The spatial distribution of consumption patterns of animal proteins, grains and flours, and its income elasticities in Nigeria

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Abstract

In this thesis the income elasticities for specific animal proteins and grains and flours food items for Nigeria are derived, and it is investigates if and which income elasticities are income dependent. In advance, the spatial differences in income elasticities between income elasticities within Nigeria are analysed, whereby a comparison is made between urban and rural households, and between northern and southern Nigeria. Prior, to get a proper understanding of the geographical difference (between zones and between rural and urban areas) the average consumption per capita is disaggregated on these levels for the specific food items. Data from the third wave (2015-2016) of the Nigerian General Household Survey–Panel (GHS-Panel) is used to conduct this research. The results confirm the expectations that the differences in income elasticities of most grains and flours becomes larger when income increases compared to animal proteins. This means that the relative demand for animal proteins is higher for households with higher income compared to grains and cereals. In addition, the results confirm that the demand for non-traditional grains is higher than for traditional grains and flours and the differences in demand become larger when income increases. Despite that most literature states that consumption patterns differentiate between urban and rural households, the results showed only differences in quantity consumed. However, between northern and southern Nigeria major differences in consumption patterns for the analysed food items were found.

Preface

When I started my thesis research at PBL Netherlands Environmental Assessment Agency, the assignment I got was to investigate future food demand in Sub-Saharan Africa. More than half a year later it resulted in a research on income elasticities in Nigeria. From a very comprehensive topic to a very specific one. I want to thank PBL, particular Henk West Hoek, to give me the opportunity to conduct my thesis research at this institute. Furthermore I want to thank Henk and Sophie for their support to steer me in the good direction and for their feedback on the report. Thereby, Sophie thank you for editing the text on grammar and spelling. From Wageningen University, I want to thank Marrit van den Berg for her help and feedback on the econometric issues I faced during the research. Furthermore, I am thankful to my parents, my brothers and Gijs for their support. Additionally, I want to thank Gijs for his patient and helpful feedback on the report.

Contents

1 Introduction

To meet future food demand is and remains a major challenge (FAO, 2018b). The world population is expected to increase with 10% in 2030 and with 26% in 2050: from 7.7 billion in 2019 to 8.5 and 9.7 billion in 2030 and 2050 respectively. The population in Sub-Saharan Africa (SSA) is projected to double by 2050 (WPP, 2019). Land and water resources are becoming scarcer, and agriculture production is expected to be increasingly affected by climate change (Calzadilla, 2013). Nowadays climate change already affects food security, the prevalence of undernourishment has increased from 17.4 to 21.8 per cent over the last six years in drought-sensitive countries, while opposite holds for other countries with an average drop from 24.6 to 23.8 per cent (FAO et al., 2019).

After a decade of decline in the global prevalence of undernourishment (PoU), this decline has stagnated over the last three years in relative terms to below 11 per cent. The absolute number of undernourished people has gradually increased to 820 million people (FAO et al., 2019). Among other factors, conflict and extreme weather events are two of the causes in SSA. Although the relative undernourishment in western Africa is lower compared to central and eastern Africa, 26.5 and 30.8% respectively, the increase in western Africa has been the highest, from 10.8 in 2013 to 14.4% in year 2017.

SSA is the most rapidly urbanizing region compared to the rest of the world (Hussein and Suttie, 2016). The urban population increases from 36.4% in 2010 up to 46% in 2030 towards a projected 57% in 2050 (Van Berkum, 2017), whereby on the long-run, a robust GDP growth is expected. According to Bennet's law, GDP growth per capita results in diets becoming more diverse with a higher share of animal protein, fats and oils (Valin et al., 2014) and fruits (Tschirley et al., 2015), as well as in an increase of the consumption of processed food (Reardon and Timmer, 2012). Van Berkum et al. (2017) stated that a food system transformation is already taking place in SSA due to changing consumption patterns of the floating middle classes towards more processed food. The increase in income and urbanization in SSA will lead to a shift from traditional cereals (like millet and sorghum) to non-traditional cereals (like wheat and rice). This shift can already be observed in the trends based on the FAO Food Balance Sheet data (country level) over the period 1992-2013.

In contrast with the expected dietary shift, conducted scenario studies towards 2030, 2050 and/or 2100 (FAO, 2018b; Rutten, Tabeu and Godeschalk, 2014; Thome et al., 2018; Van Ittersum et al., 2016; Doelman et al., 2018) show in general no strong increase in demand for these food categories. This lacking increase of demand is mainly a result of the income elasticities used, which are derived from the FAO Food Balance Sheet (FBS). The income elasticity describes how a relative change in income affects the relative change in quantity demanded (Varian, 2014).The macro FBS data are aggregated on national level without differentiation of rural and urban income quantiles. This means that no differentiation has been made in the derived income elasticities for rural and urban income quantiles. However, following Engel's law, the proportion of food expenditure will decrease when income increases (Houthakker, 1957), which means that income elasticities will be lower for higher incomes (Bijl et al., 2017). In combination with Bennet's law, traditional grain demand is expected to decrease, whereas for meat and non-traditional grains an increase is expected whereby substitution takes place. Therefore it is expected that the differences between income elasticities of different food items change when income changes. In addition, differentiation in urban and rural income classes is necessary, since there is expected that urbanization, next to growth in income, leads to shifts in diets. Therefore urban and rural income elasticities for households with a similar income might differ.

An alternative of FBS data is micro data from household surveys, like the Living Standards Measurements Study – Integrated Surveys on Agriculture (LSMS-ISA) from the World Bank conducted for seven SSA countries. Desiere et al. (2018) investigated and compared meat and fish consumption including their income elasticities between the FBS data and microdata from the LSMS households survey for the countries Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania and Uganda. Income elasticities calculated from the FBS do not estimate country-specific income elasticities correctly, especially for fish (Desiere et al., 2018). The authors illustrate the potential of the microdata from the LSMS surveys to derive income elasticities and: *"Meanwhile, these rich datasets have the potential for more in-depth analysis that exploit the data to a fuller extent. For instance, income elasticities could also be estimated for rural/urban households, by income groups or for different types of meat and fish"* (Desiere et al., 2018, p. 122). Looking at Nigeria, LSMS-ISA data is used to derive income elasticities for four meat types, namely beef, mutton, goat and chicken (Aborisade and Carpio, 2017) and processed/unprocessed food (De Brauw and Herskowitz, 2018). Both papers do not differentiate for income classes. Smeets-Kristkova, Achterbosch and Kuiper (2019) have analysed how food systems are expected to transform in Nigeria by linking the model MAGNET to the GENUS nutritional database and comparing the outcomes with LSMS-ISA data. The model does not differentiate for geographical differences nor for urban/rural consumers and recommends to do a deeper analysis on the influence of these spatial nutrition differences (Smeets-Kristkova, Achterbosch and Kuiper, 2019).

The aim of this thesis is to derive income elasticities for specific food items for animal proteins, grains and flours and investigate which income elasticities are income dependent in Nigeria. By acknowledging the potential differences in consumption patterns between northern and southern Nigeria, and between urban and rural households, the geographical influence on the derived (income dependent) income elasticities will be analysed. According to Delvaux and Paloma (2016) the proportion of households who experienced difficulties arranging enough nutrition is higher during the post-planting. Prior to the derivation of the income elasticities, the spatial-temporal differences of total expenditure per capita and the per capita consumption pattern of animal proteins, grains and flours will be analysed. So, the consumption patterns between households in northern and southern Nigeria, between the urban and rural area and between the post-planting and post-harvest period will be compared.

Among other countries, the LSMS-ISA households survey from the World Bank is available for Nigeria. Nigeria is chosen based on the proven data quality of the dataset by earlier studies (Delvaux and Paloma, 2018; De Magalhães and Santaeulàlia-Llopis, 2018; Aborisade and Carpio, 2017; De Brauw and Herskowitz, 2018; Desiere et al., 2018). In addition, Nigeria is an interesting country because half the West African population lives in Nigeria. Thereby is the population of the northern part mostly Muslim, while in the south the majority is Christian (Aborisade and Carpio, 2017) which might influence consumption patterns within Nigeria.

In the next chapter I start with a description of the economy and welfare of Nigeria. Then I zoom on the geographical differences of staple crop and animal production systems within Nigeria followed by a short description of the consumption patterns in Nigeria of staple crops and animal proteins. In chapter 3, the conceptual framework, I describe economic theories on which this research is based on and which functional forms I use. In chapter 4, the methodology is described where I discuss the used data, the empirical model, the estimation method and the variables used, and how I deal with missing data and outliers. Afterwards, in chapter 5, first I describe the results of the spatiotemporal differences in the total expenditure and the consumption patterns per capita. Subsequently, the income elasticities of the full dataset, and the northern/southern and the urban/rural subset are analysed. Finally, chapter 6 contains the conclusion and discussion.

2 Area description

Nigeria is a West African country situated in the Gulf of Guinea and surrounded by the countries Benin in the west, Niger in the north, Chad in the upper North East and Cameroon in the West. Nigeria is divided into six geopolitical zones, namely North West, North East, North Central, South West, South East and South South (Figure 1), which are divided in 36 states (Dauda, 2017; NBS, 2016a). The country has a population of around 197 million inhabitants, with a high share of youth compared to the total population (World Bank, 2019b). Thereby, with an expected population growth of around 200 million people by 2050 it is expected that Nigeria will be the third country after China and India when it comes to inhabitants (WPP, 2019).

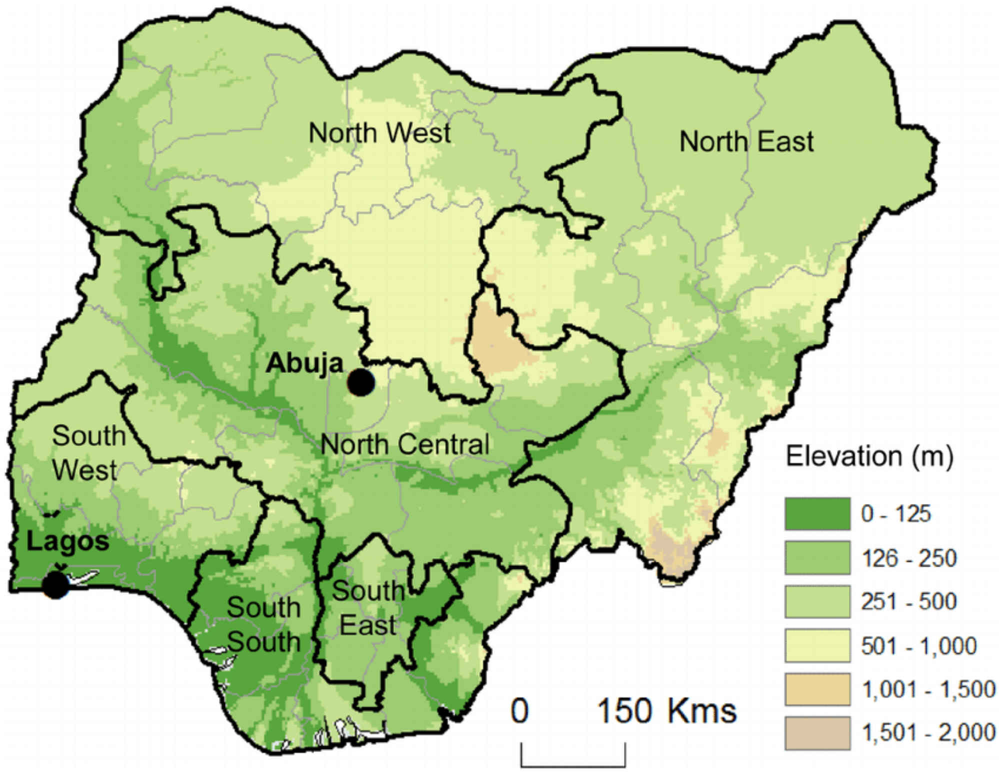

Figure 1: Nigeria with its geopolitical zones (Okorie et al., 2013)

2.1 Economy and welfare

The services sector contributes to approximately 50% to Nigeria's GDP, followed by agriculture (22%) and the oil sector (10%) (African Development Bank, 2019). The 6th largest natural gas field and the 7th largest oil field in the world are situated in Nigeria (Sanusi, 2010), making it the largest oil exporter of Africa (World Bank, 2019b). After a period of strong economic growth between 2006 and 2016, with an average GDP growth of 5,7% (World Bank, 2019b), Nigeria ended up in a recession in 2016 (African Development Bank, 2019). The growth and slowdown of the economy was mainly induced by the volatile oil prices (World Bank, 2019b). In 2017 and 2018 the economy recovered, bolstered by the revived oil price (African Development Bank, 2019). For 2019 a GDP growth rate of 2.2% is projected (World Bank, 2019a).

Although absolute GDP growth has recovered, GDP per capita growth remains low, leading to a marginal increase in poverty reduction (World Bank, 2019a). Instead, based on a study by Dauda (2017), between 2004 and 2010 the rate of people living in absolute poverty increased from 54.7% to 60.9%. Due to population growth, not only the relative level of poverty has increased, but also the absolute number of people living in poverty. Poverty is not evenly distributed over Nigeria. The poverty rate is higher in northern zones compared to the south. North West and North East are the poorest zones. Around 70% of the population lives below the one dollar per day poverty. The South West is the richest zone where around half of the population lives below this poverty line and approximately a quarter is food poor (Table 3, Dauda 2017). Next to differences across zones, poverty is higher among the rural population compared to the urban population with poverty rates of respectively 73.2% and 61.8% in 2010 (Dauda, 2017).

Table 1: "Incidence of Poverty by Categories and Geo-Political Zones." (Dauda, 2017, p. 65)

Zone	Food poor (%)	Absolute poor (%)	Relative poor (%)	A dollar per day (%)
North Central	38.6	59.5	67.5	59.7
North East	51.5	69.0	76.3	69.1
North West	51.8	70.0	77.7	70.4
South East	41.0	58.7	67.0	59.2
South South	35.5	55.9	63.8	56.1
South West	25.4	49.8	59.1	50.1

Source: Dauda (2017), retrieved from National Bureau of Statistics (2012)

The contribution of the agricultural sector to GDP is relatively low compared to the other sectors, and has declined since the 1960s, when the contribution was around 65% (Muhammad-Lawal and Atte, 2016). The decline is a result of a overlook of the sector in the 1970s when the oil boom was at its top (Olajide, Akinlabi and Tijani, 2012), which induced a severe decline in agricultural productivity (Muhammad-Lawal and Atte, 2016). Nonetheless, despite that the agricultural sector is not the major contribution to total GDP, it is a cornerstone of the Nigerian economy: two-third of the labour force is employed in the sector. Most of the agricultural labour force are resource-poor peasants, having approximately two hectares in cultivation (Muhammad-Lawal and Atte, 2016).

2.2 Staple crop and animal protein production

The geographical distribution of the major crop production across West Africa (Figure 2) shows that all different specified production regions of West Africa are present in Nigeria. In the north millet, sorghum and beans are the major crops, while in the south the crop production mainly consists of cassava and maize. In central Nigeria, which overlaps both the northern and southern zones, yam is cultivated. Figure 2 shows that the upper south and the green area located in the Nigerian state Niger in the zone North Central are the main rice-producing regions. Within West-Africa, Nigeria produces around half of the regional staple crops. Nonetheless, the growth rate of Nigeria's staple crop production is lower compared to its neighbouring countries (Elbehri et al., 2013).

