a test of the significance of the coefficient of the residual in the second stage regression can be easily interpreted as a test of endogeneity of total food expenditure. As Blundell and Robin (1999) argue, if total food expenditure is exogenous the coefficient of the residual should be insignificant.

As noted in Wooldridge (2002) and Blundell and Robin (1999), a good instrument should meet two conditions: the relevance and exogeneity conditions. The former requires that the instrument be sufficiently correlated with the endogenous variable while the latter requires that the instrument is not correlated with the error term in the demand model. Econometrically, a test for the statistical significance of the coefficient of the instrument in equation 17 would be a test for the relevance condition (Wooldridge, 2002). However, the exogeneity condition is difficult to test directly since the error term is unobserved; most often economic theory is used to decide whether it can be assumed. If the model is over-identified (i.e. if we have more instruments than endogenous regressors) a test of over-identifying restrictions in the model after an Instrumental Variable (IV) estimation is often considered as a test of the exogeneity condition for the instruments.

Household income is often not seen as an appropriate independent variable in the share equations (2 and 5) because: (a) income captured in household surveys in most cases is for very short periods (say, a month), thus, it contains considerable "temporary" elements which are irrelevant for spending decisions; and (b) income in household surveys covers only certain types of income, while other types (such as income from property) are ignored. As a result total expenditure is used as the independent variable instead. Liviation (1961), however, argued that, although income captured in household surveys is inappropriate as an independent variable in the share equation, it is reasonable to use it as an instrument for total expenditure. This is because income retains two important properties: (a) a relatively close correlation with expenditure which makes it an efficient instrument for expenditure; and (b) no correlation with the random elements in expenditures, which means essentially that income received during the period of the survey is exogenous and is not influenced by expenditures, hence will not affect expenditure shares directly.

While this might be the case in developed countries, it is debatable in developing countries, especially for low income households who are forced to spend all of their (inadequate) income on consumption, thus temporal income changes might affect consumption patterns greatly. However, due to the absence of a better instrument in most household surveys in developing countries, household income is often used as an instrument for expenditure in household demand models. Studies that have done this include Bhalotra and Attfield (1998), Blundel and Robin (1999), Ackah and Appleton (2007), Bapape and Myers (2007), Kedir and Girma (2007), Hassan (2012), Attanasio et al (2013), Osei and Eghan (2013), Wassiuw and Ibrahim (2015) and Magrini et al. (2015).

In this chapter we follow the above studies by using two measures of income (total income,[14] and average cluster income excluding the index household's income) and land ownership status of the household as instruments for total food expenditure. These instruments are meant to capture the wealth of the household. Household income and average cluster income excluding the index household's income works well as valid instruments for survey period 1991/92 and 1998/99 while total income and land ownership status work as valid instruments for survey period 2012/13.[15] Having two instruments for each period allows us the opportunity to check the validity of the instruments by testing for over-identifying

[14] In the GLSS, total income comprises of income from five sources: income from employment, agricultural income, non-farm enterprise income, income from rent, remittances and other income.
[15] We finally settled on these three instruments after experimenting with a number of variables in the GLSS. Although household income and average cluster income are not weak instruments in the case of GLSS 6, their validity was rejected in all five equations in the demand system for GLSS 6.

restrictions in the model. Results of the reduced form regression (i.e. the first stage regressions) for each period and the instrumental variable (IV) estimates used to test for over-identifying restrictions are discussed in section 2.6.3.

2.5 Estimation Technique

The main equations estimated in this chapter are 13, 18a and 18b. In the case of equation 13, since observations from each budget share equation are cross-section and collected from the same households, a multiple univariate probit-model for each commodity group would suffer from endogeneity due to correlation of errors between different equations as the household's decision to allocate expenditure on a given food group may not be independent of the probability of allocating expenditure to another food group (Maganga et al. 2014). To avoid this endogeneity problem, we adopt system estimation by employing a multivariate probit model to estimate equation 13.

For all probit models, an algorithm is required to calculate normal probability distribution functions. For univariate and bivariate probit-models different algorithms with computations based on standard linear numerical approximations, such as those based on the Newton–Raphson method have been widely used to calculate probability density functions (Maganga et al 2014). While these are more appropriate for univariate and bivariate normal cases, they are relatively inefficient and may provide poor approximations for multivariate normal cases such as equation 13 (Hajivassiliou and Ruud 1994). As a result, a number of simulation-based methods of maximum likelihood estimation of multivariate probit models have been proposed. One of these methods is employed to calculate the normal probability functions of the probit-model, proposed by Cappellari and Jenkins (2003) and implemented in STATA using the code mvprobit.

A brief exposition of this method is provided here (for detailed exposition see Cappellari and Jenkins, 2003). Recall equation 13:

$$w_i^* = f(x_i, \mu_i) + u_i, \qquad d_i^* = z_i'\partial_i + v_i$$

$$d_i = \begin{cases} 1 \ if \ d_i^* > 0 \\ 0 \ if d_i^* \leq 0 \end{cases} \qquad w_i = d_i w_i^*$$

where w_i is budget share of good i and d_i is a binary outcome that takes one if the household consumes the item, and zero otherwise; and w_i^* and d_i^* are the corresponding unobserved (latent) variables, x_i represents household expenditure and prices of commodities while z_i is a vector of household demographics and related variables; μ_i and ∂_i are vectors of parameters to be estimated while u_i and v_i are the random errors. As noted in Cappellari and Jenkins (2003), the log-likelihood function of the probit model of the above equation for a sample of *N* independent observations is given by;

$$L = \sum_{i=1}^{N} W_i log\Phi_M(\sigma_i; \Omega) \qquad (19)$$

where W_i is an optional weight for observation $i = 1, \dots \dots \dots .., N$, *M* is the number of expenditure groups and $\Phi_M(.)$ is the standard normal distribution with arguments σ_i and Ω where

$$\sigma_i = (K_{i1}\partial_1 z_1', K_{i2}\partial_2 z_2', K_{i3}\partial_3 z_3', \dots \dots \dots K_{i\mathrm{M}}\partial_\mathrm{M} z_\mathrm{M}')$$

with $K_{i1} = 2d_{ik} - 1$, for each $i, k = 1, \dots \dots .. M$ and Matrix Ω has constituent elements Ω_{jk} where $\Omega_{jJ} = 1$ for $j = 1, \dots \dots \dots M$ and $\Omega_{j1} = \Omega_{1J} = K_{i1}K_{i2}\rho_{j1}$. Clearly the above exposition shows that the log-likelihood function depends on the standard normal distribution function $\Phi_M(.)$.

Cappellari and Jenkins (2003) applied the Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator to evaluate the multivariate distribution function. This simulator exploits the fact that a multivariate normal distribution function can be expressed as the product of sequentially conditioned univariate normal distribution functions, which can be easily and accurately evaluated. The GHK has many desirable properties in the context of multivariate normal limited dependent variable models: the simulated probabilities are unbiased, they are bounded within the (0, 1) interval and the simulator is a continuous and differentiable function of the model's parameters.

As noted earlier, the mvprobit program in STATA written by Cappellari and Jenkins (2003) fits multivariate probit models using a simulation method; we therefore relied on this program to estimate equation 13 and calculated the standard normal Cumulative Density Function (CDF) and the standard normal Probability density function (PDF) to augment the AIDS and QUAIDS models. The multivariate probit results for 1991/92, 1998/98 and 2012/13 survey periods are presented in Appendix A Tables A2.7a, A2.7b and A2.7c respectively.

Having obtained the CDF and PDF from equation 13, the next equations estimated are 18a and 18b. Equations 18a and 18b are treated as a seemingly unrelated equation system for two reasons: (a) the error terms in the different share equations are related as a result of common unobserved factors that influence the budget shares in the system; and (b) the parameters in the different share equations are related due to the share equations having the same explanatory variables. Many estimators can be used to estimate a seemingly unrelated equation system. One is the iterated feasible generalized non-linear least square procedure which uses the Zeller SUR estimator to estimate the variance-covariance of the system of equation.[16] For some types of seemingly unrelated regression models (such as the one estimated in this chapter) the entire system of M-equations cannot be estimated jointly. Such systems are often referred to as singular seemingly unrelated regression models.

To solve the problem of singular seemingly unrelated regression models, the usual practice is to drop one of the M-equations and estimate the remaining M-1 equations jointly and then recover the parameters of the dropped equation from the M-1 estimated equations. The iterated feasible generalized least square estimator is preferred over other estimators because its parameters are invariant to the equation dropped during estimation; that is, you will always get the same parameter estimates regardless of the equation you eliminate. For this reason, we follow Magrini et al (2015) by employing the iterated feasible generalized non-linear least square estimator of Poi (2002) to estimate equations 18a and 18b.

2.6 Results

This section discusses the results of both the parametric and non-parametric methods presented thus far. Specific emphasis is placed on the results of the kernel and quadratic kernel regressions, strength and validity test of the instruments to account for the endogeneity of food expenditure in the AIDS and QUAIDS models, the estimated parameters of both the AIDS and QUAIDS models for the three periods, as well as the test of the joint significance of the coefficient of the quadratic expenditure term in the QUAIDS model for each share equation in each period. In addition, results of household consumption patterns (from 1991 to 2013) of cereal and cereal products are also discussed; our

[16] Others estimators include the Generalized Least square (GLS) estimator and the Feasible Generalized Least Square (FGLS) estimator.

focus is on analyzing the differences in the price and expenditure elasticities of seven cereal items in the three survey periods. We start with the results of the kernel and quadratic kernel regressions.

2.6.2 Non-parametric analysis (Kernel Regressions)

For each of the commodity groups two non-parametric regressions (kernel and quadratic kernel) of budget shares on log of total food expenditure are estimated. Figures 2.1, 2.2 and 2.3 show the resulting curves for 2012/13, 1991/92 and 1998/99 survey periods respectively. Although, both regressions specify a linear relationship, the curves show evidence of a distinct non-linear relationship between budget share and household total food expenditure for all the expenditure groups in all periods. As shown by the quadratic kernel, there is a clear evidence of a quadratic relationship between budget share and total food expenditure. For instance, in 2012/13, we note that the budget share for pulses, nut & seeds and oil & fat products all increase with total food expenditure at lower levels of food expenditure and start to decline at higher levels of food expenditure, but the share of "other food" group decreases continuously with higher levels of total food expenditure.

These results suggest that demand models which assume a linear budget share-total food expenditure relationship for these commodity groups may not be an accurate approximation of the GLSS data; hence, non-linearity should be factored in such demand models. These results compare well with the results of other studies on developing countries that have looked at the relationship between food share and total household expenditure (see, for example Hasan (2012) and Kedir & Girma (2007)).

Figure 2:1: Non-parametric curves (2012/13)

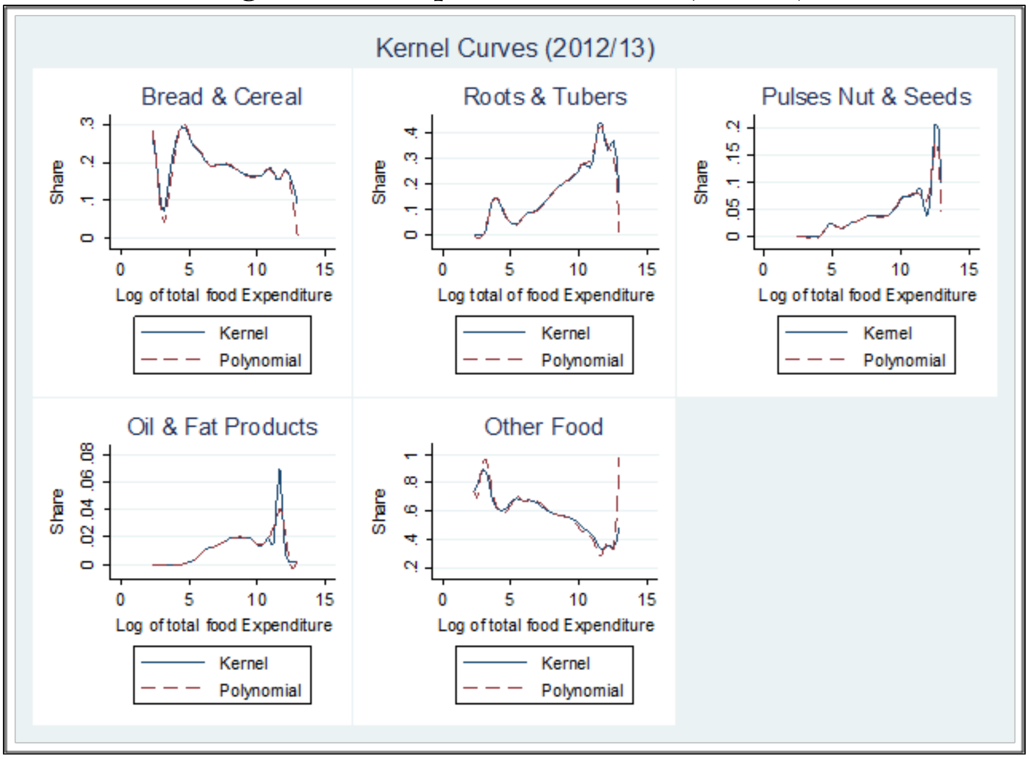


Figure 2:2: Non-parametric curves (1991/92)

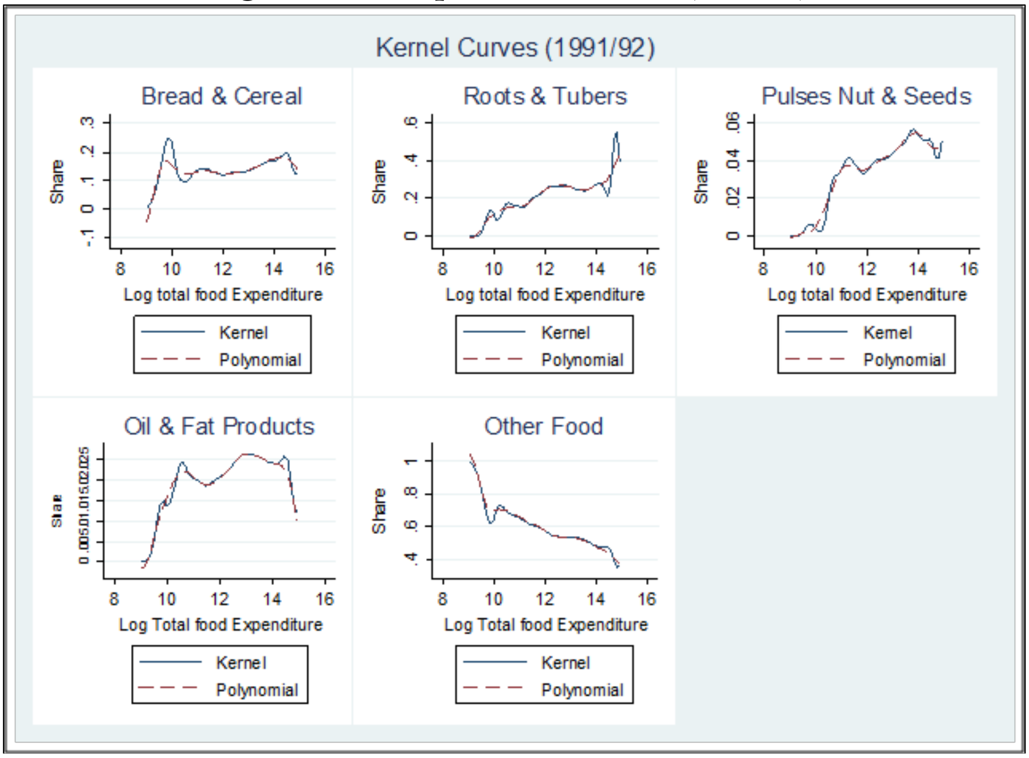
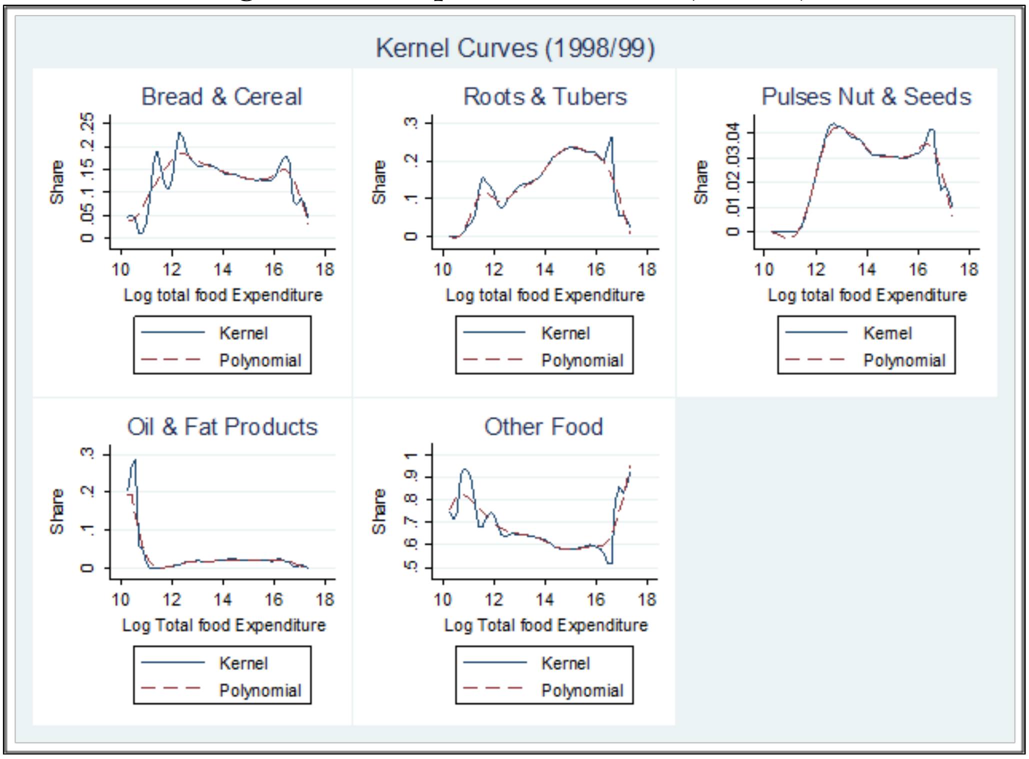


Figure 2:3: Non-parametric curves (1998/99)



Two empirical issues are often raised in a non-parametric analysis of household demand. First, total food expenditure is endogenous but we are unable to account for it in a non-parametric analysis of demand. Consequently, we cannot tell the extent to which the rejection of linearity can be explained by the endogeneity of total expenditure. This issue, however, is explicitly taken care of in the parametric method (discussed in the next sub-section) and the results are quite consistent, i.e. there is still evidence of non-linearity between expenditure share and total food expenditure.

Second, it is often suggested that the above observed non-linear relationship could have been driven by outliers in the data. However, in the case of the GLSS, a thorough search of outliers in the expenditure data was conducted. Mean and standard deviation of each expenditure variable at five locality[17] levels were calculated and outlier observations were deemed to be those observations lying more than three standard deviations above the mean value. These observations were excluded and re-estimated as the cross household locality mean value of the original data excluding the outliers identified. This process was conducted at the most disaggregated level, as far as reasonably possible (see Coulombe and McKay (2008) for further details on how outliers observations were treated). Due to the above treatment of outliers, we do not expect that the observed non-linear relationship between budget share and total food expenditure is driven by outliers in the GLSS data.

2.6.3 Parametric Analysis

We now turn to the discussion of the results of the parametric analysis. Specific results discussed include: (i) the results of the relevance and validity test of the instruments used to account for the endogeneity of total food expenditure; (ii) estimates of the multivariate probit model; (iii) the estimates of the AIDS and QUAIDS models and the Wald test of the joint significance of the coefficient of the quadratic expenditure term in each share equation in the QUAIDS model; and (iv) the estimates of the price and expenditure elasticities of cereal and cereal products in Ghana.

We start with the issue of endogeneity of total food expenditure. Two out of a possible three instruments i.e. household income, average cluster income (excluding index household) and land ownership status of the household were used as instruments to account for endogeneity of food expenditure in each period. Household income and average cluster income are valid instruments for

[17] The five localities were used: Accra, Other Urban, Rural-Coastal, Rural-Forest and Rural-Savannah.

food expenditure in 1991/92 and 1998/99 survey periods; they, however, failed the validity test in most share equations in 2012/13. Household income and land ownership status of the household perform well as valid instruments in 2012/13.

Table 2.5 presents the result of the reduced form regression of total food expenditure on prices, the instruments and selected demographic characteristics. In all periods, the instruments have significant impact on food expenditure. As expected, household income and the average cluster income impact positively on total food expenditure while land ownership status has a significant negative impact on total food expenditure. Most importantly, for all periods, the robust partial F statistics (with p-value of 0.000 in all periods) and partial R-square for the instruments is high, indicating that the instruments are relevant and good predictors of total food expenditure.[18]

[18] The partial R-square measures the correlation between the endogenous variable and the instruments after partialling out the effect of the other explanatory variable while the F statistic is the statistic for the joint significance of the coefficients on the instruments. If it is not significant, then the additional instruments have no significant explanatory power for the endogenous variable after controlling for the effect of the other explanatory variables.

Table 2.5: First Stage equation for Food expenditure (Dependent Variable: Food Expenditure)

Variable	1991/92(a)	1998/99(a)	2012/13(a)	2012/13(b)
Price of:				
Bread & Cereal	0.187***	-0.043**	0.055***	0.048***
	(0.033)	(0.014)	(0.010)	(0.010)
Roots, Tuber & Plantain	0.046*	0.114***	-0.021	-0.004
	(0.023)	(0.016)	(0.015)	(0.015)
Pulses, Nut & Seeds	-0.042	-0.058***	0.044**	0.057***
	(0.038)	(0.012)	(0.014)	(0.014)
Oil & Fat Products	-0.090**	0.099**	0.035**	0.031**
	(0.029)	(0.032)	(0.011)	(0.011)
Other Food Expenditure	0.010	-0.599**	0.157***	0.035***
	(0.025)	(0.199)	(0.149)	(0.148)
Locality				
Rural	-0.100***	-0.113***	0.089***	0.026*
	(0.030)	(0.020)	(0.013)	(0.013)
Sex of HH head				
Female	0.001	-0.042**	0.044***	0.064***
	(0.017)	(0.015)	(0.013)	(0.013)
HH size	0.342***	0.336***	0.535***	0.519***
	(0.012)	(0.011)	(0.009)	(0.009)
Age of HH head	0.068**	0.006	0.168***	0.128***
	(0.023)	(0.021)	(0.017)	(0.017)
Instruments				
HH income	0.168***	0.178***	0.153***	0.164***
	(0.008)	(0.006)	(0.005)	(0.004)
AHH income	0.074***	0.183***	0.061***	-
	(0.016)	(0.013)	(0.008)	-
Land ownership				
No	-	-	-	-0.181***
	-	-	-	(0.013)
R-square	0.366	0.451	0.350	0.354
Partial R-square	0.120	0.186	0.085	0.10
Partial F statistics	231.36	450.03	647.701	727.159
Partial F(p-val)	0.000	0.000	0.000	0.000
Sample Size	4,523	5,998	16,772	16,772

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
AHH income represents the average cluster income excluding index household's income while the land ownership status of the household is captured as either Yes or No.
(a)Instrumented: Total food expenditure; Instruments: Total income and average cluster income minus the index household's income
(b)Instrumented: Total food expenditure; Instruments: Total income and landownership status of the household. We do not report parameters estimates for all the household and demographic variables included in the reduced form equation.

Although the instruments are relevant (per the above results), it is however imperative that we check the extent to which endogeneity is a problem in equations 12a and 12b. To achieve this, we estimated the Instrumental variable

(IV) regression for each share equation in each period and endogeneity of food expenditure was tested using the Wooldridge (1995) robust score test and robust regression-based test. For each individual share equation, if the Wooldridge (1995) robust score test or the robust regression-based test statistic is significant, then total food expenditure must be treated as an endogenous variable in that particular equation.

The p-values of the Wooldridge (1995) robust score test for exogeneity of food expenditure for each share equation are presented in column 2, 4 and 8 of Table 2.6 for 1991/92, 1998/99 and 2012/13 respectively, while Tables A2.5a, A2.5b and A2.5c (in appendix A) present the IV estimates for 1991/92, 1998/99 and 2012/13 surveys respectively and Tables A2.6a, A2.6b and A2.6c (in appendix A) also present the OLS estimates for 1991/92, 1998/99 and 2012/13 surveys respectively. We found evidence of endogenous total food expenditure in at least three of the five equations for each period. Food expenditure exogeneity is rejected for bread & cereal and "other food" group in all periods while it is rejected for root, tubers & plantain in 1991/92 and 1998/99 but not in 2012/13. In addition, exogeneity of total food expenditure for oil & fat products is accepted in 1991/92 and 1998/99 but rejected in 2012/13.

The last but one column of Tables 2.7, 2.8 and 2.9 show the system coefficient estimates of the residual from the first stage regression with an indication of their significance level.[19] The results of the Wooldridge (1995) robust score test are confirmed; food expenditure is endogenous for bread & cereal and other food

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[19] As noted earlier in section 2.4, another way of assessing the potential endogeneity of food expenditure is testing the significance of the coefficient of the residual in the second stage regression (equation 18a and 18b). A significant coefficient suggests a rejection of exogeneity of total food expenditure while insignificant coefficient suggests otherwise.

groups in all periods while it is endogenous for roots, tuber & plantain in 1991/92 and 1998/99 but not in 2012/13. In addition to Wooldridge (1995)'s robust test, a comparison between the IV and OLS parameter estimates for food expenditure confirm the exogeneity of total food expenditure for only oil & fat products for 1991/92 survey; pulses, nut & seed and oil & fat for 1998/99 survey; and only roots, tubers & plantain for 2012/13 survey. The estimated IV and OLS coefficients for total food expenditure in these equations are quite similar suggesting equivalence and exogeneity of total food expenditure (see Tables A2.5a, A2.5b and A2.5c for IV estimates and Tables A2.6a, A2.6b and A2.6c for OLS estimates). All the above results thus suggest that potential endogeneity of total food expenditure is a well-founded concern which has to be accounted for.

For the instruments used to be valid instruments we require that, except through total food expenditure, they do not directly affect budget shares (i.e. they should be valid). With two instruments for each period, we can assess the validity of the instruments through an over-identification test. In this test the system residuals (equation-by-equation) are regressed on the two instruments and a joint significance test of the parameter vector of this regression is evaluated by a χ^2-test of the null-hypothesis that the parameters are jointly zero. A significant test statistic means that at least one instrument is not valid. Columns 3, 5 and 9 in Table 2.6 reports the p-values of the Wooldridge's robust score test of over-identifying restrictions (for the null-hypothesis of the instruments having no explanatory power on the system residuals, and therefore being valid as instruments) for 1991/92, 1998/99 and 2012/13 surveys respectively. For all equations the proposed instrument set does well. As seen in column 7 of Table 2.6, for 2012/13, the initial proposed instruments were invalid for all equations except oil & fats hence our decision to use total income and land ownership status of the household as instruments.

Table 2.6: Test of Exogeneity & Test of Over-identifying Restrictions

Budget shares	1991/92[a] Test of exogeneity (p-values)	1991/92[a] Test of Over-identifying restrictions (p-values)	1998/99[a] Test of exogeneity (p-values)	1998/99[a] Test of Over-identifying restrictions (p-values)	2012/13[a] Test of exogeneity (p-values)	2012/13[a] Test of Over-identifying restrictions (p-values)	2012/13[b] Test of exogeneity (p-values)	2012/13[b] Test of Over-identifying restrictions (p-values)
Bread & Cereal	0.027	0.369	0.000	0.504	0.000	0.000	0.000	0.322
Roots, Tubers & Plantain	0.000	0.674	0.000	0.497	0.767	0.004	0.413	0.137
Pulses, Nut & Seeds	0.018	0.744	0.551	0.160	0.000	0.001	0.000	0.102
Oil & Fat Products	0.967	0.117	0.463	0.554	0.001	0.104	0.007	0.380
Other Food Expenditure	0.000	0.547	0.000	0.487	0.000	0.000	0.000	0.338
Sample Size	4,523	4,523	5,998	5,998	16,772	16,772	16,772	16,772

Notes:
[a]Instrumented: Total food expenditure; Instruments: Total income and average cluster income minus the index household's income
[b]Instrumented: Total food expenditure; Instruments: Total income and landownership status of the household
***Test of Exogeneity*:** Wooldridge's (1995) robust score test and a robust regression-based test are reported. If the test statistic is significant, the variables being tested must be treated as endogenous.
Tests of Over-identifying Restrictions: Basmann's (1960) chi-squared tests are reported, as is Wooldridge's (1995) robust score test. A statistically significant test statistic always indicates that the instruments may not be valid.

Before we turn to the discussion of the results of the estimated AIDS and QUAIDS models and the Wald test of the coefficient of food expenditure square in the QUAIDS model, we discuss briefly the results of the multivariate probit model (i.e. equation 13).

Since the "other food" group does not contain zero expenditure, we do not include its share equation in the multivariate probit model; hence the system had four equations instead of five. The explanatory variables included in each share equation are the logarithm of total food expenditure, the logarithm of price indexes and household characteristics and demographic variables such as regional dummies, locality dummy, household size, quarter dummies, the poverty status of the household, age of the household's head as well as a dummy for the sex of the household's head. This resulted in 12 coefficients (excluding the constant) for each of the share equations and a total of 48 coefficients for the multivariate probit model in each period. Tables A2.7a, A2.7b and A2.7c (in appendix A) present the estimates for 1991/92, 1998/99 and 2012/13 survey periods respectively. Of the 48 estimated coefficients in each period, more than half are significant at 1 percent, 5 percent or 10 percent level with robust standard errors. Each household and demographic variable is significant in at least two share equations in each survey period.

Consistent with a priori expectation and intuition, for all equations in each period, total food expenditure is found to have a significant positive effect on the probability of consuming a particular commodity group while own price is found to have a negative effect on the probability of the household consuming a particular commodity group. There are also significant cross price effects on the probability of consuming a particular commodity group. For instance, in 1998/99 an increase in the price of bread & cereal is found to have a positive effect on the probability of consuming roots, tubers & plantain while the reverse is the case in 1991/92. From the estimated probit model, the cumulative distribution function (CDF) and probability density function (PDF) for each period are estimated and used as arguments in the AIDS and QUAIDS models to account for zero expenditure.

We now turn to the discussion of the estimates of the AIDS and QUAIDS model. As noted earlier, all the household and demographic variables included in the probit model are also included in the AIDS and QUAIDS models. However, only the coefficients on household size, in addition to the coefficient of logarithm of food expenditure (both level and square) and the logarithm of price indexes are reported and discussed here. We start with the QUAIDS model. Tables 2.7, 2.8 and 2.9, present the QUAIDS model parameter estimates of the selected variables for the five commodity groups for 1991/92, 1998/99 and 2012/13 surveys respectively. It is important to note that these estimates are the responses of budget share to changes in the explanatory variables and not elasticities.

Table 2.7: Parameter Estimates for the QUAIDS Model (1991/92)

	(log) Price of :								
Commodity group	**Bread & Cereal**	**Root & Tubers**	**Pulse, Nuts & Seeds**	**Oil & Fats**	**Other food**	**(β)**	**(λ)**	**Resid**	**HhSize**
Bread & Cereals	-0.0105					-0.0377*	-0.0193***	0.0248***	0.0149***
	(0.0063)					(0.0187)	(0.0035)	(0.0043)	(0.0028)
Roots, Tubers & Plantain	0.0262***	-0.0610***				0.0790**	0.0154***	-0.0332***	-0.0079*
	(0.0051)	(0.0068)				(0.0266)	(0.0033)	(0.0053)	(0.0034)
Pulses, Nut & Seeds	-0.0220***	0.0130***	-0.0107***			-0.0182*	-0.0083***	0.0079***	0.0059***
	(0.0026)	(0.0021)	(0.0022)			(0.0072)	(0.0016)	(0.0017)	(0.0011)
Oil & Fat Products	-0.0062***	0.0017	-0.0042**	0.0008		0.0250***	0.0034***	-0.0026	-0.0028***
	(0.0017)	(0.0013)	(0.0013)	(0.0017)		(0.0042)	(0.0007)	(0.0009)	(0.0006)
Other Food Expenditure	0.0124***	0.0200***	0.0238***	0.0078***	-0.0641***	-0.0481*	0.0088**	0.0032**	-0.0101***
	(0.0036)	(0.0041)	(0.0018)	(0.0011)	(0.0046)	(0.0196)	(0.0032)	(0.0034)	(0.0025)
Sample size	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, age of the household's head, quarter dummies, poverty status of the household as well as a dummy for the sex of the household's head.
β and λ are the coefficients of food expenditure and its square respectively while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

Table 2.8: Parameter Estimates for the QUAIDS Model (1998/99)

Commodity group	(log) Price of : Bread & Cereals	Root & Tubers	Pulse, Nuts & Seeds	Oil & Fats	Other food	(β)	(λ)	Resid	Hhsize
Bread & Cereals	-0.0492***					-0.0487***	-0.0013	0.0050***	0.0044***
	(0.0043)					(0.0125)	(0.0038)	(0.0007)	(0.0005)
Roots, Tubers & Plantain	0.0851***	-0.3518***				0.2868***	-0.0778***	-0.0073***	-0.0002
	(0.0113)	(0.0196)				(0.0117)	(0.0127)	(0.0009)	(0.0006)
Pulses, Nut & Seeds	-0.0145***	0.0604***	-0.0151***			-0.0633***	0.0134***	0.0027	0.0020***
	(0.0019)	(0.0080)	(0.0027)			(0.0087)	(0.0028)	(0.0003)	(0.0002)
Oil & Fat Products	0.0064***	-0.0326***	0.0073***	-0.0061***		0.0305***	-0.0088***	-0.0003	-0.0004***
	(0.0011)	(0.0039)	(0.0011)	(0.0013)		(0.0048)	(0.0022)	(0.0004)	(0.0001)
Other Food Expenditure	-0.0277***	0.2388***	-0.0381***	0.0251***	-0.1981***	-0.2054***	0.0744***	-0.0001***	-0.0058***
	(0.0081)	(0.0162)	(0.0058)	(0.0036)	(0.0168)	(0.0132)	(0.0138)	(0.0006)	(0.0004)
Sample size	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, age of the household's head, quarter dummies, poverty status of the household as well as a dummy for the sex of the household's head.
β and λ are the coefficients of food expenditure and its square respectively while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

Table 2.9: Parameter Estimates for the QUAIDS Model (2012/13)

Commodity group	Bread & Cereals	Root & Tubers	Pulse, Nuts & Seeds	Oil & Fats	Other food	(β)	(λ)	Resid	Hhsize
	(log) Price of :								
Bread & Cereals	-0.0362***					-0.0007*	-0.0163***	0.0150***	0.0102***
	(0.0047)					(0.0134)	(0.0015)	(0.0011)	(0.0011)
Roots, Tubers & Plantain	0.0062	-0.0653***				-0.0086*	-0.0028	-0.0092	0.0075***
	(0.0042)	(0.0079)				(0.0181)	(0.0017)	(0.0012)	(0.0007)
Pulses, Nut & Seeds	0.0021	-0.0095***	0.0123***			0.0194**	-0.0043***	0.0019***	0.0027***
	(0.0016)	(0.0024)	(0.0017)			(0.0062)	(0.0007)	(0.0005)	(0.0002)
Oil & Fat Products	0.0018*	-0.0067***	0.0006	0.0025***		-0.0017	-0.0011**	0.0015***	0.0010***
	(0.0008)	(0.0011)	(0.0006)	(0.0005)		(0.0038)	(0.0004)	(0.0002)	(0.0001)
Other Food Expenditure	0.0261***	0.0753***	-0.0055	0.0019	-0.0978***	-0.0082	0.0245***	-0.0092***	-0.0214***
	(0.0070)	(0.0103)	(0.0037)	(0.0019)	(0.0159)	(0.0196)	(0.0020)	(0.0017)	(0.0013)
Sample size	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, age of the household's head, quarter dummies, poverty status of the household as well as a dummy for the sex of the household's head.
β and λ are the coefficients of food expenditure and its square respectively while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

In total 15 price effects are estimated in each period and we found notable budget share responses to changes in relative prices. Of the 15 price effects, 12 are significant in 1991/92; all are significant in 1998/99 and 10 are significant in 2012/13. Consistent with a priori and intuition, own price is found to have a negative effect on expenditure share in all periods (except pulses, nut & seeds and oil & fat products in 2012/13) suggesting that when the price of a commodity group increases, households reduced their budget share for that commodity group and possibly increased the share of close substitutes, all things being equal. Ackah & Appleton (2007) with the LA/AIDS model found similar results for bread & cereal and root, tuber & plantain in 1991/92 and 1998/99, while Osei & Eghan (2013) also found similar results in 2005/06 for Ghana.

In all periods, total food expenditure (in level) is found to be negatively related to the expenditure share of bread & cereal suggesting that expenditure share of bread & cereal declined with increases in household total food expenditure. However, the expenditure share of root, tubers & plantain group increased with total food expenditure in 1991/92 and 1998/99 but not in 2012/13. Again, this is consistent with Ackah & Appleton (2007) and the observed expenditure patterns in Ghana between 1991 and 2013. As observed in Table 2.2, consistently, over 19% of household total food expenditure goes to root, tuber & plantain group (25% in 1991/92, 20% in 1998/99 and 19% in 2012/13), while less than 15% goes to bread & cereal except in 2012/13 where the share increased to 18%. All things being equal, given that bread & cereal and root, tubers & plantain are close substitutes, expenditure share for root, tuber & plantain group is expected to increase with total food expenditure since a higher proportion of food expenditure goes to it. This observed consumption pattern is better explained using the expenditure elasticities of the commodities. In chapter 3, the expenditure elasticities for both commodity groups for each period are estimated and discussed in detail.

Household size has a positive relationship with the expenditure shares of bread & cereal and pulses, nut & seeds in all periods while the expenditure share of roots, tuber & plantain has a negative relationship with household size in 1991/92 but a positive relationship with size in 2012/13. Expenditure share on bread & cereals group increases with household size, consistent with household consumption patterns in Ghana. The real Stone price index (see Table 2.3) for bread & cereal was high in all periods; hence expenditure share is expected to increase with household size, all things being equal.

Aside from this price effect, this is an interesting result that can be given an intuitively appealing interpretation. For the household, time spent on cooking meals at home influences the daily choice of meal for the household. The bigger the household size the more the food prepared at home, hence the more the time spent cooking food. To minimize time spent on cooking, larger households are therefore compelled to cook food with less preparation time. Compared to other food items, particularly items in roots, tubers & plantain group, rice, which takes a larger proportion of expenditure on bread & cereal, is easier to prepare and take less time. It is therefore not surprising that expenditure share of bread & cereal increases with household size.

The results of the estimated AIDS model for 1991/92, 1998/99 and 2012/13 survey periods are presented in Table 2.10, 2.11 and 2.12 respectively. Again, 15 price effects are estimated in each period. For the 1991/92 survey period, 14 out of the 15 are significant at 1%, 5% or 10%, while for the 1998/99 and 2012/13 survey periods 12 out of the 15 are significant at 1%, 5% or 10%. Interestingly, contrary to the result of the QUAIDS model, a number of the household size effects are not significant. For instance, in 1991/92, none of the coefficients of household size is significant, while four and three were significant in 1998/99 and 2012/13 respectively. In addition, compared to the QUAIDS model, the AIDS model has fewer significant coefficients of food expenditure; three are significant in 1991/92 compared to five for the QUAIDS model while four are significant in 1998/99 compared to five in the QUAIDS model.

Most importantly, there are significant differences in terms of the value of the coefficients of the two demand models. In 1991/92, the majority of the coefficients of price effects in the AIDS model are bigger than those in the QUAIDS model (12 out of 15) while in 1998/99 and 2012/13 the majority of the price effects in the AIDS model are smaller than those in the QUAIDS model. Because the price and income elasticities estimates for welfare analysis are based on the price and expenditure effects of the demand model employed, the consequence of the difference in the value of the coefficient (as observed in our case) is the tendency to either overestimate or underestimate the price and income elasticities when a demand model which is not determined by the data is used. Welfare costs are therefore likely to be biased and this will have negative implications on policy. It is therefore imperative we use the demand model which fits the available data.

