Sugar- Sweetened Beverages in Nigeria: Affordability and Expenditure and Price Elasticities

BY

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DRSARN001

SUBMITTED TO THE UNIVERSITY OF CAPE TOWN

In partial fulfilment of the requirements for the degree

Master's in commerce (Applied Economics)

Faculty of Commerce

UNIVERSITY OF CAPE TOWN

September 2021

SUPERVISOR

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DECLARATION

Declaration

I, Arnalda Vanessa Darsamo, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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DEDICATION

To *Maria Olivia Dourado Darsamo*

In loving memory of Arnaldo Meia Darsamo

ACKNOWLEDGEMENTS

My profound gratitude goes first and foremost to God Almighty. I extend my heartfelt gratitude to my family who supported me through this journey and a very special thanks to Delio, Cristina and Fatíma Darsamo, for the endless encouragement and always believing in me. Lastly, but by no means least, I extend my immense appreciation to Dr. Micheal Boachie for all the support he provided.

My sincere gratitude to the Research Unit on the Economics of Excisable Products (REEP) for funding this research.

ABSTRACT

This research examines how consumers in Nigeria respond to income and price changes of carbonated soft drinks (CSDs). I first analysed the trend in CSD and fruit juice affordability between 2005 and 2018. I subsequently estimated the own-price, cross-price and income elasticities of sugar, CSDs, chocolate drinks, milk and sachet water for Nigeria in 2013, 2016 and a pooled sample.

I used the relative income price to examine CSD and fruit juice affordability over time in Nigeria for both off-trade and on-trade consumption. For estimating the own-price, cross-price and expenditure elasticities, I used the Nigeria Household Survey, Panel (2013 and 2016) data, using the Almost Ideal Demand System. I applied Deaton's unit value model and used unit values as prices and used the Heckman procedure to correct for selection bias. For CSDs, the own-price elasticities ranged from -0.8 to -1.8. All income (approximated by household expenditure) elasticities were positive implying all the commodities are normal goods. The income elasticity of demand lies at approximately 0.4 for CSDs.

The results suggest that Nigeria can curb the consumption of excess sugar, in particular excess sugar in CSDs, by raising the price by implementing an excise tax on the sugar content in CSDs. Future research should estimate the health gains and government revenue that can be generated from such a tax. Such estimates are crucial to motivate for a sugar tax.

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List of Abbreviations

AIDS: Almost ideal demand system

ANOVA: Analysis of variance

BMI: Body mass index

CDF: Cumulative density function

CPI: Consumer price index

CSD: Carbonated soft drink

DALY: Disability adjusted life years

DUVM: Deaton's unit value model

EASI: Exact affine Stone index

GDP: Gross domestic product

GHSP: Nigeria national household survey panel

GMM: generalised method of moments

GNI: Gross national income

HDI: Human development index

IMR: Inverse Mill's ratio

IPIM: industrial price index

LMICs: Low-and middle-income countries

NCD: Non-communicable disease

OLS: Ordinary least squares

PDF: Probability density function

PPP: Purchasing power parity

QALYS: Quality adjusted life years

QUAIDS: Quadratic almost ideal demand system

RIP: Relative income price

SPI: Stone price Index

SSA: Sub-Saharan Africa

SSB: Sugar-sweetened beverage

WHO: World Health Organization

Chapter One: Introduction

Sub-Saharan African (SSA) countries are experiencing a nutrition transition towards unhealthy and unsustainable patterns of food production and consumption. Western influences on diet and lifestyle have had detrimental health effects for the population of these countries (Lustig et al., 2012). These changes in diet and lifestyle have led to a series of non-communicable diseases (NCDs) such as heart disease, hypertension, liver disease, obesity, type-two diabetes, etc. Unlike Western countries, SSA countries are much less likely to be able to cope with the strain that these diseases will place on their health systems.

The World Health Organisation (WHO) defines overweight and obesity as abnormal or excessive fat accumulation that may impair health (World Health Organization, 2020). Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his/her height in meters (kg/m^2). A BMI between 25.0 and 29.9 is defined as overweight and a BMI of 30 and above is classified as obese (Center for Disease Control and prevention, 2020, World Health Organization, 2020).

Growing incomes make unhealthy diets more affordable, resulting in higher levels of consumption of unhealthy foods. Being overweight or obese is listed by the WHO as one of the 10 leading risk factors of mortality (World Health Organization, 2002). The leading cause of obesity in adults and children is the consumption of excess sugar and high-calorie, energy-dense foods (Timpson et al., 2013). Globally, the per capita consumption of sugar has tripled over the past 50 years and sugar is currently present in almost all processed foods (Lustig et al., 2012).

Almost three-quarters of sugar consumed globally is consumed in developing countries (World Cancer Research Fund International, Undated). The WHO recommends that the intake of free sugars be less than 10% of total energy intake. This is between 5 and 10 teaspoons of sugar daily, which translates to 7.8 to 15.5 kilograms per year for adults (Ronquest-Ross et al., World Health Organization, 2015).

Humans evolved on a diet containing a low sugar content and virtually no refined carbohydrates, and have now progressed to diets that are heavily laden with sugars, with sugar estimated to account for approximately 20% of the caloric content of modern diets (Horton et al., 2015). Sugarcane is the world’s third most valuable crop, after cereals and rice, and occupies approximately 27 million hectares of land across the globe. Despite occupying a substantial portion of the world’s land, the benefits of sugar to humanity are outweighed by the costs (Horton et al., 2015).

Fructose, the sweet molecule in sugar, contains calories that one can burn for energy, but are not nutritional. There is no biochemical reaction that requires sugar and, in excess, sugar, like alcohol, can damage the liver (Robert, 2015). Evidence suggests that fructose, found in added sugars, can trigger liver toxicity and that it induces all the diseases associated with metabolic syndrome (Lustig et al., 2012). Metabolic syndrome refers to the co-occurrence of several known cardiovascular risk factors, including insulin resistance, obesity, atherogenic dyslipidaemia and hypertension (Huang, 2009, National Heart Lung and Blood Institute, 2020).

Moreover, sugar acts on the brain and creates a dependence. Specifically, sugar dampens the suppression of ghrelin, a hormone which signals hunger to the brain. This suppression stimulates appetite and promotes fat storage. Sugar also interferes with the normal transport and signalling of leptin, a hormone which helps to produce the feeling of satiety and helps the body maintain its weight. Thus, sugar can induce individuals to overeat and gain excessive weight. Furthermore, sugar supresses dopamine, affecting the signalling in the brain's reward centre, consequently decreasing the pleasure derived from food and compelling the individual to consume more food in order to attain the same pleasure that could have otherwise been derived from consuming less food (Garber and Lustig, 2011, Lustig, 2010, Lustig et al., 2012). Studies have also found that, in both animals and humans, there are substantial parallels and overlaps between drugs of abuse and sugar, from the standpoint of both brain neurochemistry and behaviour. Sugar was found to induce bingeing, craving, tolerance, withdrawal, cross-sensitisation, cross-tolerance, cross-dependence, and reward and opioid effects, similar to the effects of addictive substances (DiNicolantonio et al., 2018).

A study by Sundborn *et al.* (2019) revealed that sugary beverages, especially those with added sugars, were likely to have a major role in driving metabolic syndrome. These effects are probably due to the higher quantity of fructose, greater absorption, and the higher intrahepatic concentrations, such as bile, that result from the ingestion of sugary beverages. The study also revealed that added sugars in liquid form carry a greater risk of inducing features of metabolic syndrome than solid added sugars (Sundborn et al., 2019).

It has been estimated that 184,000 premature deaths globally each year are attributable to sugar-sweetened beverages, mostly as a result of diabetes (Singh et al., 2015, Sundborn et al., 2019). One study found that there is a positive association between consumption of carbonated soft drinks and suicide attempts among adolescents who consumed more than 3 soft drinks a day (Jacob et al., 2020).

Research has found that our bodies process liquid sugar differently than sugar in solid foods, especially foods containing fibre (Wang, 2014). The sugar we get from the consumption of a whole fruit will contain about one-fifth of the daily fibre requirement, which is digested gradually, thus releasing the sugar slowly into the blood stream. In contrast, when the same amount of sugar is consumed in liquid form, the sugar is released into the blood stream rapidly, delivering more sugar than the vital organs can handle in that space of time. The body responds to that blast of sugar by producing triglycerides. This can overload the pancreas and liver, resulting in diseases such as heart disease, liver disease and type-two diabetes (University of Carlifornia and Sugar Science, Undated).

On average, a 330ml can of a carbonated soft drink has between 8 and 10 teaspoons (37 to 42 grams) of sugar (The Coca-Cola Company, 2020, Sodamade, 2014). The World Health Organization recommends reducing free sugar intake at all stages of life to under 10% of physical calories to reduce the risk of unhealthy weight gain and dental caries. This equates to a maximum of 50 grams of sugar per day for the average adult (World Health Organization, 2015). One can of carbonated soft drink can account for up to 84% of the recommended daily sugar intake. Studies have shown that when we drink high-calorie beverages, we don't feel as full as we would if we had eaten the same number of calories (Zheng et al., 2015). This makes it easy to consume 9 teaspoons (38 grams) of sugar in a single carbonated soft drink.

Sugar-sweetened beverage (SSB) intake is associated with many chronic diseases such as diabetes mellitus and heart-related complications. For instance, research suggests that drinking just one can of carbonated soft drink of 330ml per day can increase your risk of dying from heart disease by nearly one-third (Yang et al., 2014). Another study found that people who drink one to two SSBs per day have a 26% higher risk of developing type-two diabetes, compared to people who drink less than one SSB per month (Malik and Hu, 2012). Thus, while it is important to reduce intake of all sugars, regardless of source, reducing the intake of sugar added to liquids is a beneficial and efficient approach to improving human health (Sundborn et al., 2019).

Many nutritional information on beverages is deceptive. There are about sixty different names for sugar (University of California and Sugar Science, Undated). If companies use different terminologies, individuals might not see those terms as sugar. This deceptive marketing can also impact on consumption. The increase in sugar intake observed in recent times is partly attributed to growing incomes, which result in an increased affordability of sugary drinks. Price changes, in particular price reductions, also contribute to the increased affordability of sugary drinks. Affordability refers to the ability of an individual to purchase a product (Blecher and van Walbeek, 2004). Reducing the liquid-sugar intake therefore entails reducing the affordability of these drinks. According to a study that analysed global trends in the affordability of sugar-sweetened beverages in 40 high-income countries and 42 low- and middle-income countries, sugar-sweetened beverages became more affordable in the 27-year period from 1990 to 2016 in 79 of the 82 countries in the sample (Blecher et al., 2017). Affordability increased in most countries because of a combination of increases in income and decreases in the (real) prices of sugar-sweetened beverages. In some cases, sugar-sweetened beverage price increases counteracted income increases, but in all these cases the increases in sugar-sweetened beverage prices were not large enough to make sugar-sweetened beverages less affordable (Blecher et al., 2017).

Ferretti and Mariana (2019) studied sugar-sweetened beverage affordability and the prevalence of overweight and obesity in 150 countries. The study sought to assess the impact of affordability as measured by the SSB relative income price (RIP) on the prevalence of overweight and obesity. The relative income price is the ratio of the percentage of the consumer's income required to buy a specified unit of a product (Blecher et al., 2017, Ferretti and Mariani, 2019). Results revealed that affordability is a major driver of purchasing behaviour and is significantly associated with the prevalence of both overweight and obesity. Soft-drink affordability emerged as a reliable predictor of weight outcomes even after correcting for the main potential confounding factors. Affordability is crucial in explaining cross-country differences in the quantity of SSBs consumed per capita. Age-standardized prevalence rates of overweight and obesity increased with increasing SSB affordability, *ceteris paribus* (Ferretti and Mariani, 2019).

To reduce the widespread incidence of morbidity and mortality attributable to excess sugar consumption, affordability-control measures will have to be enforced. One example is a sugar-sweetened beverage (SSB) tax. An SSB tax would not only reduce SSB consumption but would result in gains in quality-adjusted life years (QALYs), reduce disability-adjusted life years (DALYs), and generate government revenue. In Mexico, an excise tax of 1 Peso per litre on sugar-sweetened beverages was implemented in 2014. Basto-Abreu *et al*. (2019) estimated the cost-effectiveness of the tax and of an alternative tax scenario of 2 Pesos per litre. They developed a cohort simulation model calibrated for Mexico to project the impact of the SSB tax over ten years. The SSB tax of 1 Peso per litre was projected to prevent 239,900 cases of obesity and 61,340 cases of diabetes. Furthermore, the tax was predicted to result in a gain of 55,300 quality-adjusted life-years and avert 5,840 disability-adjusted life-years. The tax was estimated to save $3.98 per dollar spent on its implementation (Basto-Abreu et al., 2019).

While sugar-sweetened beverage taxes curb consumption and the associated health impacts of excess sugar consumption (Stacey et al., 2017a, Stacey et al., 2017b), the effectiveness of taxes at curbing consumption depends, among other things, on the price and income elasticity of demand for these products. Price elasticity is defined as the percentage change in the quantity demanded attributed to a one per cent change in price, *ceteris paribus* (Stacey et al., 2017a). Income elasticity is defined as the percentage change in quantities demanded attributed to a one per cent change in income, all else held constant.

Few African countries have studies on sugar-sweetened beverage price elasticities, with most studies emanating from South Africa (Du et al., 2018, Manyema et al., 2015, Manyema et al., 2014, Manyema et al., 2016, Stacey et al., 2017a, Stacey et al., 2017b, Tugendhaft et al., 2015, van Oordt, 2016), where the annual per capita sugar consumption is estimated to range between 31 and 37.1 kilograms of sugar per year, i.e. about twice the maximum of the WHO-recommended amount (Ronquest-Ross et al., 2015).

Nigeria is a key regional player in West Africa, accounting for about half of West Africa's population, with over 206 million people as of 2020, equivalent to 2.64% of the total world population (World Bank, 2020, Worldometer, 2020). It is the most populated country in Africa. With an abundance of natural resources, it is Africa's biggest oil exporter, and has the largest natural gas reserves in the continent. It is ranked by the World Bank as a low-middle income country. Nigeria had a Gini coefficient of 35.1 in 2018 (World Bank, 2021) and a human development index (HDI) of 0.539 in 2019 (United Nations Development Program, 2020). The life expectancy at birth in Nigeria in 2018 was estimated to be 54.3 years (World Bank, 2018). This implies some income inequality and relatively low longevity, education, gross national income and high poverty rates.

Chukwuonye *et al*. (2013) did a systematic review of the prevalence of overweight and obesity in adults, aged 20 years and above, in Nigeria. The study concluded that the overweight prevalence among adults in Nigeria ranged from 20.3% to 35.1%, while the prevalence of obesity ranged from 8.1% to 22.2% (Chukwuonye et al., 2013). However, like many African countries, Nigeria is faced with a double burden of malnutrition, with underweight coexisting with obesity and overweight (Manyanga et al., 2014, Modjadji and Madiba, 2019, Onyango et al., 2019, Pawloski et al., 2012, Rossouw et al., 2012, Sande et al., 2001, Wojcicki, 2014).

A number of studies have analysed the prevailing effects of the nutrition transition in Nigeria and have concluded that the transition is resulting in increased NCD prevalence (Chukwuonye et al., 2013, Bosu, 2015, Oyewole and Atinmo, 2015). These studies provide evidence of the growing problem of the nutrition transition but not how to halt and reverse the effects of this transition.

The nutrition transition is a multidimensional issue that requires a multi-pronged strategy. To my knowledge, no study has looked at the price or income elasticities of sugar-sweetened beverages in Nigeria. Given that price and tax measures are important tools to control the unhealthy production and consumption, it is important to understand how Nigerians respond to sugar-sweetened beverage price changes and how their demand for SSBs changes with changes in income. Estimates of the price elasticities of sugar-sweetened beverages can provide evidence that will inform policies aimed at curbing excess sugar-sweetened beverage demand and consumption by means of an excise tax policy. Such taxes curb demand and consumption and provide associated health benefits. While taxes are only one means of combating the negative effects of the nutrition transition, studies have shown that the health gains from such taxes are substantial (Basto-Abreu et al., 2019, Manyema et al., 2015, Manyema et al., 2014, Manyema et al., 2016).

This study seeks to analyse the trend in sugar-sweetened beverage affordability in Nigeria and to estimate the own-price elasticity, cross-price elasticity, and income elasticity of carbonated soft drinks in Nigeria. The study focuses on sugar-sweetened beverages, as previous studies have revealed that added sugars in liquids carry greater risk than solid added sugars to induce metabolic syndrome (Sundborn et al., 2019).

For the purposes of this study, the terms SSBs, soft drinks, and carbonated drinks are used interchangeably. The study defines SSBs as carbonated drinks, such as Coca-Cola, Sprite and Fanta.

1. Objectives

The objectives of this study are:

1. To estimate the affordability of 100 litres of sugar-sweetened beverages in Nigeria from 2005 to 2018.
2. To estimate the own-price, cross-price elasticity and income elasticity, approximated by household expenditure, of sugars, focusing specifically on carbonated soft drinks and other beverages containing added sugar in Nigeria.

Having introduced the study, the rest of the thesis is organised as follows: Chapter 2 discusses the trends in the affordability of sugar-sweetened beverages in Nigeria and, providing a review of the relevant literature and a discussion of the methods available to estimate SSB affordability and price and income elasticities. In chapter 3, I discuss the methods used to estimate SSB affordability and price and income elasticities for Nigeria. Chapter 4 summarises the findings from chapter 3 and Chapter 5 concludes the study.

Chapter Two: Literature Review

2.1 Sugar-sweetened beverage affordability in Nigeria

Income, price, taste, and the variety and prices of complementary and substitute goods are some of the factors that influence consumer choice (Fall Diallo et al., 2013, Rees, 1992, Singh and Verma, 2017). The consumption of normal goods tends to rise when prices drop and/or when incomes rise (Bakhshoodeh, 2017, Greenhalgh et al., 2020). Affordability refers to the quantity of resources, usually measured in terms of time or income, that a consumer needs to sacrifice in order to acquire a given quantity of a specific good or service (Blecher and Van Walbeek, 2009). As income rises, *ceteris paribus*, consumer goods become more affordable. Similarly, when prices drop, all else held constant, consumer goods become more affordable. The same is true if prices drop and income rises simultaneously, and all other factors remain constant. If both prices and incomes rise, then the effect is ambiguous, and dependent on relative magnitudes of the price and income hikes. Sugar-sweetened beverages are normal goods and hence the aggregate consumption of these goods tends to rise as the goods become more affordable through income increases, price falls or both.

Affordability accounts for relative price changes as well as changes in resources, such as income, over time. To account for price and resource changes, authors have used different proxies for income, based on data availability and consistency over the period of interest or the countries being studied.

The following section provides critical analyses of the measures used to estimate affordability in the context of sugar-sweetened beverages and a detailed opinion on the most appropriate measure given the available price data for Nigeria. This section aims to fill the gap in the literature concerning the affordability of sugar-sweetened beverages in African countries, by focusing on the most populous country in Africa, Nigeria.

A number of studies have analysed beverage affordability, focusing on alcoholic beverages, sugar-sweetened beverages or both. Some examples include Wall and Casswell (2013) who studied the affordability of alcohol as a key driver of alcohol demand in New Zealand. Kerr *et al*. (2013) studied alcohol affordability and real tax rates between 1950 and 2011 in the United States, while Fanta *et al*. (2020) studied the affordability of alcoholic products and the role of excise duties in the European Union member states. Blecher *et al*. (2018) analysed the affordability of beer in 69 countries, between 1990 and 2016.

The methods and approaches used to analyse beverage affordability are similar regardless of the type of beverage. However, this section discusses only those studies that focused specifically on SSBs, SSBs and other foods, or SSBs and alcohol, with occasional reference to methods used to estimate cigarette affordability.

Blecher *et al*. (2017) studied the global trends in sugar-sweetened beverage affordability between 1990 and 2016 for 82 countries including 10 African countries. The study adopted the methods used for estimating cigarette affordability by Blecher and van Walbeek (2004). In the tobacco literature, the relative income price (RIP) for cigarettes is a measure of the percentage of per capita gross domestic product (GDP) needed to purchase 100 packs of cigarettes per year. For their estimates of SSB affordability, Blecher *et al*. (2017) defined the RIP as the percentage of per capita GDP required to purchase 100 litres of Coca-Cola. They chose Coca-Cola as this product is ubiquitous in the countries they studied. Results of the study revealed that in 79 of the 82 countries studied, the proportion of income needed on average to purchase sugar-sweetened beverages declined between 1990 and 2016. Results also revealed that the increase in SSB affordability was largely attributed to increases in income rather than declines in SSB prices. Affordability increased in most countries because of a combination of increases in income and associated decreases in the real price of SSBs. In all the countries studied, any increases in real prices were not large enough to make sugar-sweetened beverages less affordable.

Blecher *et al*.'s (2017) study provides evidence of increased SSB affordability across 82 countries, including some African countries, and provides a simple method to estimate affordability for countries where income data may be scarce or inadequately reported. Their analysis was based on the price of Coca-Cola. However, according to the GlobalData Nigeria Soft Drinks Market Insight 2019 and 2020 reports, unbranded or generic soft drinks were more popular in Nigeria, accounting for approximately 55% of the market share, whereas Coca-Cola and Pepsi each accounted for approximately 8% of the soft drink market share in 2018 and 2019 (GlobalData, 2020, GlobalData, 2019). It might therefore be worth exploring the affordability of carbonated soft drinks across different brands to take into account the most popular beverages consumed in countries like Nigeria, where Coca-Cola only holds a small share of the market.

The use of GDP per capita as a measure of income has its strengths and weaknesses. GDP per capita is widely available and accessible. It is a particularly appropriate measure of income for low-and middle-income countries (LMICs) because it is a comprehensive measure of economic activity and includes all components of the economy, including transfer payments. However, GDP per capita is limiting in that it does not allow for the varying incomes of different social and economic groups. Moreover, the GDP per capita does not measure individuals' income as it ignores several no monetary transactions and includes, for example, the balance of remittances which in developing countries can be unstable (Frajman Ivković, 2016, Kubiszewski et al., 2013).

For some countries, where data paucity is not an issue, more sophisticated techniques have been used to estimate SSB affordability. Colchero *et al.* (2019) analysed the affordability of food and beverages in Mexico between 1994 and 2016. Their study used income quintiles over time for their affordability index, expressed by quintiles of energy density and quintiles of the nutrient-rich food index. The affordability of food and beverages was defined as the household monthly income needed to purchase 1,000 kcal. The study found that more energy-dense foods, and food and beverages with lower nutrient quality, were more affordable than healthier alternatives. Food categories with lower energy density and a higher nutrient-rich food index became less affordable over time for most income groups, but the burden was higher for lower-income households.

The study by Colchero *et al.* (2019) provides affordability estimates that account for different income quintiles, which the GDP per capita cannot account for. However, for many African countries, SSB affordability studies are lacking. This could be attributable to the scarcity of reliable price, expenditure, or income data, or to underreporting. Often expenditures on different food items are misreported in household surveys and income or wage data are not readily available. Moreover, prices of different food items such as SSBs are often available from commercial data brokers, hindering access to the price data by the larger research community. Thus, data-intensive approaches may not be applicable for some African countries.

Cuadrado *et al.* (2020) used wages and the real prices of various SSB brands to estimate the changes in SSB affordability between 2009 and 2016 in Chile. The study used time-series analyses on nationally representative consumer price index (CPI) data of 41 soft drinks in 6 beverage categories and for income. The study used a weighted average of wages based on a monthly national representative sample of different sectors of the Chilean economy. The study defined affordability as the changes in SSB prices relative to the change in the weighted average wages.

