The Economic Impact of a Sugar-Sweetened Beverages Tax in South Africa

By

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As the candidate's main supervisor, I, **S.R.D. Ferrer**, agree to the submission of this thesis;

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ABSTRACT

The newly implemented Health Promotion Levy (HPL) in South Africa (SA) imposes a tax on Sugar-Sweetened Beverages (SSBs) containing more than four grams of sugar per 100ml. The HPL is legislated in terms of Chapter VB of the Custom and Excise Act No. 91 of 1964, on SSBs manufactured in SA or imported into South Africa. There is a disagreement between the proponents of the tax (government) and opponents of the tax (beverage and sugar industry). The proponents of the tax contend that the SSBs tax will reduce obesity and boost SA's economic growth by reducing government spending on prevention and treatment of obesity-related non communicable diseases (NCDs). The opponents of the tax, on the other hand, contend that the tax will be detrimental to the growth of the SA's economy by reducing the beverage and sugar industry returns, which will, in turn, lead to labour disemployment.

There are relatively fewer published empirical studies to date in South Africa that have examined the economic impact of the SSB tax. Most of the published empirical literature to date has focused more on the health impact of the SSB tax. Furthermore, there's no empirical study that has examined the impact of the SSBs tax on the South African sugar industry.

Given this background, this study aims to investigate the economic impact of the SSBs on the South African sugar industry. This is achieved by (1) assessing the impact of the SSB tax on the quantity of sugar demanded in the domestic sugar market, and (2) determining the impact of the SSBs tax on the revenue earned by the South African sugar industry from local sugar sales and Recoverable Value (RV) price received by sugarcane growers'.

The analysis used time-series data for the period 1977-2019 and involved the use of the simultaneous equations regression method (Three Stage Least Square regression (3SLS)) and the

Vector Error Correction Model (VECM). To deal with challenges associated with time-series data, several diagnostic tests were employed. In addition, the direction of causality between domestic sugar demand and supply variables was examined using a Wald test for Granger's causality. Furthermore, a Johansen's Cointegration test was used to check the presence of long-run relationships between domestic sugar demand and supply variables.

The static demand and supply model (3SLS regression) results revealed that variables such as the real domestic price of sugar, previous period sugar consumption, and consumers' real disposable income influence the domestic sugar demand in South Africa. Whereas variables such as the real domestic price of sugar, technological changes, and the real price of sugarcane in the previous period influence the domestic sugar supply in South Africa.

From the 3SLS regression model, the own-price elasticity estimates of domestic demand and supply for sugar in South Africa were estimated to be -2.652, and 0.838, respectively. Implying that the domestic demand for sugar in South Africa is relatively more responsive to own-price changes, whereas the domestic supply of sugar is relatively less responsive to own-price changes. From the VECM, the short-run own-price elasticity estimates of domestic sugar demand and supply were estimated to be -0.301 and 0.762, respectively. Implying that in the short run both domestic sugar demand and supply are relatively less responsive to domestic sugar price changes. In addition, the long-run own-price elasticity estimates were estimated to be -2.243 and 1.809, respectively for the domestic sugar demand and supply equations. This implies that in the long run both domestic demand and supply for sugar in South Africa are relatively more responsive to domestic sugar price changes. This is because over time the South African sugar producers are likely to discover more alternative products to produce or develop close substitute in consumption that contains less sucrose sugar. Similarly, domestic sugar consumers are likely to discover more sugar substitutes in the long run.

Based on the 3SLS model's own-price elasticity estimate of domestic sugar demand (-2.265), the quantity of sugar demanded by domestic consumers of sugar was estimated to have decreased by 184 169 tons, causing a revenue loss of about R1.68 billion in the domestic sugar market. Based on the VECM short-run own-price elasticity estimate of domestic sugar demand (-0.301), the quantity of sugar demanded in the domestic sugar market was estimated to have decreased by 209 01 tons, leading to a domestic sugar revenue loss of about R190 million. Lastly, using the long-run own-price elasticity estimates of the domestic sugar demand (-2.243), the quantity of sugar demanded in the domestic sugar market was estimated to have decreased by 154 917 tons, leading to a domestic sugar revenue loss of about R1.41 billion. Furthermore, by applying the sugar industry division of proceeds formula, the RV price received by sugarcane growers' during the 2019/20 season was estimated to be lower by 9.167% when compared to the RV price that growers could have received if there was no SSBs tax.

Given the negative impact of the SSBs tax on the South African sugar industry's financial position, the study recommended the South African sugar industry to invest more on other alternative income streams, i.e., expand the production of biofuels using sugarcane as a feedstock. In this regard the study recommended the South African government to support the South African sugar industry stakeholders with legislation that will allow them to generate revenue from expanding the production of biofuels, electricity co-generation, and biochemical feedstock, amongst others. For instance, provides legislations that are necessary to promote the use of ethanol-blended petroleum and legislations necessary to enable sugar mills to sell electricity from co-generation.

Keywords: Health Promotion Levy (HPL), South African Sugar Industry, Three-Stage Least Square (3SLS), Two-Stage Least Squares (2SLS), Vector Error Correction Model (VECM), Sugar tax.

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LIST OF ACRONYMS

2SLS	Two-Stage Least Squares
3SLS	Three-Stage Least Squares
ADF	Augmented Dickey-Fuller
ADSA	Association Dietetics of South Africa
AgriBEE	Agricultural Black Economic Empowerment
AICPA	Association of International Certified Professional Accountants
AIDS	Almost Ideal Demand System
BEVSA	Beverage Association of South Africa
BFAP	Bureau for food and Agricultural Policy
BG	Breusch Godfrey
BLUE	Best Linear Unbiased Estimators
BMI	Body Mass Index
CEASIID	Censored Exact Affine Stone Index Incomplete Demand
CPI	Consumer Price Index
DAFF	Department of Agriculture Forestry and Fisheries
DTI	Department of Trade and Industry
DW	Durbin Watson
ECM	Error Correction Model
EPP	Export Parity Price
EU	European Union
FS	Famers' Share

GAIN	Global Agricultural Information
GDP	Gross Domestic Product
GLS	Generalized Least Squares
GST	Goods and Services Tax
HFCs	High Fructose Corn Syrup
HPL	Health Promotion Levy
IIED	International Institute for Environment and Development
ITAC	International Trade and Administration Committee
LMD	Local Market Demand
MGI	McKinsey Global Institute
MNCs	Multinational Companies
MS	Millers' Share
NIA	Northern Island Assembly
NAMC	National Agricultural Marketing Council
NCDs	Non-Communicable Diseases
NXI	Net Export Index
NZIER	New Zealand Institute of Economic Research
OLS	Ordinary Least Squares
QUAIDS	Quadratic Almost Ideal Demand System
RCA	Revealed Comparative Advantage
RSS	Residuals Sum of Squares
RTA	Relative Trade Advantage
RV	Recoverable Value

SACGA	South African Cane Growers' Association
SACU	South African Customs Unions
SAIPA	South African Institute of Professional Accountants
SAITP	South African Institute of Tax Professionals
SARS	South African Revenue Services
SASA	South African Sugar Association
SASID	South African Sugar Industry Directory
SASMA	South African Sugar Millers' Association
SASRI	South African Sugar Research Institute
SMRI	Sugar Milling Research Institute
SSB	Sugar-Sweetened Beverages
STATSA	Statistics South Africa
TIPS	Trade and Industrial Policy Strategies
TPC	Tax Policy Center
USDA	United States Department of Agriculture
VAR	Vector Autoregressive
VAT	Value Added Tax
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor
WHO	World Health Organizations
WOF	World Obesity Federation

CHAPTER 1. INTRODUCTION

1.1 Background of the study

Obesity, which is considered by the World Health Organization (WHO, 2019) as abnormal or excessive fat accumulation that represents a risk of health, is considered by Barness *et al.* (2019) to be one of the main causes of preventable deaths. Furthermore, it could well become the most common health challenge of the 21st century; therefore, obesity has become a major health policy issue for many countries in the world (Barness *et al*., 2019). The terms "obese" and "overweight" are similar and measured using the Body Mass Index (BMI), which is defined as a person's weight (in kilograms) divided by the square of his or her height (in meters). A person with a BMI of 30 Kg/m^2 or more is generally considered obese (BMI≥30), while a person with a BMI that is more than 25 kg/m^2 but less than 30 kg/m^2 is considered to be overweight (WHO, 2019).

Obesity and overweight results from the imbalances between the energy consumed and expended (Taijaard and Voster, 2018). They are risk factors for various Non-Communicable Diseases (NCDs), i.e., type II diabetes mellitus, cardiovascular diseases, stroke, hypertension, and some cancers (Hangoma *et al*., 2020). They are estimated to have accounted for about 7% of the 521 000 deaths in South Africa during the year 2000 (the fifth biggest cause of death) (Normal *et al*., 2007).

Politicians recognized poor health as a threat to national economic development, with preventable diseases trapping more people into vicious cycles of poverty. This is because obesity is associated with substantial personal as well as social costs, mainly through increased health care costs, due to the treatment of obesity-related NCDs (Cawley *et al*., 2019). The NCDs' health complications are expected to collectively cost about $1.2 trillion to treat globally by 2025 (World Obesity Federation [WOF], 2015).

The WHO strongly contends that there is a high correlation between the intake of added sugars and obesity. It, therefore, recommends peoples' intake of added sugars to be less than 10% of their daily energy intake. For additional health gain, it recommends a further reduction to 5% of daily energy intake (Association of Dietetics in South Africa [ADSA], 2020). Furthermore, the WHO recommends countries tax their SSBs. In response to the WHO recommendations countries like South Africa, Chile, Mexico, France, United States, among others have implemented a tax on SSBs (Stacey *et al.*, 2017a).

Obesity does not only affect human health, but also the economy. This is because obesity-related illnesses decrease workers' productivity, furthermore, they cause uncertainties in production regarding how long the workforce will remain economically active. Moreover, high taxpayers' expenditures on health instead of other areas of the economy means limited economic growth (South African Institute of Professional Accounts [SAIPA], 2015).

Previously obesity was a challenge facing mostly high-income countries. More recently, it has also become a problem for low and middle-income countries partly due to the expansion of Multinational Companies (MNCs) who are targeting new investments (Nakhimovsky *et al*., 2016). It is also a consequence of an increasing income per capita in developing countries (Bhurosy and Jeewon, 2014). According to Du *et al.* (2018), about one-third of the world is obese or overweight, with 62 percent of people living in developing countries.

According to Hofman *et al*., (2019), Sub-Saharan African countries are seen as a major growing market for the beverage and processed food industries, in contrast to the declining market in the north economies. In South Africa alone, the market for SSBs has doubled from 2,294 million litres in 1998 to 4,746 million litres in 2012 (South African National Treasury, 2016). Concomitant with the rapid growth in the market for SSBs, these industries have increased their annual spending on marketing campaigns. The energy drink industry alone has increased its spending on energy drinks advertisements from nearly zero during early 1998 to approximately R4.5 million monthly across all media by early 2013 (Stacey *et al.*, 2013).

Globalization of the food supply is also considered as another reason for high incidences of obesity even in low and middle-income countries. This is because globalization has brought a considerable change in peoples' lifestyles across the world. These changes have altered peoples' diets and decreased their levels of physical activity and hence increased their BMI.

According to Finkelstein and Strombotne (2010), the rise in obesity both nationally and internationally is a result of changes in the environment. The changes in the environment have simultaneously lowered the time and monetary cost of food consumption, while concurrently decreasing the real cost of being physically inactive at work and home. Furthermore, the changing environment has also increased consumers' demand for labour-saving, convenient, and affordable food, which leads to weight gains.

Many public health initiatives have been implemented as a means of changing people's tastes and preferences for food. These initiatives include encouraging healthy eating and educational programs about obesity, skills training, and building social support. However, these efforts have been less effective in addressing obesity (Haslam and James, 2004). Moreover, international evidence shows that certain population-based interventions and policies, such as taxes, are effective in reducing the consumption of unhealthy foods, by reducing consumers' affordability, while at the same time generating revenues for public health (Chacon *et al*., 2018).

Fiscal policy instruments in the form of taxes on energy-dense foods, such as SSBs can be used to encourage consumers to consume low quantities of high energy-containing beverages or foods, or in the form of subsidies to encourage consumers to consume healthier food items such as fruits and vegetables. The SSBs tax is an increasingly common policy tool aimed at reducing obesity prevalence by disincentivizing people from consuming more SSBs than recommended. The SSB tax proponents contend that SSBs are targeted because they are fluids with simple carbohydrates that are therefore metabolized quickly. As a result, they do not produce a feeling of satiety (unlike their comparable sweetened solid foods), hence they end up being over-consumed, leading to higher overall calorie intake (Cawley, 2009; Allcot *et al*., 2019). According to Cawley (2019), the mechanism by which SSBs lead to diabetes is that they contain a high glycemic load, which can result in insulin resistance and type 2 diabetes. Lockwood and Toubinksy (2017), in their meta-analysis study, estimated that consuming one to two servings of SSBs per day, relative to less than one serving per month, is associated with a 26% higher probability of developing type 2 diabetes and a 20% higher probability of developing metabolic syndrome. They further argued that drinking just one SSB per day increases the likelihood of an adult and child being overweight by 27% and 55%, respectively.

The proponents of the SSBs tax believe that the tax will increase public awareness about the negative health consequences of excessive SSBs intake, which is deemed necessary in an environment where marketing and other industry practices are misleading the public and undermining consumers' ability to make healthier choices. However, several studies including McKinsey Global Institute (MGI) (2014), Lee *et al*., (2016), and Seedat and Sign (2017), amongst others have revealed that obesity causes are complex, therefore addressing obesity requires a holistic approach, a tax alone is less likely to achieve its objective (Seedat and Sigh, 2017). In addition, to the SSBs tax, other practices could include the regulation of marketing, advertising, and repackaging of SSBs with an introduction of warnings about the levels of sugar on certain foods and drinks, and the possible health risks, i.e., the warnings on tobacco products (SAITP, 2017). Furthermore, other strategies might include encouraging people to participate in physical activities and increasing the availability of healthier food choices by subsidizing healthy food products, such as water, whole grain products, fruits, and vegetables.

Although there is empirical evidence that a SSBs tax policy intervention does reduce consumption of SSB, while simultaneously increasing the consumption of healthier alternative drinks as experienced in Mexico (Du *et al*., 2018), several important evidence gaps remain regarding the potential unintended consequences, and the comparative and cost-effectiveness of this policy intervention. According to the New Zealand Institute of Economic Research (NZIER, 2016), to be effective at improving peoples' health, the SSB tax must firstly be effective at increasing the price of SSBs. Secondly, the price increase must lead to a reduction in the consumption of SSBs. Thirdly, it must not only reduce the consumption of SSBs but also reduce the consumption of other high-energy calories. Fourthly, the lower energy intake must lead to lower physiological risk factors.

Fletcher *et al*., (2009) estimated the impact of a hypothetical soft drinks tax on the US obesity rate. They found that soft drink taxes do influence BMI, but with a negligible magnitude. Moreover, Fletcher *et al*., (2010) found that although soft drinks taxation brings about a moderate reduction in the consumption of soft drinks by children and adolescents in the US, this reduction is offset by an increase in consumption of other high-calorie drinks.

In South Africa, the prevalence of obesity has increased considerably. According to ADSA (2020), 68% of women, 31% of men, and 13% of children are obese. Gomo and Birg (2018), contend that the nutritional transition in South Africa is the main contributing factor to the challenge of increasing levels of obesity. There has been an expansion of supermarkets in the informal urban settlements and rural areas over the past years, increasing the availability and accessibility of less nutritious foods by low-income consumers, and therefore, resulting in a food system that is contributing to chronic, and expensive ill-health (Tugendhaft *et al*., 2016).

According to Seedat and Singh (2017), South Africa ranks within the top ten consumers of SSBs per capita worldwide, while at the same time it is the third most obese country in Africa. South Africa's SSB consumption among urban and rural communities has risen by 68.9% between 1999 and 2012, with consumption of high calorie carbonated soft drinks being the highest of all SSB categories (ADSA, 2020). Several studies contend that the frequent consumption of these SSB categories is due to their addictive nature, advertising, and their wide availability (Hofman *et al*., 2019).