Table 2.10: Parameter Estimates for the AIDS Model (1991/92)

Commodity group	Price of (log) : Bread & Cereal	Root & Tubers	Pulse, Nuts & Seeds	Oil & Fats	Other food	(β)	Resid	HhSize
Bread & Cereals	0.0228***					0.0296*	0.0063***	-0.0001
	(0.0060)					(0.0128)	(0.0018)	(0.0015)
Roots, Tubers & Plantain	0.0166***	-0.0652***				-0.0082	-0.0325***	0.0022
	(0.0047)	(0.0070)				(0.0222)	(0.0035)	(0.0025)
Pulses, Nut & Seeds	-0.0282***	0.0192***	-0.0113***			0.0091	-0.0017*	-0.0001
	(0.0026)	(0.0020)	(0.0022)			(0.0055)	(0.0008)	(0.0006)
Oil & Fat Products	-0.0394***	0.0256***	-0.0099***	0.0071***		0.0213***	0.0006	-0.0006
	(0.0020)	(0.0015)	(0.0014)	(0.0017)		(0.0035)	(0.0005)	(0.0004)
Other Food Expenditure	0.0281***	0.0038	0.0301***	0.0165***	-0.0786***	-0.0517*	0.0273***	-0.0015
	(0.0035)	(0.0041)	(0.0018)	(0.0011)	(0.0046)	(0.0217)	(0.0034)	(0.0024)
Sample size	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, , age of the household's head, quarter dummies as well as a dummy for the sex of the household's head.
β is the coefficients of food expenditure while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

Table 2.11: Parameter Estimates for the AIDS Model (1998/99)

Commodity group	Price of (log): Bread & Cereal	Root & Tubers	Pulse, Nuts & Seeds	Oil & Fats	Other food	(β)	Resid	HhSize
Bread & Cereals	-0.0518***					-0.0595***	0.0051***	0.0044***
	(0.0042)					(0.0057)	(0.0010)	(0.0006)
Roots, Tubers & Plantain	0.0590***	-0.0708***				0.0432***	-0.0072***	0.0040***
	(0.0053)	(0.0101)				(0.0106)	(0.0019)	(0.0011)
Pulses, Nut & Seeds	-0.0115***	0.0150***	-0.0084***			-0.0236***	0.0030***	0.0013***
	(0.0014)	(0.0024)	(0.0012)			(0.0027)	(0.0005)	(0.0002)
Oil & Fat Products	0.0047**	-0.0082***	0.0038***	-0.0046***		0.0055	-0.0009	-0.0001
	(0.0015)	(0.0017)	(0.0009)	(0.0012)		(0.0034)	(0.0007)	(0.0002)
Other Food Expenditure	-0.0004	0.0050	0.0010	0.0043**	-0.0099*	0.0345***	-0.0001	-0.0097***
	(0.0028)	(0.0046)	(0.0013)	(0.0016)	(0.0041)	(0.0089)	(0.0009)	(0.0009)
Sample Size	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, , age of the household's head, quarter dummies as well as a dummy for the sex of the household's head.
β is the coefficients of food expenditure while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

Table 2.12: Parameter Estimates for the AIDS Model (2012/13)

	(log) Price of :							
Commodity group	**Bread & Cereal**	**Root & Tubers**	**Pulse, Nuts & Seeds**	**Oil & Fats**	**Other food**	**(β)**	**Resid**	**HhSize**
Bread & Cereals	-0.0324***					-0.1212***	0.0071***	0.0082***
	(0.0052)					(0.0064)	(0.0008)	(0.0006)
Roots, Tubers & Plantain	0.0254***	-0.0721***				0.0515***	-0.0019*	0.0003
	(0.0037)	(0.0046)				(0.0072)	(0.0008)	(0.0005)
Pulses, Nuts & Seeds	0.0050***	0.0087***	0.0102***			-0.0170***	0.0018***	0.0014***
	(0.0012)	(0.0013)	(0.0010)			(0.0025)	(0.0003)	(0.0002)
Oil & Fat Products	0.0049***	-0.0036***	0.0009*	-0.0006		0.0033*	-0.0000	0.0001
	(0.0006)	(0.0007)	(0.0004)	(0.0021)		(0.0014)	(0.0003)	(0.0001)
Other Food Expenditure	-0.0030	0.0415***	-0.0248***	-0.0017	-0.0120*	0.0834***	-0.0071***	-0.0100***
	(0.0041)	(0.0033)	(0.0013)	(0.0017)	(0.0048)	(0.0080)	(0.0010)	(0.0006)
Sample size	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included as explanatory variables but not shown are regional dummies, locality dummy, age of the household's head, quarter dummies as well as a dummy for the sex of the household's head.
β is the coefficients of food expenditure while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size.

Column 8 in Tables 2.7, 2.8 and 2.9 presents the estimate of coefficient of interest (Lamda). It is significant for all expenditure groups in all periods except for bread & cereal group in 1998/99 and root, tubers & plantain group in 2012/13. As noted earlier in section 2.2.1, the QUAIDS model nests the AIDS model and therefore a test of the hypothesis that Lamda coefficient is equal to zero for all share equations is a test for model specification. If the hypothesis is accepted, AIDS specification is favoured while a rejection of the hypothesis will mean that the QUAIDS model is favoured. The results of the Wald test of the hypothesis for each survey period are shown in Table 2.13. Individually, we reject (at the 1% level) the AIDS specification for all expenditure groups in 1991/92 while the AIDS specification is rejected for four expenditure groups in 1998/99 and 2012/13. However, a joint test of all Lamda equal to zero was rejected in all periods (see the last row of Table 2.13). This suggests a rejection of the AIDS specification in favour of the QUAIDS model for the demand system for each of the survey periods; hence the appropriate model for the analysis in chapter 3 should be the QUAIDS model.

Table 2.13: Results of Wald test for Model specification

	1991/92		**1998/99**		**2012/13**	
Equation	***Chi²***	**p-val**	***Chi²***	**p-val**	***Chi²***	**p-val**
Bread & Cereal	31.01	0.000	0.11	0.744	121.77	0.000
Root, Tubers & Plantain	21.84	0.000	37.80	0.000	2.78	0.096
Pulses, Nut & Seeds	28.48	0.001	23.72	0.000	40.97	0.000
Oil & Fat Products	21.50	0.000	16.48	0.000	8.29	0.000
Other food expenditure	7.45	0.006	29.22	0.000	152.57	0.000
Joint test	50.98	0.000	50.87	0.000	212.01	0.000
Sample size	4,523	4,523	5,998	5,998	16,772	16,772

Note:
Two hypotheses were tested: (a) lamda the coefficient of total food expenditure square is equal to zero for each equation and (b) jointly lamda is equal to zero for all equations in the demand system.

The results of the above parametric analysis compare well with other studies in developing countries. For instance, Molina and Gil (2005) estimated a demographic version of the QUAIDS using Peruvian cross-section data for 1997 and rejected the AIDS model. Bopape (2006) also compared the AIDS and QUAIDS models in his analysis of food expenditure patterns in South Africa and also recommended QUAIDS. Abdulai and Aubert (2004) using Tanzanian food expenditure data to estimate consumption patterns also confirmed the superiority of the QUAIDS model over the AIDS model.

In summary, the results of both the parametric and non-parametric analyses indicate that, for some expenditure groups in the GLSS, higher order expenditure terms are required for an accurate explanation of household consumption behaviour. Hence, among the two demand models the one that best fits the GLSS data is the QUAIDS model. We therefore employed this model to estimate price and expenditure elasticities for the analysis in Chapter 3. Although the parametric and non-parametric analyses were done using five commodity groups, it is reasonable to believe that similar results would be achieved for the other expenditure groups generated from the GLSS expenditure data.

The results are dependent on a number of factors, including the value of α_0 and the household characteristics and demographic variables included in the QUAIDS model as these may affect the coefficient of total food expenditure squared and the Wald test results. As household consumption is not only influenced by income and prices, but also by the demographic characteristics of the household, the relationship between budget shares and total expenditure is likely to be dependent on the number and type of demographic variables included. The parametric results should therefore be interpreted with this caveat in mind. As a robustness check, we experimented with different values for α_0 and increased the number of demographic variables by two, but the results are not significantly different from the earlier ones. Notwithstanding these limitations, since the results of the non-parametric analysis suggest that a linear specification of the relationship between budget shares and total food expenditure would not explain the consumption pattern of households accurately, we are inclined to believe the parametric results are true. Moreover, the demographic variables included in the QUAIDS model are the same as included in Chapter 3.

Robustness Checks

As robustness checks on the results of both the parametric and non-parametric analyses we performed two experiments: First, as noted earlier, the kernel and quadratic kernel regression curves employed in the non-parametric analysis are sensitive to the bandwidth parameter used in the computation of the weights used in the estimation. Although the bandwidth parameter used is the optimal bandwidth parameter (see table A2.4a for the optimal bandwidth for each commodity in each period), as a robustness check of the non-parametric results we experimented with two different bandwidths; lower and upper bandwidth.

As seen in Table A2.4a, the minimum bandwidth across all periods is 0.36 while the maximum is 0.55. As noted earlier, apart from the optimal bandwidth parameter (which uses a rule), there is no rule for setting a bandwidth parameter. However, since our interest is only to check if results will differ if we assume a different bandwidth parameter, we decided to set the lower bandwidth (i.e. 0.3) slightly below the minimum bandwidth and the upper bandwidth (i.e. 0.6) slightly above the maximum bandwidth parameter. Figures A2.2a, A2.2b and A2.2c show the curves for the lower bandwidth parameter for 1991/92, 1998/99 and 2012/13 respectively while Figures A2.3a, A2.3b and A2.3c show the curves for the upper bandwidth for 1991/92, 1998/99 and 2012/13 survey respectively. As clearly seen from the figures, the shapes are quite similar to the case when we used the optimal bandwidth parameter, i.e. we still see a distinct non-linear relationship between budget shares and total food expenditure.

Second, because of the way demographic effects are modelled in the QUAIDS model, the number of household characteristics and demographic variables included is likely to affect the parameter estimates of the QUAIDS model. As noted earlier seven household characteristics and demographic variables (i.e. region, locality, age of household head, sex of household head, household size, quarter dummies and poverty status) were included in the parametric model. Again, as a robustness check of the significance of the coefficient of interest, we included two more demographic variables - ecological zone and the education level of the household head. Table 2.14 provides the Wald test results of the significance of Lamda from this estimation: clearly, the AIDS specification is still rejected confirming the results of the earlier analysis.

Table 2.14: Wald test (with inclusion of two extra demographic variables)

	1991/92		1998/99		2012/13	
Equation	***Chi²***	**p-val**	***Chi²***	**p-val**	***Chi²***	**p-val**
Bread & Cereal	15.24	0.000	102.28	0.000	115.30	0.000
Root, Tubers & Plantain	1.23	0.268	64.63	0.000	0.99	0.320
Pulses, Nut & Seeds	14.66	0.001	53.62	0.000	64.34	0.000
Oil & Fat Products	0.43	0.513	52.18	0.000	1.70	0.192
Other food expenditure	9.96	0.002	13.88	0.000	142.79	0.000
Joint test	24.20	0.000	212.22	0.000	218.53	0.000
Sample size	4,523	4,523	5,998	5,998	5,998	5,998

Note:
Two hypotheses were tested: (a) lamda the coefficient of total food expenditure square is equal to zero for each equation and (b) jointly lamda is equal to zero for all equations in the demand system.

2.6.4 Household consumption patterns of cereals in Ghana

Having established that the QUAIDS model is the best fit, we applied it to estimate household price and expenditure elasticities for cereal and cereal products in Ghana using GLSS 3, 4 and 6. These elasticities are used to explain household consumption patterns of cereal and cereal products in Ghana between 1991 and 2013.

In Ghana, cereal and cereal products are significant and important foods. Cereals (grains) such as rice, maize, millet and guinea corn are food staples in many, if not most, parts of Ghana and do not only serve as ingredients for many foods[20] and certain beverages, but as food for livestock. Cereal items captured in the GLSS include maize, wheat, rice (both imported and local), millet, guinea corn, sorghum, bread, maize flour and corn dough. However, for the purpose of this chapter, we focus on six (i.e. maize, rice, millet, guinea corn/sorghum, maize flour and bread) and put all other cereal expenditures into a residual group "other cereal expenditure". This results in a seven item demand system.

Economic theory does not provide any guidance on the number of items to include in a demand analysis; the decision is usually made on an *ad hoc* basis by the researcher. Our decision to focus on the above seven items is influenced partially by previous studies on household demand for cereals (see, for example, Wassiuw and Ibrahim (2015)) and also by the fact that four of the six items (i.e. rice, maize, maize flour and bread) are the major components of cereal and cereal products in Ghana. Hence, detailed knowledge about how households' response to price and income changes will greatly help policy makers implement the right policies to mitigate the impact of price increases. Furthermore, the seven items contain items with relatively low expenditure shares (millet and guinea corn) and others with relatively high expenditure shares (maize, rice, maize flour and bread). This

[20] Examples of food made from these grains are *kenkey, banku, Amo tuo* and *tou zaafi*

heterogeneity aids in comparing the price and income responses of items with low expenditure share and those with high expenditure shares.

To estimate the QUAIDS model for the seven items, the same empirical strategies and estimation techniques employed to estimate the QUAIDS model for the five commodity groups are employed. That is, demographic effect is captured using the Ray (1983) and Poi (2002) method where we include the same household characteristics and demographic variables included in the case of the five commodity groups; zero expenditure[21] is accounted for using the Shonkwiler and Yen (1999) approach while endogeneity of total expenditure on cereal is also accounted for using the Hausman (1978) and Blundell & Robin (1999) approach where, again, the same instruments used in the case of the five commodity groups are used.

Given the estimated parameters of the QUAIDS model (i.e. equation 18b) for the seven items, we follow Poi (2002), Tefera et al (2012) and Magrini et al (2015) to calculate, respectively, the expenditure and uncompensated price elasticities of demand for each item as follows:

$$\mu_i = \frac{\partial lnq_i}{\partial lnm} = 1 + \frac{1}{w_i}\left[\beta_i + \eta_i' z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p)}\right\}\right] \Phi(z_i'\partial_i)$$

[21] See Table A2.8 in appendix for the proportion of households with zero expenditure on the seven expenditure items for each survey period.

$$e_{ij} = \frac{\partial lnq_i}{\partial lnp_j} = \frac{1}{w_i}\left(\gamma_{ij} - \left[\beta_i + \eta_i'z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p)}\right\}\right] \times \left(\alpha_j + \sum_k \gamma_{jk} lnp_k\right) - \frac{(\beta_j + \eta_i'z)\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p)}\right\}\right]^2\right)\Phi(z_i'\partial_i) + \varphi_i\tau_{ij}\left(1 - \frac{\delta_i}{w_i}\right) - \delta_{ij}$$

where δ_{ij} is the Kronecker delta which takes the value $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$. The compensated elasticities are calculated by using the slutsky equation, $e_{ij}^c = e_{ij} + \mu_i w_j$ while the elasticities for the residual category, "Other cereal expenditure", are calculated using the adding-up restrictions proposed by Zheng and Henneberry (2009) as:

$$\sum_{i=1}^{k} w_i\mu_i = 1, \quad \sum_{i=1}^{k} w_i e_{ij} = -w_j, \quad \sum_{j=1}^{k} e_{ij} + \mu_i = 0$$

Before we discuss the estimates of the price and expenditure elasticities, we first provide some descriptive statistics for budget shares and commodity prices of the items by entire sample, locality and poverty status. Expenditure shares are obtained using the same procedure to obtain the expenditure shares for the five commodity groups. That is, for each item we first add purchased expenditure to own consumption to obtain the household expenditure on the item; we sum expenditure on all items to obtain total expenditure on cereals; and divide expenditure on an item by total expenditure on cereals to obtain the expenditure shares. After summing the expenditure on all seven items, households with zero total expenditure on cereals are dropped from the analysis. In other words, a household is included in the analysis, conditional that it has non-zero expenditure for at least one expenditure item. This reduced the sample size from 4,523 to 4,206 for 1991/92; from 5998 to 5,911 for 1998/99; and from 16,772 to 16,545 for 2012/13. Commodity prices used are the median prices of the three prices collected for each item in each cluster while the price of other cereal expenditures is set as a numeraire.

Table 2.15 shows the average budget share by entire sample, locality and poverty status while Table 2.16 presents the average real prices by entire sample and locality. Bread, rice, maize flour and maize are the major components of cereal expenditures in Ghana. In 1991/92, nationally, expenditure on bread constituted the largest share (32%) of total expenditure on cereals followed by rice and maize flour. However, not surprisingly, in 1998/99 and 2012/13, expenditure on rice constituted the largest share of total expenditure on cereals (33% in 1998/99 and 22% in 2012/13). Given that rice consumption (particularly imported rice) in Ghana generally has been rising over the last three decades coupled with data from the Ministry of Food and Agriculture (MoFA) showing that rice consumption has almost doubled since 1985 and demand was expected to rise to 850,000 tonnes in 2013/2014, this is expected. We also note a decline in expenditure share for bread over the years. It was 32% in 1991/92 and declined to 28% and 14% in 1998/99 and 2012/13 respectively.

In all periods, budget shares on maize and maize flour in rural area are higher than in urban areas. Again, this result is also not surprising because maize is mostly cultivated in rural areas and although many products can be made from maize,

maize flour is the main product rural households often make with their cultivated maize. Hence maize and maize flour is likely to be consumed more by rural households as own consumption than urban households. Households in urban areas spent more on bread and rice than households in rural areas in all periods. Furthermore, poor households spend more on maize and maize flour than non-poor households in all periods, while non-poor households spend more on rice and bread than poor households. This is also not surprising given that about 75% of the poor in Ghana are in rural areas where maize and maize flour are consumed the most, while the majority of the non-poor households are in urban areas where bread and rice are also consumed the most.

As shown in Table 2.16, in 2012/13 rice was the most expensive expenditure item (in real terms). Again, this can be attributed to the rising demand for rice as well as the rising cost of rice imports due to exchange rate depreciation and increases in international food prices. However, in 1991/92, the most expensive item was guinea corn followed by millet while the most expensive item in 1998/99 was bread followed by rice and millet. In the 1998/99 and 2012/13 surveys, rice was more expensive in rural areas than in urban areas while bread was more expensive in urban areas than in rural areas. In the case of rice, the difference in price can be attributed to transportation cost. As noted earlier, the majority of rice consumed in Ghana is imported and has to be transported to rural areas because Ghana's two main ports are in Accra and Takoradi. In addition to rising demand and rising cost of imports, transportation cost further increases the cost of imported rice in rural areas.

Table 2.15: Average expenditure share by entire sample, locality and poverty status

	Locality and Entire sample									Poverty status					
	1991/92			1998/99			2012/13			1991/92		1998/99		2012/13	
Item	Entire sample	Urban	Rural	Entire sample	Urban	Rural	Entire sample	Urban	Rural	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor
Maize	0.102	0.083	0.113	0.107	0.082	0.121	0.103	0.074	0.126	0.112	0.095	0.140	0.091	0.146	0.089
Rice	0.295	0.385	0.244	0.334	0.376	0.311	0.221	0.244	0.202	0.248	0.325	0.278	0.360	0.175	0.235
M. four	0.171	0.120	0.200	0.174	0.093	0.221	0.202	0.132	0.257	0.229	0.136	0.234	0.147	0.293	0.173
Bread	0.323	0.355	0.304	0.280	0.366	0.231	0.146	0.172	0.126	0.266	0.358	0.191	0.320	0.100	0.161
Millet	0.012	0.005	0.016	0.013	0.007	0.016	0.020	0.008	0.029	0.017	0.009	0.031	0.005	0.038	0.014
G. Corn	0.036	0.005	0.053	0.022	0.003	0.033	0.015	0.003	0.024	0.063	0.019	0.051	0.009	0.032	0.009
OthCe	0.062	0.048	0.070	0.070	0.074	0.068	0.294	0.367	0.237	0.066	0.059	0.075	0.068	0.217	0.319
Sample size	4,206	1,526	2,681	5,911	2,161	3,750	16,545	7,309	9,236	1,610	2,596	1,851	4,060	3,950	12,595

Source: Author's calculation from GLSS 3, 4 and 6

Notes:

M. flour represents Maize flour; G. Corn represents Guinea Corn; and OthCe present other cereal expenditure

These budget shares are in respect to total expenditure on Bread and Cereal. Therefore, for each household, the budget share for an expenditure item is obtained by dividing the household expenditure on that item by total expenditure on Bread & Cereals. Budget share may not sum to 1 due to rounding.

Table 2.16: Average real prices by full sample and locality

Item	1991/92 Entire sample	Urban	Rural	1998/99 Entire sample	Urban	Rural	2012/13 Entire sample	Urban	Rural
Maize (Corn)	0.0704	0.0885	0.0600	0.1059	0.0636	0.1304	2.830	2.476	3.100
Rice	0.1607	0.1989	0.1388	0.3530	0.3382	0.3615	5.720	5.129	6.172
Maize four	0.0733	0.0959	0.0602	0.1650	0.2125	0.1376	1.186	1.141	1.221
Bread	0.0851	0.0883	0.0833	0.4876	0.6902	0.3705	2.030	2.399	1.748
Millet	0.1787	0.2470	0.1396	0.2808	0.1209	0.3732	2.368	1.917	2.712
Guinea Corn	0.2112	0.2275	0.2018	0.2273	0.1214	0.2886	2.029	1.858	2.161
No. of clusters	365	100	265	300	110	190	1,200	545	655

Source: Author's calculation from GLSS 3, 4 and 6

Notes:

January 1999 Accra price was used as the based to normalize prices for GLSS 3 and 4 while January 2013 price was used to normalize prices for GLSS 6. All figures are in Ghana cedis and are prices per kilos.

Having provided some descriptive statistics of budget shares and prices, we turn to the discussion of expenditure and price elasticities of cereal and cereal products between 1991 and 2013. We start with a brief discussion of the parameter estimates of the QUAIDS model for the seven items.

Results for QUAIDS model

The estimates are presented in Table A2.9a, A2.9b and A2.9c for 1991/92, 1998/99 and 2012/13 respectively. In all, 28 price effects are estimated for each survey period and more than 50% of the estimates in each period are significant at 1%, 5% or 10% level of significance. In each period, majority of the expenditure items have negative own-price effect, suggesting an inverse relationship between budget share and own-price. The coefficient of the residual term of the reduced form regression is also significant for most items in each period, suggesting that total expenditure on cereals is endogenous in the share equation for these items and must be corrected for. In addition, the coefficient of expenditure square is significant for almost all equations in each period. This suggests the rejection of the AIDS specification for these items (see column 10 of Tables A2.9a, A2.9b and A2.9c).

Expenditure elasticities

We now turn to the discussion of the estimated expenditure elasticities. As noted in Tomek & Robinson (2003), expenditure elasticity is a measure of the responsiveness of expenditure on a commodity to a change in household income, all things being equal. Household expenditure is often used as a proxy for household income because the income measure in most budget surveys is subject to measurement errors. Knowledge of expenditure elasticities is very important in explaining household consumption patterns; they give an indication of how increments in household expenditure will be spent on the commodities the household consumes and also serve as key behavioural parameters in analysis of food policy reforms (Maganga et al., 2014). Positive expenditure elasticity for a commodity indicates that expenditure on that commodity will increase as total household expenditure increases, while negative expenditure elasticity for a commodity implies that expenditure on that particular good will decrease with increasing total expenditure. Furthermore, an expenditure elasticity of one or more indicates that expenditure on the commodity in question will increase at a greater rate than the increase in total expenditure while commodities with positive expenditure elasticity are known as normal goods and those with negative expenditure elasticities are known as inferior goods.

Table 2.17 presents the expenditure elasticity estimates for the seven cereal items by entire sample and locality while Table 2.18 presents the expenditure elasticities by poverty status of households. As would be expected, all the expenditure elasticity estimates accord with economic intuition, i.e. all the items have positive expenditure elasticities in all periods, suggesting that in Ghana all the seven cereal items are normal goods, consumption of which will increase with rising incomes. However, there are significant differences in the elasticity estimates (in terms of values) for all periods, by entire sample and locality as well as poverty status of households.

The national expenditure elasticities are presented in columns 2, 5 and 8 of Table 2.17 for the 1991/92, 1998/99 and 2012/13 surveys respectively. Nationally, maize was expenditure elastic within cereal expenditure in 1991/92 (1.344) and 1998/99 (1.051), but expenditure inelastic in 2012/13 (0.888). In other words, household expenditure on maize reacted more to changes in total expenditure for cereals in 1991/92 and 1998/99 than in 2012/13. This indicates that maize was considered a luxury in 1991/92 and 1998/99 but a necessity in 2012/13. While this suggests a change in household consumption patterns of maize over the three survey periods, more importantly it shows a clear case of a good that is a luxury at one point in time and a necessity at another time. A possible explanation of this change in consumption pattern would be the rising levels of household income. As seen in Table A2.4, average household income in Ghana has risen considerably since 1991/92. This gives households (particularly poor households) who could not afford certain items in the past ability to purchase them over time.

Table A2.4: Summary Statistics for total food expenditure, total income and household characteristics & demographic variables

	1991/92		1998/99		2012/13	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Food expenditure	33.09	22.88	227.1	16.4	4,011	2,934
Household income	37.27	44.16	216.8	30.7	15,676	46,282
Region						
Western	0.11	0.31	0.11	0.31	0.12	0.32
Central	0.11	0.32	0.12	0.32	0.10	0.31
Greater Accra	0.14	0.35	0.14	0.35	0.14	0.35
Volta	0.15	0.35	0.11	0.31	0.09	0.29
Eastern	0.09	0.29	0.14	0.34	0.12	0.32
Ashanti	0.16	0.37	0.18	0.38	0.14	0.34
Brong Ahafo	0.10	0.30	0.09	0.29	0.08	0.27
Northern	0.07	0.26	0.06	0.24	0.08	0.28
Upper East	0.02	0.15	0.02	0.14	0.07	0.25
Upper West	0.04	0.20	0.04	0.20	0.06	0.24
Locality						
Urban	0.35	0.48	0.37	0.48	0.53	0.50
Rural	0.65	0.48	0.63	0.48	0.47	0.50
Poverty status						
Poor	0.40	0.49	0.32	0.47	0.18	0.38
Non-poor	0.60	0.49	0.68	0.47	0.82	0.38
Sex of HH Head						
Male	0.68	0.47	0.66	0.47	0.69	0.46
Female	0.32	0.47	0.34	0.47	0.31	0.46
HH head's Age	44.30	15.33	45.83	15.3	45.04	15.75
Household Size	4.48	2.83	4.28	2.56	3.92	2.57

Sources: Author's calculation from GLSS 3, 4 and 6

Notes:

Total household food expenditure and income are expressed in gh₵ and are in nominal terms. Quarter dummies included but means and standard deviations not reported.

In 1991/92 and 1998/99 expenditure on maize reacted more to changes in total expenditure on cereals in both urban and rural areas, but the reverse is the case in 2012/13. However, urban expenditure elasticity for maize was higher than rural expenditure elasticity in 1991/92 and 2012/13 while in 1998/99 it is the reverse. Both poor and non-poor households considered maize as luxury in 1991/92 and 1998/99 but a necessity in 2012/13 (see Table 2.18). In addition, expenditure elasticity for maize for poor households was lower than non-poor households in 1991/92 but higher in 1998/99 and 2012/13 (see Table 2.18). This also suggests another change in consumption patterns of maize between poor and non-poor households.

Nationally, rice was considered as a necessity in both 1991/92 and 2012/13 but a luxury in 1998/99. Expenditure on rice reacted less to changes in total expenditure on cereal in both 1991/92 and 2012/13 than in 1998/99. In all periods, expenditure elasticity for rice was higher in urban areas than in rural areas, suggesting that household expenditure on rice in urban areas reacted more to changes in total expenditure on cereals than in rural areas. Non-poor household's expenditure elasticity for rice was also higher than that of poor households in all periods (see Table 2.18). Bread is considered a necessity in all periods; it has an expenditure elasticity of less than one for all household types in all periods, but it is higher for non-poor households than poor households. Maize flour was also considered a necessity nationally both in 1991/92 and 1998/99, but a luxury in 2012/13, Again, poor household expenditure on maize flour is more sensitive to changes in total expenditure on cereal than non-poor households in all periods. Millet and guinea corn are also considered as luxuries in all periods. Both have expenditure elasticities of more than one in all periods.

Table 2.17: Expenditure elasticities by entire sample and locality

Item	1991/92 Entire sample	1991/92 Urban	1991/92 Rural	1998/99 Entire sample	1998/99 Urban	1998/99 Rural	2012/13 Entire sample	2012/13 Urban	2012/13 Rural
Maize	1.344	1.400	1.352	1.051	1.004	1.041	0.888	0.879	0.865
	(0.061)	(0.082)	(0.060)	(0.021)	(0.036)	(0.022)	(0.031)	(0.046)	(0.026)
Rice	0.983	1.105	0.842	1.129	1.179	1.094	0.978	1.003	0.950
	(0.024)	(0.022)	(0.031)	(0.011)	(0.012)	(0.012)	(0.020)	(0.020)	(0.021)
Maize four	0.912	0.857	0.887	0.929	0.563	0.974	1.087	1.039	1.114
	(0.037)	(0.059)	(0.037)	(0.023)	(0.054)	(0.019)	(0.020)	(0.033)	(0.016)
Bread	0.694	0.685	0.702	0.816	0.894	0.762	0.601	0.695	0.469
	(0.023)	(0.025)	(0.024)	(0.016)	(0.016)	(0.020)	(0.030)	(0.028)	(0.032)
Millet	1.726	1.724	1.840	1.785	2.599	1.692	3.545	6.846	2.973
	(0.232)	(0.713)	(0.173)	(0.125)	(0.236)	(0.117)	(0.118)	(0.273)	(0.086)
Guinea Corn	2.404	3.707	2.234	1.758	2.903	1.689	1.930	3.869	1.796
	(0.126)	(0.919)	(0.103)	(0.086)	(0.715)	(0.068)	(0.094)	(0.411)	(0.063)
OthCe	1.417	1.373	1.486	0.832	0.827	0.878	0.975	0.998	0.950
	(0.070)	(0.099)	(0.071)	(0.041)	(0.048)	(0.044)	(0.019)	(0.017)	(0.023)
Sample size	4,206	1,526	2,681	5,911	2,161	3,750	16,545	7,309	9,236

Source: Author's estimation from the GLSS 3, 4 and 6

Notes:

The figures in parenthesis are standard errors and are obtained using the delta method.

These elasticities are conditional elasticities as defined with respect to the total expenditures on bread & cereals (i.e. not with respect to total food expenditure for the household) and are calculated at the means of household's total expenditure on bread and cereal.

OthCe represents Other Cereal expenditure.

Table 2.18: Expenditure elasticities by poverty status

Item	1991/92 Poor	1991/92 Non-poor	1998/99 Poor	1998/99 Non-poor	2012/13 Poor	2012/13 Non-poor
Maize	1.270	1.403	1.052	1.046	0.898	0.876
	(0.055)	(0.067)	(0.016)	(0.027)	(0.023)	(0.036)
Rice	0.921	1.008	1.107	1.136	0.950	0.984
	(0.028)	(0.023)	(0.013)	(0.011)	(0.024)	(0.019)
Maize flour	0.970	0.842	1.018	0.856	1.093	1.085
	(0.028)	(0.048)	(0.018)	(0.029)	(0.014)	(0.024)
Bread	0.630	0.724	0.682	0.855	0.338	0.648
	(0.027)	(0.021)	(0.024)	(0.014)	(0.042)	(0.027)
Millet	1.597	1.911	1.389	3.041	2.476	4.502
	(0.159)	(0.321)	(0.054)	(0.354)	(0.066)	(0.163)
Guinea Corn	1.926	3.428	1.370	2.874	1.572	2.343
	(0.073)	(0.239)	(0.038)	(0.223)	(0.047)	(0.145)
OthCe	1.423	1.422	0.844	0.831	0.943	0.982
	(0.064)	(0.076)	(0.037)	(0.044)	(0.025)	(0.018)
Sample size	1,610	2,596	1,851	4,060	3,950	12,595

Source: Author's estimation from the GLSS

Notes:

The figures in parenthesis are standard errors and are obtained using the delta method. Elasticities are calculated at the means of household's total expenditure on bread and cereal. OthCe represents Other Cereal expenditure

Uncompensated and Compensated price elasticities

Aside from expenditure elasticities, household consumption patterns can also be explained using uncompensated and compensated price elasticities. Uncompensated elasticity measures the response of demand to price changes when money income is held constant while compensated elasticities measure the response of demand to price changes when utility is held constant.[22] Both measures of price response are important to the understanding of consumption patterns of households. Tables 2.19 and 2.20, respectively, present the estimates of the uncompensated (Marshallian) and compensated (Hicksian) own price elasticities by entire sample and locality for all periods.

Own-price elasticities (both uncompensated and compensated) are all negative as would be expected. As shown in columns 2, 3 and 4 of Table 2.19, in 1991/92,

[22] The uncompensated elasticities are calculated on the basis of the Marshallian demand function while the compensated elasticities are calculated on the basis of the Hicksian demand function.

based on the uncompensated own-price estimates, maize, maize flour and "other cereals" were all price inelastic across all household groups while rice, bread, millet and guinea corn were all price elastic across all household groups except bread which was price inelastic in urban areas. As we indicated earlier, rice and bread took larger shares (as seen in Table 2.15) of expenditure on cereals (both at the national and local levels) in 1991/92, hence one would expect them to be price elastic while the expenditure elasticities for millet and guinea corn also indicate that they are necessities and should therefore be price elastic. However, when only the substitution effects are considered (i.e. compensated elasticities), rice and bread become price inelastic with compensated own-price elasticity estimates of -0.890 and -0.789 respectively, but millet and guinea corn still remained price elastic (see columns 2, 3 and 4 of Table 2.20).

Table 2.19: Uncompensated Own Price elasticities by full sample and locality

Item	1991/92			1998/99			2012/13		
	Entire sample	Urban	Rural	Entire sample	Urban	Rural	Entire sample	Urban	Rural
Maize	-0.703	-0.642	-0.728	-1.109	-1.147	-1.090	-1.044	-1.112	-0.998
	(0.087)	(0.108)	(0.078)	(0.042)	(0.055)	(0.037)	(0.021)	(0.030)	(0.018)
Rice	-1.180	-1.168	-1.177	-0.976	-0.995	-0.963	-1.054	-1.053	-1.053
	(0.052)	(0.040)	(0.064)	(0.027)	(0.024)	(0.029)	(0.010)	(0.009)	(0.011)
Maize four	-0.816	-0.797	-0.798	-1.083	-1.153	-1.046	-0.993	-0.966	-1.005
	(0.056)	(0.082)	(0.049)	(0.025)	(0.048)	(0.020)	(0.015)	(0.023)	(0.012)
Bread	-1.021	-0.995	-1.039	-1.127	-1.115	-1.140	-0.963	-0.992	-0.914
	(0.043)	(0.038)	(0.047)	(0.021)	(0.016)	(0.027)	(0.022)	(0.020)	(0.026)
Millet	-1.282	-1.733	-1.202	-1.065	-1.124	-1.047	-0.634	-0.472	-0.614
	(0.174)	(0.439)	(0.131)	(0.113)	(0.203)	(0.090)	(0.045)	(0.115)	(0.038)
Guinea Corn	-1.651	-3.561	-1.397	-1.628	-3.404	-1.408	-0.825	-0.368	-0.862
	(0.135)	(1.057)	(0.092)	(0.099)	(0.842)	(0.066)	(0.054)	(0.243)	(0.033)
OthCe	-0.565	-0.436	-0.613	-0.296	-0.339	-0.270	-0.679	-0.751	-0.594
	(0.145)	(0.189)	(0.129)	(0.062)	(0.058)	(0.065)	(0.028)	(0.022)	(0.034)
Sample size	4,206	1,526	2,681	5,911	2,161	3,750	16,545	7,309	9,236

Source: Author's estimation from the GLSS

Notes:

The figures in parenthesis are standard errors and are obtained using the delta method. Elasticities are calculated at the means of total expenditure on Bread and Cereal. OthCe represents other cereal expenditure.

Table 2.20: Compensated Own Price elasticities by full sample and locality

Item	1991/92 Entire sample	Urban	Rural	1998/99 Entire sample	Urban	Rural	2012/13 Entire sample	Urban	Rural
Maize	-0.568	-0.526	-0.578	-0.999	-1.068	-0.965	-0.952	-1.046	-0.889
	(0.087)	(0.108)	(0.078)	(0.042)	(0.055)	(0.037)	(0.021)	(0.031)	(0.018)
Rice	-0.890	-0.742	-0.972	-0.599	-0.550	-0.625	-0.839	-0.809	-0.861
	(0.052)	(0.039)	(0.063)	(0.027)	(0.025)	(0.029)	(0.011)	(0.010)	(0.011)
Maize four	-0.659	-0.693	-0.619	-0.919	-1.100	-0.827	-0.771	-0.828	-0.718
	(0.057)	(0.082)	(0.049)	(0.025)	(0.048)	(0.020)	(0.014)	(0.022)	(0.011)
Bread	-0.798	-0.752	-0.826	-0.899	-0.787	-0.966	-0.875	-0.872	-0.855
	(0.043)	(0.038)	(0.047)	(0.022)	(0.017)	(0.027)	(0.023)	(0.020)	(0.026)
Millet	-1.262	-1.725	-1.173	-1.042	-1.105	-1.019	-0.564	-0.417	-0.528
	(0.173)	(0.437)	(0.130)	(0.113)	(0.203)	(0.091)	(0.046)	(0.115)	(0.039)
Guinea Corn	-1.566	-3.522	-1.279	-1.589	-3.389	-1.352	-0.796	-0.355	-0.819
	(0.135)	(1.057)	(0.094)	(0.099)	(0.842)	(0.066)	(0.053)	(0.243)	(0.033)
OthCe	-0.477	-0.371	-0.509	-0.239	-0.278	-0.211	-0.394	-0.388	-0.370
	(0.145)	(0.190)	(0.129)	(0.061)	(0.057)	(0.063)	(0.025)	(0.019)	(0.031)
Sample size	4,206	1,526	2,681	5,911	2,161	3,750	16,545	7,309	9,236

Source: Author's estimation from the GLSS

Notes:

The figures in parenthesis are standard errors and are obtained using the delta method. Elasticities are calculated at the means of household's total expenditure on Bread and Cereal. OthCe represent other expenditure

Again, columns 5, 6 and 7 of Table 2.19 show the uncompensated own-price elasticity estimates for 1998/99 by entire sample and locality (urban/rural). Rice and "other cereal" were all price inelastic, while maize, maize flour, bread, millet and guinea corn were all price elastic across all household groups. Interestingly, rice, which responded more to own-price changes in 1991/92, has become price inelastic in 1998/99 while maize and maize flour which responded less to own-price changes in 1991/92 has become price elastic in 1998/99. Again, when we consider only the substitution effects, maize, rice, maize flour, bread and "other cereal" all become price inelastic across all household groups, but millet and guinea corn continue to be price elastic across all household groups (see columns 5, 6 and 7 of Table 2.20). It is only in the case of urban households that maize and maize flour become price elastic when only substitution effects are considered. This indicates the greater substitution possibilities that urban households have in responding to changes in the prices of maize and maize flour compared to rural households.

The uncompensated own-price elasticity estimates for the recent survey (i.e. 2012/13) are provided in Columns 8, 9 and 10 of Table 2.19. Compared to 1998/99 estimates, nationally and in urban areas, maize remains price elastic, but becomes price inelastic in rural areas with an estimate very close to one (-0.998). Rice becomes price elastic as it was in 1991/92 across all household groups while the other items were all price inelastic. However, the compensated own-price elasticity estimates show that all items are price inelastic across all household groups except the case of urban households where maize is price elastic.

Table 2.21 presents the uncompensated own-price elasticity estimates by poverty status for all three periods (i.e. poor and non-poor). As seen in columns 2 and 3, in 1991/92, poor households responded more to own-price change of maize, rice, maize flour and bread than non-poor households. This is in contrast to the elasticity estimates in 1998/99, where non-poor households responded more to own-price change of maize, rice, maize flour and bread. However, in 2012/13 non-poor households responded more to own-price change of maize and bread while poor households responded more to own-price change of rice, maize flour, millet and guinea corn.

Table 2.21: Uncompensated own-price elasticity by poverty status

	1991/92		1998/99		2012/13	
Item	**Poor**	**Non-poor**	**Poor**	**Non-poor**	**Poor**	**Non-poor**
Maize	-0.723	-0.689	-1.084	-1.126	-1.010	-1.059
	(0.079)	(0.093)	(0.032)	(0.048)	(0.015)	(0.025)
Rice	-1.205	-1.167	-0.960	-0.982	-1.063	-1.051
	(0.063)	(0.048)	(0.032)	(0.025)	(0.012)	(0.009)
Maize flour	-0.853	-0.774	-1.064	-1.094	-1.004	-0.987
	(0.043)	(0.071)	(0.019)	(0.029)	(0.010)	(0.017)
Bread	-1.026	-1.019	-1.161	-1.118	-0.909	-0.972
	(0.053)	(0.039)	(0.032)	(0.018)	(0.032)	(0.020)
Millet	-1.199	-1.380	-1.027	-1.180	-0.749	-0.522
	(0.123)	(0.235)	(0.047)	(0.311)	(0.026)	(0.063)
Guinea Corn	-1.377	-2.202	-1.271	-2.599	-0.911	-0.729
	(0.078)	(0.250)	(0.043)	(0.253)	(0.025)	(0.084)
OthCe	-0.598	-0.542	-0.341	-0.274	-0.557	-0.705
	(0.135)	(0.153)	(0.058)	(0.064)	(0.037)	(0.026)
Sample size	1,610	2,596	1,851	4,060	3,950	12,595

Source: Author's estimation from the GLSS 3, 4 and 6
Notes:
The figures in parenthesis are standard errors and are obtained using the delta method. Elasticities are calculated at the means of household's total expenditure on Bread and Cereal. OthCe represent other expenditure

In addition to the above findings, we also noticed significant cross price effects[23] in all periods. Tables A2.10a, A2.10b and A2.10c provide the uncompensated and compensated price elasticity matrix for 1991/92, 1998/99 and 2012/13

[23] Note that cross-price elasticities are not symmetric, meaning that the household response for a commodity to a change in the price of another commodity is not necessarily the same as the household response for the other commodity to a change in the price of the commodity in question.

respectively. Some cross-price elasticities are positive while some are negative; positive cross-price elasticity suggests that the commodities are substitutes and negative suggest that they are complements. As expected, rice and maize are substitutes while maize and maize flour are complements in all periods. Again, as expected low income households respond more to changes in the price of maize than high income households, while high income households respond more to changes in rice and bread than low income households (see Table A2.11a in appendix A).