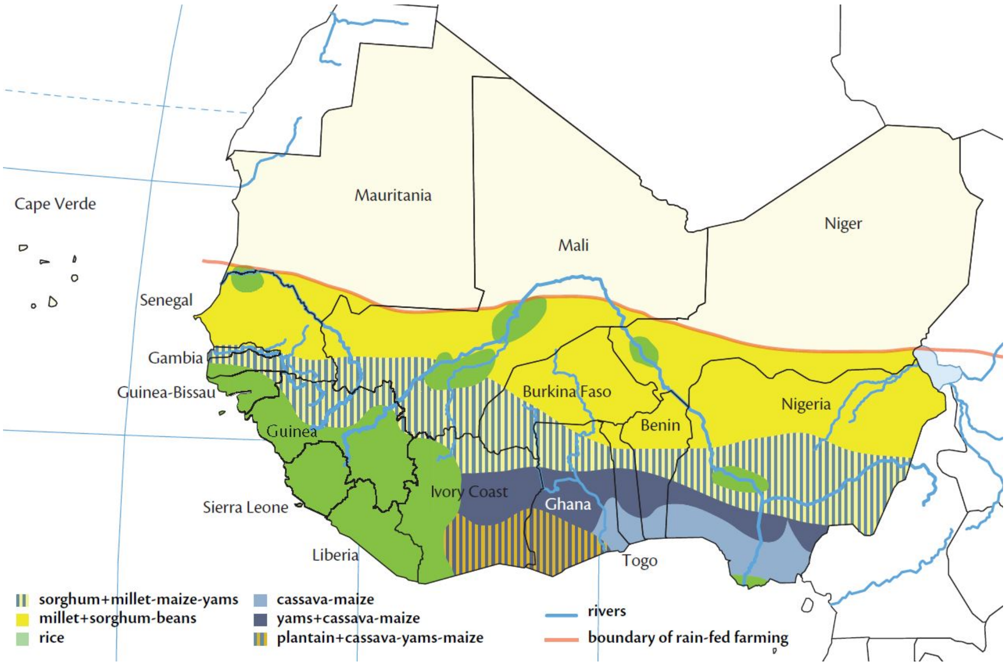

Figure 2: Staple crop production West-Africa (Source: Bureau Issala, Chaléard J.L. and SWAC; extracted from Blein et al. (2008))

Around 18.4 million cattle, 43.4 million sheep, 76 million goats and 180 million chickens are held in Nigeria (FAO, 2019). The around 0.93 million metric tonnes of fish captured and from aquaculture makes that Nigeria contributes for 32% to the total West African fish production. Like the geographical differences in crop production within Nigeria, the livestock and poultry production differs geographically.

In particular for sheep, the majority of the livestock production is held in northern Nigeria (FAO, 2019; Lawal-Adebowale, 2012). In this part of Nigeria, livestock is mainly held in a nomadic pastoral system, at which farmers travel from place to place over uncultivated pastures with their herd of around 100 to 300 animals of indigenous breeds, whereby the animals do not get supplemented feed. Chickens are also mainly held in extensive system in northern Nigeria. Around 46% of chicken of the total Nigerian chicken population is held in a free-range system (FAO, 2019). Around 78 million chickens of indigenous species are kept extensively by 6.6 million households whereby the chickens are roaming around for food and roost a nest in trees or bushes. Livestock and poultry production systems are subsistence (FAO, 2019).

Farmers in the south are using an agro-pastoral system which means they combine crop production with livestock. The herds with a size of 20 and 100 indigenous breeds are grazing on rangelands and the herd get supplementary feed. The chickens are fed with locally available resources and are sold alive on the informal market. Mostly poultry farming is combined with other agricultural activities.

One per cent of the total cattle production is being held in commercial dairy farms (FAO, 2019), whereby around 70% takes place in North Central zone (FAO, 2018a). Farms are holding around 50 to 1000 animals of exotic breeds indoor. The animals do no graze and are fed with feed supplied with essential nutrients to maximize milk yields. Intensive commercial poultry production accounts for 21% of the total poultry production (FAO, 2019) and is mainly situated in the southern zones (FAO, 2018a). These farms exists of more than 2000 chickens of an exotic breed whereby the focus is on meat or eggs producing for the market.

2.3 Consumption pattern of staple crops and animal proteins

The consumption pattern of caloric consumption in Nigeria has both the characteristics of coastal countries and Sahelian countries (table 2 from Elbehri et al., 2013). Excluded Nigeria, the cereal consumption is higher in Sahelian countries compared to the coastal countries, while the opposite holds for starchy roots. The cereal and starchy roots consumption lies between the Sahelian and the coastal consumption pattern. The Sorghum consumption is to the same magnitude of Sahelian countries, while in coastal zones sorghum has a marginal contribution to the diet. In contrast for yam and cassava, the Nigerian and coastal quantity consumed is comparable, although these roots crops are hardly eaten in Sahelian countries. Compared to the Sahelian and coastal countries the meat consumption is the lowest in Nigeria. Beef consumption is comparable to coastal countries, while poultry consumption is low compared to Sahelian and coastal countries.

Table 2: The caloric consumption (in Kcal/day/inhabitant) of Nigeria compared to Western African Sahelian and coastal countries in 2003

	Sahelian	Coastal	Nigeria
Cereals	**1684**	**934**	**1253**
Maize	191	307	179
Sorghum	374	64	362
Millet	604	36	294
Rice	372	441	284
Wheat	122	116	127
Starchy Roots	**29**	**676**	**511**
Cassava	15	371	249
Yams	4	231	204
Sweet Potato	7	11	37
Oilcrops	**75**	**98**	**90**
Goundsnuts	69	66	39
Meat/Livestock	**78**	**54**	**39**
Beef	29	13	12
Poulty	12	15	4
Goats and Sheep	22	5	7

Source: Elbehri et al., 2013 from Haggblade et al. (2012), retrieved from FAOSTAT Food Balance Sheets.

The consumption of proteins in Nigeria is among the lowest in Africa (Dauda, Ojoko and Fawola, 2016). As mentioned above the caloric consumption of meat is low compared to other West African countries, so protein intake from meat consumption is as well. In Nigeria, half of the contribution to the total protein consumption is from fish which is to all animal proteins the cheapest (Dauda, Ojoko and Fawola, 2016).

Among other food types, the production of dairy and fish cannot satisfy the demand for these products. Around 60% of the consumed dairy products are imported (FAO, 2018a). Of the total fish consumption, around half is imported in the form of frozen fish: among African countries Nigeria imports the highest amount of frozen fish (Dauda, Ojoko and Fawola, 2016).

Summarized, within Nigeria welfare is unevenly distributed, whereby there are strong spatial differences in the staple crop production and animal production systems. In northern Nigeria the poverty rates are higher than in the south, whereby in the north the animal production systems are extensive production systems and mainly subsistence. Besides, in northern Nigeria mainly sorghum and millet is produced while in south Nigeria the stable crop production mainly exists of roots, tubers and maize. In the wealthier south animal production systems are more intensified compared to the north and the majority of the commercial dairy and poultry farms are situated in central and southern Nigeria respectively.

3 Conceptual framework

As described in the introduction, due to GDP growth and population growth in SSA and in particular in Nigeria, an increase in food demand is expected. Based on Engel's law and Bennett's law I expect that Nigeria's GDP growth, which leads to an increase in household income, will not lead to the same proportion of the increase in food demand per household and will differ between staple food and animal protein.

Engel's law states that when income rises the relative contribution of income spent on food declines (Lewbel, 2008). Ernst Engel made this statement 1857 by empirically analysing the budgets of around two hundred Belgian labourers (Lewbel, 2008). He found that the food expenditure was higher for households with higher incomes and family sizes, although an increase in income resulted in a lower budget share of food expenditure. Since then, studies have proven this relationship, like Houthakker (1957) who conducted an international comparison of household surveys and confirmed Engel's law for all the around 40 analysed surveys from about 30 countries.

Next to a decrease in the budget share of food expenditure, according to Bennet's law, income growth is expected to lead to more diverse diets with a higher share in animal proteins, fats and oils (Valin et al., 2014). Based on LSMS survey data from several eastern and southern African countries Tschirley et al. (2015) found that growth in income leads to an absolute increase in the consumption of perishable products, like meat and fruits, which confirms Bennett's law.

Considering Engel's law and Bennett's law, it is expected that when income increases the share of expenditure of staple food will decrease, while for more luxury food groups like animal proteins, the budget share will decrease less or even be constant. This results in the expectation that, in general, for animal proteins the income elasticities will not change or change less when income changes, while for grains and flours the income elasticities will be income dependent. This leads to an increase in the difference between income elasticities of staple food like cereals and animal proteins when income increases.

To compute an income elasticity depending on income, the income elasticity is derived from an Engel curve, which describes how expenditure on a good or service relates to total income (Lewbel, 2008). This gives the following function whereby prices are fixed:

$$q_i = g_i(y, z) \tag{1}$$

In this function the quantity consumed good or service i, q_i, depends on total income, y, and other consumer characteristics, z, like age and household composition (Lewbel, 2008).

Besides the dependence of total income on the quantity consumed good, family size determines the number of consumed necessities, which is known as Engel equivalence scales. It means that a small family with less income compared to a large family can have an equal budget share of a necessity good (Lewbel, 2008).

Different functional forms can be used to derive the Engel curve, like the Working-Leser model. In this function the Engel curve is expressed in budget share depending on the log of income, which gives $w_i = a_i + b_i \log(y)$, where w_i is the share of y spend on good i (Lewbel, 2008). SSome authors state that the best fit of a functional form depends on the type of good, like Pais and Houthakker as cited in (Aitchison and Brown, 1954). They concluded that for necessary and luxury goods different forms are best suited, namely a semi-logarithmic ($q_i = a_i + b_i \log(y)$), and a double logarithmic form (($q_i = a_i + b_i \log(y)$)), respectively (Pais and Houthakker, as cited in Aitchison and Brown, 1954).

From a functional form with quantity consumed as dependent variable and at least one variable with the logarithmic of income as independent variable, the income elasticity can directly be derived by taking the first order the derivative (Hardy, 1978). In contrast, directly deriving the income elasticity from a functional form with the budget share as the dependent variable, like the Working Leser model, is not possible (Mohanty and Rajendran, 2003).

The most simple functional form is the double logarithmic functional form with quantity consumed as dependent variable. In this functional form the slope b_i expresses how a relative change in income leads to a relative change in the quantity consumed of good i, q_i, and is thus equal to the income elasticity:

$$\log(q_i) = a_i + b_i \log(y) \tag{2}$$

first order derivative:

$$\left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{1}{q_i}\right) = b_i\left(\frac{1}{y}\right) \tag{3}$$

$$\left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{y}{q_i}\right) = b_i \tag{4}$$

with income elasticity:

$$E_i = \frac{\%changeinquantitydemanded}{\%changeinincome} \tag{5}$$

$$E_i = \left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{y}{q_i}\right) \tag{6}$$

gives:

$$E_i = b_i \tag{7}$$

As can be seen in eq. 6, the income elasticity of the double logarithmic functional form is constant and independent of any other factor. Looking at other function forms, like the semi-logarithmic functional form, the derived income elasticity depends on quantity consumed: $E_i = \frac{b_i}{q_i}$ (Mohanty and Rajendran, 2003). This means that the semi-logarithmic functional form is not suitable for this research.

In this research, I am interested in whether income elasticities depend on income. Therefore I use a quadratic logarithmic function (Mohanty and Rajendran, 2003) which only differs from the double logarithmic function by having the quadratic of the logarithmic of income as an extra variable:

$$\ln(q_i) = a_i + b_i \log(y) + c_i \log^2(y) \tag{8}$$

By taking the first-order derivative for income, an income dependent income elasticity can be derived:

$$\left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{1}{q_i}\right) = b_i\left(\frac{1}{y}\right) + c_i\left(\frac{2\log(y)}{y}\right) \tag{9}$$

$$\left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{y}{q_i}\right) = b_i + 2c_i \log(y) \tag{10}$$

with:

$$E_i = \left(\frac{\mathrm{d}q_i}{\mathrm{d}y}\right)\left(\frac{y}{q_i}\right) \tag{11}$$

gives:

$$E_i == b_i + 2c_i \log(y) \tag{12}$$

The derived income elasticity (eq. 12) from the quadratic logarithmic functional form depends on the slopes b_i and c_i and the natural logarithmic of household income.

As earlier stated, since we expect that for animal proteins the change in demand will be less or not influenced by the change in household income, it could be that the coefficient c_i is not significant for all food items. When for a food item the result of the regressions shows an insignificant coefficient c_i, it indicates that the income elasticity does not change when income changes. Therefore, next to the quadratic functional form, I also use the double logarithmic functional form in this research. From this conceptual framework, the methodology to perform the research is derived. In the next chapter this methodology is explicated.

4 Methodology

To analyse the trends in demand for specific animal proteins, and cereal and flour food items and its income elasticities, I use the data from the third wave of the Nigerian General Household Survey–Panel (GHS-Panel) from the project Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA).

To get a proper understanding of the geographical differences (between zones and between rural and urban areas), as well as between the post-planting and post-harvest period, the average consumption per capita is disaggregated on these levels for the specific food items first. Subsequently, the income elasticities are derived by taking the first-order derivative of the Engel curve with a quadratic logarithmic functional form, with household consumption in monetary terms of a specific food type as an explanatory variable. These derived income dependent income elasticities are calculated for the medians of the household income quintiles. For food items without an income dependent income elasticity, the income elasticities are derived from a double-logarithmic functional form.

As mentioned in the introduction, there are differences in the production systems and welfare between northern and southern Nigeria, and it is expected that urbanization leads to shifts in consumption patterns. To investigate whether these differences lead to differences in income elasticities, subsets are derived from the original dataset. From the regressions from the functional form, first the income elasticity of the total dataset is calculated, where after the income elasticities from the different subsets are derived. The northern subset contains the zones North West, North East and North Central, and the southern subset contains the zones South West, South East and South South.

4.1 Data

For this research, I use both the post-planting and post-harvest period survey data of wave 3, August - October 2015 and February - April 2016 respectively (NBS, 2016b). The Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) project redesigned or implemented the General Household Survey (varies by country) and included a panel component (GHS-Panel) with a focus on agriculture (Desiere et al., 2018). The countries Burkina Faso, Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania and Uganda are part of the LSMS-ISA project and per country several waves of GHS-Panel data are available (e.g. two waves are available for Mali and four for Tanzania).

4.1.1 Sample structure

For the selection of the households, a multi-stage stratified sample design is used for the 2010 General Household Survey (GHS) (NBS, 2016a). Every year a General Household Survey is conducted in which several socioeconomic indicators are measured. To make more precise estimations of trends of poverty and socioeconomic issues, every two to three years panel survey is conducted in addition to the general survey. In 2010 the first panel survey, wave 1 of the General Household Survey-Panel (GHS-Panel), was conducted and forms the baseline. For this 2010 GHS-Panel a subsample of primary sample units (PSU) of the 2010 GHS was derived, from which 500 enumeration areas (EAs) are selected. Within each EA ten households are selected, so the total dataset consists of 5000 households.

During wave 2 and wave 3, questioners attempted to re-interview all the visited households of the previous wave, whereby the selected households are visited two times: once during the post-planting and once during the post-harvest period. Some interviewed households during wave 1 could not be located during wave 2. Despite that for these households data is missing from wave 2, still effort was made to locate and interview these households during wave 3. Therefore, from some households data is present from wave 1 and 3, but missing from wave 2.

Ultimately, of the original 5000 selected households, 4,581 households were interviewed during wave 3. So, due to attrition between the waves, not all the original 5000 selected households were able to be interviewed during all the three waves. The majority of the attrition is caused by the poor security circumstances in the North East zone, which resulted in that 14 EAs were not able to be visited in the states Borno and Yobe during wave 3. In addition, during wave 3, 20 household were only visited in the post-harvested period, of which 19 households could not be visited due to security concerns in two EAs (NBS, 2016a).

Due to the selection procedure, each household has a sampling weight at which the dataset is representative on urban and rural zone level (which resulted in 12 strata) and on national level. The EAs, the largest clusters, are the primary sample units.

4.2 Empirical model

Since I focus on income elasticity and not on price elasticity, the calculation of the income elasticity is based on the method by Angelucci and Atanasio (2011). Angelucci and Atanasio (2011) regress the budget share of a specific food item against the natural logarithmic of total income, household size and dummy variables for the region and time period, to capture price differences.

A small share of the households (one third or less) consumes specific food items both in the post-planting and post-harvest periods, making data for specific food items highly unbalanced. Therefore I do not use a panel analysis. Instead a weighted least squared (WLS) regression is conducted, since the multi-stage stratified sample design is into account.

As earlier stated, to derive income dependent income elasticities, I will use a quadratic logarithmic functional (eq. 8). Correcting for the sum of the adult equivalent unit of the household, region and time gives the following formula:

$$\ln(C^j_{ikt}) = \alpha^j + \beta^j \ln(I_i) + \gamma^j \ln^2(I_i) + \delta^j AE_i + \theta^j S_i + \nu^j_k G_k + \omega^j_k T_t + \upsilon^j_{kt} G_k T_t + \epsilon^j_{ikt} \quad (13)$$

Total consumption is C^j_{ikt} of food item i, I_i is total income, the sum of the adult equivalent unit of the household is AE_i and S_i represents whether the household is situated in an urban or rural area. Dummy variables for geography (state), time (post-planting or post-harvest period) and interaction between geography and time are G_k, T_t and G_kT_t respectively. α^j, β^j, γ^j, δ^j, θ^j, ν^j_k, ω^j_k and υ^j_{kt} are the parameters and ϵ^j_{ikt}'s are the random disturbances.

For some food items, like pork meat, religion or culture can play a role in the decision to consume the food item. Data on religion is available, however for the majority of the households the data is missing. Therefore religion is not included in the analysis. Rather, differences in consumption preferences influenced by religion and culture will be captured by the geographical dummy.