The South African Department of Health developed a 2015-2020 strategic plan for the prevention and control of Obesity. The strategic plan aims to reduce obesity by 10% by 2020 as a means of reducing the prevalence of NCDs, which accounts for about 40% of all deaths in the country (National Treasury policy paper, 2016). They contend that SSBs are among the least nutritious foods that significantly contribute to the prevalence of obesity, since they do not provide consumers with a feeling of fullness that food does, and they are generally an addition to a meal, resulting in the consumption of extra calories than one could consume from staple food alone (Seedat and Singh, 2017). As a response, the South African National Treasury started taxing SSBs as an economic mechanism to control obesity by shifting consumers' spending away from SSBs towards healthier alternatives; they termed it “Health Promotion Levy (HPL)” (Armstrong *et al*., 2016).

According to the National Treasury (2016), the SSBs tax aims to reduce consumption of sugar, in order to reduce the prevalence of obesity and associated NCDs. Taijaard and Voster (2018) contend that its objective is not to raise additional tax revenue. However, other authors have argued that the South African government's original intention may be to generate additional tax revenue to finance the burgeoning budget deficit, estimated to be approximately 4.7% of the South African GDP (National Treasury, 2019). This is supported by the fact that the sugar tax came into effect after the South African Government set a goal of reducing the budget deficit by 0.4% to 4.3% of GDP by 2021/22. In response, the South African government raised other taxes on the 1st of April 2018 (the day of the SSBs tax implementation) such as, sales tax which increased from 14% to 15%, the estate duty rate was also increased by 22c/litre, excise duties on tobacco and alcohol were also increased by 8.5% and, 10%, respectively (National Treasury, 2018).

The levy is administered under the Rates and Monetary Amounts and Amendment of Revenue Act, 2017, as passed by the Parliament on the 5th December 2017 (South African Revenue Services [SARS], 2018). It is legislated in terms of chapter VB of the Customs and Excise Act No.91 of 1964 and is imposed on SSBs manufactured in South Africa or imported into South Africa (South African National Treasury, 2016). The HPL is payable in addition to any duty prescribed in respect of the goods concerned. Moreover, for simplicity and to minimize costs, the general excise administrative principle (duty-at-source) has been applied in respect of the sugar tax (South African National Treasury, 2016). This means producers and importers of SSB are required to pay over the sugar tax to the SARS and it will be collected at the factory gates or the ports of entry (SARS, 2018).

Initially, the SSBs tax was proposed at a rate of ZAR 0.0299 per gram of sugar, equivalent to a 20% tax rate for all SSBs, and it was to be implemented on the 1st of April 2017 (Hofman *et al.*, 2019). However, due to lobbyists from the sugar industry and SSBs industry arguing that the tax will be detrimental to the South African economy in the form of a reduction in employment rate and government revenue, the tax was delayed by one year to allow for the tax adjustment by the government to mitigate the perceived negative economic effects. The tax was then implemented on the 1st April 2018 at a reduced rate of ZAR 0.021 per gram of sugar content over four grams per 100ml, making the first four grams of sugar in the 100ml to be tax-exempt. This is equivalent to the 10% tax rate. However, this is less than the WHO recommendation of 20% or more for the SSB tax to become effective in reducing SSB consumption and obesity rate (Gomo and Birg, 2018). By implementing the SSB tax South Africa became the first country to do so in Africa.

The South African government opted for a threshold tax policy design option, to incentivize producers of SSBs to reformulate their products to have a lower sugar content and, therefore reduce their tax liability (South African National Treasury, 2016). However, this policy design option has the disadvantage of higher administrative costs, due to the need to police this boundary between taxable and non-taxable products. Moreover, this is a specific rate (it is in cent per gram of sugar), it was chosen over the *ad valorem* excise duty (a tax as a percentage of volume) because the specific rates are considered to be relatively easy to administer, although the tax rate requires regular updates to at least keep up with inflation rate (Dahms, 2017). Indeed, on the 1st of April 2019, an inflationary adjustment of 5.2% increased the tax from 2.1 cents to 2.21 cents per gram of sugar above 4g/100ml (South African Institute of tax professionals [SAITP], 2019).

The tax has been welcomed by several institutions such as ADSA, South African NCDs Alliance, but has also been criticized by the South African Sugar Association (SASA), South African Cane

Growers' Association (SACGA), and producers of SSBs (SASA, 2016). The major criticisms are that the tax will lead to job losses and that there is no conclusive evidence that taxing SSBs could reduce obesity and associated NCDs (Taijaard and Vorster, 2018). However, according to Trade and Industrial Policy Strategies (TIPS) (2016), the possible loss of jobs suggested by critics is exaggerated, and data have been incorrectly interpreted.

1.2 Problem statement

Proponents of the tax (including the South African Department of National Treasury and the WHO) quote scientific evidence that high sugar intake and obesity are positively correlated (Dahms, 2017). Taxing SSBs is therefore considered to be an economic mechanism to change consumers' behavior away from consuming SSBs towards healthier alternatives, and hence help to reduce the prevalence of obesity in South Africa.

There is a very limited number of objective empirical studies that have investigated the impact of the sugar tax on the South African economy. Most of the literature published in peer-reviewed academic journals to date has focused more on the health impact of the SSBs tax. Furthermore, most of the grey literature has been written or commissioned by players' parties with a vested interest in the HPL (e.g., manufactures of SSBs, the local sugar industry, and the South African government), and may be biased. More objective empirical studies are, therefore, needed to better inform policymakers about this issue.

The published South African empirical studies to date include but are not limited to the studies by Manyema *et al.,* (2014); Stacey *et al.,* (2017a); Stacey *et al.*, (2017b); Gomo and Birg (2018) and Stacey *et al.*, (2019). The study by Manyema *et al*., (2014) was conducted before the tax proposition and implementation, to estimate the impact of a hypothetical 20% SSBs tax on obesity of South African adults. Using the SSBs own-price elasticity of demand estimates of -1.299 (estimated through a meta-analysis of studies conducted by Escober *et al*., (2013) in several American countries including the USA, Brazil, France, and Mexico), they predicted that a 20% SSBs tax would reduce the average daily energy intake by 30.0 kJ per person per day.

The study by Manyema *et al*., (2014), however, has several weaknesses including the use of the own-price elasticity estimate of demand for SSBs, which was not directly estimated for South Africa, but rather the average elasticity estimate adopted from studies done in other countries including Mexico, Brazil, France, and the USA. These countries are not necessarily comparable to South Africa in various ways including their economic growth. Furthermore, their analysis is based on a 20% tax rate, while the tax rate in South Africa is 10%, hence their results are likely to be overestimated.

In response to the weaknesses of the study conducted by Manyema *et al*., (2014), Stacy *et al*., (2017) estimated the own-price and cross-price elasticity of demand for SSBs, using the Quadratic Almost Ideal Demand System (QUAIDS) and cross-sectional household expenditure data collected by STATSA during the 2010/11 survey. They estimated the own-price elasticity of demand estimates of -1.18 on carbonated soft drinks and -1.17 on concentrates. However, the cross-price elasticity estimates of demand for 100% fruit juices and tea were found to be statistically insignificant, concluding that these items are neither substitutes nor complements in consumption. These findings were not expected, considering that a study conducted by Dharmasena and Capps (2012) in the US using a similar method, estimated the consumption of these items to be positively affected by the American SSB tax. This was also expected in South Africa since 100% fruit juices and tea are tax exempted and are expected to be substitutes for SSBs in consumption.

Using Stacey *et al.*, (2017b) own price and cross-price elasticity of demand estimates, Gomo and Birg (2018) evaluated the health impact of a 10% SSBs tax in South Africa. From a microsimulation model, and cross-sectional data collected during the South African 2010/11 household income and expenditure survey (HIES), they estimated that a 10% SSB tax would result in a 27% reduction in consumption of carbonated soft drinks and a minor reduction in consumption of other SSBs categories like concentrates. They further estimated a 16.97Kj/person/day average reduction in people's energy intake.

Most of these empirical studies have a common weakness, that is, the assumption of a 100% tax pass-through rate. Cawley and Frisvold (2015) defined a tax pass-through rate as the extent to which a tax (in this case a SSBs tax) is passed on to consumers in the form of higher prices. The pass-through rate of the tax is not always 100% (Snowdon, 2016). The pass-through rate of the tax might be less than 100% mainly when the demand for SSBs is relatively more price elastic, producers may absorb some of the tax, which was evident in Berkeley (Felber *et al*., 2015). In other cases, the pass-through rate of the tax might be more than 100% as found in Mexico and France (Grogger, 2017). In response to this weakness, Stacey *et al.*, (2019), used a linear regression analysis to determine the pass-through rate of the SSB tax to SSBs prices. They found no change in price for most tax-exempted beverage categories, i.e., bottled water and 100% fruit juices in containers of 1.2 litres or less. However, for 100% fruit juices in containers with a volume of over 1.2litres, a statistically significant reduction in price was found. For carbonates, the overall pass-through rate was estimated at 68%. However, the pass-through rate was also found to differ by containers, with a larger pass-through rate for smaller containers (<400ml) of approximately 100%, while for larger containers (≥400ml) the pass-through varies between 51% and 56%.

There’s no empirical study in South Africa or in the international literature that has yet investigated how a sugar tax on consumption of SSBs will, in turn, affects the South African sugar industry performance. This will provide important insights regarding the impacts of the SSBs tax on the financial position of sugarcane growers and millers. This study seeks to bridge this gap by employing econometric techniques and time series data to investigate the impact of the SSBs tax on the South African sugar industry.

The aim of this research is therefore to investigate the impact of the SSBs tax on the South African sugar industry. This was achieved by assessing how the SSBs tax has impacted the South African sugar industry's notional price, RV price, the quantity of sugar sold in the domestic sugar market, and the revenue earned by the South African sugar industry at the domestic sugar market.

The study used simultaneous equations modeling (3SLS and 2 SLS models), to assess price and non-price factors influencing the domestic demand and supply of sugar in South Africa. The simultaneous equations were chosen, because of their ability to address the possible endogeneity between price and quantity of sugar demanded/supplied. To determine the short-run and the long-run impact of the sugar tax, the study used cointegration and the VECM. The cointegration and a VECM offer a means of obtaining consistent and yet distinct estimates for both short-run and long-run elasticicities (Gujarati and Porter, 2009).

1.3 Research objectives

This aim of this study is to evaluate the impact of a SSB tax on the South African sugar industry. This will be achieved through the following specific objectives which are to;

i) determine the factors that influence the domestic demand and supply of sugar in South Africa.

i) determine the long-run and short-run elasticities of domestic demand and supply of sugar in South Africa.

ii) estimate the impact of the SSBs tax on the quantity of sugar demanded in the domestic market.

iii) estimate the impact of the SSBs tax on the South African sugar industry performance.

1.4 Organization of the thesis

This study is organized into seven chapters. In the present chapter the background of the study, the problem statement, and the study objectives were outlined. A literature review on the rationale for government intervention using the SSBs tax, the background information about this policy intervention including the scope of the SSBs, the tax base, e.t.c., is presented in chapter two. Adam Smith's criteria of good tax policy are included in chapter two, to assess the conformity of the South African SSBs tax to these criteria. The empirical evidence drawn from other countries that implemented a SSBs tax was further outlined in this chapter. Thereafter, the chapter provides a brief overview of the South African Sugar Industry including its legislative environment, and the challenges currently facing the South African sugar industry.

The study research methodology is outlined in chapter three. In chapter four the results of the diagnostic tests, and the static demand and supply model were outlined and discussed. In chapter five the results of a dynamic demand and supply model were outlined and discussed, while in chapter six the impacts of the SSBs tax on the South African sugar industry were presented. In the last chapter, the conclusions and recommendations drawn from the study were presented.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to present an overview of the peer-reviewed economic literature on fiscal policy interventions to address the prevalence of obesity and overweight, including the use of a tax on SSBs. The chapter begins with a more detailed discussion about the SSBs tax in South Africa. In the next section, the criteria of good tax policy are outlined, followed by a discussion of whether the SSBs tax policy conforms to these criteria. Thereafter, the economic theory on the concept of excise taxation is presented and discussed in the context of the tax on SSBs in South Africa. Finally, empirical evidence, from other countries that have implemented a similar policy is reviewed to understand the likely effects of the policy in South Africa. This is discussed with respect to the legislative environment of the South African sugar industry, the challenges that it currently faces, and its response to those challenges.

2.2 The economic rationale of the SSBs tax

Economists agreed that when conditions of a market failure exist, then government intervention to either directly or indirectly address the reason for market failures may be warranted. For example, if market failures arise due to inadequately defined property rights, the government can intervene to define them adequately, or to counteract the effects of the market failure, i.e., by imposing a tax or a subsidy to align private costs and benefits to public costs and benefits (Cawley, 2004; Finkelstein, 2005 and NZIER, 2017). Under this circumstance government intervention can increase social welfare, not necessarily because the government knows better than private players in the market, but because of the existence of technological or institutional features which implies the fundamental working of the market which normally ensures that all opportunities for gains from trade are exhausted (NZIER, 2017).

With SSBs several market failures are reported to exist (Brownell *et al*, 2009). The first Market failure is a negative externality, which is the costs imposed on third parties through consumption or production (Cawley *et al*., 2019). The consumption of SSBs is believed to impose a negative externality on society because the full costs of consuming SSBs are not fully borne by individual consumers of SSBs (Tiffin *et al*., 2014). The NCDs resulting from the consumption of SSBs impose external costs to the society in the form of large government spending on health care systems, these costs are passed on to the society in the form of higher taxes and higher health insurance premiums (Cawley *et al*., 2009). This causes SSBs to be overconsumed in the society, the tax then aims to reduce consumption of SSBs to a socially optimum level where the full external costs are taken into consideration (Tiffin *et al.*, 2014).

The second and most important market failure is the internalities, defined as the cost that consumers impose on themselves in the future through their behavior (taking actions that are not in their own best interest) in the present. This is also known as a time-inconsistent preference (Allcott and Sunstein, 2015). Many people make consumption decisions with imperfect information, i.e., not knowing the future health impact of high consumption of sugar and other products that have a high sugar content (Taijaard and Voster, 2018). Children especially are a compelling example of this, the extensive marketing of SSBs, further distorts these decisions as they raise the perceived benefits of consuming SSBs. According to Freudenberg (2014), significant resources are invested in the marketing of energy-dense products because they are cheap to produce and are highly palatable. According to Tugendhaft *et al.,* (2015), it is the extensive marketing that led to a 56% increase in Coca-Cola consumption from 2002 to 2012, in 2012 the consumption of

Coca-Cola in South Africa was estimated at 285 serving per person per year, making South Africa a number ten consumer of Coca-Cola in the world.

From a large number of policy instruments that could be used to address market failures associated with the overconsumption of SSBs, Briggs (2016), contends that a sugar tax is best amongst them. This is because the standard economic theory stipulates that an increase in the product price has a negative influence on the quantity of a product demanded. Therefore, the fiscal policy intervention in the form of taxing SSBs can play an essential role in correcting the market failures by incentivizing consumers to reduce their consumption of SSBs (the dietary risk factors for NCDs), through the influence of prices on the quantity demand.

The main reason why SSBs impose a negative externality in the society is that the market price for SSBs does not include the full cost of a product to individuals and society. Therefore, the aim of a SSB tax is to correct negative externalities associated with SSBs consumption by causing producers and consumers of SSBs to internalize the cost associated with their production and consumption of SSBs in the society. The tax on SSBs is an example of a "Pigouvian tax or corrective tax" because its principal objective is to correct for negative externalities, i.e., the growing social costs associated with the high intake of added sugars particularly in the form of SSBs (obesity, diabetes, cardiovascular diseases). Using a SSB tax, various negative externalities associated with SSB consumption (increased health care cost) will be re-assigned from the broader society to SSB producers and consumers. However, some economists argued that a tax alone will not have a significant impact on obesity, mainly because obesity is a multifactorial condition that requires a holistic approach to address (Taijaard and Voster, 2018).