The study found that carbonated drinks, concentrates, and waters became less affordable over time. The study found no changes in the affordability for juices and energy-sports drinks.

Paraje and Pincheira (2018) used a similar approach to Colchero *et al.* (2019) and Cuadrado *et al.* (2020) for their study on the affordability of beer and sugar-sweetened beverages in 15 Latin American countries. The study relied on official statistics on price indices for beer and SSBs/carbonated beverages, the general CPI, and the nominal wage index in the 15 Latin American countries.

Due to the inclusion of various countries, some adjustments were made to ensure a fair cross-country comparison. In most of the countries, beer and soft drink prices were taken from the CPI. However, CPI data for Argentina since 2007 were not reliable and therefore the study used the wholesale industrial price index (IPIM) instead. For Peru, the authors used nominal prices compiled by the National Statistics Institute and Informatics in the metropolitan Lima area. For income, monthly information was found for only eight countries. In most cases, this corresponded to general nominal wage indexes, with the exception of Costa Rica, for which a minimum wage index was obtained. For Colombia, the authors used an average of wages in the manufacturing industry for two types of jobs (workers and employees), and for the manufacturing industry as a whole. They measured the expected rate of growth of the affordability indicator for SSBs and for beer in each of the 15 countries in the sample. This was defined as the ratio of the nominal wage to the price of the good. Results of the study revealed that in nine of the 15 countries analysed, the affordability (whether absolute or relative) of SSBs or beer increased.

Ferretti and Mariani (2019) analysed the sugar-sweetened beverage affordability and the prevalence of overweight and obesity in a cross section of 150 countries. They used Euromonitor data on soft drink sales, in both volume and value. They computed the per capita annual consumption of SSBs in each country by dividing the total sales (in volume) of non-carbonated drinks, which included ready-to-drink tea, coffee, and juices, as well as sports/energy drinks, and carbonated soft drinks by the total population of a country. Their study did not specify beverage prices by brands. The per capita annual consumption of SSBs included on-trade and off-trade sales of both domestically manufactured and imported beverages. They derived an average market price of SSBs at the country level by dividing the total sales in value by total sales in volume. These average annual prices, expressed in local currency, were converted to a common currency using purchasing power parity (PPP) conversion factors from the World Bank's International Comparison Program database. They used the relative income price method, defining the RIP as the percentage of the consumer's income required to purchase one hundred litres of beverage. For a standard and consistent measure of income across all countries, the authors used the gross national income (GNI) per capita. Ferretti and Mariani's results were consistent with other studies mentioned in this chapter. On average, SSBs were more affordable in high-income countries, with 100 litres of beverage accounting for 0.88% of the GNI compared to 24.58% of the GNI in low-income countries.

The studies from South America provide estimates of SSB affordability across a wide range of SSB products. While this is ideal, it may not always be possible to include a wide range of SSB products, particularly when data are scarce. For some countries, wages and income data are not readily available, as shown in the study by Paraje and Pincheira (2018). Some studies have used more standard and consistent measures for SSBs and income for cross-country analyses of SSB affordability, as was done by Blecher *et al*. (2017) and Ferretti and Mariani (2019).

Blecher et al. (2017) found that SSBs became more affordable in 9 of the African countries studied, including Nigeria. These findings were consistent with the findings for the African countries studied by Ferretti and Mariani (2019).

2.2 Sugar-sweetened beverage income and price elasticities in Nigeria

Several studies have analysed the price and income elasticities of consumables, focusing mostly on different food items and tobacco products. Income and price elasticities refer to the percentage changes in the quantities demanded of the good or service of interest as a result of a one per cent change in income or in the price of the good or service, *ceteris paribus*. Cross-price elasticities refer to the percentage change in the quantities demanded of a particular good or service in response to price changes in another good or service, all else held constant. Elasticities gauge how responsive consumers will be to changes in prices and income. For normal goods, consumers tend to demand more of the good or service if income rises, whereas for inferior goods, consumers tend to demand less of the good as income rises (Liebhafsky, 1969).

A number of models have been designed to estimate the income and price elasticities. Deaton and Muellbauer (1980) designed the Almost Ideal Demand System (AIDS) which provides an arbitrary first-order approximation to any demand system. The AIDS satisfies the axioms of choice exactly. In consumer theory these axioms are defined as follows:

1. Completeness, implying that consumers can make comparisons and discriminate, and that they have the knowledge to evaluate alternatives.

2. Transitivity, meaning that the consumer’s choices are consistent. That is, if good A is preferred to good B and good B is preferred to good C, then good A is also preferred to good C.

3. Continuity, implying that sudden preference reversals do not occur.

4. Local non-satiation, meaning that the consumer always places a positive value on more consumption.

5. Diminishing marginal rate of substitution, which means that consumers prefer diversity in consumption (Jehle and Reny, 2011).

Another advantage of the AIDS is that it aggregates perfectly over consumers without invoking parallel linear Engel curves. An Engel curve describes how a consumer's purchases of a good varies as the consumer's total resources, usually proxied by total income or total expenditures, vary. Engel curves may also depend on demographic variables and other consumer characteristics. The AIDS has a functional form which is consistent with known household-budget data. Moreover, the AIDS avoids the need for non-linear estimation, and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters (Deaton and Muellbauer, 1980). Another important advantage of the AIDS model is that it provides an identification strategy for avoiding endogeneity of prices by considering differences in quality choice (Chacon *et al*., 2018).

The i^{th} equation in the AIDS model can be defined as follows:

$$w_{ih} = \alpha_i + \gamma_{ij} lnp_{jh} + \beta_i \ln\left(\frac{X_h}{P_h}\right) + u_{ih} \qquad \text{i=1,…,n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2.1]$$

and where, in observation h;

- w_{ih} is the budget (expenditure) share of the i^{th} good;
- lnp_{jh} is the natural log of the price of the j^{th} *good*;
- $\ln X_h$ is the natural log of total expenditure;
- u_{ih} is the random or error term; and
- lnP_h is the natural log of the translog price index used to deflate total expenditure defined by:

$$lnP_h = \alpha_0 + \sum \alpha_j \, lnp_j + \frac{1}{2}\sum_i^n \sum_j^n \gamma_{ih} lnp_{ih} lnp_{jh} \qquad \text{h=1,…n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [2.2]$$

This price index (lnP_h) makes the system non-linear and often leads to difficulties, especially when using time-series data (Blanciforti and Green, 1983). To overcome this problem, Deaton and Meullbauer (1980) suggest using another linear price index to linearize the AIDS model. The only difference between the AIDS model and the linear approximation AIDS model (LA/AIDS) is the price index (Taljaard et al., 2004).

The Stone's price index, as suggested by Deaton and Meullbauer (1980), which can be used to replace the translog price index given in equation 2.2, is defined as follows:

$lnP^* = \sum_{i=1}^{n} w_{i,h} \, lnP_{i,h}$ …………………………………………………………….[2.3]

Stone's price index (P*) is therefore used. If prices are highly collinear, P may be approximately proportional to P*, i.e., P; P*. In the extreme case when P is exactly (linearly) proportional to P*, the Linear Approximation of the Almost Ideal Demand System (LA/AIDS) model can be used to estimate the parameters of the AIDS model (Green and Alston, 1990).

Deaton (1988) applied the LA/AIDS model but used unit values as a proxy for prices. Unit values are the reported expenditure per unit of the good purchased, given by:

$$Unit\ value\ of\ good\ i = \frac{total\ expenditure\ on\ good\ i}{quantity\ purchased\ of\ good\ i}$$

In this paper, I refer to Deaton's Unit Value Model as the DUVM.

Another form of the demand system equation is the Quadratic Almost Ideal Demand System (QUAIDS), which was introduced by Banks *et al.* (1997). The QUAIDS adds a quadratic logarithmic income term to the AIDS specification of Deaton and Muellbauer (1980). The QUAIDS accounts for the potential quadratic form of Engel curves for some durable and luxury goods. In their 1997 study, Banks *et al.* highlighted that models that fail to account for Engel curvature can generate important distortions in the patterns of welfare losses associated with a tax increase, based on their findings on pooled data from the United Kingdom.

To deal with the empirical nonlinear form of the Engel curve, and to propose a more flexible model, Lewbel and Pendakur (2009) used Shephard's lemma to approximate real income. Shephard's lemma states that the partial derivative of the cost function with respect to each input price equals the input demand (Färe and Logan, 1983). Lewbel and Pendakur (2009) designed the Exact Affine Stone Index (EASI). This linear approximation implies the use of the Stone price index (SPI), as in the case of the Linear Approximation of the Almost Ideal Demand System. Even with this restriction, among the advantages of the EASI model is the possibility of using a higher order of the polynomial real income, which enables it to better fit the Engel function.

In the next part of this section, I describe the models used by different authors to estimate income and price elasticities for specified goods. Most studies have focused on various food items and tobacco products, with some studies looking specifically at sugar-sweetened beverages.

Deaton (1988) estimated the price elasticities for different food items for Côte D'Ivoire using 1979 household survey data. Deaton used household expenditure on different food items to estimate food prices. This method is ideal for countries where food price data are not readily available. Deaton treated market prices as unobservable variables, which directly determine quantities purchased and are 'indicated' by unit values. Food expenditures and quantities are measured with error implying that unit values, which are the ratios of expenditures to quantities purchased, are also error-ridden, with errors that are likely to be negatively correlated with quantities. If left unchecked, this leads to unreliable estimates.

Deaton applied 3 steps in his estimations. He used Ordinary Least Squares (OLS) on within-cluster data to estimate the effects of total expenditure and household characteristics. This step also estimates the error measurement variances and covariances. In the second step, Deaton stripped the budget and characteristics effect to compute cluster averages of the budget shares corrected for measurement error. Regressing these corrected expenditure shares on the unit values yields the ratio of responses to price of the share and the unit value. In the last step, Deaton used a theory of quantity and quality elasticities to extract the effect of price on budget shares (Deaton, 1988).

Deaton's findings revealed that all the income elasticities of demand, approximated by expenditure, for beef, fish and cereals were all between zero and one. The quality elasticity is a measure of the change in the quality of commodities purchased with respect to a change in the total expenditure, *ceteris paribus* (Hicks and Johnson, 1968, Iyengar, 1963). Deaton found all the price elasticities of quantity to be negative and to rage between -0.8 to -1.6.

By using unit values as a proxy for prices, Deaton's method provides an alternative to price elasticity estimates for data-scarce countries where price data are lacking or not available. A number of studies have adopted the Deaton method in the estimation of price elasticities for products like tobacco. Chelwa and van Walbeek (2019) used the Deaton method to estimate cigarette demand's response to price increases in Uganda. The study used cross-sectional household survey data from Uganda for 2005 and 2009. This study used the assumption made by Deaton, that prices vary between and not within clusters. The study focused on households that reported positive cigarette consumption, thus estimating the conditional cigarette price elasticities of demand. The study estimated the quality effects in the unit value, a price proxy. The study concluded that prices did indeed vary between clusters and that cigarette demand was responsive to prices, with the cigarette demand estimated to fall by 3% for every 10% increase in cigarette prices.

Chacon *et al*. (2018) estimated the expenditure and own- and cross-price elasticities for sugar-sweetened beverages and non-sugar-sweetened beverages in Guatemala on 11,536 sampled households. The study applied Deaton's AIDS model, using unit values as a proxy for prices and household expenditure as a proxy for household income. The beverages included in the study were milk, soft drinks, juice, and bottled water. The beverages were not disaggregated by brands as such detail was not provided in the data. Furthermore, the estimates were not based on a complete demand system due to data limitations.

Chacon *et al*. (2018) reported elasticities for the entire population, for groups by area (urban/rural), and as a robustness exercise, elasticities were reported by a measure of poverty (poor/non-poor). They bootstrapped the sample 500 times to obtain standard errors for all elasticities reported. They found that the own-price elasticity of soft drinks is -1.39, which suggests that a 10% price increase would decrease the demand for soft drinks by 13.9%. The elasticities for milk, juices, and bottled water were also negative, which suggest that the demand for these beverages would drop in response to price increases. Own-price elasticity for soft drinks was found to be significantly higher for rural households (-2.09) than for urban ones (-0.80). All the beverages studied were found to have positive income elasticities, which implies that they are all normal goods.

Chacon *et al*.'s study is highly applicable for many African economies as Guatemala is rural for the most part and has a high proportion of people living in poverty. The soft drink industry has adapted its marketing strategies to reach the poorer populations in rural areas (Chacon *et al*., 2018). Moreover, the data limitations that the authors encountered are similar to many data limitations found in a number of African survey datasets.

Paraje (2016) also used Deaton's unit value method to estimate the income and price elasticities for SSBs and other beverages for 38,234 households in Ecuador using 2011 and 2012 data. Paraje grouped the beverages in broad categories because of data paucity. The results of the study revealed that the SSB own-price elasticities were between –1.33 and –1.17, depending on the socio-economic group. Own-price elasticity for non-SSBs was between -1 and -1.24. The estimated income elasticities revealed that both SSBs and non-SSBs were normal goods with elasticities decreasing for higher socio-economic groups.

Several other studies use or adapt Deaton's method in order to estimate the price elasticities for foods, beverages and tobacco products (Colchero et al., 2015, Guerrero-López et al., 2017, Taljaard et al., 2004). However, the Deaton method has not escaped criticism. Gibson and Rozelle (2005) argue that using unit values as a proxy for actual prices results in biased estimates even after correcting for quality effects and measurement error. Gibson and Rozelle suggest using data from a price survey for each commodity and mapping these prices to each household (Gibson and Rozelle, 2005). Alternatively, one can use time series data on aggregate consumption and an aggregate measure of prices to estimate price elasticities (Chelwa, 2015). However, obtaining sound time series data is a challenge for most sub-Saharan African countries. Deaton's method overcomes these challenges and provides plausible estimates of demand responses to price changes even for countries with household income and price data paucity.

Colchero *et al*. (2015) analysed the price elasticities of the demand for sugar-sweetened beverages and soft drinks in Mexico. They estimated a demand system for beverages and food using the Linear Approximation of the Almost Ideal Demand System. They used a system of cross-sectional, nationally representative, surveys with a two-stage stratified probabilistic design which contains information on income and expenditure as well as on household characteristics, socio-demographic data, and daily food and beverage expenditures for one week. The analytical sample was 73,311 households (19,512 in 2006, 27,994 in 2008, and 25,805 in 2010). They classified beverages and foods into eight categories, and thus the demand system had 8 equations, one for each group of beverages or foods, including soft drinks. Unit values were derived from household daily expenditure and quantity purchased was analysed in litres or kilograms. Prices were averaged at the municipality level to reduce the potential measurement error at the household level. Price elasticity for soft drinks was estimated to be -1.06 and -1.16 for SSBs. They also found that an increase in the price of SSBs was associated with a decrease in snack consumption, indicating that SSBs and snacks are complements. Higher elasticities were found among households living in rural areas (for soft drinks), in more marginalized areas, and for those with lower incomes. Implementation of a tax on soft drinks or on SSBs could decrease consumption, particularly among the poor.

Guerrero-López et al. (2017) estimated the own- and cross-price elasticities for milk, coffee, tea and other infusions, plain bottled water, soft drinks, other flavoured beverages, sweet snacks, sugar and honey, and desserts in Chile. They used the Linear Approximation of the Almost Ideal Demand System Model for household expenditure data from 10,527 households. To linearize the model, the authors used the Laspeyres price index. In order to treat the censored nature of the response variable, the authors modelled the probability of positive consumption for each category by using a probit model and then calculated the Inverse Mills Ratio (IMR). The IMR of each category was included in the respective equation of the demand system. The LA/AIDS was estimated by Ordinary Least Squares

(OLS) regression with the number of adults, zone, educational level of the head of the household, age of the household head, age squared, income, and number of children under 5 years as covariates, and calculated the price elasticity of participation. The intensity price-elasticity for households with positive purchases was estimated using an OLS regression for the logarithm of the quantity consumed as a function of the logarithm of the unit value and a set of co-variables. Total price-elasticity was calculated by adding the participation and intensity price-elasticities. Price elasticities for soft drinks were also estimated by income quintile.

Results of the study revealed that the price elasticity of all the eight categories was elastic. The price elasticity of soft drinks was −1.37. The price elasticity of bottled water was −3.20. This implies that the demand for bottled water was very sensitive to changes in price. The estimations of cross-price elasticities showed that the degree of substitution of soft drinks for bottled water was higher than for other beverages and high-energy dense foods.

The techniques used by Colchero *et al*. (2015) and Guerrero-López *et al*. (2017) are innovative but the data in many African countries may not permit replicating this approach. For many African countries, income and expenditure surveys are readily available. For some countries, the response rates on income are not as complete as the responses on expenditures. Moreover, the response rates on prices are also often not complete in many African countries, and as a result a proxy for prices, such as unit values, and total household expenditure as a proxy for household income, are often used.

Other studies have also used the LA/AIDS model in the analysis of demand for food items. Jumah *et al*. (2008) used the Linear- Approximation of the Almost Ideal Demand System to analyse the demand for cassava in Lagos. While cassava is not a sugar-sweetened beverage, the applications used in this study can be used to learn about consumption patterns in Nigeria.

The aim of Jumah *et al*.'s study was to estimate a separable demand system for cassava food products (*fufu, gari* and *lafun*). The study sampled 300 households in the Lagos metropolitan area. The study used the quantity of three cassava products consumed by households and total expenditure data, and demographic characteristics of each sampled household. The unit costs of the different cassava types were derived from the reported purchase quantity and total expenditure on cassava food products. The authors used a geometric mean, with expenditure shares as weights, to compute the price indices from the aggregated commodity bundles. The demographic variables included were area of residence (for low-income, medium-income and high-income areas), the educational level of the head of the household, and religion.

The authors assumed weak separability among and within the commodity groups and analysed the consumer expenditure allocation problem in three stages. The first stage considers the allocation of the consumers' total expenditure between various commodities, such as food, housing, transport, entertainment etc. They assumed that the food group is weakly separable from all the other commodities demanded by the consumer. In the second stage, they allocated the expenditure between different food groups, and, in the third stage, the allocation of expenditure between different cassava food products. They estimated the AIDS model by means of seemingly unrelated regressions (SUR).

The study findings revealed that households residing in high-income areas allocated a higher proportion of their expenditure to *gari* than to *lafun*, compared to households residing in low-income areas. The demand was found to be price inelastic for all three of the cassava products. Own-price elasticities ranged from -0.67 for *lafun*, to -0.72 for *fufu*, and -0.97 for *gari*.

Other studies that used the LA/AIDS model for food items include those by Taljaard, *et al*. (2004) who estimated the demand for meat in South Africa between 1970 to 2000, while Armagan and Akbay (2008) did a similar study for Turkey in 2011. Islam *et al*. (2007) estimated the income price elasticities for different types of rice in Bangladesh.

Zhen *et al*. (Zhen et al., 2014) predicted the effects of sugar-sweetened beverage taxes on the demand for food and beverages in a large demand system, using the censored Exact Affine Stone Index (EASI) for 23 packaged foods and beverages, and a numéraire good in the United States. The objective of the study was to predict the effect of sugar-sweetened beverage taxes on the demand for 23 categories of packaged foods and beverages, including regular carbonated soft drinks, sports/energy drinks, and fruit drinks.

The study used household food purchase data from the 2006 Nielsen Homescan panel. Each household was provided with a handheld scanner and instructed to scan the Universal Product Code (UPCs) of products purchased at retail outlets. The household was also required to record purchased quantities and coupons used and to identify the retailer from which the product was purchased.

Zhen *et al*. (2014) extended the EASI model to the use of censored data for households reporting zero expenditures. They used instrumental variables to account for potential price endogeneity arising from omitted variables and measurement errors in censored demand. Zehn *et al*. estimated the demand system with a composite numéraire good that represents all goods and services not individually modelled in the system. Of the 576 median price elasticities, only 38 are statistically insignificant. All own-price elasticities were found to be statistically significant and negative at the median.

The approach used by Zhen *et al*. is data-intensive and it is unlikely that their approach can be replicated in many African countries. However, the approach used by Guerrero-López *et al*. (2017) and Chacon *et al*. (2018) for Chile and Guatemala, respectively can be easily applied to African countries, given that household expenditure data are available in Africa, albeit with some limitations in the data.

Few studies on SSB elasticities have been done for African countries, with the bulk emanating from South Africa. In 2017, prior to the implementation of the sugar-sweetened beverage tax in South Africa, Stacey *et al*. (2017a) used household expenditure data to analyse demand system elasticities and policy implications in South Africa. They combined sub-national price data with the Income and Expenditure Survey (IES) 2010/2011 by Statistics South Africa. Stacey *et al*. estimated a version of the flexible Quadratic Almost Ideal Demand System (QUAIDS) that accounts for censoring (due to a non-negligible proportion of non-expenditure on certain product categories).

Stacey *et al*. used Roy's identity, a generalized indirect utility function, to derive a system of *k* Engel curve regressions of expenditure share for each product: carbonated soft drinks, concentrates, fruit juice, tea and coffee, milk, and sugar (reported for income quintiles), for both prices and total expenditure. To account for the significant presence of non-expenditure on beverages and resulting censoring, they adopted the two-step approach. In the first step, they estimated a probit regression of the probability of non-zero purchase on household characteristics for each product. In the second step, they estimated an altered version of the conventional QUAIDS system, taking the first step estimates and adjusting the traditional QUAIDS form using estimates of the values of a standard normal cumulative density function (CDF) and probability density function (PDF).

When "unit-value" prices, derived by dividing expenditure by quantity, are used, a measurement error results. When quality is unobserved, as is typically the case, expenditure share and price will be endogenous. Stacey *et al*. (2017a) adopted the solution proposed by Deaton and adapted by Colchero *et al*. (2015), of using regional average product prices (Colchero et al., 2015, Deaton, 1987). This approach limits the extent to which local supply shocks influence purchase decisions, and the extent to which quantity-quality decisions at the household level could introduce endogeneity between product prices and household expenditure shares.

To test robustness, the authors tested the utilization of other household variables as controls, combining fruit juice and sugar-sweetened beverages into a single sweetened soft drink variable, and including junk foods as a part of the demand system. The study results suggested that the demand for these products is sufficiently price-elastic that a sugar tax could substantially reduce consumption.

The estimated own price elasticity of carbonated soft drinks was −1.18, of concentrates −1.17, and of sugar −2.42. The magnitude of the CSDs own-price elasticity was greater than one, implying that CSDs were price elastic. The total expenditure elasticity of the products studied was positive and approximately unit elastic, indicating proportionate increases in income would result in proportionate increases in demand for the beverages studied.

Another study from Africa is the study on household demand for food and nutrients in Tanzania, using cross-sectional data, by Bdulai and Aubert (2004). The study used data from 500 households in Dar es Salaam and focused on cereals and pulses, milk and milk products, fat and oil, meat, fish and eggs, fruits and vegetables, and 'other foods. Other than milk, no beverages were included in this study. Information was also collected on various demographic characteristics. The study used a weighted average of prices on specific items reported by households.

The authors used non-parametric regression and employed a smooth local regression technique to examine the shape of the Engel curves. The results indicated that budget shares were not linear in expenditure, suggesting that the LA/AIDS would not adequately represent consumer behaviour in their analysis and for this reason the authors used the QUAIDS model. For each nutrient demand equation, a single-equation generalised method of moments (GMM) estimator was used and was implemented in an instrumental variable estimation. This approach automatically accounts for heteroscedasticity by implementing White's heteroscedasticity consistent covariance estimator. The authors used a Hausman specification test to ascertain the consistency of the instrumental variable estimates. Findings revealed that the instrumental variable approach was consistent. Results of the study revealed that the food expenditure elasticities of all commodity groups were positive, indicating that all the commodities were normal goods, and consumption of these foods would increase as incomes increased.