Taking the first-order derivative for total household income of the above-mentioned function (eq. 13), the income elasticity can be derived. This is equal to eq. 12, whereby only the coefficients β^j and γ^j remain. Since I expect that not all derived income elasticities are income dependent, in advance the income elasticity of the double logarithmic functional form is derived. As mentioned in the previous chapter, in contrast to the quadratic logarithmic functional form, the double logarithmic functional does not contain a quadratic of the natural logarithmic of total household income. Therefore, the first order derivative of the reduced model of eq. 13 is used, so leaving out the quadratic term. The slope of the natural logarithmic of income in this double log model is equal to the income elasticity (see eq. 7).

4.3 Estimation method

Just a single WLS regression is not appropriate to derive the income elasticities, since not all households consumed the analysed specific food items during the recall period of seven days. The income elasticities are calculated for consumers and non-consumers. However, the non-consuming households might have different characteristics than the consuming households which influences whether to consume or not consume the food item. This means that zero consumption is not a measured quantity consumed like all other measured values of quantity consumed, but an actual choice of a relevant decision-maker (the household) to not participate with other consuming households (Greene, 2007 from Andersson et al., 2012).

In this case, a Cragg's Double Hurdle model is a logical choice to deal with zeros within the dataset. A Cragg's Double Hurdle model is a corner solution model and assumes that the zero consumption of the household is an actual choice (Greene, 2007 from Andersson et al., 2012). By making use of a probit analysis in the first stage, there will be analysed whether a household decides to consume the food item or not. Thereafter a truncated regression is conducted. Since in this analysis the logarithmic of consumption of the food item is taken and the logarithmic of zero does not exist, zero consumption is treated as missing value. Despite that the Cragg's Double Hurdle model is the most logical choice to conduct, due to missing values instead of zeros in this analysis, it is impossible the use this model.

Wooldridge (2009) recommends using a two-stage Heckman selection model in cases when logarithmic values as dependent values include zeros. The two-stage Heckman selection model consists of a probit model in the first stage, and a WLS regression model in the second stage. The inverse Mill's ratio (IMR), estimated from the probit analysis, is used as omitted variable in the WLS regression model (Dougherty, 2016). Thus, the IMR corrects for the differences in characteristics of consuming households and non-consuming households, so now the income elasticities are derived for the consuming and non-consuming households, instead of only for the non-consuming households.

When the two-stage Heckman selection model is used, a valid explanatory variable in the first stage or a valid instrument has to be used which affects the selection but not the outcome in the second stage (Wolfolds and Siegel, 2019). So, the variable or the instrument should explain whether the household will consume the food item or not, but does not have an influence on how much of the food item is consumed by the household. In this research no proper instrumental variable can be found which meets this condition.

It is questionable whether the consuming and non-consuming households have different characteristics per food item, which influences their choice to participate, so if the sample selection is biased. Since the length of recall period is seven days, it is plausible that the households who decide to consume the specific food item during this week is a coincidence. If the interview was a week later presumably the composition of the consuming households could be totally different. This assumption is strengthened by the fact that a small share of the households (one third or less) consumes specific food items both in the post-planting and post-harvest periods. The practical issue that no proper instrumental variables are available, and the assumption that the consuming and non-consuming households do not have other characteristics that induce the decision to participate (in this case consuming a specific food item), made me decide to not include an IMR in the WLS regression.

The survey design, so the sampling weight, strata and primary sample units, are included in the regression analysis from which the income elasticities are derived. By taking into account the sample design in the regression model, the outcomes are representative on national level and also on the subset levels (northern and southern Nigeria and urban and rural households), since the strata are the urban and rural zones. Each household has a sample weight, depending on the representativeness of specific characteristics of the household within the nation.

Instead of applying the OLS regression, taking into account sampling weight leads to the use of a weighted least squares regression (WLS). The estimated coefficients will be corrected for distortion by over and under representation of specific household types (Solon, Haider and Wooldrigde, 2015). Including the strata and primary sample units affects the standard errors (Aneshensel, 2012).

Also for deriving the consumption patterns per capita, the total expenditure distribution per capita and the household income quintiles, the sampling weight was taken into account. In advance, the dataset is balanced for the estimation of the consumption patterns per capita and the income distribution per capita. So households which are presented in only one of the periods are removed. This is done, because now for each food item the quantity consumption per capita and the total expenditure per capita in the post-planting and post-harvest period can be compared.

4.4 Variables used, missing data and outliers

The information on age and sex is used to calculate the adult equivalent unit (AEU). By using the AEU, the different calorie requirements per household member depending on age and sex are taken into account (unknown FAO report published in 2004 from Dary and Imhoff-Kunsch, 2010). The AEU is standardized for male consumers with an age between 18 and 30 years. The AEU and its sum per household are used in the analyses to determine average consumption per capita, and to derive income elasticities.

Total income data is not present in the dataset. Total income can be derived from direct and indirect income, if proper information of market prices are present. Instead, based on Delvaux and Paloma (2018) whom used Wave 2 (2012-2013) of the Nigerian GHS-Panel data, total annual expenditure on consumption per capita is present in the data and thus used, with the assumption that the amount saved by households is independent from total income (Grosh and Glewwe, 2000).

To derive the income elasticities per food item, I use as dependent variable the logarithmic of the household consumption of the food item expressed in monetary terms. However, the household consumption is not expressed in monetary terms in the dataset, so several steps are taken to derive the total household consumption in monetary terms (in Nigerian Naira). Per food item, the quantity consumed is given with information on how much of the consumed food is purchased, and whether it is acquired from own production or from a gift. Of the purchased food, besides the quantity, the expenditure in monetary terms (in Nigerian Naira) is given. The unit values of the quantities reported vary. So first the quantities are converted to kg or litre, by making use of the given conversion factors. During the next step, for households who purchased (a part of) the consumed food item, the price per kg or per litre is derived. By knowing the price per kg or per litre, the household consumption is converted to monetary terms. Besides, for households who consumed but did not purchase the food item, the median price per state and season (harvest or planting period) is used to convert the consumed quantity into monetary terms.

In some cases converting the unit values to kilogram or litres is impossible, due to the absence of conversion factors. For these households the quantities are changed into missing values.

After calculating the household consumption per food item in monetary terms, per food item the 1% of the largest and smallest positive values is trimmed. For wild game and bush meat no regression was conducted due a low share of households who consumed wild game and bush meat also purchased the food item, so the derived household expenditure of this food item is unreliable.

Before deriving the average per capita food consumption disaggregated on the level of state, sector (rural/urban) and time period, I have winsorized the 2.5% of the largest and smallest values of the consumed quantity per the food item for all households with positive consumption. This is done to remove outliers in the dataset which are presumably incorrect. Thereafter the mean is calculated for all the households with positive consumed quantities. For households who did consume the food item but with an unknown consumed quantity, the calculated means are imputed. Thereafter the average consumption per capita is derived for all the households (so for consumers and non-consumers) by dividing the household consumption by the household sum of the AEU. This results in a standardized average consumption per capita is for male consumers with an age between 18 and 30 years which is representative on rural or urban state level.

5 Results

To get a proper understanding of which factors influence income elasticities in Nigeria, first I analyse if there are differences in the total expenditure per capita and the consumption patterns between post-planting and post-harvest periods, rural and urban households and zones. In the second part of this chapter, I will present the results of the income elasticities from the double logarithmic and quadratic logarithmic functional forms described in the previous chapter, whereby income elasticities between rural and urban households and northern and southern Nigerian households are compared.

5.1 Total expenditure per capita and consumption patterns

5.1.1 Spatiotemporal differences in total expenditure per capita

Roughly speaking, based on the definition used for the household survey, two-third of the Nigerian population lives in rural areas (Figure 3). Between zones, the degree of urbanization differs (Figure 2). Southern Nigeria is more urbanized compared to the northern zones, whereby in the South West Lagos is situated and therefore mainly urban.

The distribution of weekly total expenditure per capita of the post-planting and post-harvest period shows a similar distribution (Figure 3). Comparing the medians between these periods, the urban weekly total expenditure per capita is 3.3% lower in the post-harvest period while for rural households it is 5.8% higher (Table 3). However, based on the paired sample t-test, total weekly expenditure per capita between these periods do not differ significantly (Appendix: Table A1).

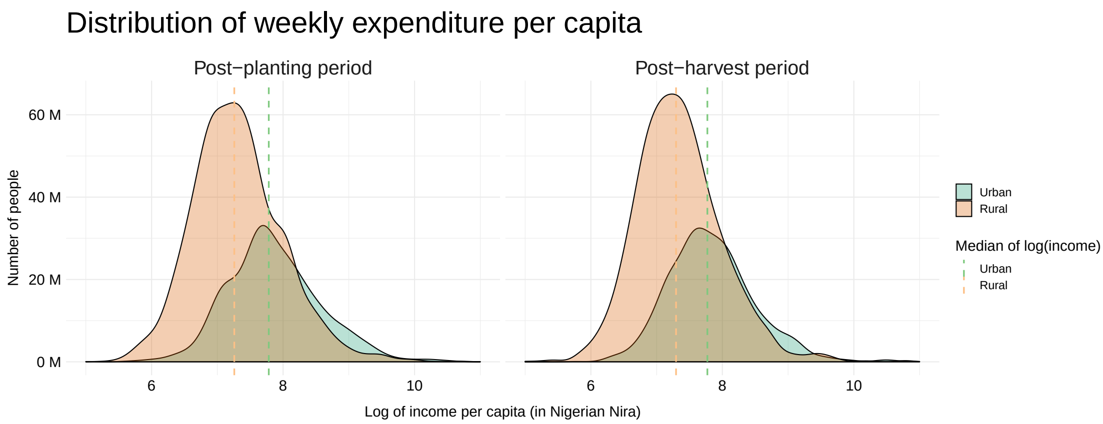

Figure 3: Distribution of weekly expenditure per capita

Table 3: Median of weekly income per capita

	# of observations	Post planting	Post harvest	Difference	Rel. difference (%)
Urban	1243	2399	2373	-66	-3.3
Rural	2989	1419	1474	69	5.8

Notes: The results are derived from balanced panel data.

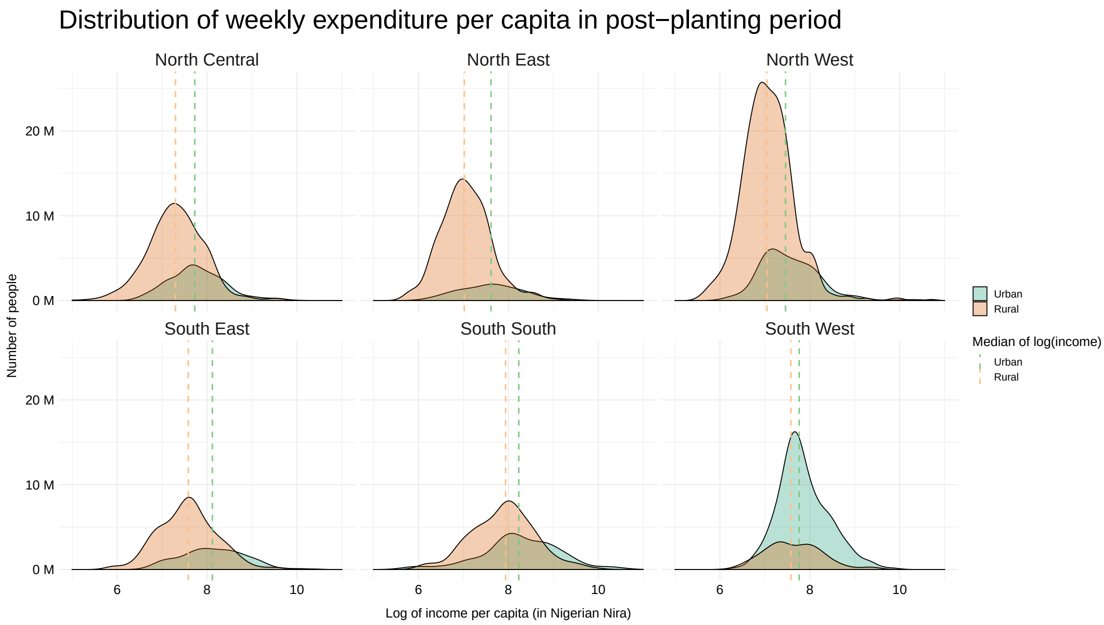

Figure 4: Distribution of weekly expenditure per capita in the post-planting period in each of the six zones.

Weekly total expenditure per capita differs between zones and between rural and urban households within zones (Figure 4). As can be seen in Figure 4, total expenditure per capita is higher for southern rural and urban households compared to the northern households, whereby the differences in rural and urban households are larger in the north. Next to the significant differences between rural and urban households, the geographical differences (north and south) are larger than the differences between urban and rural households (Appendix: Table A2 an Table A3). Besides, these results show that the differences between urban and rural total expenditure are smaller than between north and south.

5.1.2 Spatiotemporal differences per capita in consumption of animal proteins, and grains and flours

No major differences in the consumption patterns of the analysed food groups between the post-harvest and post-planting period can be observed (Figure 5). For most food items this holds as well (Appendix: Figure A1), only for seven of the twenty-four food items the differences between the two periods are significant ($p<0.05$) (Appendix: Table A4).

Comparing the northern and southern zones and rural and urban areas per zone, the differences in consumption patterns between the north and the south seems larger than between rural and urban areas per zone (Figure 5). In the southern zones the weekly consumption per capita (standardized for a man with an age between 18 and 30 years) of meat, fish and, to a lesser account, dairy and eggs is higher compared to the north, while the opposite holds for grains and flours (including bread). The higher consumption of grains and flours in the north does not mean that the consumption of carbohydrates is higher. Only the flours of cassava and yam are included in this research, not cassava, yam or other tuber and roots crops itself.

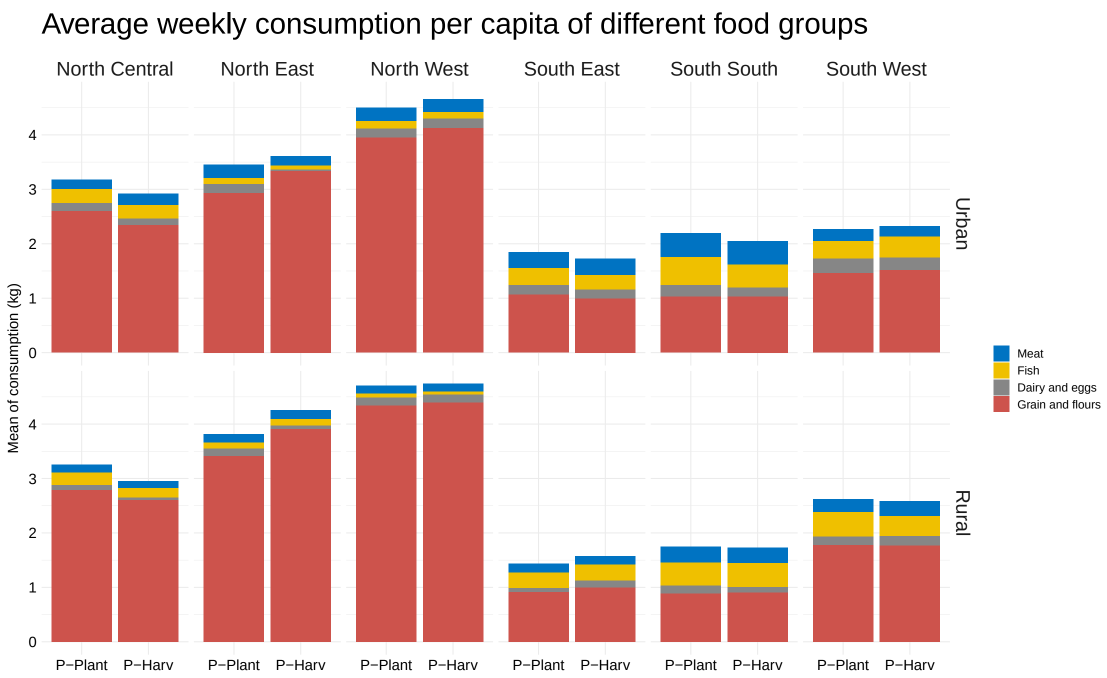

Figure 5: Consumption per capita for the food groups meat, fish, milk and eggs and cereal and flour. The consumption per capita represents a male consumers with an age between 18 and 30 years (AEU=1).