It is worth noting that our expenditure elasticity estimate for maize in 1991/92 is in contrast to the estimate reported by Wassiuw and Ibrahim (2015). They found all the expenditure elasticities to be less than one. Such differences are expected because of the difference in the demand model used in the estimation. Based on the fact that our choice of demand model was based on which best fits the data, we are inclined to believe that the price and expenditure elasticity estimates presented in this chapter are more accurate and can be used more reliably for policy analysis.

2.7 Conclusion

This chapter presented empirical evidence to show that the most appropriate demand model for estimating household price and income responses in Ghana is the Quadratic Almost Ideal Demand System of Banks et al (1997). As already noted, in developing countries a thorough understanding of household consumption patterns is necessary for the effective design of food security policies as well as tax policies. Such consumption patterns are estimated using a household demand model, the choice of which should be dependent on the available data.

Chapter 3 presents analysis of the welfare effect of observed price change on household welfare in Ghana, which requires estimation of a demand model. This chapter explained in detail the procedure used in deciding on the appropriate model. Both parametric and non-parametric methods were employed and the results reject the traditional AIDS model, but favour the more flexible QUAIDS model. This is the first study to have done such an analysis for Ghana using the GLSS; previous studies assume a linear relationship between expenditure shares and total expenditure by employing restrictive functional forms such as the LA/AIDS models to estimate price and income response of households in Ghana.

Having established the appropriate model for the analysis in chapter 3, as an update to Wassiuw and Ibrahim (2015), we estimated household consumption patterns for cereal and cereal products between 1991 and 2013 (divided into three periods - 1991/92, 1998/99 and 2012/13). We focussed on seven items (maize, rice, maize flour, bread, millet, guinea corn and other cereals) and estimated expenditure and price elasticities for these items. Based on the estimates of expenditure elasticities, all items are normal goods in all periods, suggesting that the consumption of these items will increase with rising household incomes.

In 1991/92 and 1998/99, expenditure on maize was found to be more responsive to changes in total expenditure on cereal across all household groups, but less responsive in 2012/13. This does not only reflect changes in consumption patterns, but also shows the case where a commodity is a luxury at some point and a necessity at another time (a feature the QUAIDS is suited to identify).

Furthermore, urban household expenditure on maize reacted more to changes in total expenditure on cereal than rural household expenditure on maize in all periods except in 1998/99. In addition, urban household expenditure on rice reacted more to changes in total expenditure on cereal than rural household expenditure on rice, while non-poor household expenditure on rice reacted more to changes in total cereal expenditure than poor household expenditure on rice. Bread is considered a necessity across all household groups, but non-poor household expenditure on bread reacted more to changes in total cereal expenditure than poor household expenditure.

In 2012/13, based on the uncompensated own-price elasticities, maize and rice were all price elastic across all household groups (except rural households) while bread, maize flour, millet and guinea corn were all price inelastic. However, when only the substitution effects are considered (i.e. compensated elasticities), maize, rice, maize flour and bread all become price inelastic, with compensated own-price elasticity estimates of less than unity. It is only in the case of urban households that maize remains price elastic when both the uncompensated and compensated elasticity estimates are considered. While the uncompensated own-price elasticities for maize, in 1998/99 and 2012/13, showed that maize responded more to price changes, the reverse was the case in 1991/92. For bread, both poor and non-poor household responded more to price changes in 1991/92 and 1998/99 but the reverse is true in 2012/13. We also noticed significant cross price effects in all periods. For instance, as expected, rice and maize were substitutes while maize and maize flour are complements.

The findings in this chapter show that there are substantial differences in the consumption patterns of cereal items in terms of location (urban/rural), as well as the poverty status of the households, and over time. Therefore, the design of anti-poverty and nutrient enhancement programs for cereals in Ghana needs to be location specific and take into account these behavioural differences in cereal expenditures.

Chapter 3 : The impact of observed price increases on household welfare in Ghana (1991-2013): a Quadratic Almost Ideal Demand System Approach

3.1 Introduction

Between 2000 and 2013, the international food market saw an unprecedented rise in food prices (Ferreira et al., 2008). After falling to a record low in the early 2000s, food prices rose substantially between early 2003 and the second quarter of 2008. From mid-2008, a brief decline lasted until mid-2009 (FAO, 2011). By early 2011 international food prices had reached levels higher than in mid-2008 (FAO, 2011). Staple foodstuff such as rice, wheat and maize all saw unprecedented price increases. For instance, by the second quarter of 2008, the price of wheat and maize were three times higher than in early 2003 and the price of rice was five times higher (von Braun, 2008; Tefera et al., 2012). In June 2010, the price of maize and wheat had increased by 74 percent and 84 percent, respectively, compared to mid-2008.

In developing countries, such increases in food prices are a major concern to poor households as well as policy makers because of the negative implications for the welfare of poor households. Poor households in developing countries have small and irregular incomes, of which they spend between 60-80 percent on food. Food price increases will only mean that they spend even more of their income on food (World Food Program, 2012). This will not only mean that they have less for their other needs, but they will also start to cut down on the number of meals per day and reduce the quality of the food they consume, which may have negative health implications on the households. Furthermore, in their bid to find other sources of income to sustain the household, they tend to sell assets such as livestock which may further push the household closer to destitution (World Food Program, 2012).

Between 1991 and 2013, both food and non-food items in Ghana have seen significant price fluctuations. For instance, the overall year-on-year inflation (in constant 2002 prices) stood at 35.9 percent in December 1990. It went up to 70.8 percent in December 1995 and later fell to 40 percent and 8.8 percent in 2000 and 2012 respectively (all in December). Furthermore, the year-on-year food price inflation which stood at 32 percent in December 1990 rose to 67.2 percent, while non-food price inflation also rose from 38 percent to 72.8 percent during the same period. At the end of December 2012, the year-on-year food and non-food price inflation were 4 percent and 11.6 percent respectively. These price fluctuations in food and non-food inflation make Ghana an interesting case for studying the welfare effect of observed price changes. Hence the objective of this chapter is to estimate the welfare effect of observed price changes on Ghanaian households from 1991 to 2013 using the Ghana living standard surveys 3, 4, and 6. Our analysis considers three periods of observed price changes; 1991/92 to 2012/13, 1991/92 to 1998/99, and 1998/99 to 2012/13.

Two effects of food price increases on household welfare can be identified: consumer effect and producer effect. For households that are net-food consumers, food price increases result in a negative effect on welfare while those that are net-food producers gain from price increases through increases in household income (Tefera et al 2012). Ideally, a welfare analysis of price changes should capture both effects. However, the present study only focuses on the consumer effect.[24] The standard approach of compensating variation (CV) which

[24] Although the GLSS capture production quantities, they do not capture enough information on production cost to enable us to measure profit of net food producing households; hence we are unable to capture supply responses of food price increase effectively.

requires estimates of price and income elasticities is adopted to measure the effect of price changes on household welfare. As shown in Chapter 2, the Quadratic Almost Ideal Demand System of Banks et al. (1997) best fit the available data; hence it is adopted to estimate price and expenditure responses of households (see Chapter 2 for detailed explanation on why this method was adopted).

The present study is not the first to measure consumer welfare effects of food price changes or estimate price and expenditure elasticities for households in Ghana. Studies such as Ackah and Appleton (2007), Osei and Eghan (2013), Minot and Dewina (2013) and Wassiuw and Ibrahim (2015) have all tried to measure the consumer effect of price changes in Ghana. The present study is innovative in three respects. First, it is the first study on Ghana that has explicitly dealt with the issue of zero household consumption. Zero household consumption implies a censored dependent variable and estimation techniques which do not take this into account will yield biased results (Heien and Wessells, 1990). The Shonkwiler and Yen (1999) method is adopted to deal with this zero household expenditure in our estimation.

Second, it is the first study on the consumption effect of price changes in Ghana that estimates the price and expenditure elasticities taking into consideration the non-linear budget share-total expenditure relationship. That is, using the Quadratic Almost Ideal Demand System (QUAIDS). All other studies used the linear approximate Almost Ideal Demand System, which does not consider a non-linear budget share to total expenditure relationship. The linear model does not capture expenditure patterns accurately in the GLSS and therefore for welfare analysis a model that captures a non-linear relationship is more appropriate (see Chapter 2 for details).

Third, the study focuses on three periods of price changes by using GLSS 3, 4, and 6. All other studies focused on just one period. However, one period analysis does not allow us to measure the heterogeneities in the consumption effect of price changes over time.

The rest of the chapter is organized as follows: Section 3.2 provides a brief overview of the trends in commodity price changes in Ghana between 1991 and 2013. Section 3.3 provides a detailed description of the compensating variation method of measuring the consumption effect of price changes while section 3.4 describes the data used for the analysis and provides some descriptive statistics. The empirical strategy for estimation is discussed in section 3.5 while section 3.6 reports the results of the elasticity estimates and the welfare analysis due to price changes from 1991 to 2013 and section 3.7 concludes the chapter.

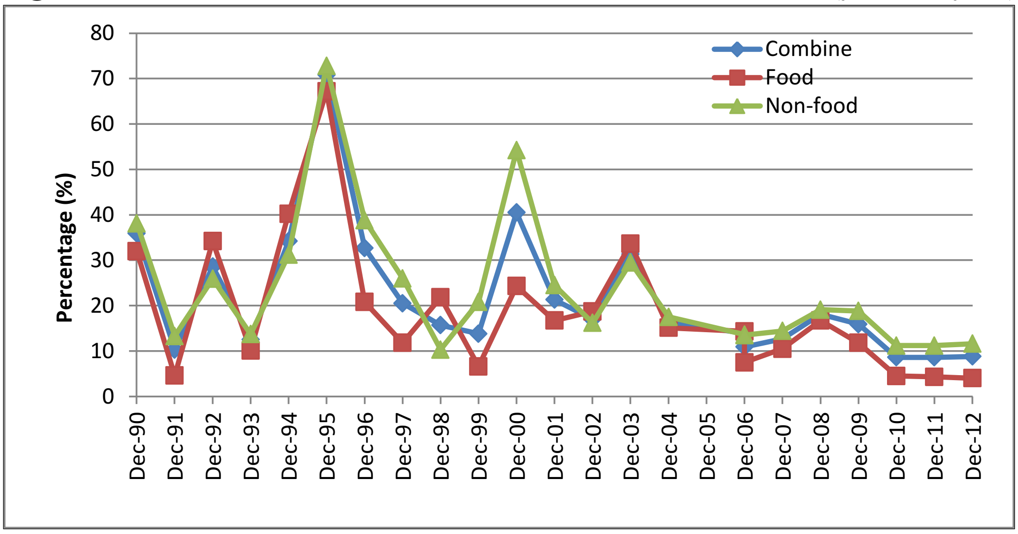
3.2 Price changes in Ghana

Between 1990 and 2013, Ghana experienced volatile and high inflation rates and a number of external and internal factors were identified to explain these trends. Among the external factors were increases in international prices of crude oil and global economic crises [25] which affected virtually all economies in the world. Internal factors included rising input costs, poor agricultural production, increases in electricity tariffs and erratic power supply, exchanges rate depreciation as well as increases in money supply (CEPA, 2009).

[25] Including those that occurred in 2007/08 and 2010/11.

Figure 3.1 shows the trends in inflation for Ghana over the period 1990-2012 (see Table A3.2 for the data). Clearly evident in the figure is the erratic and volatile movements of commodity prices in Ghana. Since 1990, inflation in Ghana has remained generally high with rates ranging between 70.8% in 1995 and 8.6% in 2010 with a dramatic rise between 1990 and 1995; inflation was 10.3% in 1991 but rose to 70.8% in 1995 (all-time high during 1990s and 2000s). Increases in petroleum prices, money supply and depreciation of the Ghana cedi were identified as the causes of the surge in inflation between 1990 and 1995 (CEPA, 2009; Adu & Marbuah, 2011). Money supply grew at 46% in 1994; petroleum prices increased by 20% in 1993, 18% in 1994, and 24% in 1995; the Cedi depreciated by 25% in 1994, and 28% in 1995. Other factors identified include poor agricultural production and international food crises which increased the prices of Ghana's imports thus fuelling increases in domestic prices. Inflation, however, fell to 32.7% in 1996 and 13.8 % in 1999; this was attributed to reductions in the rate of money growth, relatively stable exchanges rates and improved agricultural productivity. This fall was, however, short lived as inflation shot to 40.5% in December 2000 due to increased money supply, increased fuel prices, and depreciation of the Cedi.

Figure 3:1: Trends in Combined, food and non-food inflation (year-on-year)



Inflation rates in the 2000s were relatively lower compared to the rates in the 1990s. For instance, in December 2004 inflation was 16.4% but fell to 12.7% in 2007. The factors which contributed to this trend included: the use of resources from debt relief and debt cancellation from the HIPC and Multilateral Debt Relief Initiative, new aid flows and external loans and inward private transfers (including remittances) by the central bank to "buy off" the otherwise accelerated rates of inflation in the economy (CEPA, 2009; Adu & Marbuah, 2011). The adoption of the inflation targeting framework by the Bank of Ghana which anchored inflationary expectations in its new monetary policy agenda of price stability and economic growth was also cited. However, due to external shocks such as the high international food prices and global financial crisis, excessive government expenditure resulting in huge fiscal deficit of 13.9% of GDP and exchange rate depreciation, inflation went to 18.1% in 2008 but fell to 8.8% in 2012. Between 1990 and 2013, non-food inflation was higher than food inflation for most of the years except 1992, 1994, 1998 and 2003. Thus, the higher inflation during this period was largely driven by increases in non-food prices, though food inflation was also high.

3.3 Methodology

There are many approaches to measuring the welfare effect of price changes on households (see Nicita, 2004; Porto, 2005). However, a standard approach that is widely used is the one that calculates the money income that has to be given to the household after the price changes to make it as well-off as it was before the price changes (see, for example, Deaton, 1989, 1997; Minot and Goletti, 2000; Friedman and Levinsohn, 2002; Ackah and Appleton, 2007; and Leyaro et al., 2010). This method is the Compensating Variation (CV) approach. We rely on this approach to measure the welfare effect of price changes in Ghana. Detailed explanation of this method is provided below.

3.3.2 Compensating Variation Approach

Suppose the minimum expenditure necessary for a household to achieve a specific utility level, u^0, at a given price vector p^0, is $c(p^0, u^0)$ and the minimum expenditure level necessary to achieve the same utility level when prices alter to p^1, is $c(p^1, u^0)$, then the difference between $c(p^0, u^0)$ and $c(p^1, u^0)$ is the change in income necessary to ensure the household is indifferent between facing prices p^0 and p^1. As noted in Hicks (1954), this change in income is the compensating variation,[26] and is expressed as:

$$CV = c(p^1, u^0) - c(p^0, u^0) \qquad (1)$$

where the superscripts *0* and 1 refers to before and after the price change respectively.

As noted in Friedman and Levinsohn (2002) two welfare effects of price change can be estimated by equation 1: the first-order effect and second-order effect. A first-order Taylor expansion of equation 1 with respect to the original prices and an application of the Shepherd lemma condition simplify equation 1 as:

$$CV \approx \sum_{i=1}^{k} h_i\,(p^0, u^0)(p_i^1 - p_i^0) \qquad (2)$$

where $h_i(p^0, u^0)$ is the initial Hicksian demand for good *i* given the original price vector p^0 and $p_i^1 - p_i^0$ is the change in price of commodity *i*. If $h_i(p^0, u^0)$ and $p_i^1 - p_i^0$ are replaced with *q* and *Δp* respectively, equation 2 can be written as:

[26] A positive *CV* implies a requirement of more spending to achieve the same utility level as before the price changes and thus there is a decrease in consumer welfare. By contrast, a negative *CV* implies a drop in spending, and thus a gain in consumer welfare.

$$CV \approx q\Delta p \tag{3}$$

where q is a $1\ x\ k$ row vector of commodity groups, Δp is a $k\ x\ 1$ column vector of price changes and k the number of commodity groups in the total demand system. As noted in Friedman and Levinsohn (2002) and Leyaro et al. (2010), equation 3 approximates the income necessary to ensure that the household is indifferent between facing prices $p^0$and p^1. In other words, it is the amount of money the household should be given at the new set of prices in order to attain the initial level of utility. Friedman and Levinsohn (2002) called this the first-order effect of the price change because it does not consider behavioral responses of households. For estimation purposes, equation 3 is reformulated in terms of budget shares and proportionate price changes (see Friedman and Levinsohn, 2002; Leyaro et al., 2010) as follows:

$$CV \approx \sum_{i=1}^{k} w_i \Delta lnp_i \tag{4}$$

where i refers to the commodity group in the system and w_i is the budget share for good i.

When commodity prices change some commodities become cheaper relative to others. There is therefore the tendency for households to substitute commodities whose relative prices have disproportionately increased with those with relatively low prices (Leyaro et al., 2010). For this reason the costs of attaining initial utility levels will increase less rapidly than equation 4 may suggest if substitution effects of price changes are considered and equation 4 may overestimate the consumer welfare effect of a price change (Leyaro et al., 2010). Friedman and Levinsohn (2002) have shown that an application of a second-order Taylor expansion to equation 1 with respect to original prices and a subsequent application of the

Shepherd's lemma as well as Hotelling's lemma conditions will result in the simplification of equation 1 as:

$$CV \approx \sum_{i=1}^{k} h_i(p^0, u^0)(p_i^1 - p_i^0) + \frac{1}{2}\sum_{i=1}^{k}\sum\nolimits_{j=1}^{k} \frac{\partial h_i(p^0, u^0)}{\partial p_j}(p_i^1 - p_i^0)\left(p_j^1 - p_j^0\right) \qquad (5)$$

where $h_i(p^0, u^0)$ and $p_i^1 - p_i^0$ are as defined earlier in equation 2 and $p_j^1 - p_j^0$ is the change in the price of commodity j. Again, if we replace, $h_i(p^0, u^0)$, $p_i^1 - p_i^0$, $p_j^1 - p_j^0$ and $\frac{\partial h_i(p^0,u^0)}{\partial p_j}$ with q, Δp_i, Δp_j and s respectively, equation 5, can be written as:

$$CV \approx q\Delta p_i + \frac{1}{2} s\Delta p_i \Delta p_j \qquad (6)$$

where q is still a $1\ x\ k$ row vector of commodity groups, Δp_i andΔp_j are again a $k\ x\ 1$ column vector of price changes and s is the $k\ x\ k$ matrix of compensated derivatives of demand. As was done for equation 3, equation 6 can be reformulated in terms of budget shares and proportional price change as:

$$CV = \sum w_i \Delta lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} c_{ij} \Delta lnp_i\, \Delta lnp_j \qquad (7)$$

where the expression c_{ij} contains the Slutsky derivatives s_{ij} and is defined by the expression:

$$c_{ij} = \frac{p_i s_{ij} p_j}{C} \qquad (8)$$

With some simple algebraic manipulation we can show that c_{ij} is equivalent to $w_i \varepsilon_{ij}$, where ε_{ij} is defined as the compensated price elasticity of good i with respect to price change of group j. Thus we can restate expression (7) as:

$$CV \approx \sum_{i=1}^{k} w_i \Delta lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} w_i \varepsilon_{ij}\, \Delta lnp_i \Delta lnp_j \qquad (9)$$

As noted in Friedman and Levinsohn (2002), Leyaro et al. (2010) and Magrini et al. (2015), the first term in equation (9) measures the first-order effect on welfare due to a price change while the last term captures the second-order effect of the price change. Our objective in this chapter is to estimate these two effects of a price change on Ghanaian households using three rounds of the Ghana Living Standard Survey. Our focus is on three periods of price change: between 1991/92 and 2012/13; 1991/92 and 1998/99; 1998/99 and 2012/13. The proportionate price change between each period is obtained by using the Fisher price index. For example, If $P_{1991/92}$ and $P_{1998/99}$ represent an observed price of 1991/92 and 1998/99 respectively, the observed price change between these periods is calculated as:

$$\Delta p = \frac{P_{1998/99} - P_{1991/92}}{P_{1991/92}}$$

3.3.2 Estimating price and expenditure responses

The standard compensating variation (CV) approach to measure the consumer effect of a price change requires estimates of how households respond to price and income changes (i.e., price and income elasticities). These estimates are not only useful for computing the consumer effect of price changes, but they also give some idea of household consumption patterns. Price and income responses of households are estimated using household demand system. There are many such demand systems. However, the best model that fit the GLSS, as shown in chapter

2 is the Quadratic Almost Ideal Demand System of Banks et al. (1997).[27] The QUAIDS model for an M-good system as:

$$w_i = \alpha_i + \sum_{j=1}^{k} \gamma_{ij} \ln p_j + \beta_i \ln\left[\frac{X}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left\{\ln\left[\frac{X}{a(p)}\right]\right\}^2 + \varepsilon_i \quad (10)$$

where w_i is the share of the total expenditure $\boldsymbol{X}$ allocated to the i^{th} item while p_j is the price of j^{th} commodity while $a(p)$ and $b(p)$ are price indices given as:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{k} \alpha_i \, lnp_i + \frac{1}{2}\sum_{i=1}^{k}\sum_{j=1}^{k} \gamma_{ij} \; lnp_i lnp_j$$

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

where $\boldsymbol{k}$ denotes the number of commodity groups (nine in our case), *i* and *j* indicate the commodity groups. The theoretical restrictions of adding-up, homogeneity and symmetry are imposed to make the demand function derived from equation 10 consistent with theory. The adding-up restriction is satisfied if $\sum_i^n w_i = 1$ for all *m* and *p* and this requires that

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

Homogeneity and Slutsky symmetry are also satisfied when

$$\sum_{i=1}^{k} \gamma_{ji} = 0, \quad \text{and} \quad \gamma_{ij} = \gamma_{ji} \quad \text{repectively.}$$

The expenditure and price elasticities are derived from the budget share equations (i.e., equation 10) respectively as:

$$\mu_i = 1 + \frac{1}{w_i}\left[\beta_i + \frac{2\lambda_i}{b(p)}\left\{ln\left[\frac{X}{a(p)}\right]\right\}\right]$$

[27] A number studies in both developed and developing countries have supported the use of the QUAIDS model to estimate household price and income response. Examples are Abdulai (2002), Banks *et al.* (1997) and Blundell & Robin (1999), Fisher *et al.* (2001), Bopape's (2006), Abdulai & Aubert (2004) and Meenkashi & Ray (1999).

$$e_{ij} = -\delta_{ij} + \frac{1}{w_i}\left(\gamma_{ij} - \left[\beta_i + \frac{2\lambda_i}{b(p)} ln\left\{\frac{X}{a(p)}\right\}\right] \times \left(\alpha_j + \sum_l \gamma_{jl} lnp_j\right) - \frac{\beta_j \lambda_i}{b(p)}\left[ln\left\{\frac{X}{a(p)}\right\}\right]^2\right)$$

where δ_{ij} is the Kronecker delta taking the value $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$. The compensated elasticities are then calculated by using the Slutsky equation, $e_{ij}^c = e_{ij}^u + e_i w_j$. The section below discusses the datasets, provides some descriptive statistics of the data and also shows how the variables needed to estimate equations (9) and (10) were constructed.

3.4 Data Sources and Description

As noted in chapter 1, the data sources for this chapter are the Ghana Living Standard Survey (GLSS) 3, 4 and 6. These surveys are appropriate for this analysis because they contain household's consumption data and provide all the information we need to estimate the model presented in the methodology section to measure the welfare impact of observed price changes in Ghana between 1991 and 2013. For each survey, household expenditure information was collected through personal household interviews. These interviews were done over a number of visits to the household with a specified day interval (recall period), and thus lasted for a period that depends on the number of visits and the recall period (See Table A3.1 in appendix B for number of visits and recall period for each survey).

For each household, expenditures captured during each visit are summed over the number of visits to obtain the total household expenditure over the survey period. Thus, due to the difference in the number of visits and the recall period for the surveys, the reference period for the captured expenditure differs between the surveys.[28] However, for the welfare analysis of observed price changes there is the need to match the timing of expenditure for all surveys as all expenditure should be expressed in one consistent reference period.

While the GLSS 3 and 4 datasets already contain expenditure data expressed on an annual basis using a methodology that is based on the number of visits to the household and the expenditure recall period (See Coulombe and McKay, 2008 for more details), GLSS 6 does not have such annual figures for the commodities considered in this chapter. As a result, there is the need to express household expenditure in GLSS 6 on an annual basis. For consistency, we therefore employed the same method used in the case of GLSS 3 and 4 where the amounts recorded for each visit were summed across the interview period (i.e., number of visits multiplied by the recall period), and then multiplied up by a scalar which is obtained by dividing 365 days by the days the household was interviewed. This was done for each food expenditure item considered in this chapter.

If each item captured in the GLSS were considered as a separate element in the demand systems presented in section 3.3.2, our model would become too complex and almost impossible to estimate (Magrini et al, 2015; Ecker and Qaim, 2011). Therefore, it is important we aggregate the items into commodity groups. Even though choosing higher-level aggregation implies lower quality, but more tractability, the complexity of the estimation justifies creating nine commodity groups. We essentially maintain four of the groups in chapter 2 (i.e. bread & cereals; roots, tubers & plantain; pulses, nut & seeds; and oil & fat products) and further disaggregate the "other food" group into five groups (i.e. vegetables &

[28] For example, in the case GLSS 4 where households were visited six times (first visit is excluded) within a five-day interval, the reference period for food expenditure is 30 days or one month.

fruits; meat; fish; non-alcoholic drinks and other food). These five groups in addition to the four groups maintained from Chapter 2 represent all the food consumption basket of households captured in the GLSS. Table 3.1 presents the individual items of each group.

Table 3.1: Commodity Groupings

Commodity Group	Individual items
Bread & Cereals	Maize, Rice (local and imported), Maize Flour, Bread, Millet and Guinea Corn/Sorghum
Roots, Tubers & Plantain	Cassava, Cocoyam, Yam, Plantain, Gari and Cassava Dough
Pulse, Nuts & Seeds	Beans, Palm Nuts and Ground Nuts
Vegetables & Fruits	Tomatoes, Onion, Okro, Garden Eggs, Pepper, Avocado Pear, Banana, Orange and Pineapple
Meat	Chicken, Beef, Pork, Goat and Mutton
Fish	Dried Fish, Smoke Fish and Fresh Fish,
Oil & Fats Products	Groundnut Oil, Palm Kennel Oil, Palm Oil and Margarine
Non-Alcoholic Drinks	Coffee, Chocolate Drinks and Tea
Other Food Expenditure	All other food expenditure captured in the GLSS but not included in the above groups

Source: Author's compilation from the GLSS

As in Chapter 2, the demand model presented in section 3.3.2 is estimated at the household level and requires three sets of variables for each household: budget shares of the commodity groups, total food expenditure and the price indices of the commodity groups. These were obtained using the same procedure as in Chapter 2 (and again missing expenditure data were replaced with zero).

The average national budget shares of the commodity groups are shown in Table 3.2 while the average budget share by locality and ecological zone are shown in Tables A3.4, A3.4b and A3.4c (in appendix B) for 1991/92, 1998/99 and 2012/13 respectively. On average, food expenditure accounts for over 60% of household expenditure in 1991/92 and 1998/99, but accounted for less in 2012/13 (55%).

Even though households in both rural and urban areas spent a high proportion of their expenditure on food, the proportion spent on food in the rural areas is higher than in the urban areas. In all three ecological zones, food expenditure constitutes a high proportion of total expenditure in all periods, highest in the Savannah zone.

Table 3.2: Average budget shares

Expenditure	**1991/92**	**1998/99**	**2012/13**
Food Expenditure Share	0.60	0.61	0.55
Budget share			
Bread & Cereals	0.13	0.14	0.18
Root, Tubers & Plantain	0.25	0.20	0.19
Pulses, Nut & Seeds	0.04	0.03	0.04
Vegetables & Fruits	0.09	0.02	0.15
Meat	0.05	0.01	0.07
Fish	0.16	0.10	0.15
Oil & Fat Products	0.02	0.02	0.02
Non-Alcoholic Drinks	0.01	0.01	0.02
Other Food Expenditure	0.25	0.46	0.19
Sample size	4,523	5,998	16,772

Source: Authors' calculation

Notes: For each household, the budget share for an expenditure group is obtained by dividing the household expenditure on that commodity group by the household total food expenditure. GLSS 4 does not have purchase expenditure on vegetables & fruits and meat; it has only own-consumption.

Roots, tubers & plantain accounted for a larger proportion of household total food expenditure in 1991/92 and 1998/99 but falls in 2012/13 (same as in Chapter 2). Bread & cereals group accounted for the second largest share of food expenditure in all periods except in 1991/92 where fish accounted for the second largest share of food expenditure. Average budget share for the commodity groups varies considerably among region, locality and ecological zone. Bread & cereals accounted for a larger proportion of household food expenditure in the three northern regions (Northern, Upper East and Upper West regions) in all periods, while roots, tubers & plantain also accounted for a larger proportion of food expenditure in the Western, Central, Volta, Eastern, Ashanti and Brong

Ahafo regions (see Tables A3.3a, A3.3b and A3.3c in appendix B for average regional budget shares).

In 2012/13 the average budget share on vegetable & fruits was higher in the Greater Accra Region compared to all regions (see Table A3.3a in appendix B) while the least consumed commodity group in all regions in all periods is non-alcoholic drinks. In 1991/92 and 1998/99 the average budget share on root, tubers & plantain was the highest both in rural and urban areas (see Tables A3.3a and A3.4b in appendix B). This pattern, however, changes in 2012/13. In the savannah zone, households spent more on bread & cereal in all periods while more was spent on roots, tubers & plantain in the forest zone in all periods (see Tables A3.4a, A3.4b and A3.4c in appendix B). Tables 3.3 and 3.4 report expenditure shares by deciles of per capita household expenditure. In 1991/92 and 2012/13 the poor spent more on bread & cereals, roots, tubers & plantain and pulses, nut & seeds whilst the rich spent more non-alcoholic drinks, vegetables & fruits, meat, fish and oil & fat products.

Table 3.3: Expenditure shares by decile of per capita consumption in 1991/92 and 1998/99

Commodity group	1	2	3	4	5	6	7	8	9	10
					1991/92 (N= 4,523)					
Bread & Cereals	0.181	0.148	0.140	0.143	0.124	0.134	0.135	0.136	0.134	0.131
Root, Tubers & Plantain	0.203	0.259	0.268	0.277	0.261	0.252	0.240	0.227	0.210	0.175
Pulses, Nut & Seeds	0.058	0.055	0.047	0.054	0.045	0.040	0.040	0.040	0.036	0.030
Vegetables & Fruits	0.090	0.104	0.102	0.097	0.102	0.103	0.100	0.099	0.101	0.092
Meat	0.030	0.029	0.034	0.032	0.039	0.041	0.053	0.053	0.059	0.071
Fish	0.147	0.190	0.188	0.183	0.178	0.172	0.171	0.164	0.148	0.132
Oil & Fat Products	0.008	0.018	0.021	0.020	0.026	0.023	0.026	0.025	0.025	0.027
Non-Alcoholic Drinks	0.003	0.001	0.002	0.002	0.006	0.007	0.009	0.011	0.012	0.021
Other Food Expenditure	0.280	0.196	0.199	0.192	0.220	0.228	0.227	0.245	0.275	0.321
Food Expenditure	0.650	0.632	0.638	0.643	0.610	0.607	0.596	0.600	0.594	0.523
					1998/99 (N=5,998)					
Bread & Cereals	0.221	0.168	0.150	0.142	0.144	0.135	0.129	0.127	0.124	0.120
Root, Tubers & Plantain	0.116	0.186	0.231	0.238	0.230	0.243	0.228	0.213	0.201	0.163
Pulses, Nut & Seeds	0.057	0.044	0.033	0.035	0.032	0.030	0.029	0.027	0.029	0.026
Vegetables & Fruits	0.028	0.022	0.021	0.023	0.021	0.020	0.022	0.020	0.022	0.026
Meat	0.009	0.012	0.010	0.009	0.008	0.010	0.011	0.013	0.015	0.020
Fish	0.056	0.061	0.070	0.068	0.074	0.076	0.074	0.075	0.074	0.072
Oil & Fat Products	0.012	0.017	0.022	0.022	0.024	0.023	0.022	0.024	0.022	0.020
Non-Alcoholic Drinks	0.008	0.007	0.007	0.007	0.007	0.010	0.010	0.011	0.015	0.016
Other Food Expenditure	0.493	0.483	0.456	0.456	0.461	0.453	0.474	0.489	0.497	0.537
Food Expenditure	0.631	0.640	0.632	0.632	0.614	0.610	0.606	0.592	0.581	0.568

Source: Author's calculation from GLSS 3 and 4

Table 3.4: Expenditure shares by decile of per capita consumption in 2012/13 (N=16,772)

Commodity group	1	2	3	4	5	6	7	8	9	10
Bread & Cereals	0.295	0.231	0.207	0.183	0.178	0.169	0.158	0.149	0.141	0.125
Root, Tubers & Plantain	0.150	0.198	0.207	0.210	0.207	0.210	0.195	0.182	0.165	0.139
Pulses, Nut & Seeds	0.066	0.056	0.049	0.043	0.043	0.036	0.034	0.029	0.026	0.023
Vegetables & Fruits	0.143	0.144	0.143	0.145	0.143	0.145	0.147	0.155	0.153	0.155
Meat	0.038	0.059	0.059	0.068	0.072	0.077	0.086	0.081	0.093	0.103
Fish	0.122	0.137	0.150	0.156	0.154	0.158	0.158	0.161	0.152	0.147
Oil and Fat Products	0.012	0.016	0.020	0.020	0.019	0.022	0.020	0.019	0.019	0.017
Non-Alcoholic Drinks	0.007	0.009	0.009	0.013	0.015	0.016	0.020	0.022	0.027	0.030
Other Food Expenditure	0.168	0.150	0.156	0.163	0.169	0.167	0.182	0.200	0.225	0.261
Food Expenditure	0.602	0.586	0.574	0.566	0.558	0.550	0.541	0.533	0.524	0.513

Source: Author's calculation from GLSS 6

The commodity group price indices were obtained using the same procedure as in Chapter 2 where a Stone price index is constructed for each commodity group. Table 3.5 reports the mean of the real stone price indices for all surveys. As shown, meat emerges as the most expensive commodity group in 2012/2013 followed by non-alcoholic drinks and fish. However, in 1991/92 and 1998/99 the most expensive commodity group was non-alcoholic drinks. This was followed by pulses, nut & seeds in 1998/99 and oil & fat products in 1991/92. The least expensive commodity groups in 1991/1992 and 1998/99 was root, tuber & plantain while the least expensive commodity group in 2012/13 was vegetables & fruits.

Table 3.5: Real Stone Price index

Commodity Group	1991/92	1998/99	2012/13
Bread & Cereals	0.1134	0.3123	3.0293
Root, Tubers & Plantain	0.0905	0.1170	2.6683
Pulses, Nut & Seeds	0.2269	1.0438	2.5018
Vegetables & Fruits	0.4348	0.5710	1.0683
Meat	0.4745	0.6441	8.4359
Fish	0.2658	0.6303	4.2559
Oil & Fat Products	0.6197	0.1994	2.7771
Non-Alcoholic Drinks	0.8386	1.2592	5.3667
No. of clusters	365	300	1,200

Source: Author's calculation

Note: January 1999 Accra price was used as the based to normalize prices for GLSS 3 and 4 while 2006 price was used to normalize prices for GLSS 6. All figures are in Ghana cedis.

3.5 Empirical Strategy and Estimation Technique

Four empirical issues are addressed in this chapter: setting the value of α_0 in the QUAIDS model specification; capturing the effect of household and demographic variables in the QUAIDS model; dealing with zero household expenditure; and accounting for endogeneity of total food expenditure. All are dealt with in the same way as in Chapter 2: (i) α_0 is set slightly below the minimum values of total expenditure; (ii) household and demographic variables are captured using the scaling technique of Poi (2002) and Ray (1983); (iii) zero consumption is corrected for using Shonkwiler and Yen (1999) with the multivariate probit (see Tables A3.6a, A3.6b and A3.6c in appendix B for the multivariate probit estimation results); and (iv) endogeneity of food expenditure is accounted for using the augmented approach of Blundell & Robin (1999) where the same instruments employed in Chapter 2 are used (see Table A3.5 in appendix B for results of exogeneity and over-identifying restrictions test for the nine commodity group system).

Household characteristic and demographic variables included are the same as the ones included in Chapter 2 (See Table A2.4 in appendix A for the summary statistics of these variables). We capture seasonal effects by introducing quarter dummies to reflect when the household was interviewed. The sample is fairly evenly divided between the four quarters of the year. Table 3.6 report the incidence of zero household expenditure for all commodity groups. For bread & cereal, root, tubers & plantain, pulses nut & seeds and oil & fat products, the proportions are as in Chapter 2. For the extra four groups added, zero consumption is particularly high for the non-alcoholic drink and meat in all periods, but very small for the vegetables and fruits in 1991/92 and 1998/99. Again, compare to GLSS 3 and 4, GLSS 6, has a higher incidence of zero expenditure, yet it has the least missing expenditure data.

Table 3.6: Incidence of zero expenditure (%)

Commodity Group	1991/92	1998/99	2012/13
Bread & Cereals	7.55	1.95	5.57
Root, Tubers & Plantain	5.91	6.67	12.34
Pulses Nut & Seeds	20.24	16.49	32.61
Vegetables & Fruits	2.49	24.02	1.81
Meat	38.84	75.69	30.28
Fish	6.92	11.84	8.94
Oil & Fat Products	34.21	26.31	36.19
Non-Alcoholic Drinks	60.56	42.21	48.86
Other Food Expenditure	0.00	0.00	0.00
Sample size	4,523	5,998	16,772

Source: Author's calculation from GLSS 3, 4 and 6.

As in Chapter 2, the final empirical version of the QUAIDS model estimated after addressing all the empirical issues is:

$$w_i^* = \alpha_i \Phi(z_i'\partial_i) + \sum_{j=1}^{k} \gamma_{ij}\Phi(z_i'\partial_i) lnp_j + (\beta_i + \eta_i' z)\Phi(z_i'\partial_i) ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\}$$

$$+ \frac{\lambda_i}{b(p)c(p,z)}\Phi(z_i'\partial_i)\left[ln\left\{\frac{X}{\overline{m}_0(z)a(p)}\right\}\right]^2 + \delta_i \varphi(z_i'\partial_i)$$

$$+ \pi_1 \acute{V}_1 + \varepsilon_i \qquad (11)$$

Again, the iterated feasible generalized non-linear least square procedure of Poi (2002) was employed to estimate equation 11. One of the k demand equations was omitted from the system (the obvious choice was the equation for residual group) and its parameters were recovered from the estimates of the $k-1$ equations to satisfy the adding-up restriction. The price of the "other food expenditure" item[29] was treated as a numeraire and we set its price to unity.

Given the estimated parameters of the QUAIDS model, again we follow Poi (2002), Tefera et al (2012) and Magrini et al (2015) to calculate the expenditure and price elasticities of demand for each commodity group as follows:

[29] This was done to simplify our analysis. The other expenditure item comprises of a larger number of items which makes it difficult to generate a price index for this expenditure item.

$$\mu_i = \frac{\partial lnq_i}{\partial lnm} = 1 + \frac{1}{w_i}\left[\beta_i + \eta_i' z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p)}\right\}\right]\Phi(z_i'\partial_i) \quad (12a)$$

$$e_{ij} = \frac{\partial lnq_i}{\partial lnp_j} = \frac{1}{w_i}\Bigg(\gamma_{ij} - \left[\beta_i + \eta_i' z + \frac{2\lambda_i}{b(p)c(p,z)} ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p)}\right\}\right] \times \left(\alpha_j + \sum_k \gamma_{jk} lnp_k\right) - \frac{(\beta_j + \eta_i' z)\lambda_i}{b(p)c(p,z)}\left[ln\left\{\frac{X}{\overline{m}_0(z)\alpha(p}\right\}\right]^2\Bigg)\Phi(z_i'\partial_i) + \varphi_i\tau_{ij}\left(1 - \frac{\delta_i}{w_i}\right) - \delta_{ij} \quad (12b)$$

where δ_{ij} is the Kronecker delta which takes the value $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$. The compensated elasticities are calculated by using the slutsky equation:

$$e_{ij}^c = e_{ij} + \mu_i w_j \quad (12c)$$

Again, the elasticities for the residual category, "other food expenditure", are calculated using the adding-up restrictions proposed by Zheng and Henneberry (2009) as:

$$\sum_{i=1}^{k} w_i\mu_i = 1, \quad \sum_{i=1}^{k} w_i e_{ij} = -w_j, \quad \sum_{j=1}^{k} e_{ij} + \mu_i = 0$$

3.5.1 Separability of food and non-food expenditure

Like other studies on welfare analysis of price increases, we assume that utility is separable between food and non-food consumption, and only focus on food consumption items. Hence we use the total household food expenditure in the QUAIDS model and not the total household expenditure. There are two main reasons for this assumption. First, food and non-food consumption items in the GLSS are captured at different time horizons (respondents are asked to recall expenditure on non-food items over a long period, i.e. one year, and often relate to the year prior to the survey year) combined with the fact that many non-food items are purchased only very irregularly. Second, and more fundamentally, we do not have information on the prices of non-food items; we only have information on their expenditure values. This implies that we cannot construct price indices for non-food items.