Obayelu et al. (2009) estimated the income, price, and cross-price elasticities of roots and tubers, cereals, legumes, animal protein, fruits and vegetables, and oil, as well as the impact of the socio-economic variables on households' food demand in Nigeria. To incorporate demographic effects into a demand system, the authors used pooled data across all households and across the selected states in North-Central Nigeria for the analysis. All own-price elasticities of the six food groups analysed showed that they are price inelastic. The results for income elasticity showed that animal protein consumption is the most sensitive to income changes, while fats and oil are the least sensitive to income changes. Factors that positively and significantly affected demand for legumes, fruits and vegetables, animal protein, cereals, and roots and tubers were household size, level of education, primary occupation, access to credit, presence of children under 6 years old. Household size was found to affect the demand for animal protein negatively.

While their study provides the income and price elasticities of roots and tubers, cereals, legumes, animal protein, fruits and vegetables, and oil, Obayelu *et al*.'s (2009) estimates exclude price and income elasticities for sugar-sweetened foods or beverages. Thus, there is a need to understand how Nigerians' consumption patterns respond to changes in income and in the prices of sugar-sweetened-foods and-beverages.

Of the two Nigerian studies presented in this paper, none focused specifically on sugar or sugar-sweetened products and none of them used nationally representative data. This reflects a gap in the literature for nationally representative sugar-market demand studies for Nigeria.

The use of Deaton's Almost Ideal Demand System is quite common in the literature, not just for SSBs but also for other foods. Deaton himself estimated the own-price, cross price and income elasticities for cereal, meats, fats and dairy products in Pakistan for 1984-1985, rural Maharashtra for 1983 (2018) and Cote d'Ivoire for 1985 data (1988). Taljaard et al. (2004) also used the AIDS model to estimate the income, own- and cross-price elasticities for meat in South Africa using data from 1970 to 2000.

In the studies that used the AIDS to estimate the own-price elasticities for SSBs, the estimates were found range from -0.9 to -2.09, with majority of the estimates suggesting that SSBs are relatively elastic (Chacon et al., 2018, Colchero et al., 2015, Guerrero-López et al., 2017, Paraje, 2016). The income elasticity estimates for SSBs were found to be positive in all studies indicating that SSBs are normal goods. The estimates for the SSB income elasticities ranged from 0.45 to 1.2 (Chacon et al., 2018, Paraje, 2016). The expenditure elasticity of quality for SSBs in Guatemala was found to be 0.07. This positive quality elasticity suggests that when household expenditure increases, the unit values of SSBs also increase, *ceteris paribus*.

Studies that used other methods found similar own price elasticities for SSBs as those that used the AIDS. Stacey et al. (2017) used the quadratic almost ideal demand system (QUAIDS) to estimate the own and cross-price elasticities for SSB and other beverages for South Africa and found that SSBs are relatively elastic, with an own-price elasticity of -1.18.

Nigeria does not have many studies using the AIDS or any other approach, that focused on foods relevant to this study, hence the rationale for this study.

Chapter Three: Methodology

3.1 Assumptions and Definitions

For the purposes of this study, affordability is defined as the percentage in the GDP per capita required to purchase 100 litres of soft drinks in Nigeria. The study focuses on the period between 2005 and 2018.

This study analyses the affordability of carbonated soft drinks and fruit juices. Carbonated drinks are defined as sweetened, non-alcoholic drinks containing carbon dioxide, including carbonated fruit juices ("sparkling juices"). Carbonated teas and energy drinks are excluded. Carbonates are an aggregation of cola carbonates and non-cola carbonates, whether regular or low-calorie. For the analysis of sugar-sweetened beverage (SSB) affordability, this study uses data from Euromonitor International, which includes both naturally and artificially-sweetened carbonates (Euromonitor, 2020).

The juice category covers all still packaged juice obtained from fruits or vegetables by mechanical processes, reconstituted or fresh, often including pulp or fruit/vegetable puree. All unpackaged juices are excluded (Euromonitor, 2020).

Off-trade refers specifically to sales through retail outlets. These include sales through the following channels: supermarkets/hypermarkets, discounters, convenience stores, independent small grocers, forecourt retailers, food/drink/tobacco specialists, other grocery retailers, non-grocery retailers, vending, home shopping, internet retailing, and direct selling. On-trade refers to sales through foodservice outlets, such as bars, restaurants, cafés, hotels, and other catering establishments (Euromonitor International, undated).

For the analysis of SSB income and price elasticity, this study considers carbonated soft drinks (CSD) consumption and expenditure reported in the 7 days preceding data collection. CSD is restricted to carbonated drinks, such as Coca-Cola. The study also analyses the price and income elasticities of sugar, chocolate drinks (e.g., Milo and other hot chocolate drinks), and sachet water. Chocolate drinks are reported in powder form. Sugar and chocolate drinks are reported in kilograms, while the other commodities are measured in litres. Other definitions and assumptions are listed below:

1. An individual is defined as employed if he/she worked in an income-generating activity that was not permanently closed during the period of interest.

2. Adults are defined as all individuals aged 15 and above.

3. This study used data from the Nigeria National Household Survey Panel (GHSP), which does not provide price data. This study uses Deaton's unit value method to estimate price and income elasticities for CSDs, sugar, chocolate drinks, fresh milk, and sachet water and uses unit values as a proxy for prices. Unit values are the proportions of the reported amount paid for the food item to the reported quantity purchased (see equation 3.3).

4. This study uses Deaton's method of estimating the price elasticity of demand and therefore adopts his assumption that prices vary between clusters and not within clusters (Deaton, 1988).

5. This study uses enumeration areas (EAs) as clusters, as the EAs are the smallest geographical units in the survey.

All expenditures are converted to weekly expenditures for the purpose of this study and reported in 2009[1] Naira per litre for beverages and Naira per kilogram for sugar and chocolate drinks (powder). Expenditures reported for annual intervals were multiplied by 7/365, and expenditures reported for monthly intervals were multiplied by 7/30, to convert them to weekly expenditures.

3.2 Data

This study makes use of the average per capita annual off-trade and on-trade consumption of carbonated drinks and juices for Nigeria between 2005 and 2018. The data are derived from Euromonitor (2020). Beverage prices are reported in current Nigerian Naira and converted to 2009 real prices using the CPI data provided by the Central Bank of Nigeria (Central Bank of Nigeria, 2020b). Using GDP per capita as a proxy for income, this study used the real GDP per capita in 2009 Nigerian Naira[2] as reported by the Central Bank of Nigeria (Central Bank of Nigeria, 2020b).

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[1] 2009 was the latest available base year for the CPI provided by the Central Bank of Nigeria at the time of the analysis.
[2] The real GDP per capita was used to rule out any population growth influences on the measure of affordability. I used the real GDP per capita (and real prices) as this was the historical GDP data available from the Nigeria National Bureau of Statistics at the time of the analysis, but nominal price and nominal GDP data could have been used to estimate the same ratios.

For the estimation of income and price elasticities, I use data from the Nigeria General Household Survey Panel (GHS-Panel), 2013 and 2016 waves, available from the World Bank central data catalog (Nigeria National Bureau of Statistics, 2013, Nigeria National Bureau of Statistics, 2016). The sample is collected according to a two-stage probability sampling frame. The data are collected by the Nigeria National Bureau of Statistics and the World Bank. The Survey was designed to be representative at the national level as well as at the zonal level (both rural and urban). Therefore, there are 12 strata consisting of urban and rural areas for the six geopolitical zones. Two rounds of data are collected for every wave, one at the post-planting season and the second at the post-harvest season. The same households have been visited during each round (post-planting and post-harvest) and each wave, since the first wave (2010/2011), with a partial refreshing of the GHS-Panel implemented in the fourth wave (2018/2019). 2019 data is the fourth wave of a panel study that aimed to follow 5,000 households between 2010 and 2019. The dataset contains variables on demographics, household expenditure patterns, household composition, and the educational and occupational status of household members. Household expenditure variables include household consumption and expenditure (in the preceding seven days for 2013 and 2016) on different food items and monthly, biannual, and annual expenditures on other household items.

The 2013 wave consisted of 4,851 households and the 2016 wave consisted of 4,581 households. This study uses the 2013 and 2016 post-harvest data, and the pooled data for the post-harvest periods, which is when the data of interest were collected. The study uses the pooled sample to increase the sample size. I use the 2013 and 2016 panels as if they were separate cross-sectional surveys as done by Chelwa (2015). Given the number of households that reported purchasing the foods and beverages of interest, it was not possible to use the data as a panel dataset. Approximately 17% of households reported positive expenditure on CSD and only 6% reported positive expenditure on milk in the second (2013) and the third (2016) post-harvest waves.

The 2010 wave was excluded due to reporting issues on the units of food and beverages consumed and purchased. The 2010 wave did not accurately convert the non-standard food units reported by respondents into standard units like kilograms and litres. Thus, to avoid biases, the first wave was excluded from this study. The later waves, waves two (2013) to four (2019), provided a conversion factor to convert reported non-standard units into standard units. However, for the fourth wave (2019), the conversion factors still had some gaps, resulting in inconsistencies in crucial variables for this study. Thus, this study only uses wave two post-harvest data, which was collected in 2013, and wave three post-harvest data, collected in 2015/2016.

3.3 Data cleaning and analysis

Data cleaning and all data analyses were done using Stata 15.1. for the estimation of income and price elasticities. For SSB affordability, analysis was done on Microsoft Excel.

3.4 Method

The present study estimates the sugar-sweetened beverage affordability for carbonated soft drinks and juices between 2005 and 2018 in Nigeria. The study defines the relative income price (RIP) as the proportion of the real GDP per capita, in 2009 Nigerian Naira, required to purchase 100 litres of the carbonated soft drinks and juices. It uses the mean annual retail selling price per litre of carbonated drinks and juices as a proxy for prices. One limitation of the data is that retail selling prices are not disaggregated by brands, meaning that the price used is the average price across all brands. The RIP is estimated as illustrated in equations 3.1 and 3.2 below:

$$P_{ixt} = \frac{\overline{Exp}_{ixt}}{\bar{C}_{ixt}} \quad [3.1]$$

where P_{ixt} is the estimated price per litre of the specified beverage i (carbonated drinks or juices) in time t, expressed in 2009 prices, purchased in outlet x (i.e., on-trade or off-trade), $\overline{Exp}_{ixt}$ is the average real per capita expenditure in 2009 values for the specified beverage i, in year t, in outlet x and $\bar{C}_{ixt}$ is the per capita annual consumption of the specified beverage i in litres in year t, in outlet x.

P_{ixt} is multiplied by 100 to derive the estimated price per 100 litres of the drink:

$$RIP_{ixt} = \frac{\bar{P}_{ixt}}{GDP_t} * 100 \quad [3.2]$$

where RIP_{ixt} is the estimated relative income price of the specified beverage i, in time t. $\bar{P}_{ixt}$ is the estimated real price per litre in time t derived from equation 3.1. GDP_t is the real GDP per capita in Naira for year t.

For SSB income and price elasticities, this study uses Deaton's Unit Value Model (DUVM) as explained in detail in chapter 5 of *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy* by Angus Deaton (Deaton, 2018).

The DUVM uses unit values as a proxy for prices. Unit values are defined as the values per unit of a commodity, e.g., beverages or sugar, estimated by dividing the total expenditure on each commodity (food or beverage item) by the quantity purchased, as shown in equation 3.3.

$$uv_{Ghc} \equiv \frac{x_{Ghc}}{q_{Ghc}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.3]$$

Where uv_{hc}, is the unit value of the specified food item in cluster c in household h. X and q are the expenditure on and quantities of the specified commodity purchased, respectively. G represents the beverage or food item. For this study, the beverages included are carbonated soft drinks (CSDs), chocolate drinks, fresh milk, sachet water and sugar. X, the expenditure, is converted from nominal values to 2009[3] real values in Nigerian Naira. I use the average Consumer Price Index (CPI) for all goods in 2013 and 2016 to convert nominal values in 2013 and 2016, respectively, to real 2009 values. CPI data was obtained from the Nigeria Bureau of Statistics and the Central Bank of Nigeria (National Bureau of Statistics (NBS), 2020, Central Bank of Nigeria, 2020a).

The DUVM involves two stages in the estimation of prices and expenditure elasticities. The first stage includes the within-cluster regressions, and the second stage the between cluster regressions.

The standard demand equation (3.4) and the unit value equation (3.5) are shown below:

$$w_{Ghc} = \alpha_G^0 + \beta_G^0 lnx_{hc} + \gamma_G^0 z_{hc} + \sum_{H=1}^{M} \theta_{Gh} ln\pi_{hc} + (fe_{Gc} + u_{Ghc}^0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . [3.4]$$

$$lnuv_{Ghc} = \alpha_G^1 + \beta_G^1 lnx_{hc} + \gamma_G^1 z_{hc} + \sum_{H=1}^{M} \psi ln\pi_{hc} + u_{Ghc}^1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.5]$$

As previously, c and h represent the cluster and household, respectively and G represents the beverage or food item. The term $lnuv_{Ghc}$ is the natural log of the 2009 real unit value[4], estimated in equation 3.3 in cluster c for household h and good G; lnx is the natural log of total household weekly expenditure[5] converted from nominal values to the 2009 real value. The term z is a vector of demographic characteristics[6]: these are the household size, household male ratio, the age in years of the household head, a dummy variable for the household head's gender (0=female, 1=male), the household head's educational level, the household adult share, and the proportion of employed individuals in the household.

[3] 2009 was the latest available base year for the CPI provided by the Central Bank of Nigeria at the time of the analysis.
[4] All reported expenditures were converted to real 2009 values.
[5] .
[6] For the pooled sample, this also included a dummy variable for the year (0=2013, 1=2016).

The term w_{Ghc} is the share of sugar or beverage expenditure to the total household expenditure in household h and cluster c, while u^1_{Ghc} and u^0_{Ghc} are the standard regression error terms and *fe* is the cluster fixed effects, treated as an additional error to u^0_{Ghc}. Unobserved prices are represented by $ln\pi$. Ideally the prices would be included as a control variable, but the data do not capture this information. I therefore assume that market prices do not vary within each cluster, as Deaton suggests (Deaton, 2018). This is true for most villages in African countries, where each village would have a single market and prices are likely to be the same across a group of households (Deaton, 2018). By adding dummy variables for each cluster, equation 3.5 can be extended to include prices.

This study includes up to 461 clusters; therefore, I use the *areg* command, with the option "absorb cluster" in Stata to run the cluster fixed-effects regression used for linear regressions with a large dummy-variable set. This estimates the regression with implicit dummies for each cluster.

In the first stage, the budget shares, the natural logarithms of the unit values, the household characteristics, and the household expenditures are de-meaned. As prices are (assumed to be) constant within clusters, the de-meaning removes all the prices and fixed effects, allowing for the consistent estimation of the coefficients $\alpha, \beta, and\ \gamma$.

The first-stage estimates are used to estimate the cluster averages in the second stage as illustrated in equations 3.6 and 3.7 below:

$$\tilde{\gamma}\,^0_{Gc} = \frac{1}{n_c}\sum_{i=1}^{n_c}\left(w_{\,Gic} - \tilde{\beta}^0_G lnx_{ic} - \tilde{\gamma}\,^0_{G.}z_{ic}\right) \ldots \text{[3.6]}$$

$$\tilde{\gamma}^1_{+Gc} = \frac{1}{n^+_{Gc}}\sum_{i=1}^{n_c}\left(lnuv_{\,ic} - \tilde{\beta}^1_G lnx_{ic} - \tilde{\gamma}^1_{G.}z_{ic}\right) \ldots \text{[3.7]}$$

Where n_c is the number of households in each cluster c, and y^0_{Gc} and y^1_{Gc} are the cluster average demand and cluster average unit values, respectively. The term n^+_{Gc} represents the number of households in cluster c which purchased good G (and thus reported unit values) and the tildes indicate estimates derived from the first, within-cluster stage.

The variances and covariances of μ^0 and μ^1 in equations 3.4 and 3.5 are estimated using the first-stage regressions. The estimators of these matrices are derived from equations 3.8 to 3.10.

$$\tilde{\sigma}_{GH} = (n - C - k)^{-1}\sum_c \sum_{h\epsilon c} e^0_{Gch}\, e^0_{Hhc} \ldots \text{[3.8]}$$

$$\tilde{\omega}_{GH} = (n - C - k)^{-1}\sum_c \sum_{h\epsilon c} e^1_{Gch}\, e^1_{Hhc} \ldots \text{[3.9]}$$

$$\tilde{\chi}_{GH} = (n - C - k)^{-1} \sum_c \sum_{h\epsilon c} e^1_{Gch}\, e^0_{Hhc} \quad [3.10]$$

Where σ_{GH} is the variance-covariance matrix of the $\mu^{0\prime}s$, ω_{GH} is the variance-covariance matrix of the $\mu^{1\prime}s.\chi_{GH}$ is the covariance of μ^0 (columns) and μ^1 (rows). The terms e^0 and e^1 are the residuals from the first stage, within-cluster budget share and unit value regressions, respectively. *n* is the number of observations (households), *C* is the number of clusters and *k* is the number of regressors.

The elements for the inter-cluster variance and covariance matrices (of γ^0_G and γ^1_G) are derived from equations 3.6 and 3.7,

$$\tilde{q}_{GH} = cov(\hat{\gamma}^0_{Gc}, \hat{\gamma}^0_{Hc}), \tilde{S}_{GH} = cov(\hat{\gamma}^1_{Gc}, \hat{\gamma}^1_{Hc}), \tilde{t}_{GH} = cov(\hat{\gamma}^1_{Gc}, \hat{\gamma}^0_{Hc}) \quad [3.11]$$

Deaton states that using the $\hat{\gamma}^0$ and the $\hat{\gamma}^1$ to run a between-cluster multivariate ordinary least squares (OLS) regression results in 3.12:

$$\mathcal{B}_{OLS} = \tilde{S}^{-1}\tilde{T} \quad [3.12]$$

The elements of $\tilde{S}$ and $\tilde{T}$ are derived from 3.11. The G^{th} column of β_{OLS} is a vector of OLS coefficients of $\hat{\gamma}^0_G$ regressed on all the values of $\hat{\gamma}^1$ as explanatory variables. Note that this estimator does not account for the influence of μ^0 and μ^1 when the cluster size is finite.

In classic demand theory, consumers respond to price hikes by reducing their quantity demanded for a particular good or service. Goods tend to be heterogenous, and even the homogenous goods, such as milk, can vary significantly in quality (e.g., long-life, full cream, low-fat, fat-free, etc.) With quality heterogeneity, households may respond to higher prices by switching to a lower grade or quality with a smaller decline in the quantity consumed. A given amount of refined sugar for example, may cost more than the same amount of unrefined sugar, and households could switch between consuming refined sugar to consuming unrefined sugar, in a response to price hikes. Deaton describes this as "quality shading".

While Deaton uses unit values when prices are not reported, unit values are not the same as prices, as unit values conceal the degree of quality heterogeneity. Unit values are positively related to total household income, as higher-income earning households tend to consume higher-quality commodities. Unit values vary with the choice of quality and market prices. Since unit values are choice variables, using them to explain demand patterns could result in simultaneity bias (Deaton, 2018). Deaton circumvents this by defining quality as the value of a bundle of goods at fixed reference prices relative to its physical volume[7] and assuming that preferences are separable over bundles of goods.[8]

Moreover, since unit values are derived from the reported household expenditure and the quantities purchased by households, measurement error in quantity is transmitted to measurement error in unit values, including a spurious negative correlation (Deaton, 2018). This measurement error will bias the price elasticity estimates (Deaton, 2018).

The errors-in-variable estimator with measurement error correction is given by equation 3.13.

$$\widetilde{\mathcal{B}} = \left(\tilde{S} - \widetilde{\Omega}\widetilde{N}_{+}^{-1}\right)^{-1}\left(\tilde{T} - \tilde{X}\widetilde{N}^{-1}\right) \qquad [3.13]$$

Where $\widetilde{N}_{+}^{1} = C^{-1}\sum_{c} D(n_{c}^{+})^{-1}, D(n_{c}^{+})$ is a diagonal matrix formed from the elements of n_{Gc}^{+}, and the matrix $\widetilde{N}^{-1}$ is the corresponding quantity formed from the values of n_c. The first-stage parameters and residuals are used to make the covariance matrices in equations 3.8 to 3.11. These results are used to calculate the $\widetilde{\mathrm{B}}$ matrix in equation 3.13.

The probability limit of the $\widetilde{\mathrm{B}}$ matrix in the presence of quality effects is given by:

$$plim\,\widetilde{\mathcal{B}} = \mathcal{B} = (\Psi')^{-1}\Theta' \qquad [3.14]$$

$$\Psi = I + D(\beta^{1})D(e)^{-1}E \qquad [3.15]$$

$$E = -\Psi + D(\varpi)^{-1}\Theta \qquad [3.16]$$

$$e = \iota - \beta^{1} + \beta^{0}D(\varpi)^{-1} \qquad [3.17]$$

Where ψ is the elasticity of unit value with respect to (unobserved) price given by $\frac{\delta ln uv_G}{\delta ln\pi_H}$, and *E* is the price elasticities matrix and *D(.)* is a diagonalization operator that converts the vector into a diagonal matrix.

Equations 3.15 to 3.17 are merged with equation 3.14 to retrieve Θ and *E* from *B*.

[7] $\xi_G = P_G^0.q_G/k_G.q_G$ defines quality, which is a function of consumption bundle q_G, and any deviation towards more costly goods and away from less costly goods will increase the quality of the bundle as a whole.
[8] Deaton describes this in greater detail in his book *The Analysis of Household Surveys: A Microeconometric Approach to Development Polic*y, pages 293-299.

$$\Theta = \mathcal{B}'\Psi = \mathcal{B}'[I - D(\zeta)\mathcal{B}' + D(\zeta)D(\bar{\omega})]^{-1} \text{......}[3.18]$$

The $\widetilde{\mathcal{B}}$ matrix in equation 3.13 is corrected using the first stage estimates to derive the parameters of Θ or the elasticity matrix using 3.18. The elements of ζ are defined by equation 3.19.

$$\zeta_G = [(1 - \beta_G^1)\bar{\omega}_G + \beta_G^0\,]^{-1} \text{......}[3.19]$$

The variance-covariance matrix for the estimated parameters and elasticities was obtained by bootstrapping in the second stage. Bootstrap samples were derived from the "purged" budget shares and unit values from equations 3.6 and 3.7, respectively.

To complete the system by adding a single "non-food" commodity and to impose (approximate) symmetry, Deaton uses the Almost Ideal Demand System functional form by Deaton and Muellbauer (1980) as shown in equation 3.20.

$$\omega_G = \alpha_G^0 + \beta_G^0 \ln\left(\frac{\chi}{\pi}\right) + \sum_{H=1}^{M} \theta_{GH}^* ln\pi_H \text{......}[3.20]$$

Where π is a linearly homogenous price index from all prices, for which Deaton uses a Stone index, as given in equation 3.21.

$$ln\pi = \sum_{H=1}^{M} \bar{\omega}_H ln\pi_H \text{......}[3.21]$$

Substituting 3.21 into 3.20 results in 3.22:

$$\omega_G = \alpha_G^0 + \beta_G^0 ln\chi + \sum_{H=1}^{M} \theta_{GH}^* ln\pi_H = \alpha_G^0 + \beta_G^0 ln\chi + \sum_{H=1}^{M} (\theta_{GH}^* - \beta_G^0\,\bar{\omega}_{H)} ln\pi_H \text{......}[3.22]$$

The MxM Θ matrix from 3.22 is calculated from 3.18. Θ^* is the corresponding (M+1)x (M+1) matrix for the complete system. The final column of Θ^*, which uses the homogeneity restriction, is derived from equation 3.23, while the final row is derived from equation 3.24 as shown below.

$$\theta_{GM+1}^* = -\beta_G^0 - \sum_{H=1}^{M} \theta_{GH} \text{......}[3.23]$$

$$\theta_{M+1G}^* = -\sum_{H=1}^{M} \theta_{HG}^* \text{......}[3.24]$$

Deaton assumes some plausible quality elasticity for the non-food category and calculates the extended vector ζ^* from 3.21.