Spatial differences in meat and dairy and eggs are both present in the quantity consumed, as earlier mentioned, and in the type of food items consumed (Figure 6.a and Figure 6.b). This can be explained by the different production systems in which livestock and poultry is held across Nigeria. As earlier explained in the introduction, these production systems are subsistence, so most of the production in the north is for own consumption while in the south the production systems are more intensive or commercial, whereby (part of) the production is sold on (informal) markets.

Across all zones, the contribution of beef consumption to the total meat consumption is the highest, whereby the consumption of beef is higher in the south compared to the north and urban consumption is higher compared to rural consumption. In the north, 56% and 32% of respectively the urban and rural population consumed beef, while in the south 52% and 47% of respectively the urban and rural population consumed beef. Nonetheless, the consumption per capita in the urban north is lower, and the share of consumed beef by the urban population is higher compared to the southern urban population. In the north, the urban beef consumption is around two times higher than the rural beef consumption (Table 4).

Almost all mutton consumption is in the north, which is declared by the fact most sheep are held in this part of Nigeria. However, in the north, the consumption in urban and rural households does not significantly differ ($P<0.05$). The goat consumption is also higher in the north, whereby the urban/rural difference is small in north (Table 4) and not significant in the south (Table 5).

The consumption of chicken shows the same pattern compared to beef consumption (Figure 6.a). Chickens are mainly consumed in the south (Figure 6.a) and by urban households (Table 5). The major gap in consumption between the north and the south can be declared by the fact that poultry production in the north is mainly subsistence, while in the south intensive poultry production is situated (FAO, 2018a).

Across Nigeria almost no pork is consumed, whereby there is no difference between consumption in north and south Nigeria ($P<0.05$) (Appendix: Table A5 and Table A6). In the north the urban/rural consumption significantly differs ($P< 0.05$), by which 0.2% and 1.7% of the urban and rural population respectively consumed pork. Next to pork meat, wild game and bushmeat are the only meat category mainly consumed by the rural population, whereby the consumption hereof is concentrated in the South South and South West.

Table 4: Urban and rural weekly consumption per capita in northern Nigeria

Food item	Mean urban consumption per capita	Fraction of urban population consumes the food item	Mean urban consumption per capita	Fraction of rural population consumes the food item	P-value
Beef	0.14	0.56	0.07	0.32	0.00
Mutton	0.02	0.06	0.01	0.06	0.19
Goat	0.03	0.10	0.03	0.16	0.01
Chicken	0.03	0.08	0.02	0.06	0.00
Pork	0.00	0.00	0.00	0.02	0.00
Wildgame	0.00	0.00	0.00	0.01	0.01
Fresh fish	0.07	0.15	0.05	0.13	0.07
Frozen fish	0.05	0.22	0.02	0.11	0.00
Smoked fish	0.02	0.12	0.02	0.11	0.50
Dried fish	0.02	0.19	0.02	0.17	0.57
Agricultural eggs	0.02	0.17	0.00	0.03	0.00
Local eggs	0.00	0.02	0.00	0.04	0.06
Fresh milk	0.07	0.17	0.09	0.20	0.00
Tinned milk	0.05	0.10	0.01	0.03	0.00
Milk powder	0.01	0.22	0.00	0.06	0.00
Sorghum	0.72	0.46	1.45	0.72	0.00
Millet	0.53	0.37	0.73	0.50	0.00
Local rice	0.83	0.59	0.82	0.74	0.81
Imported rice	0.39	0.46	0.10	0.13	0.00
Maize flour	0.44	0.29	0.41	0.29	0.45
Yam flour	0.07	0.11	0.03	0.04	0.00
Cassava flour	0.08	0.14	0.11	0.15	0.05
Wheat flour	0.03	0.06	0.01	0.02	0.00
Bread	0.17	0.65	0.09	0.41	0.00

Notes: These results are conducted from a two sample weighted t-test to compare the consumption per capita per food item between urban and rural consumers in northern Nigeria

Table 5: Urban and rural weekly consumption per capita in southern Nigeria

Food item	Mean urban consumption per capita	Fraction of urban population consumes the food item	Mean urban consumption per capita	Fraction of rural population consumes the food item	P-value
Beef	0.19	0.52	0.14	0.47	0.00
Mutton	0.00	0.01	0.00	0.00	0.14
Goat	0.01	0.04	0.02	0.05	0.56
Chicken	0.07	0.15	0.03	0.07	0.00
Pork	0.00	0.01	0.00	0.01	0.20
Wildgame	0.01	0.01	0.03	0.05	0.00
Fresh fish	0.07	0.11	0.10	0.14	0.00
Frozen fish	0.22	0.65	0.17	0.59	0.00
Smoked fish	0.07	0.22	0.07	0.28	0.46
Dried fish	0.02	0.20	0.04	0.34	0.00
Agricultural eggs	0.05	0.37	0.02	0.19	0.00
Local eggs	0.00	0.01	0.00	0.03	0.00
Fresh milk	0.00	0.00	0.00	0.00	0.20
Tinned milk	0.13	0.16	0.07	0.11	0.00
Milk powder	0.04	0.45	0.02	0.39	0.00
Sorghum	0.01	0.01	0.01	0.01	0.09
Millet	0.00	0.00	0.00	0.00	0.58
Local rice	0.07	0.08	0.18	0.28	0.00
Imported rice	0.70	0.90	0.48	0.69	0.00
Maize flour	0.01	0.02	0.02	0.03	0.05
Yam flour	0.14	0.27	0.06	0.10	0.00
Cassava flour	0.08	0.14	0.08	0.15	0.36
Wheat flour	0.07	0.13	0.03	0.05	0.00
Bread	0.29	0.83	0.22	0.73	0.00

Notes: These results are conducted from a two sample weighted t-test to compare the consumption per capita per food item between urban and rural consumers in southern Nigeria

As already mentioned fish is an important protein source and the cheapest among all animal proteins (Dauda, Ojoko and Fawola, 2016), and can be find back in the consumption pattern of animal proteins and grains and flours (Figure 5). However, absolute fish consumption and relative contribution to the total animal protein intake differs between zones (Figure 6.b.). A significantly higher amount of fish is consumed in the south compared to the north (except for dried fish between urban north and south) (Figure 6.b.; Appendix: Table A5 and Table A6). Looking at the urban/rural differences, in the north only frozen fish consumption significantly differs, and urban consumption is more than two times higher (Table 4). In the south, except for smoked fish, per fish type the consumption significantly differs between urban and rural consumers. Nonetheless, as can be seen in Figure 6.b, the differences remain small (Table 5). As earlier mentioned, around half of the total fish consumption is imported in the form of frozen fish: among African countries Nigeria imports the most frozen fish (Dauda, Ojoko and Fawola, 2016). This imported frozen fish is the most consumed fish type across most zones in Nigeria (Figure 6.b).

In general the urban egg and dairy consumption is higher than the rural consumption (Figure 6.c; Table 5 and Table 6). Only local egg consumption does not differ between rural and urban consumers. The egg consumption is higher in the south compared to the north and is higher at the urban population. Nonetheless the total fraction of local eggs is neglectable compared to agricultural eggs. Mainly in the north the quantity consumed of local eggs is to the same magnitude of agricultural eggs (Figure 6.c.; Table 6). This consumption is in line with the spatial differences of poultry production systems.

Looking at milk consumption, the milk consumption in southern Nigeria is higher than in the north, whereby generally speaking the urban consumption is higher than the rural consumption (Figure 6.c.; Appendix: Table A5 and Table A6). Milk powder is presented in kilograms in concentrated form. Since the highest amount of milk powder is consumed in the south and in urban households, the actual dairy consumption of southern Nigeria and urban households is higher than presented in Figure 6.c. Nonetheless, the type of milk consumed strongly differs between the north and the south, which can be explained by the differences in production system between the north and the south described in the introduction. In mainly North West and North East almost all milk consumption is fresh milk, which comes from the extensive nomadic postal production system. As earlier mentioned, around 60% of the consumed dairy in Nigeria is from imports (FAO, 2018a) and explains the high share in consumption of tinned milk and milk powder in the wealthier south Nigeria.

Both in quantity consumed and consumed food items the grains and flour consumption between the north and the south strongly differs, whereby there seems to be a strong relationship between the geographical differences in consumption (Figure 6.d.) and production (Figure 2) within Nigeria. Sorghum, millet, local rice and maize flour is mainly consumed in the north while a larger amount of imported rice and bread are consumed in the south. Cassava flour and yam flour are mainly consumed in the zones North Central and South West. This consumption pattern is comparable with the geographical distribution of staple crop production earlier described in the introduction.

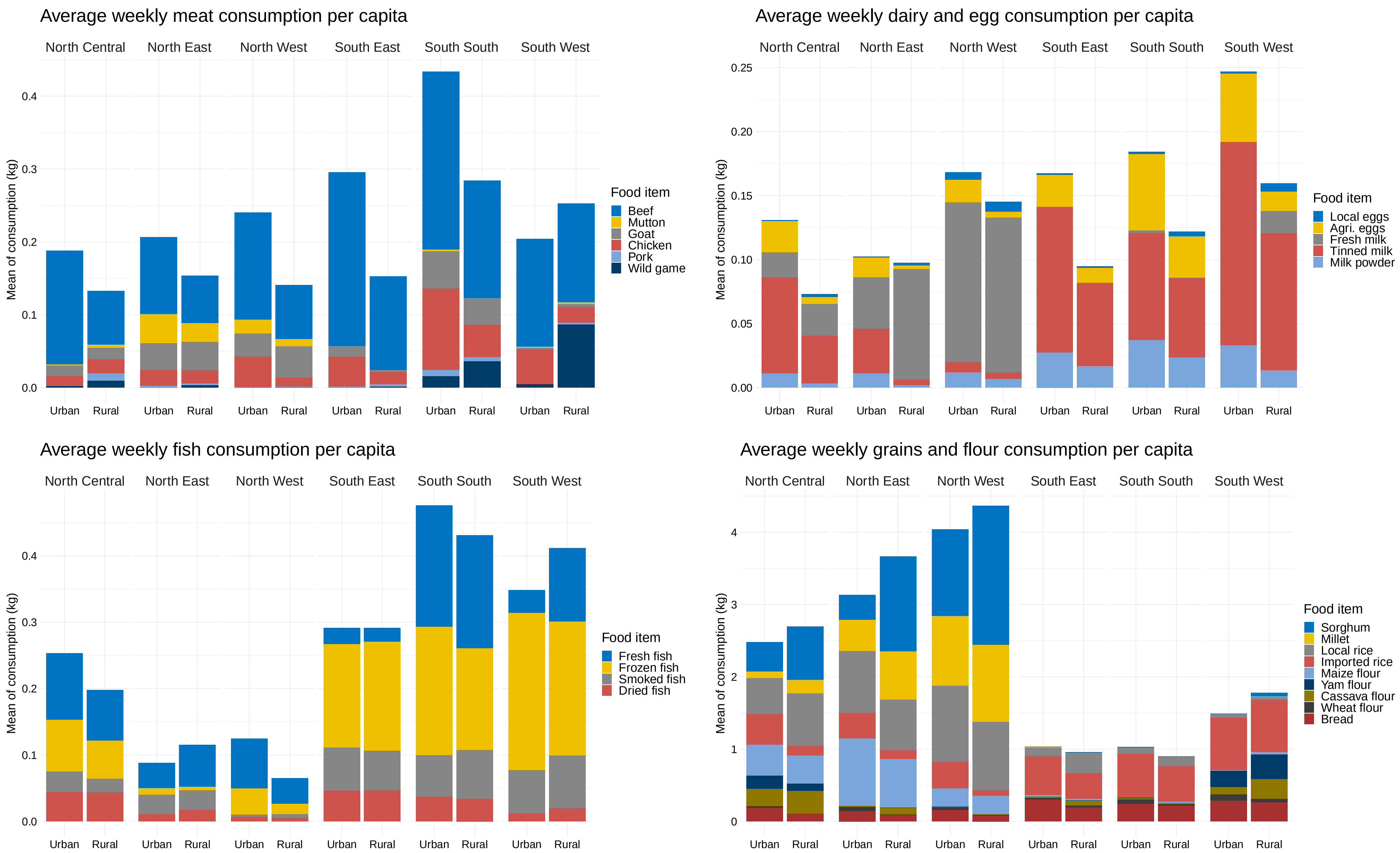

Figure 6: Consumption per capita for the food groups **a.** meat, **b.** fish, **c.** milk and eggs and **d.** cereal and flour products. The consumption per capita represents a male consumers with an age between 18 and 30 years (AEU=1).

Looking at the northern rice consumption, the total amount is roughly the same in urban households compared rural households, while the share of imported rice is higher. In the South East, a similar pattern can be observed, whereby urban households hardly consumed local rice. In rural households the share of local rice in total rice consumption is substantially higher.

In the three northern zones, the grains and flour consumption seems higher for rural consumers (Figure 6.d.), which is mainly caused by approximately two times higher sorghum consumption in the rural areas (Table 4) and to a lesser extent to a higher consumption of millet. The lower total incomes in the south might be the cause of this higher consumption. Households with higher incomes have substituted a part of their staple crop consumption for animal proteins. For other perishable food items it can be expected as well, however, this is not studied in my thesis.

5.2 Income elasticities

For almost all grains and flours food items, the quadratic logarithmic functional form gives better results, which in contrast does not apply to the majority of the animal protein food items (Appendix: Tables A7-A11). As mentioned in the previous chapters, the derived income elasticities from the quadratic logarithmic functional form depend on income, while from the double logarithmic function the income elasticity remains constant when income changes. So, the results of the quadratic and double logarithmic functional forms, which is conform to the expectations, indicate that generally speaking the income elasticities of grains and flours food items are income dependent, while for most animal protein food items the income elasticities are not influenced by changes in income.

Except for fresh milk, all the income dependent income elasticities are lower for higher quintiles (Table 6). For mutton, milk powder, cassava flour and wheat flour, the coefficient of the quadratic of the logarithmic of income is significant at a level of $p<0.10$. For all other food items with income dependent income elasticities, the coefficient of the quadratic of the logarithmic of income is significant for $p<0.05$ or $p<0.01$ (Appendix: Tables A7-A11).

Generally speaking, an increase in household income in the first quantile leads to a relative higher increase in grain and flour demand compared to the increase of the demand of most animal protein food items (Table 6). In contrast, an increase in household income in the highest quintile leads to a slight relative increase in demand for most grains and flours, while it leads to a decrease in demand of sorghum and millet. This means that for the highest income quintile, the relative demand of animal proteins becomes higher compared to the demand of grains and flours. Nonetheless, differences between the income elasticities of food items per food group are observed (Table 6).

Table 6: Income elasticities per food item of the full data set

	Quintiles [1]	Q1	Q2	Q3 (median income)	Q4	Q5
Meat	Beef			0.46		
	Mutton	0.62	0.47	0.37	0.26	0.10
	Goat			0.34		
	Chicken			0.28		
Fish	Fresh fish			0.46		
	Frozen fish	0.37	0.33	0.31	0.29	0.25
	Smoked fish			0.29		
	Dried fish			0.41		
Dairy and eggs	Agricultural eggs			0.43		
	Local eggs			0.22		
	Fresh milk	-0.01	0.09	0.16	0.22	0.33
	Tinned milk			0.33		
	Milk powder	0.75	0.69	0.65	0.61	0.55
Grains and flours	Sorghum	0.48	0.32	0.23	0.13	-0.02
	Millet	0.45	0.34	0.27	0.19	0.08
	Local rice	0.71	0.58	0.50	0.42	0.28
	Imported rice	0.50	0.42	0.36	0.30	0.21
	Bread			0.46		
	Maize flour			0.30		
	Yam flour	0.38	0.28	0.23	0.17	0.07
	Cassava flour	0.35	0.29	0.25	0.21	0.14
	Wheat flour	0.63	0.50	0.42	0.33	0.19

Notes: Food items whereby the income elasticities are only represent for Q3 (median income), the income elasticity is derived from the double logarithmic functional form. For other food items the income elasticities are income dependent and derived from the quadratic functional form.
[1] The income quintiles are derived from the full dataset. For each quintile the median is respesented. Q3 represents the median of the third quintile, which is equal to median income.

Of all meat types, only of mutton the income elasticity is income dependent (Table 6). For a median income the income elasticities of mutton and goat are to the same magnitude. As earlier mentioned, almost all mutton consumption takes place in northern Nigeria and comes from subsistence production systems. This might indicate that mutton is mainly consumed by poorer households. This explains that for these lower income households an increase income leads to a relatively stronger increase in mutton demand compared to higher income households. In contrast, higher income households might choose to consume relatively more other meat types like beef.