The assumption of separability is a strong one and combined with the fact that it is based on the lack of the necessary data to estimate a demand system covering all expenditure items; if it is invalid our welfare estimates will be biased. However, in the context of the GLSS, we have reason to believe that the cost of imposing separability is likely to be small: food consumption on average has been around 60% of total expenditure (except in 2012/13 where it dropped to 55%) while 30–35% of total expenditure is on general household expenses such as rent, utilities, education, frequently purchase non-food items and less frequently purchase non-food items. There may be the possibility of some substitution between food and non-food items, but with food such a major part of household budgets, this is likely to be relatively small.

3.6 Results

In this section we present the results of the empirical exercises. We start with the discussion of the results of the reduced-form equation of total food expenditure (log) on prices, demographic characteristics and the instruments. The reduced-form equation estimates for all surveys are reported in Table 3.7. As seen from the table, even with the inclusion of the four extra commodity groups, the instruments perform well as they have a significant correlation with total food expenditure. Household income and cluster average income (less the index household's income) have a significant positive effect on total food expenditure while land ownership status has a significant negative effect on total food expenditure. The partial R square is high and partial F statistics are all significant at the 1% level. Again, in all surveys, household size is a significant determinant of household total food expenditure while locality is a significant determinant of total food expenditure in 1991/92 and 1998/99 but not in 2012/13.

The exogeneity and over-identifying restrictions tests are presented in Table A3.5 in appendix B. In 1991/92 exogeneity of total food expenditure is rejected for bread & cereals, root, tubers & plantain, pulses, nuts & seeds, fish and non-alcoholic drinks, while in the 1998/99 survey exogeneity of total food expenditure is rejected for bread & cereal, root, tubers & plantain, vegetables & fruits, fish and other food expenditure. However, in 2012/13 exogeneity of total food expenditure was rejected for all share equations except oil & fat products. The above results suggest that total food expenditure is endogenous in most of the share equations and therefore controlling for endogeneity of total expenditure is required.

For share equations in which exogeneity of food expenditure is accepted (examples are meat, vegetable & fruits and oil & fat products in 1991/92; in Table A3.5 in appendix B), results are not affected as long as the instruments used are strong and valid instruments in their share equation. As seen in Table A3.5 (in appendix B), in all periods the instruments are valid in all share equations except in 2012/13 where the instruments are not valid for meat share equation (i.e. valid in eight out of the nine share equations)[30]. Having estimated the reduced-form

[30] Although the instruments are not valid in the share equation for meat for the 2012/13 survey period, we are willing to tolerate the bias associated with this for lack of instruments that are valid in all nine share equations at the same time. Moreover, we finally settled on these instruments after experimenting with a number of variables in the GLSS and these instruments are the only variables that were valid instruments in eight out of the nine share equations. All other variables we experimented with were valid in less than five of the nine share equations.

equation for each period, the residuals from a period's equation were predicted and added as explanatory variables in the demand system for that period to correct for endogeneity of total food expenditure.

Table 3.7: First Stage equation for Food Expenditure (Dependent Variable: Food Expenditure)

Variable	1991/92[(a)]	1998/99[(a)]	2012/13[(b)]
Price of:			
Bread & Cereal	0.208***	-0.043**	0.033**
	(0.037)	(0.014)	(0.011)
Roots, Tuber & Plantain	0.063*	0.116***	-0.007
	(0.025)	(0.017)	(0.015)
Pulses, Nut & Seeds	-0.046	-0.054***	0.036*
	(0.040)	(0.012)	(0.014)
Vegetables & Fruits	-0.031	0.001	0.009
	(0.028)	(0.009)	(0.016)
Meat	-0.023	0.160***	0.124***
	(0.022)	(0.026)	(0.017)
Fish	0.018	-0.058***	0.073***
	(0.033)	(0.016)	(0.012)
Oil & Fat Products	-0.093**	0.104**	0.009
	(0.031)	(0.033)	(0.011)
Non-alcoholic Drinks	-0.033	0.005	0.057***
	(0.027)	(0.012)	(0.014)
Other Food expenditure	0.029	-0.728***	0.884***
	(0.029)	(0.203)	(0.149)
Locality			
Rural	-0.082*	-0.098***	0.025
	(0.032)	(0.022)	(0.013)
Sex of HH head			
Female	-0.007	-0.045**	0.065***
	(0.018)	(0.015)	(0.013)
HH size	0.346***	0.335***	0.517***
	(0.012)	(0.011)	(0.009)
Age of HH head	0.071**	0.009	0.128***
	(0.024)	(0.021)	(0.017)
Instruments			
HH income	0.161***	0.179***	0.166***
	(0.008)	(0.006)	(0.004)
AHH income	0.077***	0.193***	-
	(0.016)	(0.013)	-
Land ownership			
No	-	-	-0.192***
	-	-	(0.013)
R-square	0.36	0.46	0.45
Partial R-square	0.12	0.19	0.22
Partial F statistics	207.78	446.04	691.29
Partial F (p-val)	0.000	0.000	0.000
Sample size	4,523	5,998	16,772

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). Robust standard errors in parentheses.
AHH income represents the average cluster income excluding index household's income while the land ownership status of the household is captured as either Yes or No.
(a)Instrumented: Total food expenditure; Instruments: Total income and average cluster income minus the index household's income
(b)Instrumented: Total food expenditure; Instruments: Total income and land ownership status of the household.

We now provide a brief discussion of the results of the multivariate probit model. As done in chapter 2, we do not include the "other food" group in the multivariate probit model since it does not have zero consumption. This implies that the multivariate probit model estimated comprised of eight equations instead of nine. With seven household characteristic and demographic variables, nine commodity price indices and food expenditure as explanatory variables, each probit equation consist of 17 coefficients (excluding the constant term) and a total of 136 coefficients in the system.

Tables A3.6a, A3.6b and 3.6c in appendix B present selected parameter estimates of the multivariate probit model for 1991/92, 1998/99 and 2012/13 respectively. It is important to note that these estimates are not marginal effects, but they give the direction of what the marginal effects will be. As expected, changes in total food expenditure have a significant positive impact on the household's decision to consume each food group in all periods (see the first row of Tables A3.6a, A3.6b and 3.6c in appendix B). There are also significant own-price and cross price effects in all periods. For instance, in 1991/992 and 1998/99, for commodity groups such as bread & cereals, root, tuber & plantain and vegetables & fruits, changes in own-price had significant negative effects on the household's decision to consume these commodity groups while in 2012/13 changes in own-price of meat and fish also had significant negative effects on the household's decision to consume meat and fish. Furthermore, in 1991/92 and 2012/13, a change in the price of root, tubers & plantain impacted negatively on the household's decision to consume bread & cereals.

We turn to the discussion of the estimates of the QUAIDS model for each period. The information in Tables 3.8, 3.9 and 3.10 relate to selected parameter estimates of the QUAIDS model with the imposition of the conventional homogeneity and symmetry restrictions. For all surveys, the budget share for most commodity groups is responsive to price (both own and cross price) and expenditure changes, and to most of the demographic and location dummies. In total, 45 price effects (price responses), 9 total food expenditure effects and 9 total food expenditure square effects are estimated for each period. Out of the 45 price effects, 24 (53%) were significant at 1%, 5% or 10% in 1991/92 (see Table 3.8) while 35 (78%) were significant at 1%, 5% or 10% in 1998/99 (see Table 3.9) and 31 (67%) were significant at 1%, 5% or 10% in 2012/13 (see Table 3.10). For each period, the budget share of the majority of the commodity groups is responsive to changes in total food expenditure. For instance, out of the 9 total food expenditure effects, 7 were significant at 1%, 5% or 10% in 1991/92 and 1998/99 (see column 11 of Table 3.8 and 3.9) while all 9 were significant at 1%, 5% or 10% in 2012/13 (see column 11 of Table 3.10).

The justification of the use of the QUAIDS model instead of AIDS model is clearly evident in column 12 of Tables 3.8, 3.9 and 3.10. The coefficient of the quadratic term (i.e. λ) which was the coefficient of interest in chapter 2, was significant for all 9 commodity groups at 1% in 1991/92; 7 commodity groups at 1% or 10% in 1998/99; and 6 commodity groups at 1% in 2012/13. Although we do not report the estimates relating to the household characteristics and demographic variables, the coefficient of household size is significant for most commodity groups in all periods.

Table 3.8: Parameter estimates for the QUAIDS model (1991/92)

	(Log) Price of:											
Commodity	**Bread & Cereal**	**Root & Tubers**	**Pulse, Nuts & Seeds**	**Veg & Fruits**	**Meat**	**Fish**	**Oil & Fat**	**Non-alcoholic**	**Other Food**	**(β)**	**(λ)**	**Resid**
Bread & Cereals	-0.0176*									0.0691***	0.0078***	-0.0011***
	(0.0077)									(0.0115)	(0.0012)	(0.0011)
Roots &Tubers	0.0315***	-0.0529***								-0.0137	-0.0120***	0.0048***
	(0.0049)	(0.0062)								(0.0143)	(0.0010)	(0.0011)
Pulses & Seeds	-0.0233***	0.0204***	-0.0057*							0.0320***	0.0031***	-0.0012*
	(0.0027)	(0.0022)	(0.0026)							(0.0048)	(0.0006)	(0.0006)
Veg & Fruits	-0.0010	-0.0037	-0.0046*	-0.0029						-0.0014	-0.0021***	-0.0004
	(0.0028)	(0.0022)	(0.0018)	(0.0027)						(0.0058)	(0.0005)	(0.0004)
Meat	-0.0045	-0.0033	-0.0088***	0.0016	0.0029					0.0585***	-0.0032***	0.0059***
	(0.0031)	(0.0023)	(0.0018)	(0.0016)	(0.0024)					(0.0065)	(0.0005)	(0.0006)
Fish	0.0325***	-0.0288***	0.0051	-0.0040	-0.0062**	-0.0071				-0.0764***	-0.0090***	-0.0007***
	(0.0047)	(0.0037)	(0.0028)	(0.0022)	(0.0023)	(0.0046)				(0.0109)	(0.0009)	(0.0008)
Oil & Fat	-0.0030	-0.0024	0.0011	-0.0004	0.0036***	-0.0024	-0.0015			0.0052*	-0.0012***	0.0016
	(0.0017)	(0.0014)	(0.0014)	(0.0012)	(0.0010)	(0.0016)	(0.0014)			(0.0026)	(0.0002)	(0.0002)
Non-Alcoholic	0.0035**	0.0005	0.0015	-0.0007	0.0031***	-0.0002	-0.0013	-0.0025**		0.0109***	0.0006***	0.0005**
	(0.0012)	(0.0007)	(0.0011)	(0.0009)	(0.0006)	(0.0010)	(0.0009)	(0.0009)		(0.0027)	(0.0001)	(0.0002)
Other food exp	-0.0182***	0.0387***	0.0143***	0.0157***	0.0116***	0.0110**	0.0062***	-0.0038***	-0.0756***	-0.0842***	0.0160***	-0.0093***
	(0.0039)	(0.0043)	(0.0018)	(0.0024)	(0.0022)	(0.0040)	(0.0011)	(0.0011)	(0.0073)	(0.0189)	(0.0013)	(0.0014)
Sample size	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523	4,523

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). Standard errors are in parentheses.
Included as explanatory variables, but not shown are household characteristics and demographic variables.
β and λ are the coefficients of food expenditure and its square respectively while resid is the coefficient of the residual from the reduced form regression for total food expenditure and hhsize is the household size. Veg & fruits, Vegetables and fruits; other food exp, other food expenditure.

Table 3.9: Parameter estimates for the QUAIDS model (1998/99)

	(Log) Price of:											
Commodity	Bread & Cereal	Root & Tubers	Pulse, Nuts & Seeds	Veg & Fruits	Meat	Fish	Oil & Fat	Non-alcoholic	Other Food	(β)	(λ)	Resid
Bread & Cereals	-0.0485***									-0.0631***	0.0042	0.0035***
	(0.0050)									(0.0133)	(0.0028)	(0.0007)
Roots &Tubers	0.0899***	-0.3558***								0.2909***	-0.0574***	-0.0044***
	(0.0122)	(0.0245)								(0.0114)	(0.0112)	(0.0009)
Pulses & Seeds	-0.0157***	0.0649***	-0.0168***							-0.0690***	0.0112***	0.0021***
	(0.0023)	(0.0091)	(0.0033)							(0.0096)	(0.0027)	(0.0003)
Veg & Fruits	-0.0042**	0.0108	-0.0020	-0.0030***						-0.0107	0.0035*	-0.0013***
	(0.0015)	(0.0074)	(0.0014)	(0.0005)						(0.0085)	(0.0017)	(0.0002)
Meat	-0.0043**	0.0286***	-0.0058***	-0.0021*	-0.0065**					-0.0377***	0.0091***	0.0010*
	(0.0015)	(0.0054)	(0.0013)	(0.0009)	(0.0025)					(0.0059)	(0.0018)	(0.0004)
Fish	0.0135***	-0.0261*	0.0067*	0.0036***	0.0039*	-0.0021				0.0315	-0.0041	-0.0022***
	(0.0027)	(0.0132)	(0.0027)	(0.0010)	(0.0018)	(0.0029)				(0.0172)	(0.0044)	(0.0005)
Oil & Fat	0.0068***	-0.0346***	0.0075***	0.0004	0.0080***	-0.0020	-0.0062***			0.0315***	-0.0066***	-0.0001
	(0.0013)	(0.0045)	(0.0013)	(0.0007)	(0.0014)	(0.0014)	(0.0014)			(0.0046)	(0.0016)	(0.0004)
Non-Alcoholic	-0.0016*	0.0099***	-0.0012*	-0.0010***	0.0012	0.0001	0.0017***	-0.0006		-0.0082**	0.0026***	0.0003
	(0.0006)	(0.0025)	(0.0006)	(0.0003)	(0.0007)	(0.0006)	(0.0005)	(0.0004)		(0.0028)	(0.0007)	(0.0001)
Other food exp	-0.0359***	0.2123***	-0.0375***	-0.0025	-0.0230***	0.0025	0.0185***	-0.0084***	-0.1260***	-0.1652***	0.0375***	0.0010***
	(0.0080)	(0.0178)	(0.0061)	(0.0050)	(0.0039)	(0.0102)	(0.0034)	(0.0018)	(0.0189)	(0.0168)	(0.0106)	(0.0006)
Sample size	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998	5,998

Notes:

(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). Standard errors are in parentheses.

Included as explanatory variables, but not shown are household characteristics and demographic variables.

β and λ are the coefficients of food expenditure and its square respectively, while resid is the coefficient of the residual from the reduced-form regression for total food expenditure and hhsize is the household size. Veg & fruits, Vegetables and fruits; other food exp, other food expenditure.

Table 3.10: Parameter estimates for the QUAIDS model (2012/13)

	(Log) Price of:											
Commodity	**Bread & Cereal**	**Root & Tubers**	**Pulse, Nuts & Seeds**	**Veg & Fruits**	**Meat**	**Fish**	**Oil & Fat**	**Non-alcoholic**	**Other Food**	**(β)**	**(λ)**	**Resid**
Bread & Cereals	-0.0071**									-0.0821***	-0.0123***	0.0067***
	(0.0024)									(0.0075)	(0.0009)	(0.0010)
Roots &Tubers	0.0178***	-0.0457***								0.0838***	0.0166***	-0.0124***
	(0.0021)	(0.0036)								(0.0094)	(0.0012)	(0.0015)
Pulses & Seeds	0.0047***	0.0133***	0.0086***							-0.0163***	-0.0027***	0.0042***
	(0.0008)	(0.0012)	(0.0011)							(0.0029)	(0.0005)	(0.0006)
Veg & Fruits	-0.0041**	0.0014	-0.0090***	-0.0053*						-0.0331***	0.0008	0.0009***
	(0.0013)	(0.0016)	(0.0010)	(0.0022)						(0.0059)	(0.0007)	(0.0008)
Meat	0.0052***	-0.0106***	0.0057***	0.0048***	-0.0133***					0.0657***	0.0029***	-0.0005
	(0.0014)	(0.0016)	(0.0009)	(0.0013)	(0.0019)					(0.0045)	(0.0006)	(0.0008)
Fish	-0.0018	-0.0012	-0.0100***	0.0104***	0.0009	-0.0019				0.0499***	-0.0055***	-0.0039***
	(0.0014)	(0.0017)	(0.0009)	(0.0013)	(0.0012)	(0.0019)				(0.0039)	(0.0007)	(0.0007)
Oil & Fat	0.0028***	-0.0022***	0.0011**	0.0036***	-0.0034***	0.0017**	-0.0013			0.0089***	-0.0001	-0.0007**
	(0.0004)	(0.0006)	(0.0004)	(0.0007)	(0.0006)	(0.0006)	(0.0023)			(0.0009)	(0.0002)	(0.0003)
Non-Alcoholic	-0.0002	0.0019**	0.0006	-0.0025***	-0.0005	0.0032***	0.0003	-0.0002		0.0042**	0.0007***	-0.0006*
	(0.0005)	(0.0006)	(0.0005)	(0.0006)	(0.0006)	(0.0005)	(0.0004)	(0.0005)		(0.0016)	(0.0002)	(0.0002)
Other food exp	-0.0173***	0.0253***	-0.0150***	0.0007	0.0113***	-0.0013	-0.0027**	-0.0027**	0.0018	-0.0809***	-0.0005	0.0057***
	(0.0022)	(0.0024)	(0.0014)	(0.0020)	(0.0022)	(0.0020)	(0.0010)	(0.0010)	(0.0047)	(0.0084)	(0.0008)	(0.0011)
Sample size	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772	16,772

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). Standard errors are in parentheses.
Included as explanatory variables, but not shown are household characteristics and demographic variables.
β and λ are the coefficients of food expenditure and its square respectively, while resid is the coefficient of the residual from the reduced-form regression for total food expenditure and hhsize is the household size. Veg & fruits, Vegetables and fruits; other food exp, other food expenditure.

3.6.1 Expenditure elasticities

As noted earlier, the focus of this chapter is to measure the welfare cost of price changes on households in Ghana. The method adopted requires that we estimate household expenditure elasticities for the commodity groups used in the welfare analysis. As noted in Chapter 2, expenditure elasticities measure how responsive household demand for commodities is to changes in household income. They provide information on which commodities households spend more of their incomes on when they experienced income changes as well as which commodities are necessities and which are luxuries to households. Such information about household consumption patterns is very important for poverty and nutritional programs.

Using the estimated parameters of the QUAIDS model, the expenditure elasticity for each commodity group evaluated at the sample means for each period is obtained through equation 12a. These estimates are reported in Table 3.11. As we expected, in each period, all food groups are normal goods, consumption of which will increase with rising incomes (all expenditure elasticities are positive). For the 1991/92 survey, expenditure elasticity ranges between 0.679 and 1.320; between 0.595 and 1.402 for the 1998/1999 survey; and between 0.717 and 1.372 for 2012/13. Although all expenditure elasticities are positive for all periods, there are significant differences in terms of value for each period. Bread & cereals turn out to be a necessity within food expenditure in all periods; this is not surprising because they are one of the main staple foods consumed by the households in Ghana, particularly the poorest decile households. The estimates are 0.944 for 1991/92 survey, 0.742 for 1998/99 and 0.827 for 2012/13.

Table 3.11: Expenditure Elasticities at sample means

Commodity Groups	1991/92	1998/99	2012/13
Bread & cereals	0.944	0.742	0.827
	(0.018)	(0.028)	(0.016)
Root, tubers & plantain	1.186	1.402	1.372
	(0.012)	(0.023)	(0.020)
Pulses, nut & seeds	1.028	0.595	0.964
	(0.025)	(0.056)	(0.032)
Vegetables & fruits	1.066	1.389	0.899
	(0.012)	(0.059)	(0.017)
Meat	1.320	1.384	1.284
	(0.024)	(0.098)	(0.023)
Fish	1.117	1.191	1.078
	(0.014)	(0.045)	(0.011)
Oil & fat products	1.150	1.123	1.150
	(0.023)	(0.096)	(0.022)
Non-Alcoholic Drinks	0.823	1.165	0.838
	(0.064)	(0.057)	(0.037)
Other food expenditure	0.679	0.867	0.717
	(0.018)	(0.011)	(0.017)
Sample size	4,523	5,998	16,772

Source: Author's calculation from GLSS 3, 4 and 6
Note: Figures in parenthesis are standard errors

In contrast, roots, tubers & plantain appear to be luxury goods within food expenditure in all periods with the highest expenditure elasticity estimate recorded in 1998/99 (1.402). This is surprising if one considers the fact that they are one of the main staple foods. However, if one looks at it from the perspective of the time the household spends in preparing meals often made from items in this group (an example is fufu), this result could be expected.[31] Meals prepared from items in the roots, tuber & plantain group take longer to prepare, and therefore, their consumption is not as affordable as meals from items in the bread & cereal group. Furthermore, as seen in table A3.8, the average own consumption for roots, tubers & plantain is higher than average purchase expenditure for all periods. This suggests that, in Ghana roots, tubers & plantain are most likely

[31] In Ghana, the main meal prepared from items in the root, tubers & plantain groups is fufu which requires longer time to prepare and also not consumed on its own but is consumed with soup. Compared to bread & cereal group, consumption of fufu is not as affordable as meals prepared from items in the bread & cereal group.

home grown foods, so purchases are a 'luxury' addition to own consumption. It is therefore not be surprising if households in Ghana consider roots, tubers & plantain as luxury.

For pulses, nut & seed the expenditure elasticities were 1.028, 0.595 and 0.964 for 1991/92, 1998/99 and 2012/13 respectively. This indicates that pulses, nut & seed was considered a luxury in 1991/92 but a necessity in 1998/99 and 2012/13. Vegetables & fruits were considered a luxury in 1991/92 and 1998/99 with expenditure elasticities of 1.066 and 1.389 respectively, but a necessity in 2012/13 with an expenditure elasticity of 0.899. This suggests a change in consumption patterns of vegetables & fruits across survey periods which may be attributed to increase in the awareness of the nutritional benefits of consuming vegetables & fruits.

The recent survey (i.e. 2012/13 survey) indicates that non-alcoholic drinks are considered a necessity and this is also not surprising, particularly when items in this group are mainly items that are consumed as breakfast in Ghana. Oil & fat products are also considered a luxury within food expenditure in all periods while "other foods" are also considered a necessity within food expenditure in all three periods. Finally, meat and fish groups are considered as luxury goods in all periods, but meat has higher expenditure elasticity than fish in all periods. This result compares well with previous studies in Ghana and studies in other developing countries (see, for example Ackah & Appleton (2007) and Bapope & Myers (2007))

3.6.2 Uncompensated and compensated own and cross-price elasticities

Aside from the expenditure elasticities, we also require the uncompensated and compensated price elasticities to estimate the welfare effects of price changes on households. Just like the expenditure elasticities, knowledge of uncompensated and compensated price elasticities also provides significant insight into the consumption patterns of households; therefore before we proceed to discuss the results of the welfare effects of price changes, we provide a brief discussion of these elasticities. Using equations 12b and 12c, the uncompensated (Marshallian) and compensated (Hicksian) own-price elasticities estimated at the sample means are reported in Table 3.12. The full set of estimates, including the cross-price elasticities is available in Tables A3.7a, A3.7b and A3.7c in appendix B for 1991/92, 1998/99 and 2012/13 respectively.

As expected, all the uncompensated and compensated own-price elasticities of demand are negative (thus conforming to theory) and the compensated own-price elasticities are lower than the uncompensated own-price elasticities (thus also conforming to theory). As a general comment on the own-price elasticities we observe that most of the commodity groups appear to be price elastic within food expenditure. In absolute terms, the uncompensated own-price elasticities for the 1991/92 survey range between 0.960 and 1.267; between 0.883 and 1.283 for the 1998/99 survey; and between 0.776 and 1.253 for the 2012/13 survey. Based on the uncompensated own-price elasticity, bread & cereal and pulses, nut & seeds were price elastic in 1991/92 and 1998/99 but price inelastic in 2012/13 while root, tubers & plantain, vegetable & fruits, oil & fat products and non-alcoholic drinks were all price elastic in all survey periods. Furthermore, meat was price inelastic in 1991/92 but price elastic in 1998/99 and 2012/13, while fish was price elastic in 1991/92 and 2012/13 but price inelastic in 1998/99.

Table 3.12: Own-price Elasticities at the sample means

	1991/92	1998/99	2012/13
Marshallian (uncompensated)			
Bread & Cereals	-1.119	-1.220	-0.983
	(0.055)	(0.019)	(0.011)
Root, tubers & plantain	-1.257	-1.283	-1.253
	(0.027)	(0.023)	(0.019)
Pulses Nut and Seeds	-1.136	-1.178	-0.776
	(0.061)	(0.026)	(0.026)
Vegetables & Fruits	-1.036	-1.125	-1.014
	(0.027)	(0.019)	(0.015)
Meat	-0.960	-1.268	-1.189
	(0.051)	(0.168)	(0.025)
Fish	-1.056	-0.997	-1.005
	(0.029)	(0.021)	(0.012)
Oil and fat products	-1.065	-1.177	-1.071
	(0.058)	(0.059)	(0.130)
Non-Alcoholic Drinks	-1.267	-1.035	-1.003
	(0.095)	(0.036)	(0.030)
Other Foods	-1.192	-0.883	-0.890
	(0.026)	(0.014)	(0.028)
Hicksian (compensated)			
Bread and Cereals	-0.989	-1.115	-0.833
	(0.056)	(0.020)	(0.011)
Root, tuber & Plantain	-0.984	-0.997	-1.021
	(0.026)	(0.023)	(0.019)
Pulses, Nut & Seeds	-1.093	-1.159	-0.737
	(0.061)	(0.026)	(0.026)
Vegetables & Fruits	-0.931	-1.093	-0.882
	(0.027)	(0.019)	(0.015)
Meat	-0.896	-1.250	-1.093
	(0.050)	(0.168)	(0.025)
Fish	-0.874	-0.913	-0.845
	(0.028)	(0.021)	(0.012)
Oil & fat products	-1.039	-1.153	-1.050
	(0.058)	(0.059)	(0.130)
Non-Alcoholic drinks	-1.259	-1.022	-0.988
	(0.095)	(0.036)	(0.030)
Other Foods	-1.024	-0.462	-0.756
	(0.027)	(0.011)	(0.027)
Sample size	4,523	5,998	16,772

Source: Author's calculation

If only substitution effects are considered (compensated own-price elasticities), bread & cereals are price elastic in 1991/92 and 2012/13 but price inelastic in

1998/99, while root, tuber & plantain group are price inelastic in 1991/92 and 1998/99 but price elastic in 2012/13. Furthermore, fish is price inelastic in all periods but meat is price elastic in 1998/99 and 2012/13. As noted in Abdulai (2004), compensated price elasticities provide a more accurate picture of cross-price substitution between commodity groups, since they are a measure of the substitution effects net of income. From Tables A3.7a, A3.7b and A3.7c in appendix B, it is observed that most of the compensated cross-price elasticities are positive, indicating that the relevant commodity groups are substitutes. However, their magnitudes are low, suggesting that substitution possibilities are quite limited. As would be expected, bread & cereal and root, tubers & plantain are substitutes; meat and fish are substitutes; bread & cereal and pulses, nut & seed are complements.

3.6.3 Welfare cost of price changes: Compensating Variation

While the estimated QUAIDS parameters and the implied expenditure and price elasticities discussed above are interesting in their own right, the main focus of this chapter is the estimation of the welfare effects of observed price changes in Ghana between 1991 and 2013. As noted earlier, our measure of the welfare effects is the compensating variation: the amount of income that needs to be given to a household to make the household indifferent between the old price vector and the new price vector. Budget shares, observed price changes and the estimated compensated (Hicksian) price elasticities of the commodity groups in Table 3.1 are used to estimate this compensation variation for each period. Since the interest of policy makers is to formulate policies that maximise consumer welfare, such a monetary measure of welfare effect will enhance policy greatly.

Based on when the GLSS 3, 4 and 6 were collected, the welfare effect of price changes over the period of analysis (between 1991 and 2013) is further disaggregated into three periods: 1991/92 to 1998/99; 1998/99 to 2012/13; between 1991/92 and 2012/13 (the overall period). For each period, two welfare effects are estimated; first-order effect and the full-price effect. Computation for the first-order effect is performed using equation (4) while the computation of the full-price effect is performed using equation (9). As explained earlier, the first-order effect (FOE) approximates the effects of observed price changes without considering the substitution effects of the price changes. Essentially, this is the same as assuming that the cross-price elasticities for the commodities considered in the analysis are all zeros. The full-price effect, however, considers both the first-order effects and substitution effects in household consumption, thereby capturing behavioural responses of households. Although the first-order (FOE) approximation may capture a large part of the effect of price changes on welfare, as noted in Friedman and Levinsohn (2002), ignoring substitution effects (household behavioural responses) in the analysis may lead to significant biases in the analysis.

The observed price changes considered are price changes that occur at the cluster level and we assume that all households in the same cluster face the same prices (law of one price). Due to differences in the number of clusters captured in the three surveys,[32] we have situations where not all clusters in one survey may be found in another survey. However, in order to measure the price changes between two periods, we need to match clusters which are found in both surveys. All

[32] The 1991/92 survey (GLSS 3) had 365 clusters while the 1998/99 (GLSS 4) survey had 300 clusters and the recent survey had 1,200 clusters.

clusters that are not in both paired surveys are automatically dropped from the welfare analysis for the period.[33]

Columns 2, 4 and 6 of Tables 3.13 and 3.14 report the estimated average FOE as a percentage of initial total food expenditure of households for each of the periods. Because price changes might not have uniform impacts across household groups, the welfare estimates are reported by different household groups in order to illustrate which households in Ghana are most vulnerable to price increases. Since the compensation variation (CV) is the income needed to compensate households for them to be as well-off as they were before the price change, a positive CV implies households are worse off by the price change while a negative CV means households are better off by the price change. As seen in Table 3.13, the estimated national first-order welfare effect shows a decline in household welfare in all periods. On average, nationally, 28.56% of 1991/92 household food expenditure is needed to compensate households for the observed price increases between 1991/92 and 1998/99, 137% of 1998/99 household food expenditure is needed to compensate households for the observed price increases between 1998/99 and 2012/2013, and almost twice the value of 1991/92 household food expenditure is needed to compensate households for the observed price increases between 1991/92 and 2012/13.

[33] As a result, the number of households included in the 1991/92-1998/99 period reduced from 4,523 to 3,164 but for the other two periods (1991/92 to 2012/13 and 1998/99 to 2012/13), it happened that all households were included in the analysis.

Table 3.13: Welfare Effect of Price Changes

Household category	1991/92-1998/99 FOE (%)	1991/92-1998/99 FE (%)	1998/99-2012/13 FOE (%)	1998/99-2012/13 FE (%)	1991/92-2012/13 FOE (%)	1991/92-2012/13 FE (%)
National	28.56	17.26	136.73	93.89	199.74	181.65
Locality						
Urban	21.60	5.96	114.24	84.31	172.83	147.67
Rural	31.61	22.22	149.69	99.41	215.28	201.29
Income group						
1st quintile	29.51	26.15	139.92	66.54	211.14	183.33
2nd quintile	33.41	25.00	151.33	101.42	219.21	207.96
3rd quintile	27.23	20.14	145.84	108.52	206.87	193.86
4th quintile	29.69	6.93	136.41	103.08	201.67	188.11
5th quintile	25.67	13.95	121.77	88.22	180.54	157.07
Urban						
1st quintile	21.93	8.68	119.89	76.25	176.98	156.13
2nd quintile	7.87	3.58	129.93	90.27	187.57	164.71
3rd quintile	14.01	4.59	122.07	93.58	178.83	157.27
4th quintile	24.85	2.59	116.40	90.93	180.20	152.82
5th quintile	24.11	8.91	106.94	78.10	165.08	139.18
Rural						
1st quintile	29.77	26.75	143.23	64.94	214.52	186.03
2nd quintile	37.74	29.84	157.36	104.56	226.83	218.38
3rd quintile	30.73	24.26	155.18	114.40	218.57	209.14
4th quintile	32.12	9.12	149.88	111.25	215.80	211.34
5th quintile	27.74	20.62	142.61	102.46	201.64	181.45
Region						
Western	8.68	-13.24	154.89	152.13	195.45	127.79
Central	22.67	15.97	122.65	81.77	195.37	178.88
Greater Accra	19.20	2.11	103.31	82.76	154.79	126.55
Volta	34.69	27.79	157.73	102.83	231.86	133.74
Eastern	35.55	27.45	154.03	129.05	227.86	197.65
Ashanti	29.30	8.24	114.89	45.55	212.82	117.20
Brong Ahafo	50.72	49.87	171.27	150.14	235.17	228.05
Northern	27.13	21.92	156.87	61.83	180.13	84.55
Upper East	42.77	28.57	124.99	57.84	157.92	37.31
Upper West	21.69	18.34	125.33	26.79	154.15	58.91
Sample size	3,164	3,164	5,998	5,998	4,523	4,523

Source: Author's calculation from GLSS 3, 4 and 6

Note: Compensating variation for each period is measured as a proportion of initial total food expenditure. For example, compensating variation for the period 1991/92 to 2012/13 is measured as a proportion of 1991/92 total food expenditure. A positive compensating variation represents a decline in welfare while a negative compensation variation represents an improvement in welfare.

FOE represents first order effect; FE represents full effect.

Table 3.14: Welfare Effects of Price Changes by Poverty Status and Ecological Zone

Household category	1991/92-1998/99 FOE (%)	1991/92-1998/99 FE (%)	1998/99-2012/13 FOE (%)	1998/99-2012/13 FE (%)	1991/92-2012/13 FOE (%)	1991/92-2012/13 FE (%)
Poverty status						
Poor	30.72	24.45	145.67	84.70	213.13	196.62
Non-poor	26.97	11.99	132.46	80.28	191.33	172.25
Urban						
Poor	10.69	4.25	125.92	85.50	179.68	158.95
Non-poor	24.14	7.46	111.94	84.08	171.17	144.89
Rural						
Poor	33.88	28.38	150.18	84.52	220.73	205.18
Non-poor	29.09	15.39	149.35	109.98	209.90	197.47
Ecological Zone						
Coastal	17.95	6.03	121.22	87.71	174.72	161.55
Forest	34.28	18.82	141.04	103.18	226.04	187.83
Savannah	35.74	32.95	153.31	83.33	194.89	120.38
Sample size	3,164	3,164	5,998	5,998	4,523	4,523

Source: Author's calculation from GLSS 3, 4 and 6

Note: Compensating variation for each period is measured as a proportion of initial total food expenditure. For example, compensating variation for the period 1991/92 to 2012/13 is measured as a proportion of 1991/92 total food expenditure. A positive compensating variation represents a decline in welfare while a negative compensation variation represents an improvement in welfare.

FOE represents the first-order effect; FE represents full effect.

Based on the first order effect, rural households suffered more from the observed price changes in each period. Between 1991/92 and 1998/99, the average welfare loss for rural households is 32% of 1991/92 total household food expenditure; between 1998/99 and 2012/2013 it is 150% of 1998/99 total household food expenditure and 215% of 1991/92 household food expenditure between 1991/92 and 2012/13. Furthermore, compared to non-poor households, a higher proportion of poor household total food expenditure is needed to compensate poor households for the observed price changes for all periods of price changes (see Table 3.14). In other words, poor households suffered more from the observed price increases in all periods. This result mirrors the findings of Ackah and Appleton (2007), Leyaro et al (2010), Tefera et al., (2012), Magrini et al., (2015) and Mbegalo and Yu (2016) which find that poorer households suffer more from the observed price increases than non-poor households. However, within poorer households, we find that rural poor households suffered more from price increases than urban poor households in all periods. This is contrary to an earlier study of Ackah and Appleton (2007) on Ghana which estimated the welfare effect of observed price changes in the 1990s focusing on six commodity groups. In this study, the linear-approximate AIDS model was employed to estimate household responds to price and income changes while the compensating variation (CV) method was used to estimate both first and second order effects of price changes. Their conclusion was that the distributional burden of observed price changes in the 1990s fell mainly on the urban poor. Two reasons may account for the difference in findings: (i) the present study employed the Quadratic Almost Ideal Demamd model to estimate household price and income response while Ackah and Appleton (2007) used the linear approximate AIDS model and (ii) the present study disaggregated total food expenditure into nine commodity groups while Ackah and Appleton (2007) diaggregated total food expenditure into six commodity groups.

Although the findings of our study is contrary to Ackah and Appleton (2007), it however supports the finding of Leyaro et al (2010) on Tanzania[34] which analysed the effect of food price changes on household consumption (welfare) in Tanzania during the 1990s and 2000s simulating the welfare effect attributable to tax reforms and concluding that the distributional burden of food price increases fell mainly on the rural poor.

[34] Although, there are significant regional and ecological differences (i.e. regional and ecological heterogeneity) in first-order effects across periods, compared to households in other regions, the Brong Ahafo region suffered more from the observed price changes in all periods, while the Savannah zone suffered more from the observed price increases in both sub-periods periods but not for the overall period between 1991/92 and 2012/13. This is somewhat surprising but may be simply due to clusters being dropped because they could not be paired.

Columns 3, 5 and 7 of Tables 3.13 and 3.14 report the full-price effects (FE) of observed price changes.[35] As expected the full-price effects are lower than the first order effects. This supports the findings of Friedman and Levinsohn (2002), Ackah and Appleton (2007), and Leyaro et al (2010), which find that FOE tends to overestimate the welfare consequences of observed price increases. Although, the full-price effects are lower, the patterns observed are similar to the first-order effects. Nationally, on average 17% of 1991/92 total household food expenditure is needed to compensate households for observed price increases between 1991/92 and 1998/99; 94% of 1998/99 total household food expenditure is needed to compensate households for observed price increases between 1998/99 and 2012/13; and 182% of 1991/92 household food expenditure is needed to compensate households for observed price increases between 1991/92 and 2012/13.

Again, compared to urban households, rural households were more affected by observed food price increases in each period when substitution effects are considered. This supports the argument that urban households have greater substitution possibilities in responding to food price changes. For instance, between 1991/92 and 1998/99, welfare loss of rural households was 16 percentage points more than the welfare loss of urban households, while between 1991/92 and 2012/13, the welfare loss of rural households was 54 percentage points more than the welfare loss of urban households. In addition, welfare losses are higher for rural poor households than urban poor households. By income group (quintiles), we note heterogeneities in full-price effects across periods. For

[35] To measure the full effects of price changes for each period, the compensated (Hicksian) elasticities used are those that pertain to the initial year. For instance, for the period between 1991/92 and 1998/99, 1991/92 estimated compensated elasticities are used. Similarly for the period between 1991/92 and 2012/13, 1991/92 estimated compensated elasticities are used.

all rural quintiles, welfare losses are higher than urban quintiles. Between 1991/92 and 1998/99 households in both urban and rural areas who suffered the least from food price increases are those in the fourth quintile while between 1991/92 and 2012/13 for both rural and urban those in the top quintiles (i.e. Richest) suffered the least from food price increases, but the 'richest' rural quintile (the fifth) fared much worse than the 'richest' urban quintile.

Generally, we observed that the longer the period of analysis, the higher the welfare losses of price changes; the welfare losses are higher between 1991/92 and 2012/13 (22 years) followed by the period 1998/99 to 2012/13 (15 years) and the period 1991/92 to 1998/99 (8 years). In a developing country such as Ghana, where prices are flexible upward but not downward, it is expected that the longer the period of analysis, the bigger the price changes, hence the higher the welfare losses of price changes. Thus, the welfare effect of price increases depends on the extent of the price increases.

It is must be noted that the above welfare effects are relative to the total food expenditure of households and therefore are expected to be higher compared to when they are relative to total household expenditure. The primary motivation behind our study is to show how households in Ghana have been affected by observed food price increases. Hence welfare effects are taken as percentages of the initial total food consumption. Thus, the estimated welfare loss or gain is expected to be much larger than the welfare change when the welfare change is expressed as the percentage of the total expenditure. Moreover, we assumed separability between food and non-food by excluding non-food items from the analysis.

Many studies have done this and our results compare well with such studies. For example, Akbari et al. (2013) estimated food demand system using the QUAIDS model and studied the welfare impacts of food price changes on Iranian households between 2009/10 and 2011/12. They found that for all households, the first order effects as a proportion of 2009/2010 household food expenditure was 51% and the second order effect was 50% of food expenditure. The second order effects dropped to 12% when computed as the proportion of the total household expenditure. Attanasio et al. (2013) also estimated a QUAIDS model of demand for food and analysed the welfare consequences of food price increases in Mexico. They found that the welfare loss (second order effect) as a percentage of the food expenditure ranges from 17% to 23% due to price changes in Mexico between December 2003 and April 2011. The welfare loss was 23% for the poorest consumers in the sample, but around 17% for the least poor households.

3.7 Conclusion

This chapter empirically estimates the price and expenditure elasticities for nine commodity groups in Ghana using the GLSS 3, 4 and 6 data sets and used these elasticities to estimate the welfare cost of observed food price changes in Ghana between 1991 and 2013. The welfare effect was measured using compensating variation and three periods of observed food price changes were considered: between 1991/92 and 1998/99; between 1998/99 and 2012/13; between 1991/92 and 2012/13. For each period two welfare effects were estimated; first-order effect and full-price effects.

The Quadratic Almost Ideal Demand System of Banks et al (1997) was adopted to estimate the price and expenditure elasticities and the two-step approach of Shonkwiler and Yen (1999) was used to account for the presence of zero consumption expenditure. In addition, the scaling technique of Ray (1983) and Poi (2002) which accounts for the effect of demographic variables on the household's total expenditure as well as the composition of goods consumed by the household was used to capture the effects of demographic variables. Endogeneity of total household food expenditure was also accounted for by applying the augmented regression approach of Hausman (1978) and Blundell & Robin (1999) where household income, average cluster income (less index household income) and land ownership status of household were used as an instrument for total food expenditure.