Applying 3.15 to the complete system results in 3.25 and 3.26:

$$\Theta^* = \mathcal{B}^{*\prime}\Psi^* \quad [3.25]$$

$$\Psi^* = I + D(\zeta^*)D(\varpi^*) - D(\zeta^*)\mathcal{B}^{*\prime} \quad [3.26]$$

Eliminating $\mathcal{B}^*$ yields equation 3.27:

$$\Psi^* = [I + D(\zeta^*)D(\varpi^*)]^{-1}[I + D(\zeta^*)\Theta^*] \quad [3.27]$$

Equations 3.16 and 3.17 calculate the full-system matrix of the price elasticities and total income or expenditure elasticities.

$$\theta_{GH} + \beta_G^0\varpi_H = \theta_{HG} + \beta_H^0\varpi_G \quad [3.28]$$

To satisfy the symmetry condition (see equation 3.28), Deaton uses an approximation that relies on the validity of the empirical finding that the quality elasticities are small. This implies that Ψ is approximately equal to the identity matrix, such that Θ and $\mathcal{B}'$ are approximately equal. This implies that the matrix $\mathcal{B} + \varpi\beta^{0\prime}$ should be symmetric.

Equation 3.29 rearranges the "*vec*[9]" of matrix $\mathcal{B}$ to become the transposition of the $\mathcal{B}$.

$$Kvec\mathcal{B} = vec\mathcal{B}' \quad [3.29]$$

Matrix *L* selects from the *vec* of a square matrix the elements that lie below the diagonal in the original matrix and thus the restriction on $\mathcal{B} + \varpi\beta^{0\prime}$ can be expressed by equation 3.30

$$L(I - K)(vec\mathcal{B} + \beta^0 \otimes \varpi) = 0 \quad [3.30]$$

Matrix *L* prevents each symmetry from being applied twice.

Equation 3.30 can be written as *Rb=r* if *b* replaces $vec\mathcal{B}$.

The last step in completing the system entails replacing $\left(\tilde{S} - \tilde{\Omega}\tilde{N}_+^{-1}\right)^{-1}$ in equation 3.13 with *A* and defining the restricted estimate of $\mathcal{B}$ by equation 3.31.

$$vec\tilde{\mathcal{B}}_R = vec\tilde{\mathcal{B}} + (I \otimes A)^{-1}[R(I \otimes A)^{-1}R']^{-1}(r - Rvec\tilde{\mathcal{B}}) \quad [3.31]$$

[9] The "vec" operator converts a matrix into a vector by stacking a matrix's columns and arranging these columns vertically.

3.5 Correction for non-purchasing and non-consuming households: CSD expenditure and price elasticity

This study uses the 2013 (wave 2), 2016 (waves 3) and pooled data (waves 2 and 3) from the Nigeria General Household Survey Panel. If a household never reported expenditure on the food and beverages of interest in either of the two waves used in this study, across the period of interest, these households are treated as true non-consumers or not part of the market (Thomas, 1972).

There are typically three categories that households with zero expenditures belong to:

1. Non-purchasers: zero expenditures are reported as these households never consume the commodities of interest because of health concerns, religious beliefs, or other reasons.

2. Infrequent purchasers: zero expenditures are reported because of the timing of the survey. A longer survey might capture non-zero expenditures in these households, but if the reporting period is short, in this case seven days, these households are unlikely to have purchased any of the commodities during the preceding seven days. Non-perishable foods, such as sugar, are purchased infrequently and in sufficient quantities to be stored and consumed over an extended period and thus are not captured in the dataset when the question on expenditure is limited to a short period, e.g., did the household purchase any sugar in the last seven days?

3. Potential purchasers: these households might buy a certain food commodity if some economic factor changed, such as a fall in the price of the goods or an increase in the per capita household income. Tobit models have been widely used in cases of surveys that include zero expenditures. The standard Tobit model assumes that at some level of the explanatory variables (for example, a certain level of per capita income), non-purchasers will become purchasers. However, the standard Tobit model is particularly restrictive, not allowing for different factors to affect the probability of purchase and the conditional level of expenditures. It assumes that "the decision to consume a given food item is the same as the decision about the amount of the food to consume" (Haines et al., 1988).

The choice of appropriate econometric method for the price and income elasticity estimation should be based on which of these categories the households with zero expenditure belong to (Blisard and Blaylock, 1993, Blaylock and Blisard, 1991).

Unfortunately, the typical household expenditure survey does not provide the information needed to determine to which category of non-purchasers a household belongs (Deaton and Irish, 1984), as is the case with the Nigeria General Household Survey Panel. Additional questions are essential to determine if non-purchasers ever purchase the product, and if so when they last purchased it, or if potential purchasers would ever purchase the product and which economic factors would influence their decision to purchase the product. However, additional questions have the disadvantage of potentially reducing a survey's response rate.

Heckman's (1979) procedure corrects for selection bias and allows the decisions to purchase and the amount purchased to be modelled separately. The Heckman procedure is detailed below.

$P_i = \alpha D_i + \varepsilon_i$ ……………………………………………………………………………3.32

A probit analysis, a maximum likelihood (ML) technique, is used to estimate equation 3.32.

Where P_i takes the value one if expenditures are reported by the i^{th} household and zero otherwise. D_i is a vector of exogenous explanatory factors and ε_i is the error term.

The inverse Mills' ratio is used to obtain consistent estimates of β in the budget share equation (equation 3.4) and the unit value equation (equation 3.5).

The Mills' ratio (MR) reflects the probability that an observation with specific characteristics will be selected into the observed, truncated sample (James, 1980). The inverse Mills' ratio (IMR) is calculated from the density (ϕ) and the distribution (Φ) functions for a standard normal variable in the ML estimate of equation 3.32. The inverse Mills' ratio is given by equation 3.33.

$\lambda_i = \frac{\phi(Z_i)}{1-\Phi(Z_i)}$ ……………………………………………………………………3.33

$Z_i = \frac{-\alpha D_i}{\sigma_\varepsilon}$……………………………………………………………………………..3.34

The inverse Mills' ratio, denoted λ, is included in the OLS estimation of the budget share and unit value equations (equations 3.4 and 3.5 respectively). The regression used for the estimation of expenditures greater than zero can then be written as equation 3.35 for the budget share equation and as per equation 3.36 for the unit value equation:

$w_{Ghc}|lnx_{Ghc} > 0 = \alpha_G^0 + \beta_G^0 lnx_{hc} + \gamma_F^0 z_{hc} + \sum_{H=1}^{M} \theta_{Gh} ln\pi_{hc} + \beta_{\lambda G}\lambda_{Ghc} + (fe_{Gc} + u_{Ghc}^0)$……..3.35

$lnuv_{Ghc}|lnx_{Ghc} > 0 = \alpha_G^1 + \beta_G^1 lnx_{hc} + \gamma^1 z_{hc} + \sum_{H=1}^{M} \psi ln\pi_{hc} + u_{Ghc}^1$……………………….……3.36

Equations 3.35 and 3.36 are thus estimated for the truncated subsample with positive expenditures only.

Stata's DUVM command was used for this study to include the Heckman approach and, thus, the inverse Mill's ratio in the elasticity estimates. Other advantages of using Stata's built-in procedure for the DUVM is that it allows the use of sampling weights to consider the level of representativeness of each observation. It also makes it possible to produce elasticities for different population groups.

To distinguish between the DUVM with and without the selection bias correction, this study refers to the estimates obtained with the Heckman procedure as the IMR, and the estimates without the Heckman procedure as the DUVM.

Chapter Four: Results

4.1 Sugar-sweetened beverage affordability

Tables 4.1 and 4.2 present the real GDP per capita in Naira, the SSB expenditure per capita in Naira, and the SSB consumption per capita in litres between 2005 and 2018 for off-trade and on-trade consumption.

Table 4.1: Percentage of real GDP per capita required to purchase 100 litres of carbonated soft drinks (CSD), off-trade

Year (t)	**Ave. real per capita expenditure on CSD (EXP) [1]**	**Annual CSD* consumption (litres per capita*(C) [2]**	**Real price per 100 litres of CSD* [3] ($\bar{P}$)**	**Ave. real per capita expenditure on juices (EXP) [4]**	**Annual juices consumed (litres per capita) [5]**	**Real price per 100 litres of juices* ($\bar{P}$) [6]**	**Real GDP per capita (Naira) [7]**	**Carbonated drinks affordability (RIP)* [8]**	**Juice affordability (RIP)* [9]**
2005	720.33	5.6	12 863	232.88	1.2	19 407	269 866	4.8%	7.2%
2006	740.19	5.1	14 514	248.07	1.3	19 082	280 595	5.2%	6.8%
2007	780.87	5.2	15 017	266.58	1.4	19 041	293 306	5.1%	6.5%
2008	832.31	5.6	14 863	279.91	1.5	18 660	306 200	4.9%	6.1%
2009	826.2	6.0	13 770	294.47	1.6	18 404	323 059	4.3%	5.7%
2010	786.87	6.0	13 114	291.74	1.7	17 161	344 550	3.8%	5.0%
2011	775.72	6.2	12 512	307.29	1.8	17 072	353 251	3.5%	4.8%
2012	743.76	6.0	12 396	318.67	1.9	16 772	358 371	3.5%	4.7%
2013	802.11	6.5	12 340	346.60	2.1	16 505	368 052	3.4%	4.5%
2014	815.68	6.7	121 74	366.75	2.2	16 670	380 674	3.2%	4.4%
2015	829.12	7.1	11 678	382.38	2.3	16 625	381 058	3.1%	4.4%
2016	761.46	7.6	10 019	399.25	2.3	17 359	365 300	2.7%	4.8%
2017	764.4	7.5	10 192	369.32	2.3	16 058	358 830	2.8%	4.5%
2018	709.06	7.5	9 454	371.71	2.4	19 407	356 350	2.7%	4.3%

Source: Euromonitor, Central Bank of Nigeria, (2020b), Euromonitor (2020) *Author's estimates. Column [3] is obtained by dividing column [1] by column [2] and multiplying by 100. Column [6] is obtained by dividing column [4] by column [5] and multiplying by 100.

Table 4.2: Percentage of real GDP per capita required to purchase 100 litres of carbonated soft drinks (CSD) and juices, on-trade

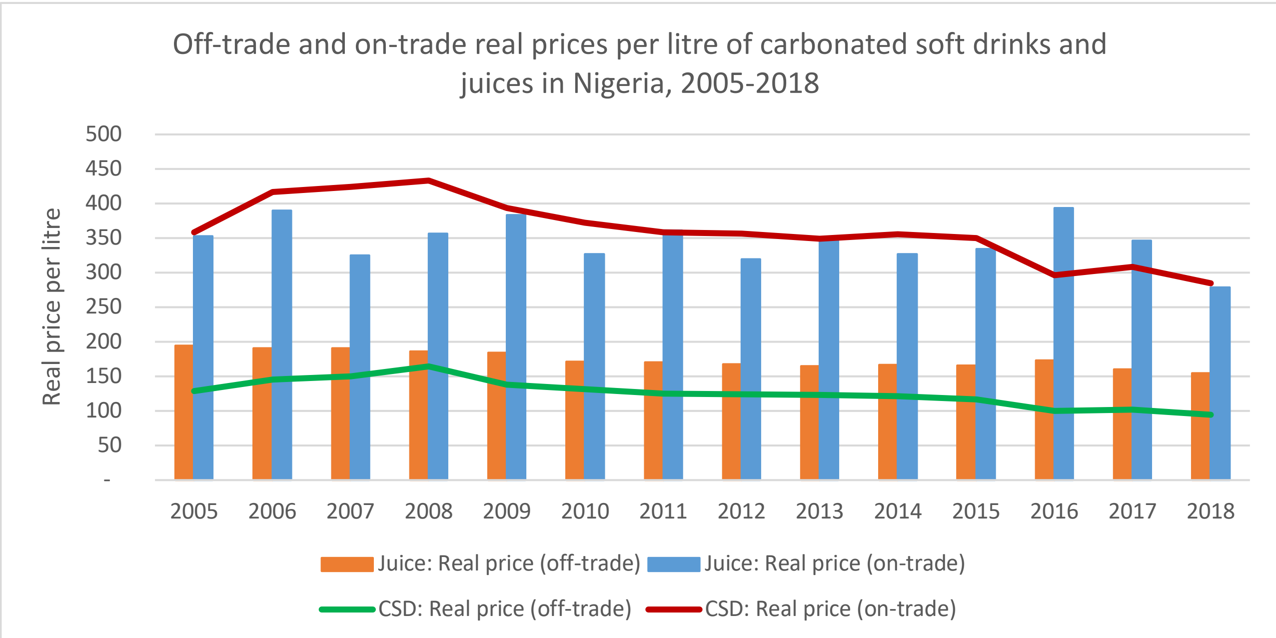
Year (t)	**Ave. real per capita expenditure on CSD (EXP) [1]**	**Annual CSD* consumption (litres per capita) (C) [2]**	**Real price per 100 litres of CSD *[3] ($\bar{P}$)**	**Ave. real per capita expenditure on juices (EXP) [4]**	**Annual juices consumed (litres per capita) [5]**	**Real price per 100 litres of juices * ($\bar{P}$) [6]**	**Real GDP per capita (Naira) [7]**	**Carbonated drinks affordability (RIP)* [8]**	**Juice affordability (RIP)* [9]**
2005	368.16	1.6	23 010	105.98	0.3	35 326	269 866	8.5%	13.1%

2006	380.66	1.4	27 190	116.85	0.3	38 950	280 595	9.7%	13.9%
2007	410.88	1.5	27 392	130.01	0.4	32 503	293 306	9.3%	11.1%
2008	430.08	1.6	26 880	142.66	0.4	35 664	306 200	8.8%	11.6%
2009	461.27	1.8	25 626	153.34	0.4	38 335	323 059	7.9%	11.9%
2010	458.49	1.9	24 131	163.27	0.5	32 654	344 550	7.0%	9.5%
2011	465.87	2	23 293	180.70	0.5	36 139	353 251	6.6%	10.2%
2012	464.50	2	23 225	191.73	0.6	31 956	358 371	6.5%	8.9%
2013	496.46	2.2	22 566	209.12	0.6	34 853	368 052	6.1%	9.5%
2014	513.92	2.2	23 360	228.97	0.7	32 710	380 674	6.1%	8.6%
2015	537.20	2.3	23 360	233.85	0.7	33 408	381 058	6.1%	8.8%
2016	469.95	2.4	19 581	236.00	0.6	39 333	365 300	5.4%	10.8%
2017	474.68	2.3	20 638	207.63	0.6	34 604	358 830	5.8%	9.6%
2018	437.42	2.3	19 018	194.84	0.7	27 834	356 350	5.3%	7.8%

Source: Euromonitor, Central Bank of Nigeria, (2020b), Euromonitor (2020) *Author's estimates. Column [3] is obtained by dividing column [1] by column [2] and multiplying by 100. Column [6] is obtained by dividing column [4] by column [5] and multiplying by 100.

Figure 4.1 illustrates the trend in real (2009) prices (in Naira) per litre for carbonated drinks and juices in Nigeria. The on-trade prices have fluctuated over time but the off- trade prices for carbonated drinks and juices have decreased steadily over time.

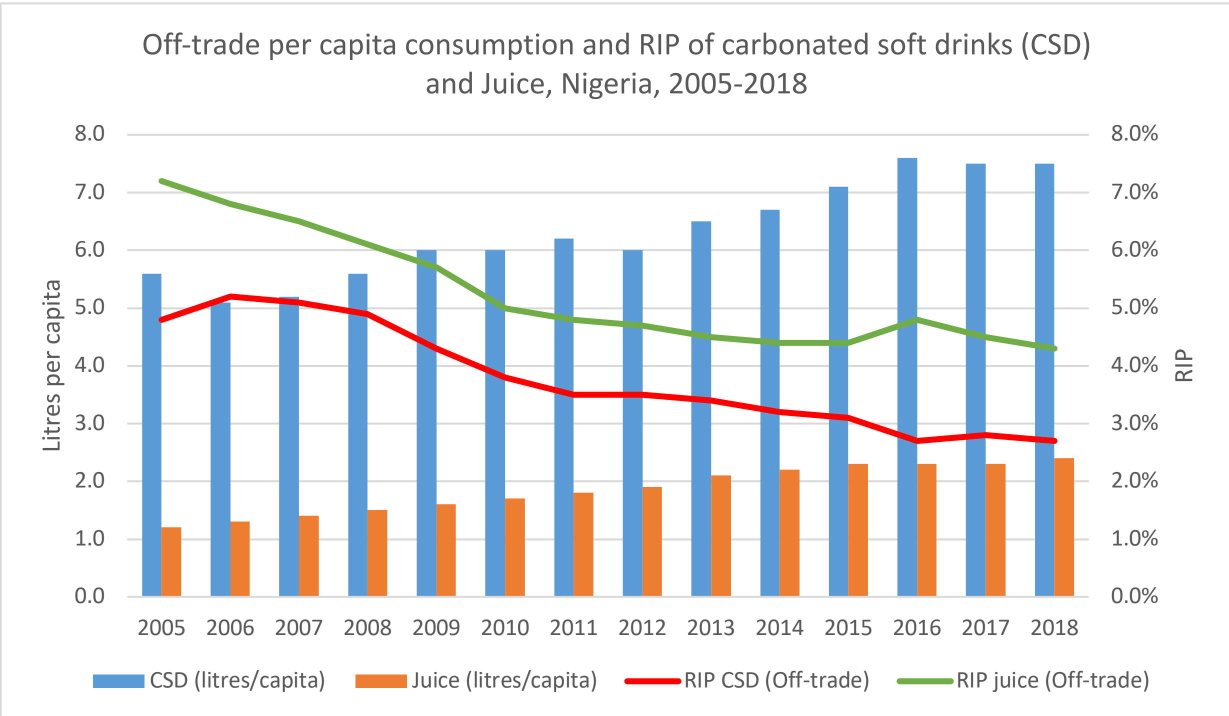
Figure 4.1: Off-trade and on-trade real prices per litre of carbonated soft drinks (CSD) and juices in Nigeria, 2005-2018



Source: Author's estimates based on Euromonitor, 2020.

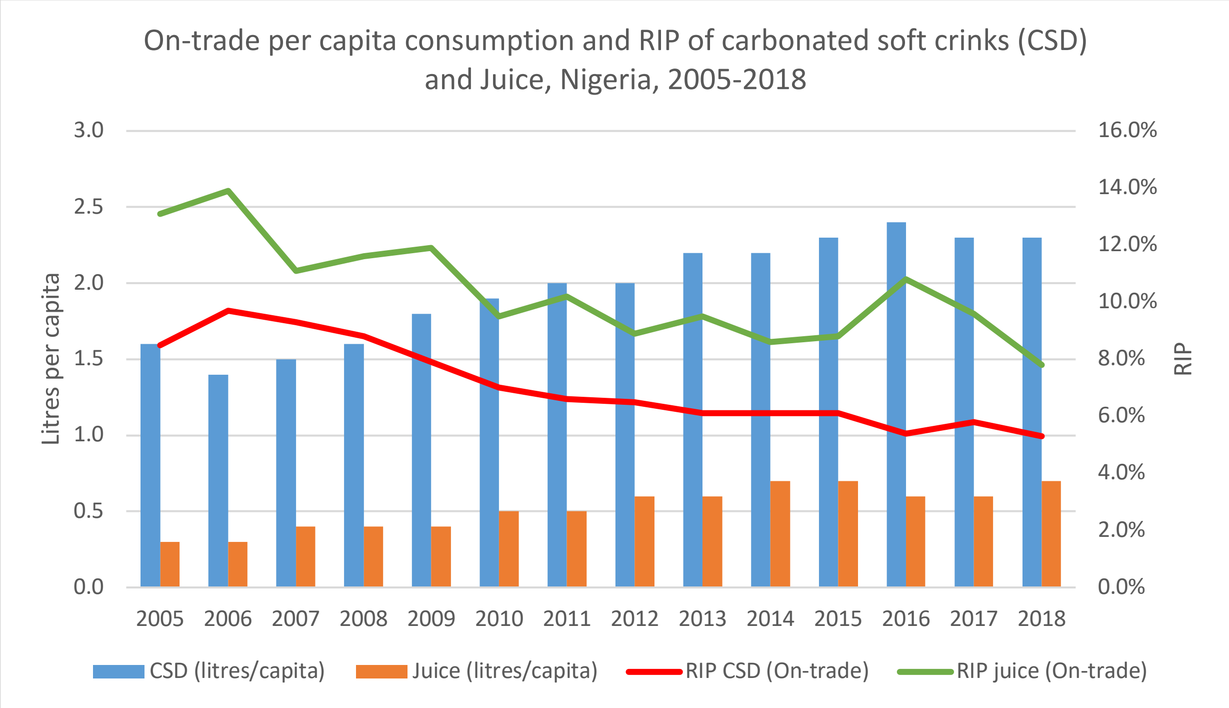
Figures 4.2 and 4.3 illustrate the trends in the RIP and the annual litres consumed per capita. It can be seen from Figures 4.2 and 4.3 that SSBs, in particular carbonated drinks and juices, have become relatively more affordable in Nigeria since 2005. This is in line with findings by Blecher and colleagues (2017) for Nigeria in their study on the global trends in the affordability of sugar-sweetened beverages, 1990–2016. This implies that, in the effort to curb consumption of SSBs, one could potentially use a price adjustment such as an SSB tax. These findings are consistent for both carbonated drinks and juices regardless of whether these are consumed off-trade or on-trade. However, as is typically the case, on-trade consumption is less affordable than off-trade for both beverages; as shown in Figure 4.1.

Figure 4.2: Off-trade per capita consumption and RIP of carbonated soft drinks (CSD) and juice, Nigeria, 2005-2018



Source: Author's estimates based on Euromonitor, 2020.

Figure 4.3: On-trade per capita consumption and RIP of carbonated soft drinks (CSD) and juice, Nigeria, 2005-2018



Source: Author's estimates; Euromonitor, 2020.

Figure 4.3 illustrates a similar trend to that shown in Figure 4.2. The annual per capita consumption of both carbonated soft drinks (CSD) and juices has increased over time for both off-trade and on-trade. As mentioned previously, the retail selling price for carbonated drinks fluctuated during the period 2005 to 2018, while that of juices increased steadily until 2016 (refer to Figure 4.1).

Worth noting is that while it may appear that the annual per capita consumption of carbonated drinks and juice is relatively low in Nigeria compared to other countries, there could be sub-groups of the population whose SSB consumption is much higher. In Mexico, it was estimated that the SSB consumption per capita in 2015 was 166.98 litres, for south Africa this was 103.24 litres, While for Algeria, it was estimated to be 46 litres (Ferretti and Mariani, 2019). The estimated per capita annual consumption for SSBs in Nigeria of approximately 9 litres consumed off-trade and on-trade is similar to that found for other African countries such as Burkina Faso and Togo in 2010 (Singh et al., 2015). Further research on SSB consumption in Nigeria is required to determine if subgroups of the Nigerian population are consuming more sugar, through SSBs, than the WHO daily recommended allowance. This could indicate whether measures to curb SSB affordability in Nigeria are required.

4.2 CSD expenditure and price elasticity

The summary statistics with the variables of interest for wave 2 (2013) and wave 3 (2016) of the Nigeria National Household Survey Panel (GHSP), are presented in Table 4.3.