The extent to which a tax on SSB can address internalities is highly dependent on consumers' awareness about the rationale for SSB tax (i.e., to reduce obesity and associated NCDs). The study conducted by Sanchez *et al.*, (2016) in Mexico also revealed that an improvement in consumers' awareness is highly significant in addressing the internalities associated with SSBs consumption, as adults who were more aware of the SSB tax reported a decrease in their consumption of SSBs.

2.3 Scope of the SSBs tax and the tax rate

"The tax is levied on SSBs, which are beverages that contain added caloric sweeteners (i.e., sucrose, high fructose corn syrup (HFCS), etc.), they include but they are not limited to soft drinks, fruit drinks, fruit-juice concentrates, sports drinks, energy and vitamin water drinks, sweetened iced tea, and lemonade, among others" (National Treasury Policy Paper, 2016:16). All other beverage items that contain natural built-in sugars are tax-exempt, i.e., unsweetened milk and milk products and 100 percent fruit juice (Gomo and Birg, 2018). The tax is levied on the SSB based on the sugar ingredient they contain, and the reason for taxing the sugar ingredient rather than the whole product, it's to incentivize producers to reformulate their products by reducing the concentration of the taxed ingredient (South African National Treasury, 2016).

There is controversy concerning the exemption of 100% fruit juices. The South African National Treasury contends that beverage items that contain naturally built sugars have some nutritional value unlike SSBs (South African National Treasury, 2016). Health organizations, such as Healthy Living Alliance (HEALA), contends that government should also include 100% fruit juices in the scope of the tax, because they contain a type of sugar called fructose, with some fruit juices containing even more sugar than soft drinks (Makwela, 2020). The exclusion of 100% fruit juices is, therefore, confusing people and creating the erroneous impression that fruit juices are healthier than SSBs. Including fruit juices is, therefore, seen as a policy decision that will ensure the kind of a tax base that will minimize other types of sugary drinks available for consumers to substitute more expensive SSBs.

Initially, the tax on SSBs was introduced at ZAR 0.0229, equivalent to a 20% tax rate, for all non-alcoholic drinks containing added sugars (Gomo and Birg, 2018). However, due to the intense lobbying by the sugary beverage industry, the tax was reduced to ZAR 0.021 per gram of the sugar content exceeding 4 grams per 100ml, implying that the first four grams of the 100ml are free from the levy (SARS, 2018). The National Treasury (2016), referred to this as a threshold approach excise tax regime, and the main reason for choosing the threshold approach was to provide manufacturers or consumers of SSBs an incentive to reduce their tax liability by shifting to lower sugar-containing SSBs. However, this tax option offers some disadvantages such as being more complex to administer, and the need to adjust the threshold level over time to accounts for inflation. Indeed, on the 1st of April 2019, an inflationary adjustment of 5.2% increased the tax from 2.1 cents to 2.21 cents per gram of sugar above 4g/100ml (South African Institute of Tax Professionals [SAIT], 2019).

2.4 Tax base

According to Lloyd and Mac-Laren (2018), in deciding which tax base to adopt, it is important to reflect the fundamental purpose of the tax, which is to alter the behaviour of SSBs manufacturers, retailers, and consumers. Manufacturers need to be encouraged to reduce the sugar content of their branded drinks, retailers need to pass on the tax-induced price increase as much as possible, and those who consume unhealthy volumes of SSBs need to reduce their consumption of SSBs.

There are two options for the choice of a tax base, i.e., the tax can be based on the value of the purchase or be based on the quantity purchased. In simple economic terms, this is a choice between an *ad valorem* tax and a specific tax (Mac-Laren, 2018). An *ad valorem* tax is a tax specified as a percentage of the product price and, therefore, the tax is levied on the value of sales, the specific tax on the other hand is charged as a fixed amount per unit of the product and so, in effect, it is a tax levied on the volume of sales (Keen, 1998).

According to Lloyd and Mac-Laren (2018), deciding the tax option to implement between an *ad valorem* tax and a specific tax is highly dependent on (a) the policy objectives of introducing the tax, and (b) the assumed market structure in which the tax is applied. In a perfectly competitive single homogeneous good partial equilibrium market, *ad valorem* and specific tax yield the same outcome for the quantity transacted, the price, the tax revenue generated, and social welfare, provided that they are applied at the same rate. In this case, there’s no need to choose between these two forms of tax.

However, there is no perfectly competitive single homogeneous partial equilibrium market, therefore, the specific tax and an *ad valorem* tax will never yield the same outcome. Bonnet and Rèquillart (2013), concluded that if the policy objective is to reduce consumption of sugar, then the specific tax applied to the sugar content is the best choice. Moreover, specific rates are much easier to administer, even though they require regular adjustments for inflation; the *ad valorem* excise duties can be partly avoided through under-invoicing and can, therefore, become complex to administer if there’s no agreement on the value of the good at the point of sale (South African National Treasury, 2016). An *ad valorem* tax base is also problematic when less expensive products are deliberately introduced to undermine the intent of the tax. For all these reasons South

Africa implemented a specific tax. However, according to Lloyd and MacLaren (2018), tax designs that have progressive multiple rates are most likely to have greater efficacy than a single tax rate.

2.5 Good tax policy design

This section aims to evaluate whether a tax on SSBs is a good tax policy, by assessing the Adams Smith criteria of a good tax policy which includes, equity and fairness criterion, certainty criterion, economy criterion, and convenience criterion.

2.5.1. Criteria of a good tax policy

According to Hiort and Leijon (2015), different tax systems are often to a greater or lesser extent, deigned according to Addams Smith's maxims of a good tax policy. In *The Wealth of Nations* (1776), Adam Smith argued that taxation should follow four principles, i.e., fairness, certainty, convenience, and efficiency. These principles are outlined as follows;

i) **Equity and fairness criterion**

According to the equity and fairness criterion, all taxpayers should be taxed on absolute equality bases (Adedokun *et al.*, 2015). In simplicity, this criterion applies the principle of horizontal equity and vertical equity (Dahms, 2017). Horizontal equity provides that two taxpayers with equal abilities to pay (same level of income) should pay the same amount of tax (Association of International Certified Professional Accountants [AICPA], 2017). If a taxpayer has a greater ability to pay than another taxpayer, the concept of vertical equity comes into play, meaning that a person with a greater ability to pay (higher level of income) should pay more tax (Adedokun *et al*., 2015; Dahms, 2017).

ii) **Certainty criterion**

Certainty rather than the ambiguity of a person's tax liability is vital. This criterion provides that the tax rules should specify how the tax amount is determined when the tax payment should occur, and what will be the tax payment method (Hiort and Leijon, 2015). The rules of a tax system must enable taxpayers to determine what is subject to tax (the tax base) and the tax rate(s). Taxpayers should also have the ability to determine their tax liabilities based on the nature of their transactions (AICPA, 2017). Certainty is important to a tax system because it helps to improve compliance with the tax rules and it increases respect for the tax system.

iii) **Economy criterion**

The economy criterion states that the cost incurred by the government from the tax collection should be relatively lower when compared to the tax revenue received by the government (Adedokun *et al*., 2014). If the cost of collecting the tax exceeds the total revenue received from the tax, it is not worthwhile to levy it. Also, a good tax needs to be a little burdensome to the citizens as much as possible, i.e., it must be designed in a manner that the administrative costs incurred by taxpayers are low (Hiort and Leijon, 2015).

iv) **Convenience criterion**

The timing and the tax payment method should be convenient to the taxpayer (Dahms, 2017). A tax on goods or services should be levied at a convenient time for the contributor, i.e., the assessment of a tax upon the purchase of goods should occur at a time of purchase when a consumer still has a choice on whether or not to buy the good. The convenience criterion is vital to ensure that taxpayers comply with the tax system, the more difficult it is to pay a tax, the more likely it that a tax payment will not occur.

2.5.2 Conformity of the sugar tax to the criteria of a good tax policy

The SSBs tax does not conform to Adam Smith's criteria of a good tax policy. Firstly, the tax does not satisfy the equity and fairness criterion, because it is regressive, i.e., the tax burden relative to taxpayer's income decreases as income increases (Adedokun *et al*., 2014). This contradicts the vertical equity principle. A regressive tax is not fair, and it doesn't account for taxpayers' ability to pay. However, the regressive nature of the tax has been counteracted with an argument that low-income populations are the worse affected by NCDs linked to unhealthy eating habits (Taijaard and Vorster, 2018). Therefore, the tax will benefit them as they will replace SSBs with healthier alternatives, e.g., water.

Secondly, the tax does not comply with the economy criterion. The threshold approach used in South Africa complicates the tax base calculation, and hence it increases the administration costs for SARS (Dahms, 2017). Thirdly, the tax does not comply with the certainty criterion, the threshold approach used makes it difficult to calculate the amount of the sugar content contained by each SSB brand. Fourthly, the tax does not meet the convenience criterion, this is because of the difficulties in determining the tax base and the relatively high administration cost is an inconvenience to the taxpayer.

2.6. The economics of excise taxation

Excise taxes are an example of what has been traditionally called indirect taxes, which are taxes imposed on a transaction rather than directly on a person or corporation (Giertz, 2019). Excise taxes are narrow-based consumption taxes, i.e., they are levied on specific goods and services (tobacco taxes, alcoholic beverage taxes, sugary beverage taxes, luxury goods, gambling, etc.), they are also known as 'sin taxes' (Actionaid Internal Briefing, 2018). They can be levied on either domestically produced goods or imported goods. They can also be collected at various stages including the point of production, the wholesale level, or the retail level.

The excise taxes are unlike the general consumption taxes, such as value-added tax (VAT) sometimes referred to as goods and services tax (GST), whose bases are typically defined to include all goods and services (Cnossen, 2010). Furthermore, the primary purpose of levying the general consumption taxes is to raise revenue.

2.6.1 Rationale for excise taxation

The use of excise taxes is justified by a variety of rationales. Most excise taxes in the past and continuing in developing countries have been enacted for revenue purposes, mainly because of their ease of administration than other taxes (Chaloupka *et al*., 2019). This is because goods that are subject to excise taxation are easy to identify, they have a relatively high volume of sales, and they have fewer producers, making them convenient for revenue collection (Cnossen, 2010). Furthermore, these goods generally have fewer close substitutes and most of them are addictive products, hence their consumption remains high despite excise tax-induced price increases, leading to higher revenues being collected.

Excise taxes mostly are levied as charges for the cost that consumers or producers of demerits goods impose on others, but not reflected on prices (Chaloupka *et al*., 2019). The principal objective of excise taxes is to reduce the production and consumption of demerits goods by causing both producers and consumers to internalize the negative externalities imposed by demerits goods in the society, this induces them to reduce their activities to the socially optimal level. According to (Giertz, 1999), taxes that are based on this rationale are also called sumptuary excises, they include taxes on alcoholic beverages, tobacco products, SSBs, etc. When imposed as a technique for dealing with negative externalities they can be termed “Pigouvian (corrective) tax” (Lloyd and MacLaren, 2018). However, most goods and services that are subject to a sumptuary tax have a relatively own-price inelastic demand, as a result these taxes generally have a little impact on consumption (Cnossen,2010).

2.6.2 Regressivity of excise taxes

Because excise taxes are indirect taxes borne by consumers, they are generally regressive (Actionaid, 2018). A large burden of the tax is usually borne by low-income consumers because they tend to spend a larger share of their income on the tax compared to the high-income consumers (Chaloupka *et al*., 2019). However, a counterargument from the proponent of excise taxes is that the health burden is also greater amongst the low-income groups, and hence coupled with their greater price sensitivity, excise taxes have a progressive health impact (Chaloupka *et al*., 2019).

In countering the regressive nature of excise duties, other studies have suggested excise taxes to be made progressive (Cnessen, 2010). The progressive tax is defined as a tax in which high-income earners are required to pay a higher tax than the low-income earners (Warnet, 2007). However, the disadvantage is that the progressivity of excise taxes becomes relatively more complex when the identity of consumers for taxed items and the possibility of exemptions are considered (Actionaid, 2018).

2.6.3 The incidence of an excise tax

When the government introduced taxes on products, how much is paid by consumers (Pass-through rate) is a key question for understanding the incidence of taxation (Antweiler, 2018). The answer to the question of who will bear a large tax burden between consumers and producers depends crucially on the market structure and the product's own-price elasticity of demand and supply (Cawley and Frisvold, 2018).

Assuming a perfectly competitive market, the sharing of a tax burden is largely dependent on the product's own-price elasticity of demand and supply (Kotlikoff and Summers, 1987). For instance, if consumers' demand for sugary beverages is completely own-price insensitive (i.e., the perfectly inelastic own-price elasticity of demand), producers in this circumstance can fully pass on the tax burden to consumers without experiencing a decline in sugary beverage sales. In this case, consumers will bear a full burden of the tax and producers will have no incentive to reformulate.

Another extreme case is when the product demand is perfectly own-price elastic, under this scenario producers will not pass the tax to consumers' (the product price will not change) because they will lose a larger proportion of their sales. In this case, producers of SSBs will have an incentive to reformulate their products to reduce their tax liability by reducing the concentration of a taxed ingredient (sugar). In an intermediate case where the own-price elasticity of demand is partially elastic (neither perfectly inelastic nor perfectly elastic), the tax will be partly paid by producers and consumers, and the exact proportions will be determined by the product own-price elasticity of demand and supply (Krugman and Wells, 2012).

2.7. The intended and unintended consequences of SSBs taxation

Several pieces of evidence from the real-world experiments show that the unintended consequences of the SSB tax are common, whereas the intended consequences are very rare (Snowdon, 2016).

2.7.1 The intended consequences

For the SSBs tax to reduce consumption of SSBs several assumptions must hold. The first assumption is that a larger burden of the tax must be borne by producers (relatively price inelastic demand and a relatively more price elastic supply) so that they can increase consumer prices (pass on the tax to consumers). Given an imperfect competition, exercise taxes could lead to large price increases, in some cases larger than even the tax rate when the taxed goods (SSBs) contain fewer substitutes (Anderson *et al*., 2001). The second assumption requires SSBs to be ordinary goods, i.e., a price increase should reduce the quantity demanded. The final assumption is that the SSBs tax should lead to a significant reduction in total energy intake.

The SSBs tax will raise the price of SSBs, leading to a decline in the quantity of SSBs demand, as a result, people will consume fewer calories thereby reducing the incidence of obesity (Snowdon, 2016). Since obesity is associated with several adverse health conditions, fewer people will get ill. The economic justification for this is that illness from obesity imposes externalities or spillover costs on the rest of the society (Taaijard and Vorster, 2018). Figure 2.1 adapted from Snowdon (2016), provides a summary of how a SSBs tax is supposed to work to lead to its desired consequences, i.e. reduction in obesity and associated NCD.