For all surveys, the estimated expenditure elasticities indicate that all commodity groups are considered as normal goods by households, and as expected, within food expenditure, bread & cereals are necessities (because they are staple foods in Ghana) while meat, fish and oil & fat products are considered luxuries. Surprisingly, root, tubers and plantain appear to be luxuries within food expenditure. This may be due to the time required for preparing meals made from items in the root, tubers & plantain group. We noticed a fall in the expenditure elasticity for bread & cereal in 2012/13 compared to 1991/92.

In Ghana, households appear sensitive and responsive to price changes of the commodities they consume. Again, as expected, all the uncompensated and compensated own-price elasticities of demand were negative while the compensated own-price elasticities were lower than uncompensated own-price elasticities. In all periods, the majority of the uncompensated own-price elasticities are greater than one. Cross price effects were also present in all periods; bread & cereals and root, tuber & plantain are substitutes while cereal and pulse nuts & seeds are complement. Again, meat and fish are substitutes.

In all three periods of food price changes, the analysis show that all household groups experienced a decline in welfare. Based on the full-price effect, between 1991/92 and 1998/99, nationally the welfare loss due to price increases is 17% of 1991/92 total household food expenditure, but 94% of 1998/99 total household food expenditure is needed to compensate households for observed price increases between 1998/99 and 2012/13; 182% of 1991/92 household food expenditure is needed to compensate households for observed price increases between 1991/92 and 2012/13. Although there are differences in magnitude for each period, in all periods, compared to richer households, a higher proportion of poorer household expenditure is needed to compensate poorer households for observed price changes.

However, within poorer households, we find that rural poor households suffered more from price increases than urban poor households. This is contrary to an earlier study of Ackah and Appleton (2007) but supports the finding of Leyaro et al (2010) on Tanzania. There are significant regional and ecological differences within and across periods, but households in the Savannah zone suffered more from the observed price changes. Considering the distributional impacts of price changes for households by income group (quintiles), welfare losses are higher for rural quintiles than corresponding urban quintiles. Indeed, over the whole period (i.e. between 1991 and 2013), the rural quintile with the lowest welfare loss fared worse than every urban quintile. Also over the whole period, for both rural and urban quintiles, households in the top quintiles (i.e. richest) suffered the least from food price increases, but the 'richest' rural quintile (the fifth) fared much worse than the 'richest' urban quintile. The results demonstrate the important effect of food prices on vulnerability to or exacerbating poverty, especially in rural areas.

Chapter 4 : Willingness-To-Pay (WTP) for Price Stability by Rural Households in Ghana

4.1 Introduction

The recent food crises of 2008 and 2010/11 which resulted in large food price increases in the international food market was also associated with high food price volatility for most food commodities (Bellemare et al., 2013). Estimates by the Food and Agricultural Organisation (FAO) (2010) show that food price ten-year volatility reached a record high for almost 30 years in December 2010[36]. This high price volatility resuscitated interest in the impact of price volatility in developing countries and that led to several food price stabilisation policies being reintroduced, including buffer stock systems, administrative pricing and temporal suspension of tariffs on imported commodities such as rice and wheat (Bellemare et al., 2013; Cudjoe et al., 2009; Magrini et al, 2015). In the case of Ghana, the National Food Buffer Stock Company (NAFCO) was established in 2010 as part of the strategy to reduce post-harvest losses, ensure price stability and establish emergency grain reserves.

The impact of high food price volatility on rural households depends on whether households are net consumers or net producers. For net consuming households, higher food price volatility can lead to great hardship especially when food expenditure constitutes a significant proportion of the total income (60-80% of income). For net producing households (i.e. farmers), food price increases may be

[36] The measure of volatility reported in this instance is the implied volatility which is based on the Black-Scholes option pricing formula. It represents the market's expectation of how much the price of a commodity is likely to move and tends to be more responsive to current market conditions i.e. subject to the law of demand and supply. Although it is widely used, it however rests on the assumption that logarithmic transformations of price returns are normally distributed and that their volatility is constant. These are quite strong assumptions.

beneficial (Mckay and Tarp, 2014), but increases associated with high volatility create uncertainty for the household which may act as a disincentive to produce more. For these reasons, price stability is often valued greatly by both net consuming and net producing households. It is therefore not surprising that price stabilisation policies were reintroduced in most developing countries in the wake of the food crises.

The 2008 and 2010/11 food crises have come and gone. However, due to the growing world population and income in emerging economies, increased demand for food and feed crops for the production of biofuels, and greater frequency and intensity of weather-related disasters in different parts of the world due to climate change, global food prices are expected to rise again and such increases will be associated with price volatility; hence more food price stabilisation policies would be required in developing countries. Detailed knowledge of what rural households would be willing to pay for price stability will be important to policy makers in their bid to formulate price stabilisation policies.

In developing countries (particularly Africa), most studies that have addressed the issue of price and household welfare have focused more on price changes and welfare rather than price volatility and welfare. Examples are Ackah and Appleton (2007), Ferreira et al. (2008), Simler (2010), Tefera et al. (2012), Minot and Dewina (2013) and Magrini et al. (2015)). This suggests that little is known about price volatility and welfare of households in developing countries. Studies that have tried to estimate the effect of price volatility on household welfare in developing countries include Rapsomanikis and Sarris (2005), Bellemare et al (2013), Mckay and Tarp (2014) and Magrini et al (2015).

Rapsomanikis and Sarris (2005) combined household data and commodity price time series to estimate income uncertainty that emanates from price and production volatility under different scenarios of exposure to the international and domestic markets shocks for Ghana, Vietnam and Peru. They found that market and non-market uncertainties significantly affect the variability of income of households, especially households that specialize in few commodities. McKay and Tarp (2014) also investigated how global price spikes impacted on rural welfare (specifically rice farmers) in Vietnam during 2006-12. They combined data from the Vietnam Access to Resources Household Survey (VARHS), the Vietnam Household Living Standard Survey (VHLSS) and available macro-data to analyse the responses of domestic producer and consumer prices to the 2008 price spike. They found that the Vietnamese government was effective in taking policy actions to limit the extent of transmission of the world price spike while poorer rice farming households benefitted more from the price increases.

Bellemare et al (2013) developed an analytical framework and an empirical strategy for estimating the impact of price volatility on rural households and used panel data from rural Ethiopian households to illustrate their strategy (a full explanation of this strategy is provided below). They found that the welfare gains from eliminating price volatility increases in household income. In other words, non-poor households benefit more from price stability than poor households, making food price stabilization a distributionally regressive policy. This chapter makes a contribution to the above literature by estimating the extent to which rural households (specifically maize, rice and millet farmers) in Ghana value price stability. Specifically, it estimates how much such households are willing to pay for price stability.

For Ghana, few studies have tried to estimate the effect of price change on consumer welfare (see Ackah and Appleton (2007), Minot and Dewina (2013) and Chapter 3 of this thesis), but no study has looked at the effect of price volatility on rural welfare. This study will be the first to make the attempt to measure willingness to pay for price stability by rural households in Ghana. Using the GLSS 6 data (2012/13), we employ the methodology proposed by Bellemare et al (2013) and focus on three major grains in Ghana: maize, rice and millet. These are the main cereals (along with sorghum) produced and consumed in Ghana; hence price stability is likely to be important. In terms of total output of cereals, maize contributes almost 60 per cent while rice and millet contribute 10 per cent each.

The rest of the chapter is organised as follows. Section 4.2 explores the trends in production and domestic prices of maize, rice and millet while Section 4.3 explains the Bellemare et al (2013) methodology of measuring willingness to pay for price stability. Section 4.4 discusses the data set used, Section 4.5 discusses the results, and Section 4.6 concludes by considering implications.

4.2 Production and Prices of Maize, Rice and Millet in Ghana

In this section we explore the trends in production (consumption has already been discussed in chapter 2) and domestic prices of maize, rice and millet in Ghana. Monthly wholesale prices in two major markets are analysed: Accra, as Ghana's capital and largest consumer market for both maize and local rice; and Tamale, as the supply market for millet and local rice. We start with maize since it is the largest among the three crops.

4.2.1 Trends in production and prices of Maize

Maize is an important crop for Ghana's agricultural sector and for food security. It is the largest staple crop, accounts for 50-60% of total cereal production and the number one crop in terms of area planted[37] as well as the second largest commodity crop in the country after cocoa (Ministry of Food and Agriculture (MOFA), 2013). Most production is by smallholder farmers (about 70 per cent) and it is grown throughout Ghana, although mainly in the middle southern part (Brong Ahafo, Eastern and Ashanti provinces) where 84 per cent is grown, with the remaining 16 per cent being grown in the northern regions of the country (Northern, Upper East and Upper West regions). Maize production in Ghana is largely under rain-fed conditions[38].

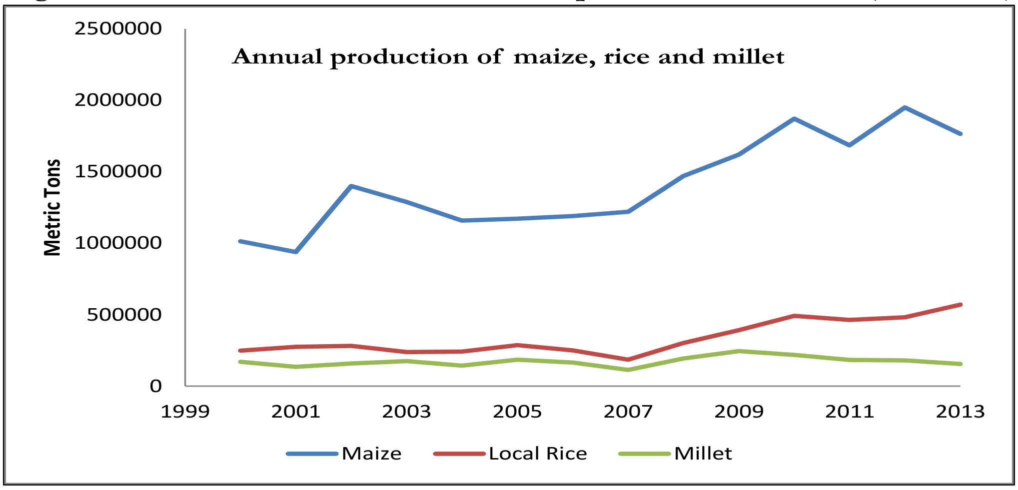
As seen in Figure 4.1, although there were periods of decline in maize production, generally production has been increasing steadily over the past few years with an average supply at 1.6 million/Tonnes over the period 2000-2013 (Ministry of Food and Agriculture (MOFA), 2013). The highest production recorded since 2000 is 1.9 million/Tonnes occurring in 2012 with the lowest occurring in 2001. Upward trend in production is observed from 2008 to 2013 with very sharp increases occurring in 2010 and 2013. This can be attributed to a number of government policies. Among them are the introduction of a 50 per cent subsidy for fertilizer in 2008 to make it affordable for producers and increase fertilizer use and the establishment of the National Food Buffer Stock Company (NAFCO) in

[37] It account for about 1,000,000 hectares in 2011 and 2012

[38] This is often leads to annual variations in production quantities.

2010 with the intention to buy, preserve, store, sell, and distribute excess grains (including maize) in warehouses across the country.

Figure 4:1: Annual Maize, Rice and Millet production in Ghana (2000-2013)



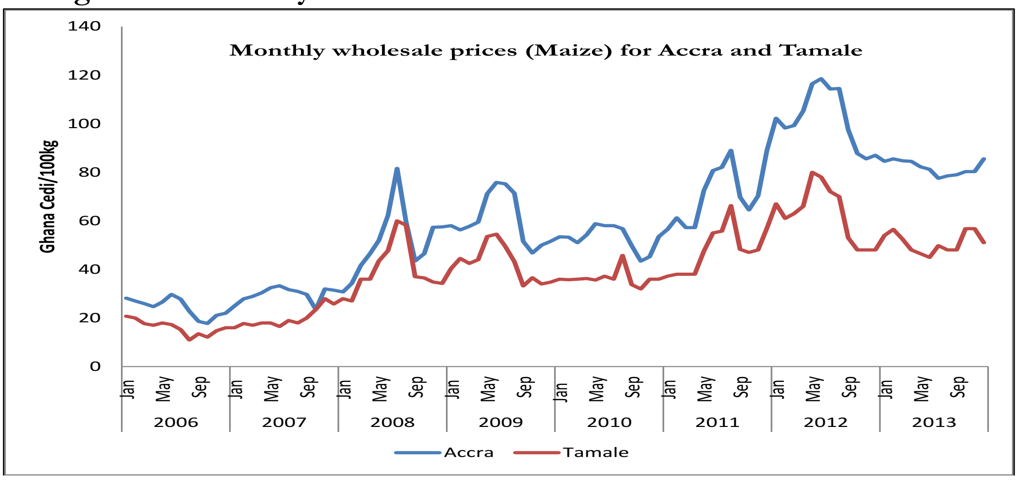
Source: Drawn from data obtained from the Ministry of Food and Agriculture (MOFA), Ghana

Although maize production has been increasing, production continues to fall below the achievable average yield. For instance in 2013, the average yield registered was 1.7 metric tons (mt) per hectare against an estimated achievable yield of around 6 metric tons (mt) per hectare (MOFA, 2013). Factors such as drought during critical early stages of crop growth, low soil nutrient levels (particularly nitrogen and phosphorus), and pest and disease infestations have been cited as the limiting factors to maize production. Poor management practices such as low plant populations, inappropriate planting time, inadequate control of weeds, lack of credit, limited use of inputs (especially fertilizer and improved seeds) as well as untimely application of adequate quantities of fertilizers, and poor market access have also been identified as some of the limiting factors to maize production (Adu et al., 2014).

Figure 4.2 shows the monthly wholesale price of maize in Accra and Tamale while Figure A4.1 (in appendix C) shows the real average rural wholesale prices.

Although there is an upward trend in monthly wholesale prices, what is evident in Figure 4.2 is the high volatility of wholesale prices; the kind which farmers would want to avoid. For instance, between January 2006 and December 2006, Accra wholesale price of 100kg in Ghanaian cedi (₵) of maize changed every month, i.e. 12 times in a year; from a high of ₵28 it ended the year at ₵22[39]. Similar patterns are observed for other years. Maize prices in Accra are generally higher than maize prices in Tamale, but movement in prices in both markets are quite similar. For both markets, very sharp increases occurred in 2008 and 2012 and these are attributed to the high increased in demand for maize in the poultry and livestock industry due to the support government provided to the poultry industry and the imposition of tariff on imported chicken which provided the incentive for poultry farmers to produce more chicken for local market since importers were finding it difficult to import chicken.

Figure 4:2: Monthly Wholesale Prices for Maize in Accra and Tamale



Source: Drawn from data obtained from Food and Agriculture Organisation (FAO)

4.2.2 Trends in production and prices Local (Paddy) Rice

Rice is the second most important food staple after maize in Ghana and it is cultivated both as a food and cash crop, making it an important crop for food security. Just like maize production, rice production is also done by smallholder

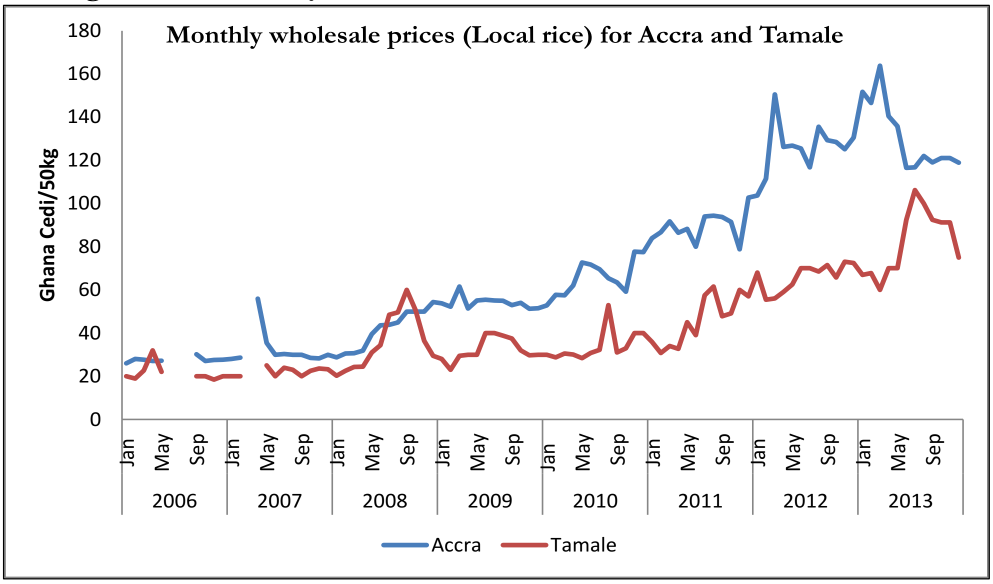
[39] The current exchange rate for the dollar is gh ₵4.4 to a dollar

farmers and is grown mainly in the three northern regions (Upper East, Upper West and Northern) and the Volta region. However, unlike maize, Ghana depends on imports of rice to meet its domestic demand. As of 2002, the self-sufficiency ratio of rice was fluctuating within the range of 26 per cent to 65 per cent, with an average production level of 178,000 metric tons per annum, attesting to the fact that Ghana is a net importer of rice (Ackah et al 2012). In 2005, total rice consumption amounted to about 500,000 tons, with imports of about 453,000 tonnes. Like maize, the average yield of rice is much lower than estimated achievable average yield of 6.5 metric ton per hectare.

The shortfall in production showcases the potential of using the local rice industry as an instrument for improving food security in Ghana. Improving production levels will not only reduce the import bill on rice but will also ensure availability and income security for agricultural households in Ghana.

Ghana's local (paddy) rice production has being rising steadily with small annual fluctuations. Between 2007 and 2013, local rice (paddy) production was in the range of 185,000 and 570,000 metric tons with an average production of about 412,000 metric tons. The upward trend in production is attributed to the reduced emphasis on conventional irrigation schemes, the increased research and technology transfer aimed at an efficient utilization of agricultural inputs and government fertilizer subsidy programme (MOFA, 2013). It is also attributed to government's commitment to increase rice yields by introducing improved high yielding, disease resistant rice varieties to producers and assisting them to adopt low cost water management practices (USDA, 2012).

Figure 4:3: Monthly Wholesale Prices for Rice in Accra and Tamale



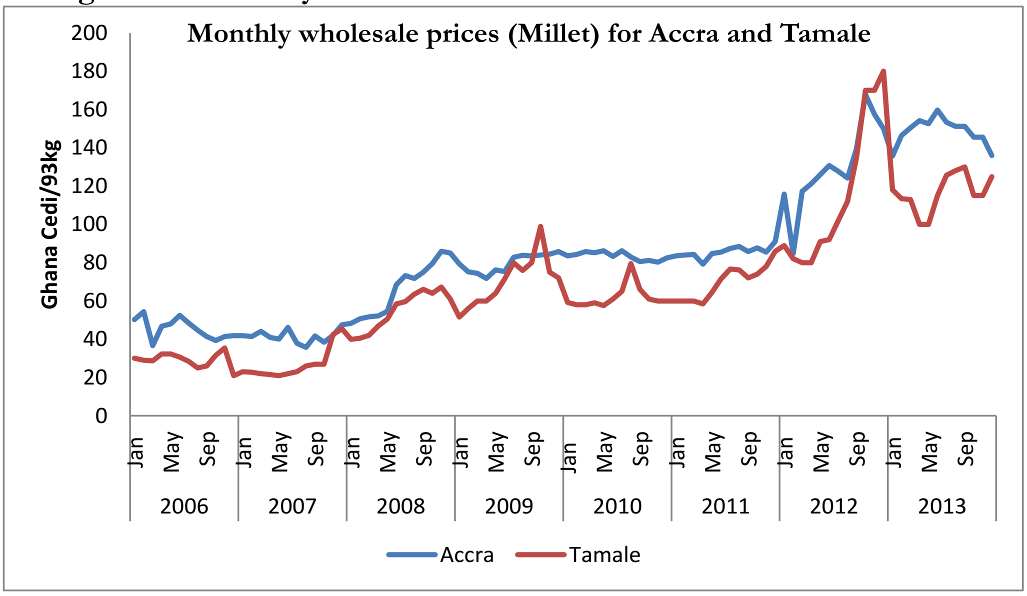
Source: Drawn from data obtained from Food and Agriculture Organisation (FAO)

Monthly wholesale price of local (paddy) rice for Accra and Tamale are shown in Figure 4.3. As in the case of maize, there is evidence of high price volatility in prices in both markets. On the average, wholesale prices changes not less than 10 times in a year although some of the changes are very marginal. Sharp increases can be observed in 2012 and 2013. For instance in January 2012, Accra wholesale of 50kg of paddy rice was ₵104, increased to ₵152 in January 2013 and to ₵164 in March 2013 (almost a 50 per cent increase from January 2012 to March 2013). These sharp increases may be attributed to the global food crisis that was experienced between 2011 and 2012 and oil crises that hit the country during these periods.

4.2.3 Trends in production and prices Millet

Millet is the least produced cereal in Ghana. It is also produced mainly through smallholder farming and grown largely in Upper East, Upper West and Northern regions (covering 29% total land area in the three regions), of the country which makes it a crop with impact on the poor in the three regions for food security and poverty alleviation. Millet thrives well in Northern Ghana compared to other crops because it grows under warm and dry conditions, and is suitable for infertile and low water holding soils (CGIAR, 1996; Darfour & Rosentrater, 2016). Millet is consumed largely in the three northern regions and is first in importance as a staple food and less in importance as a cash crop. In other words, it is a traditional crop grown by most households for food, and sold only as a last resort for money. Available data show that millet production has been decreasing over the last 10 years (see Figure 4.2). Production was 245,550 metric tons in 2009 but reduced to 155,131 metric tons in 2013; 37 per cent reduction in production. This is mainly attributed to farmers in the Northern region converting land to cultivate maize which offer them better opportunities in terms of income.

Figure 4:4: Monthly Wholesale Prices for Millet in Accra and Tamale



Note: Data was obtained from Food and Agriculture Organisation (FAO)

Just like rice and maize, millet prices also show significant price volatility although not as volatile (Figure 4.4). Sharp increases were observed between January 2012 and January 2013. For instance Accra's wholesale price per bag of 93 kg in January 2012 was ₵116 and increased to ₵160 in June. This represents a 37 per cent increase in price over the period. Similar pattern is observed in Tamale; the price in January 2012 was at ₵89, increased to 180 in December same year but fell to ₵115 by mid of 2013.

4.2 Methodology

To estimate how much rural farmers of the three grains (i.e. maize, rice and millet) value price stability, we adopt the measure of willingness to pay (WTP) for price stabilization proposed by Bellemare et al (2013) which relies on the previous work of Turnovsky et al. (1980), Schmitz et al. (1980) and Barrett (1996). This measure of willingness to pay (WTP) captures the effect of multiple commodity price volatility on the household by recognizing the dual roles of the household as both a consumer and producer of the commodities under consideration. Recognition of this dual role allows Bellemare et al (2013) to summarize demand and supply-side factors of the market in a single variable which they call marketable surplus (i.e. the difference between production and consumption) and derives the household's matrix of price risk aversion coefficients by specifying a two-period unitary agricultural household model. This price aversion coefficient matrix is employed to estimate the willingness to pay for price stability by households. The next sub-section explains how we estimate the price risk aversion for the farmers of the three commodities following Bellemare et al. (2013). The notation we use is the same as that used by Bellemare et al (2013).

4.2.1 Estimation of Price Risk Aversion

Bellemare et al, (2013) assumed the household maximises utility of consumption subject to a budget constraint that reflects production decisions made subject to uncertainty of commodity prices faced by the household in a subsequent period. This subsequent period price is represented by the vector $p = (p_1, \ldots\ldots, p_k)$ where k is the number of commodities. The dual roles of the household allow the household to consume and produce each commodity at the same time, yielding a vector of marketable surplus of the commodities, $\boldsymbol{x} = (x_1, \dots, x_k)$ where a negative (positive) value of any x indicates net consumption (surplus). It is assumed the household also receives income y from a number of sources such as the revenue from the sale of crops, wages from its labour endowment, revenue from the sale of endowment of other inputs, and transfers such as remittances.

With some manipulation which we do not show here[40], this model will imply a variable indirect utility function of the form $EV(p, y)$, where E is the expectation operator (Bellemare et al., 2013). Let p_i denote the price of commodity i, and p_j denote the price of commodity j, V_y denotes the first derivative of the indirect utility function with respect to income, V_{pp} denotes the vector of second derivatives of the indirect utility function with respect to prices, and V_{yp}denotes the vector of second derivatives of the indirect utility function with respect to income and prices, respectively.

To obtain the price risk aversion coefficient for each household, Bellemare et al (2013) first derived the matrix of the second derivatives of the household's indirect utility function relative to the vector of prices faced by the household as:

$$\begin{bmatrix} V_{p1p1} \dots & V_{p1pk} \\ \vdots & \vdots \\ V_{pkp1} \dots & V_{pkpk} \end{bmatrix} \tag{1}$$

and then used this matrix to obtain the matrix of price risk aversion analogous to Pratt's (1964) coefficient of absolute income risk aversion which can be defined as:

[40] See the online version of Bellemare et al (2013), especially appendix A.

$$A = -\frac{1}{V_y} * V_{pp} = -\frac{1}{V_y} * \begin{bmatrix} V_{p1p1} \dots & V_{p1pk} \\ \vdots & \vdots \\ V_{pkp1} \dots & V_{pkpk} \end{bmatrix} = \begin{bmatrix} A_{11} \dots & A_{1k} \\ \vdots & \vdots \\ A_{k1} \dots & A_{kk} \end{bmatrix} \quad (2)$$

Again, with some manipulation (see online version of Bellemare et al (2013)) A_{ij} in equation (2) can be simplified as:

$$A_{ij} = -\frac{M_i}{p_j}\left[\beta_j\left(\eta_j - R\right) + \varepsilon_{ij}\right] \quad (3)$$

where M_i is the marketable surplus of commodity i, p_j is the price of commodity j, β_j is the budget share of the marketable surplus of commodity j, (which is obtained as $\beta_J = p_j M_J / y$), η_j is the income elasticity of marketable surplus of commodity j, R is the Arrow-Pratt coefficient of relative risk aversion of the household, and ε_{ij} is the cross-price elasticity of the marketable surplus of commodity i, relative to the price of commodity *j*. The diagonal elements of matrix A measures the price risk aversion of each household with respect to individual commodity prices, and the sign of each diagonal element indicates whether welfare decreases, increases or is unaffected by volatility of prices. If $A_{ii} > 0$ then welfare is decreasing in the volatility of the price of i, while if $A_{ii} < 0$ then welfare is increasing in the volatility of the price of i. However, if $A_{ii} = 0$ then welfare is unaffected by the volatility of the price of i. We estimate all the elements of matrix A and employ it to estimate the willingness to pay for price stability. The next subsection provides a detailed explanation of how we measure willingness to pay.

4.2.2 Measuring Willingness to Pay for Price Stabilisation (WTP)

As noted in the introduction, our objective in this chapter is to estimate the willingness to pay for price stability by households who cultivate grains such as maize, rice and millet. Bellemare et al (2013) defined the WTP to eliminate all price risk as the amount of money which, when subtracted from wealth given expected price levels $E(p)$, results in the individual being indifferent to the random prices p and income y. This is stated in terms of expectation as:

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

where income y may be random. Following the standard procedure, Bellemare et al. (2013) approximated the left hand side of equation (4) using the first-order Taylor series expansion in the direction of certainty around the mean price and income, and applied a second-order Taylor expansion around mean price and income in all dimensions involving risk for the right-hand side. This expansion results in the measure of WTP to stabilise the prices of all *k* commodities as:

$$WTP = \frac{1}{2}\left[\sum_{j=1}^{k}\sum_{i=1}^{k}\sigma_{ij}\frac{V_{pjpi}}{V_y} + 2\sum_{i=1}^{k}\frac{V_{ypi}}{V_y}\sigma_{yi}\right] \qquad (5)$$

If income is assumed to be uncorrelated with prices equation (5) can be written as:

$$WTP = \frac{1}{2}\left[\sum_{j=1}^{k}\sum_{i=1}^{k}\sigma_{ij}A_{ij}\right] \qquad (6)$$

where σ_{ij} is the covariance of prices i and j. Based on equation (6), the WTP for price stability is interpreted as the sum of the covariances of prices weighted by the money metric impact of price variation on indirect utility. For a single commodity i WTP simplifies to:

$$WTP_i = \frac{1}{2}\sigma_{ii}A_{ii} - \sum_{i\neq j}^{k}\sigma_{ji}A_{ji} \qquad (7)$$

Our interest is to estimate equation (7) for Ghana for each of maize, rice and millet. However, before we can do that we first need to estimate the matrix of price risk aversion, equation (3), for all three commodities. Such estimation requires knowledge of the own and cross price elasticities of marketable surplus for each commodity for each household and the income elasticity. The next section explains the empirical strategy employed to estimate these elasticities and the data set used.

4.3 Data and Descriptive Statistics

Although Bellemare et al (2013) illustrated their measure of willingness to pay using panel data of Ethiopian households, we are limited to using cross section data. As this does not give variation over time, the results should be interpreted with this caveat in mind. The cross section data used is the Ghana Living Standard Survey (GLSS) 6 which was conducted in 2012/13. It has a sample of 16,772 households spread across the country and includes 1,200 clusters.

As noted in Chapter 1, a multi sampling technique was employed to record both the household consumption and production quantities for the commodities under consideration. Out of the sample of 16,772, there were 7,445 urban households and 9,327 rural households. As the focus here is on rural households, the sample size used is the 9,327 rural households. For all of these households, purchased and own consumption data are available. However, not all of them cultivated each of the three commodities. For instance, out of the 9,327 rural households, 5,678 cultivated maize while 1,321 and 1,253 households cultivated millet and rice respectively. The number of households who cultivated all the three items was 593 while those who cultivated both maize and rice at the same was 1,239. For those households which did not cultivate a particular item, we replace their production with zero.

Marketable surplus

In Bellemare et al (2013), the marketable surplus of each commodity for each household is defined as the difference between the household's consumption (both purchased and own consumption) and production of the commodity. This essentially is the net surplus of the household. However, in agricultural economics it is more usual to define marketable surplus as production minus own consumption ignoring purchases, i.e. the harvest available to sell. Often the difference may not matter, but strictly the two are equal only when total consumption is equal to own consumption, i.e. own consumption meets all consumption requirements and anything extra is sold. However, since the interest is to assess the effect of price volatility on rural households (both farmers and non-farmers) we adopted Bellemare et al (2013)'s definition of marketable surplus. Bellemare et al (2013) expressed this marketable surplus in quantities (not value). Thus, both household consumption and production for each commodity should be expressed in quantities for us to be able to calculate the marketable surplus for each commodity.

To calculate the marketable surplus for each of the three commodities, three data issues were addressed. First, household purchased consumption in GLSS 6 (2012/13) is not captured in quantities. Own consumption and production data are captured in quantities. As a result, purchased consumption has to be converted from value to quantities to arrive at the marketable surplus of the commodity. We divided the purchased consumption by the cluster price of the commodity to obtain the quantities. Although this approach does not account for any quality effect and may lead to measurement error, given data availability this is the best approach we can adopt.

Second, although, production data is captured in quantities, the unit of harvest differs from household to household. For the three commodities considered the unit of harvest included kilogram, mini bag, maxi bag, basket, American tin, bowl, etc. Since the cluster prices (of maize, rice and millet) reported in the GLSS are expressed in kilograms we convert all units to kilograms using conversion rates obtained from the Ministry of Food and Agriculture (MOFA) and the Ghana Statistical Services (GSS). By this conversion rate maxi bag of maize, rice and millet are equivalent to 100, 84 and 101 kilograms respectively while the mini bag is equivalent 60 kilograms for maize, 46 kilograms for rice and 53 kilograms for millet. A basket of maize is equivalent to 11.5 kilograms; 25 kilogram for rice and 29 kilograms for millet (see Table A4.1 in appendix C for the conversion rate of other units of harvest).

Third, the Bellemare et al (2013) model is a two-period unitary household model where production decisions are made in period one and sale and own consumption decisions are made in the next period. The household can be a net seller, net buyer, or autarkic (household with marketable surplus of zero), and can switch among these positions over time (especially close to versus long after the harvest). These switching positions can be smoothed in the analysis by using production and consumption data over a longer period such as a year. While consumption data captured in the GLSS are annualised and captured in the year of survey, production quantities are captured at two levels: for two weeks in the year of survey and for the whole year before the year of survey. Using two weeks' production quantities will not smooth the switching positions of the households so we want to annualise recognizing that over a year a household may be a net seller, net buyer or autarkic at different times. To do this we used data on production over the past year and the current consumption data. Essentially we are assuming that production decisions are made in the year before the survey while sale and own consumption decisions are made in the year of survey[41]. We acknowledge that this is a very strong assumption but given the data, this is the closest we can get to describing the household production over the year. Our results should therefore be interpreted with this caveat in mind.

Treatment of outliers

Due to the way purchased consumption of the household was converted to quantities some outlier values for marketable surplus of the commodities are expected. Indeed, preliminary investigations showed that these outliers caused some values of the WTP to lie far outside the 0 to 100 per cent interval. As a remedy, we followed Bellemare et al., (2013) where for each commodity we kept only the observations that lies within the 99 per cent confidence interval (i.e., ± 2.576 standard deviations) around their median. This led to 405 observations being dropped from the analysis. Hence the final sample employed in the analysis is 8,922. Specially, the number of observations below the 99 per cent confidence interval that were dropped are 15, 98 and 39 for maize, rice and millet respectively, while those above that were dropped are 104, 56 and 93 for maize, rice and millet.

4.3.1 Descriptive statistics

As shown in the methodology section, the variables of concern are the commodity prices and marketable surplus for each household for the commodities in question. In Ghana agricultural households (mainly smallholder farmers) sell their produce using a number of outlets including pre-harvest

[41] Of course this assumption will be more plausible if households have good storage facilities.

contractor, farm gate buyer, community market, and selling directly to the consumer. For each commodity considered in this chapter, about 90 per cent of households reported that they sold their produce using the community market. Furthermore, in rural communities the majority of households usually buy their food stuff from the biggest market in the community. As noted in Chapters 2 and 3, the GLSS also collected community price data for a number of items (including those used in this chapter) from a local market (normally the biggest market in the community). Hence, these prices are utilised in this chapter. For each cluster and each commodity, three different prices[42] were collected from different locations in the community market, so we use the average of the three prices.

Table 4.1 provides the mean for the marketable surplus of the three commodities. A positive mean marketable surplus for a commodity indicates that the average rural household is a net seller of a commodity, and a negative mean marketable surplus indicates that the average rural household is a net buyer of a commodity. As seen in the table, the average rural household is a net buyer of rice but a net seller for maize and millet. Maize is the most cultivated cereal crop in Ghana and production has always exceeded consumption making Ghana self-sufficient in maize production. It is therefore not surprising that the average rural household is a net-seller of maize. Ghana is a net importer of rice; consumption far outweighs the level of production in Ghana. Indeed, 70 per cent of rice consumption is accounted for by imports, hence it is not surprising that the average rural household is net-buyer. As noted in section 4.2, millet is grown by most rural households for food, and sold only as a last resort for money or when the household have excess; hence we do not expect the household to be a net buyer.

[42] For most of the items the three prices were the same

Table 4.1: National Average marketable surplus (N=8,922)

Crop	Mean (kg)	Std. Dev	Median (kg)	Zero observation (%)
Maize	248.9	726.7	6.9	24
Rice	-175.3	346.9	-81.1	18
Millet	16.3	109.9	0.0	80

Source: Author's calculation from GLSS 6

The last column of Table 4.1 shows the proportion of households with zero marketable surpluses (autarkic category). Such households neither produced nor consumed the commodities during the survey periods (due to some constraints including price, location etc.) or the household produced exactly what they consumed. These households will not be affected by price volatility or fluctuations since they will be price risk neutral as per our analysis in section 4.2.1. Zero marketable surpluses is quite significant for millet (80 per cent), but it is not surprising since millet is consumed and cultivated mostly in three relatively poor regions (Northern, Upper East and Upper West) where it is a staple food (households are effectively constrained to consume what they grow because production rarely exceeds consumption needs) and not in the other seven regions in Ghana.

In the case of rice and maize, 18% and 24% of households have zero marketable surpluses respectively. These proportions may appear high but could reflect the number of poor households constrained to consume what they grow. Another possible explanation could be data entry errors where missing household consumption and production data are replaced with zero.

Table 4.2 shows the average marketable surplus by region, poverty status and ecological zones. The average rural household is a net seller of maize in all regions except Greater Accra(not surprising because the sample contains only 197 rural households in Accra and out of this only 37 and 5 cultivated maize and rice respectively), while poor and non-poor households as well as households in all ecological zones are net sellers of maize. For rice, households in all regions are net buyers except the northern and upper west regions. Since rice is grown largely in the three northern regions, this result is expected. Furthermore, both poor and non-poor households as well as households in all ecological zones are net-buyers of rice. Households located in all the three northern regions as well as poor and non-poor households and those located in the savannah zone are net sellers of millet, underscoring the importance of the millet industry for food security in the three northern regions.

Table 4.2: Average Marketable surplus (Kg) by Region, Poverty Status and Ecological Zone

Category	Maize	Rice	Millet
Region			
Western	30.59	-349.15	-0.17
Central	100.69	-395.32	-0.01
Greater Accra	-100.47	-287.67	-0.18
Volta	114.69	-122.64	3.49
Eastern	141.14	-329.93	-0.39
Ashanti	243.62	-403.76	-1.25
Brong Ahafo	450.21	-74.21	4.58
Northern	579.04	48.25	55.61
Upper East	98.73	-72.24	23.31
Upper West	503.26	17.41	50.14
Rural			
Poor	335.74	-62.24	34.97
Non-poor	199.72	-239.25	5.76
Ecological Zone			
Coastal	16.64	-301.99	-0.04
Forest	179.86	-312.71	-0.20
Savannah	379.76	-9.59	36.52
Sample size	8,922	8,992	8,922

Source: Author's calculation from the GLSS 6.

Table 4.3 further characterises average marketable surplus by focussing on net buying and net selling households for only the households with non-zero marketable surpluses; 51 per cent, 10 per cent and 13 per cent of households are net sellers (i.e. had positive marketable surplus) of maize, rice and millet respectively while 25 per cent, 72 per cent and 7 per cent are net buyers for maize, rice and millet respectively. The sales of the average net selling households are greater than the purchases of the average net buying households for all commodities. However, the sales of the average rural household for maize is greater than the sales for both rice and millet while the purchases of the average household for rice is greater than the purchases for maize and millet. Given that maize accounts for 50-60% of total cereal production in Ghana and 70% of rice consumption are imported the above results are expected.

Table 4.3: National average marketable surplus (excluding zero)

	Net Buyer			Net seller		
Crop	**Mean (kg)**	**Std dev**	**Proportion of household (%)**	**Mean (kg)**	**Std dev**	**Proportion of household (%)**
Maize	-263.5	422.9	25	622.92	809.1	51
Rice	-282.7	319.2	72	289.67	355.53	10
Millet	-147.9	154.7	7	208.71	170.19	13

Source: Author's calculation from GLSS 6
Notes: Sample size is 8,922

The descriptive statistics of real price[43] of each of the commodity (including sorghum), household income, household characteristics and demographic variables included in the study and the average budget share of the three commodities are presented in Table 4.4. The household income measure used in this chapter includes wage income, income from non-farm enterprise, agricultural income, rental income and remittances. Based on these sources of income, the average income for rural household was approximately ₵10,158.62 (this is about $2,308 at an exchange rate of ₵ 4.4 to the dollar). In real terms, of the three commodities, local (paddy) rice had the highest average price followed by maize.

[43] Prices are deflated using an index provided in GLSS 6 data.

Based on the findings in Chapters 2 and 3, this is not surprising; increases in demand for rice have resulted in price increases. Sorghum is the least expensive commodity.

Table 4.4: Descriptive statistics for the Independent Variables and Budget share of the three commodities (N=8,922)

Variable	Mean	Std. Dev	Median
Real prices (Gh Cedi/per kg):			
Maize	3.11	5.64	2.00
Rice	5.95	3.76	5.75
Millet	2.63	3.21	2.54
Sorghum	2.15	0.89	2.24
Income (Gh Cedi)	10,158.6	30281.1	4,195.4
Budget share (Marketable surplus)			
Maize	0.20	1.37	0.003
Rice	-0.45	3.36	-0.060
Millet	0.029	0.33	0.00
Household characteristics			
Household size	4.75	2.99	4
Age of household head	47.4	16.4	45
Region			
Western	0.11	0.31	0
Central	0.09	0.29	0
Greater Accra	0.02	0.14	0
Volta	0.11	0.32	0
Eastern	0.11	0.31	0
Ashanti	0.09	0.28	0
Brong Ahafo	0.10	0.30	0
Northern	0.13	0.33	0
Upper East	0.12	0.33	0
Upper West	0.13	0.33	0
Ecological zone			
Coastal	0.12	0.33	0
Forest	0.41	0.49	0
Savannah	0.46	0.50	0
Sex of the household head			
Male	0.76	0.43	1
Female	0.24	0.43	0
Poverty status			
Poor	0.36	0.48	0
Non-poor	0.64	0.48	1

Source: Author's calculation from the GLSS 6

The average rural household size and age of head of household are 4.75 and 47 respectively. In addition, more of the households included in the analysis are non-poor; headed by male; and located in forest and savannah areas. It is not surprising that only 2 per cent of households are located in the Greater Accra as the sample is restricted to rural households (so these would be at the periphery of the region). As is expected, the average rural household spends more of its income on rice (i.e. 45%) and receives 20 per cent and 3 per cent of income in the form of revenue from maize and millet. Given that the average household is a net seller of maize and millet, and a net buyer of rice, these results are expected. Although a budget share of 45 per cent may seem very high for rice, recall (from Chapter 2) that nationally 30 per cent of total expenditure on cereal and cereal product is devoted to rice. Moreover, both demand and prices for rice have been increasing and the household is expected to spend more on rice.