Table 4.3: Summary statistics

Variable	2013	2016	Pooled sample
Average household size	6.4	5.7	6.0
Average age of household head in completed years	52.0	52.8	52.4
Average proportion of adults	61.5%	65.9%	63.7%
Average proportion of male heads	84.5%	79.7%	82.2%
Average proportion of adults employed	68.9%	86.3%	77.5%
Proportion of household heads with primary education and above	57.0%	60.6%	58.8%
Average household real expenditure (Naira)	5,532	4,445	4,999
% Of households with positive sugar expenditure	40.9%	42.4%	41.6%
% Of households with positive CSD expenditure	17.0%	16.6%	16.7%
% Of households with positive chocolate drinks expenditure	15.4%	15.7%	15.5%
% Of households with positive milk expenditure	6.5%	6.2%	6.3%
% Of households with positive sachet water expenditure	20.6%	23.1%	21.8%
Average sugar share to household expenditure (conditional on positive sugar expenditures).	3.2%	2.6%	2.9%
Average CSD share to household expenditure (conditional on positive CSD expenditures).	2.0%	2.3%	2.2%
Average chocolate drinks share to household expenditure (conditional on positive chocolate drinks expenditures).	3.3%	2.8%	3.1%
Average milk share to household expenditure (conditional on positive milk expenditures).	4.9%	3.7%	4.3%
Average sachet water share to household expenditure (conditional on positive sachet water expenditures).	1.3%	1.6%	1.4%
Average unit value per kg of sugar (Naira)	467	742	605
Average unit value per litre of CSD (Naira)	124	134	129
Average unit value per kg of chocolate drinks (Naira)	1,543	2,535	2,036
Average unit value per litre of milk (Naira)	95	98	96
Average unit value per litre of sachet water (Naira)	16	34	25
Average weekly quantity in kg of sugar consumption	0.25	0.34	0.29
Average weekly quantity in litres of CSD consumption	0.20	0.21	0.21

Average weekly quantity in kg of chocolate drink consumption (in powder)	0.03	0.04	0.03
Average weekly quantity in litres of milk consumption	0.13	0.11	0.12
Average weekly quantity in litres of sachet water consumption	2.33	2.31	2.3
Total number of clusters	431	437	461
Total number of households	4,761	4,579	9,340

Source: Nigeria National Bureau of Statistics 2013, 2016.

The underlying assumption of the Deaton method is that unit values vary spatially. I tested for spatial variation in unit values using the analysis of variance (ANOVA). The results of the ANOVA are in line with the assumption that unit values vary spatially. The *F*-statistic and the *p*-value are associated with the null hypothesis of no spatial variation in unit values. The *p*-value indicates that the null hypothesis of no spatial variation in unit values is rejected in all three cases (2013, 2016, and the pooled sample) for all the food items, with the exception of CSDs in 2016. A large *F*-statistic implies variation in unit values. These results are presented in Table 4.4.

Although not large, the results show that the proportion of price variation for CSD prices/unit values between clusters is approximately 57% in 2013, 29% in 2016, and 69% in the pooled sample. For milk, the proportion of price variation between clusters is approximately 70% in 2013, 73% in 2016, and 55% in the pooled sample. This proportion of price variation between clusters is reflected by the values of R^2 in Table 4.4 An attempt was made to include non-alcoholic malt drinks, but the assumption of unit value variation between clusters was not met for malt drinks. The ANOVA results for the malt drinks were not included in this paper.

Table 4.4: Testing the spatial variation hypothesis

	2013				2016				Pooled 2013-2016			
	F statistic	P value	R^2	N	F statistic	P value	R^2	N	F statistic	P value	R^2	N
Sugar	2.77	0.00	0.39	1,943	3.06	0.00	0.39	1,942	3.00	0.000	0.2504	3,885
CSD	2.49	0.00	0.57	813	0.78	0.99	0.29	761	1.50	0.000	0.29	1,574
Choc.	1.98	0.00	0.48	730	1.91	0.00	0.47	718	1.85	0.000	0.31	1,448
Milk	5.67	0.00	0.69	310	5.46	0.00	0.73	282	4.96	0.000	0.55	592

Water	2.19	0.00	0.48	982	1.83	0.00	0.34	1,057	1.64	0.000	0.24	2,039

Source: Author's estimates, (Nigeria National Bureau of Statistics, 2013, Nigeria National Bureau of Statistics, 2016).

Notes: In Table B2 in the appendix, where the sample is treated for extreme unit values, the null hypothesis of no spatial variation is rejected in all cases, including for CSDs in 2016.

Figure 4.4 illustrates the variation in unit values for CSDs in 2013, 2016, and in the pooled sample (2013-2016).[10]

Figure 4.4: Variation in unit values for SSBs by cluster[11] (2013, 2016, and 2013-2016)

Source: Author's estimates. The clusters are represented by numbers on the x-axis.

In the 2013 sample, there was less variation in the unit values for CSDs, in comparison to the 2016 data. All unit values were converted to real 2009 values.

[10] Figure B1 in the appendix illustrates the unit values by cluster for a robust sample where the data was treated for extreme values. The treatment of the extreme unit values is described in detail in section 4.4.

[11] The clusters are presented as numerical values and are read on the x-axis of Figure 4.4.

The 2016 sample is excluded from the analysis in this section as CSDs did not satisfy the assumption of spatial variation in unit values. However, I use the 2016 sample for the pooled sample analysis in this section.

Table 4.5 displays the coefficients from the within-cluster regressions for budget shares. These results are derived from equation 3.4. The standard errors are presented in square parentheses. All of the expenditure elasticities (e_x) are positive and less than unity and all, except sugar are significant at the 5% level or 1% level. The expenditure elasticity for CSDs in 2013 was found to be 0.43 which is similar to that found for Ecuador (0.46) (Paraje, 2016). All the commodities have negative coefficients on β_0 (natural log of real household expenditure) and thus have total expenditure elasticities that are less than unity. Milk accounts for the highest proportion of the total budget share at approximately 4.9%, followed by chocolate drinks at 3.3% and sugar at 3.2%. Deaton also found similar budget shares for rural Maharashtra in 1983, where dairy products accounted for 5.3% of the budget shares (Deaton, 2018). Other variables were statistically significant for some food items but not across all food items.

Table 4.5: Within-cluster regression for budget shares (2013)

Variable	Sugar (n=1,733)		CSD (n=754)		Choc. Drinks (n=667)		Milk (n=240)		Sachet water (n=876)	
e_x	0.134	[0.095]	0.432***	[0.075]	0.668***	[0.067]	0.614***	[0.164]	0.267**	[0.126]
$\bar{w}$ (%)	3.227		2.028		3.344		4.892		1.277	
Ln real expenditure	-0.024***	[0.003]	-0.012***	[0.001]	-0.007**	[0.003]	-0.022***	[0.006]	-0.008***	[0.001]
Ln household size	0.009**	[0.003]	0.004	[0.002]	-0.001	[0.005]	-0.003	[0.008]	-0.002	[0.002]
Male ratio	0.000	[0.001]	0.000	[0.001]	-0.003*	[0.002]	0.002	[0.003]	-0.000	[0.000]
Household head age in years	0.000*	[0.000]	0.000	[0.000]	-0.000	[0.000]	0.000	[0.000]	0.000*	[0.000]
Household adult share	0.010*	[0.005]	0.002	[0.004]	0.005	[0.006]	-0.011	[0.018]	-0.001	[0.003]
Household head gender= male	0.007**	[0.003]	-0.002	[0.003]	0.007	[0.004]	0.013	[0.007]	0.000	[0.002]
Ratio employed	0.001	[0.003]	-0.002	[0.002]	-0.002	[0.004]	-0.002	[0.006]	0.001	[0.002]
Household head educ.= other	-0.006*	[0.003]	0.009	[0.008]	-0.012	[0.013]	-0.021	[0.007]	-0.001	[0.004]
Household head educ.= pre-primary	-0.011	[0.010]	0.008	[0.006]	-0.006	[0.009]	.	.	.	.
Household head educ.= primary	-0.008***	[0.002]	-0.000	[0.003]	-0.003	[0.006]	-0.011	[0.006]	-0.001	[0.002]
Household head educ.= secondary	-0.001	[0.003]	0.001	[0.003]	-0.008	[0.006]	-0.010	[0.007]	-0.001	[0.003]
Household head educ.=tertiary	-0.001	[0.003]	0.002	[0.003]	-0.001	[0.007]	-0.002	[0.008]	-0.001	[0.003]
Constant	0.194***	[0.020]	0.118***	[0.012]	0.100***	[0.022]	0.220***	[0.045]	0.081***	[0.010]
R-squared	0.551		0.608		0.620		0.684		0.517	

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. *Sample weighted to be representative of the Nigerian population in 2013.

The results of the within-cluster regression for the budget shares of the pooled sample are shown in Table 4.6. As with the 2013 sample, all the commodities have positive coefficients less than unity on total household expenditure elasticity (e_x) and all are significant at the 5% or 1% level. Milk is the most important commodity, accounting for 4.3% of the budget share. The magnitude of the coefficients of the natural log of household expenditure of each commodity is similar to that found for the 2013 sample, at least to the first decimal place, except for chocolate drinks.

Table 4.6: Within-cluster regression for budget shares for the pooled sample (2013 and 2016)

Variable	Sugar (n=3,556)		CSD (n=1,490)		Choc. Drinks (n=1,365)		Milk (n=490)		Sachet water (n=1,883)	
e_x	0.155**	[0.051]	0.394***	[0.062]	0.562***	[0.073]	0.344***	[0.092]	0.324***	[0.064]
$\bar{w}$ (%)	2.895		2.171		3.050		4.343		1.427	
Ln real expenditure	-0.022***	[0.001]	-0.013***	[0.001]	-0.010***	[0.002]	-0.022***	[0.003]	-0.008***	[0.001]
Ln household size	0.007***	[0.001]	0.000	[0.001]	-0.002	[0.002]	-0.003	[0.004]	-0.001	[0.001]
Male ratio	0.001	[0.000]	0.001	[0.000]	-0.001	[0.001]	0.000	[0.001]	-0.000	[0.000]
Household head age in years	0.000*	[0.000]	-0.000	[0.000]	-0.000	[0.000]	0.002	[0.000]	0.000	[0.000]
Household adult share	0.002	[0.003]	-0.002	[0.002]	0.003	[0.005]	-0.007	[0.010]	-0.000	[0.002]
Household head gender= male	0.004**	[0.002]	0.001	[0.001]	0.002	[0.003]	-0.013	[0.012]	-0.000	[0.001]
Ratio employed	-0.000	[0.001]	-0.001	[0.001]	0.000	[0.002]	-0.002	[0.003]	0.002**	[0.001]
Household head educ.= other	-0.001	[0.002]	0.002	[0.003]	0.001	[0.012]	-0.001	[0.005]	0.000	[0.002]
Household head educ.= pre-primary	-0.008	[0.010]	0.005	[0.007]	-0.010	[0.013]	-0.004	[0.028]	0.000	[0.009]
Household head educ.= primary	-0.006***	[0.002]	0.000	[0.002]	0.003	[0.003]	-0.002	[0.005]	0.001	[0.001]
Household head educ.= secondary	-0.002	[0.002]	-0.002	[0.002]	0.003	[0.004]	0.000	[0.006]	0.002	[0.001]
Household head educ.=tertiary	0.001	[0.002]	-0.002	[0.002]	0.006	[0.004]	0.001	[0.007]	0.002**	[0.001]
Year= 2016	-0.010***	[0.001]	0.001	[0.001]	-0.009***	[0.002]	-0.009**	[0.003]	0.002**	[0.001]
Constant	0.194***	[0.007]	0.133***	[0.007]	0.125***	[0.015]	0.244***	[0.026]	0.083***	[0.004]
R-squared	0.459		0.494		0.344		0.579		0.418	

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Tables 4.5 to 4.6 present the parameter estimates of equation 3.4. For 2013, presented in Table 4.7, apart from CSDs, all the quality elasticities are positive, but only those of sugar, chocolate drinks and sachet water are statistically significant at the 5% level. This is given by the log of real household expenditure, defined as the first derivative of the natural log of unit values with respect to the natural log of total real household expenditures. Sugar has the highest quality elasticity at approximately 0.15. All of the positive quality elasticities are modest and range from approximately 0.04 for milk to 0.15 for sugar. None of the other covariates were statistically significant across all commodities.

Table 4.7: Within-cluster regression for unit values (2013)

Variable	Sugar (n=1,730)		CSD (n=753)		Choc. Drinks (n=667)		Milk (n=240)		Sachet water (n=874)	
Ln real expenditure‡	0.149**	[0.036]	-0.030	[0.026]	0.130**	[0.056]	0.004	[0.101]	0.126**	[0.081]
Ln household size	-0.066	[0.059]	0.050	[0.047]	0.013	[0.072]	0.085	[0.124]	0.002	[0.083]
Male ratio	-0.007	[0.017]	-0.017	[0.013]	-0.029	[0.030]	-0.114	[0.108]	0.038	[0.027]
Household head age in years	-0.000	[0.002]	0.000	[0.002]	0.002	[0.002]	-0.001	[0.004]	-0.001	[0.004]
Household adult share	0.154	[0.120]	-0.038	[0.069]	0.137	[[0.147]	-0.346	[0.257]	0.313*	[0.174]
Household head gender= male	0.051	[0.073]	0.031	[0.037]	0.019	[0.078]	0.023	[0.140]	-0.038	[0.109]
Ratio employed	0.039	[0.063]	-0.062	[0.061]	-0.029	[0.094]	0.060	[0.180]	-0.110	[0.117]
Household head educ.= other	0.126	[0.092]	0.294	[0.197]	-0.464	[0.477]	-0.207	[0.149]	0.243	[0.187]
Household head educ.= pre-primary	0.140	[0.117]	0.401	[0.347]	-0.235	[0.244]	.	.	.	.
Household head educ.= primary	-0.043	[0.070]	0.104**	[0.048]	-0.009	[0.107]	-0.344	[0.307]	-0.060	[0.104]
Household head educ.= secondary	-0.000	[0.075]	0.085**	[0.043]	-0.068	[0.117]	-0.308	[0.211]	-0.071	[0.146]
Household head educ.=tertiary	-0.034	[0.086]	0.036	[0.066]	0.076	[0.116]	-0.115	[0.189]	-0.110	[0.140]
Constant	4.350**	[0.350]	4.720***	[0.248]	5.735***	[0.461]	5.127***	[0.935]	1.065**	[0.576]
R-squared	0.445		0.632		0.546		0.661		0.476	

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. Sample weighted to be representative of the Nigerian population in 2013. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß¹ of equation 3.6 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

For the pooled sample, all the expenditure elasticities of quality are positive, and most are statistically significant at the 5% or 1% level, with the exception of CSDs. These estimates are presented in Table 4.8. Milk has the highest quality elasticity at approximately 0.15. All of the quality elasticities range from approximately 0.01 for CSDs to 0.15 for milk. The response of quality to household size is negative for all commodities, except CSDs, and is statistically significant for sugar and CSDs at the 5% and 10% level, respectively. The elasticity of household size tends to be larger and negative when the corresponding elasticity of total household expenditure is larger and positive. This implies that increases in household size tend to reduce income (or, more specifically, the income per capita).

Table 4.8: Within-cluster regression for unit values for the pooled sample (2013 and 2016)

Variable	Sugar (n=3,553)		CSD (n=1,490)		Choc. Drinks (n=1,362)		Milk (n=489)		Sachet water (n=1,880)	
Ln real expenditure‡	0.109***	[0.027]	0.011	[0.029]	0.112**	[0.047]	0.146**	[0.050]	0.090**	[0.045]
Ln household size	-0.104**	[0.039]	0.070*	[0.038]	-0.090	[0.061]	-0.011	[0.069]	-0.016	[0.061]
Male ratio	-0.021	[0.014]	-0.001	[0.015]	-0.018	[0.025]	-0.44**	[0.020]	0.009	[0.025]

Household head age in years	0.002	[0.001]	-0.001	[0.001]	0.003	[0.002]	0.000	[0.002]	-0.000	[0.002]
Household adult share	0.080	[0.085]	-0.017	[0.077]	-0.095	[0.127]	-0.214	[0.158]	0.151	[0.131]
Household head gender= male	-0.060	[0.052]	-0.061	[0.044]	-0.174**	[0.063]	-0.178	[0.188]	-0.100	[0.070]
Ratio employed	0.003	[0.029]	-0.013	[0.026]	-0.031	[0.040]	0.001	[0.055]	0.019	0.044]
Household head educ.= other	0.068	[0.056]	0.058	[0.088]	-0.149	[0.297]	-0.049	[0.088]	0.100	[0.142]
Household head educ.= pre-primary	-0.011	[0.309]	-0.007	[0.223]	-0.259	[0.312]	-1.043***	[0.464]	0.108	[0.707]
Household head educ.= primary	0.062	[0.047]	0.004	[0.049]	0.096	[0.085]	-0.209**	[0.074]	0.046	[0.084]
Household head educ.= secondary	0.073	[0.050]	0.016	[0.054]	0.135	[0.098]	-0.251**	[0.093]	0.026	[0.091]
Household head educ.=tertiary	0.020	[0.059]	0.073	[0.057]	0.154	[0.103]	-0.106	[0.107]	-0.003	[0.097]
Year=2016	-0.457***	[0.030]	-0.225***	[0.029]	-0.182***	[0.048]	-0.298***	[0.049]	-0.018	[0.049]
Constant	4.754***	[0.222]	4.59***	[0.233]	6.197***	[0.038]	3.777***	[0.425]	1.418***	[0.368]
R-squared	0.330		0.349		0.338		0.594		0.240	

Source: Author's estimates. P<0.05, ***P<0.01. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to $ß^1$ of equation 3.6 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table 4.9 lists the own- and cross-price elasticities for the complete system, with bootstrapped standard errors in square parentheses. The bootstrapped standard errors are calculated by making 1,000 draws from the cluster (second stage) data, recalculating the elasticity estimates for each commodity then "finding (half) the length of the interval that is symmetric around the bootstrapped mean, and that contains 68.3% of the bootstrapped estimates" (Deaton, 2018, page 317).

The top panel of Table 4.9 presents the own and cross-price elasticities for the complete system without symmetry. The rows show the commodity being affected and columns show the commodity whose price is changing. The diagonals, highlighted blue, present the own-price elasticities. With the exception of chocolate drinks, all of the own-price elasticities are statistically different from zero and only some of the cross-price elasticities are statistically different from zero in the top panel. Increases in the price of sugar decrease the consumption of all the commodities, except for non-food items. While increases in the price of CSDs increase the consumption of all the commodities except that of CSDs and milk.

The restricted estimates for the complete system are presented in the bottom panel of Table 4.9. Commodities that are well determined in the top panel of Table 4.9, that is, those with substantial unit value variation in the data, show little change in the estimates presented in the bottom panel. The symmetry-constrained estimates allow for the use of the effect of a well-determined good, such as the effect of CSDs on chocolate drinks, to "fill in" the estimate of the effect of chocolate drinks on CSDs. CSDs and sugar appear to be complements in 2013, as shown by the cross-price elasticities in both the top and bottom panels of Table 4.9, but the estimates are more precise in the bottom panel. According to the estimates, chocolate drinks and sugar were also complement goods in 2013.

The cross-price elasticities of sugar and chocolate drinks, non-food and chocolate drinks, non-food and water, and milk and water are the only cross-price elasticities that are statistically different from zero in both the top and bottom panel. All of the own-price elasticities are negative and greater than -1.

Table 4.9: Estimates of the extended matrix of elasticities to complete the system, 2013 (DUVM)

Unconstrained estimates, 2013												
	Sugar		**CSD**		**Choc.**		**Milk**		**Water**		**Non-food**	
Sugar	-0.691***	[0.058]	0.012	[0.491]	-0.323***	[0.181]	-0.028	[0.135]	-0.159	[0.104]	0.908	[0.556]
CSD	-0.078	[0.026]	-0.844**	[0.433]	0.127	[0.162]	0.056	[0.473]	0.115	[0.241]	0.220	[1.108]
Choc.	-0.032	[0.254]	0.980	[0.730]	0.104	[0.338]	0.166	[0.872]	-0.138*	[0.442]	-1.871	[2.021]
Milk	-0.065	[0.071]	-0.054*	[0.235]	0.369**	[0.181]	-0.430**	[0.223]	-0.043*	[0.125]	-0.232	[0.529]
Water	-0.042	[0.209]	0.280	[0.669]	0.627**	[0.276]	0.881	[0.701]	-0.910***	[0.362]	-1.229	[1.661]
Non-food	0.001	[0.006]	0.013	[0.170]	0.022**	[0.007]	0.013	[0.020]	-0.003*	[0.010]	-0.314***	[0.047]
Symmetry-constrained estimates, 2013												
Sugar	-0.717***	[0.014]	-0.139***	[0.025]	-0.136***	[0.052]	-0.025	[0.021]	0.063**	[0.024]	0.671***	[0.045]
CSD	-0.102***	[0.017]	-0.957*	[0.959]	0.611**	[0.607]	0.037	[0.412]	0.012	[0.135]	-0.005	[0.883]
Choc.	-0.086***	[0.028]	0.463**	[0.470]	0.133	[0.341]	0.121	[0.205]	-0.047	[0.102]	-1.377***	[0.445]
Milk	-0.0511**	[0.005]	0.009	[0.135]	0.058	[0.087]	-0.427***	[0.062	0.098**	[0.024]	-0.182	[0.128]
Water	0.109**	[0.042]	0.033	[0.337]	-0.133	[0.328]	0.760**	[0.181]	-0.768***	[0.205]	-0.393	[0.368]
Non-food	0.002***	[0.000]	0.004	[0.006]	0.017***	[0.004]	0.012***	[0.002]	0.004**	[0.001]	-0.307***	[0.005]

Source: Author's estimates. Bootstrapped standard errors are in square brackets *P<0.1, **P<0.05, ***P<0.01.

The own- and cross-price elasticities for the pooled sample (2013-2016) are presented in Table 4.10. All of the own-price elasticities are negative and that of CSDs is less than -1, implying that, on average, a 10% increase in the price of CSDs would result in approximately 11% decrease in the demand for CSDs, *ceteris paribus*. CSDs and sugar appear to be complements in the pooled sample, as shown by the cross-price elasticities in both the top and bottom panels of Table 4.10. Milk and sugar are also complements, as shown in the top and bottom panels of Table 4.10, however the estimate is more precise in the bottom panel. The own-price elasticities for all commodities are statistically different from zero.