Generally, the income elasticities of the meat items are lower than the income elasticities found in the literature for this region. From the meta-analysis of income elasticities in Africa (Melo et al., 2015) the income elasticities of meat, red meat and white meat (range from 0.96 to 1.14) were higher compared to the income elasticities of beef, mutton and goat in this study, except for chicken (0.28). However, a study using the same dataset as in this study (Aborisade and Carpio, 2017) derived contrary elasticities for beef and chicken compared of the outcomes of this study. The conducted income elasticities were in this study 0.69 for beef and 2.78 for chicken (Aborisade and Carpio, 2017). The only explanation of these major differences in derived income elasticities, while using the same dataset, is that Aborisade and Carpio (2017) used a linear approximate almost ideal demand system (LA-AIDS). With an AIDS model the functions of specific food items are within an equation system whereby a price index is (part of) a dependent variable, which is derived from the prices of all investigated food items. In contrast, market prices of other food items do not have an influence on the derived income elasticities in this study, whereby there is only is corrected for the spatiotemporal differences in the price of food item wherefore the income elasticity is derived. Next to this differences, in this study the (natural logarithmic of) consumption in monetary terms is used as dependent variable, while in a AIDS model the budget share is taken.

As for meat, between different fish items differences in income elasticities are found (Table 6). The income elasticity of fresh fish is almost equal to the income elasticity beef, and the income elasticity of smoked fish is comparable to chicken. Only for frozen fish the income elasticity is income dependent, and at the same time the lowest among all fish types. This can be explained by the fact that frozen fish is the cheapest and highest accessible animal protein source in mainly in the south due to imports. Comparing the results with literature, Ezedinma, Kormawa and Chianu (2006) found an expenditure elasticity of 0.68 for fish for urban households. In contrast, Dalhatu and Ala (2010) found an income elasticity of 0.075 for fish for the city Sokoto, situated in the upper North West of Nigeria. Dauda, Ojoka and Fawole (2016) found an income elasticity of 0.11 for frozen fish conducted a study in the city Katisha, situated as well in the upper north of Nigeria. Nonetheless differences in literature are found, all elasticities are, as found in this study, positive and smaller than one, indicating fish can be seen as a normal good.

The derived income elasticities of the different dairy and egg food items (Table 6) are in line with the geographical differences of the production and consumption patterns across Nigeria. The low income dependent income elasticity of fresh milk, which increases when income increases, and the low income elasticity of agricultural eggs, can be explained by the fact that these food items are mainly produced in extensive and highly subsistence farm systems. It might be that a change in household income will have a low influence on the output of subsistence farm systems. So, when income increases households will consume more agricultural eggs, tinned milk and milk powder, which is mainly from commercial production systems or from imports, since the local production systems cannot meet the increase in demand. This explains why the income elasticities of agricultural eggs, tinned milk and milk powder are much higher than the income elasticities of local eggs and fresh milk: an increase in demand induced by income growth for eggs and milk can be fulfilled with commercial and imported products.

Of all grains and flours, only the income elasticities of the food items bread and maize flour do not depend on changes in income, whereby the income dependent income elasticities show differences between the traditional and non-traditional grains and flours (Table 6). For all income quintiles the income elasticities of wheat flour, local rice and imported rice are higher compared to millet, sorghum, cassava flour and yam flour (Figure 7). In addition, as can be seen in figure 7, for sorghum and millet the relative difference - and in the case of millet also the absolute difference – between the income elasticities of the lowest and highest quintiles is the largest among all grain and flour food items. For the highest quintile the income elasticity becomes negative for these two food items.

The derived income elasticities of grains and flours are of the same magnitude as found in the meta-analysis about income elasticities in Africa (Colen et al., 2018; Melo et al., 2015), namely 0.27 for cereals in West-Africa (Colen et al., 2018). The elasticities for rice and millet are 0.36 and 0.22 respectively for Africa. Only the derived elasticity of 2.55 for sorghum (number of estimates was 2) is not comparable with the income elasticities found in the meta-analysis, and seems not reliable (Melo et al., 2015).

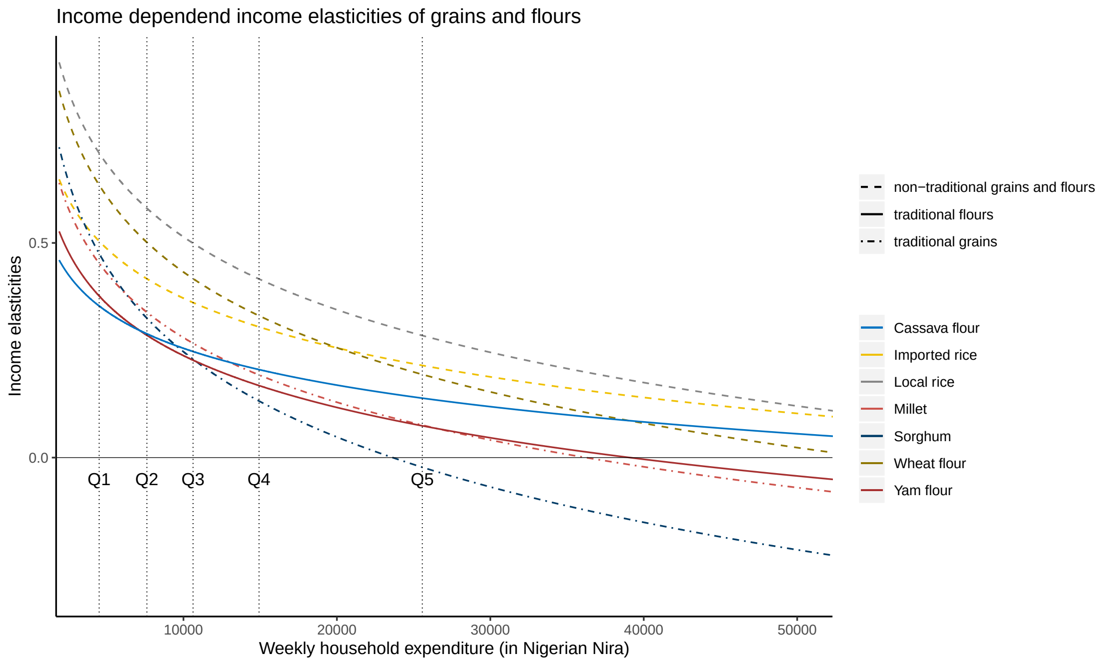

Figure 7: Income dependent income elasticities for grains and flours.

5.2.1 Spatial differences in income elasticities

For food items with more than 200 observations in both subsets, a Chow test is conducted to test if the coefficients of the subsets are equal. This means that for food items between the northern/southern and urban/rural subsets whereby the Chow test is not rejected, I did not prove that the coefficients of the subsets are different. In that case no differentiation in the income elasticities between urban and rural households, and northern and southern Nigeria can be made.

The outcomes of the Chow test shows that the differences income elasticities between urban and rural households is smaller than the differences between northern and southern Nigeria. For seven food items the coefficients of the urban and rural subsets are equal, so the derived income elasticities are not different (Table 7). In contrast, based on the Chow test of the northern and southern subsets, for two food items the coefficients between the double logarithmic functional form and between quadratic functional form for respectively goat and local rice were not significantly different (Table 8). Generally speaking this rejects the assumption that consumption preferences changes due to urbanization, which is in contrast with what would be expected. Meanwhile, the outcomes of the Chow test are consistent with the consumption patterns on urban/rural zone level derived earlier, which shows that the differences between zones, and mainly between northern and southern zones, is higher than between urban and rural households within zones.

Generally speaking, the income elasticities of meat and fish food items marginally differ between northern and southern Nigeria, and all income elasticities of dairy and eggs and grains and flours are higher in northern Nigeria compared to southern Nigeria. In contrast, no clear similarities or differences are found between income elasticities of urban and rural households.

However, markable differences between the income elasticity of urban and rural household are found in poultry food items. The urban income elasticity of chicken is more than three times higher than the rural income elasticity, and the income elasticity of agricultural eggs is higher for urban households compared to rural households. This strong difference might be explained by the fact that urban households have more access to chicken and eggs produced in commercial farm systems compared to rural households, whereby the rural households rely on local production from more extensive production systems. This is consistent with the consumption patterns (Table 6), the share of chicken to total meat consumption and the share of agricultural eggs to total eggs and dairy consumption is higher for urban consumers compared to rural consumers.

Comparing the urban income elasticities with the income elasticities for three major Nigerian cities (Abuja, Kaduna and Kano) conducted by Ezedinma, Kromawa and Chianu, (2006), again the elasticities of beef and chicken show contrary results. The elasticities of 0.82 for beef and 2.03 for chicken derived by Ezedinma, Kromawa and Chianu, (2006) are to the same magnitude as the derived elasticities by Aborisade and Carpio (2017) which are described in the previous section. Also income elasticities for milk and eggs, 0.92 and 1.35 respectively, derived by Ezedinma, Kromawa and Chianu,

(2006) are higher compared to the urban income elasticities in this study. Like Aborisade and Carpio (2017), Ezedinma, Kromawa and Chianu, (2006) used a linear approximate almost ideal demand system (LA-AIDS) which might explain the differences with the income elasticities I derived in this research.

Of all grains and flours, only for imported rice, bread and yam flour, the income elasticities differ between urban and rural households (Table 7) and between northern and southern Nigeria (Table 8). For cassava flour the income elasticities between the north and the south significantly differ as well (Table 8). For yam flour, only the income elasticity for rural households and southern Nigeria are income dependent. In contrast, the income elasticities of urban households and northern Nigeria do not change when income changes. Thereby, yam flour is among the grains and flour the only food item whereby the urban elasticity is higher than the (median of) rural income elasticity, and among all food items the only food item with a higher northern than (median of) southern income elasticity. The sample size cannot explain the appearance of an income dependent income elasticity in one of the subsets. The northern and southern subsets have a roughly equal income elasticity, while the urban subset has an income elasticity which is around 80% higher (Appendix: Table A20 and Table A21).

Table 7: Urban and rural income elasticities per food item

		Urban					Rural				
	Quintiles [1]	Q1	Q2	Q3 (median income)	Q4	Q5	Q1	Q2	Q3 (median income)	Q4	Q5
Meat	Beef			0.46					0.47		
	Goat [2]			0.26					0.38		
	Chicken			0.40					0.12		
Fish	Fresh fish [2]			0.48					0.46		
	Frozen fish	0.45	0.40	0.37	0.34	0.29	0.31	0.28	0.26	0.23	0.20
	Smoked fish			0.29					0.30		
	Dried fish			0.35					0.45		
dairy and eggs	Agricultural eggs	0.65	0.57	0.53	0.48	0.41			0.37		
	Tinned milk			0.34					0.32		
	Milk powder			0.54					0.66		
Grains and flours	Sorghum [2]			0.23			0.49	0.33	0.24	0.13	-0.02
	Millet [2]			0.34			0.47	0.34	0.26	0.18	0.05
	Local rice [2]	0.69	0.55	0.46	0.37	0.23	0.70	0.59	0.53	0.46	0.36
	Imported rice	0.40	0.35	0.32	0.29	0.24	0.56	0.46	0.40	0.33	0.23
	Bread			0.42					0.50		
	Maize flour [2]			0.20			0.62	0.46	0.36	0.26	0.10
	Yam flour			0.22			0.40	0.24	0.14	0.04	-0.12
	Cassava flour [2]			0.00 [3]			0.50	0.41	0.36	0.30	0.21

Notes: Food items whereby the income elasticities are only represent for Q3 (median income), the income elasticity is derived from the double logarithmic functional form. For other food items the income elasticities are income dependent and derived from the quadratic functional form. For local eggs and wheat flour both subsets are smaller than 200 observations. For mutton, fresh milk and cassava flour the urban subsets are smaller than 200 observations.

[1] The income quintiles are derived from the full dataset. For each quintile the median is respesented. Q3 represents the median of the third quintile, which is equal to median income.

[2] The chow test is not rejected. There is no difference in the urban/rural data sets, so the urban and rural income elasticities are not different.

[3] Coefficient of log total expenditure was not significantly different from zero in double logarithmic regression (Annex XXX, table XXX).

Table 8: Northern and Southern income elasticities per food item

		North					South				
	Quintiles [1]	Q1	Q2	Q3 (median income)	Q4	Q5	Q1	Q2	Q3 (median income)	Q4	Q5
Meat	Beef			0.44					0.46		
	Goat [2]			0.33					0.37		
	Chicken			0.28					0.27		
Fish	Fresh fish			0.47					0.46		
	Frozen fish			0.37			0.36	0.33	0.31	0.28	0.25
	Smoked fish			0.33					0.28		
	Dried fish			0.39					0.42		
Dairy and eggs	Agricultural eggs			0.51					0.42		
	Tinned milk			0.47					0.29		
	Milk powder			0.95					0.57		
Grains and flours	Local rice [2]	0.77	0.65	0.57	0.50	0.37	0.53	0.41	0.34	0.26	0.14
	Imported rice			0.41			0.47	0.39	0.33	0.28	0.20
	Bread			0.49					0.45		
	Yam flour			0.26			0.37	0.28	0.22	0.16	0.07
	Cassava flour	0.58	0.42	0.32	0.22	0.05			0.18		

Notes: Food items whereby the income elasticities are only represent for Q3 (median income), the income elasticity is derived from the double logarithmic functional form. For other food items the income elasticities are income dependent and derived from the quadratic functional form. For local eggs and wheat flour both subsets are smaller than 200 observations. For mutton, fresh milk, sorghum, millet and maize flour only the Southern subsets are smaller than 200 observations.

[1] The income quintiles are derived from the full dataset. For each quintile the median is respesented. Q3 represents the median of the third quintile, which is equal to median income.

[2] The chow test is not rejected. There is no difference in the urban/rural data sets, so the urban and rural income elasticities are not different.

The income elasticities of local rice are higher compared to imported rice. Thereby, striking differences in the outcomes of the Chow tests between local and imported rice are found. Despite that the number of observations of local rice one of the highest among all food items and comparable to imported rice, it is not proven that the coefficients of the northern/southern and urban/rural subsets are different for local rice. So, there cannot be stated that the elasticities of local rice between the subsets are different.

Comparing the income elasticity of local rice with the income elasticities of imported rice for urban and rural households, the income elasticity of local rice and imported rice for urban households become equal when income becomes higher than the median of the fifth quintile (Figure 8). For urban households with a weekly expenditure of around 40,000 Nigerian Nira or higher the income elasticity of imported rice is higher than for local rice (figure 8). Based on the derived kg price from the survey, results from the t-test shows that the median prices of local rice and imported rice are 228.7 and 762.3 Nigerian Nira per kilogram respectively, and are significantly different (Appendix: Table A37). Due to the fact that the market price of imported rice is more than three times higher than for local rice, households might choose to spend relatively more on local rice compared to imported rice when their income increases.

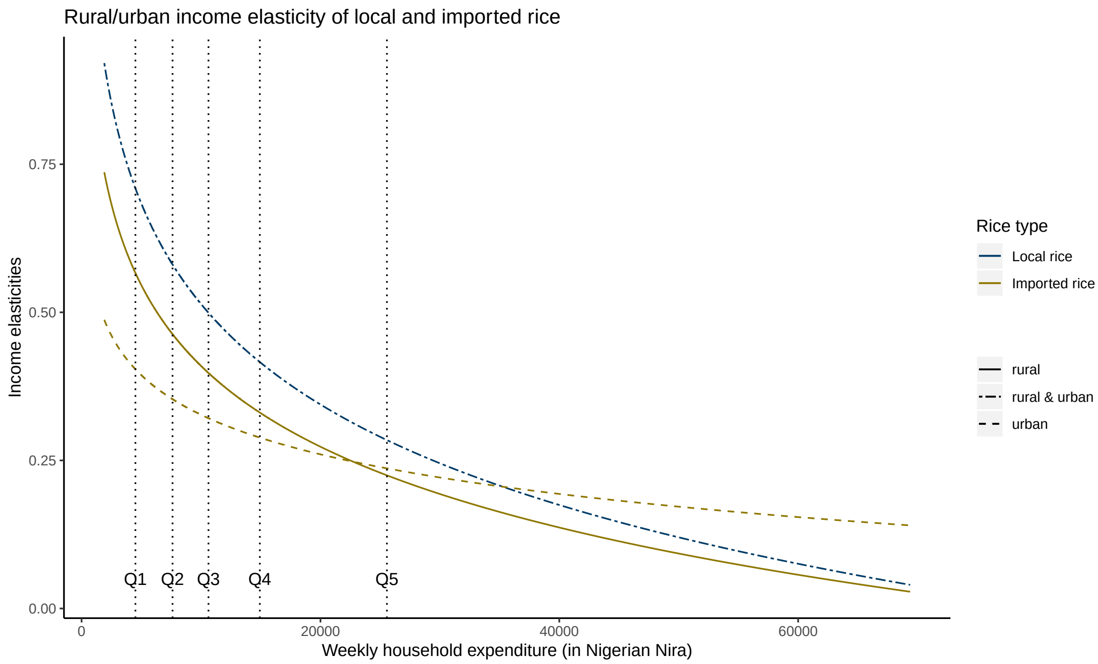

Figure 8: The income dependent income elasticity of local rice from the full dataset and the income dependent income elasticities of imported rice for urban and rural households. The Q1-Q5 represents the median of the five income quintiles. The levels of weekly household expenditure are derived from the household survey data, so the graph is not extrapolated.