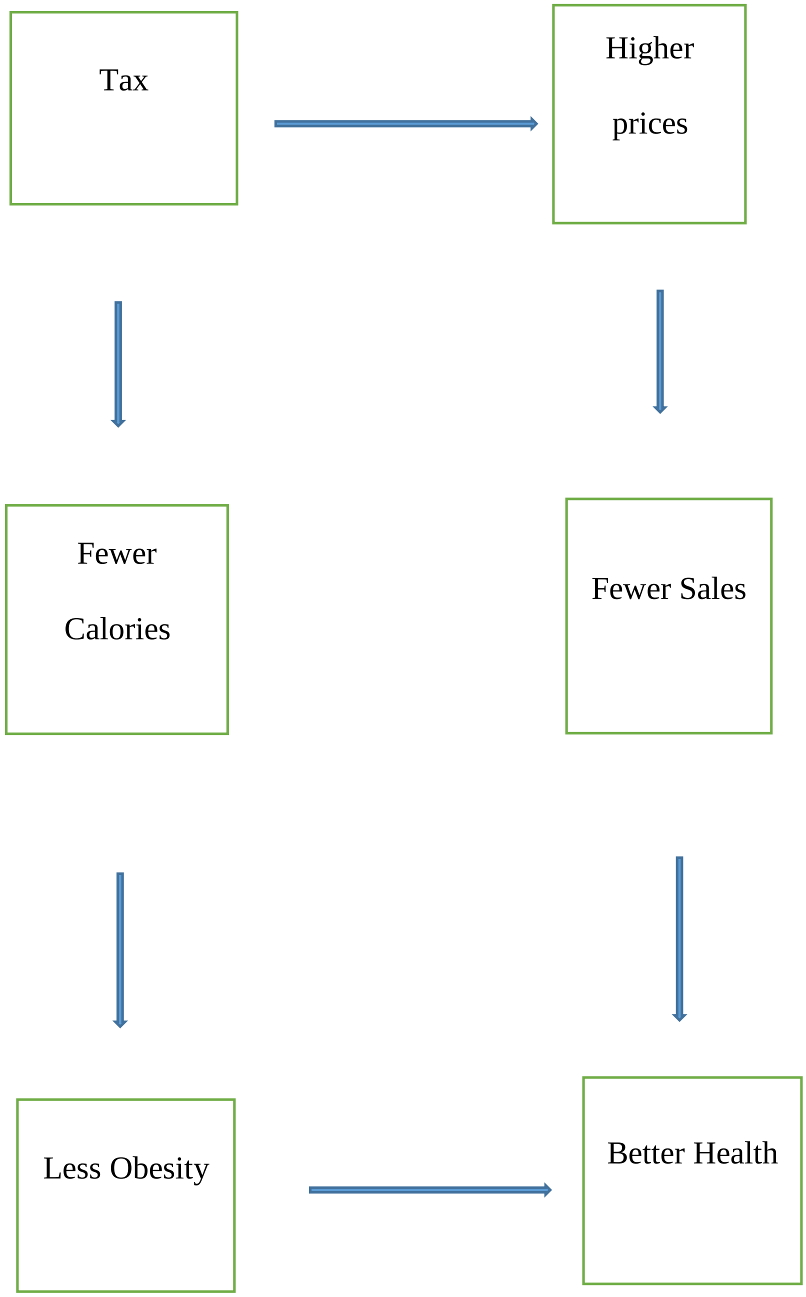


Figure 2.1: A Summary of how the SSBs tax is intended to work (Snowdon, 2016)

2.7.2 The unintended consequences

Many researchers concur that the evidence base linking excessive SSB intake and weight gain is strong, therefore, reducing SSB consumption is a key weight management and weight gain prevention strategy (Malik *et al.*, 2006). However, several researchers have voiced skepticism about whether a tax on SSBs would lead to a significant reduction in obesity. Their arguments are based on the consumers' possibility of substituting for other untaxed high energy-containing beverages, therefore, not necessarily significantly reducing their total energy intake.

Several studies using various cross-price elasticities estimates of demand for SSBs have estimated that an increase in SSBs price would lead to a small increase in the purchase of milk and 100% fruit juice (Andreveya *et al*., 2010). Finkelstein *et al.*, (2010) estimated that a 20% tax on SSBs would reduce the mean caloric intake per capita by 10 Kcal/day, of which 3 kcal (30%) would be compensated for by an increase in other untaxed beverages purchases. However, the effects of compensation and beverage substitution depend on a range of factors, particularly age. For instance, young children consume more milk and juice, they are likely to substitute SSBs with milk or 100% fruit juices (Fletcher *et al*., 2010).

Moreover, there's a possibility that in the long run, the consumption of SSBs will return to normal levels. Fitch Solutions (2019) predicted a gradual recovery in carbonated drinks demand over 2020-2023. This was also evident in Mexico where there was a recovery in spending on carbonated drinks two years after the implementation of a tax on SSBs. Coca-Cola South Africa has already reported a lower decline in its sales volume.

The following is the summary of other several ways in which a tax on SSBs may not lead to better health outcome that it is designed for (Snowdon,2016):

i) Businesses may decide to absorb the tax instead of passing the tax to consumers (the demand for the product is more price elastic) in the form of higher prices. In this case, if prices remain constant, the industry profit will decline but the quantity of SSBs consumed will not decline.

ii) The tax may not be absorbed by the industry, but consumers may value SSBs in a manner that they are willing to pay even higher prices, (i.e., the demand for the product is relatively own-price inelastic), by cutting other parts of their household budget expenditures or simply work longer hours or borrow money.

iii) Consumers may respond to the tax by simply switching to cheaper brands of the product or shopping in cheaper shops. In this case, consumers who switch towards cheaper brands will suffer a welfare loss from consuming inferior goods but will not consume fewer calories.

iv) Consumers may buy less of the targeted product but more of other high-calorie products. For example, consumers may substitute Coca-Cola with beer. Therefore, in this case, the substitution effect triggered by the tax will lead to fewer sales of the targeted product but with no net reduction in the total calorie intake.

v) Manufacturers of SSBs may avoid the tax by switching towards artificial sweeteners. According to FitchSolution (2019), South African SSBs manufacturers are already practicing such, as they are keeping actual sugar at less than 4g and use more of the caloric sweeteners. Sprite now has 3.1 g, iron brew 3.5g, and crème soda 3.7 g of sugar per 100 ml.

2.8 Lessons from other countries that implemented a tax on SSBs

A tax on SSBs has been implemented in several countries and regions. These countries implemented this tax because of a strong belief that high consumption of SSBs is among the leading factors behind the prevalence of obesity and associated NCDs. As a result, a tax on SSB was implemented to disincentivize unhealthy diets and thereby offset the fiscal and economic cost of obesity.

Several studies have been conducted in countries that implemented a tax on SSBs. However, in all these studies the evidence suggesting that the sugar tax improves people's health is weak. The study conducted by the NZIER (2017), pointed out that many of the studies with problems of methodological flows and incomplete measurements (in particular, studies that did not account for consumers' substitution towards other cheaper calories), tends to overestimate the reduction in SSBs demand as a result of the SSBs tax, whereas studies that rely on more soundly methods tend to report the reduction in the intake of SSBs that is too small to generate health benefits and could easily be canceled out by substituting with other sources of sugar or calories.

2.8.1 Mexico

Reducing SSBs intake became the Mexican target in fighting obesity and related NCDs. Public health professionals advocated for the introduction of the excise tax on SSBs manufacturers at a rate of one Mexican peso per litre (10% tax per litre), and they carried out a strong and well-focused public awareness campaign about the health consequences of consuming SSBs (Sanchez *et al*,.2018). The tax became effective from the 1st January 2014 (Seedat and Singh, 2017). The tax was also considered as a source of revenue used to pay for purified water fountains in schools (Donaldson, 2015).

Colchero *et al.,* (2018), conducted a study to estimate the changes in sales of SSBs and plain water after a one peso per litre excise SSBs tax was implemented. Using sales data from the monthly surveys of the manufacturing industry from January 2007 to December 2017 and the Ordinary Least Square (OLS) regression, they found a 12% decline in per capita purchases of SSB after one year of the tax implementation, with a 17% reduction on those from the lower socioeconomic status, and a 9.7% decrease in the second year. Concomitant to the decrease in consumption of SSBs they also found a 4% increase in bottled water purchases after the first year of the tax implementation revealing that people were substituting SSBs with water.

Arteaga *et al.,* (2017), used a time series approach and the beverage industry data to estimate the impacts of a one Mexican peso per litre tax on the consumption of soft drinks in Mexico. They found a 12.8% increase in the price of SSB induced by the tax and a corresponding per-capita reduction in SSBs consumption of about 3.8%, which is relatively smaller when compared to the findings by most studies that used the cross-sectional household survey data.

Sanchez *et al.,* (2016), conducted a study to evaluate the potential signaling effects of the Mexican SSBs tax, by analyzing an association between awareness and opinion about the effectiveness of the SSBs tax on current consumption of SSBs since its implementation. Sanchez *et al.,* (2016), used logistic regression and the cross-sectional analysis of the 2016 survey and food-frequency questionnaire data from the Mexican National Health and Nutritional Survey (ENSANUT). They found that the adults who were more aware of the SSB tax were most likely to report a reduction in their consumption of SSBs. They concluded that a reduction in the purchase of SSBs may not be completely explained by the economic elastic nature of SSBs' demand, but it may also be an outcome of consumers' increasing awareness about the detrimental health effects of SSBs.

2.8.2 United States (Berkeley California)

In November 2014, Berkeley California became the first and the only US city to impose an excise tax on caloric (but not diet) SSBs for public health purposes (Cawley and Frisvold, 2015). Most of the US have sales taxes on SSBs (for revenue purposes), however, they are typically too low to have a meaningful impact on consumption. The tax was implemented at $0.01-per-ounce on SSBs, including soda; energy; sports; fruit-flavoured drinks; sweetened water; coffee and tea; and syrups used to make SSBs (Falbe *et al.,* 2016).

Cawley and Frisvold (2015), estimated the extent to which a tax on SSBs is passed through to consumers in the form of higher prices. They used a difference in difference model and the price data collected from various brands and sizes of SSBs and other beverages before and after the implementation of the tax, from the near census of convenience stores and supermarkets in Berkeley, California, and price data from stores in the control city. Across all brands and sizes of products examined, 43.2% of the Berkeley tax was passed on to consumers.

Dharmasena and Capps (2012), assessed the effects of a 20% tax on SSBs consumption by the US, using the Nielson Homescan Panel data for the period 1998 to 2003 and the QUAIDS model. The consumption of isotonic (sports and energy drinks), regular soft drinks, and fruit drinks was found to have been negatively impacted by the tax. Under the assumption of a 100% pass-through rate of the tax to prices, and consideration of demand interrelationships among non-alcoholic beverages, they estimated a reduction in consumption of isotonic, regular soft drinks, and fruit drinks of 1.98 OZ, 45.03 OZ, and 4.06 OZ per month, respectively.

Falbe *et al*., (2016), used a repeated cross-sectional design to examine the changes in pre-to post-tax consumption of SSBs in low-income households of Berkeley versus cities of Oakland, San

Francisco, and California. They estimated a 21% decrease in Berkeley's sales of SSBs, accompanied by a 4% increased consumption of SSBs in the comparison cities, this was an outcome of cross-border shopping. Water consumption also increased more in Berkeley (63%) than in comparison cities (19%).

2.8.3 Denmark

Denmark introduced a tax on sweetened soft drinks in the early 1930s, which by 2013 was levied at a rate of €0.22 per litre and it raised about €60 million revenue per year. However, the Danish government also reported a loss of about €38.9 million in VAT owing to illegal sales (Hains, 2017). The tax was further criticized as being ineffective in curbing sugar consumption as citizens were able to bypass the effects of the tax by traveling to neighbouring countries such as Sweden or Germany, this activity is commonly known as cross-border shopping (Standfford, 2012). Therefore, the tax was reduced by half in 2013 and it was fully eliminated on the 1st of January 2014 (Northern Island Assembly [NIA], 2015).

Job losses, the regressive nature of the tax, etc., were the other reasons for the Danish government to abolish the tax (Dahms, 2017). Other Danish government's major concerns about the tax were the increasing expenses for administrating the sugar tax.

2.8.4 Finland

Finland introduced a soft drink tax in the early 1940s at a rate of 0.045€/litre (Cappaci *et al*., 2019; Jysma *et al*., 2019). During those times the initial objective of this excise tax was to raise revenue from SSBs. However, during 2011 some adaptations were made to the tax law, the tax was repackaged as a health measure. Finland introduced an excise tax on sweets, chocolates, ice creams, chewing gums, and other naturally or artificially sweetened products in January 2011 (Poloheimo, 2012).

According to Jysma *et al*., (2019), the tax was introduced at a rate of 0.75€/kg on solid tax liable products. In addition, a tax on sweetened beverages was raised from 0.045€/litre to 0.075€/litre. The tax rates were subsequently increased so that from 1 January 2012 onwards, the valid rates were 0.95 €/kg for solid taxable products and 0.11€/litre for sweetened beverages. In January 2014, the tax rate was further increased for sweetened beverages with a sugar content higher than 0.5 g/100ml as the tax rate was raised to 0.22€/litre (Dahms, 2017).

During 2017, however, the Finland government abolished the sweet tax but kept the tax on soft drinks (Jysma *et al*., 2019). The sweet tax wasn't in line with the principle of neutrality which is essential in Finish tax registration (Poloheimo, 2012). The Sweet tax was based on custom categories, not on the sugar content of the products, for instance, products such as candies and chocolates were taxed, but not biscuits and mousses even if they carry the same or high sugar content. This resulted in the production of biscuits with high sugar content, resembling chocolates, and candy more and more.

2.8.5 France

In France, the 'soda tax' of 7.16 cents per litre was introduced in January 2012, following a suggestion that sugar or sweetener-containing drinks are unhealthy, hence their consumption should be reduced (Berardi *et al*., 2016). The French soda tax applies to all non-alcoholic beverages with added sugar or sweetener, such as soda, flavoured water, and fruit-flavoured drinks.

Berardi *et al.*, (2016), examined the effects of the French soda tax on soda prices using the store level price data collected by prixing and the difference-in-difference demand approach. They estimated an average of 7.75 cents per litre increase in the price of soda, equivalent to the 100% tax pass-through. The fruit drink prices increased by 7.1 cents per litre, equivalent to 94% passthrough. For flavoured waters, the prices increased by 4.7 cents per litre, equivalent to a 62% tax pass-through.

Capacci *et al.,* (2019) assessed the effects of the French soft drink taxes on prices and purchases of soft drinks and fruit juices, using the household scanner data and the difference in difference approach. Capacci *et al*., (2019), found that the tax was transmitted to the prices of taxed drinks, with the full transmission for soft drinks and partial transmission for fruit juices. There was an immediate decrease in taxed products sales directly after the implementation of the tax, however the tax effect on quantity purchased was smaller for soft drinks, i.e., a 2% decrease in soft drinks purchases was estimated, but the reduction was larger when the households in the top consumption quartile were considered, a 10% reduction was estimated.

2.9. The SSB industry response to the sugar tax

According to Fitch Solutions (2019), there are three main strategies that beverage producers can adopt to reduce their tax burden. The first possible strategy is product reformulation, i.e., reducing the sugar content of their brands/products to reduce the amount of tax due (Veerman *et al*., 2016). Moreover, SSB producers are aware that some consumers are increasingly becoming more health-conscious, as a result, SSB manufacturers are making large efforts to produce low-sugar drinks that sell equally well or better than high-sugar variates.

Product reformulation is considered by most authors as a strategy that offers the largest potential for health improvements on individuals with obesity, diabetes, and tooth decay (Veerman *et al*., 2016). The Coca-Cola Company has started reformulating its Fanta and Sprite products to reduce the amount of sugar while increasing its focus on zero sugar drinks and accelerating a portfolio expansion of low/no added sugar drinks. According to ADSA (2020), the Coca-Cola company's product reformulation has led to a 26% reduction in the total sugar content of its product.

Product reformulation, however, could either reduce or increase the demand for reformulated products as consumers may take time to adapt to new tastes offered by reformulated products. According to GAIN (2019a), the beverage sector has already reported a reduction in demand for some of its re-formulated products, as consumers have been slow in adapting to new tastes offered by reformulated products. Moreover, they have also reported a decrease in demand for their original products (i.e., products with high sugar content), this might be due to high product prices induced by the SSBs tax, as well as growing consumers' anti-sugar sentiments and awareness that high sugar consumption is linked to obesity, diabetes, stroke, and heart disease.

The second possible strategy is to reduce product pack size, Coca-Cola reduced the volume of its products by 10% (ADSA, 2020), this strategy is known as shrinkflation. Beverage producers' have realized that many consumers tend to be more responsive to a price change than a change in product size, as a result, consumers will not feel any impact on their wallet from this strategy. From the onset of the sugar tax proposition, the company reduced its 500ml can to 440ml, and the standard 330ml cans to 300ml. This strategy is intended to protect the company's gross margins, as the price will remain the same, but the production cost will be lower. A third strategy is the production of zero sugar products. The Coca-Cola company also expanded its production of zero sugar products. This product includes coke zero sugar, tab zero sugar.

There wasn't enough information about other SSBs producers, but it was assumed that they have followed similar practices as the Coca-Cola company. According to GAIN (2019a), these strategies have led to at least a 30% reduction in sugar usage by the beverage industry since the introduction of the tax in April 2018. This translates to a 30% decrease in the amount of sugar sold to the beverage industry since April 2018.

2.10 The anticipated effects of a sugar tax on the South African SSBs industry, total energy intake, and government revenue.

This section outlines the likely effects of a sugar tax on the South African SSBs industry (consumption of SSBs, and the real price of SSBs), people's total energy intake, and government revenue, by using the recent own price and cross-price elasticity of demand for SSBs estimated in South Africa.