Finally, Table 4.5 present the variance and covariance matrix of prices of the three commodities included in this chapter. As noted in the methodology section, to estimate the willingness to pay for price stability the price variance and covariance play an important role. Since our data are a cross section and prices are captured at the cluster level (the number of clusters included is 655), our price variation is at the cluster level. Among the three commodities, maize price exhibits significant price variation across clusters followed by rice and millet. As noted earlier, for maize the average household is a net selling household and the average marketable surplus of net selling households is greater than net buying households, hence the high price variation of maize suggest that stabilising maize price is more likely to generate welfare gains than would stabilising the price of the other two commodities. However, this remains an empirical question.

Table 4.5: Variance-Covariance Matrix of Nominal Prices

	Maize	Rice	Millet	Sorghum
Maize	30.93			
Rice	1.62	14.72		
Millet	3.60	1.65	10.31	
Sorghum	0.12	0.70	0.66	0.80

Source: Author's calculation from GLSS 6

Note: These covariance are measured in monetary terms (i.e.,Gh Cedi).

4.4 Empirical strategy and Estimation Technique

Because the methodology explained in sub-sections 4.2.1 and 4.2.2 uses marketable surplus of each commodity, we are unable to use the elasticities obtained in the earlier chapters for the analysis in this chapter. Hence we follow the strategy employed by Bellemare et al (2013) to estimate the own and cross price elasticities of marketable surplus for each of the commodities. Following Bellemare et al (2013) a reduced form regression of the marketable surplus of each commodity is obtained as:

$$M_{ihc}^{*} = \alpha_i + \eta_i y_{hc}^{*} + \sum_{j=1}^{k} \varepsilon_{ij} p_{jhc}^{*} + \lambda_i H_{hc} + v_{ihc} \tag{8}$$

where *i* denotes a specific commodity (i.e., maize, rice and millet), *h* denotes the household, c denotes the cluster, y denotes household income; p_j is a vector of the prices of all commodities (including *i*); H is a vector of household characteristics (we include household size, the age of the household head, regional dummies to capture regional effect, poverty status, sex of the household head and ecological zone) and v is the error term. Since the marketable surplus of each commodity for each household is the difference between the production and consumption we are likely to have negative and zero values. This will pose an estimation problem which we avoid by transforming all variables in equation (8) using the inverse hyperbolic sine transformation. This form of transformation does not only allow us to keep the negative as well as the zero-values, but it also allows us to interpret the coefficients as elasticities (see Burbidge et al. (1988) and Pence (2006) for further details). The asterisk (*) in equation (8) therefore denotes the transformed variable[44].

The estimated coefficient on household income is the income elasticity of the marketable surplus of commodity *i*, while the estimated coefficient on price p_j is the elasticity of the marketable surplus of commodity *i* with respect to price *j*. Since equation (8) is a system of three equations, the seemingly unrelated regression (SUR) method was employed. As noted in Bellemare et al (2013), estimating by SUR brings an efficiency gain over estimating the various equations in the system separately when the dependent variables are all regressed on the same set of regressors. It also helps us to avoid potential endogeneity problem. We estimate equation (8) over 8,922 households across 655 clusters and combine the estimates to obtain the point estimate of price risk aversion coefficient (equation 3) for each commodity. The results of our estimation are presented and discussed in the next section.

4.5 Results

We discuss in order the estimated results of the marketable surplus equation (8) for all three commodities, the estimated price risk aversion coefficients and estimated household WTP for price stability. As shown in Table A4.2 (in appendix C), for the working sample, few households are net buyers or sellers for millet, and few are net sellers for rice, so this will weaken the accuracy or robustness of results for these categories of households. However, there are enough households in the net buyer category for rice and net seller category for

[44] Following Burbidge et al. (1988) each variable is transformed using $y^* = \ln(y + (y^2+1)^{\frac{1}{2}})$

maize, hence we focus more on these categories of households because results are more likely to be reliable.

4.5.1 Price and Income Elasticity of Marketable Surplus

The results for estimating equation (8) are presented in Table 4.6. The coefficients of interest (own-price and income elasticity) are in bold. Intuitively, one would expect the own-price elasticity coefficients to be positive. That is, as the price of commodity i increases, households buy less or sell more of that same commodity, depending on whether they are net buyers or net sellers to begin with. The estimated own-price elasticity of demand for maize and rice confirm this intuition. The elasticities for both maize and rice are positive and significant at 1 per cent. However, the estimated own-price elasticity for millet is negative and not significant.

In the case of maize, as noted earlier, the average rural household is a net seller therefore the estimated own-price elasticity of 0.5 per cent means that a 1 per cent increase in price will result in half a per cent increase in marketable surplus, suggesting a low supply response to price changes. This inelastic response is not surprising as maize production in Ghana is rain-fed and grown once in a year, and farmers do not have enough storage facilities to store any excess harvest. For rice (where the average household is a net buyer), the estimated own-price elasticity indicates that a 1 per cent increase in price of local (paddy) rice will lead to only a 0.3 per cent increase in market surplus. This very inelastic response suggests that producers are very constrained in their ability to increase production.

The income elasticity shows the extent to which marketable surplus responds to changes in income. Intuitively, we expect it to be positive for net selling households because higher income is often associated with larger harvest and weaker liquidity constraints in financing the purchase of inputs such as fertilizer and improved seeds (Dercon & Christiaensen 2011; Bellemare et al., 2013). However, if the household is a net buyer, the income elasticity is expected to be negative given that the good is a normal good. Maize has a positive and significant income elasticity of 0.3 whereas millet and rice have negative but very small income elasticities.

Aside from the own price and income elasticities, the results are revealing about how marketable surplus of the commodities react to changes in household size. Intuitively, one expects larger households to consume more so, especially for net sellers, will be associated with lower marketable surplus. The coefficient on household size is negative and significant for both maize and rice (but insignificant for millet).

Table 4.6: Marketable Surplus Equation Estimates

Variables	Maize	Rice	Millet
Price of:			
Maize	**0.525*** **	-0.618***	-0.079
	(0.102)	(0.071)	(0.049)
Local Rice	0.016	**0.308*** **	0.115***
	(0.077)	**(0.053)**	(0.037)
Millet	-0.583***	0.909***	**-0.058**
	(0.134)	(0.092)	**(0.064)**
Sorghum	-0.262	0.560***	0.190**
	(0.160)	(0.110)	(0.077)
Household Income	**0.285*** **	**-0.099*** **	**-0.056** **
	(0.045)	(0.031)	(0.022)
Household size	-0.164*	-0.707***	0.099
	(0.098)	(0.068)	(0.047)
Age of household head	0.418***	0.088	-0.001
	(0.153)	(0.106)	(0.074)
Sample size	8,922	8,922	8,922

Note: Standard are in parenthesis. *** p<0.01, ** p<0.05, * p<0.1. Own price and income elasticities are in bold. Also included in the model are regional dummies, poverty status, sex of head of house and ecological zone, but given that these results are ancillary we do not report.

4.5.2 Price Risk Aversion

We now turn to the discussion of the estimated price risk aversion coefficients. The price and income elasticities estimates above are combined with the results in Table 4.5 to estimate the price aversion coefficient (both own and cross price) for each commodity using equation (3). Table 4.7 reports the estimated matrix of the average own and cross price risk aversion for all the commodities, where we fix the value of the relative (income) risk aversion coefficient (R) to be equal to 1 following Bellemare et al. (2013).

Because all prices are measured in cedi and all quantities are measured in kilograms, the various coefficients of price risk aversion in Table 4.7 can be compared to one another. The elements on the diagonal are the direct effects of fluctuations in the price of the commodities, i.e. the own-price risk aversion. All the diagonal elements are positive for all commodities. This suggests that for each commodity, the average household is own-price risk averse. In other words, for each commodity, welfare of the average household decreases with fluctuations in prices (Bellemare et al, 2013). The aversion over price fluctuations for rice (105.98) is quite high compared to the other two products. This can be explained by the fact that the budget share of rice is 45 per cent (see Table 4.4) of household income and rice has the highest marketable surplus (net buyer) of the three commodities, so it is reasonable that households would be more averse to price fluctuations compared to the other two commodities.

The commodity with lowest price aversion is millet (6.73). This is also not surprising because millet's contribution to household revenue is less than 4 per cent with a very small marketable surplus, coupled with the fact that millet is important as a staple food rather than as a cash crop. The own-price risk aversion coefficient for maize for the average household is 33.71, indicating that maize price fluctuations will hurt the average rural household.

Table 4.7: Estimated Matrix of Price Risk Aversion (R=1)

	Maize	**Rice**	**Millet**
Maize	33.71	3.17	69.70
	(5.21)	(1.62)	(2.25)
Rice	-45.36	105.98	125.35
	(1.87)	(6.17)	(2.68)
Millet	4.49	0.09	6.73
	(0.42)	(0.18)	(0.57)
Sample size	8,922	8,922	8,922

Note: These are the average coefficient of price risk aversion. Standard errors are in parenthesis (these are obtained using the delta method). Figures in bold denote average own-price risk aversion, i.e., the welfare impact of variance in the price of a given commodity. Elements not in bold denote average cross-price risk aversion, i.e., the welfare impact of covariance between the prices of two commodities. A positive (negative) coefficient indicates that the average household loses (gains) from variability in the prices of the commodities considered by a given cell.

The off-diagonal elements of Table 4.7 measure the cross-price risk aversion for the average household i.e. the indirect impacts on welfare of the volatility in each price. In other words, they measure the impacts on welfare of the covariance between a given price and the prices of all the other commodities considered, holding everything else constant. We note that the average rural household in the data is price risk averse over the prices of maize and millet (reading coefficients as row-column, given the positive signs on the maize-millet and millet-maize coefficients), suggesting that volatility in prices of both commodities (covariance) hurt the average household.

Furthermore, the average household is price risk averse over the prices of rice-millet (reading coefficients as row-column, given the positive signs on the rice-millet and millet-rice coefficients). These results underscore the importance of factoring in second order effects of price changes in welfare analysis. Table 4.8 characterises the own-price risk aversion coefficient by net seller and net buyers:

net buyers of the three commodities are on average price risk averse, especially for maize and rice (compared to net sellers) whereas net sellers of maize appear price risk loving on average although very small.

Table 4.8: Own-price risk aversion coefficient for Net Sellers and Net Buyers

Commodity	Net Seller	Net Buyers
Maize	-0.65	135.21
	(9.57)	(6.93)
Rice	53.32	140.17
	(6.50)	(8.50)
Millet	41.75	20.36
	(3.95)	(3.06)
Sample size	8,922	8,922

Standard errors are in parenthesis (these are obtained using the delta method). A positive (negative) coefficient indicates that the average household loses (gains) from variability in the prices of the commodities considered by a given cell.

4.5.3 Willingness to pay for price stability

Having discussed the risk aversion coefficients of households we now turn to the estimated WTP for price stability (equation 6 and 7). Table 4.9 presents the WTP as a proportion of household income for each commodity, as well for all commodities together. Commodity prices often fluctuate in tandem (due to common shocks) and the household can substitute commodities either in production or consumption. Welfare measure of price volatility should therefore consider both the variance in each commodity price series and the covariances among these price series (i.e. both diagonal and off-diagonal elements of Table 4.7. Ignoring the covariances between prices means we are not allowing for substitution in consumption and production, which in principle, may lead to a biased estimate of the total welfare impacts of price vector volatility. For this reason the WTP is estimated at three levels: ignoring covariance (i.e. not allowing substitution), including row covariance and column covariances (i.e. allowing for substitution).

If the covariances between prices (second order effects) are ignored the average rural household will be willing to give up 5 per cent of its income to stabilise just the price of maize; 8 per cent of income to stabilise the price of rice and less than 1% of income to stabilise just the price of millet. However, to stabilise the price of all three commodities at the same time (total WTP), the average rural household will be willing to give up approximately 13 per cent of its income. Although ignoring covariances between prices may bias downward or upward (the sign of the bias is impossible to determine *ex ante*) commodity-specific WTP estimates and total WTP, these results give the indication that rural households would benefit more from prevention of price volatility of rice than maize and millet. Total WTP of 13 per cent may seem a rather high figure, but full price stabilisation is practically difficult to achieve hence this figure should represent an upper bound on the welfare gains associated with price stabilisation (Bellemare et al., 2013).

When column covariances are included, the commodity for which the average household would be willing to pay the highest proportion of its budget to stabilize the price is still rice with 8 per cent. Likewise, when row covariances are included, rice is still the commodity for which the average household would be willing to pay the highest proportion of its budget to stabilize the price (6 per cent of income), followed by maize (3 per cent of income) and millet (less than 1 per cent of income). Ultimately, the inclusion of either column or row covariances indicate that the stabilisation of all three prices simultaneously will require the average household giving up approximately 9 per cent of its income. This is lower than the case of ignoring covariances suggesting that ignoring the covariances between prices would overestimate household WTP for price stability of the three commodities.

Tables 4.10 and 4.11 show WTP by net selling and net buying households respectively. We noted that net buyers of rice and maize are hurt more by price volatility than net sellers. Indeed, for maize, average net selling household gain from price volatility.

Table 4.9: Estimated Average WTP for price stabilisation (Full Sample)

Crop	Ignoring Covariance		Including Covariance Row-based		Including Covariance column-based	
	WTP	Std. Err	WTP	Std. Err	WTP	Std. Err
Maize	0.051	0.0079	0.026	0.0079	0.056	0.0079
Rice	0.077	0.0045	0.064	0.0043	0.076	0.0044
Millet	0.004	0.0003	0.002	0.0002	-0.042	0.0009
Total	0.132	0.0093	0.092	0.0092	0.092	0.0092

Source: Author's calculation from GLSS 6

Table 4.10: Estimated Average WTP for price stabilisation (Net Seller)

	Ignoring Covariance		Including Covariance Row-based		Including Covariance column-based	
Crop	WTP	Std. Err	WTP	Std. Err	WTP	Std. Err
Maize	-0.001	0.0146	-0.059	0.0143	0.001	0.0145
Rice	0.039	0.0047	0.026	0.0040	0.026	0.0040
Millet	0.021	0.0020	0.009	0.0015	-0.014	0.0025

Source: Author's calculation from GLSS 6

Table 4.11: Estimated Average WTP for price stabilisation (Net Buyers)

	Ignoring Covariance		Including Covariance Row-based		Including Covariance column-based	
Crop	WTP	Std. Err	WTP	Std. Err	WTP	Std. Err
Maize	0.206	0.0105	0.225	0.0109	0.213	0.0105
Rice	0.102	0.0061	0.085	0.0060	0.103	0.0061
Millet	0.010	0.0015	0.008	0.0014	-0.006	0.0024

Source: Author's calculation from GLSS 6

To ascertain the distribution of total WTP across households, we plot the estimated household-specific total WTP (for all commodities) and income using the second-degree fractional polynomial regression[45] and 95 per cent confidence band. To do this we first split the sample into two groups of households: those with income below the average household income and those with income above the average household income. This was done so we can compare the effect of price volatility on similar households.

Figure 4.5 shows the plot for households with income below the average while Figure 4.6 shows the plot for households with income above the average. Low income households (poor rural household with income lower than the average household income) are willing to give up a larger proportion of their income in order to stabilize prices, and WTP decreases steadily as income rises, reaching zero at about average income of 4,000 Ghana cedis[46]. This is consistent with poorer households being more likely to be net buyers (or consumption constrained), and being more vulnerable to price volatility. This finding is contrary to what Bellemare et al (2013) found for rural households in Ethiopia. However, for households with income above the average household income, willingness to pay for price stability increases with income. The intuition behind this result is that the majority of households with income above the average income (i.e. wealthier households) in the data are net buyers of rice, thus are hurt more by price volatility and would be willing to pay more for price stability.

[45] Royston and Altman (1997), provide a good discussion of fractional polynomial regression including its usefulness.

[46] This equivalent to 910 dollars at an exchange rate if $1: 4.4 Ghana cedis

Figure 4:5: Fractional polynomial regression of household WTP for households with income below average household income

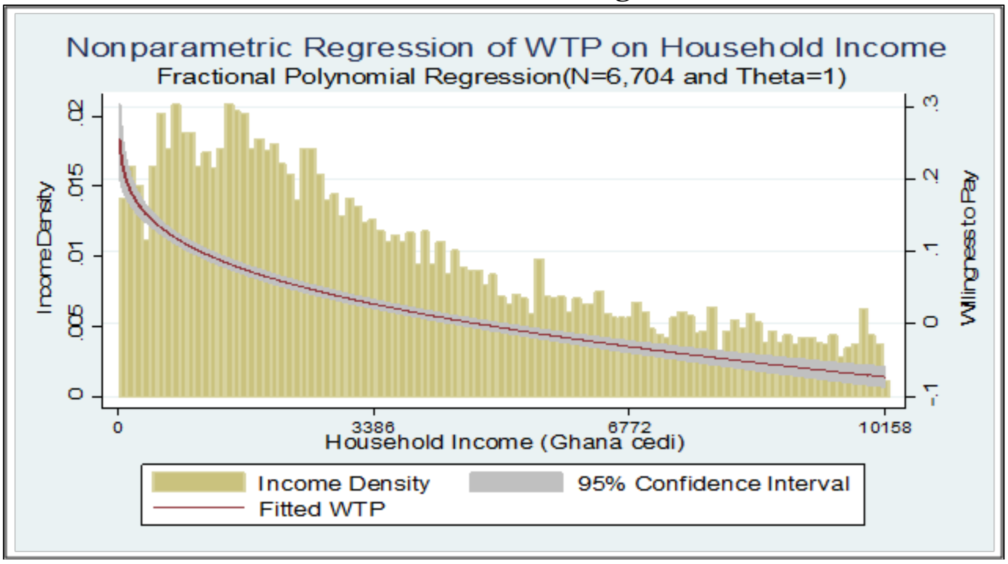
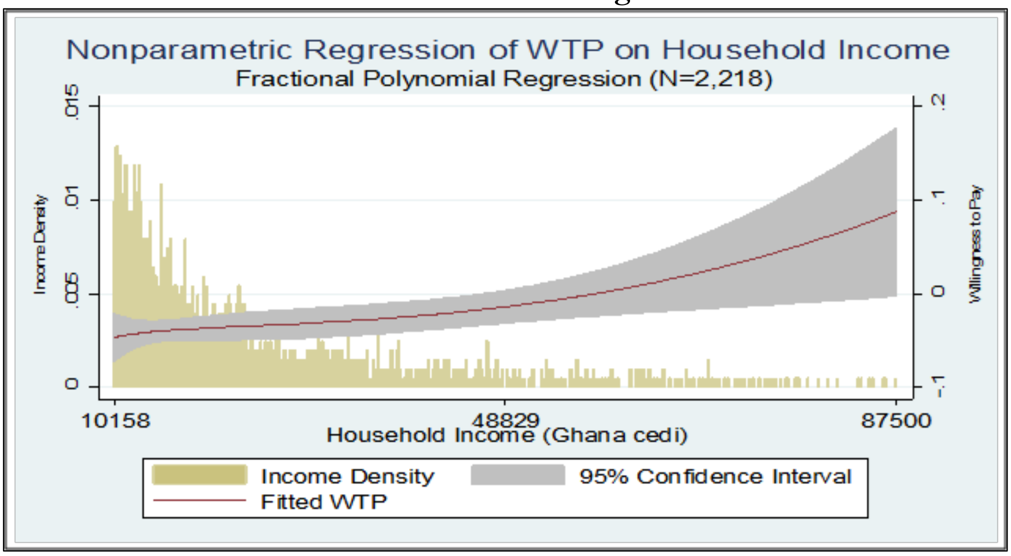


Figure 4:6: Fractional polynomial regression of household WTP for households with income above average household income



Robustness Checks

As a robustness check on the results, we excluded all household and demographic characteristics in the marketable surplus equation and regressed marketable surpluses on only prices and income of households. Although the results obtained by doing this were different quantitatively (which expected), the core qualitative results remain. That is, the average rural household was own-price risk averse for all three commodities and the average rural household is willing to pay higher proportion of income to stabilise the price of rice compared to maize and millet. Table 4.12 and 4.13 show the estimated price-risk aversion matrix and estimated willingness to pay for price stability. The average rural household is more own-price averse for rice than maize and is willing to pay 10 per cent of income for price stability of just rice as well as 18 per cent of income for price stability of all three products at the same time.

Table 4.12: Estimated risk Aversion (without household characteristics)

	Maize	**Rice**	**Millet**
Maize	167.18	16.92	22.46
	(7.05)	(2.18)	(1.07)
Rice	-95.32	185.27	208.60
	(1.87)	(7.46)	(4.46)
Millet	6.65	0.23	5.82
	(0.49)	(0.22)	(0.56)
Sample	8,922	8,922	8,922

Note: These are the average coefficient of price risk aversion. Standard errors are in parenthesis (these are obtained using the delta method). Figures in bold denote average own-price risk aversion, i.e., the welfare impact of variance in the price of a given commodity. Elements not in bold denote average cross-price risk aversion, i.e., the welfare impact of covariance between the prices of two commodities. A positive (negative) coefficient indicates that the average household loses (gains) from variability in the prices of the commodities considered by a given cell.

Table 4.13: Estimated Average WTP for price stabilisation (without household characteristics) N=8,922

Crop	Ignoring Covariance		Including Covariance Row-based		Including Covariance column-based	
	WTP	Std. Err	WTP	Std. Err	WTP	Std. Err
Maize	0.094	0.0107	0.091	0.0109	0.096	0.0106
Rice	0.104	0.0054	0.085	0.0052	0.107	0.0053
Millet	0.003	0.0003	0.006	0.0002	-0.022	0.0008
Total	0.201	0.0119	0.181	0.0120	0.181	0.0120

Source: Author's calculation from GLSS 6

Limitations

Although the results provided in this chapter give some indications of how rural households are affected by price volatility and for that matter how much they are willing to pay for price stability, these results however, suffer from important limitations that need to be acknowledged and discussed. First, in order to focus solely on price volatility, Bellemare et al (2013) assume away the effect of other sources of volatility (examples are income and output volatility) on the welfare of the households. However, household welfare depends on the prices faced by the household as well as the household's income. Therefore, a welfare measure should also factor in income changes to provide a complete picture of price risk aversion.

Second, as noted earlier, to recognise the changing position of the household over time we used the previous year's production quantities and survey year consumption to measure marketable surplus of the household. Implicitly we are assuming that production last year corresponds to available harvest this year. This is a strong assumption, however given the data this is the best we can do. Our results should therefore be interpreted with this caveat in mind. For future research, a possible solution could be exploring the production data over the previous two weeks in the survey to assess how this compares to production last year to identify a scaling factor to scale the two weeks quantities to annual quantities. Furthermore, we can also find out how close the survey for a household is to the harvest period (given that households are surveyed at different times of the year) to identify at what point in the surplus cycle producing households are (e.g. at harvest hence surplus, or after stored produce has been used hence in deficit) when they are surveyed. The analysis would then be distinguishing producing households according to whether they are net surplus or deficit at the time of the survey.

4.6 Conclusion

This chapter makes a contribution to the literature on the effect of price volatility on the welfare of rural households by estimating for Ghana the price aversion coefficient and willingness to pay for price stability by households who cultivate maize, rice and millet. Using GLSS 6 and focussing on only rural households, the

Bellemare et al (2013) method of estimating price risk aversion and willingness to pay for price stability was adopted for maize, rice and millet. We found that the average rural household is a net producer of maize and millet but a net purchaser of rice. Consistent with this, estimates of price risk aversion show that the average household is more price risk averse with respect to the price of rice compared to the price of maize and millet.

Furthermore, if covariances between prices of the three commodities are ignored, the average rural household will be willing to give up 8 per cent of its income to stabilise the price of just rice; 5 per cent to stabilise the price of only maize; less than 1 per cent to stabilise the price of millet alone; but 13 per cent to stabilise the price of all three at the same time. Including column covariances has little effect on the WTP of the average household, although it generates a negative WTP for millet. However, if row covariances are included (i.e. if we allow substitution between commodities), the WTP of the average household falls to 6 per cent of income for just rice and 3 per cent of income to stabilise the price of just maize. Including row or column covariances, the average household will be willing to give up 9 per cent of income to simultaneously stabilise the price all three commodities.

Contrary to the findings of Bellemare et al (2013) for rural Ethiopia, we found that low income households are willing to give up a higher proportion of their income to stabilise the prices of all three commodities suggesting that poor households suffer more from price volatility than non-poor households. This seems plausible for Ghana as poor households have low levels of production for own consumption but, as shown in Chapter 3, suffer greater welfare consumption loses from higher food prices.

This analysis provides useful information to policy makers about how households would value price stability, although the results should however be interpreted with the following caveats in mind. First, Bellemare et al (2013) had access to panel data whereas we only have cross section data (as also the case for Magrini et al 2015). Second, the willingness to pay is estimated as a proportion of the household income, but this will be subject to measurement errors. Third, the purchased consumption data in the GLSS is not in terms of quantities but rather in terms of expenditure value. We obtained consumption quantities by dividing household expenditure by the cluster price for each commodity, which may be another source of measurement error.

A broader concern is that this is not a cost-benefit analysis. Price stabilisation schemes are expensive to implement so we cannot claim that the welfare benefit represented by WTP would exceed the costs of implementation. Although administratively difficult to design, targeting subsidies as a method of price stabilisation can reduce the costs. Our analysis suggests that schemes that stabilise the prices of rice and maize for the poorest households are the most likely to generate a net welfare gain. Richer households appear better able to respond to price volatility and are less in need of stable prices.

Chapter 5 : Conclusion and Recommendation

5.1 Introduction

In developing countries, food expenditure constitutes more than 60 per cent of total household expenditure. This is particularly the case for poor households who earn less income and are often vulnerable to food price increases. In response to food price increases, poor households reduce the number and quality of the meals they consume in a day and spend less on other needs such as education, shelter and health. Food price increases could be beneficial to rural agricultural net producer households, but if such price increases are associated with price volatility it creates uncertainty which may act as a disincentive for agricultural households to produce more to take advantage of price increases. The world population and income in emerging economies are expected to rise dramatically in the coming decades; demand for food and feed crops for the production of biofuels are also expected to increase; the correlation of agricultural commodity and oil prices may strengthen while the intensity of weather-related disaster in different parts of the world is expected to increase due to climate change. In response to the above, food prices are expected to increase in the coming decades and such increases will be associated with price volatility.

Poor households in developing countries will be the worst affected by food price increases. Therefore, an understanding of the implications of food price increases and volatility on household welfare will provide information for policy makers in developing countries useful for formulating food security responses, nutritional improvement programs, and targeted poverty reduction strategies (Haq et al., 2011; Dubihlela and Sekhampu, 2014). While there are extensive empirical studies on the effect of food price increases and volatility on household welfare in developed and developing countries, relatively little is known for African countries. This thesis contributes on an Africa country by analyzing the impact of food price increases and volatility on households in Ghana.

The objective of the thesis was to answer a number of key research questions, which to our knowledge have not been investigated or fully investigated so far for Ghana. These include: (a) what is the nature of commodity budget share-food expenditure relationship in Ghana? In other words, which of the two widely used demand models (i.e. AIDS and QUAIDS) is more appropriate for Ghana? (b) What are the distributional impacts of observed price changes in Ghana? Which category of household suffers more from price changes? (c) How much will agricultural households be willing to pay for price stability?

These questions are addressed in the three empirical chapters of the thesis. In Chapter one, the context, overview and the motivation of the thesis are discussed while a summary of the results, future research areas and policy recommendations are provided in this chapter. To measure the welfare effects of price changes on households in Ghana, knowledge of the consumption patterns of households is required. Consumption patterns are often obtained by estimating demand models for households. While there are many such models with their own advantages and disadvantages, it is imperative that we use a demand system that best fits the available data. The two widely used demand models, the AIDS and QUAIDS, are employed in Chapter 2 on three data sets (the GLSS 3, 4 and 6) to determine which is most appropriate for (or best fits) the Ghanaian data. Both parametric and non-parametric methods were employed in the selection process. As far as welfare analysis of price changes in Ghana is concerned, this is the first time such as an analysis is done using the GLSS. Previous studies on welfare effects of price changes employed prior specification of the demand system (i.e. assumed without any testing that a selected model was appropriate). Having ascertained which model best fits the data, QUAIDS was used to estimate household consumption patterns of cereals and cereal products in Ghana between 1991 and 2013. The objective was to identify the differences in consumption patterns and how these patterns are changing over the years.

Chapter 3 measures the welfare effect of observed price changes in Ghana over three periods and investigated the distributional effect of the burden of price increases among different household groups and across periods. The standard approach of compensating variation was employed with the QUAIDS model to estimate household price and income responses that were used to calculate the compensation variation of observed price changes. Separability between food and non-food consumption was assumed and endogeneity of total food expenditure was corrected for using the augmented regression approach of Hausman (1978) and Blundell & Robin (1999) where household income, cluster average income (less index household income) and land ownership status of the households were used as instruments. Demographic effects were also captured using the scaling technique introduced by Ray (1983) and zero consumption was corrected for using the Shonkwiler and Yen (1999) approach. For Ghana, this is the first time the effect of zero consumption is captured in household demand estimation.

Chapter 4 measured the effect of price volatility and price risk on rural households using a method proposed by Bellemare et al., (2013) which addresses the relationship between price risk aversion and volatility by deriving a measure of willingness to pay (WTP) for price stabilization as a proportion of income. Using the GLSS 6, we focus on maize, rice and millet and show how much rural households are willing to pay for price stability of these commodities. Trends in production and prices of these items in two major markets (Accra and Tamale) in Ghana were analysed. Again, as far as Ghana is concerned, this is the first time the effect of price volatility on rural households is measured.

5.2 Summary of major findings

Detailed discussions have been provided in each chapter so here is only a brief summary. Like other large household surveys, the expenditure module of the GLSS suffers from missing data. Researchers who use this module either analyse complete data or replace missing data with zero. Complete data analysis will be legitimate only when data is missing completely at random, i.e. households with and without missing data are not different from each other. However, for GLSS 3 and 4, an analysis of missingness of household expenditure using correlation and logistic regression shows that missingness is associated with other variables. For instance, rural households are more likely to have missing data than urban households, while female headed households are less likely to have missing data than male headed households and non-poor households are less likely to have missing data than poor households. Consequently, studies that analyze only complete data are likely to generate biased results.

In Chapter 2 both the parametric and non-parametric methods employed to decide on the appropriate model specification for estimating household response to price and income changes rejected the traditional AIDS model in favor of the more flexible QUAIDS model. This suggests that studies that assume a linear relationship between budget shares and total food expenditure by using linear expenditure models are likely to generate misleading results particularly for welfare effects of price changes. The QUAIDS model is therefore more appropriate for estimating consumption patterns of households than the AIDS model. This result compares well with other studies in developing countries. See for example, Molina and Gil (2005), Bopape (2006) and Abdulai and Aubert (2004).

The analysis of household consumption patterns reveals a number of interesting results about household consumption of cereal and cereal products in Ghana. Estimates of expenditure elasticities indicate that all cereal items are considered as normal goods, so consumption of these items will increase with rising household income. In all periods, bread was found to be a necessity for all household groups. This is not surprising as bread is a basic staple food item consumed on a daily basis by almost all households in Ghana, part of almost every household's breakfast. Furthermore, in 1991/92 and 1998/99, maize was considered a luxury by all household groups, but appeared to be a necessity in 2012/13. This illustrates how changes in consumption patterns can mean that a commodity is a luxury at one point but a necessity when circumstances change (the reverse could also occur). Two possible explanations can be offered for this change. First, incomes have risen since 1991 and relative prices have changed so households may be able to afford items that previously were considered relatively expensive. Second, due to technological advances there has been a significant reduction in the amount of time required to prepare maize for consumption, so effectively maize became more affordable to the household.

As another example, rice was considered a luxury in 1998/99 but a necessity in 1991/92 and 2012/13. Between 1994 and 1997 (i.e. prior to the 1998/99 survey), high exchange rate depreciation coupled with rising international food prices resulted in high inflation rates in Ghana. Considering that a high proportion of rice consumed in Ghana is imported it is not surprising that in 1998/99 households saw rice as a luxury.

In 1998/99 and 2012/13, maize was price elastic for urban households, but price inelastic for all household groups in 1991/92. This finding holds for both first order effects and when behavioural responses (substitution effects) are allowed for, and for both the uncompensated and compensated elasticity estimates. This illustrates the greater ability of urban households to switch from maize to other items as there are greater substitution opportunities in urban areas. This shift to price elastic compared to the situation in 1991/92 may also illustrate effects of rising incomes (faster in urban than rural areas). The compensated own-price elasticities show that both rice and bread are price inelastic across all household groups in all periods. In the case of bread, this is not surprising considering that it is a necessity. We also noticed significant cross price effects for cereals consumption. For instance, rice and maize are substitutes while maize and maize flour are complements.

Chapter 3 estimates two measures of welfare effects (first order and full-price effects) of price changes for three periods. In terms of the effect of price changes on poor and non-poor households, we do not see significant differences over time, although there are differences in magnitude of welfare effects. In all periods, compared to non-poor households, a higher proportion of poorer household food expenditure is needed to compensate for observed price changes. Within poorer households, we find that rural households suffered more from price increases than urban households in all periods. This is contrary to an earlier study of Ackah and Appleton (2007) for Ghana, although we use a different demand model and cover more food commodity groups, but supports the finding of Leyaro et al (2010) on Tanzania. As the analysis focused only on consumption effects of price changes (household production was not incorporated) it should not be surprising that the rural poor suffer more from price changes. This is a concern for food security and poverty reduction strategies because in Ghana 75% of the poor are in rural areas. There are significant regional differences (i.e. regional heterogeneity) in first order effects: compared to other regions, households in the Brong Ahafo region suffered more from observed price changes in all periods.

Chapter 4 notes that the average rural household is net producer of maize and millet but a net purchaser of rice, and finds that households are more price risk averse with respect to the price of rice compared to the price of maize and millet. if substitution between prices of the three commodities are ignored, we estimate that the average rural households are willing to pay 13 per cent of their income to stabilise the price of maize, rice and millet simultaneously while if substitution between prices are allowed, rural households are willing to pay 9 per cent of income to stabilise the price of all three commodities at the same time. This suggests that ignoring substitution between prices would overestimate the rural household WTP to stabilise the prices of maize, rice and millet. Furthermore, low income rural households are willing to pay higher proportion of income to stabilise prices an indication that they are hurt more by price volatility.

5.3 Limitations of the study

The findings of this thesis should be interpreted with some caveats in mind. First is the issue of endogeneity of food expenditure. Because of a possible correlation between food expenditure and the error term (the unobserved factors) in the household demand model, food expenditure is often treated as endogenous. While GMM is an estimation method to address this, it is not appropriate when using cross section data. The Instrumental Variable (IV) approach is therefore adopted and three variables (household income, cluster average income less index household income and land ownership status) were used as instruments to correct for endogeneity of food expenditure. Although these instruments pass the tests of validity and exogeneity conditions, income captured in household survey is subject to measurement errors and may not be an ideal way to account for endogeneity.

Second, the welfare effects measured are consumption effects of price changes which do not include production effects. We focus on only consumption effect because of data availability issues. The GLSS data does not offer us the opportunity to measure both consumption and production effects at the same time because the data on farm production and cost are quite limited. This was also a limitation noted in Chapter 4 as accurate consistent data on market surplus were not available, so we had to estimate using data on consumption and production but measured over slightly different reporting periods. Given this measurement error there may be some bias in the estimates (although only likely to have quantitative rather than qualitative effects).

Third, replacing missing expenditure data with zero suggests that we know the true value of missing data with certainty; hence the variance is understated and precision is overstated resulting in confidence intervals and significance levels being too optimistic. Since zero is the minimum an expenditure can be, replacing missing data with zero may underestimate expenditure on certain foods in the analysis which may bias the results although we belief it may be legitimate in the case of the GLSS.

5.4 Policy Implications

In developing countries, knowledge about the welfare effect of price changes is vital for poverty reduction strategies as well as tax reforms policies. Such policies should properly target the segment of the population who will suffer more from price increases. As indicated by the findings of this study, those who suffer more from observed price changes are poor households. This implies that food security, nutritional and cash transfer programs such as Livelihood Empowerment Against Poverty (LEAP) are required to target poor households particularly the rural poor. Furthermore, as shown in chapter 2, rice and maize are major staples in Ghana and consume by the poor as well as the non-poor households. The expenditure and own-price elasticities estimates from the recent survey (GLSS 6) indicate that poor households are more responsive to changes in the price of rice and maize compared to changes in the household income. Consequently, government policies aimed at fighting malnutrition and poverty focusing on these two food items should be more price related than income related since poor households respond more to price changes compared to income changes.

The analysis in Chapter 4 showed the importance of price volatility and the extent to which rural households would be willing to pay for price stability, especially for maize and rice. If the government considers the reintroduction of price stabilization policies it can focus on maize and rice since they are the commodities which rural households are willing to pay higher proportion of income for price stability. Furthermore, since millet is cultivated mainly in the three northern regions and these regions have highest poverty levels, government can target the millet industry by offering support to farmers as way of ensuring food security in the three northern regions.

5.5 Areas of future research

As noted in Divoma (2015), price increases will be more welfare enhancing if they stimulate agricultural production which may generate new jobs for households, particularly rural households. This aspect of the welfare effect of price changes was not captured in the thesis. However, it would be interesting to see how price increases affect agricultural employment particularly in the rural areas. The extent to which gender of the household head or the farmer affects the welfare impact of price changes was not explored, but there will be gender differences in consumption behaviour. Again, as noted in Divoma (2015), rising food prices are likely to be welfare-enhancing in areas where women are farmers, because female spending patterns tend to be more child-friendly.

It will be useful to investigate such effects amongst agricultural households in Ghana. Although Ghana does not have a recognized general equilibrium model, it does have the Social Accounting Matrix (SAM). It will also be interesting and useful if this matrix is used to capture both the production and consumption effect of price increases at the same time. Although the way we dealt with missing household data is legitimate, it will be interesting to see how results change if other methods of dealing with missing data (such as multiple imputation) are employed.

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Appendix A

Table A2.1: Regional Distribution of Sample

Region	Number of households			
	1991/92	**1998/99**	**2005/06**	**2012/13**
Western	483	639	834	1,718
Central	515	700	689	1,602
Greater Accra	632	859	1,257	1,924
Volta	659	640	720	1,574
Eastern	409	820	914	1,804
Ashanti	733	1,060	1,574	1,981
Brong Ahafo	454	540	795	1,621
Northern	338	360	795	1,702
Upper East	110	120	600	1,447
Upper West	190	260	509	1,399
Sample	4,523	5,998	8,673	16,772

Source: Author's compilation from GLSS 3, 4, 5 and 6.

Table A2.2: Percentage of household with missing purchase expenditure

Expenditure Group	1991/92	1998/99	2012/13
Bread and Cereal			
Maize	76	68	0.1
Rice	40	23	0.1
Maize flour	79	73	0.1
Bread	26	14	0.1
Millet	95	96	0.1
Guinea Corn	94	96	0.1
Roots and Tubers			
Cassava	58	53	0.1
Cocoyam	80	83	0.1
Yam	57	48	0.1
Plantain	57	55	0.1
Gari	51	39	0.1
Cassava Dough	82	76	0.1
Sample Size	4,523	5,998	16,772

Source: Author's calculations from GLSS 3, 4 and 6

Notes:

All values are expressed in percentages except the last row, which represents the sample size of each round.

The percentages of each round were obtained by dividing the number of households with non-reported purchase expenditure for each item by the sample of households for each round.