6 Discussion and conclusion

In this research, I identified for which food items the derived income elasticities are income-dependent for animal proteins and grains and flours. In addition, the income elasticities of urban and rural households and between northern and southern Nigeria are compared. Prior, the temporal spatial-distribution of total expenditure per capita and consumption pattern per capita of animal proteins and grains and flours are analysed.

The results confirm that the income elasticities of grains and flours are income dependent and decreasing when income increases, while in contrast the income elasticity of most animal proteins food items do not change when income changes. For higher-income households, this results in a relatively higher increase in demand for animal proteins compared to grains and flours, and for some grains and flours products a decrease in demand when income increases. An increase in income for households in the lowest quintile leads to a relatively higher demand for most grains and flour food items (in particular the grains) compared to the majority of the animal protein food items.

Next to differences between food groups, the results prove that growth in income leads to a relatively higher demand for non-traditional grains and flours compared to traditional grains, and substitution between non-traditional and traditional grains and flours takes place. The income elasticities of in particular sorghum and millet are lower compared to local and imported rice, wheat flour and bread. For the highest quintile the income elasticity of sorghum and millet are negative, indicating that these traditional grains are substituted for non-traditional grains.

Northern Nigeria is less wealthy compared to southern Nigeria and the consumption patterns of animal proteins, and grains and flours differ both in types of consumed food items as in quantity consumed. In contrast, the urban/rural differences per zone are mainly in the quantity consumed, induced by differences in urban and rural income heights; in all zones the urban total expenditure was higher. A higher amount of animal proteins is consumed in the south and, within zones, in urban areas, while grains and flours are consumed more in the north. In the north the consumption is higher in rural households compared to urban. The differences in total expenditure and consumption between the post-planting and post-harvest period are not noteworthy.

In contrast to the income elasticities of urban and rural households, a clear pattern in the income elasticities of northern and southern Nigeria is found. For meat and fish, the income elasticity from significantly different slopes showed minor differences. In contrast, for all dairy and eggs and most grains and flour types, the income elasticities were higher in the north compared to the south.

It is questionable if the absence of significant slopes of the quadratic of the logarithmic of income in the regression of the quadratic logarithmic functional form for mainly animal proteins can be explained by economic theories, or is mainly caused by the number of observations in dataset per food item. As earlier described, despite a robust amount of households were interviewed two times during Wave 3, per food item the amount of observations differs with in general more observations for grains and flour compared to animal protein food items. By comparing the specific food of the full dataset and the subsets by focussing on whether there is a quadratic correlation and also taking into account the number of observations in the datasets, it can be concluded that the number of observations in de dataset does not (mainly) cause the quadratic relationship.

Although beef and bread are among the four food items with the highest number of observations, namely bread, imported rice, local rice and beef with a number of observations of 5350, 4147, 4053 and 3857 respectively (Appendix: Table A7 and Table A10), the derived income elasticities of both food items do not change when income changes. In contrast, the number of observation of yam flour, with an income-dependent income elasticity, is 956. The number of observations is lower than for animal protein food items like smoked fish, dried fish and agricultural eggs with income elasticities which are not influenced by changes in income. This comparison indicates that the size of the dataset is not the main driver of whether the income elasticity of a food item is income dependent.

For food items with income dependent income elasticities, only for urban/rural households or for only northern/southern Nigeria, the appearance of these income dependent income elasticities cannot be explained by the size of the subsets. As earlier mentioned, for yam flour the sample size of the urban and rural subsets are 615 and 341 respectively; only for the rural households the income elasticity is income dependent.

By using state as a geographical dummy and as an interaction dummy with time, the loss in degrees of freedom might cause the insignificant coefficients of the quadratic terms in the regressions for food items which are consumed in most or all the 36 states. However, the results of the regression with zone as dummy, and as interaction dummy with time, there are only minor differences in the outcomes (Appendix: Tables A32-A36). This proves that the use of state as dummy is not a limitation for the regression, whereby the preference of using state over zone as dummy is that it might capture spatial differences in price better.

The income elasticities derived in this research are generally lower than described in the literature. As earlier mentioned, the literature which derived higher income elasticities compared to this study, used an AIDS model. In contrast to our method, prices of all researched food items have an influence on the derived income elasticity of specific food items. Since market prices are not included in this study, the influence of price differences between food items on the derived income elasticities are not taken into account.

Since in this thesis I did not use a demand system. Therefore own- and cross-prices elasticities were not derived and not taken into account. I recommend to investigate how to combine a quadratic logarithm functional form, or other functional forms which can derive income dependent income elasticities, with a demand systems, and analyse if this method performs better. In addition, (most) models use price elasticities as well, so research on how to derive price elasticities from a demand system which also derives income dependent income elasticities, might further improve food demand models.

At last, I recommend to derive income elasticities of the specific food items of all other food groups, like vegetables and roots and tubers, differentiation in processed and non-processed, so future food demands can be fully modelled on a detailed level.

The analysed income elasticities give a proper insight in how a change in household income affects the changes in demand of specific food items analysed in this thesis. These results are consistent with the theory and prospects of Nigeria, and Sub-Saharan Africa in general: growth in income leads to a shift in diets with more animal proteins and non-traditional grains. By using these derived income elasticities in food demand models and making food demand models suitable for income dependent income elasticities, the shift to more animal protein rich diets with a higher share in non-traditional grains should appear in future scenario studies.

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Appendix

Table A1: Total expenditure per capita in post-planting and post-harvest period for urban and rural areas

	Number of observations	Total expenditure per capita in post-planting period	Total expenditure per capita in post-planting period	Difference in total expenditure per capita	P-value
Total expenditure per capita for urban areas	1243	3448.1	3230.8	217.3	0.15
Total expenditure per capita for rural areas	2989	1979.4	2004.1	-24.7	0.69

Notes: These results are conducted from a paired t-test to compare total expenditure per capita the between post-planting and post-harvest period

Table A2: Difference in total expenditure per capita the between urban and rural areas for northern and southern Nigeria

	Number of observations	Total expenditure per capita for urban areas	Total expenditure per capita for rural areas	Difference in total expenditure per capita	P-value
Total expenditure per capita for northern Nigeria	4442	2675.4	1565.8	1109.6	0.00
Total expenditure per capita for southern Nigeria	4022	3729.0	2957.9	771.1	8.26e-12

Notes: These results are conducted from a two sample weighted t-test to compare total expenditure per capita the between urban and rural areas

Table A3: Difference in total expenditure per capita the between northern and southern Nigeria for urban and rural areas

	Number of observations	Total expenditure per capita for northern Nigeria	Total expenditure per capita for southern Nigeria	Difference in total expenditure per capita	P-value
Total expenditure per capita for urban areas	2486	2675.4	3729	154.4	1.19e-11
Total expenditure per capita for rural areas	5978	1565.8	2957.9	-24.7	0.00

Notes: These results are conducted from a two sample weighted t-test to compare total expenditure per capita the between northern and southern Nigeria

Table A4: Consumption in post-harvest and post-planting period

Food item	Mean consumption per capita in post-planting period	Fraction of population consumes food item in post-planting period	Mean consumption per capita in post-planting period	Fraction of population consumes food item in post-harvest period	P-value
Beef	0.12	0.45	0.12	0.44	0.57
Mutton	0.01	0.03	0.01	0.03	0.40
Goat	0.03	0.10	0.02	0.09	0.19
Chicken	0.04	0.10	0.03	0.08	0.01
Pork	0.00	0.01	0.00	0.01	0.96
Wildgame	0.01	0.02	0.01	0.02	0.95
Fresh fish	0.08	0.14	0.06	0.12	0.02
Frozen fish	0.11	0.41	0.10	0.41	0.87
Smoked fish	0.04	0.18	0.04	0.19	0.31
Dried fish	0.02	0.23	0.02	0.22	0.36
Agricultural eggs	0.02	0.20	0.02	0.17	0.00
Local eggs	0.00	0.03	0.00	0.02	0.00
Fresh milk	0.05	0.10	0.04	0.08	0.00
Tinned milk	0.06	0.10	0.06	0.09	0.44
Milk powder	0.02	0.29	0.02	0.27	0.90
Sorghum	0.72	0.31	0.70	0.29	0.51
Millet	0.38	0.22	0.37	0.20	0.81
Local rice	0.47	0.39	0.54	0.42	0.00
Imported rice	0.37	0.55	0.35	0.52	0.05
Maize flour	0.21	0.14	0.26	0.14	0.00
Yam flour	0.07	0.14	0.06	0.13	0.31
Cassava flour	0.09	0.15	0.10	0.14	0.31
Wheat flour	0.03	0.07	0.03	0.06	0.12
Bread	0.18	0.67	0.17	0.62	0.05

Notes: These results are conducted from a paired t-test to compare per food item the consumption per capita the between post-planting and post-harvest period

Table A5: Urban consumption in northern and southern Nigeria

Food item	Mean consumption per capita in northern Nigeria	Fraction of northern population consumes the food item	Mean consumption per capita in southern Nigeria	Fraction of southern population consumes the food item	P-value
Beef	0.14	0.56	0.07	0.32	0.00
Mutton	0.02	0.06	0.01	0.06	0.19
Goat	0.03	0.10	0.03	0.16	0.01
Chicken	0.03	0.08	0.02	0.06	0.00
Pork	0.00	0.00	0.00	0.02	0.00
Wildgame	0.00	0.00	0.00	0.01	0.01
Fresh fish	0.07	0.15	0.05	0.13	0.07
Frozen fish	0.05	0.22	0.02	0.11	0.00
Smoked fish	0.02	0.12	0.02	0.11	0.50
Dried fish	0.02	0.19	0.02	0.17	0.57
Agricultural eggs	0.02	0.17	0.00	0.03	0.00
Local eggs	0.00	0.02	0.00	0.04	0.06
Fresh milk	0.07	0.17	0.09	0.20	0.00
Tinned milk	0.05	0.10	0.01	0.03	0.00
Milk powder	0.01	0.22	0.00	0.06	0.00
Sorghum	0.72	0.46	1.45	0.72	0.00
Millet	0.53	0.37	0.73	0.50	0.00
Local rice	0.83	0.59	0.82	0.74	0.81
Imported rice	0.39	0.46	0.10	0.13	0.00
Maize flour	0.44	0.29	0.41	0.29	0.45
Yam flour	0.07	0.11	0.03	0.04	0.00
Cassava flour	0.08	0.14	0.11	0.15	0.05
Wheat flour	0.03	0.06	0.01	0.02	0.00
Bread	0.17	0.65	0.09	0.41	0.00

Notes: These results are conducted from a two sample weighted t-test to compare per food item the urban consumption per capita between northern and southern Nigeria

Table A6: Rural consumption in northern and southern Nigeria

Food item	Mean consumption per capita in northern Nigeria	Fraction of northern population consumes the food item	Mean consumption per capita in southern Nigeria	Fraction of southern population consumes the food item	P-value
Beef	0.19	0.52	0.14	0.47	0.00
Mutton	0.00	0.01	0.00	0.00	0.14
Goat	0.01	0.04	0.02	0.05	0.56
Chicken	0.07	0.15	0.03	0.07	0.00
Pork	0.00	0.01	0.00	0.01	0.20
Wildgame	0.01	0.01	0.03	0.05	0.00
Fresh fish	0.07	0.11	0.10	0.14	0.00
Frozen fish	0.22	0.65	0.17	0.59	0.00
Smoked fish	0.07	0.22	0.07	0.28	0.46
Dried fish	0.02	0.20	0.04	0.34	0.00
Agricultural eggs	0.05	0.37	0.02	0.19	0.00
Local eggs	0.00	0.01	0.00	0.03	0.00
Fresh milk	0.00	0.00	0.00	0.00	0.20
Tinned milk	0.13	0.16	0.07	0.11	0.00
Milk powder	0.04	0.45	0.02	0.39	0.00
Sorghum	0.01	0.01	0.01	0.01	0.09
Millet	0.00	0.00	0.00	0.00	0.58
Local rice	0.07	0.08	0.18	0.28	0.00
Imported rice	0.70	0.90	0.48	0.69	0.00
Maize flour	0.01	0.02	0.02	0.03	0.05
Yam flour	0.14	0.27	0.06	0.10	0.00
Cassava flour	0.08	0.14	0.08	0.15	0.36
Wheat flour	0.07	0.13	0.03	0.05	0.00
Bread	0.29	0.83	0.22	0.73	0.00

Notes: These results are conducted from a two sample weighted t-test to compare per food item the rural consumption per capita between northern and southern Nigeria

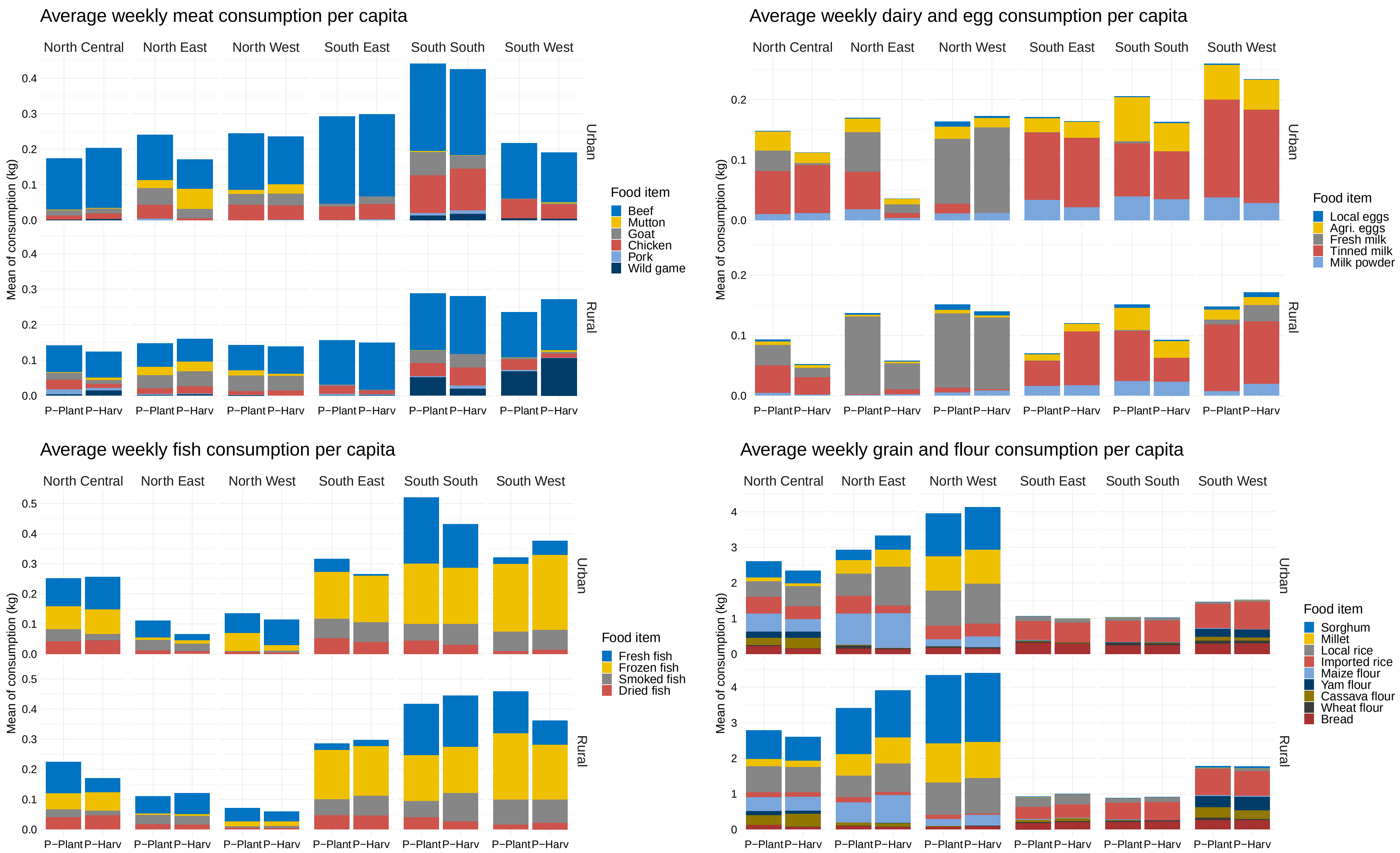

Figure A1: Consumption per capita for the food groups **a.** meat, **b.** fish, **c.** milk and eggs and **d.** cereal and flour products. The consumption per capita represents a male consumers with an age between 18 and 30 years (AEU=1).