Table 4.10: Estimates of the extended matrix of elasticities to complete the system, 2013-2016 (DUVM)

Unconstrained estimates, 2013-2016						
	Sugar	**CSD**	**Choc.**	**Milk**	**Water**	**Non-foods**

Sugar	-0.671***	[0.142]	-0.853**	[0.646]	-0.033	[0.385]	-0.060	[0.152	-0.064	[0.227]	1.418**	[0.501]
CSD	-0.071**	[0.054]	-1.083***	[0.126]	0.043	[0.075]	-0.070**	[0.043]	-0.226	[0.188]	1.095***	[0.307]
Choc.	0.058	[0.102]	0.951	[0.333]	-0.693**	[0.277]	0.264	[0.154]	1.270	[0.503]	-2.520	[0.836]
Milk	0.012	[0.105]	0.101	[0.451]	0.103	[0.343]	-0.801***	[0.136]	0.597	[0.271]	-0.499	[0.467]
Water	0.169	[0.116]	-0.025*	[0.642]	0.272	[0.055]	0.381**	[0.221]	-0.064**	0.343]	-1.145	[0.544]
Non-foods	0.004	[0.003]	0.002	[0.016]	0.005	[0.014]	0.006	[0.006]	0.024	[0.010]	-0.304***	[0.017]
Symmetry constrained estimates, 2013-2016												
Sugar	-0.763***	[0.027]	-0.176***	[0.047]	0.044	[0.033]	-0.014**	[0.0018]	0.172*	[0.046]	0.474***	[0.094]
CSD	-0.142***	[0.037]	-1.005***	[0.341]	0.117**	[0.040]	-0.038**	[0.032]	-0.030	[0.076]	0.701**	[0.403]
Choc.	0.020	[0.022]	0.093**	[0.034]	-0.835***	[0.073]	0.071***	[0.036]	0.220*	[0.070]	-0.241	[0.148]
Milk	-0.019**	[0.010]	-0.028**	[0.022]	0.065**	[0.030]	-0.857***	[0.018]	0.183**	[0.037]	0.161**	[0.075]
Water	0.255	[0.069]	-0.058	[0.147]	0.516**	[0.161]	0.507**	[0.101]	0.330*	[0.344]	-1.964	[0.598]
Non-foods	0.002**	[0.001]	-0.002	[0.003]	0.006***	[0.002]	0.005***	[0.001]	0.013	[0.003]	-0.287***	[0.006]

Source: Author's estimates. Bootstrapped standard errors are in square brackets. *P<0.1, **P<0.05, ***P<0.01.

4.3 Correction for selection bias: CSD expenditure and price elasticity

Stata's DUVM command was used to address selection bias, using the Heckman's (1979) procedure. The 2013 sample was weighted to be nationally representative of the 2013 population. The estimates are similar to those of the DUVM estimates presented earlier for the expenditure elasticities, and expenditure elasticities of quality, at least to the first decimal place, for the majority of the estimates.

Table 4.11: Estimated expenditure and quality elasticities: DUVM vs. IMR

Description	**Year**	**Sugar**		**CSD**		**Choc. drink**		**Milk**		**Water**	
		DUVM	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**
Expenditure elasticities	2013°	0.134	0.068	0.432***	0.384***	0.667***	0.644***	0.615***	0.549***	0.267**	0.357**
	2013-2016	0.155**	0.134**	0.394***	0.374***	0.562***	0.580***	0.344***	0.368***	0.324***	0.327***
Expenditure elasticity of quality	2013°	0.149***	0.159***	-0.030	-0.013	0.130**	0.126*	0.004	-0.054	0.126**	0.121**
	2013-2016	0.109***	0.121***	0.011	0.010	0.112**	0.120**	0.146**	0.127**	0.090**	0.113**

Source: Author's estimates.

º Sample weighted to be representative of the Nigerian population in 2013. **P<0.05, ***P<0.01

The own- and cross-price price elasticities using the Heckman procedure are presented in Tables 4.12 and 4.13. The results for budget share and unit value regressions using the Heckman procedure (IMR) for the 2013 and the pooled samples are presented in Appendix A.

All of the own-price elasticities are statistically different from zero, are negative and greater than -1. The majority of the cross-price elasticities are statistically different from zero. As with the DUVM estimates for the 2013 sample, increases in the price of sugar decrease the demand for of all the commodities and sugar and CSDs appear to be complements.

Table 4.12: Estimated own-and cross-price elasticities with symmetry restrictions, quality correction, and correction for selection bias (Inverse Mill's Ratio), 2013

	Sugar		CSD		Choc.		Milk		Water	
Sugar	-0.717***	[0.004]	-0.038***	[0.002]	-0.015***	[0.002]	-0.035***	[0.002]	-0.032***	[0.003]
CSD	-0.059***	[0.001]	-0.837***	[0.004]	0.237***	[0.003]	0.014***	[0.002]	0.053***	[0.002]
Choc.	-0.029***	[0.002]	0.138***	[0.005]	-0.023***	[0.005]	0.083***	[0.003]	0.021***	[0.004]
Milk	-0.031***	[0.003]	0.003	[0.004]	0.068***	[0.004]	-0.557***	[0.006]	0.087***	[0.004]
Water	-0.073***	[0.001]	0.077***	[0.002]	0.062***	[0.002]	0.294***	[0.001]	-0.781***	[0.003]

Source: Author's estimates. Bootstrapped standard errors are in square brackets. ***P<0.01. Sample weighted to be representative of the Nigerian population in 2013

The estimates for the pooled sample using the Heckman procedure are presented in Table 4.13. All of the own-price elasticities are negative and greater than -1, even that of CSDs, which was estimated to be less than -1 when using the DUVM, see Table 4.10.

Table 4.13: Estimated own-and cross-price elasticities with symmetry restrictions, quality correction, and correction for selection bias (Inverse Mill's Ratio), 2013-2016 (unweighted)

	Sugar		CSD		Choc.		Milk		Water	
Sugar	-0.678**	[0.016]	-0.136***	[0.034]	0.033**	[0.014]	-0.049***	[0.005]	0.140**	[0.046]
CSD	-0.182***	[0.026]	-0.766**	[0.223]	0.266***	[0.040]	0.066**	[0.020]	0.625***	[0.087]
Choc.	0.018	[0.015]	0.186**	[0.055]	-0.878***	[0.060]	0.100***	[0.018]	0.250**	[0.115]
Milk	-0.040***	[0.008]	0.031	[0.040]	0.077**	[0.026]	-0.801***	[0.014]	0.282**	[0.080]
Water	0.277***	[0.022]	0.967***	[0.056]	0.544***	[0.054]	0.861***	[0.026]	2.477***	[0.314]

Source: Author's estimates. Bootstrapped standard errors are in square brackets. **P<0.05, ***P<0.01.

4.4 Robustness check: CSD expenditure and price elasticity

The own- and cross-price elasticities presented in Tables 4.9 to 4.13 are likely to be influenced by extreme unit values. In order to address this, I use the procedure followed by Colchero *et al*. (2015) and define extreme unit values as those that exceed the average unit values at the cluster level plus two standard deviations and replace these unit values with the average of the unit values at the cluster level (excluding the extreme values) plus 2 standard deviations (Colchero *et al*., 2015). The results of the ANOVA tests, budget shares and unit value regressions for the robust samples are presented in Appendix B. For the robust samples, all commodities met the assumption of spatial variation in unit values including CSDs in the 2016 sample. This section will therefore present the expenditure elasticities, cross-price and own-price elasticities for sugar, CSDs, chocolate drinks, milk, and sachet water for the robust 2013, robust 2016 and the robust pooled data.

The results for the unconstrained and constrained own- and cross-price elasticities estimates using the DUVM for the robust pooled data are provided in Table 4.14. As was the case with the DUVM estimates without the correction for extreme unit values, the results presented in Table 4.14 suggest that CSDs and sugar, CSDs and water, and milk and sugar, are complements, but the estimates are more precise in the bottom panel. Chocolate drinks and CSDs are complements in the robust pooled sample (Table 4.14) but not in the pooled sample (Table 4.10). The own-price elasticities for sugar and SSBs are less than -1 and statistically significant at the 1% level. All the other own-price elasticities are also statistically significant at the 1% level.

Table 4.14: Robustness check for the estimates of the extended matrix of elasticities to complete the system, robust pooled (2013-2016) (unweighted)

Unconstrained estimates, 2013-2016 (Robustness check)												
	Sugar		**CSD**		**Choc.**		**Milk**		**Water**		**Other**	
Sugar	-1.051***	[0.038]	-0.724**	[0.392]	0.087	[0.118	-0.021***	[0.103]	-0.178*	[0.201]	1.811***	[0.576]
CSD	-0.086	[0.146]	-1.265***	[0.391]	-0.041	[0.114]	-0.176	[0.139]	-0.520	[0.464]	0.682**	[0.787]
Choc.	0.174	[0.345]	0.510*	[0.630]	-0.865***	[0.209]	0.130	[0.287]	0.876	[0.989]	-1.494	[1.383]
Milk	0.069	[0107]	0.543	[0.504]	0.027	[0.147]	-0.768***	[0.156]	0.659	[0.353]	-1.017	[0.748]
Water	0.079**	[0.063]	0.213	[0.197]	0.105**	[0.109]	0.251***	[0.063]	-0.938***	[0.207]	-0.124	[0.401]
Other	0.002	[0.004]	0.005	[0.007]	0.003	[0.003]	0.003	[0.003]	0.103	[0.012]	-0.288***	[0.016]
Symmetry-constrained estimates, 2013-2016 (Robustness check)												
Sugar	-1.078***	[0.012]	-0.145**	[0.018]	0.112***	[0.016]	-0.043**	[0.017]	0.041*	[0.022]	0.850***	[0.046]
CSD	-0.149***	[0.018]	-1.036***	[0.110]	-0.047	[0.033]	-0.120	[0.053]	-0.200	[0.062]	1.146***	[0.203]
Choc.	0.084***	[0.013]	-0.044	[0.027]	-0.789***	[0.030]	0.126***	[0.025]	0.190*	[0.043]	-0.238**	[0.081]
Milk	-0.037***	[0.012]	-0.089	[0.038]	0.116***	[0.022]	-0.837***	[0.035]	0.145**	[0.045]	0.214	[0.101]

Water	0.075*	[0.042]	-0.383	[0.119]	0.448**	[0.100]	0.385**	[0.119]	-1.037***	[0.2449]	0.100	[0.427]
Other	-0.001**	[0.000]	-0.005	[0.002]	0.007***	[0.000]	0.004***	[0.001]	0.003	[0.002]	-0.270***	[0.005]

Source: Author's estimates. Bootstrapped standard errors are in square brackets. **P<0.05, ***P<0.01.

The results for the estimates using the Heckman procedure on the robust pooled data are presented in Table 4.15. As with the DUVM estimates, the estimates presented in Table 4.15 suggest that CSDs and sugar are complements.

Table 4.15: Robustness check for the estimated own- and cross-price elasticities with symmetry restrictions, quality correction, and correction for selection bias (Inverse Mill's Ratio), 2013-2016 (unweighted)

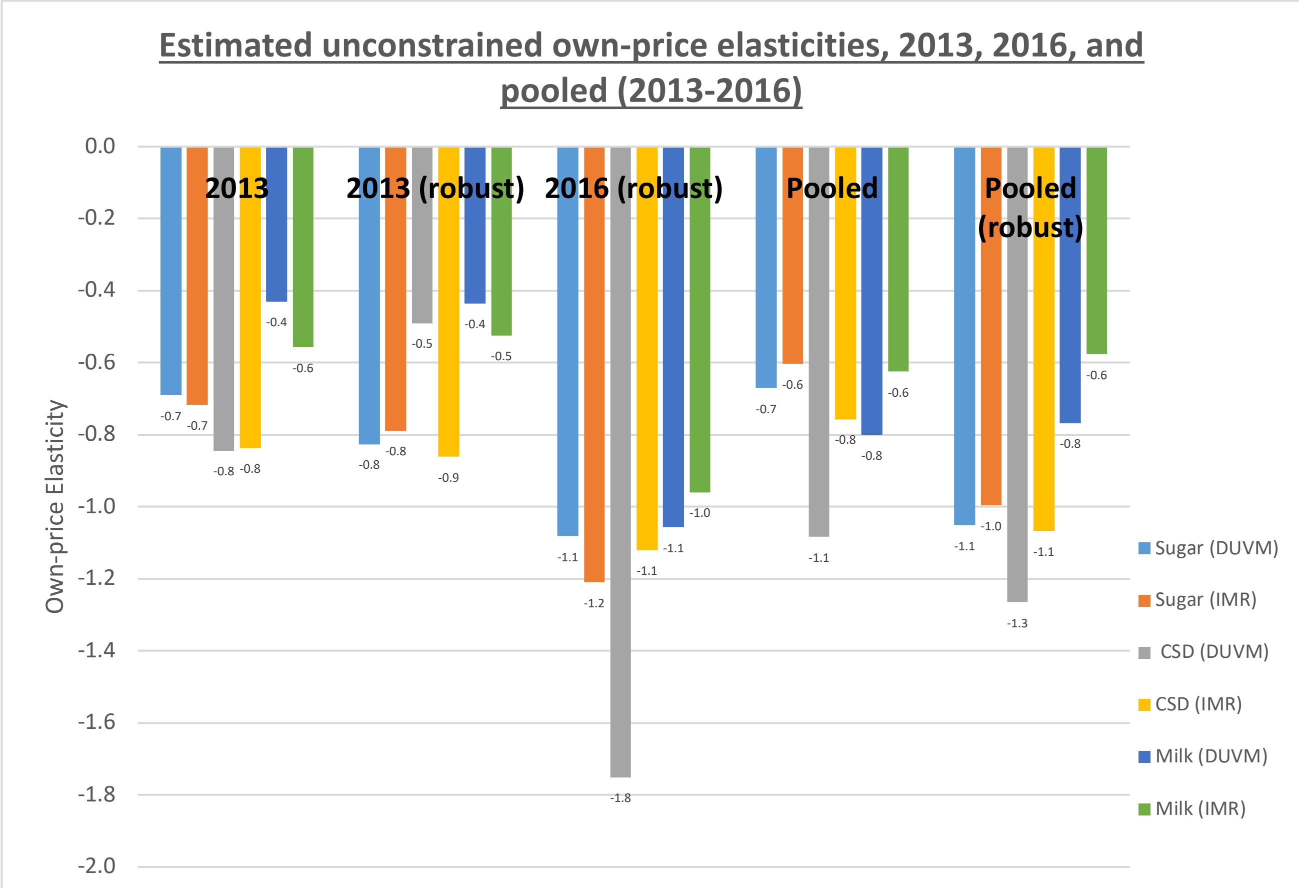
	Sugar		**CSD**		**Choc.**		**Milk**		**Water**	
Sugar	-1.034***	[0.252]	-0.227	[0.333]	0.162	[0.273]	-0.078	[0.067]	0.002	[0.138]
CSD	-0.307	[0.250]	-0.741**	[0.346]	-0.156	[0.275]	0.011	[0.074]	0.171	[0.260]
Choc.	0.141	[0.288]	-0.117	[0.387]	-0.885**	[0.329]	-0.022	[0.101]	0.082	[0.278]
Milk	-0.059	[0.100]	0.003	[0.147]	-0.009	[0.143]	-0.809**	[0.068]	0.254	[0.292]
Water	-0.001	[0.068]	0.258	[0.171]	0.184	[0.130]	0.775**	[0.096]	-0.249	[0.921]

Source: Author's estimates. Bootstrapped standard errors are in square brackets. **P<0.05, ***P<0.01.

The own-and cross-price elasticity estimates for the robust 2013 and robust 2016 data using the DUVM are presented in Table B9 of the Appendix. The cross- and own-price elasticity estimates for the robust 2013 and robust 2016 data using the Heckman procedure are presented in Table B10 of the Appendix.

The DUVM, which does not account for selection bias using the inverse Mill's ratio, and the Heckman procedure (IMR), that did account for the inverse Mill's ratio, both produced similar own-price elasticities for sugar and CSDs in 2013. The own-price elasticity estimates for sugar are similar for both the DUVM and the Heckman procedure for the robust 2016 sample, the pooled sample, and the robust pooled sample. For CSDs the estimates across both methods were similar in the 2013 sample and the robust pooled samples. Despite the variation in the own- price elasticity estimates for CSDs, the results fall within the range of estimates found in other studies that used the DUVM (-2.09 to -0.8) for the estimates that are statistically significant (Chacon et al., 2018, Colchero et al., 2015, Paraje, 2016). These results are illustrated in Figure 4.5. The own-price elasticities for milk were relatively inelastic and similar for both methods across all the samples. The own-price elasticities for milk fall within the range for those found for rural households in Guatemala (-0.44 to -1.04) in 2014 (Chacon et al., 2018).

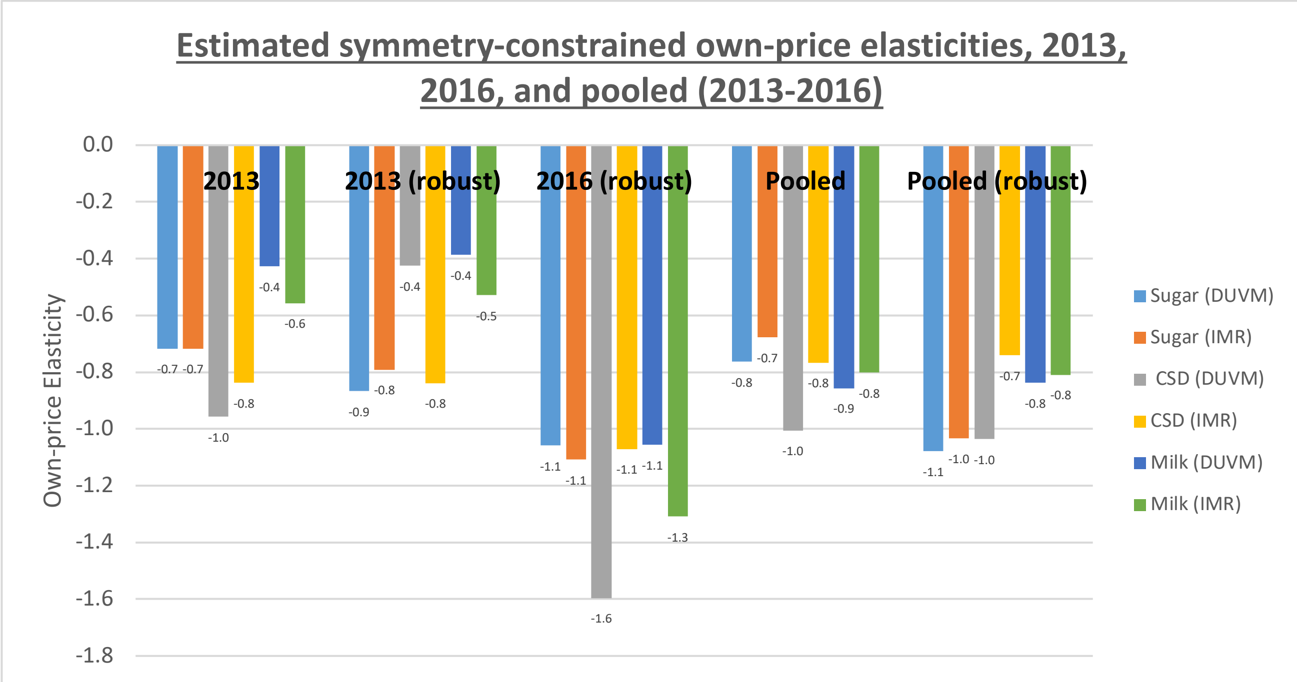
Figure 4.5: Unconstrained own-price elasticity for selected commodities 2013, 2016, pooled sample and robustness check pooled sample



Source: Author's estimates. The IMR refers to the Heckman procedure with the correction for selection bias using the inverse Mill's ratio. For the IMR, estimates are unconstrained and quality corrected. Note that the own-price elasticity for CSDs in the robust 2013 data is not statistically significant. All other own-price elasticities are statistically different from zero.

Figure 4.6 illustrates the symmetry-constrained own-price elasticity estimates using the DUVM and Stata's Heckman procedure (IMR), using the inverse Mill's ratio to correct for selection bias. Although the symmetry-constrained estimates are only approximately valid, and assume no quality effects in the DUVM method, the 2013 sample for both methods produced similar results for sugar in all cases. For CSDs the results for the two methods varied, with a more pronounced variation in the robust 2016 sample. The estimates for milk vary between -0.4 to -1.3, but despite this wide variation, these estimates still fall within the range of the estimates found for Guatemala and Mexico (Chacon et al., 2018, Colchero et al., 2019). However, note that the symmetry-constrained estimates using the DUVM are only partially valid and assume no quality effects.

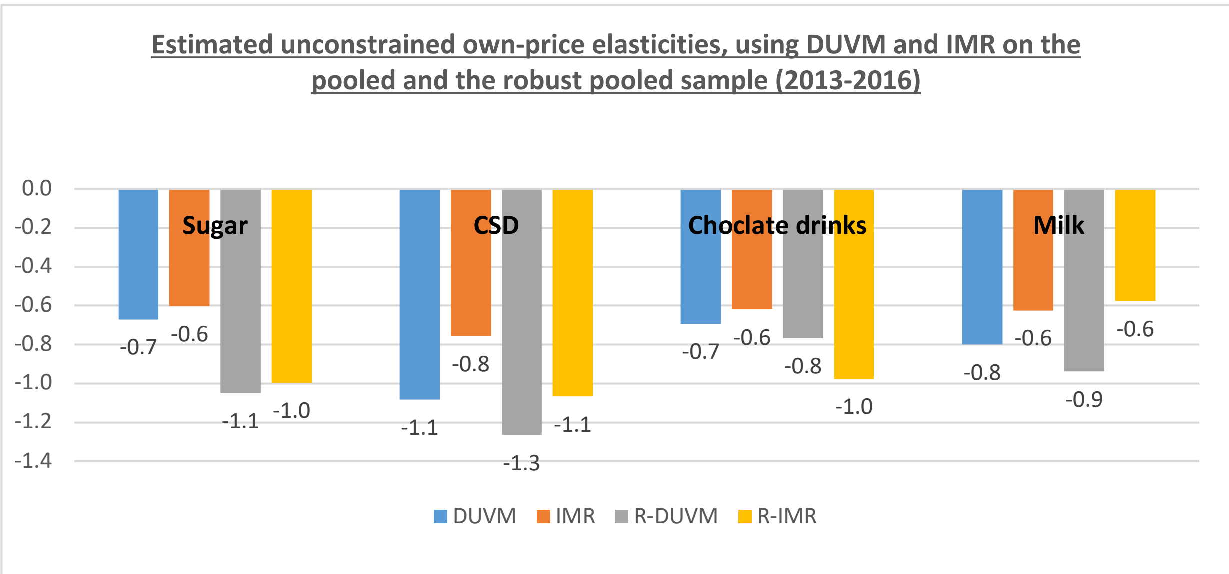
Figure 4.6: Symmetry-constrained own-price elasticity estimates for selected commodities



Source: Author's estimates. For the IMR the estimates are symmetry constrained and corrected for quality effects. Note the own-price elasticity for CSDs in the robust 2013 data is not statistically significant. All other own-price elasticities are statistically different from zero.

Figure 4.7 illustrates that, the own-price elasticity estimates for the robust pooled samples were slightly higher than those for the pooled sample. The DUVM estimates for the robust samples were the highest for sugar, CSDs and milk. The DUVM method produced more similar estimates for the pooled and robust pooled samples than the Heckman procedure. Milk was the only commodity where the estimates were very similar for the pooled and robust pooled samples using the Heckman procure.

Figure 4.7: Estimated unconstrained own-price elasticities, 2013, 2016, pooled and robust sample (2013-2016) using the DUVM and the Heckman's procedure (IMR) for selected commodities



Source: Author's estimates.
*R-DUVM is the robust sample using the DUVM method and R-IMR is the robust sample using the Heckman's procedure (inverse Mill's ratio).