Table A2.3: Logistic regression for missingness and demographic characteristics

Variable	1991/92 (Odds ratio) Maize	Rice	Yam	1998/99 (Odds ratio) Maize	Rice	Yam
Region						
Central	1.300	0.997	0.518*	1.250	1.821*	0.655
	(0.489)	(0.213)	(0.137)	(0.380)	(0.452)	(0.224)
G. Accra	0.593	1.688*	0.853	0.781	2.118**	0.716
	(0.199)	(0.418)	(0.246)	(0.249)	(0.542)	(0.190)
Volta	1.566	1.931***	0.433**	0.162***	2.058**	1.043
	(0.493)	(0.369)	(0.121)	(0.049)	(0.501)	(0.301)
Eastern	0.169***	1.633*	0.560	0.459**	2.627***	0.700
	(0.051)	(0.335)	(0.180)	(0.132)	(0.593)	(0.198)
Ashanti	1.306	0.949	0.225***	1.037	2.036*	0.421**
	(0.357)	(0.170)	(0.059)	(0.424)	(0.559)	(0.118)
B. Ahafo	2.094*	1.898**	0.578	0.712	2.341*	0.710
	(0.740)	(0.367)	(0.172)	(0.258)	(0.839)	(0.346)
Northern	0.159***	2.202***	0.301***	0.172***	6.306***	1.507
	(0.053)	(0.481)	(0.096)	(0.056)	(1.827)	(0.549)
U. East	0.509	5.965***	0.409	0.168***	2.458	0.870
	(0.201)	(3.190)	(0.212)	(0.051)	(1.425)	(0.556)
U. West	0.088***	1.425	0.062***	0.524	3.689***	0.716
	(0.036)	(0.457)	(0.025)	(0.242)	(1.219)	(0.256)
Locality						
Rural	1.590**	3.873***	11.48***	0.849	1.193	2.421***
	(0.282)	(0.499)	(1.802)	(0.176)	(0.195)	(0.468)
Sex of head						
Female	0.823*	0.651***	0.674***	0.795*	0.660***	0.778*
	(0.077)	(0.049)	(0.058)	(0.085)	(0.063)	(0.079)
Poverty status						
Non-poor	0.657***	0.526***	0.448***	0.677**	0.521***	0.550***
	(0.072)	(0.040)	(0.037)	(0.085)	(0.052)	(0.055)
Sample size	4,523	4,523	4,523	5,998	5,998	5,998

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)
Standard errors in parentheses.
The reference category for region is the western region; for locality is urban; for sex of household head is male; and poverty status is poor.

Table A2.4: Summary statistics for total food expenditure, total income and household characteristics & demographic variables

Variable	1991/92 Mean	1991/92 SD	1998/99 Mean	1998/99 SD	2012/13 Mean	2012/13 SD
Food expenditure	33.09	22.88	227.1	16.4	4,011	2,934
Household income	37.27	44.16	216.8	30.7	15,676	46,282
Region						
Western	0.11	0.31	0.11	0.31	0.12	0.32
Central	0.11	0.32	0.12	0.32	0.10	0.31
Greater Accra	0.14	0.35	0.14	0.35	0.14	0.35
Volta	0.15	0.35	0.11	0.31	0.09	0.29
Eastern	0.09	0.29	0.14	0.34	0.12	0.32
Ashanti	0.16	0.37	0.18	0.38	0.14	0.34
Brong Ahafo	0.10	0.30	0.09	0.29	0.08	0.27
Northern	0.07	0.26	0.06	0.24	0.08	0.28
Upper East	0.02	0.15	0.02	0.14	0.07	0.25
Upper West	0.04	0.20	0.04	0.20	0.06	0.24
Locality						
Urban	0.35	0.48	0.37	0.48	0.53	0.50
Rural	0.65	0.48	0.63	0.48	0.47	0.50
Poverty status						
Poor	0.40	0.49	0.32	0.47	0.18	0.38
Non-poor	0.60	0.49	0.68	0.47	0.82	0.38
Sex of HH Head						
Male	0.68	0.47	0.66	0.47	0.69	0.46
Female	0.32	0.47	0.34	0.47	0.31	0.46
HH head's Age	44.30	15.33	45.83	15.3	45.04	15.75
Household Size	4.48	2.83	4.28	2.56	3.92	2.57
Sample size	4,523	4,523	5,998	5,998	16,772	16,772

Sources: Author's calculation from GLSS 3, 4 and 6

Notes:

Total household food expenditure and income are expressed in gh₵ and are in nominal terms. Quarter dummies included but means and standard deviations not reported.

Table A2.4a: Optimal Bandwidth

Commodity group	Optimal Bandwidth 1991/92	Optimal Bandwidth 1998/99	Optimal Bandwidth 2012/13
Bread & Cereal	0.46	0.52	0.44
Roots, Tubers & Plantain	0.38	0.42	0.41
Pulses, Nut & Seeds	0.45	0.42	0.46
Oil & Fat Products	0.39	0.37	0.46
Other food	0.40	0.55	0.36

Notes: Optimal Bandwidth based on the normal scale bandwidth selection approach, often called the "Rule-of-Thumb" (ROT) bandwidth selector.

Table A2.5a: IV Estimate of individual share equations for 1991/92 (N=4,523)

Variable	Expenditure share				
	Bread & Cereal	**Root & Tubers**	**Pulses & Nuts**	**Oil & Fats**	**Other food**
Food expenditure	-0.014	0.094***	0.018***	0.004*	-0.102**
	(0.009)	(0.012)	(0.004)	(0.002)	(0.013)
Price of:					
Bread & Cereal	-0.013	0.009	-0.013***	-0.004*	0.020
	(0.007)	(0.010)	(0.003)	(0.002)	(0.010)
Roots & Tubers	0.008*	-0.012	0.001	0.003	0.001
	(0.004)	(0.008)	(0.002)	(0.002)	(0.007)
Pulses & Nut	-0.030***	0.047***	0.002	-0.000	-0.019
	(0.007)	(0.013)	(0.003)	(0.002)	(0.012)
Oil & Fat	-0.009	0.008	0.009**	-0.004	-0.005
	(0.006)	(0.010)	(0.003)	(0.003)	(0.009)
Other Food	-0.042***	0.043***	0.006***	0.010***	-0.017*
	(0.005)	(0.008)	(0.002)	(0.002)	(0.007)
Locality					
Rural	-0.062***	0.151***	0.016***	0.005**	-0.111***
	(0.006)	(0.009)	(0.002)	(0.002)	(0.009)
Sex of HH head					
Female	0.003	0.017**	0.003*	0.006***	-0.029***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)
HH size	0.014**	0.005	-0.002	-0.001	-0.016*
	(0.004)	(0.006)	(0.002)	(0.001)	(0.007)
Age of HH head	0.001	0.007	0.003	-0.003*	-0.008
	(0.004)	(0.007)	(0.002)	(0.001)	(0.007)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
Total food expenditure is the instrumented variable while Total income and average cluster income minus index household's income are the instruments.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.5b: IV Estimate of individual share equations for 1998/99 (N=5,998)

Variable	Expenditure share				
	Bread & Cereal	**Root & Tubers**	**Pulses & Nuts**	**Oil & Fats**	**Other food**
Food expenditure	-0.034***	0.089***	0.003**	0.002	-0.057***
	(0.005)	(0.007)	(0.002)	(0.001)	(0.007)
Price of:					
Bread & Cereal	-0.017***	0.013***	0.005***	-0.001	0.001
	(0.003)	(0.003)	(0.001)	(0.001)	(0.004)
Roots & Tubers	0.023***	-0.041***	0.001	-0.001*	0.020***
	(0.003)	(0.004)	(0.001)	(0.001)	(0.004)
Pulses & Nut	-0.004*	0.024***	-0.004***	0.001	-0.016***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Oil & Fat	0.009	-0.078***	0.001	-0.002	0.071***
	(0.005)	(0.008)	(0.002)	(0.001)	(0.008)
Other Food	0.018	0.395***	0.049***	0.003	-0.465***
	(0.033)	(0.047)	(0.013)	(0.009)	(0.050)
Locality					
Rural	-0.008*	0.066***	0.002*	-0.003***	-0.058***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)
Sex of HH head					
Female	0.003	0.026***	0.005***	0.003***	-0.036***
	(0.002)	(0.004)	(0.001)	(0.001)	(0.004)
HH size	0.031***	-0.002	0.003**	0.001	-0.033***
	(0.003)	(0.004)	(0.001)	(0.001)	(0.004)
Age of HH head	-0.001	0.032***	-0.002	0.001	-0.030***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
Total food expenditure is the instrumented variable while Total income and average cluster income minus index household's income are the instruments.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.5c: IV Estimate of individual share equations for 2012/13 (N=16,772)

Variable	Expenditure share: Bread & Cereal	Root & Tubers	Pulses & Nuts	Oil & Fats	Other food
Food expenditure	-0.148***	1.023***	0.024***	-0.009**	0.164***
	(0.014)	(0.013)	(0.005)	(0.003)	(0.019)
Price of:					
Bread & Cereal	0.016***	1.008**	0.003**	0.004***	-0.031***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.004)
Roots & Tubers	0.008	0.960***	0.007***	-0.002*	0.019**
	(0.004)	(0.005)	(0.002)	(0.001)	(0.006)
Pulses & Nut	-0.006	1.010*	0.004**	0.002**	-0.010*
	(0.004)	(0.004)	(0.002)	(0.001)	(0.005)
Oil & Fat	0.009***	1.001	-0.002	0.002***	-0.010**
	(0.003)	(0.003)	(0.001)	(0.001)	(0.004)
Other Food	0.034	0.927	0.028*	0.045***	-0.134*
	(0.037)	(0.040)	(0.014)	(0.009)	(0.056)
Locality					
Rural	0.015***	1.070***	0.022***	-0.001	-0.106***
	(0.004)	(0.005)	(0.002)	(0.001)	(0.006)
Sex of HH head					
Female	-0.003	1.005**	0.004**	0.006***	-0.011*
	(0.004)	(0.003)	(0.001)	(0.001)	(0.005)
HH size	0.108***	1.058***	0.000	0.008***	-0.175***
	(0.007)	(0.007)	(0.003)	(0.001)	(0.009)
Age of HH head	0.005	1.067***	0.004*	0.004***	-0.080***
	(0.004)	(0.004)	(0.002)	(0.001)	(0.006)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
Total food expenditure is the instrumented variable while Total income and land ownership status of the household are the instruments.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.6a: OLS Estimate of individual share equations for 1991/92 (N=4,523)

Variable	Expenditure share				
	Bread & Cereal	**Root & Tubers**	**Pulses & Nuts**	**Oil & Fats**	**Other food**
Food expenditure	0.007*	0.022***	0.009***	0.004***	-0.042***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)
Price of:					
Bread & Cereal	-0.014	0.020	-0.011***	-0.003	0.009
	(0.007)	(0.010)	(0.003)	(0.002)	(0.010)
Roots & Tubers	0.008*	-0.012	0.001	0.003	0.001
	(0.004)	(0.008)	(0.002)	(0.002)	(0.007)
Pulses & Nut	-0.032***	0.048***	0.002	-0.000	-0.017
	(0.007)	(0.012)	(0.003)	(0.002)	(0.011)
Oil & Fat	-0.008	0.001	0.008*	-0.004	0.003
	(0.006)	(0.009)	(0.003)	(0.003)	(0.009)
Other Food	-0.041***	0.039***	0.006**	0.010***	-0.015*
	(0.004)	(0.008)	(0.002)	(0.002)	(0.007)
Locality					
Rural	-0.056***	0.136***	0.015***	0.005**	-0.099***
	(0.005)	(0.009)	(0.002)	(0.002)	(0.009)
Sex of HH head					
Female	0.006*	0.013*	0.002	0.006***	-0.027***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)
HH size	0.004	0.037***	0.002*	-0.000	-0.044***
	(0.002)	(0.004)	(0.001)	(0.001)	(0.004)
Age of HH head	0.001	0.009	0.003	-0.003*	-0.010
	(0.004)	(0.007)	(0.002)	(0.001)	(0.007)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.6b: OLS Estimate of individual share equations for 1998/99 (N=5,998)

	Expenditure share				
Variable	**Bread & Cereal**	**Root & Tubers**	**Pulses & Nuts**	**Oil & Fats**	**Other food**
Food expenditure	-0.012***	0.041***	0.003***	0.001	-0.032***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Price of:					
Bread & Cereal	-0.016***	0.011***	0.004***	-0.001	0.001
	(0.003)	(0.003)	(0.001)	(0.001)	(0.004)
Roots & Tubers	0.019***	-0.036***	0.000	-0.001	0.017***
	(0.002)	(0.004)	(0.001)	(0.001)	(0.004)
Pulses & Nut	-0.002	0.021***	-0.004***	0.001	-0.015***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Oil & Fat	0.007	-0.076***	0.002	-0.002	0.070***
	(0.005)	(0.007)	(0.002)	(0.001)	(0.007)
Other Food	0.023	0.360***	0.048***	0.002	-0.432***
	(0.032)	(0.044)	(0.012)	(0.009)	(0.048)
Locality					
Rural	-0.004	0.058***	0.003**	-0.003***	-0.053***
	(0.003)	(0.004)	(0.001)	(0.001)	(0.005)
Sex of HH head					
Female	0.005*	0.022***	0.005***	0.003***	-0.035***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.004)
HH size	0.020***	0.021***	0.003***	0.001	-0.045***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Age of HH head	-0.001	0.032***	-0.002	0.001	-0.029***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.005)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.6c: OLS Estimate of individual share equations for 2012/13 (N=16,772)

Variable	Expenditure share				
	Bread & Cereal	**Root & Tubers**	**Pulses & Nuts**	**Oil & Fats**	**Other food**
Food expenditure	0.979***	1.021***	1.006***	1.001*	0.994
	(0.003)	(0.002)	(0.001)	(0.001)	(0.003)
Price of:					
Bread & Cereal	1.012***	1.006*	1.003***	1.004***	0.975***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Roots & Tubers	0.999	0.965***	1.008***	0.997**	1.032***
	(0.004)	(0.004)	(0.002)	(0.001)	(0.006)
Pulses & Nut	0.991**	1.009*	1.005**	1.002**	0.992
	(0.003)	(0.004)	(0.002)	(0.001)	(0.005)
Oil & Fat	1.010***	1.001	0.998	1.002**	0.989**
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)
Other Food	0.858***	0.949	1.054***	1.030***	1.132**
	(0.025)	(0.033)	(0.013)	(0.008)	(0.053)
Locality					
Rural	1.048***	1.087***	1.018***	1.002**	0.861***
	(0.003)	(0.004)	(0.001)	(0.001)	(0.004)
Sex of HH head					
Female	1.011***	1.010**	1.002	1.006***	0.973***
	(0.003)	(0.003)	(0.001)	(0.001)	(0.004)
HH size	1.013***	1.009***	1.002***	1.001***	0.976***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Age of HH head	1.010*	1.001***	1.020	1.040***	0.998***
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the demand model are also included but the parameters for regional dummies, poverty status of the household as well as quarter dummies are not reported.

Table A2.7a: Multivariate probit estimate for 1991/92 (N=4,523)

Variable	Expenditure group: Bread & Cereal	Root & Tubers	Pulses & Nuts	Oil & Fats
Food expenditure	0.665***	0.932***	0.727***	0.733***
	(0.055)	(0.066)	(0.043)	(0.040)
Price of:				
Bread & Cereal	-0.383**	-0.367**	-0.299***	-0.249**
	(0.119)	(0.136)	(0.090)	(0.082)
Roots & Tubers	0.058	-0.104	0.179**	-0.157**
	(0.071)	(0.088)	(0.060)	(0.050)
Pulses & Nut	-0.238*	0.545***	-0.288**	0.702***
	(0.121)	(0.157)	(0.092)	(0.090)
Oil & Fat	-0.023	0.448***	0.115	-0.274***
	(0.101)	(0.099)	(0.074)	(0.071)
Demographic variables				
Region	0.087***	-0.160***	0.035**	-0.098***
	(0.016)	(0.021)	(0.012)	(0.011)
Locality	-0.852***	0.561***	-0.049	-0.540***
	(0.101)	(0.108)	(0.068)	(0.064)
Sex of HH head	-0.073	0.410***	0.164**	0.292***
	(0.064)	(0.090)	(0.050)	(0.047)
HH size	-0.054	0.133*	0.137***	-0.010
	(0.048)	(0.056)	(0.035)	(0.034)
Age of HH head	-0.315***	-0.047	-0.016	-0.142*
	(0.084)	(0.099)	(0.064)	(0.060)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the demand model are also included but the parameters poverty status of the household and quarter dummies are not reported.

Table A2.7b: Multivariate probit estimate for 1998/99 (N=5,998)

Variable	Expenditure group: Bread & Cereal	Root & Tubers	Pulses & Nuts	Oil & Fats
Food expenditure	0.739***	0.836***	0.548***	0.615***
	(0.067)	(0.053)	(0.034)	(0.032)
Price of:				
Bread & Cereal	-0.162**	0.237**	0.262***	0.274***
	(0.061)	(0.076)	(0.041)	(0.038)
Roots & Tubers	0.008	-0.669***	-0.278***	-0.297***
	(0.090)	(0.086)	(0.044)	(0.042)
Pulses & Nut	0.017	0.492***	-0.032	0.142***
	(0.054)	(0.113)	(0.032)	(0.039)
Oil & Fat	0.235	-0.446**	0.127	-0.396***
	(0.199)	(0.144)	(0.086)	(0.078)
Demographic variables				
Region	-0.026	-0.204***	0.028**	-0.075***
	(0.024)	(0.020)	(0.011)	(0.010)
Locality	0.073	0.368***	0.181**	-0.045
	(0.117)	(0.109)	(0.058)	(0.055)
Sex of HH head	0.311**	0.495***	0.181***	0.315***
	(0.098)	(0.079)	(0.045)	(0.042)
HH size	0.055	0.168**	0.195***	0.065*
	(0.067)	(0.051)	(0.032)	(0.030)
Age of HH head	-0.267*	0.121	0.007	-0.007
	(0.119)	(0.091)	(0.059)	(0.055)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the QUAIDS demand model are also included but the parameters for poverty status of the household and quarter dummies are not reported.

Table A2.7c: Multivariate probit estimate for 2012/13 (N=16,772)

Variable	Expenditure group: Bread & Cereal	Root & Tubers	Pulses & Nuts	Oil & Fats
Food expenditure	0.526***	0.576***	0.564***	0.497***
	(0.030)	(0.025)	(0.020)	(0.019)
Price of:				
Bread & Cereal	-0.097**	-0.014	0.044*	0.135***
	(0.035)	(0.028)	(0.021)	(0.020)
Roots & Tubers	-0.069	-0.015	-0.112***	-0.181***
	(0.056)	(0.041)	(0.032)	(0.031)
Pulses & Nut	0.164***	-0.047	-0.325***	0.036
	(0.043)	(0.032)	(0.024)	(0.024)
Oil & Fat	0.086**	-0.004	-0.114***	0.043
	(0.029)	(0.029)	(0.022)	(0.019)
Demographic variables				
Region	-0.001	-0.131***	-0.035***	-0.062***
	(0.009)	(0.008)	(0.006)	(0.006)
Locality	0.422***	0.191***	0.297***	0.067**
	(0.047)	(0.036)	(0.026)	(0.025)
Sex of HH head	0.407***	0.390***	0.185***	0.313***
	(0.048)	(0.038)	(0.027)	(0.026)
HH size	0.447***	0.384***	0.239***	0.236***
	(0.032)	(0.025)	(0.019)	(0.019)
Age of HH head	-0.068	0.190***	0.028	0.069*
	(0.056)	(0.044)	(0.035)	(0.035)

Notes:
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Robust standard errors in parentheses.
All demographic variables included in the demand model are also included but the parameters for poverty status of the household and quarter dummies are not reported.

Table A2.8: Proportion of households with zero consumption for items in the Bread and Cereal group

Expenditure item	1991/92	1998/99	2012/13
Maize	67	63	64
Rice	33	23	16
Maize flour	52	46	34
Bread	21	15	36
Millet	87	93	87
Guinea Corn	83	91	88
Other Cereal expenditure	67	55	12
Sample size	4,523	5,998	16,772

Source: Calculations from GLSS 3, 4 and 6
Notes:
All values are expressed in percentages except the last row.

Table A2.9a: QUAIDS Parameter Estimate for Bread & Cereal group (1991/92) N=4,206

	Price of :									
Item	**Maize**	**Rice**	**Maize flour**	**Bread**	**Millet**	**Guinea corn**	**Other Cereal**	**β**	**λ**	**Resid**
Maize (Corn)	0.031***							-0.036	0.010***	0.005
	(0.009)							(0.021)	(0.003)	(0.003)
Rice	-0.024**	-0.066***						0.148***	-0.023***	0.015***
	(0.009)	(0.015)						(0.020)	(0.004)	(0.002)
Maize flour	-0.003	-0.017	0.016					0.024	-0.027***	0.003
	(0.007)	(0.009)	(0.010)					(0.023)	(0.004)	(0.003)
Bread	0.012	0.070***	-0.018	-0.065***				-0.147***	0.002	0.003
	(0.008)	(0.012)	(0.010)	(0.015)				(0.024)	(0.003)	(0.002)
Millet	0.004*	0.014***	0.005*	0.000	-0.004			-0.017	0.005***	-0.001
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)			(0.010)	(0.001)	(0.001)
Guinea Corn	-0.012***	0.018***	0.011**	0.023***	-0.013***	-0.027***		-0.011	0.021***	-0.017***
	(0.003)	(0.004)	(0.003)	(0.005)	(0.002)	(0.005)		(0.011)	(0.002)	(0.002)
Other Cereal	-0.009	0.005	0.005	-0.023**	-0.006	0.001	0.027**	0.040**	0.011***	-0.009***
	(0.006)	(0.007)	(0.005)	(0.007)	(0.004)	(0.007)	(0.009)	(0.014)	(0.003)	(0.002)

Notes:
All prices are in logarithms
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included but not shown are the demographic characteristics of households.
β and λ are the coefficients of expenditure on bread & cereal and its square respectively while resid is the coefficient of the residual from the reduced form regression of total bread and cereal expenditure.

Table A2.9b: QUAIDS Parameter Estimate for Bread & Cereal group (1998/99) N=5,911

Item	Price of : Maize	Rice	Maize flour	Bread	Millet	Guinea corn	Other Cereal	β	λ	Resid
Maize (Corn)	-0.012**							-0.057***	-0.006***	0.013***
	(0.004)							(0.012)	(0.001)	(0.002)
Rice	-0.007	0.018*						0.151***	0.002	-0.003
	(0.005)	(0.009)						(0.015)	(0.001)	(0.002)
Maize flour	-0.027***	0.029***	-0.021***					-0.104***	-0.016***	0.007***
	(0.003)	(0.004)	(0.005)					(0.016)	(0.001)	(0.002)
Bread	0.024***	0.027***	0.007	-0.061***				0.028*	0.007***	-0.008***
	(0.003)	(0.006)	(0.004)	(0.007)				(0.014)	(0.001)	(0.002)
Millet	0.006***	-0.007**	0.008***	0.003	-0.001			0.007	0.003***	-0.004***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)			(0.006)	(0.001)	(0.001)
Guinea Corn	-0.005**	0.013***	-0.006**	-0.001	0.004**	-0.014***		-0.015*	0.006***	-0.008***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)		(0.007)	(0.001)	(0.001)
Other Cereal	0.021***	-0.074***	0.009***	0.001	-0.013***	0.008***	0.047***	-0.011	0.005***	0.003
	(0.004)	(0.005)	(0.003)	(0.004)	(0.002)	(0.002)	(0.004)	(0.011)	(0.001)	(0.001)

Notes:
All prices are in logarithms
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included but not shown are the demographic characteristics of households.
β and λ are the coefficients of expenditure on bread & cereal and its square respectively while resid is the coefficient of the residual from the reduced form regression of total bread and cereal expenditure.

Table A2.9c: QUAIDS Parameter Estimate for Bread & Cereal group (2012/13) N=16,545

	Price of :									
Item	**Maize**	**Rice**	**Maize flour**	**Bread**	**Millet**	**Guinea corn**	**Other Cereal**	**β**	**λ**	**Resid**
Maize (Corn)	-0.020***							0.030***	-0.007***	0.007***
	(0.003)							(0.007)	(0.001)	(0.001)
Rice	0.009***	-0.014***						0.037***	-0.002***	-0.002
	(0.002)	(0.002)						(0.009)	(0.001)	(0.001)
Maize flour	0.001	0.020***	0.003					-0.074***	0.004***	-0.005
	(0.003)	(0.002)	(0.004)					(0.010)	(0.001)	(0.001)
Bread	-0.018***	0.009***	-0.003	-0.018***				0.031**	-0.008***	0.003***
	(0.003)	(0.002)	(0.003)	(0.004)				(0.011)	(0.001)	(0.001)
Millet	0.022***	0.009***	0.010***	0.006***	-0.005***			-0.020***	0.008***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)			(0.004)	(0.000)	(0.000)
Guinea Corn	0.013***	0.000	0.001	0.004**	-0.008***	-0.004		-0.030***	0.004***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)		(0.003)	(0.000)	(0.000)
Other Cereal	-0.006	-0.032***	-0.029***	0.021***	-0.034***	-0.009***	0.090***	0.025*	0.001	-0.002*
	(0.004)	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.007)	(0.013)	(0.001)	(0.001)

Notes:
All prices are in logarithms
(* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$).
Standard errors are in parentheses.
Included but not shown are the demographic characteristics of households.
β and λ are the coefficients of expenditure on bread & cereal and its square respectively while resid is the coefficient of the residual from the reduced form regression of total bread and cereal expenditure.

Table A2.10a: Price elasticities (1991/92) N=4,206

Item	Price of: Maize	Rice	M. flour	Bread	Millet	G. Corn	OthCe
	Mashallian (uncompensated) price elasticities						
Maize	-0.703	0.366	-0.109	-0.022	0.043	-0.096	-0.091
	(0.087)	(0.087)	(0.067)	(0.077)	(0.018)	(0.034)	(0.058)
Rice	0.085	-1.180	-0.014	0.204	0.042	0.043	0.007
	(0.028)	(0.052)	(0.029)	(0.040)	(0.008)	(0.014)	(0.023)
M. flour	-0.019	0.001	-0.816	-0.141	0.018	0.030	0.016
	(0.040)	(0.053)	(0.056)	(0.052)	(0.012)	(0.020)	(0.028)
Bread	0.054	0.282	-0.033	-1.021	0.004	0.075	-0.054
	(0.025)	(0.037)	(0.028)	(0.043)	(0.009)	(0.017)	(0.023)
Millet	0.318	0.810	0.124	-0.149	-1.282	-1.043	-0.504
	(0.162)	(0.236)	(0.182)	(0.217)	(0.174)	(0.193)	(0.307)
G. Corn	-0.376	-0.105	-0.125	0.173	-0.347	-1.651	0.028
	(0.102)	(0.110)	(0.101)	(0.142)	(0.064)	(0.135)	(0.185)
OthCe	-0.154	-0.107	-0.048	-0.506	-0.090	0.053	-0.565
	(0.095)	(0.116)	(0.077)	(0.116)	(0.058)	(0.104)	(0.145)
	Hicksian (compensated) price elasticities						
Maize	-0.568	0.031	0.122	0.412	0.059	-0.048	-0.008
	(0.087)	(0.082)	(0.067)	(0.078)	(0.018)	(0.035)	(0.058)
Rice	0.014	-0.890	0.156	0.521	0.054	0.078	0.068
	(0.028)	(0.052)	(0.029)	(0.039)	(0.008)	(0.014)	(0.023)
M. flour	0.073	0.269	-0.659	0.153	0.029	0.062	0.072
	(0.039)	(0.050)	(0.057)	(0.051)	(0.012)	(0.020)	(0.028)
Bread	0.124	0.487	0.086	-0.798	0.012	0.099	-0.011
	(0.024)	(0.036)	(0.028)	(0.043)	(0.009)	(0.017)	(0.023)
Millet	0.492	1.320	0.421	0.408	-1.262	-0.982	-0.397
	(0.157)	(0.210)	(0.178)	(0.255)	(0.173)	(0.195)	(0.305)
G. Corn	-0.134	0.605	0.289	0.948	-0.319	-1.566	0.177
	(0.099)	(0.113)	(0.097)	(0.152)	(0.064)	(0.135)	(0.182)
OthCe	-0.011	0.312	0.196	-0.049	-0.073	0.103	-0.477
	(0.094)	(0.112)	(0.076)	(0.118)	(0.058)	(0.104)	(0.145)

Source: Author's calculation from the GLSS 3

Notes:

All prices are in logarithms

The figures in parenthesis are standard errors and are obtained using the delta method.

M. flour represents maize flour while G. Corn represents Guinea Corn and OthCe represent other expenditure

Table A2.10b: Price elasticities (1998/99) N=5,911

Item	Price of: Maize	Rice	M. flour	Bread	Millet	G. Corn	OthCe
	Mashallian (uncompensated) price elasticities						
Maize	-1.109	0.067	-0.256	0.181	0.060	-0.047	0.186
	(0.042)	(0.043)	(0.027)	(0.033)	(0.013)	(0.016)	(0.037)
Rice	0.028	-0.976	0.068	0.023	-0.021	0.041	-0.234
	(0.014)	(0.027)	(0.012)	(0.018)	(0.007)	(0.008)	(0.016)
M. flour	-0.138	0.200	-1.083	0.038	0.045	-0.037	0.047
	(0.017)	(0.024)	(0.025)	(0.021)	(0.008)	(0.010)	(0.015)
Bread	0.092	0.136	0.046	-1.127	0.010	-0.002	0.029
	(0.013)	(0.022)	(0.013)	(0.021)	(0.006)	(0.006)	(0.015)
Millet	0.403	-0.807	0.461	-0.036	-1.065	0.311	-1.051
	(0.106)	(0.191)	(0.091)	(0.129)	(0.113)	(0.101)	(0.161)
G. Corn	-0.297	0.365	-0.446	-0.265	0.184	-1.628	0.328
	(0.076)	(0.126)	(0.077)	(0.077)	(0.060)	(0.099)	(0.100)
OthCe	0.303	-1.034	0.141	0.123	-0.189	0.121	-0.296
	(0.056)	(0.077)	(0.034)	(0.057)	(0.029)	(0.031)	(0.062)
	Hicksian (compensated) price elasticities						
Maize	-0.999	0.285	-0.070	0.474	0.074	-0.024	0.259
	(0.042)	(0.044)	(0.028)	(0.033)	(0.013)	(0.016)	(0.037)
Rice	0.090	-0.599	0.268	0.338	-0.007	0.066	-0.156
	(0.014)	(0.027)	(0.012)	(0.018)	(0.007)	(0.008)	(0.016)
M. flour	-0.041	0.511	-0.919	0.297	0.058	-0.017	0.111
	(0.016)	(0.023)	(0.025)	(0.020)	(0.008)	(0.010)	(0.014)
Bread	0.178	0.409	0.190	-0.899	0.020	0.016	0.086
	(0.012)	(0.022)	(0.013)	(0.022)	(0.006)	(0.006)	(0.014)
Millet	0.589	-0.209	0.777	0.462	-1.042	0.350	-0.927
	(0.107)	(0.184)	(0.105)	(0.122)	(0.113)	(0.101)	(0.155)
G. Corn	-0.113	0.953	-0.134	0.226	0.207	-1.589	0.450
	(0.077)	(0.127)	(0.079)	(0.072)	(0.060)	(0.099)	(0.097)
OthCe	0.390	-0.756	0.288	0.355	-0.178	0.139	-0.239
	(0.056)	(0.076)	(0.036)	(0.057)	(0.029)	(0.031)	(0.061)

Source: Author's calculation from the GLSS 4
Notes:
All prices are in logarithms
The figures in parenthesis are standard errors and are obtained using the delta method.
M. flour represents maize flour while G. Corn represents Guinea Corn and OthCe represent other expenditure

Table A2.10c: Price elasticities (2012/13) N=16,545

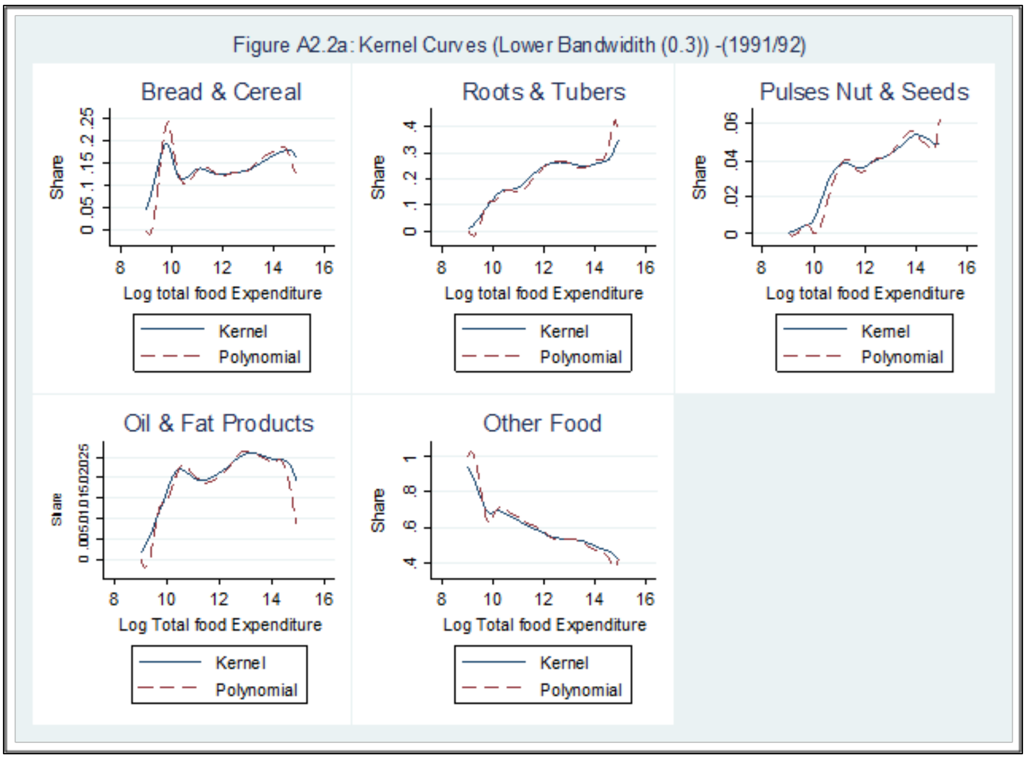
Item	Price of: Maize	Rice	M. flour	Bread	Millet	G. Corn	OthCe
	Mashallian (uncompensated) price elasticities						
Maize	-1.044	0.153	-0.043	-0.074	0.125	0.060	-0.064
	(0.021)	(0.015)	(0.018)	(0.021)	(0.007)	(0.006)	(0.034)
Rice	0.063	-1.054	0.083	0.059	0.025	-0.008	-0.146
	(0.008)	(0.010)	(0.009)	(0.009)	(0.003)	(0.003)	(0.015)
M. flour	-0.042	0.066	-0.993	-0.062	0.080	0.023	-0.159
	(0.009)	(0.008)	(0.015)	(0.010)	(0.005)	(0.004)	(0.016)
Bread	-0.022	0.174	0.008	-0.963	-0.045	-0.008	0.256
	(0.015)	(0.013)	(0.015)	(0.022)	(0.007)	(0.006)	(0.030)
Millet	0.370	-0.297	0.349	-0.774	-0.634	-0.149	-2.410
	(0.035)	(0.029)	(0.048)	(0.059)	(0.045)	(0.033)	(0.114)
G. Corn	0.309	-0.330	0.149	-0.253	-0.182	-0.825	-0.798
	(0.042)	(0.036)	(0.047)	(0.067)	(0.043)	(0.054)	(0.114)
OthCe	-0.032	-0.110	-0.088	0.072	-0.112	-0.027	-0.679
	(0.010)	(0.008)	(0.010)	(0.013)	(0.006)	(0.005)	(0.028)
	Hicksian (compensated) price elasticities						
Maize	-0.952	0.348	0.138	0.056	0.142	0.073	0.194
	(0.021)	(0.015)	(0.017)	(0.021)	(0.007)	(0.006)	(0.030)
Rice	0.164	-0.839	0.282	0.202	0.045	0.007	0.139
	(0.007)	(0.011)	(0.008)	(0.009)	(0.003)	(0.003)	(0.012)
M. flour	0.071	0.305	-0.771	0.097	0.101	0.040	0.158
	(0.009)	(0.008)	(0.014)	(0.010)	(0.005)	(0.004)	(0.013)
Bread	0.040	0.306	0.130	-0.875	-0.033	0.002	0.431
	(0.015)	(0.013)	(0.014)	(0.023)	(0.007)	(0.006)	(0.026)
Millet	0.737	0.483	1.071	-0.255	-0.564	-0.096	-1.376
	(0.038)	(0.032)	(0.051)	(0.052)	(0.046)	(0.033)	(0.094)
G. Corn	0.509	0.095	0.542	0.029	-0.143	-0.796	-0.235
	(0.044)	(0.037)	(0.050)	(0.063)	(0.043)	(0.053)	(0.102)
OthCe	0.069	0.105	0.110	0.215	-0.093	-0.012	-0.394
	(0.011)	(0.009)	(0.009)	(0.013)	(0.006)	(0.005)	(0.025)

Source: Author's calculation from the GLSS 6
Notes:
All prices are in logarithms
The figures in parenthesis are standard errors and are obtained using the delta method.
M. flour represents maize flour while G. Corn represents Guinea Corn and OthCe represent other expenditure

Table A.2.11a: Expenditure elasticities by quintile (2012/2013) N=16,545

Item	1	2	3	4	5
Maize	0.897	0.902	0.896	0.875	0.818
	(0.022)	(0.027)	(0.030)	(0.037)	(0.052)
Rice	0.944	0.974	0.982	0.986	0.988
	(0.025)	(0.020)	(0.019)	(0.019)	(0.019)
Miaze flour	1.093	1.090	1.086	1.085	1.082
	(0.014)	(0.017)	(0.020)	(0.024)	(0.036)
Bread	0.290	0.564	0.634	0.666	0.675
	(0.044)	(0.031)	(0.027)	(0.026)	(0.027)
Millet	2.467	2.913	4.199	5.057	6.849
	(0.065)	(0.088)	(0.148)	(0.189)	(0.272)
Guinea Corn	1.558	1.895	1.978	2.504	3.819
	(0.045)	(0.084)	(0.100)	(0.165)	(0.336)
OthCe	0.942	0.959	0.970	0.983	0.997
	(0.025)	(0.023)	(0.021)	(0.018)	(0.015)

Source: Author's calculation from the GLSS 6
Notes:
All prices are in logarithms
The figures in parenthesis are standard errors and are obtained using the delta method.