Table A7: Double log and quadratic log regression results for meat food items

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.462***	0.537	0.327***	3.162**	0.331***	−0.164	0.269***	−0.594	0.102	−2.259
	(0.019)	(0.374)	(0.074)	(1.469)	(0.045)	(0.702)	(0.051)	(0.835)	(0.062)	(1.814)
Quadratic of log income		−0.004		−0.150*		0.026		0.044		0.128
		(0.020)		(0.077)		(0.037)		(0.042)		(0.097)
Household Adult Equivalent	0.031***	0.031***	0.013	0.011	0.010	0.010	0.014	0.014	−0.016	−0.011
	(0.005)	(0.005)	(0.012)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)	(0.024)	(0.024)
Constant	2.230***	1.874	3.230***	−10.070	2.763***	5.108	4.185***	8.437**	5.554***	16.420*
	(0.176)	(1.764)	(0.657)	(6.916)	(0.432)	(3.349)	(0.505)	(4.156)	(0.654)	(8.456)
Observations	3,857	3,857	306	306	880	880	653	653	129	129

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A8: Double log and quadratic log regression results for fish food items

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.451***	0.718	0.301***	0.927***	0.261***	−0.352	0.400***	−0.206
	(0.036)	(0.744)	(0.020)	(0.257)	(0.030)	(0.547)	(0.031)	(0.626)
Quadratic of log income		−0.014		−0.033**		0.033		0.032
		(0.039)		(0.014)		(0.030)		(0.034)
Household Adult Equivalent	−0.001	−0.001	0.025***	0.024***	0.022**	0.022**	0.015*	0.016*
	(0.012)	(0.012)	(0.008)	(0.008)	(0.009)	(0.009)	(0.008)	(0.008)
Constant	1.810***	0.539	2.903***	0.001	3.722***	6.581***	2.158***	4.997*
	(0.368)	(3.544)	(0.183)	(1.199)	(0.290)	(2.512)	(0.303)	(2.896)
Observations	1,163	1,163	3,309	3,309	1,642	1,642	2,204	2,204

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A9: Double log and quadratic log regression results for dairy and egg food items

	Agricultural eggs		Local eggs		Fresh milk		Tinnend milk		Milk powder	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.429***	1.088	0.247**	1.017	0.163***	−1.628**	0.336***	0.899	0.606***	1.729***
	(0.028)	(0.711)	(0.118)	(2.007)	(0.058)	(0.783)	(0.046)	(0.739)	(0.037)	(0.602)
Quadratic of log income		−0.034		−0.041		0.096**		−0.029		−0.058*
		(0.037)		(0.109)		(0.042)		(0.039)		(0.031)
Household Adult Equivalent	0.028**	0.027**	0.036*	0.037*	0.028**	0.030***	0.006	0.006	0.005	0.003
	(0.011)	(0.011)	(0.019)	(0.019)	(0.011)	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)
Constant	0.453*	−2.725	2.206*	−1.410	4.047***	12.328***	1.818***	−0.862	−0.816**	−6.172**
	(0.263)	(3.417)	(1.127)	(9.172)	(0.560)	(3.631)	(0.430)	(3.518)	(0.332)	(2.895)
Observations	1,446	1,446	189	189	805	805	780	780	2,087	2,087

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A10: Double log and quadratic log regression results for grain food and flour items

	Sorghum		Millet		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.198***	3.079***	0.222***	2.579***	0.507***	2.760***	0.332***	1.910***	0.469***	0.718*
	(0.039)	(0.531)	(0.039)	(0.486)	(0.025)	(0.406)	(0.021)	(0.331)	(0.020)	(0.381)
Quadratic of log income		−0.157***		−0.128***		−0.122***		−0.083***		−0.013
		(0.029)		(0.026)		(0.022)		(0.018)		(0.020)
Household Adult Equivalent	0.093***	0.091***	0.068***	0.068***	0.062***	0.060***	0.128***	0.126***	0.050***	0.050***
	(0.008)	(0.008)	(0.010)	(0.009)	(0.006)	(0.006)	(0.008)	(0.008)	(0.006)	(0.006)
Constant	4.151***	−8.993***	3.868***	−6.864***	1.195***	−9.165***	2.709***	−4.698***	1.033***	−0.137
	(0.334)	(2.435)	(0.435)	(2.253)	(0.236)	(1.840)	(0.192)	(1.541)	(0.184)	(1.770)
Observations	2,961	2,961	2,087	2,087	4,053	4,053	4,147	4,147	5,350	5,350

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A11: Double log and quadratic log regression results for grain food and flour items

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.269***	1.629*	0.183***	1.759***	0.229***	1.409**	0.289***	2.961**
	(0.051)	(0.917)	(0.050)	(0.666)	(0.043)	(0.671)	(0.071)	(1.405)
Quadratic of log income		−0.073		−0.084**		−0.064*		−0.136*
		(0.049)		(0.035)		(0.036)		(0.071)
Household Adult Equivalent	0.070***	0.070***	0.125***	0.121***	0.077***	0.076***	0.046*	0.039
	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.025)	(0.025)
Constant	1.039**	−5.273	3.930***	−3.330	2.610***	−2.815	3.133***	−9.956
	(0.487)	(4.273)	(0.514)	(3.162)	(0.404)	(3.097)	(0.659)	(6.865)
Observations	1,412	1,412	956	956	1,252	1,252	274	274

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A12: Urban: Double log and quadratic log regression results for meat food items

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.458***	1.246**	-	-	0.261**	−1.207	0.403***	−1.321	-	-
	(0.027)	(0.606)	(-)	(-)	(0.088)	(1.626)	(0.086)	(2.065)	(-)	(-)
Quadratic of log income		−0.041		-		0.074		0.086		-
		(0.032)		-		(0.082)		(0.101)		-
Household Adult Equivalent	0.048***	0.047***	-	-	0.045	0.046	−0.006	−0.007	-	-
	(0.008)	(0.008)	(-)	(-)	(0.027)	(0.027)	(0.024)	(0.024)	(-)	(-)
Constant	2.186***	−1.624	-	-	3.867***	11.117	2.850***	11.482	-	-
	(0.266)	(2.916)	(-)	(-)	(0.786)	(8.006)	(0.859)	(10.505)	(-)	(-)
Observations	1,540	1,540	74	74	192	192	292	292	19	19

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A13: Rural: Double log and Quadratic log regression results for meat food items

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.466***	0.289	0.445***	1.622	0.384***	−0.521	0.119**	0.581	0.108	−2.907
	(0.028)	(0.518)	(0.092)	(2.263)	(0.054)	(0.869)	(0.060)	(0.748)	(0.076)	(2.349)
Quadratic of log income		0.009		−0.063		0.048		−0.024		0.165
		(0.028)		(0.121)		(0.046)		(0.039)		(0.128)
Household Adult Equivalent	0.020***	0.020***	0.007	0.005	−0.005	−0.005	0.040***	0.039***	−0.043*	−0.039
	(0.006)	(0.006)	(0.015)	(0.015)	(0.011)	(0.011)	(0.015)	(0.015)	(0.024)	(0.023)
Constant	2.258***	3.096	2.188***	−3.313	2.274***	6.475	5.605***	3.363	5.292***	19.005
	(0.254)	(2.415)	(0.794)	(10.533)	(0.530)	(4.069)	(0.569)	(3.601)	(0.723)	(10.738)
Observations	2,317	2,317	232	232	688	688	361	361	110	110

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A14: Urban: Double log and Quadratic log regression results for fish food items

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.476***	−1.294	0.355***	1.269***	0.291***	−1.509	0.353***	−0.779
	(0.078)	(1.241)	(0.031)	(0.421)	(0.047)	(1.026)	(0.047)	(1.109)
Quadratic of log income		0.090		−0.048**		0.094*		0.059
		(0.063)		(0.022)		(0.054)		(0.058)
Household Adult Equivalent	−0.001	0.001	0.023*	0.022*	0.006	0.008	0.000	0.002
	(0.017)	(0.016)	(0.013)	(0.013)	(0.014)	(0.014)	(0.013)	(0.014)
Constant	1.860**	10.500*	2.350***	−1.930	3.459***	12.029**	2.596***	7.999
	(0.830)	(6.147)	(0.284)	(1.984)	(0.452)	(4.840)	(0.479)	(5.202)
Observations	354	354	1,457	1,457	502	502	647	647

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

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Table A15: Rural: Double log and Quadratic log regression results for fish food items

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.457***	1.786**	0.259***	0.874**	0.299***	0.098	0.446***	−0.765
	(0.043)	(0.873)	(0.030)	(0.352)	(0.038)	(0.736)	(0.044)	(0.766)
Quadratic of log income		−0.070		−0.033*		0.011		0.065
		(0.045)		(0.019)		(0.040)		(0.042)
Household Adult Equivalent	−0.008	−0.009	0.025***	0.025***	0.021**	0.021**	0.012	0.014
	(0.015)	(0.015)	(0.009)	(0.009)	(0.011)	(0.011)	(0.010)	(0.010)
Constant	1.536***	−4.722	3.297***	0.475	3.405***	4.336	1.848***	7.473**
	(0.405)	(4.146)	(0.280)	(1.611)	(0.364)	(3.312)	(0.395)	(3.516)
Observations	809	809	1,852	1,852	1,140	1,140	1,557	1,557

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A16: Urban: Double log and Quadratic log regression results for dairy and egg food items

	Agricultural eggs		Local eggs		Fresh milk		Tinned milk		Milk powder	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.461***	1.851**	0.519	−14.457	0.189	-	0.338***	1.216	0.544***	1.848*
	(0.040)	(0.767)	(0.386)	(14.887)	(0.115)	(-)	(0.070)	(1.041)	(0.051)	(0.965)
Quadratic of log income		−0.071*		0.758			−0.046		−0.067	
		(0.040)		(0.769)		(-)		(0.054)		(0.049)
Household Adult Equivalent	0.031*	0.029*	0.029	0.078	0.012	-	−0.003	−0.003	0.001	−0.000
	(0.016)	(0.016)	(0.059)	(0.059)	(0.024)	(-)	(0.019)	(0.019)	(0.018)	(0.018)
Constant	0.069	−6.657*	−0.136	72.619	3.630	-	1.768***	−2.439	−0.144	−6.445
	(0.374)	(3.690)	(4.153)	(70.611)	(1.081)	(-)	(0.652)	(5.037)	(0.467)	(4.729)
Observations	859	859	39	39	135	135	410	410	963	963

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A17: Rural: Double log and Quadratic log regression results for dairy and egg food items

	Agricultural eggs		Local eggs		Fresh milk		Tinned milk		Milk powder	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.371***	0.133	0.171	4.185***	0.121**	−1.524*	0.323***	0.097	0.664***	1.571**
	(0.057)	(0.962)	(0.119)	(1.516)	(0.060)	(0.913)	(0.066)	(1.100)	(0.046)	(0.732)
Quadratic of log income		0.012		−0.215**		0.090*		0.012		−0.048
		(0.051)		(0.082)		(0.050)		(0.059)		(0.038)
Household Adult Equivalent	0.024*	0.025*	0.046**	0.053**	0.034***	0.036***	0.013	0.013	0.004	0.003
	(0.013)	(0.013)	(0.022)	(0.021)	(0.010)	(0.010)	(0.018)	(0.018)	(0.012)	(0.012)
Constant	1.128**	2.271	2.837**	−15.825**	4.396***	11.913***	2.159***	3.226	−1.372***	−5.646
	(0.511)	(4.570)	(1.104)	(6.931)	(0.595)	(4.180)	(0.598)	(5.103)	(0.403)	(3.480)
Observations	587	587	150	150	670	670	370	370	1,124	1,124

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A18: Urban: Double log and Quadratic log regression results for grain food and flour items

	Sorghum		Millet		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.234**	1.883	0.344**	2.088	0.412***	3.016***	0.296***	1.215***	0.421***	0.740
	(0.076)	(1.250)	(0.102)	(1.222)	(0.052)	(0.583)	(0.032)	(0.438)	(0.030)	(0.564)
Quadratic of log income		−0.087		−0.091		−0.138***		−0.048**		−0.017
		(0.065)		(0.061)		(0.032)		(0.023)		(0.030)
Household Adult Equivalent	0.076**	0.075**	0.035	0.035	0.076***	0.075***	0.145***	0.144***	0.067***	0.066***
	(0.025)	(0.025)	(0.023)	(0.022)	(0.014)	(0.014)	(0.011)	(0.011)	(0.011)	(0.010)
Constant	3.928***	−3.885	2.562*	−5.759	1.726***	−10.566***	2.919***	−1.432	1.453***	−0.068
	(0.639)	(5.950)	(1.060)	(6.125)	(0.467)	(2.691)	(0.304)	(2.053)	(0.280)	(2.640)
Observations	449	449	361	361	679	679	2,111	2,111	2,141	2,141

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A19: Rural: Double log and Quadratic log regression results for grain food and flour items

	Sorghum		Millet		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.292***	3.047***	0.309***	2.597***	0.548***	2.388***	0.382***	2.222***	0.498***	0.444
	(0.037)	(0.603)	(0.037)	(0.585)	(0.026)	(0.469)	(0.034)	(0.505)	(0.031)	(0.384)
Quadratic of log income		−0.152***		−0.126***		−0.100***		−0.098***		0.003
		(0.033)		(0.032)		(0.026)		(0.027)		(0.021)
Household Adult Equivalent	0.084***	0.083***	0.065***	0.064***	0.054***	0.053***	0.110***	0.109***	0.042***	0.042***
	(0.008)	(0.007)	(0.009)	(0.009)	(0.006)	(0.006)	(0.009)	(0.009)	(0.006)	(0.006)
Constant	3.369***	−9.088***	3.418***	−6.916**	0.843***	−7.550***	2.383***	−6.176***	0.794***	1.044
	(0.317)	(2.751)	(0.452)	(2.669)	(0.240)	(2.125)	(0.303)	(2.336)	(0.277)	(1.796)
Observations	2,512	2,512	1,726	1,726	3,374	3,374	2,036	2,036	3,209	3,209

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A20: Urban: Double log and Quadratic log regression results for grain food and flour items

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.198**	−1.758	0.216***	1.320	0.078	−1.029	0.349***	1.410
	(0.091)	(1.367)	(0.053)	(0.852)	(0.059)	(1.163)	(0.093)	(1.738)
Quadratic of log income		0.102		−0.058		0.059		−0.053
		(0.073)		(0.044)		(0.062)		(0.086)
Household Adult Equivalent	0.112***	0.115***	0.116***	0.112***	0.080***	0.082***	0.026	0.023
	(0.017)	(0.017)	(0.015)	(0.015)	(0.018)	(0.017)	(0.038)	(0.040)
Constant	1.640*	10.945	3.612***	−1.523	4.055***	9.228*	2.650***	−2.587
	(0.861)	(6.353)	(0.551)	(4.094)	(0.571)	(5.466)	(0.788)	(8.654)
Observations	282	282	615	615	407	407	156	156

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A21: Rural: Double log and Quadratic log regression results for grain food and flour items

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.367***	3.204***	0.177**	3.024***	0.381***	1.904*	−0.199	7.145**
	(0.059)	(1.024)	(0.076)	(0.907)	(0.057)	(1.000)	(0.151)	(2.668)
Quadratic of log income		−0.153***		−0.155***		−0.083		−0.379**
		(0.056)		(0.049)		(0.055)		(0.139)
Household Adult Equivalent	0.046***	0.047***	0.139***	0.138***	0.065***	0.066***	0.110***	0.120***
	(0.010)	(0.010)	(0.024)	(0.024)	(0.015)	(0.015)	(0.034)	(0.031)
Constant	2.690***	−10.374**	2.572***	−10.548**	1.243**	−5.682	8.585***	−26.329**
	(0.520)	(4.700)	(0.588)	(4.211)	(0.523)	(4.529)	(1.588)	(12.575)
Observations	1,130	1,130	341	341	845	845	118	118

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A22: North: Double log and quadratic log regression results for meat food items