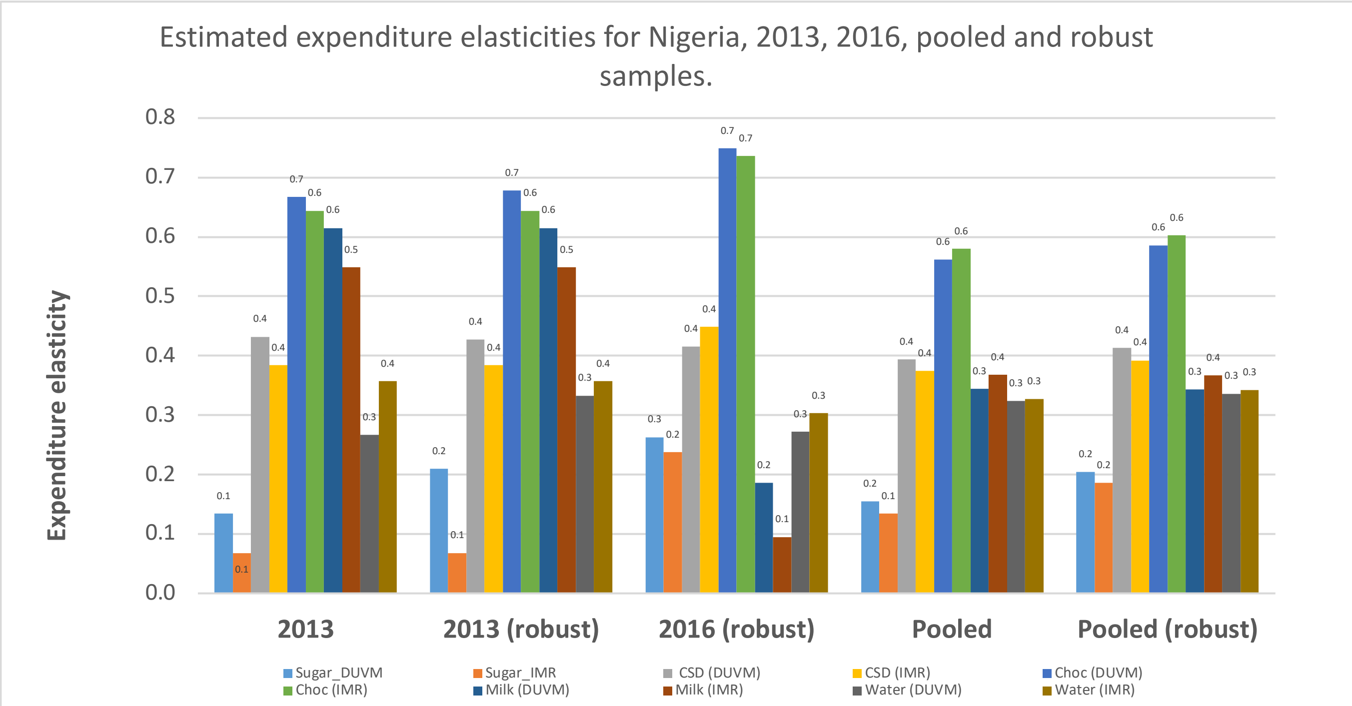
For the IMR, estimates are unconstrained with quality correction.

Figure 4.8 illustrates the expenditure elasticities for sugar, CSDs, chocolate drinks, milk, and sachet water using the DUVM, and the Heckman's procedure (IMR), on the 2013, robust 2016, pooled, and robust pooled samples.

For the pooled and robust pooled samples, the estimates using both methods are similar. All estimates in the pooled and robust samples are positive and there are negligible differences in the estimates for the pooled sample and the robust pooled sample.

The expenditure elasticity estimates for sugar range between approximately 0.1 and 0.2. For chocolate drinks, the expenditure elasticity ranges between 0.6 and 0.7, for milk the range is 0.1 to 0.4 and for water, the expenditure elasticity estimates range between 0.3 and 0.4. For CSDs, the expenditure elasticity estimates are approximately 0.4, implying that, on average, a 10% increase in income (proxied by expenditure) would result in an approximately 4% increase in the demand for CSDs, *ceteris paribus*. The income elasticity estimates for CSDs fall within the range of those found for Ecuador, which ranged from 0.46 to 1.30 (Paraje, 2016).

Figure 4.8: The estimated expenditure elasticities for Nigeria, 2013, 2016, pooled and robustness check pooled sample using the DUVM and the Heckman's procedure (IMR)



Source: Author's estimates.

Table 4.16 shows the cross-price elasticities for the commodities with respect to a 1% increase in the price of CSDs for both methods across all data samples. For the estimates that are statistically significant at the 1% to 10% level, sugar is a complement to CSDs, meaning that increases in the price of CSD will result in a decline in the consumption of sugar and vice versa. This is consistent for the statically significant estimates across all samples for both methods for sugar. For chocolate drinks, milk, and sachet water the estimates are less consistent.

Chocolate drinks appear to be substitutes to CSDs in the robust pooled estimates using the DUVM and in 2013 and the pooled sample, using the IMR. However, in the robust 2013 and the robust 2016 samples using the IMR, chocolate drinks appear to be complements to CSDs. The results show that milk is a complement to CSD in the 2013 and robust 2013 samples using the DUVM, but a substitute to CSDs in the robust 2016 using the DUVM and robust 2013 using the IMR. Water is a complement to CSDs in 2013 as shown by the estimates derived from the DUVM using the robust 2013 and pooled samples, but substitutes in 2013 (DUVM and IMR), robust 2013 and pooled samples using the IMR.

Table 4.16: Own-price elasticities in response to 1% increase in price of CSDs

Cross price elasticity (1% increase in price of SSB)										
	DUVM °					IMR ° °				
Commodity	**2013**	**Robust 2013**	**Robust 2016**	**Pooled**	**Robust Pooled**	**2013**	**Robust 2013**	**Robust 2016**	**Pooled**	**Robust pooled**
Sugar	0.012	0.071	-0.235**	-0.853**	-0.724**	-0.038***	-0.020	-0.259**	-0.136***	-0.227
Choc.	0.980	-0.370	0.107	0.951	0.510*	0.138***	-0.014**	-1.071*	0.186***	-0.117
Milk	-0.054*	-0.095*	0.440*	0.101	0.543	0.003	0.025***	-0.249	0.031	0.003
Water	0.280*	-0.914*	0.055	-0.025*	0.213	0.077***	0.158***	0.158	0.967***	0.258

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.
° Unconstrained estimates. ° °symmetry-constrained with quality correction.

The results from the DUVM and the DUVM with the Heckman's Procedure (IMR) are close for most of the cross-price, own-price and expenditure elasticities, implying that selection did not bias the elasticities estimated using the DUVM. However, for CSD and sachet water, there are significant variations in the estimated own-price elasticities for the DUVM and Heckman's procedure (IMR) methods for the unconstrained estimates, even for the 2013 and pooled samples. For the 2016 robust sample, the unconstrained own-price elasticities for CSDs using the DUVM and the Heckman's procedure (IMR) differed significantly. This could indicate that selection was biasing up the estimated own-price elasticities for CSDs in the DUVM estimates. While the DUVM estimates are for the most part similar to those of the Heckman's Procedure (IMR), the results of the CSDs price elasticities for the robust 2016 sample suggest that it is worth checking and correcting for selection bias.

4.5 Limitations: Sugar-sweetened beverage affordability

One of the limitations of using the GDP per capita in the analysis of sugar-sweetened beverage affordability is that it does not account for the variation in the distribution of income. However, GDP per capita is readily available and is regarded as a good indicator of living standards (Blecher and Van Walbeek, 2009).

The present study uses Euromonitor data which does not disaggregate between SSB brands. The retail selling prices used in the study are the averages across all carbonated drink brands and juices such as fruit juices, vegetable juices, freshly squeezed juices, reconstituted juices, etc. Ideally, the retail selling price per brand would be used, but such data are not available.

Deaton and Muellbauer (1980) used reported expenditures to estimate unit values for food price estimates when price data were unavailable. Like Blecher *et al*. (2017), who used the average price when the price data were collected in more than one city, this study also uses the average price, but uses the average price across all beverage brands.

For the analyses on the expenditure and price elasticities of sugar-sweetened beverages, some beverage categories such as fruit juices and bottled water, were excluded from the analyses due to a low number of households reporting positive expenditures for these beverages. According to the University of Carlifornia and Sugar Science (Undated), there are 61 different names for sugar, which are often hidden in beverages such as fruit juices. However, it was not possible to explore the price and expenditure elasticities for some of these beverages in this study as a result of the low number of households reporting consumption and expenditure on these beverages.

This study estimated the expenditure, own-price, and cross-price elasticities of demand for households that reported both positive purchases of and expenditure on the following 5 commodities: sugar, SSBs, chocolate drinks, milk, and sachet water. Households that reported positive purchases but zero expenditure on these commodities were excluded from the analysis.

Potential sources of endogeneity in the model can be attributed to measurement errors in prices, arising from the reported quantity of sugar and/or beverage expenditures by the households. The Nigeria General Household Survey Panel, waves 2 and 3, contains significant numbers of non-purchasers or non-consumers for the food and beverage categories analysed in this study. A robustness check was done to average unit values at the cluster level to minimize measurement error, as described in section 4.4

Moreover, when data contains substantial numbers of non-purchasers or non-consumers, as is the case with the Nigeria General Household Survey Panel waves 2 and 3, OLS can yield biased and inconsistent estimates (Amemiya, 1984, Cragg, 1971, Maddala, 1983). The Heckman procedure was used to address this bias.

The study does not disaggregate the estimates by income groups due to the low number of households reporting positive expenditures for some of the commodities analysed in this study.

4.6 Discussion

Results of this study show that SSBs, both carbonated drinks and juices, are becoming more affordable and the per capita consumption is increasing in Nigeria for both off-trade and on-trade consumption. Without interventions to curb consumption by raising prices, sugar-sweetened beverages are likely to become more affordable and, consequently, more widely consumed in Nigeria. Further research is essential to understand the intensity of SSB consumption by sub-groups in Nigeria and determine if interventions to curb excessive consumption are necessary.

The second aim of this paper was to estimate the expenditure, own-, and cross-price elasticities for CSDs, as well as those of sugar, chocolate drinks, milk, and sachet water in Nigeria. Some beverages, such as fruit juices, were not analysed as few households reported positive expenditures on these beverages.

Sugar was found to be relatively price inelastic to relatively elastic, with price elasticity estimates ranging between -0.6 and -1.1. This means that, on average, a 10% increase in the price of sugar would result in a 6% to 11% decline in the demand for sugar, all else held constant.

For carbonated drinks, the own-price elasticities (that were statistically significant at the 1%-10% level) were found to be relatively inelastic in the 2013 sample and the robust 2013 sample for both the Deaton’s Unit Value Model (DUVM) and the Heckman’s procedure (IMR). For the robust 2016, the pooled sample and the robust pooled sample, the own-price elasticities for carbonated drinks were found to be relatively elastic for both methods except for the IMR in the pooled sample. The Own-price elasticities for CSDs range from -0.8 to -1.8, meaning that, on average, a 10% increase in the prices of these beverages would lead to an 8% to18% decline in the demand for CSDs, all else held constant[12].

All the expenditure elasticities were positive, implying that all the commodities are normal goods. Thus, as income rises by 10%, the demand for these commodities will rise by approximately 1% to 2% for sugar, approximately 4% for CSDs, and approximately 6% to 7% for chocolate drinks, as shown in Figure 4.8

Sugar and CSDs were found to be complements meaning that as the price of CSDs rises, the demand for sugar would fall and vice versa, all else held constant. Carbonated soft drinks and the other commodities studied appeared to be substitutes for most of the estimates, although several cross-price elasticities estimated by the DUVM were not statistically significant.

[12] Note that the robust 2013 estimate of own-price elasticity of -0.5 for CSDs was not statistically significant.

Chapter Five: Conclusion

5.1 Summary

Excess sugar consumption is a concern because of the health effects associated with diets laden with sugars and, more especially, liquid sugars. In chapter one, I highlighted some of the health effects of excessive sugar consumption, as well as how these effects differ for liquid sugars and solid sugars. The aim of this study was to examine the trends in affordability of sugar-sweetened beverages in Nigeria and to analyse how consumers respond to price and income changes of carbonated soft drinks in Nigeria. For affordability, the study included juices and carbonated soft drinks consumed on-trade and off-trade. For income and price elasticities of carbonated soft drinks the study focused on sugar and drinks consumed at home, which include carbonated soft drinks, chocolate drinks, milk, sachet water and solid sugar.

5.2 Conclusion

In chapter four, the trend of SSB affordability and consumption in Nigeria was illustrated. Sugar-sweetened beverages were found to have become more affordable over time, between 2005 and 2018, in Nigeria. Some sugar-sweetened beverages such as fruit juices were excluded as few households reported positive expenditures on the beverages. An attempt was made to include non-alcoholic malt drinks, but these beverages did not meet the assumption of spatial variation in unit values and were therefore excluded from the analysis. The findings suggest that carbonated soft drink demand in Nigeria is responsive to changes in price and income. Carbonated soft drinks were found to be responsive to price changes, with own-price elasticities ranging from -0.8 to -1.8. The income elasticity for CSDs, proxied by expenditure, was found to be approximately 0.4. This implies that as CSDs become more affordable through income rises, the demand for CSDs will rise, by approximately 4% for every 10% increase in income, *ceteris paribus*. This is consistent with evidence from other developing countries, where the demand for sugar-sweetened beverages is responsive to total expenditure changes (Chacon et al., 2018, Paraje, 2016).

A sugar tax should be introduced in Nigeria to curb SSB consumption. A sugar tax would likely drive SSB manufacturers to avoid the sugar tax by substituting sugar with non-caloric sweeteners in their beverages. Thus, the revenue returns of the tax could be less than its public health benefits.

However, despite the tactics by the SSB industry to avoid a sugar tax, findings from other developing countries have shown that a sugar tax is effective in curbing the negative effects of excessive sugar consumption, such as obesity, strokes and type-two diabetes (Basto-Abreu et al., 2019, Manyema et al., 2015, Summan et al., 2020).

5.3 Future research

It has been estimated that 184,000 premature deaths globally each year are attributable to sugar-sweetened beverages, mostly as a result of diabetes (Singh et al., 2015, Sundborn et al., 2019).

The income elasticities and cross- and own-price elasticities measure how responsive consumers are to income and price changes, respectively, when all else is held constant. Put differently, the income and price elasticities measure how demand changes as income and price change, *ceteris paribus*. Income and price elasticities can thus be used to estimate the health gains that would emanate from decreasing the affordability of SSBs in an effort to curb the demand for these beverages. Given the results obtained in this study, it is possible that a sugar tax would be effective not only in raising prices and decreasing demand, but also in increasing public revenues, which, in turn, could be used to support public health interventions. It would also be likely that a significant increase in taxes and prices could also result in a reduction in the incidence of NCDs attributable to high sugar diets and related mortality.

The results from this study have shown that Nigerians are responsive to income, cross- and own-price changes in sugar, carbonated drinks and other beverages. Future research should estimate the gains in quality-adjusted life years, aversion of disability-adjusted life years, and how much government revenue would be generated from a specified sugar tax. Such estimates would provide crucial motivation for a sugar tax.

5.4 Recommendations

Nigeria can curb the consumption of excess sugar, in particular in carbonated drinks, by enforcing price changes, such as levying an excise tax on the sugar content in SSBs such as carbonated drinks. It is imperative that the excise tax is inflation-adjusted, revised periodically, and accompanied by other policies to ensure that SSBs do not become more affordable over time. Policies and interventions to reduce carbonated soft drink demand and consumption could include restricting soft drink marketing, especially marketing aimed at children.

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Appendix A

Table A1: Within cluster regression for unit values using the IMR, 2013

Variables	Sugar	SSB	Choc. drinks	Milk	Water
Ln real expenditure‡	0.159***	-0.014	0.126*	-0.054	0.121**
Ln household size	-0.133	0.063	0.087	0.170	0.006
Household head age in years	0.000	0.000	0.002	-0.001	-0.001
Household adult share	0.199	-0.027	0.113	-0.327	0.341**
Male ratio	-0.001	-0.018	-0.023	-0.115***	0.037
Ratio employed	0.042	-0.077	0.048	0.062	-0.114
Household head gender=male	0.062	0.023	-0.010	0.018	-0.039
Household head educ.= other	0.121	0.289**	-0.433	-0.206	0.252
Household head educ.= pre-primary	0.138	0.405	-0.244	0.000	0.000
Household head educ.= primary	-0.046	0.100	0.016	-0.345***	-0.044
Household head educ.= secondary	-0.016	0.078	-0.033	-0.308	-0.062
Household head educ.=tertiary	-0.043	0.025	0.119	-0.109	-0.098
Constant	4.212***	4.776***	5.706***	5.191***	1.096**
Observations	1,714	743	647	239	862
R-squared	0.445	0.638	0.554	0.661	0.480

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß[1] of equation 3.5 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table A2: Within cluster regression for budget shares using the IMR, 2013

Variables	Sugar	SSB	Choc. drinks	Milk	Water
Ln real expenditure	-0.024***	-0.013***	-0.008***	-0.002***	-0.008***
Ln household size	0.014***	0.007	0.000	-0.001	-0.003
Household head age in years	0.000**	0.000	-0.000	0.000	0.000
Household adult share	0.009**	0.002	0.005	-0.008	-0.001
Male ratio	0.000	0.000	-0.002	0.002	-0.000
Ratio employed	0.002	-0.002	0.000	-0.002	0.001
Household head gender=male	0.007**	-0.003	0.006	0.012	-0.000
Household head educ.= other	-0.007**	0.008	-0.010	-0.0211***	-0.001
Household head educ.= pre-primary	-0.011	0.008	-0.006	0.000	0.000
Household head educ.= primary	-0.008***	-0.000	-0.001	-0.0133	-0.002
Household head educ.= secondary	-0.001	0.000	-0.006	-0.010	-0.002
Household head educ.=tertiary	0.001	0.002	0.002	-0.002	-0.001
Constant	0.201***	0.125***	0.096***	0.221***	0.081***
Observations	1,717	744	647	239	864
R-squared	0.551	0.610	0.639	0.683	0.529

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Table A3: Within cluster regression for unit values using the IMR, pooled sample

Variables	Sugar	CD	Choc. drinks	Milk	Water
Ln real expenditure‡	0.121***	0.010	0.120*	0.127**	0.113**
Ln household size	-0.209**	0.090	-0.069	-0.087	-0.032
Household head age in years	0.002	-0.001	0.002	0.001	-0.001
Household adult share	0.060	-0.022	-0.094	-0.257	0.169
Male ratio	-0.022	-0.002	-0.017	-0.044**	0.008
Ratio employed	-0.016	-0.042	-0.024	0.031	-0.021
Household head gender=male	-0.064	-0.044	-0.173***	-0.322	-0.114
Household head educ.= other	0.066	0.048	-0.139	-0.027	0.103
Household head educ.= pre-primary	-0.021	-0.008	-0.38	-1.007**	0.129

Household head educ.= primary	0.057	-0.014	0.133	-0.208***	0.081
Household head educ.= secondary	0.063	-0.002	0.173	-0.244***	0.045
Household head educ.=tertiary	0.012	0.049	0.197	-0.108	0.001
Year=2016	-0.458***	-0.218***	-0.191***	-0.292***	-0.012
Constant	4.656***	4.652***	6.026***	3.948***	1.284***
Observations	3,485	1,449	1,293	484	1,808
R-squared	0.330	0.354	0.342	0.599	0.245

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß[ı] of equation 3.5 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table A4: Within cluster regression for budget shares using the IMR, pooled sample

Variables	Sugar	CSD	Choc. drinks	Milk	Water
Ln real expenditure	-0.022***	-0.013***	-0.009***	-0.022***	-0.008***
Ln household size	0.010***	0.001	-0.000	-0.005	-0.001
Household head age in years	0.000*	-0.000	0.000	0.000	0.000
Household adult share	0.001	-0.002	-0.000	-0.007	-0.001
Male ratio	0.001	0.001	-0.001	0.000	-0.000
Ratio employed	-0.000	-0.000	0.002	-0.003	0.001
Household head gender=male	0.003	0.001	0.000	-0.012	-0.001
Household head educ.= other	-0.001	0.002	0.002	-0.001	0.001
Household head educ.= pre-primary	-0.009	0.005	-0.008	-0.005	0.001
Household head educ.= primary	-0.006***	0.001	0.007**	-0.002	0.002
Household head educ.= secondary	-0.002	-0.002	0.006	0.001	0.002
Household head educ.=tertiary	0.001	-0.002	0.010***	0.001	0.002
Year=2016	-0.010***	0.001	-0.008***	-0.010***	0.002***
Constant	0.200***	0.137***	0.105***	0.238***	0.080***
Observations	3,488	1,450	1,296	485	1,811
R-squared	0.457	0.494	0.374	0.568	0.409

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Appendix B

Table B1: Summary statistics

Variable	Robust 2013	Robust 2016	Robust pooled sample
Average household size	6.4	5.7	6.0
Average age of household head	52.0	52.8	52.4
Average proportion of adults	61.5%	65.9%	63.7%
Average proportion of male heads	84.6%	79.7%	82.2%
Average proportion of adults employed	69.0%	86.3%	77.5%
Proportion of household heads with primary education and above	57.0%	60.6%	58.8%
Average household real expenditure (Naira)	5,532	4,444	4,999
% of households with positive sugar expenditure	39.7%	42.0%	41.3%
% of households with positive CSD expenditure	16.9%	16.4%	16.6%
% of households with positive chocolate drinks expenditure	15.1%	15.6%	15.5%
% of households with positive milk expenditure	6.4%	6.1%	6.3%
% of households with positive sachet water expenditure	20.3%	22.7%	21.5%
Average sugar share to household expenditure	3.2%	2.6%	2.9%
Average CSD share to household expenditure	2.0%	2.3%	2.2%
Average chocolate drinks share to household expenditure	3.3%	2.8%	3.1%
Average milk share to household expenditure	4.9%	3.7%	4.3%
Average sachet water share to household expenditure	1.3%	1.6%	1.4%
Average real value per kg of sugar (Naira)	374	244	346
Average real value per litre of CSD (Naira)	108	83	96
Average real value per kg of chocolate drinks (Naira)	1,342	1,462	1,464
Average real value per litre of milk (Naira)	93	70	82
Average real value per litre of sachet water (Naira)	12	17	14
Average weekly quantity in kg of sugar consumption	0.25	0.34	0.29
Average weekly quantity in litres of CSD consumption	0.20	0.21	0.21
Average weekly quantity in kg of choc. drink consumption	0.027	0.04	0.03
Average weekly quantity in litres of milk consumption	0.13	0.11	0.12
Average weekly quantity in litres of sachet water consumption	2.33	2.31	2.32
Total number of clusters	433	437	461
Total number of households	4761	4,579	9,340

Table B2: Testing for spatial variation hypothesis using the robust sample

	Robust 2013				Robust 2016				Robust Pooled sample			
	F statistic	**P value**	**R^2**	**n**	**F statistic**	**P value**	**R^2**	**N**	**F statistic**	**P value**	**R^2**	**n**
Sugar	2.49	0.000	0.364	1,889	3.86	0.000	0.451	1,922	3.11	0.000	0.251	3,811
CSD	2.05	0.000	0.523	805	2.18	0.000	0.543	749	1.91	0.000	0.347	1,554
Choc.	2.00	0.000	0.481	718	1.63	0.000	0.435	716	1.68	0.000	0.286	1,434
Milk	5.79	0.000	0.691	306	3.10	0.000	0.600	280	3.67	0.000	0.470	586
Water	2.36	0.000	0.500	967	1.40	0.000	0.324	1,038	1.78	0.000	0.256	2,005

Source: Author's estimates

Table B3: Within Cluster Regression for Budget Shares Using the DUVM and IMR, Robust 2013 Sample