2.10.1 The effects of the SSBs tax on the price of SSBs

Although SSB producers are sometimes able to absorb some or all the tax without raising prices, experiences have shown that in the case of a SSBs tax they are likely to increase profits by raising prices beyond what is needed to accommodate the tax (Snowdon, 2016). The extent to which prices will increase relative to the tax (the pass-through rate of the tax) depends on factors such as consumer's responsiveness to price changes, i.e., the own-price elasticity of demand. In general, the demand is relatively more own-price elastic, the larger the number of close substitutes in consumption, the larger the number of alternative uses to which a commodity can be put to, the larger the proportion of income spent on the commodity, the more luxurious the commodity is, the longer the time planning horizon, etc., (Guerrero-Lopez *et al.,* 2017). In the case where the demand is relatively own-price inelastic, it is in the sellers' interest to pass on a larger burden of the tax to consumers in the form of high prices, since by not doing so, they would simply reduce their profits for a very little commercial gain (NZIER, 2017). However, sellers may also have an incentive to bear some of the economic burdens of the tax, to maintain their sales volumes in the presence of untaxed substitutes. In the case where the demand is relatively more price elastic, the large burden of the tax will be borne by sellers since consumers will be more responsive to price changes.

In South Africa, the own-price elasticity of demand for SSBs was estimated by Stacey *et al.*, (2017b) to be imperfect elastic (-1.18), using a combination of the expenditure survey and sub-national price data with the QUAIDS. Therefore, in the South African case, some, but not all of the tax may be passed on to consumers in the form of higher retail prices. However, it remains unclear whether this is a long-run or short-run own-price elasticity estimate. Furthermore, Stacey *et al.*, (2017b) used data for a period in which there was no significant product reformulation taking place, consumers may be more responsive now as there are more reformulated products in the markets, i.e., low/zero sugar products.

According to Cawley *et al.*, (2019), the pass-through rate of the tax (the percentage by which tax is passed on to consumers in the form of higher prices) may vary across countries and cities because the own-price elasticity of demand for SSBs may vary based on local preferences for SSBs, income levels, and the extent by which residents consider untaxed beverages to be close substitutes for taxed beverages. Cross-border shopping, i.e., the consumers' ease of access to untaxed beverages from neighbouring countries may also increase the own-price elasticity of demand for SSBs and reduce the tax pass-through rate.

The evidence of the pass-through rate of the SSBs tax is inconclusive. For instance, the study conducted by Groggier (2017) in Mexico found an over-shift (more than 100% pass-through rate) of a nationwide soda tax to the retail prices of soda. In Mexico, a 9% tax increased the price of high-calorie soda by 12%. A similar outcome was reported by Berardi *et al.*, (2016) in France.

However, Berkeley's soda tax was found to have modest effects on prices, the pass-through rate of this tax type was about 47% for the overall SSBs, and 69% for soda (Cowley and Frisvold, 2015; Falber *et al.*, 2015). However, even if the tax fully translates to higher prices, it remains uncertain whether it will be an effective measure to address obesity and overweight.

In the short run, however, the price may not change. This is because in the short run prices tend sticky (Perloff, 2012). Therefore, in the presence of untaxed close substitutes for the product in question, sellers will have to bear some of the economic burdens of the tax to maintain their sales volume (NZIER, 2017). However, in the long run, this is unlikely to occur as it will imply that SSB producers' are operating at a loss. Furthermore, in the long run, they will have enough time to reformulate their products thereby reduce their tax liability.

2.10.2 The effects of the SSBs tax on consumption of SSBs

The basic economic theory deduces that higher prices generally decrease the quantity demand of a commodity (Quirmbach *et al.*, 2018). If, however, a product takes a large proportion of consumers' spending the price increase will only reduce the quantity demanded of the commodity if a decrease in consumers' real disposable income is large enough to make consumers change their shopping behaviours (Snowdon, 2016).

The SSBs tax reduces the consumption of SSBs through two main effects (Fitchsolutions, 2019). The first effect is the purchasing power effect, the higher SSBs prices induced by the SSBs tax reduce consumers' real disposable income, this is the key reason why low-income households are largely affected by the SSBs, since they spend a larger proportion of their income on SSBs. The second effect is the substitution effect. As SSBs become more expensive, the likelihood of consuming less expensive drinks instead of more expensive drinks will increase. It is expected that this substitution effect will have a positive impact on demand for mineral waters, fruit and vegetable juices, as consumers are expected to switch to these alternatives which are deemed healthier. Fitch solutions (2019) forecasted that consumer spending on mineral water will increase from ZAR 499 million in 2018 to ZAR 1.07 billion in 2023. However, consumers can switch from more expensive brands to less expensive brands with the same or more sugar content, violating the principal objective for taxing SSBs.

Like the effect of a SSBs tax on SSB prices, the effects of a SSBs tax on the consumption of SSBs depend more on the own-price elasticity of demand for SSBs. The own-price elasticity of demand is defined as the percentage change in the quantity demanded of a good resulting from a 1% change in the good own price (Powel e*t al.*, 2013). Understanding the own-price elasticity of demand for SSBs is thus a key consideration before concluding on the extent to which the consumption of SSBs will be affected by the SSBs tax (Powel *et al*, 2013). The relatively less price elastic demand for SSBs will imply that consumers are less responsive to price changes and hence the quantity consumed will decrease by a smaller extent given a tax-induced price increase. However, a relatively more price elastic demand for SSBs will mean a large decline in SSBs consumption given a tax-induced price increase.

Stacey *et al.*, (2017b) estimated the demand for SSBs in South Africa to be relatively own-price elastic (-1.18). This implies that the consumption of SSBs is more likely to decrease with an increase in the price of SSBs, making SSBs tax a cost-effective measure for reducing consumption of SSBs. Mexico is an example, as a 10% tax per litre tax on SSBs which caused a 12% increase in the real price of SSBs, it's experienced an approximately 8% reduction in the purchase of SSBs within one year of the tax implementation (Sanchez *et al.*, 2018).

Moreover, the effect of a price increase (due to a SSBs tax) on the consumption of SSBs will vary between different income groups, as consumers' price responsiveness varies across different income groups, with high-income consumers' of SSBs being less responsive to changes in SSBs price compared to low-income consumers' (Sharma *et al.*, 2014). As a result, the large reduction in consumption of SSBs is likely to be by low-income consumers. Figure A1 in Appendix A, adopted from Stats SA (2019) reports on household beverages consumption expenditure, shows the South African household consumption expenditure on different beverage categories during mid-2019. Beer consumption at 36.5% is higher than all other beverage categories, followed by fizzy drinks (13.3%), the liqueur has the lowest consumption expenditure (1.2%). The wine and whiskey consumption expenditures at 7.2% and 5.6%, respectively are relatively higher than even the expenditure on coffee (5.6%) and fruit juice (4.3%), probably because wine and whiskey are expensive relative to coffee and fruit juice.

2.10.3 The effects of the SSBs tax on the total energy intake

The economic theory of demand predicts an inverse relationship between the price of SSBs and the quantity of SSBs purchased and hence consumed. However, using the SSBs tax as a way of improving people's dietary habits is far more complicated. This is because food is a necessity, and hence the overall consumption of food is relatively insensitive to price changes. When the relative prices of food change, consumers substitute the relatively more expensive food items with relatively less expensive food items. Therefore, if the price of SSB increases consumers may shift their consumption towards other cheaper high energy-containing beverages (Sarlio-Lahteenkorva and Winkler, 2015), such as fruit juices, or switch towards the same products categories that are inferior (i.e., switch from Coke to Zip). In this case, the daily energy intake may remain unaffected or may even increase. Alternatively, they may shift towards diet drinks or water, resulting in a net reduction in their total energy intake (Quirmbach *et al*., 2018).

The extent to which consumers switch towards SSB substitutes is strongly dependent on the cross-price elasticity of demand for SSBs. Cross price elasticity of demand for SSBs measures the change in quantity demand of a given SSB when the price of another product changes. The early literature ignored substitution (cross-price effects) and focused only on the own-price elasticity of demand to estimate changes in caloric intake, weight reduction, and tax revenue. As a result, they produced misleading results (Brownell *et al*., 2000). Cross-price elasticities of demand need therefore to be considered carefully when planning and designing food taxes.

High-calorie substitutes for SSBs include fruit juices, full-fat milk, wine, and beer. The evidence shows that consumers indeed do switch to these drinks to some extent when SSBs are taxed (Snowdon, 2016). The study conducted by Spoon University (2019), compared the sugar and calorie content of various fruits juices for selective brands including Minute Maid (apple juices), Tropicana (orange juice), Dole (pineapple juice), Ocean Spray (cherry juice), simply lemonade juice, with selective brands of PepsiCo (Mountain Dew and Pepsi drink), Coca-Cola Company (Sprite, Coca-Cola and Fanta). A nearly similar sugar and calorie content was estimated, i.e., a 100ml can of Coca-Cola has 11.7 grams of sugar and 22 calories, while 100ml Minute Maid apple juice has 10.9g of sugar and 46.7 calories, a 100ml can of Fanta drink has 11.8g of sugar and 50.6 calories, while a 100ml Simply lemonade juice has 11.8g of sugar and 50.6 calories.

Several studies abroad have estimated the effects of the SSBs tax on total energy intake. Zhen *et al.*, (2011) using a Consord Exact Affine Stone Index Incomplete Demand (CEASIID) system approach, estimated a 13.2 kcal reduction in calorie intake for low-income populations and 5.6

Kcal for high-income population, because of one-half cent per ounce tax on SSBs in the US. Smith *et al.*, (2010) using the Almost Ideal Demand System (AIDS) also estimated a 36.9 Kcal decline in calorie intake per day in adults and 42.7 calories decline per day in children's following a 20% soda tax in the USA. Arteaga *et al.*, (2017) estimated a 3.5% reduction in the total energy intake in Mexico following a 10% SSBs tax, using the industry data and time-series data modeling approach.

In South Africa, a few studies also evaluated the impact of the sugar tax on total energy intake. Gomo and Birg (2018) estimated a 16.97kg/person/day total energy reduction following a 10% tax, using the own-price elasticity estimates from the study done by Stacey *et al.*, (2017b). Manyema *et al.*, (2014), under a 20% tax consideration, found a reduction in total energy intake of 36 KJ per person per day, using a mathematical simulation model.

2.10.4 The effects of the SSBs tax on government revenue

The main objective of the SSB tax is to reduce the incidence of obesity by reducing the consumption of SSB. However, it is still debatable that the other objective is to generate revenue for the government, which will be allocated for the provision of merit goods such as better health care services, safe and clean water, and subsidize healthy food items, etc.

According to the SAITP (2019), by 31 December 2018, the sugar tax raised about R3.25 billion in revenues, of which the taxation on locally produced sugary drinks comprises R3.2 billion of this amount. This is 1.32 billion higher than government revenue projections when the SSBs tax was introduced in April 2018, i.e., revenue projections of about R1.9 billion. According to the (SAICA) (2019), this is also higher in comparison to other behavioral taxes, which includes all plastic bag levy, universal service fund, levies on financial services, CO_2 motor vehicle emissions, incandescent light bulb levy, tire levy, and International Oil Pollution Compensation Fund (IOPCF).

These higher revenue projections might either suggest a lag effect in terms of consumers' response to changes in the price of SSBs or consumers are relatively less responsive to a change in the price of SSBs (in contradiction with Stacey *et al.*, (2017b) own-price elasticity estimate of demand for SSBs, i.e., -1.18). Implying that to date a SSBs tax has been less successful at achieving its objective of reducing the consumption of SSBs. Several organizations including Healthy Living Alliance (HEALA), ADSA, etc., which are in support of the HPL have requested the South African National Treasury to consider increasing the tax to the initially proposed 20% rate (ADSA, 2020).

2.11 The general overview of the South African sugar industry

The South African sugar industry is more than 150 years old and is important not only for its GDP contribution (Bureau for Food and Agricultural Policy [BFAP], 2014). Between 2009 and 2012, sugarcane was the largest agricultural commodity produced in South Africa by volume and the seventh-largest agricultural commodity produced by value, furthermore, it represented about 17.4% of the total annual value of field crop production (Department of Agriculture, Forestry and Fisheries [DAFF], 2014).

The South African sugar industry comprises of a symbiotic relationship between sugarcane growers, represented by the South Africa Cane Growers Association (SACGA) and South African Farmers' Development Association (SAFDA), and millers', who are represented by the South African Sugar Millers' Association (SASMA) (South African Sugar Industry Directory, [SASID], 2019). Their mutual dependent relationship is managed by the South African Sugar Association (SASA), which is an organization that represents the interest of both parties at the industrial and agricultural sector level. SASA provides both SACGA and SASMA with specialized independent services in administration, marketing, logistics, and research activities of sugarcane cultivation, and the industrial factory production of raw and refined sugar, syrup, and specialized sugars, and a range of by-products and co-products. Moreover, the South African sugar industry has the potential to become a producer of renewable energy, biofuels, and bioplastics in line with developments in the global sugar sector (SASA, 2019).

There are about 21 926 registered sugarcane growers in South Africa, however, this represents a steep decline from 50 000 registered sugarcane producers during 2003 (National Agricultural Marketing Council [NAMC], 2011 and SASA, 2020). The possible reasons for this decline might be a steep rise in input prices, anomalous weather patterns including severe droughts experienced during the 2015/16 production season, lack of finance because of a global recession. Another reason that accounted for a significant decline in the number of sugarcane growers was the abolishment of an A& B pool price. Previously small-scale growers were paid a higher A-pool price which guaranteed a premium price that was well above export prices (Darroch and van der Riet, 1994). Of the 21 926 sugarcane growers, 20 771 are small-scale growers producing about 10% of the total crop (SASA, 2020). About 1 126 are large scale growers producing approximately 80% of the total sugarcane crop, the remaining 10% of production is accounted for by miller-cumplanter (MCP), which usually refers to sugarcane estates owned directly by millers but sometimes also includes ‘group’ schemes, such as in restitution cases (Dubb, 2020).

A map showing the sugarcane production areas in South Africa is presented in Figure 2.2.

Figure 2.2: Map of sugarcane production areas in South Africa (SASA, 2019)

The map shows that sugarcane is grown in the KwaZulu-Natal and Mpumalanga province (SASID, 2019). The KwaZulu-Natal province is the predominant sugarcane growing region, with its sugarcane growers contributing approximately 87% of the gross farming income earned by sugarcane farmers in South Africa (SASA, 2016). About 95% of the sugarcane production in KwaZulu-Natal province is rain-fed, with limited irrigated areas, while the production in the Mpumalanga province is fully irrigated using the center-pivots, sprinklers, and the canal system (GAIN, 2019a).

The South African sugar industry is amongst the world's leading cost-competitive producers of sugar ranking in the top 15 out of approximately 120 sugar-producing countries worldwide (SASA, 2019). Noyakaza (2019), assessed the competitive status of the South African sugar industry during the period 2001 to 2012 relative to the top 10 sugar-producing countries, namely, Brazil, Thailand, China, Mexico, Belgium, Netherlands, Canada, Germany, and the USA. Three indices, i.e., Balassa Revealed Comparative Advantage (RCA), the Net Export Index (NXI), and Relative Trade Advantage (RTA) of Volrath were employed. The indices revealed that the South African sugar industry is competitive, but its competitive performance was surpassed by Brazil (most competitive) and Thailand. It was further noted from Noyakaza's (2019) findings that although the South African sugar industry remained competitive, its competitive status has been declining.

The industry produces an estimated average of 2.2 million tons of sugar per season, from about 20 million tons of sugarcane crushed (SASA, 2020). However, during the 2015/16 season, the sugar industry reported a decline to approximately 1.6 million tons of sugar (SASA,2016). This could be attributed to different factors including the severe 2015/16 draught which affected most of the central and eastern parts of South Africa and was declared the worst drought since 1992 (SASA, 2016). Almost 75% of sugar produced in South Africa is marketed in the Southern African Customs Union (SACU), which is known as Local Market Demand (LMD), it consists of South Africa, Botswana, Lesotho, and Namibia. The remaining 25% is sold to the other parts of Africa, Asia, and the Middle East (SASA, 2014). The LMD market usually takes first preference, given its relatively lucrative and stable prices, while the export market is more subjected to price and exchange rate volatility.