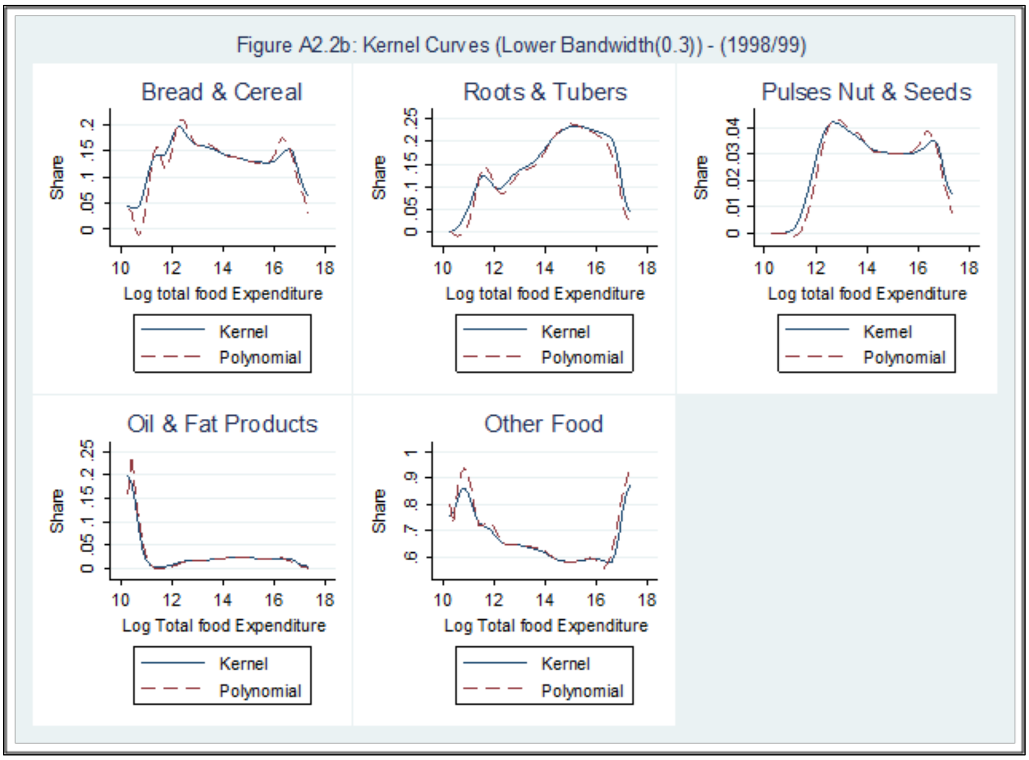


Figure A2.2b: Kernel Curves (Lower Bandwidth(0.3)) - (1998/99)
Bread & Cereal
Roots & Tubers
Pulses Nut & Seeds
Oil & Fat Products
Other Food
Share
Log total food Expenditure
Log Total food Expenditure
Kernel
Polynomial

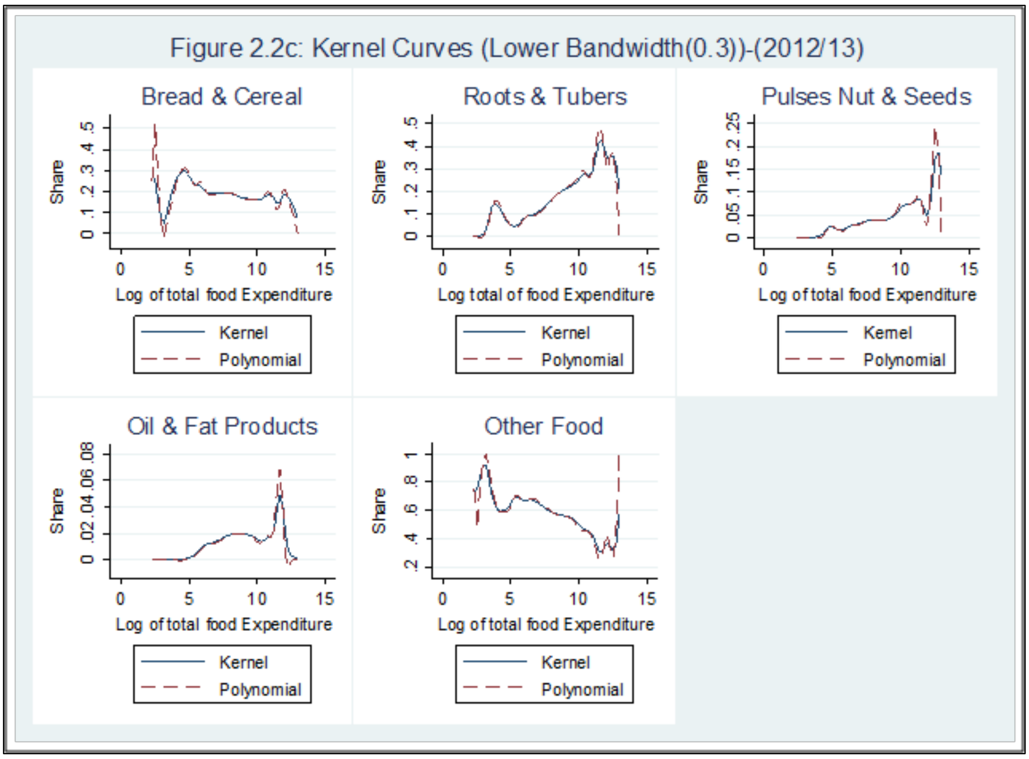


Figure 2.2c: Kernel Curves (Lower Bandwidth(0.3))-(2012/13)
Bread & Cereal
Roots & Tubers
Pulses Nut & Seeds
Oil & Fat Products
Other Food
Share
Log of total food Expenditure
Log total of food Expenditure
Kernel
Polynomial

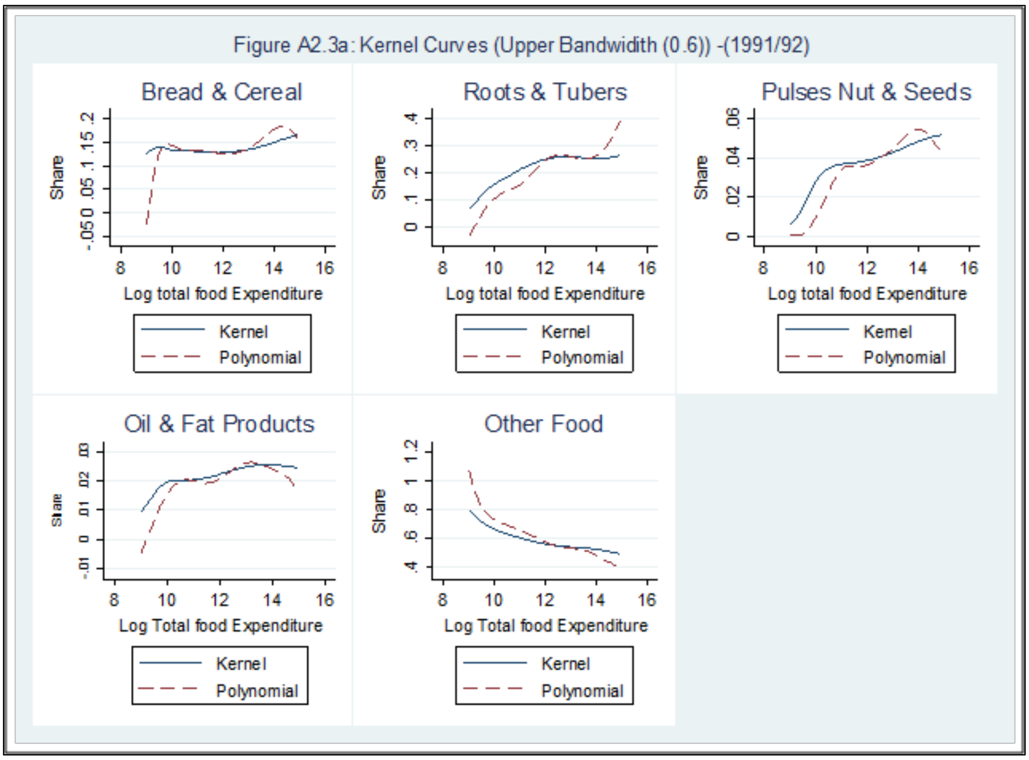


Figure A2.3a: Kernel Curves (Upper Bandwidth (0.6)) -(1991/92)
Bread & Cereal
Roots & Tubers
Pulses Nut & Seeds
Oil & Fat Products
Other Food
Share
Log total food Expenditure
Log Total food Expenditure
Kernel
Polynomial

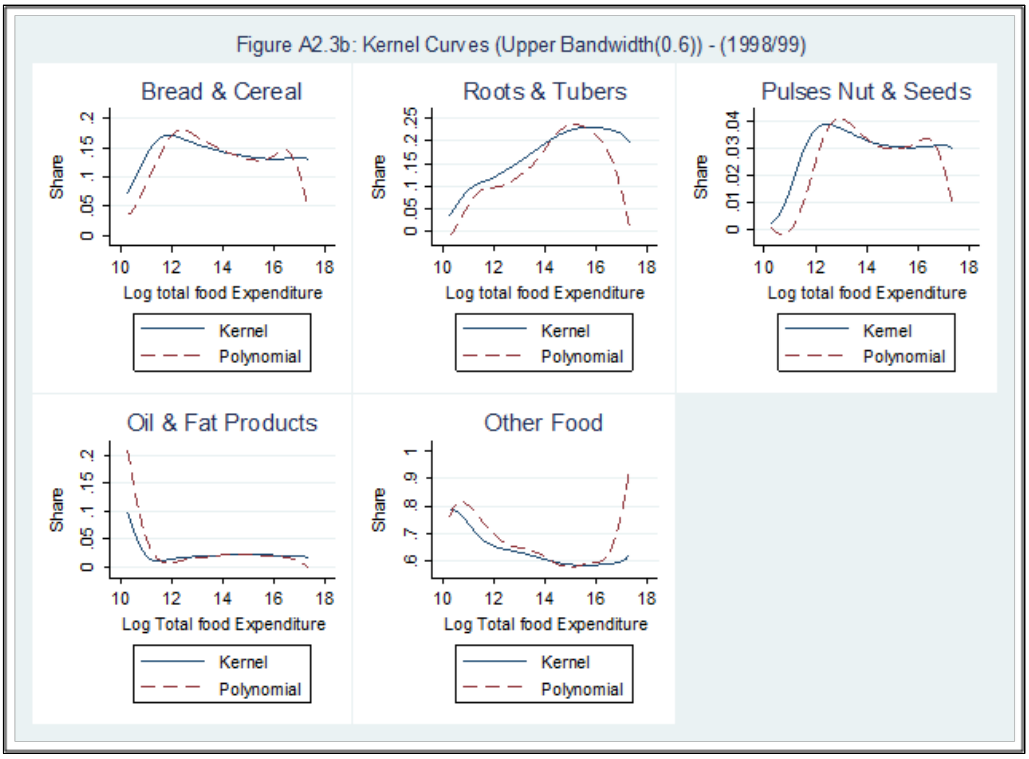


Figure A2.3b: Kernel Curves (Upper Bandwidth(0.6)) - (1998/99)
Bread & Cereal
Roots & Tubers
Pulses Nut & Seeds
Oil & Fat Products
Other Food
Share
Log total food Expenditure
Log Total food Expenditure
Kernel
Polynomial

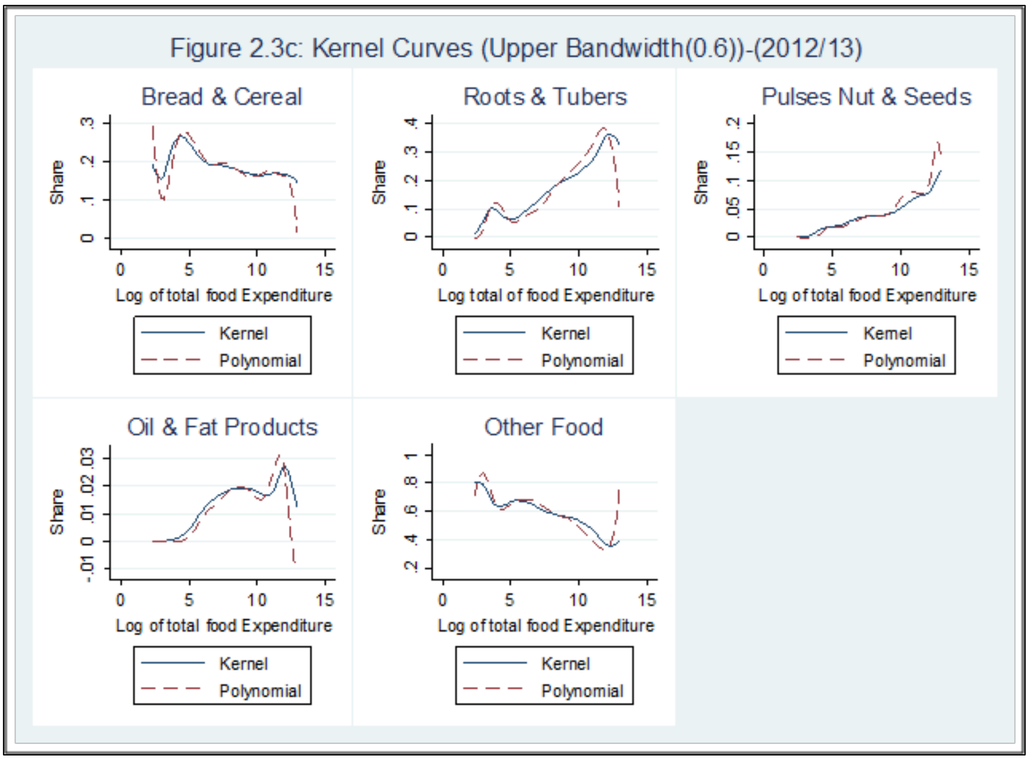


Figure 2.3c: Kernel Curves (Upper Bandwidth(0.6))-(2012/13)
Bread & Cereal
Share
0 .1 .2 .3
0 5 10 15
Log of total food Expenditure
Kernel
Polynomial
Roots & Tubers
Share
0 .1 .2 .3 .4
0 5 10 15
Log total of food Expenditure
Kernel
Polynomial
Pulses Nut & Seeds
Share
0 .05 .1 .15 .2
0 5 10 15
Log of total food Expenditure
Kernel
Polynomial
Oil & Fat Products
Share
-.01 0 .01 .02 .03
0 5 10 15
Log of total food Expenditure
Kernel
Polynomial
Other Food
Share
.2 .4 .6 .8 1
0 5 10 15
Log of total food Expenditure
Kernel
Polynomial

Figure A2.2: Map of Ghana

Appendix B

Table A3.1: Visits and Day-interval for data collection

	No. of visits		Days interval of Visit	
Data set	**Urban**	**Rural**	**Urban**	**Rural**
GLSS 3 (1991/92)	11	8	3	2
GLSS 4 (1998/99)	7	7	5	5
GLSS 5 (2005/06)	11	11	3	3
GLSS 6 (2012/13)	7	7	3	3

Source: Compilation from GLSS 3, 4, 5 and 6 reports

Table A3.2: Consumer Price index and Year/Year inflation Dec 1990-Dec 2012 (2002=100)

	Combine		Food		Non-food	
Month/Year	**Index**	**Year-on-year inflation**	**Index**	**Year-on-year inflation**	**Index**	**Year-on-year inflation**
Dec-90	6.9	35.9	9.3	32.0	5.7	38.1
Dec-91	7.6	10.3	9.7	4.6	6.5	13.3
Dec-92	9.8	28.6	13.0	34.2	8.1	25.9
Dec-93	11.0	12.5	14.3	10.1	9.3	13.7
Dec-94	14.7	34.2	20.0	40.2	12.1	31.2
Dec-95	25.1	70.8	33.5	67.2	21.0	72.8
Dec-96	33.3	32.7	40.5	20.8	29.1	38.8
Dec-97	40.2	20.5	45.3	11.8	36.7	26.0
Dec-98	46.5	15.7	55.1	21.8	40.5	10.3
Dec-99	52.9	13.8	58.7	6.6	48.9	20.8
Dec-00	74.4	40.5	73.0	24.3	75.4	54.2
Dec-01	90.2	21.3	85.2	16.7	93.9	24.5
Dec-02	105.5	17.0	101.1	18.7	109.1	16.2
Dec-03	138.5	31.3	135.2	33.6	141.3	29.5
Dec-04	161.3	16.4	155.6	15.1	166.0	17.5
Dec-05	183.7	13.9	177.8	14.3	188.5	13.6
Dec-06	203.8	10.9	191.2	7.5	214.1	13.5
Dec-07	229.8	12.7	211.3	10.5	244.8	14.4
Dec-08	271.5	18.1	246.7	16.7	291.7	19.1
Dec-09	314.8	15.9	275.9	11.8	346.6	18.8
Dec-10	341.8	8.6	288.3	4.5	385.5	11.2
Dec-11	371.2	8.6	300.6	4.3	428.7	11.2
Dec-12	404.0	8.8	312.5	4.0	478.6	11.6

Source: Ghana Statistical Service (GSS)

Table A3.3a: Average Expenditure share (%) by Region (1991/1992) N=4,523

Commodity Group	**Western**	**Central**	**G. Accra**	**Volta**	**Eastern**	**Ashanti**	**B. Ahafo**	**Northern**	**Upper East**	**Upper West**
Bread & Cereals	0.085	0.100	0.142	0.091	0.174	0.105	0.084	0.255	0.244	0.370
Roots, Tubers & Plantain	0.290	0.258	0.124	0.293	0.217	0.287	0.335	0.124	0.055	0.054
Pulses, Nuts & Seeds	0.025	0.035	0.027	0.033	0.039	0.032	0.033	0.070	0.135	0.127
Vegetables & Fruits	0.109	0.102	0.095	0.110	0.104	0.096	0.099	0.086	0.113	0.054
Meat	0.031	0.023	0.064	0.046	0.037	0.067	0.060	0.052	0.065	0.034
Fish	0.229	0.220	0.122	0.216	0.205	0.151	0.169	0.064	0.039	0.027
Oils & Fat Products	0.022	0.023	0.023	0.026	0.027	0.031	0.026	0.017	0.001	0.004
Non- Alcoholic Drinks	0.007	0.010	0.020	0.006	0.006	0.011	0.007	0.005	0.005	0.001
Other Food Expenditure	0.202	0.229	0.384	0.178	0.191	0.221	0.187	0.327	0.343	0.330
Food Expenditure	0.615	0.631	0.499	0.612	0.616	0.550	0.580	0.650	0.684	0.774

Source: Author's calculation from GLSS 3

Table A3.3b: Average Expenditure share (%) by Region (1998/1999) N=5,998

Commodity Group	Western	Central	G. Accra	Volta	Eastern	Ashanti	B. Ahafo	Northern	Upper East	Upper West
Bread & Cereals	0.122	0.110	0.129	0.171	0.121	0.116	0.112	0.255	0.290	0.230
Roots, Tubers & Plantain	0.261	0.230	0.115	0.185	0.257	0.238	0.291	0.099	0.043	0.033
Pulses, Nuts & Seeds	0.023	0.027	0.026	0.042	0.026	0.020	0.027	0.063	0.060	0.097
Vegetables & Fruits	0.024	0.017	0.024	0.023	0.016	0.019	0.035	0.037	0.014	0.023
Meat	0.012	0.007	0.016	0.010	0.014	0.013	0.010	0.018	0.012	0.022
Fish	0.078	0.101	0.066	0.072	0.060	0.081	0.084	0.031	0.012	0.028
Oil & Fat Products	0.019	0.026	0.017	0.027	0.024	0.025	0.020	0.017	0.001	0.007
Non- Alcoholic Drinks	0.012	0.007	0.015	0.011	0.009	0.010	0.009	0.015	0.006	0.013
Other Food Expenditure	0.448	0.474	0.591	0.459	0.474	0.479	0.412	0.465	0.561	0.545
Food Expenditure	0.589	0.633	0.535	0.598	0.599	0.589	0.656	0.648	0.720	0.661

Source: Author's calculation from GLSS 4

Table A3.3c: Average Expenditure share (%) by Region (2012/2013) N=16,772

Commodity Group	Western	Central	G. Accra	Volta	Eastern	Ashanti	B. Ahafo	Northern	Upper East	Upper West
Bread & Cereals	0.131	0.138	0.138	0.191	0.140	0.116	0.118	0.241	0.357	0.314
Roots, Tubers & Plantain	0.235	0.211	0.105	0.210	0.219	0.202	0.327	0.175	0.032	0.087
Pulses, Nuts & Seeds	0.022	0.027	0.016	0.030	0.022	0.019	0.027	0.065	0.100	0.092
Vegetables & Fruits	0.136	0.150	0.176	0.142	0.144	0.159	0.129	0.143	0.139	0.156
Meat	0.066	0.048	0.082	0.061	0.065	0.101	0.111	0.076	0.064	0.066
Fish	0.193	0.177	0.164	0.180	0.215	0.160	0.132	0.099	0.078	0.060
Oil & Fat Products	0.016	0.026	0.019	0.024	0.020	0.016	0.015	0.019	0.015	0.010
Non- Alcoholic Drinks	0.022	0.020	0.027	0.012	0.014	0.018	0.014	0.018	0.010	0.017
Other Food Expenditure	0.180	0.203	0.272	0.150	0.160	0.209	0.128	0.165	0.205	0.198
Food Expenditure	0.514	0.551	0.494	0.564	0.560	0.518	0.546	0.617	0.622	0.570

Source: Author's calculation from GLSS 6

Table A3.4a: Average Expenditure share (%) by Locality and Ecological Zone (1991/1992) N=4,523

	Locality		Ecological Zone		
Commodity	**Urban**	**Rural**	**Coastal**	**Forest**	**Savannah**
Bread & Cereals	0.134	0.140	0.132	0.093	0.218
Roots, Tubers & Plantain	0.179	0.258	0.187	0.297	0.182
Pulses, Nuts & Seeds	0.029	0.049	0.030	0.032	0.076
Vegetables & Fruits	0.098	0.098	0.100	0.103	0.089
Meat	0.070	0.037	0.045	0.055	0.045
Fish	0.128	0.182	0.175	0.188	0.099
Oil & Fat Products	0.026	0.022	0.023	0.028	0.016
Non- Alcoholic Drinks	0.016	0.005	0.014	0.008	0.004
Other Food Expenditure	0.319	0.208	0.294	0.195	0.270
Food Expenditure	0.528	0.637	0.573	0.579	0.664

Source: Author's calculation from GLSS3

Table A3.4b: Average Expenditure share (%) by Locality and Ecological Zone (1998/1999) N=5,998

	Locality		Ecological Zone		
Commodity group	**Urban**	**Rural**	**Coastal**	**Forest**	**Savannah**
Bread & Cereals	0.132	0.145	0.131	0.121	0.202
Roots, Tubers & Plantain	0.149	0.234	0.160	0.257	0.154
Pulses, Nuts & Seeds	0.027	0.036	0.029	0.024	0.059
Vegetables & Fruits	0.020	0.024	0.021	0.020	0.030
Meat	0.014	0.012	0.012	0.013	0.015
Fish	0.067	0.073	0.080	0.074	0.046
Oil & Fat Products	0.022	0.021	0.022	0.023	0.016
Non- Alcoholic Drinks	0.015	0.008	0.013	0.009	0.011
Other Food Expenditure	0.555	0.446	0.533	0.459	0.467
Food Expenditure	0.548	0.636	0.574	0.603	0.659

Source: Author's calculation from GLSS 4

Table A3.4c: Average Expenditure share (%) by Locality and Ecological Zone (2012/2013) N=16,772

	Locality		Ecological Zone		
Commodity group	**Urban**	**Rural**	**Coastal**	**Forest**	**Savannah**
Bread & Cereals	0.148	0.209	0.175	0.130	0.263
Roots, Tubers & Plantain	0.151	0.208	0.151	0.240	0.150
Pulses, Nuts & Seeds	0.023	0.053	0.025	0.022	0.074
Vegetables & Fruits	0.159	0.139	0.155	0.142	0.144
Meat	0.090	0.063	0.059	0.078	0.075
Fish	0.159	0.141	0.182	0.183	0.091
Oil & Fat Products	0.020	0.017	0.022	0.019	0.015
Non- Alcoholic Drinks	0.025	0.011	0.023	0.016	0.014
Other Food Expenditure	0.226	0.159	0.210	0.171	0.173
Food Expenditure	0.490	0.603	0.530	0.542	0.594

Source: Author's calculation from GLSS 6

Table A3.5: Test of Exogeneity & Test of Over-identifying Restrictions

Budget shares	1991/92[a] Test of exogeneity (p-values)	1991/92[a] Test of Over-identifying restrictions (p-values)	1998/99[a] Test of exogeneity (p-values)	1998/99[a] Test of Over-identifying restrictions (p-values)	2012/13[b] Test of exogeneity (p-values)	2012/13[b] Test of Over-identifying restrictions (p-values)
Bread & Cereal	0.0141	0.2579	0.0000	0.4998	0.0000	0.4549
Roots, Tubers & Plantain	0.0000	0.1584	0.0000	0.3932	0.0000	0.3667
Pulses, Nut & Seeds	0.0115	0.6766	0.3353	0.0951	0.0002	0.1179
Vegetables & Fruits	0.4263	0.9626	0.0000	0.6285	0.0205	0.2531
Meat	0.8496	0.8302	0.7333	0.1212	0.0000	0.0035
Fish	0.0000	0.2069	0.0002	0.1032	0.0000	0.1294
Oil & Fat Products	0.3648	0.6060	0.5557	0.5762	0.1056	0.1300
Non-Alcoholic Drinks	0.0106	0.6000	0.1289	0.6134	0.0000	0.6075
Other food Expenditure	0.4435	0.7515	0.0000	0.8681	0.0000	0.3757
Sample size	4,523	4,523	5,998	5,998	16,772	16,772

Notes:

[a]Instrumented: Total food expenditure; Instruments: Total income and average cluster income minus the index household's income

[b]Instrumented: Total food expenditure; Instruments: Total income and landownership status of the household

***Test of Exogeneity*:** Wooldridge's (1995) robust score test and a robust regression-based test are reported. If the test statistic is significant, the variables being tested must be treated as endogenous.

Tests of Over-identifying Restrictions: Basmann's (1960) chi-squared tests are reported, as is Wooldridge's (1995) robust score test. A statistically significant test statistic always indicates that the instruments may not be valid.

Table A3.6a: Multivariate Probit estimate for 1991/92 (N=4,523)

	Bread & Cereal	Roots & Tubers	Pulses Nut & Seeds	Vegetables & Fruits	Meat	Fish	Oil & Fat	Non-Alcoholic
Food expenditure (log)	0.690***	0.930***	0.735***	0.896***	0.844***	0.472***	0.789***	0.821***
	(0.061)	(0.069)	(0.046)	(0.093)	(0.043)	(0.055)	(0.044)	(0.046)
Price of (log):								
Bread & Cereals	-0.315*	-0.325*	-0.227*	-0.466*	0.100	-0.112	-0.341***	-0.002
	(0.138)	(0.154)	(0.102)	(0.222)	(0.093)	(0.131)	(0.095)	(0.100)
Roots, Tubers & Plantain	0.081	-0.067	0.289***	0.285	-0.079	-0.031	-0.204***	-0.033
	(0.086)	(0.100)	(0.071)	(0.161)	(0.059)	(0.087)	(0.058)	(0.065)
Pulses, Nut & Seeds	-0.219	0.480**	0.182	0.045	-0.075	-0.065	0.559***	0.023
	(0.140)	(0.173)	(0.101)	(0.214)	(0.095)	(0.142)	(0.099)	(0.097)
Vegetables & Fruits	-0.052	0.001	-0.163*	-0.498**	0.127	-0.011	0.113	-0.078
	(0.101)	(0.122)	(0.078)	(0.173)	(0.070)	(0.104)	(0.072)	(0.074)
Meat	-0.147	0.198*	-0.096	0.025	0.196***	0.231**	0.556***	0.260***
	(0.075)	(0.089)	(0.058)	(0.140)	(0.051)	(0.074)	(0.053)	(0.060)
Fish	0.158	0.001	-0.083	-0.210	0.087	0.013	-0.090	-0.025
	(0.118)	(0.101)	(0.088)	(0.207)	(0.080)	(0.097)	(0.084)	(0.085)
Oil & Fat Products	0.026	0.387***	0.040	-0.270	-0.249**	0.351***	0.227**	-0.242**
	(0.115)	(0.108)	(0.083)	(0.199)	(0.077)	(0.101)	(0.079)	(0.084)
Non-Alcoholic Drinks	0.051	-0.291*	-0.192**	-0.518***	0.085	0.028	-0.320***	-0.048
	(0.104)	(0.114)	(0.073)	(0.155)	(0.067)	(0.097)	(0.068)	(0.070)
Other Food	-0.318**	0.420***	0.410***	1.011***	0.121	0.114	0.283***	-0.090
	(0.105)	(0.124)	(0.074)	(0.175)	(0.067)	(0.104)	(0.070)	(0.067)
Demographic variables								
HH size	-0.049	0.154**	0.154***	0.299***	-0.017	0.309***	-0.002	-0.241***
	(0.052)	(0.059)	(0.038)	(0.082)	(0.036)	(0.051)	(0.036)	(0.037)

Notes:
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Standard errors in parentheses.
Household characteristics and demographic variables included are region, sex of household head, household size, locality and age of household head but only the estimate for household size is reported.

Table A3.6b: Multivariate Probit estimate for 1998/99 (N=5,998)

	Bread & Cereal	Roots & Tubers	Pulses Nut & Seeds	Vegetables & Fruits	Meat	Fish	Oil & Fat	Non-Alcoholic
Food expenditure (log)	0.751***	0.824***	0.553***	0.400***	0.652***	0.487***	0.609***	0.472***
	(0.069)	(0.054)	(0.034)	(0.031)	(0.034)	(0.039)	(0.032)	(0.030)
Price of (log):								
Bread & Cereals	-0.191**	0.231**	0.234***	0.039	-0.072	0.160**	0.262***	0.074*
	(0.065)	(0.085)	(0.044)	(0.036)	(0.042)	(0.054)	(0.041)	(0.033)
Roots, Tubers & Plantain	0.014	-0.642***	-0.326***	-0.164***	-0.109*	-0.258***	-0.332***	0.001
	(0.101)	(0.093)	(0.047)	(0.044)	(0.046)	(0.066)	(0.045)	(0.039)
Pulses, Nut & Seeds	0.016	0.476***	-0.039	0.038	0.024	0.316***	0.092*	-0.039
	(0.059)	(0.130)	(0.034)	(0.033)	(0.040)	(0.083)	(0.040)	(0.030)
Vegetables & Fruits	0.022	0.062	0.032	-0.033	-0.116***	-0.068*	0.066**	-0.197***
	(0.050)	(0.044)	(0.024)	(0.021)	(0.022)	(0.029)	(0.022)	(0.019)
Meat	-0.239	-0.007	0.079	0.050	0.140*	-0.110	0.073	0.218***
	(0.149)	(0.107)	(0.071)	(0.063)	(0.063)	(0.078)	(0.063)	(0.058)
Fish	-0.014	-0.034	-0.017	0.042	0.053	0.009	0.003	-0.052
	(0.113)	(0.101)	(0.047)	(0.042)	(0.044)	(0.059)	(0.045)	(0.038)
Oil & Fat	0.212	-0.368*	0.101	-0.423***	0.490***	-0.680***	-0.400***	0.199**
	(0.210)	(0.152)	(0.090)	(0.080)	(0.080)	(0.110)	(0.082)	(0.074)
Non-alcoholic drinks	0.107	-0.092	0.069	0.105**	0.143***	0.115*	0.044	0.075*
	(0.082)	(0.066)	(0.036)	(0.033)	(0.032)	(0.049)	(0.034)	(0.030)
Other Foods	0.023	0.082	-0.069	0.370***	0.484**	-0.269***	-0.274	-0.145*
	(0.211)	(0.981)	(0.548)	(0.493)	(0.500)	(0.661)	(0.507)	(0.458)
Demographic variables								
HH size	0.061	0.210***	0.185***	-0.039	-0.018	-0.133***	0.049	0.092**
	(0.069)	(0.053)	(0.033)	(0.030)	(0.032)	(0.040)	(0.031)	(0.028)

Notes:
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Standard errors in parentheses.
Household characteristics and demographic variables included are region, sex of household head, household size, locality and age of household head but only the estimate for household size is reported.

Table A3.6c: Multivariate Probit estimate for 2012/13 (N=16,772)

	Bread & Cereal	Roots, Tubers &Plantain	Pulses Nut & Seeds	Vegetable & Fruits	Meat	Fish	Oil & Fat	Non-Alcoholic drinks
Food expenditure (log)	0.552***	0.734***	0.550***	0.710***	0.767***	0.777***	0.566***	0.468***
	(0.024)	(0.020)	(0.016)	(0.032)	(0.017)	(0.022)	(0.016)	(0.015)
Price of (log):								
Bread & Cereals	0.061	-0.069*	0.091***	-0.063	-0.050*	0.050	0.083***	0.005
	(0.037)	(0.029)	(0.020)	(0.055)	(0.020)	(0.031)	(0.019)	(0.018)
Roots, Tubers & Plantain	-0.057	-0.008	0.050	-0.050	-0.073**	-0.094*	-0.199***	-0.003
	(0.056)	(0.037)	(0.028)	(0.080)	(0.028)	(0.043)	(0.026)	(0.025)
Pulses, Nut & Seeds	0.094*	-0.028	0.224***	0.237***	0.057*	0.057	0.001	0.118***
	(0.044)	(0.030)	(0.022)	(0.062)	(0.022)	(0.034)	(0.021)	(0.021)
Vegetables & Fruits	0.183**	-0.314***	0.010	0.019	-0.024	0.100*	0.105***	-0.117***
	(0.062)	(0.041)	(0.030)	(0.093)	(0.030)	(0.047)	(0.029)	(0.028)
Meat	-0.196***	-0.261***	0.002	-0.006	-0.222***	-0.172***	-0.170***	-0.018
	(0.056)	(0.042)	(0.030)	(0.081)	(0.031)	(0.047)	(0.029)	(0.027)
Fish	0.064	0.131***	-0.047*	0.097	-0.010	-0.254***	0.005	0.121***
	(0.044)	(0.032)	(0.022)	(0.067)	(0.023)	(0.034)	(0.022)	(0.021)
Oil & Fat Products	0.051	0.015	-0.103***	-0.036	0.002	0.066*	0.037	-0.053*
	(0.032)	(0.030)	(0.023)	(0.066)	(0.020)	(0.028)	(0.020)	(0.021)
Non-Alcoholic drinks	0.065	0.048	0.000	-0.016	-0.097***	-0.008	0.055*	-0.110***
	(0.046)	(0.032)	(0.025)	(0.070)	(0.025)	(0.036)	(0.023)	(0.023)
Other Food	0.957	-0.704	0.887***	0.755	0.304***	0.258	0.038***	0.815**
	(0.533)	(0.423)	(0.283)	(0.828)	(0.290)	(0.450)	(0.274)	(0.258)
Demographic variables								
HH size	0.239***	0.104***	0.092***	0.139**	-0.015	0.165***	0.063***	-0.158***
	(0.034)	(0.025)	(0.018)	(0.052)	(0.019)	(0.027)	(0.018)	(0.017)

Notes:
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Standard errors in parentheses.
Household characteristics and demographic variables included are region, sex of household head, household size, locality and age of household head but only the estimate for household size is reported.

Table A3.7a: Price Elasticities for 1991/92 (N=4,523)

Price of:	Bread & Cereals	Root, Tuber & Plantain	Pulses, Nuts & Seeds	Vegetables & Fruits	Meat	Fish	Oil & Fat	Non-Alcohol drinks	Other food Exp
Marshallian (uncompensated) Price Elasticities									
Bread & Cereals	**-1.119**	0.235	-0.168	-0.003	-0.030	0.242	-0.021	0.026	-0.108
Root, Tuber & Plantain	0.109	**-1.257**	0.082	-0.033	-0.025	-0.146	-0.014	-0.001	0.101
Pulses, Nuts & Seeds	-0.557	0.476	**-1.136**	-0.112	-0.213	0.115	0.025	0.035	0.339
Vegetables & Fruits	-0.020	-0.048	-0.048	**-1.036**	0.013	-0.048	-0.006	-0.009	0.136
Meat	-0.139	-0.117	-0.191	0.004	**-0.960**	-0.167	0.067	0.058	0.126
Fish	0.182	-0.193	0.027	-0.035	-0.045	**-1.056**	-0.017	-0.003	0.023
Oil & fat Products	-0.149	-0.123	0.042	-0.032	0.145	-0.120	**-1.065**	-0.056	0.209
Non-Alcohol drinks	0.402	0.078	0.166	-0.064	0.341	-0.001	-0.133	**-1.267**	-0.346
Other Food Expenditure	-0.026	0.206	0.068	0.093	0.067	0.083	0.032	-0.010	**-1.192**
Hicksian (compensated) Price Elasticities									
Bread & Cereals	**-0.989**	0.453	-0.128	0.090	0.016	0.396	0.002	0.035	0.126
Root, Tuber & Plantain	0.271	**-0.984**	0.132	0.083	0.032	0.047	0.013	0.010	0.395
Pulses, Nuts & Seeds	-0.416	0.714	**-1.093**	-0.011	-0.163	0.282	0.049	0.045	0.593
Vegetables & Fruits	0.126	0.198	-0.004	**-0.931**	0.064	0.126	0.019	0.001	0.400
Meat	0.042	0.188	-0.135	0.134	**-0.896**	0.048	0.097	0.070	0.452
Fish	0.335	0.065	0.074	0.075	0.009	**-0.874**	0.009	0.007	0.300
Oil & Fat Products	0.009	0.142	0.090	0.082	0.201	0.067	**-1.039**	-0.046	0.494
Non-Alcohol drinks	0.515	0.268	0.200	0.017	0.381	0.133	-0.113	**-1.259**	-0.142
Other Food Expenditure	0.067	0.363	0.096	0.160	0.100	0.193	0.048	-0.004	**-1.024**

Table A3.7b: Price Elasticities for 1998/99 (N=5,998)

Price of:	Bread & Cereals	Root, Tuber & plantain	Pulse, Nuts & Seeds	Vegetables & Fruits	Meat	Fish	Oil & Fat products	Non-Alcohol drinks	Other food Exp
	Marshallian (uncompensated) Price Elasticities								
Bread & Cereals	**-1.220**	0.273	-0.027	-0.026	0.005	0.069	0.019	0.000	0.165
Root, Tuber & Plantain	0.094	**-1.283**	0.021	0.032	-0.004	-0.002	-0.041	0.006	-0.224
Pulses, Nuts & Seeds	-0.097	0.300	**-1.178**	-0.036	-0.011	0.057	0.081	0.011	0.277
Vegetables & Fruits	-0.248	0.284	-0.076	**-1.125**	-0.070	0.126	-0.007	-0.041	-0.233
Meat	-0.036	-0.073	-0.052	-0.124	**-1.268**	0.067	0.401	0.157	-0.457
Fish	0.075	0.038	0.007	0.046	0.015	**-0.997**	0.005	-0.011	-0.369
Oil & Fat Products	0.071	-0.344	0.108	-0.001	0.251	0.024	**-1.177**	0.041	-0.097
Non-Alcohol Drinks	-0.056	0.153	0.017	-0.083	0.192	-0.068	0.080	**-1.035**	-0.365
Other Food Expenditure	0.030	0.015	0.010	0.001	-0.006	-0.031	0.001	-0.005	**-0.883**
	Hicksian (compensated) Price Elasticities								
Bread & Cereals	**-1.115**	0.425	-0.003	-0.009	0.014	0.122	0.034	0.008	0.524
Root, Tuber & Plantain	0.290	**-0.997**	0.066	0.064	0.014	0.097	-0.012	0.021	0.456
Pulses, Nuts & Seeds	-0.013	0.422	**-1.159**	-0.022	-0.003	0.099	0.094	0.018	0.566
Vegetables & Fruits	-0.053	0.569	-0.031	**-1.093**	-0.052	0.224	0.022	-0.026	0.440
Meat	0.159	0.211	-0.007	-0.093	**-1.250**	0.164	0.430	0.172	0.215
Fish	0.242	0.281	0.045	0.073	0.030	**-0.913**	0.030	0.002	0.209
Oil & Fat Products	0.229	-0.114	0.145	0.025	0.266	0.103	**-1.153**	0.053	0.447
Non-Alcohol Drinks	0.108	0.392	0.054	-0.057	0.207	0.014	0.104	**-1.022**	0.200
Other Food Expenditure	0.152	0.192	0.038	0.021	0.006	0.030	0.019	0.004	**-0.462**

Table A3.7c: Price Elasticities for 2012/13 (N=16,772)

Price of:	Bread & Cereals	Root, Tuber & plantain	Pulse, Nuts & Seeds	Vegetables & Fruits	Meat	Fish	Oil & Fat products	Non-Alcohol drinks	Other food Exp
Marshallian (uncompensated) Price Elasticities									
Bread & Cereals	**-0.983**	0.093	0.037	0.001	0.037	0.030	0.019	0.001	-0.062
Root, Tuber & Plantain	-0.004	**-1.253**	0.054	-0.053	-0.073	-0.072	-0.018	0.003	0.043
Pulses, Nuts & Seeds	0.147	0.317	**-0.776**	-0.229	0.145	-0.221	0.031	0.013	-0.390
Vegetables & Fruits	-0.011	0.018	-0.060	**-1.014**	0.036	0.077	0.025	-0.013	0.043
Meat	0.003	-0.153	0.065	0.014	**-1.189**	-0.026	-0.050	-0.014	0.066
Fish	-0.014	-0.023	-0.064	0.047	0.005	**-1.005**	0.012	0.017	-0.053
Oil & Fat Products	0.130	-0.134	0.061	0.168	-0.195	0.084	**-1.071**	0.013	-0.206
Non-Alcohol Drinks	0.004	0.132	0.035	-0.105	-0.025	0.184	0.020	**-1.003**	-0.080
Other Food Expenditure	-0.039	0.155	-0.074	0.061	0.070	0.017	-0.012	-0.005	**-0.890**
Hicksian (compensated) Price Elasticities									
Bread & Cereals	**-0.833**	0.245	0.071	0.123	0.098	0.153	0.034	0.015	0.093
Root, Tuber & Plantain	0.246	**-1.021**	0.109	0.150	0.029	0.133	0.007	0.027	0.300
Pulses, Nuts & Seeds	0.322	0.494	**-0.737**	-0.087	0.217	-0.077	0.048	0.030	-0.210
Vegetables & Fruits	0.153	0.183	-0.024	**-0.882**	0.103	0.211	0.042	0.002	0.211
Meat	0.237	0.083	0.117	0.203	**-1.093**	0.165	-0.027	0.008	0.306
Fish	0.183	0.175	-0.021	0.206	0.085	**-0.845**	0.031	0.035	0.149
Oil & Fat Products	0.340	0.077	0.107	0.338	-0.109	0.256	**-1.050**	0.033	0.009
Non-Alcohol Drinks	0.157	0.287	0.068	0.019	0.038	0.309	0.035	**-0.988**	0.077
Other Food Expenditure	0.092	0.287	-0.045	0.167	0.123	0.124	0.001	0.007	**-0.756**

Table A3.8: Average Expenditure by Purchase Expenditure and Own Consumption

Commodity Group	1991/92 Purchase expenditure (Gh ₵)	1991/92 Own consumption (Gh ₵)	1998/99 Purchase expenditure (Gh ₵)	1998/99 Own consumption (Gh ₵)	2012/13 Purchase expenditure (Gh ₵)	2012/13 Own consumption (Gh ₵)
Bread & Cereals	3.6799	0.9831	25.0173	5.6151	600.91	501.58
Roots, Tubers & Plantain	3.3551	5.1047	22.4022	27.2276	470.68	939.59
Pulses, Nuts & Seeds	0.9078	0.5650	5.9856	1.0966	114.80	198.33
Vegetables & Fruits	2.5805	0.5871	1.7995	2.6545	638.62	260.94
Meat	1.7086	0.1670	2.7509	1.3380	398.43	190.53
Fish	5.0002	0.0902	14.7663	1.4937	805.87	50.15
Oil & Fat Products	0.7387	0.0715	4.4125	0.2919	107.45	11.60
Non- Alcoholic Drinks	0.3318	n/a	2.7348	n/a	92.22	n/a
Sample size	4,523	4,523	5,998	5,998	5,998	5,998

Source: Author's calculation from GLSS 3, 4 and 6

Note: All figures are in Ghana cedis (Gh ₵)

Appendix C

Table A4.1: Conversion Rates into Kilograms

Unit of Harvest	Conversion Rate (in kilograms) Maize	Paddy rice	Millet
Maxi bag	100	84	101
Mini bag	60	46	53
Basket	11.5	25	29
Figures	0.7	-	-
Olonka	3.5	1.8	3
America Tin	3.5	0.8	-
Margarine Tin	0.7	0.8	1.2
bowl	2.8	2.8	2.7
Stick	2	-	-

Source: Ministry of Food and Agriculture (MOFA) and Ghana Statistical Services (GSS)

Table A4.2: Proportion of sample who are net-seller, net buyer and Autarkic

Commodity	Proportion of household (%) Net Seller	Net Buyer	Autarkic
Maize	51	25	24
Rice	10	72	18
Millet	13	7	80