Variables	Sugar		CSD		Choc. drinks		Milk		Water	
	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR
Ln real expenditure	-0.24***	-0.024***	-0.012***	-0.013***	-0.007**	-0.008***	-0.022***	-0.023***	-0.008***	-0.008***
Ln household size	0.009**	0.014***	0.004	0.007***	-0.002	0.000	-0.003	-0.001	-0.002	0.003
Household head age in years	0.000	0.000**	0.000	0.000	-0.000	-0.000	0.000	0.000	0.000	0.000
Household adult share	0.010*	0.009**	0.002	0.002	0.005	0.005	-0.012	-0.008	-0.008	-0.001
Male ratio	0.000	0.000	0.000	0.000	-0.003	-0.002	0.002	0.002	-0.000	-0.000
Ratio employed	0.001	0.002	-0.002	-0.002	-0.002	0.000	-0.002	-0.002	0.001	0.001
Household head gender=male	0.007**	0.007**	-0.002	-0.003	0.007	0.006	0.013*	0.012	0.000	-0.000
Household head educ.= other	-0.006*	-0.006**	0.009	0.008	-0.012	-0.010	-0.021**	-0.021***	-0.008	-0.001
Household head educ.= pre-primary	-0.011	-0.011	0.008	0.008	-0.006	-0.006	.	0.000	.	0.000
Household head educ.= primary	-0.008***	-0.008***	-0.000	-0.000	-0.003	-0.001	-0.011*	-0.011	-0.001	-0.002
Household head educ.= secondary	-0.001	-0.001	0.001	0.000	-0.008	-0.006	-0.010	-0.010	-0.001	-0.002
Household head educ.=tertiary	0.001	0.001	0.002	0.002	-0.001	0.002	-0.002	-0.002	-0.000	-0.001
Constant	0.194***	0.201***	0.118***	0.125***	0.099***	0.096***	0.220***	0.221***	0.081	0.081***
Observations	1,733	1,717	754	744	667	647	240	239	879	864
R-squared	0.551	0.551	0.600	0.610	0.620	0.639	0.684	0.683	0.523	0.529

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Table B4: Within cluster regression for unit values using the DUVM and IMR, robust 2013 sample

Variables	Sugar		CSD		Choc. drinks		Milk		Water	
	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR
Ln real expenditure‡	0.075*	0.085***	-0.018	-0.017	0.126**	0.125***	-0.052	-0.054	0.059	0.057
Ln household size	-0.002	-0.044	0.019	0.023	0.038	0.116	0.085	0.170	0.054	0.088
Household head age in years	-0.001	-0.001	0.000	0.000	0.002	0.002	-0.001	-0.001	-0.000	-0.000
Household adult share	0.194	0.167	-0.014	-0.020	0.213	0.189	0.346	-0.327	0.190	0.211
Male ratio	-0.012	-0.011	-0.016	-0.016	-0.034	-0.028	-0.114	-0.115***	0.031	0.031
Ratio employed	0.000	0.003	-0.052	-0.057	-0.075	-0.063	0.060	0.062	-0.070	-0.073
Household head gender=male	-0.017	-0.014	0.009	0.009	-0.046	-0.040	0.023	0.018	-0.017	-0.011
Household head educ.= other	0.081	0.080	0.067	0.066	-0.419	-0.381	-0.207	-0.206	0.329*	0.337*
Household head educ.= pre-primary	0.149	0.148	0.393	0.395	0.183	-0.187	.	0.000	.	0.000
Household head educ.= primary	0.018	0.017	0.085**	0.087**	0.066	0.064	-0.344	-0.345***	-0.012	0.000
Household head educ.= secondary	-0.010	-0.021	0.038	0.037	0.002	0.042	-0.308	-0.308	0.030	0.035
Household head educ.=tertiary	-0.004	-0.013	0.060	0.062	0.140	0.187	-0.115	-0109	0.004	0.011
Constant	4.878***	4.814***	4.773***	4.791***	5.661***	5.660***	5.111	5.174***	1.412**	1.450***
Observations	1,678	1,663	745	735	655	635	237	236	859	847
R-squared	0.394	0.393	0.566	0.567	0.546	0.557	0.644	0.644	0.527	0.534

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß[1] of equation 3.5 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table B5: Within cluster regression for budget shares using the DUVM and IMR, robust 2016 sample

Variables	Sugar		CD		Choc. drinks		Milk		Water	
	DUVM	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**
Ln real expenditure	-0.018**	-0.019***	-0.014***	-0.0135***	-0.006	-0.005**	-0.027***	-0.03***	-0.011***	-0.009***
Ln household size	0.005**	0.008***	-0.002	-0.004	-0.006	-0.004	0.003	0.003	0.000	0.000
Household head age in years	0.000	0.000	-0.000	0.000	-0.000	0.000	0.000	0.000	-0.000	-0.000
Household adult share	-0.002	-0.004	-0.006*	-0.005	-0.003	-0.010	0.006	0.004	0.002	0.001
Male ratio	0.001*	0.001	0.001*	0.001	-0.001	-0.000	0.000	0.000	0.000	-0.000
Ratio employed	-0.001	-0.001	-0.002	-0.001	-0.000	0.003	-0.004	-0.005	0.002	0.001
Household head gender=male	0.002	0.001	0.002	0.003	0.004	-0.003	-0.022	-0.018	0.000	-0.002
Household head educ.= other	-0.001	-0.000	0.008	0.007	0.005	0.007	-0.001	0.003	-0.002	0.000
Household head educ.= pre-primary	-0.013***	-0.013	0.0005*	0.006	-0.007	-0.006	-0.004	-0.002	-0.002	-0.001
Household head educ.= primary	-0.004*	-0.003	0.000	0.002	-0.001	0.009**	0.007	0.009	-0.001	0.001
Household head educ.= secondary	-0.002	-0.001	-0.005	-0.003	0.000	0.010**	0.014**	0.015	-0.000	0.001
Household head educ.=tertiary	0.000	0.002	-0.004	-0.004	-0.001	0.009	0.012	0.014	0.001	0.002
Constant	0.157***	0.172***	0.154***	0.140***	0.093**	0.062***	0.263***	0.296***	0.104***	0.093***
Observations	1,822	1771	737	706	698	649	250	246	1,007	947
R-squared	0.480	0.475	0.593	0.574	0.423	0.418	0.680	0.658	0.358	0.528

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Table B6: Within cluster regression for unit values using the DUVM and IMR, robust 2016 sample

Variables	Sugar		CSD		Choc. drinks		Milk		Water	
	DUVM	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**
Ln real expenditure‡	0.053	0.030	-0.034	-0.032	0.032	0.086	0.082	0.061	0.060	0.115
Ln household size	-0.132**	-0.112	0.035	0.019	-0.037	-0.169	0.017	-0.106	-0.066	-0.044
Household head age in years	0.006**	0.004***	-0.000	0.001	0.007	0.003	-0.003	-0.002	-0.001	-0.002
Household adult share	-0.094	-0.0142	-0.002	-0.098	-0.089	-0.243	-0.034	0.051	0.101	0.186
Male ratio	-0.007	-0.004	-0.020	-0.029**	-0.063	-0.042	-0.031	-0.032	0.033	0.004
Ratio employed	-0.023	-0.037	-0.037	-0.050	-0.050	-0.0925	0.078	0.038	0.107**	0.012
Household head gender=male	0.020	-0.030	-0.032	-0.015	-0.352**	-0.237**	-0.009	0.142	-0.016	-0.032
Household head educ.= other	-0.105*	-0.042	0.038	0.065	0.888**	0.815	0.135	0.046	0.001	-0.026
Household head educ.= pre-primary	-0.047	-0.056	-0.084*	-0.080	-0.247	-0.423	-0.904***	-0.864**	-0.069	-0.059
Household head educ.= primary	0.123**	0.130**	0.019	0.003	0.292*	0.190	-0.148	0.188	-0.062	-0.066
Household head educ.= secondary	0.065	0.0626	0.004	0.015	0.281	0.234	-0.113	0.170	-0.171	-0.208
Household head educ.=tertiary	0.040	0.042	0.095	0.045	0.124	0.213	0.086	0.041	-0.090	-0.234
Constant	4.647***	4.741***	4.718***	4.732***	6.155***	6.296***	3.832***	3.687***	1.713**	1.295**
Observations	1,805	1754	725	694	693	644	248	244	987	927
R-squared	0.511	0.464	0.578	0.558	0.477	0.478	0.633	0.656	0.326	0.327

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß[1] of equation 3.5 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table B7: Within cluster regression for budget shares using the DUVM and IMR, robust pooled sample

Variables	Sugar		CSD		Choc. drinks		Milk		Water	
	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR
Ln real expenditure	-0.020***	-0.22***	-0.014***	-0.013***	-0.009***	-0.009***	-0.023***	-0.022***	-0.009***	-0.008***
Ln household size	-0.007***	0.010****	0.001	0.001	-0.002	-0.000	-0.000	-0.005	-0.001	-0.001
Household head age in years	0.000	0.000*	-0.000	-0.000	-0.000	0.000	0.000	0.000	0.000	0.000
Household adult share	0.004	0.001	-0.002	-0.002	0.004	-0.000	-0.002	-0.007	0.001	-0.001
Male ratio	0.001	0.001	0.001	0.001	-0.002**	-0.001	0.000	0.000	-0.000	-0.000
Ratio employed	0.000	-0.000	-0.001	-0.000	0.000	0.002	0.000	-0.003	0.002	0.001
Household head gender=male	0.003	0.003	0.001	0.001	0.003	0.000	-0.012	-0.012	0.000	-0.001
Household head educ.= other	-0.002	-0.001	0.003	0.002	0.003	0.002	-0.005	-0.001	-0.002	0.001
Household head educ.= pre-primary	-0.011	-0.009	0.004	0.005	-0.009	-0.008	-0.005	-0.005	-0.001	0.001
Household head educ.= primary	-0.006***	-0.006***	-0.001	0.001	-0.001	0.007*	-0.004	-0.002	-0.001	0.002
Household head educ.= secondary	-0.002	-0.002	-0.003	-0.002	-0.001	0.006	-0.001	0.001	-0.001	0.002
Household head educ.=tertiary	0.000	0.0001	-0.003	-0.002	0.003	0.010***	0.001	0.001	0.000	0.002
Year=2016	-0.009***	-0.010***	0.001	0.001	-0.007***	-0.008***	-0.009**	-0.010***	0.001	0.002***
Constant	0.175***	0.200***	0.141***	0.137***	0.115***	0.105***	0.242***	0.238***	0.091***	0.080***
Observations	3,555	3,488	1,491	1,450	1,365	1,296	490	485	1,883	1,811
R-squared	0.455	0.457	0.507	0.494	0.400	0.374	0.559	0.568	0.424	0.409

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Table B8: Within cluster regression for unit values using the DUVM and IMR, robust pooled sample

Variables	Sugar		CSD		Choc. drinks		Milk		Water	
	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR	DUVM	IMR
Ln real expenditure‡	0.062**	0.069***	-0.008	-0.007	0.087**	0.097**	0.147**	0.128**	0.083**	0.097**
Ln household size	-0.092**	-0.071	0.026	0.032	-0.021	-0.040	-0.010	-0.109	-0.031	-0.06
Household head age in years	0.002*	0.001	-0.000	0.000	0.005*	0.002	-0.001	0.001	-0.001	-0.002
Household adult share	0.063	0.087	0.002	-0.048	-0.037	-0.061	-0.367**	-0.268	0.135	0.197
Male ratio	-0.009	-0.013	-0.023*	-0.019**	-0.052*	-0.031	-0.072	-0.046**	0.038*	0.015
Ratio employed	0.003	-0.025	-0.025	-0.025	-0.029	-0.043	0.044	0.043	0.070*	-0.007
Household head gender=male	0.007	-0.042	-0.011	-0.009	-0.242***	-0.174***	-0.109	-0.316	-0.041	-0.069
Household head educ.= other	-0.002	0.049	0.005	0.0148	-0.027	-0.109	-0.070	-0.003	0.251**	0.236**
Household head educ.= pre-primary	0.058	-0.022	-0.005	-0.014	-0.110	-0.219	-1.071***	-0.999**	0.098	0.123
Household head educ.= primary	0.089**	0.073	0.013	0.000	0.169*	0.146	-0.238	-0.201***	0.017	0.046
Household head educ.= secondary	0.043	0.036	0.015	0.018	0.238**	0.199**	-0.239**	-0.240***	-0.008	0.003
Household head educ.=tertiary	0.041	0.023	0.043	0.035	0.163	0.208**	-0.055	-0.104	0.010	-0.045
Year=2016	-0.431***	-0.453***	-0.305***	-0.282***	-0.149**	-0.152***	-0.306***	-0.279***	-0.038	-0.043
Constant	5.014***	4.920***	4.630***	4.761***	6.251***	6.150***	3.983***	3.916***	1.613***	1.361***
Observations	3,483	3,417	1,470	1,429	1,348	1,279	485	480	1,846	1,774
R-squared	0.382	0354	0.497	0.486	0.324	0.322	0.517	0.557	0.257	0.262

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. ‡ Praise and Houthakkakker in Deaton (2018) page 289 refer to ß[1] of equation 3.5 (Ln real expenditure) as "quality elasticities" or the expenditure elasticity of quality.

Table B9: Own-and-cross-price elasticities for the robust 2013 and robust 2016 samples, DUVM

Unconstrained estimates, 2013 and 2016 (robust)												
	Sugar		CSD		Choc.		Milk		Water		Other	
	2013	2016	2013	2016	2013	2016	2013	2016	2013	2016	2013	2016
Sugar	-0.826***	-1.082***	0.071	-0.235**	-0.095***	-0.193	0.026*	-0.171*	0.038***	-0.017	0.504***	1.384***
CSD	-0.077	-0.211	-0.490	-1.751***	0.061	-0.391**	-0.000	-0.091	0.123	-0.545**	-0.020	2.608**
Choc.	0.289*	-0.017	-0.370	-0.107	0.130	-0.928**	-0.182***	0.041	-0.154	-0.034	-0.505	0.277
Milk	-0.044	0.095	-0.095*	0.447*	0.176*	0.384	-0.435**	-1.057***	-0.012**	0.591**	-0.044	-0.728
Water	-0.227*	-0.022	0.914*	0.055	0.444	-0.169	0.945**	0.088	-1.106*	-1.475***	-1.362**	1.190*
Other	0.002**	-0.001**	0.002	-0.003**	0.018***	-0.000	0.009**	-0.002**	-0.001**	0.000	-0.300***	-0.252***
Symmetry-constrained estimates, 2013 and 2016 (robust)												
Sugar	-0.867**	-1.058***	0.214	-0.182*	-0.134	0.009	0.136	-0.007	0.085	0.022	0.284	0.900**
CSD	-0.114	-0.155*	-0.424	-1.596***	0.064**	-0.265	0.055	0.003	0.074	-0.274***	-0.058	1.905***
Choc.	0.221	-0.003	-0.255	-0.259	0.083***	-1.001	-0.060	0.108	-0.097	-0.093	-0.683**	0.479
Milk	-0.082	-0.004	0.059	0.006	0.184	0.125	-0.387	-1.056***	-0.011	0.221**	-0.217*	0.440
Water	-0.335	0.037	1.962	-0.538	0.426**	-0.181	1.330	0.447**	-1.208	-1.490***	-2.567	1.392***
Other	-0.000**	-0.002**	0.013***	-0.011	0.017**	-0.001	0.015***	0.003	-0.001	-0.003	-0.314***	-0.244***

Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01.

Table B10: Estimated own- and cross-price elasticities with symmetry restrictions, quality correction, and correction for selection bias (Inverse Mill's Ratio), robust 2013 and robust 2016 samples

	Sugar		CSD		Choc.		Milk		Water	
	2013	2016	2013	2016	2013	2016	2013	2016	2013	2016
Sugar	-0.791***	-1.108**	-0.002	-0.259**	0.099***	0.040	0.014***	0.048**	-0.055***	-0.184**
CSD	-0.009***	-0.291*	-0.839***	-1.071*	-0.028***	-0.284	0.037***	0.245**	0.109***	-0.347**
Choc.	-0.068***	0.023	-0.025***	-0.249	0.064***	-1.074***	0.017***	0.297***	0.053***	-0.235**
Milk	-0.001	0.036	0.014**	0.158	0.021***	0.238**	-0.529***	-1.038***	0.122***	0.420***
Water	-1.20***	-0.306***	0.158***	-0.516***	0.138***	-0.404***	0.411	0.993***	-0.956***	-2.457***

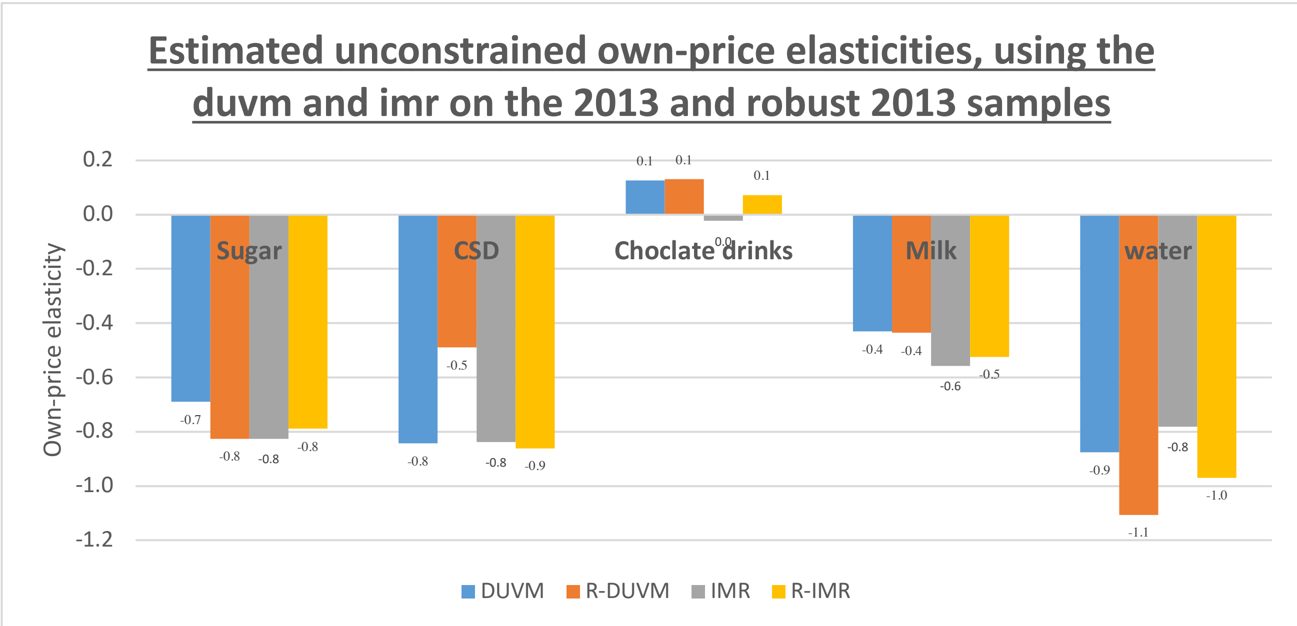
Source: Author's estimates. *P<0.1, **P<0.05, ***P<0.01. Sample weighted to be representative of the Nigerian population in 2013

Table B11: Estimated price elasticities with symmetry restrictions, quality correction and correction for selection bias (inverse mill's ratio) vs. results from the DUVM estimates on the robust samples

	Year	Sugar		CSD		Choc. Drink		Milk		Water	
		DUVM	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**	**DUVM**	**IMR**
Expenditure elasticities	2013º	0.210**	0.068**	0.427***	0.384***	0.678***	0.644***	0.615***	0.549****	0.333**	0.357**
	2016 º	0.263***	0.238***	0.415***	0.449***	0.749***	0.736***	0.186	0.095	0.272**	0.303**
	2013-2016	0.204***	0.186**	0.413***	0.392**	0.586***	0.603***	0.343***	0.367***	0.336***	0.342***
Expenditure elasticity of quality	2013º	0.075*	0.085***	-0.018	-0.017	0.126**	0.122***	-0.052	-0.054	0.059	0.057
	2016 º	0.053	0.030	-0.040	-0.032	0.032	0.086	0.082	0.061	0.060	0.115
	2013-2016	0.062*	0.069***	*0.008	-0.007	0.087**	0.097**	0.147**	0.128**	0.083**	0.097**

Source: Author's estimates.
º Sample weighted to be representative of the Nigerian population in 2013 and 2016.

Figure B2: The Estimated unconstrained own-price elasticities for 2013 and the robust 2013 samples using the DUVM and the Heckman procedure (IMR)

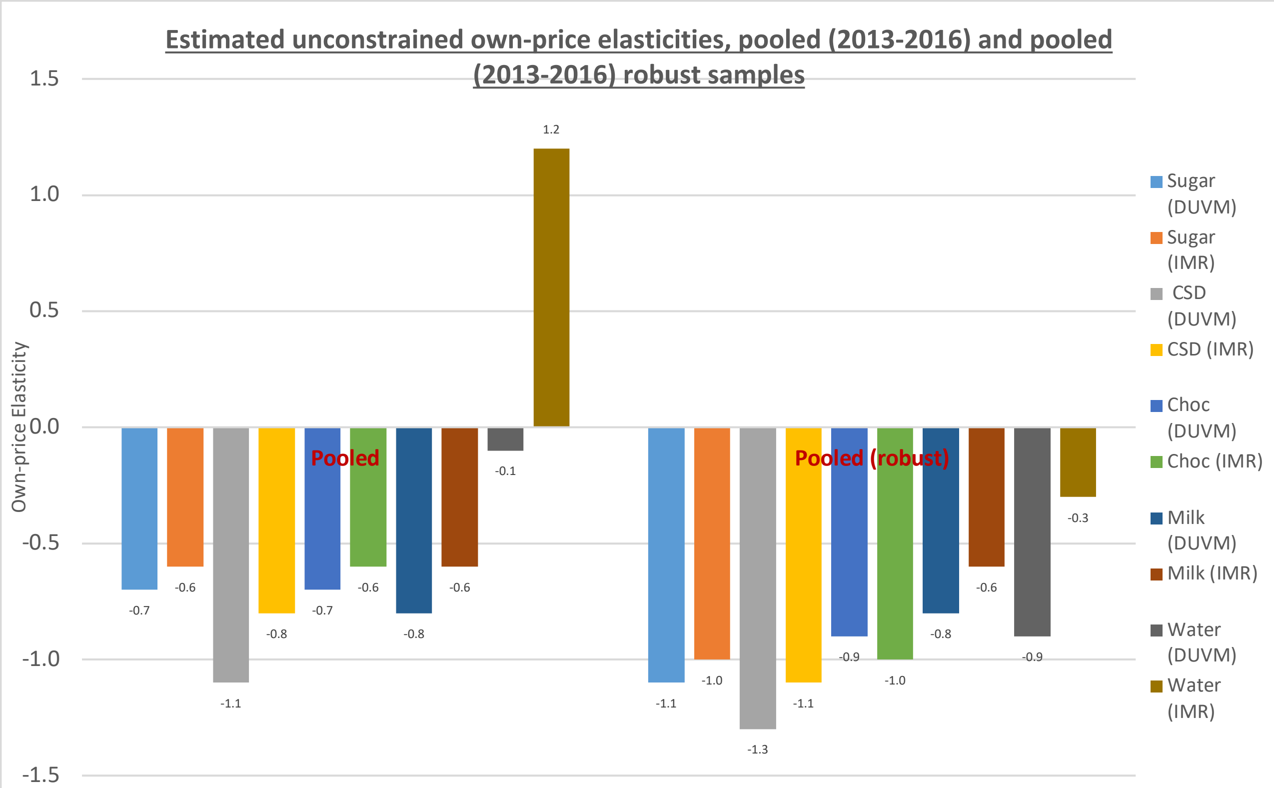


Source: Author's estimates.

R-DUVM is the robust sample using the DUVM method and R-IMR is the robust sample using the Heckman's procedure (inverse Mill's ratio).

Note that the R-DUVM estimate for CSDs, chocolate drinks and milk are not statistically different from zero.

Figure B3: The Estimated unconstrained own-price elasticities for pooled (2013-2016) and pooled (2013-2016) robust samples using the DUVM and the Heckman procedure (IMR)



Source: Author's estimates.

R-DUVM is the robust sample using the DUVM method and R-IMR is the robust sample using the Heckman's procedure (inverse Mill's ratio).