Sugar is a consumer product sold directly to the public, a raw material for the food and beverage industry. According to GAIN (2019), the industrial demand for sugar accounts for about 60% of the total domestic demand for sugar, the remaining 40% is the household demand for sugar.

Sugar is manufactured by 6 milling companies with 14 sugar mills operating in the sugarcane growing regions, the Kwazulu-Natal region alone has 12 mills, while the other two mills are in Mpumalanga (Mahmood, 2013). The 12 sugar mills in KwaZulu-Natal are located at Pongola, Umfolozi, Amatikulu, Felixton, Darnall, Gledhow, Maidstone, Umzimkhulu, Sezela, Eston, Noodsberg, and Dalton. These mills can further be categorized into five regions, namely North Coast, South Coast, Midlands, Tugela, and Zululand. The other two sugar mills are in Mpumalanga, in the Malelane and Komatipoort regions (SACGA, 2012). These mills are distributed amongst six companies including, Illovo sugar limited, Tongaat-Hullet Sugar Limited, RCL foods sugar and milling (PTY)LTD, Gledhow Sugar Company (PTY)LTD, UCL company limited, and Umfolozi sugar mill (PTY) LTD. These sugar mills are located near the cane supply because sugarcane is a bulky commodity that requires rapid post-harvest processing to preserve the sucrose in the cane stalk (SSID, 2019). The financial feasibility of these significant capital investments (sugar mills) is therefore dependent on the sustainable sugarcane supply in each mill supply area.

2.11.1 The structure of the South African sugar industry

The structure of the South African sugar industry is presented in Figure 2.3.

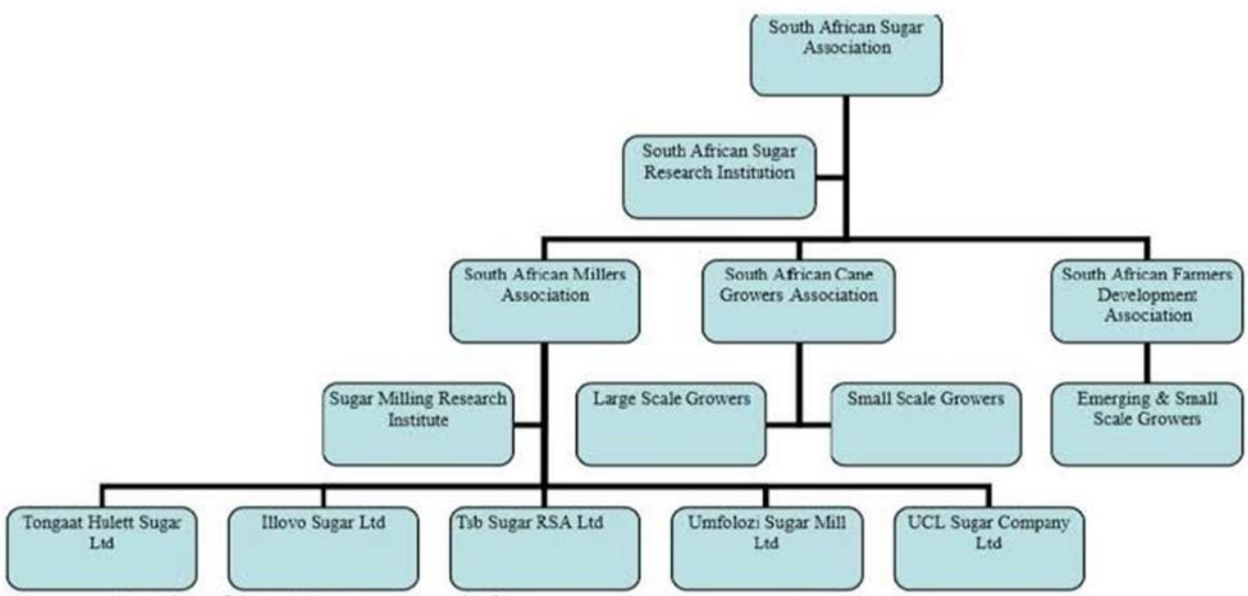


Figure 2.3: The structure of the South African sugar industry (SASA, 2014)

The South African Sugar Association (SASA) is considered as the highest decision-making authority in the industry on common issues of interest for sugarcane growers and millers. The South African Sugar Research Institute (SASRI) is tasked with researching sugarcane varieties, pests, diseases, and crop protection. Moreover, SASRI provides extension and meteorology services to industry players (Sihlobo, 2018). The Sugar Milling Research Institute (SMRI) is also involved in research and technical services for the South African sugar milling and refining industries.

The South African sugarcane growers are represented by the South African Cane Growers Association (SACGA) and South African Farmers Development Association (SAFDA). The South African Sugar Millers Association (SASMA) represents the interest of the six sugar millers: Tongaat Hulett Sugar Ltd, Illovo Sugar Ltd, RCL Foods Sugar and Milling (PTY)LTD, Gledhow Sugar Company, Umfolozi Sugar Mill Ltd, and UCL company Ltd.

2.11.2 The sugar industry contribution to the South African economy

The independent survey of the costs of production for more than 100 global sugar industries, ranked the South African sugar industry among the top 15 competitive producers of high-quality sugar (Pilusa, 2016). This makes the South African sugar industry to be an integral part of the country's economy through its contribution to South Africa's foreign exchange earnings. This is because the South African sugar industry is a net exporter of sugar, with the net export value of all sugar products ranging between US$200m and US$300m since 2000 (SASA, 2019).

The sugar industry provides approximately 85 000 direct job employment (representing more than 11% of the total agricultural workforce) and 350 000 indirect employments in numerous support industries in the two provinces where sugarcane is grown and processed, namely KwaZulu-Natal and Mpumalanga (SASA, 2019). This represents a significant percentage of the total agricultural workforce in South Africa. Furthermore, it is estimated that about one million (2%) of South Africa's population depend on the sugar subsector for providing a living (SASA, 2017). The sugar industry also supports sugarcane farmers' who are registered with SACGA and SAFDA as they receive an RV price payment for the tonnage of sugarcane, they deliver to the sugar industry for crushing.

2.11.3 Trends in sugarcane and sugar production over the years

Sugarcane and sugar production in South Africa has decreased significantly since the 2000/01 season driven by both decline in area under cane and cane yield. Over the past decades, the tons of sugarcane harvested decreased from 23.8 million tons during the 2000/01 season to 16.7 million tons during the 2011/12 season, this is equivalent to a drop of about 7.06 million tons or 29.7% (BFAP, 2018). The BFAP (2018), contended that a 51% or just over 47 000-hectare decline in small-scale growers' area under cane was the main reason for a yield decline. Moreover, the severe 2015/16 droughts were another reason for such a drastic drop in sugarcane and sugar production during the 2015/16 season (AgriSETA, 2018). Cane crushed decreased by 2 894 million tons during the 2015 /16 season, this negatively affected the quantity of saleable sugar produced, i.e., the sugar produced dropped by 508 016 tons to 1 684 354 tons from 2 192 370 during the 2015/16 season (SASA, 2017). From the season 2017/18 to 2019/20 season onwards, the sugarcane and sugar production started to retain back to its normal yields, it is estimated to have increased from 1 607 592 tons during the 2016/17 season to 2 328 750 during the 2019/20 season.

The area under cane, area harvested, sugarcane crushed, and the total sugar production in tons from 2011/12 to the 2019/20 production season are presented in Table 2.1. The table shows that between the 2012/13 and 2013/14 seasons the total tons of sealable sugar produced (both national and international market) increased from 2 019 821 tons to 2 435 229 tons, but between the 2014/15 and 2016/17 seasons saleable sugar production decreased drastically, i.e., there was a drop in sugar production of about 26.7%. The reasons for this huge drop include a decline in area under sugarcane and 2015/16 droughts that affected eastern and central South Africa, considered to be worse since 1992

Table 2.1: Trends in sugarcane and sugar production in South Africa (2012-2020)

Season	**Area under cane (ha)**	**Area harvested (ha)**	**Cane crushed (tons)**	**Sugar production (tons)**
2012/13	371,662	257,095	17,278,020	2,019,821
2013/14	378,922	265,939	20,032,969	2,435,229
2014/15	381,707	272,590	17,755,504	2,192,370
2015/16	370,335	258,497	14,861,401	1,684,354
2016/17	360,000	260,000	15,074,610	1,607,592
2017/18	362,000	275,000	17,388,177	2,063,507
2018/19	363,000	280,000	19,031,688	2,257,502
2019/20	365,000	282,000	19,500,000	2,328,750

Source: Global Agricultural Information Network GAIN (2019b)

The decline in area under cane and draughts decreased both sugarcane harvested and crushed during the 2014/15 and 2015/16 seasons. After the 2015/16 season, the table shows a return to normal levels for both sugarcane crushed, and sugar produced. The improvement in sugarcane quality, better factory recoveries, and an increase in sugarcane delivered to the mills for crushing were amongst the reasons for the improvement in cane crushed and sealable sugar produced post-2015/16 season (GAIN, 2019).

2.11.4 The sugar industry pricing system

The cane payment system is a sensitive issue that is seldom debated and documented in the public domain, as it can be a subject of mistrust and sometimes conflicts between farmers' and millers' (Lejars *et al*., 2010). Furthermore, they are often based on complex sophisticated formulae that are country-specific or mill specific, therefore, misunderstanding arises over time (Ledjers *et al.*,2010). During the period 1926-1999, the South African sugar industry was using the sucrose-based payment system. With a sucrose-based payment system, the division of proceeds between growers and millers was determined by the quantity of sucrose delivered to the mill, with little consideration of the recoverable content of sugar (Moor, 2000). In doing so the sucrose cane payment system had a weakness of failing to recognize each grower's contribution to the production of high-quality sugar. This is because not all the sucrose in cane delivered to the mill can be recovered as sugar, according to Kadwa (2019), the amount of sugar that can be extracted during the milling process does not only depends on cane sucrose content, but it also depends on non-sucrose and fibre.

The sucrose-based cane payment system further reduces individual sugarcane producers' incentive to improve their sugarcane quality since the benefits resulting from quality improvements were shared equally amongst all growers (Moor, 2000). As a result, growers do not bear the full cost of excessive time delays between the period of sugarcane harvesting and sugarcane crushing, thereby reducing growers' incentive to avoid delays from sugarcane harvesting to crushing, leading to a loss in sugar quality (measured as recoverable sugar).

The SASA Cane Quality Task Group was formed in 1996, following the inherent weaknesses of the sucrose cane payment system. The Recoverable Value (RV) cane payment system was then introduced during the 2000/01 milling season, to incentivize growers to produce high-quality sugarcane, i.e., to maximize sucrose, while concurrently minimizing non-sucrose and fibre content-with the negative impact of fibre being greater than non-sucrose content (Kadwa, 2019). Under this payment system, growers are paid based on the quality of sugarcane they deliver at the mills known as Recoverable Value (RV) tonnage, their payment is determined by using the industry agreed division of proceeds formula (discussed in details in section 2.11.6). The price paid to sugarcane growers' is known as RV price. The RV price per ton is determined by dividing growers' share from industry proceed with the total tons of RV cane delivered by growers' to the mill in a given season, after accounting for operating cost (Pilusa, 2016).

The RV payment equation can be written as follows:

$$RV\% = S - dN - cF \quad (2.1)$$

Where;

RV%: recoverable percentage value.

S: sucrose % cane delivered.

N: non-sucrose % cane delivered.

F: fibre % cane delivered.

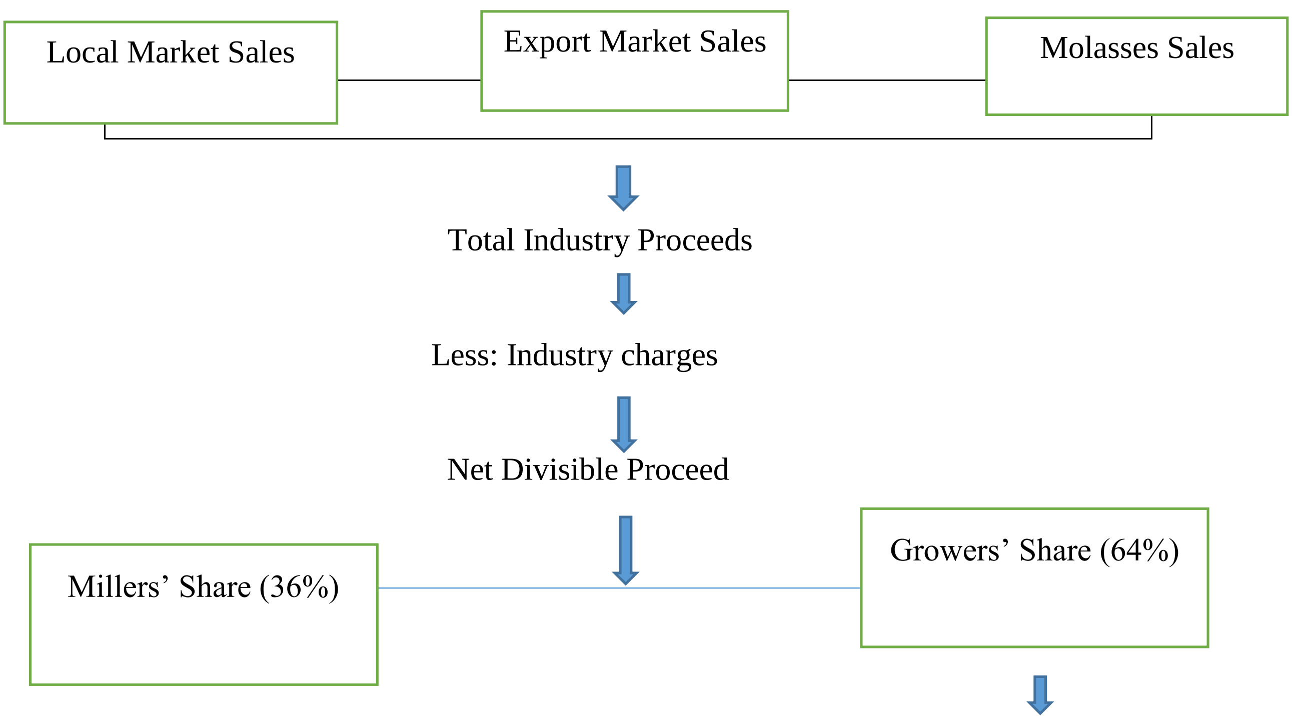
d: the relative value of sucrose lost from sugar production per unit of non-sucrose taking into account the value of molasses recovered per unit of non-sucrose.

c: loss of sucrose from sugar production per unit of fibre.

The RV% cane generally ranges from 9% to 14% throughout the sugar milling season (Kadwa, 2018). From the RV payment equation, it can be shown that the RV payment system penalizes (rewards) growers for producing poor (high) quality sugarcane by subtracting non-sucrose and fibre content from the total sucrose of delivered sugarcane.

2.11.5 Sugar industry proceeds and the price system

The RV price is determined using the sugar industry division of proceeds formula is illustrated in Figure 2.4.



$$\text{RV Price} = \frac{\text{Growers Share of divisible proceeds}}{\text{Total tons RV delivered in the industry}}$$

Figure 2.4: The South African sugar industry division of proceeds formula (SASA, 2017)

The various sugar industry costs including the SASA administration levy and, South African Sugarcane Research Institute (SASRI) funding, among others, are deducted from the total industry proceeds which is the gross revenue received from domestic and export sales of sugar and molasses, to yield industrial net divisible proceeds. The net divisible proceeds are then divided between farmers and millers according to the fixed division of proceeds ratio to yield the Farmers' Share (FS) and Millers' Share (MS). The FS is approximately 64% of the industry proceeds, while the MS is approximately 36%. Proceeds are estimated and distributed monthly until the fixed price per ton of RV paid to farmers is calculated at the end of the season by dividing FS by the total tonnage of RV cane delivered for milling.