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.440***	−0.052	0.333***	3.376**	0.324***	0.748	0.316***	0.170	0.043	−2.261
	(0.033)	(0.628)	(0.078)	(1.674)	(0.049)	(0.886)	(0.065)	(1.108)	(0.075)	(2.433)
Quadratic of log income		0.026		−0.161*		−0.023		0.008		0.126
		(0.033)		(0.088)		(0.047)		(0.058)		(0.133)
Household Adult Equivalent	0.021***	0.021***	0.012	0.009	0.002	0.002	0.001	0.001	−0.007	−0.009
	(0.007)	(0.007)	(0.012)	(0.013)	(0.010)	(0.010)	(0.018)	(0.018)	(0.025)	(0.024)
Constant	2.543***	4.876	3.182***	−11.147	3.233***	1.251	4.206***	4.906	6.050***	16.530
	(0.329)	(2.961)	(0.689)	(7.936)	(0.461)	(4.188)	(0.569)	(5.250)	(0.759)	(11.117)
Observations	1,654	1,654	290	290	664	664	257	257	82	82

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A23: South: Double log and quadratic log regression results for meat food items

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.467***	0.775*	0.132	8.145	0.356***	−1.494	0.247***	−1.942	0.179	−1.913
	(0.024)	(0.447)	(0.190)	(4.316)	(0.086)	(1.558)	(0.069)	(1.667)	(0.099)	(3.426)
Quadratic of log income		−0.016		−0.440		0.094		0.109		0.111
		(0.024)		(0.232)		(0.078)		(0.082)		(0.179)
Household Adult Equivalent	0.044***	0.043***	0.096	0.037	0.040	0.041	0.022	0.022	−0.035	−0.018
	(0.007)	(0.007)	(0.075)	(0.081)	(0.037)	(0.037)	(0.021)	(0.022)	(0.056)	(0.060)
Constant	2.138***	0.664	3.825	−32.131	2.394***	11.515	4.377***	15.311*	3.221***	12.959
	(0.214)	(2.111)	(1.528)	(19.733)	(0.808)	(7.751)	(0.675)	(8.471)	(0.989)	(16.186)
Observations	2,203	2,203	16	16	216	216	396	396	47	47

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A24: North: Double log and Quadratic log regression results for fish food items

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.488***	0.432	0.377***	1.061	0.317***	0.780	0.363***	−0.861
	(0.060)	(1.290)	(0.051)	(1.083)	(0.046)	(0.849)	(0.053)	(0.846)
Quadratic of log income		0.003		−0.037		−0.025		0.066
		(0.068)		(0.059)		(0.045)		(0.046)
Household Adult Equivalent	−0.001	−0.001	0.046***	0.046***	0.023*	0.023*	0.020*	0.021*
	(0.015)	(0.015)	(0.015)	(0.015)	(0.013)	(0.013)	(0.011)	(0.011)
Constant	2.127***	2.390	2.582***	−0.572	2.989***	0.838	2.741***	8.335**
	(0.531)	(6.085)	(0.498)	(4.966)	(0.421)	(3.911)	(0.475)	(3.827)
Observations	605	605	582	582	534	534	895	895

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A25: South: Double log and Quadratic log regression results for fish food items

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.428***	0.735	0.295***	0.875***	0.248***	−0.684	0.414***	0.112
	(0.045)	(0.871)	(0.020)	(0.267)	(0.035)	(0.649)	(0.038)	(0.834)
Quadratic of log income		−0.016		−0.031**		0.050		0.016
		(0.046)		(0.014)		(0.035)		(0.044)
Household Adult Equivalent	−0.003	−0.004	0.019**	0.018**	0.019	0.020*	0.012	0.012
	(0.019)	(0.019)	(0.009)	(0.009)	(0.011)	(0.011)	(0.012)	(0.012)
Constant	2.040***	0.566	2.988***	0.292	3.860***	8.209***	2.030***	3.459
	(0.442)	(4.133)	(0.188)	(1.248)	(0.339)	(2.980)	(0.367)	(3.901)
Observations	558	558	2,727	2,727	1,108	1,108	1,309	1,309

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A26: North: Double log and Quadratic log regression results for dairy and egg food items

	Agricultural eggs		Local eggs		Fresh milk		Tinned milk		Milk powder	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.513***	1.004	0.354**	−0.002	0.164***	−1.512*	0.453***	1.813	0.955***	1.305
	(0.076)	(1.368)	(0.166)	(2.520)	(0.058)	(0.810)	(0.077)	(1.432)	(0.091)	(1.065)
Quadratic of log income		−0.025		0.019		0.090**		−0.071		−0.018
		(0.072)		(0.139)		(0.044)		(0.075)		(0.056)
Household Adult Equivalent	0.012	0.012	0.032	0.031	0.028**	0.030***	−0.028	−0.029	−0.040*	−0.039*
	(0.035)	(0.035)	(0.023)	(0.024)	(0.011)	(0.011)	(0.018)	(0.018)	(0.023)	(0.023)
Constant	0.129	−2.248	1.204	2.861	4.042***	11.788***	1.016	−5.452	−2.867***	−4.512
	(0.628)	(6.608)	(1.537)	(11.326)	(0.565)	(3.754)	(0.758)	(6.859)	(0.807)	(5.063)
Observations	275	275	120	120	794	794	209	209	369	369

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A27: South: Double log and quadratic log regression results for dairy and egg food items

	Agricultural eggs		Local eggs		Tinnend milk			Milk powder
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.417***	1.063	0.027	0.547	0.299***	0.604	0.562***	1.515**
	(0.031)	(0.731)	(0.116)	(3.450)	(0.053)	(0.843)	(0.038)	(0.681)
Quadratic of log income		−0.033		−0.027		−0.016		−0.050
		(0.038)		(0.181)		(0.044)		(0.035)
Household Adult Equivalent	0.032***	0.031***	0.036	0.036	0.024	0.024	0.011	0.009
	(0.010)	(0.010)	(0.037)	(0.038)	(0.017)	(0.017)	(0.012)	(0.012)
Constant	0.557*	−2.564	4.848***	2.346	2.129***	0.671	−0.414	−4.971
	(0.290)	(3.513)	(1.131)	(16.368)	(0.492)	(4.034)	(0.344)	(3.279)
Observations	1,171	1,171	69	69	571	571	1,718	1,718

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A28: North: Double log and Quadratic log regression results for grain food and flour items

	Sorghum		Millet		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.196***	3.176***	0.222***	2.579***	0.585***	2.689***	0.412***	1.793*	0.517***	0.063
	(0.039)	(0.538)	(0.039)	(0.488)	(0.027)	(0.433)	(0.042)	(0.929)	(0.030)	(0.535)
Quadratic of log income		−0.163***		−0.128***		−0.114***		−0.073		0.024
		(0.029)		(0.026)		(0.024)		(0.050)		(0.029)
Household Adult Equivalent	0.094***	0.092***	0.068***	0.068***	0.045***	0.044***	0.067***	0.067***	0.031***	0.031***
	(0.008)	(0.008)	(0.010)	(0.009)	(0.006)	(0.006)	(0.010)	(0.009)	(0.007)	(0.007)
Constant	4.166***	−9.422***	4.180***	−6.595***	0.728***	−8.951***	2.426***	−4.072	0.480*	2.596
	(0.327)	(2.466)	(0.456)	(2.238)	(0.239)	(1.976)	(0.403)	(4.315)	(0.263)	(2.461)
Observations	2,931	2,931	2,082	2,082	3,032	3,032	900	900	2,057	2,057

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A29: South: Double log and quadratic log regression results for grain food and flour items

	Sorghum		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.410	3.761	0.332***	2.525***	0.305***	1.791***	0.444***	0.833*
	(0.182)	(5.836)	(0.038)	(0.721)	(0.024)	(0.348)	(0.028)	(0.429)
Quadratic of log income		−0.167		−0.118***		−0.079***		−0.021
		(0.289)		(0.040)		(0.019)		(0.023)
Household Adult Equivalent	−0.074	−0.073	0.120***	0.113***	0.151***	0.148***	0.066***	0.065***
	(0.050)	(0.049)	(0.011)	(0.010)	(0.009)	(0.008)	(0.009)	(0.009)
Constant	1.337	−15.447	2.593***	−7.479**	2.889***	−4.087**	1.216***	−0.614
	(1.704)	(29.396)	(0.349)	(3.240)	(0.215)	(1.617)	(0.248)	(2.006)
Observations	30	30	1,021	1,021	3,247	3,247	3,293	3,293

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A30: North: Double log and quadratic log regression results for grain and flour items

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.280***	1.278	0.246***	2.381	0.313***	3.161**	0.308***	1.675
	(0.053)	(0.977)	(0.074)	(1.669)	(0.070)	(1.300)	(0.110)	(1.791)
Quadratic of log income		−0.054		−0.113		−0.154**		−0.070
		(0.052)		(0.087)		(0.071)		(0.093)
Household Adult Equivalent	0.069***	0.069***	0.128***	0.125***	0.058***	0.058***	0.077**	0.076**
	(0.010)	(0.010)	(0.021)	(0.020)	(0.017)	(0.016)	(0.030)	(0.030)
Constant	3.408***	−1.217	3.145***	−6.842	2.830***	−10.249*	2.644**	−3.983
	(0.461)	(4.533)	(0.645)	(7.965)	(0.613)	(5.943)	(1.028)	(8.658)
Observations	1,335	1,335	259	259	652	652	115	115

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A31: South: Double log and quadratic log regression results for grain and flour items

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.059	4.225*	0.174***	1.698**	0.158***	0.090	0.280***	3.836*
	(0.140)	(2.234)	(0.052)	(0.731)	(0.053)	(0.782)	(0.087)	(1.984)
Quadratic of log income		−0.216*		−0.081**		0.004		−0.180*
		(0.118)		(0.038)		(0.042)		(0.100)
Household Adult Equivalent	0.119***	0.108**	0.124***	0.119***	0.101***	0.101***	0.034	0.022
	(0.042)	(0.040)	(0.014)	(0.015)	(0.016)	(0.016)	(0.034)	(0.035)
Constant	2.254	−17.827	4.034***	−2.988	3.196***	3.506	3.278***	−14.201
	(1.436)	(10.663)	(0.539)	(3.451)	(0.479)	(3.640)	(0.792)	(9.773)
Observations	77	77	697	697	600	600	159	159

Notes: Dummy variables for geography (state), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A32: Double log and quadratic log regression results for meat food items with state as geographical dummy

	Expenditure Beef		Expenditure Mutton		Expenditure Goat		Expenditure Chicken		Expenditure Pork	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.444***	0.349	0.371***	2.598	0.354***	−0.497	0.282***	−0.486	0.161*	−3.132**
	(0.020)	(0.412)	(0.089)	(1.656)	(0.047)	(0.781)	(0.046)	(0.886)	(0.080)	(1.515)
Quadratic of log income		0.005		−0.118		0.045		0.039		0.178**
		(0.022)		(0.088)		(0.041)		(0.045)		(0.081)
Household Adult Equivalent	0.031***	0.031***	0.000	−0.001	0.006	0.007	0.023	0.023	−0.030	−0.023
	(0.006)	(0.006)	(0.015)	(0.015)	(0.012)	(0.012)	(0.014)	(0.015)	(0.018)	(0.018)
Constant	2.202***	2.659	3.114***	−7.353	3.110***	7.139*	4.078***	7.853*	4.551***	19.736***
	(0.188)	(1.953)	(0.815)	(7.831)	(0.437)	(3.713)	(0.459)	(4.386)	(0.811)	(6.987)
Observations	3,857	3,857	306	306	880	880	653	653	129	129

Notes: Dummy variables for geography (zone), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A33: Double log and quadratic log regression results for fish food items with state as geographical dummy

	Expenditure fresh fish		Expenditure frozen fish		Expenditure smoked fish		Expenditure dried fish	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.441***	0.594	0.310***	1.234***	0.310***	−0.195	0.417***	−0.181
	(0.043)	(0.750)	(0.020)	(0.295)	(0.033)	(0.561)	(0.037)	(0.719)
Quadratic of log income		−0.008		−0.049***		0.027		0.032
		(0.039)		(0.016)		(0.030)		(0.038)
Household Adult Equivalent	−0.010	−0.010	0.019**	0.018**	0.008	0.009	0.005	0.007
	(0.011)	(0.011)	(0.008)	(0.008)	(0.010)	(0.010)	(0.009)	(0.009)
Constant	2.255***	1.523	2.963***	−1.329	3.128***	5.485**	2.087***	4.895
	(0.415)	(3.570)	(0.185)	(1.385)	(0.316)	(2.598)	(0.345)	(3.342)
Observations	1,163	1,163	3,309	3,309	1,642	1,642	2,204	2,204

Notes: Dummy variables for geography (zone), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A34: Double log and quadratic log regression results for dairy and egg food items with state as geographical dummy

	Agricultural eggs		Local eggs		Fresh milk		Tinnend milk		Milk powder	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.444***	1.394**	0.172	0.081	0.091	−2.452***	0.322***	0.710	0.609***	1.139*
	(0.031)	(0.684)	(0.114)	(1.744)	(0.063)	(0.918)	(0.045)	(0.721)	(0.036)	(0.615)
Quadratic of log income		−0.049		0.005		0.136***		−0.020		−0.027
		(0.035)		(0.095)		(0.050)		(0.038)		(0.032)
Household Adult Equivalent	0.021*	0.020*	0.024	0.024	0.048***	0.052***	0.006	0.006	0.008	0.006
	(0.011)	(0.011)	(0.022)	(0.022)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
Constant	0.834***	−3.774	3.281***	3.710	4.379***	16.177***	2.600***	0.745	−0.608*	−3.199
	(0.289)	(3.291)	(1.059)	(8.047)	(0.617)	(4.240)	(0.407)	(3.431)	(0.324)	(2.943)
Observations	1,446	1,446	189	189	805	805	780	780	2,087	2,087

Notes: Dummy variables for geography (zone), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A35: Double log and quadratic log regression results for grain food and flour items with state as geographical dummy

	Sorghum		Millet		Local rice		Imported rice		Bread	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log income	0.219***	2.022***	0.223***	1.449**	0.499***	2.618***	0.329***	1.798***	0.501***	0.937***
	(0.039)	(0.600)	(0.049)	(0.663)	(0.025)	(0.411)	(0.025)	(0.363)	(0.024)	(0.357)
Quadratic of log income		−0.099***		−0.067*		−0.115***		−0.078***		−0.023
		(0.032)		(0.036)		(0.023)		(0.020)		(0.019)
Household Adult Equivalent	0.087***	0.086***	0.067***	0.068***	0.061***	0.059***	0.129***	0.127***	0.046***	0.046***
	(0.009)	(0.008)	(0.012)	(0.012)	(0.006)	(0.006)	(0.009)	(0.009)	(0.006)	(0.006)
Constant	3.171***	−5.026*	3.057***	−2.520	1.523***	−8.206***	2.777***	−4.142**	0.802***	−1.249
	(0.356)	(2.803)	(0.430)	(3.076)	(0.227)	(1.854)	(0.220)	(1.683)	(0.210)	(1.654)
Observations	2,953	2,953	2,086	2,086	4,053	4,053	4,147	4,147	5,350	5,350

Notes: Dummy variables for geography (zone), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A36: Double log and quadratic log regression results for grain and flour items with state as geographical dummy

	MaizeFlour		YamFlour		CassavaFlour		WheatFlour	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log income	0.264***	1.962**	0.197***	2.134**	0.216***	1.306*	0.282***	1.349
	(0.053)	(0.907)	(0.052)	(0.834)	(0.047)	(0.781)	(0.070)	(1.479)
Quadratic of log income		−0.091*		−0.103**		−0.059		−0.054
		(0.049)		(0.044)		(0.042)		(0.076)
Household Adult Equivalent	0.070***	0.070***	0.101***	0.097***	0.083***	0.082***	0.044*	0.042*
	(0.011)	(0.011)	(0.014)	(0.014)	(0.014)	(0.014)	(0.025)	(0.024)
Constant	3.196***	−4.690	3.958***	−5.087	3.312***	−1.698	2.904***	−2.311
	(0.511)	(4.204)	(0.481)	(3.911)	(0.424)	(3.594)	(0.654)	(7.147)
Observations	1,411	1,411	955	955	1,252	1,252	274	274

Notes: Dummy variables for geography (zone), urban/rural, time (post-planting or harvest period) and interaction between geography and time are included in the regression

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table A37: Difference in market price of local rice and imported rice

	Local rice	Imported rice	Difference	P-value
Mean rice price (in Nigerian Naira)	228.7	762.3	533.6	0.031

Notes: These results are conducted from a two sample weighted t-test to compare the price difference of local rice and imported rice