The LMD receives priority to the South African sugar industry. This is because prices realized from the local sugar market are typically higher than sugar export prices. The difference in local and export market prices is attributable to the protection afforded to the sugar industry against world distortion. The South African government protects the sugar industry from imports by using an import tariff, based on the Dollar-Based Reference Price (DBRP). The DBRP is implemented through a variable tariff formula (Mboyisa, 2017). In South Africa, the DBRP is currently at $680 per ton (DTI, 2019). This DBRP is designed to ensure that an importer will pay at least the equivalent of $680 for imported sugar (Kadwa, 2018).

Price discrimination is another factor that is responsible for local market prices being lower than the export prices. The price discrimination is an outcome of sugar export demand being relatively more price elastic relative to the local demand for sugar. According to SACGA (2019), this is owing to a large supply of sugar in the export market, because of many sugar-producing countries benefiting from production subsidies and other forms of their government interventions.

2.11.6. Trends in the RV price

The trends in the RV price paid to growers from the 2012/13 season to the 2018/19 season is outlined in Table 2.2 and Figure 2.5, respectively.

Table 2.2: The trends in the real RV price paid to growers (2012-20)

Season	**Price (Rands/Recoverable Value Ton)**	**Percentage Change**
2012/13	3 197. 32	6%
2013/14	3 137. 87	-2%
2014/15	3 437. 97	10%
2015/16	3 979.22	16%
2016/17	4 931 .91	24%
2017/18	4 187. 11	-15%
2018/19	3 574. 41	-15%
2019/20	4220.58	18%
2020/21	4677.41	11%

*Values are in real terms (ZAR 2010)

Source: SACGA (2020**)**

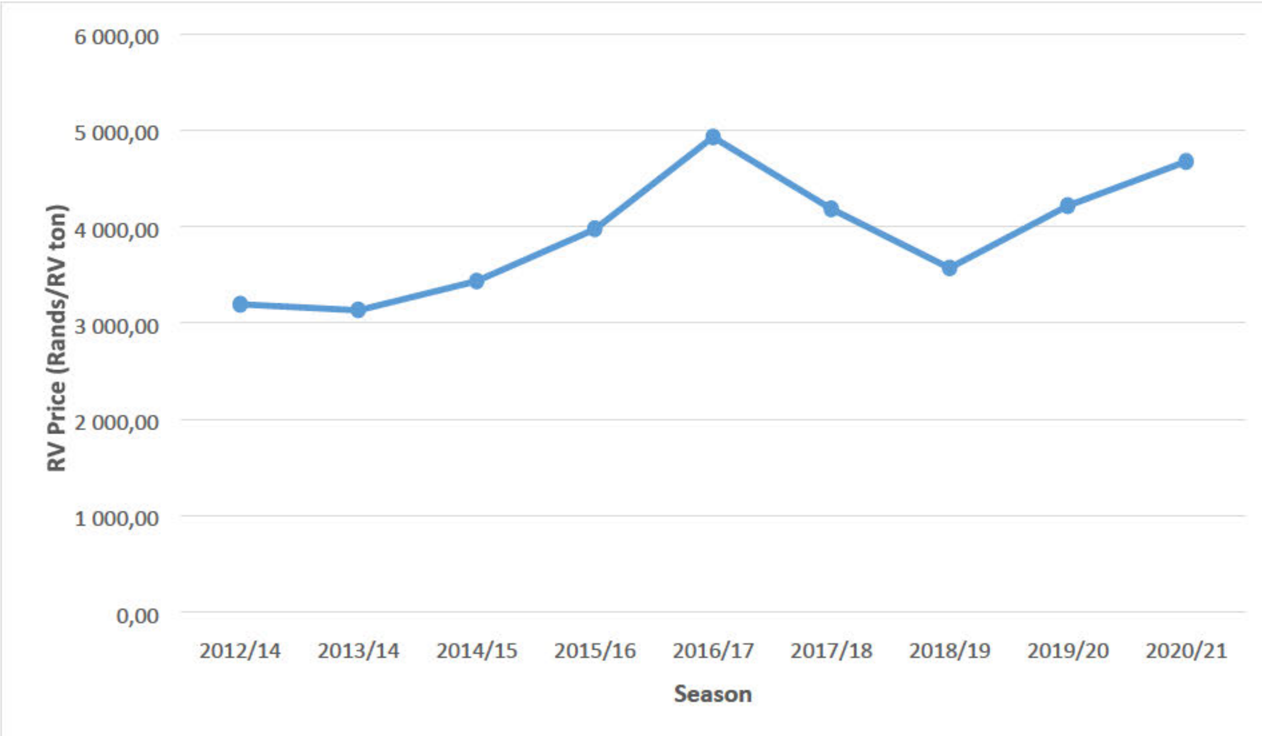


Figure 2.5: Trends in RV price (2012-2020) (SACGA, 2020)

From the table, it can be shown that the RV price between these periods has been fluctuating. From the 2012/13 season to the 2013/14 season the RV priced dropped by 2%. During the 2014/15, 2015/16, and 2016/17 seasons the RV price improved by 10%, 16%, and 24% respectively. This represents a significant improvement in the quality of sugarcane (Recoverable Value Tonnage) delivered by farmers to the mills during these periods. It is very interesting to see that the RV price continued to improve despite the 2015/16 severe droughts, according to Kadwa (2018), the main reason for this was the minimal sugar exports, due to low harvested sugarcane triggered by the severe droughts. Relatively more sugarcane crop was sold on the local market, which increased the RV price since local market prices generally exceed export prices.

During the 2017/18 season, the RV price dropped by approximately 15%. During this season, the sugar industry temporary lost its tariff protection owing to disagreements between the Department of Trade and Industry (DTI) and the sugar industry in terms of increasing tariff protection, i.e., increasing the Dollar Based Reference Price (DBRP) from US$566/ton to US$856/ton (DTI, 2018). This resulted in a high volume of sugar imports during this season, about 517 967 tons of sugar were reported to have been imported from January to December 2017 or 417 959 tons between April 2017 and March 2018 (Kadwa, 2018). This caused a loss in the domestic market share for the local sugar industry, resulting in about 40% of sugar being exported. During the 2018/19 season, the RV price also dropped by 15% due to the decrease in the overall sugar cane quality (GAIN, 2019b).

During the 2019/20 season, the RV price increased by 18%, positive price factors, including a stronger weighted average estimated world sugar price, i.e., during the 2018/19 season the world sugar price was estimated at 13.13 US/lb, whereas the 2019/20 world price improved to 12.14US/lb (SACGA, 2020). Furthermore, an increase in the local market demand for sugar, a reduction in the local sugar rebates budget of R21m, and a weaker weighted average Rand to US Dollar Exchange rate (R17.11 vs R16.88) are amongst other factors that contributed to the improvement in RV price. The RV price payable at the end of July for the 2020/21 season has been declared at R4667.41 per ton (SACGA, 2020)

2.11.7 Challenges facing the South African sugar industry

Many challenges are facing the South African sugar industry, which leads to an uncertain decision-making environment. According to Baird. (2018) the South African sugar industry, which is vital, strategic, and labor-intensive should be expanding and creating more jobs instead of shrinking and disemploying its workers.

Ortmann (2005), identified the AgriBEE (Agricultural Black Economic Empowerment in Agriculture), new labour legislation and minimum wage, property (rural land) taxes, skills levies, water rights uncertainties, HIV/AIDS, a volatile exchange rate, and high transport and communication costs, as the major challenges facing the South African sugarcane farmers. The recent major challenges include the low tariff protection against low-priced sugar imports, the tax on SSBs, low global sugar prices, and high input costs.

According to Kadwa (2019), the global competitiveness of the South African sugar industry has been adversely affected by a large number of issues which include the increase in farmworkers wage due to the recent increase in farmworkers minimum wage (11% increase), implementation of the SSB tax, decreasing raw sugar export prices, ineffective implementation and management of price protection measures to protect South African sugar industry from cheap sugar imports, and the absence of government intervention towards supporting the establishment of the local biofuels industry.

As a result of the HPL and an over-supply of cheap sugar imports, during the 2018/19 season, the domestic market sales of sugar in South Africa decreased to the level last seen during the 1983/84 drought season (GAIN, 2019b). As a result, more than one million tons of sugar had to be exported (the highest volume since 2005/06) at prices far below even the sugar industry cost of productions (SACGA, 2019). This reduced the 2018/19 season RV price by 14.6% compared to the 2017/18 season RV price, at times when the industry production cost has increased due to substantial labour cost and fuel price increase (Kadwa, 2018).

2.11.8 Sugar imports from other countries

An oversupply of cheap sugar imports is another major challenge facing the South African sugar industry. According to Kadwa (2018), the reasons for the oversupply of cheap sugar import include low tariff protection and huge subsidies provided to sugar producers from other countries, notably Brazil, Thailand, the United Arab Emirates, India, and Australia, which export massive amounts of subsidized sugar. The Indian government alone offers its sugar producers a US$150/ton rebate/subsidy, on sugar exports, this unfair practice makes Indian sugar more competitive in the global sugar market (Agri-orbit, 2019).

According to Kadwa (2018), about 517 967 tons of sugar were reported to have been imported from January to December 2017. This reduced the local sugar industry’s domestic market share and caused it to export approximately 40% of sugar at a lower export parity price (EPP), this drops the sugar industry's notional price by more than 20% during the 2017/18 season. Furthermore, in a bid to tackle the impact of imports and to recapture the market share, the sugar industry further dropped the sugar notional price by 13.5% on the 22nd of March 2018 (Kadwa,2019). All of these reduced the income earned by the South African sugar industry (Department of Trade and Industry [DTI], 2019).

According to BFAP (2018), during the 2016/17 season, the sugar imports into South Africa were substantially higher due to the extremely low world price, high market price of domestic sugar, and a low level of tariff protection for a large part of the season. From August to September 2017, there was no tariff in place at all, leading to over 160 thousand tons of sugar imported duty-free in South Africa (BFAP, 2018). According to the NAMC (2011), the importers have realized that the SACU market is not as rigidly protected as other sugar-producing markets, as a result, the imports into the SACU market have risen drastically over the recent years. Furthermore, the SACU duty-free imports from Eswatini increased during 2018/19, and could potentially continue depleting local sugar sales, which could further negatively impact the South African sugar industry.

In South Africa, the DBRP has been at $566 per ton since April 2014, i.e., designed to ensure that an importer pay at least the equivalent of $566 for imported sugar (Kadwa, 2018). The South African sugar industry contended that $566 per ton provides insufficient protection from world market imports, as it is below even the local sugar industry cost of production (Mboyisa, 2017). The South African sugar industry stakeholders, therefore, requested the International Trade Administration Commission (ITAC) (an autonomous statutory body that independently investigates and recommends reasonable and optimal tariff rates after careful consideration of variable factors and in line with South Africa's obligation to the WTO) to increase the DBRP from $566/ton to $856/ton to encourage the production of sugar, which can compete against low priced imported sugar. However, the ITAC responded by increasing the DBRP to $680/ton instead of a requested $856 /ton. Once the new tariff was announced, the industry increased the notional prices of sugar by 19.5% (SACGA, 2019). However, this increase was still lower than the early 2017 prices, as the growers and industry members couldn't recover their cost of production (SACGA, 2019).

The impact of low tariff protection is further exacerbated by the South African sugar industry's limited access to the lucrative European Union (EU) market, despite previous trade agreements and ongoing reform in the EU sugar sector (NAMC, 2011). During 2010/11 year the limited access to the EU market caused the South African sugar industry to export approximately 35% of its sugar to the world market at prices considerably below local market returns (NAMC, 2011). Improving the South African sugar industry access to the EU market is considered important in enhancing the

South African sugar industry revenues and reversing the declining revenue from domestic sugar sales induced by intense competition from the cheap sugar importers.

The cheap sugar imports have put the South African sugar industry under substantial pressure, leading to major job losses and fear that the industry is collapsing completely. The impact is more severe on small-scale farmers who are already in debt, owing millers money from the previous seasons (SAFDA, 2019). Moreover, a large number of small-scale growers don't have access to finance, meaning that they don't have enough funds to manage their field or replant.

2.11.9 The tax on sugar-sweetened beverages (SSBs)

Although the HPL is directly targeting the manufactures of SSBs, it has an indirect negative impact on the South African sugar industry. The impact is potentially large because historically the industrial demand for sugar has accounted for about 60% of domestic market sugar sales in South Africa (GAIN, 2019). According to SACGA (2019), the HPL is estimated to have reduced the domestic sugar sales by approximately 120 000 to about 250 000 tons from the onset of the SSBs tax implementation to 2019.

The HPL has reduced the domestic market sales of sugar in three main ways. Firstly, the HPL has reduced the quantity of SSBs demanded by the South African consumers' by increasing the real price of SSBs. This caused a reduction in the quantity of SSBs manufactured, and hence the quantity of sugar demanded by SSBs manufactures from the South African sugar industry (sugar is a derived demand in the manufacturing of SSBs). Secondly, the HPL has reduced the demand for sugar by SSB producers, due to their product reformulation, i.e., using artificial sweeteners or reducing the sugar content of their beverages (BFAP, 2019). Thirdly, the consumers' demand for sugar has decreased due to the growing consumers' anti-sugar sentiments and awareness that high sugar consumption is linked to obesity, diabetes, stroke, and heart disease (GAIN, 2019).

Reduced sugar industry revenue is also attributable to an increase in the proportion of sugar sold to the sugar export markets due to a reduction in domestic sugar demand. An increase in sugar exports at the expense of local market sugar sales is detrimental to the South African sugar industry because prices realized from the exported sugar are typically lower than domestic market prices.

The difference in the local market and export market prices is attributable to the protection afforded to the sugar industry against distortions in the world market (Kadwa, 2020). According to SACGA (2018), many sugar-producing countries are benefitting from production subsidies and other forms of government interventions, which tend to lower the world price of sugar relative to what it would be in the absence of such interventions.

The SACGA (2019) estimated that the SSBs tax resulted in a decline of about R1.3 billion in the domestic sugar industry revenue within one year of its implementation (April 2018-April 2019). The 5.2% increase in the tax as of 1st April 2019 was expected to exacerbate this problem, as it was estimated to reduce the sugar industry domestic revenue by a further R1.8 billion by the end of December 2019 (SAITP, 2019).

According to the SACGA (2019), the impact of the SSBs tax on employment is difficult to quantify but is expected to reduce employment in sugarcane production by 10 000 jobs, *ceteris paribus*. Additional job losses are likely to be in the sugarcane milling and beverage industries. SACGA (2018) also expressed concerns that reduced profitability of sugar milling may reduce capital investment by sugarcane milling companies, which has negative repercussions for sugarcane producers (e.g., increased risk of mill stoppages), which may further contribute to a reduction in the area under sugarcane and therefore, reduced employment in sugarcane production.

2.11.10 The sugar industry response to these challenges

In response to dwindling profit due to the sugar tax, low tariff protection against cheap sugar imports, sugarcane growers are diversifying to long-term crops including avocado, macadamia nuts, and citrus amongst other crops (BFAP, 2018). This is seen as a strategy that could increase the sugar industry's profitability. However, as a consequence of this strategy, the sugar industry is expected to lose approximately 50 thousand hectares of land by 2027 (BFAP, 2018).

Sugarcane farmers are diversifying to long-term crops, and therefore, even if sugarcane production becomes favourable (i.e., increased tariff protection, sugar tax ban, etc.) it is less likely that farmers will switch back to sugarcane as the establishment of these crops is capital intensive. Furthermore, there are reports that sugar milling companies are also diversifying to other alternative sweeteners. Therefore, in the medium to long-term, there might be some structural changes in the South African sugar industry GAIN (2019a).

Moreover, at present, the sugar industry stakeholders are exploring other opportunities for generating alternative income streams by expanding ethanol production for fuel, biogas, biomaterials, and electricity generation. This could be achieved by redirecting the annual sugar cane crop used in the production of sugar for the export market (where it receives lower prices due to intense competition from the lower-cost sugar producers from other countries) to the production of sugar by-products (Kadwa, 2016, Mafunga *et al.*, 2019).

According to the DTI (2018), the over-reliance on sugar production without investing in other alternative products is unsustainable. Currently, the South African sugar industry produces small amounts of bioethanol by fermenting the molasses produced as one of its by-products. However, unlike other countries, the bio-ethanol produced from sugarcane in South Africa is not used in fuels but rather in alcohols, inks, and paints, and by the pharmaceutical industry (Cartwright, 2007). According to Kohler (2016), up to two percent of South Africa's liquid fuel requirements (about 400 million litres) could be produced from ethanol manufactured from sugar which is currently exported to the world market.

However, the sugar industry is more likely to reap the benefits of these opportunities if the government introduces appropriate measures and policies to support the sugar industry (GAIN, 2019b). Kohler (2016), recommended government support in the form of a guaranteed minimum selling price for bioethanol production of 95% of the basic fuel price, exemption from fuel taxes besides, specific capital investment allowances are required.

2.12 Discussion and conclusions

The objective of this chapter was to review the literature covered in the context of SSBs tax locally and globally. This was necessary to identify the knowledge gaps in this subject area. The literature revealed that globally there is no conclusive evidence linking the SSB tax to obesity reduction, with most literature revealing that obesity is a multifactorial issue that requires a holistic approach to be addressed instead of targeting a single ingredient (sugar).

Most of the peer-reviewed literature focuses more on the health impact of the SSBs tax. Therefore, globally there remains a knowledge gap about the economic impact of a tax on SSBs. The fewer peer-reviewed literature that assessed the economic impact of the SSBs (i.e., the impact government revenue, the impact on labour employment, etc.), failed to account for the impact of product reformulation by SSB manufacturers and the impact of consumers' possible substitution towards cheaper alternatives or healthier options.

The literature that covered the implications of a SSBs tax in the context of the South African sugar industry was also reviewed, given the ongoing sugar industry concerns that amongst all challenges currently facing the industry (e.g., rising input cost, an oversupply of sugar imports, sugar price variabilities, etc.), a tax on SSBs is the most detrimental challenge. There is no empirical study that examined the indirect impacts of a SSB tax on the South African sugar industry.

Having identified the potential knowledge gaps in this chapter. The next chapter (chapter three) presents a detailed overview of the research methodology used to partly address these knowledge gaps, i.e., to assess the economic impact of a SSBs tax on the South African sugar industry.

CHAPTER 3: RESEARCH METHODS

3.1 Introduction

The research methods used in this study are outlined in this chapter. The analytical and conceptual framework, which forms the foundation of the study is presented in section 3.2. The data analysis techniques and empirical models' specifications are outlined in sections 3.3 and 3.4, respectively. The model diagnostic tests, i.e., multicollinearity test and serial Autocorrelation test, are presented in section 3.5. Lastly, the sources of data are outlined in section 3.7.

3.2. The theoretical and conceptual framework

The aim in this section is to present the theoretical and conceptual framework of this study which is about fiscal policy (government) intervention in the economy, the economic theory of demand and SSBs tax mechanism in reducing obesity.

3.2.1 Fiscal policy intervention in the economy

When it comes to decision-making, economists operate under three broad principles: rationality, consumer sovereignty, and market efficiency (NZIER, 2017). "Rationality assumes that all individuals seek maximization of their interest which includes material goods as well as less tangible interest and objectives, including social recognition and status" (Rodmond, 2000:179). The principle underlying consumer sovereignty states that the basis of assessing policies should be the welfare of individuals as they are the best judges of their welfare and the economic choices, they make are effective in advancing their self-interests (Penz, 1986). Market efficiency means that as a result of people making decisions based on their preferences, the entire economy will reach a position in which there will be no better use of resources available other than that, this could also be referred to as economically efficient in the sense that there's no other alternative use of resources that will yield higher net benefits (NZIER, 2017). However, under certain circumstances where conditions that lead to efficient outcome does not hold, a market failure is said to exist, the situation in which individual rationality does not lead to group rationality (Friedman, 2014).

In the presence of market failures, the rationality principle does not hold, hence the government/ fiscal policy intervention may be justified to correct the market failures. Obesity is considered as a market failure, in the sense that it is the failure of the food and beverage industry to act in the best interest of society (Rose and Mukhopadhyay, 2015). The decision-makers in the food and beverage industry are more concerned about profit maximization, as a result, they don't provide consumers with full information about the negative health effects associated with the food they produce. Free sugars are perceived as one of the leading obesities causing factors, the WHO has recommended peoples' daily sugar intake to be at most 10% of their total daily energy calories, and a further 5% reduction for the additional health benefits (WHO, 2015).

Market failures have led to the taxation of SSBs in many countries including South Africa. Policymakers contend that SSBs contain more sugar while at the same time they have very little nutritional value (Barardi *et al.*, 2017). The tax on SSBs is thus considered as a corrective tax for market failures as it causes producers and consumers of SSBs to internalize the negative externalities associated with SSBs consumption.

3.2.2 The economic theory of the demand for SSBs

The idea for taxing SSB as an attempt of reducing obesity stems from the economic demand theory of an inverse relationship between the quantity of the commodity demand and its price. People allocate their budget between different food categories and beverages based on their relative prices (Quirmbach *et al.*, 2018). Taxing SSB is expected to increase the price of SSB. An increase in the price of any commodity including SSB can be discomposed into two effects, *viz*., the income and substitution effect (Hines, 2013). The income effect quantifies the change in the quantity of a commodity demanded as a consequence of a change in consumers' real disposable income due to a change in the real price of a commodity, whereas the substitution effect quantifies the impact of a change in the quantity of a commodity demanded as a consequence of consumers substituting to other products (Perloff, 2012). While the substitution effect always reduces the quantity of a commodity demanded, the income effect of a price change on the quantity of a good demanded depends on whether a good is normal or inferior (Tomek and Kaiser, 2014). For a normal good a decrease (increase) in consumers' real disposable income due to a change in the real price of a commodity decreases (increases) the quantity of a commodity demanded. In the case of an inferior good a decrease (increase) in consumers' real disposable due to a commodity's price change, increases (decreases) the quantity of a commodity demanded.

An increase in the price of SSB, as a consequence of SSB producers partially or fully passing the tax burden to consumers, is likely to reduce the consumption of SSB, since SSBs are normal goods. Moreover, if healthier substitutes become cheaper relative to their unhealthier counterparts, the demand for healthier substitutes in consumption is expected to increase (South African National Treasury, 2016).

The extent of the SSBs price increase in response to the SSBs tax and the extent by which the quantity of SSBs demanded will be affected are highly dependent on the own-price elasticity of demand for SSBs. The demand for SSBs could be relatively own-price inelastic ($E_p < |-1|$), i.e., consumers of SSBs might reduce their SSBs consumption by a less proportion relative to the SSBs price increase. This is evident under circumstances where consumers derive a higher utility on a given item in such a way that they are willing to reduce the consumption of other items to compensates for the price increase in the product of their choice, this is usually the case when the product in consideration has a very limited number of possible substitutes or no substitutes at all, this also holds when a good is necessary for people's survival (necessity good).

The demand for SSBs might also be relatively own-price elastic ($E_p > |-1|$), i.e., consumers of SSBs might reduce their SSBs consumption by a large proportion relative to the price increase induced by the SSBs tax. This is common when consumers can easily substitute the good or the good is not highly essential for their daily survival (luxury good). The own-price elasticity of the demand for SSBs might also be unitary elastic (Ep= -1), i.e., a case in which a proportional decline in SSBs consumption exactly equals the proportional increase in the price of SSBs.

The own-price elasticity of demand for SSBs also tends to vary by country. According to the meta-analysis study conducted by Escober *et al.*, (2013), the absolute value of the own-price elasticity of demand for SSBs is larger for high-income countries than it is for low-income countries. In middle-income countries like Brazil and Mexico, the own-price elasticity of demand for SSBs ranged between -0.85 to -1.085, whereas in high-income countries like the USA and France the own-price elasticity of demand for SSBs ranged between -2.206 to -4.445 (Escober *et al*.,2013). In countries where the demand for SSBs is relatively own-price inelastic, the SSBs price will increase by a large extent in response to the SSBs tax, in other cases it might even exceed the magnitude of the tax, causing SSBs consumers to bear a larger tax burden relative to SSB producers (Snowdon, 2016). In countries where the SSBs demand is relatively more price elastic, the price will increase by a smaller extent relative to the tax, and hence producers will bear a larger share of the tax burden.

On other hand, the extent to which the consumption of SSBs will be affected by the HPL depends on both the own-price elasticity of demand for SSBs and cross-price elasticity of demand for SSBs. Based on the cross-price elasticity estimates the product is regarded as a substitute if the cross-price elasticity of demand is positive, suggesting an increase in the quantity of SSBs demanded given an increase in the price of another product. The product is regarded as a compliment if the cross-price elasticity of demand is negative implying a decline in the quantity of SSBs demanded given another product price increase.

Economic theory predicts that taxes raise the price of a normal good to consumers, resulting in a reduction in the quantity of the good demanded and consumed. Taxes on unhealthy foods are considered an attractive policy intervention as they don't only promise positive health benefits, but also generate tax revenues for the government, which can be invested towards public health initiatives (Sharma *et al.,* 2014).

3.2.3 SSBs tax mechanism in reducing obesity

The conventional economic theory suggests that, in response to a tax, the profit-maximizing firms will increase product prices, with the magnitude of the price increase being determined by the own-price elasticity of the product demand (Hines, 2008). However, in the case of ingredient-based taxes, producers also face an additional decision which is whether to reformulate their product to reduce the levels of the taxed ingredient (reduce their tax liability) or to develop other substitutes, i.e., sugar-free carbonates. Product reformulation also involves some costs, with some costs being fixed and others being variable. There is also a possibility that firms may respond by re-focusing their advertising efforts. Therefore, there is not much *ex-ante* information about how firms will respond to SSBs taxes.

According to the NZIER (2017) and Snowdon (2016), the SSBs tax will only be effective in addressing the problem of obesity in a way that improves peoples' health outcomes provided that the following assumptions are met;

i) The tax imposition will increase the price of SSBs items relative to their substitutes in consumption.

ii) With a price increase, the consumption of the taxed item will decrease.

iii) The total energy intake will decrease with a reduction in the consumption of SSBs.

iv) Lower energy intake will lead to lower physiological risk factors linked with obesity

v) Lower physiological risk factors will lead to better people's health outcomes.

3.3 Analytical techniques

This section discusses the research methods used in this study, -i.e., the simultaneous equations modeling and VECM, empirical model diagnostic tests (multicollinearity and serial autocorrelation)- as well as sources of data used in this study.

3.3.1 The static sugar demand and supply model

The factors influencing the domestic demand and supply of sugar were determined using the static demand and supply model. Sufiullin (2018), defined the static model as one in which the time factor is not explicitly considered. With such models, there is no distinction between short-run and long-run estimates. The static models assume that once equilibrium is achieved, it remains unchanged period after period, this equilibrium is termed a stationary state.

3.3.1.1. The simultaneous equations model

The single-equation model, i.e., the model in which there is a single dependent variable (y) and one or more explanatory variables (x's), assumes a unidirectional (one-way) cause and effect relationship that runs from x's to y's, in which x is the cause and y is an effect (Gujarati and Porter, 2009). In practice, economic relationships are often bi-directional (two-way) cause and effect relationships, in such a way that a distinction between dependent and independent variables becomes invalid (Dushmanitch, 1990).

Estimation of relationships in which there is a simultaneity (joint dependence) among variables requires a system of simultaneous equations, with the system of equations describing the joint dependence of variables. In the presence of simultaneity, the Ordinary Least Squares (OLS) method cannot be used. This is because simultaneity violates an important OLS Assumption, which states that the explanatory variables should either be non-stochastic or, if stochastic, should be distributed independently of the stochastic disturbance term (Gujarati and Porter, 2009). In this situation, the use of OLS will give estimates that are both biased and inconsistent, i.e., the estimators do not converge to their true population mean even if the sample size increases indefinitely.

If there is a two-way association in a function, then the function should not be treated in isolation in a single equation model, but rather as a wider system of equations that can effectively describe the relationship among all variables. The method of two-stage least square (2SLS) and three-stage least square (3SLS) becomes a better method to use.

The 2SLS method involves the application of OLS in two successive stages, while the 3SLS method is a straightforward extension of 2LS that involves the application of OLS in three successive stages. The first two stages are the same as 2SLS, except that only the reduced form equations are used with the 2SLS parameters being discarded. The third stage involves the application of generalized least squares (GLS), which is the application of least squares to a set of transformed equations, in which the transformation is required to obtain the reduced form residuals of the previous stage (Koutsoyiannis, 1977).

3.3.1.2 The choice between the 2SL and 3SLS

Although both the 2SLS and 3SLs methods will generate biased estimates, the 2SLS and 3SLS estimates are both efficient and consistent. The 3SLS method is, however, considered to be superior as it produces estimates that are more efficient (smaller standard errors) than the 2SLS method, particularly for large samples (Besley, 1988). This is mainly because the 3SLS method uses more information than the 2SLS method.

The 3SLS method utilizes the knowledge of all zero restrictions in the entire system, making use of all information available in the systems of equations, it is termed the "Full information" method, the 2SLS method on other hand is termed the "limited information" method as it only utilizes the knowledge of zero restrictions in the equation under consideration (Basley, 1998). The 3SLS method, however, has disadvantages of large data requirements, high computational costs, and high sensitivity to specification bias, one specification error is transmitted to the entire systems of equations (Koutsoyiannis, 1977). Moreover, if the model is very small, the accuracy in the specification of the equations is uncertain, and there is a possibility that the disturbance terms are uncorrelated then it is preferable to apply the 2SLS model instead of the 3SLS model.

The 3SLS, then, becomes an estimator of choice only when the researcher considers a gain in efficiency to be more important relative to computational cost and when the potential for such gain is high. However, the 3SLS estimator reduces to the 2SLS estimator if the variance-covariance matrix across equations is diagonal or if all equations in the systems are just identified (Baltagi, 1998).

3.3.1.3 The identification problem

The equation is said to be identified if the numerical estimates of the parameters of a structural equation can be obtained from the estimated reduced-form coefficients, if this cannot be done, then that equation is unidentified, or underidentified. According to Gujarati and Porter (2009), an identified equation may either be exactly (just) identified or overidentified. The equation is said to be exactly identified if unique numerical values of the structural parameters can be obtained, it is, however, overidentified if more than one numerical value can be obtained for some parameters of the structural equation.

According to Gujarati and Porter (2009), the 2SLS regression method can only be used for structural parameters in a system of simultaneous equations that are exactly or over-identified. Similarly, the 3SLS regression can only be used for structural parameters in the system of equations that are either exactly identified or over-identified (Koutsoyiannis, 1977). Therefore, the test of identification is essential when dealing with data analysis involving the use of simultaneous equations.

The identification problem was analyzed using the order, and rank conditions as the necessary and sufficient conditions respectively. Based on the order conditions, a given equation to be identified must exclude at least one exogenous variable which is part of a simultaneous equation model

(Taghvaee *et al*., 2017). According to Gujarati and Porter (2009), under order conditions there are three possible scenarios outlined as follows;

- The equation can be under-identified, i.e., the number of excluded exogenous variables in the equation under consideration but not in the entire model is less than the number of endogenous variables contained in the equation minus one (K-k<m-1).
- The equation can be exactly identified, i.e., the number of exogenous variables excluded from the equation but not in the entire model exactly equals the number of endogenous variables contained in the equation minus one (K-k=m-1).
- The equation can be over-identified, i.e., the number of exogenous variables excluded in the equation but not in the entire model exceeds the number of endogenous variables in the equation minus 1 (K-k>m-1)

M= number of endogenous variables in the entire simultaneous equations model.

m= number of endogenous variables in the equation under consideration.

K=number of exogenous variables in the entire simultaneous equations model.

k=number of exogenous variables in the equation under consideration.

3.3.1.4. The simultaneous equations model specification

The model to be estimated consists of two stochastic responses, i.e., the domestic sugar demand and supply. The real domestic price of sugar ($realprice_t$) and domestic quantity of sugar sales (tons) per annum are determined by the intersection of the domestic sugar demand and supply equation. Both real domestic price of sugar ($realprice_t$) and domestic quantity of sugar sales ($sugar\_sales_t$) are considered as endogenous variables since their values are determined within the model.

The previous period price of sugarcane ($caneprice_{t-1}$) was added in the domestic sugar supply equation because the supply of agricultural outputs tends to respond to the price of inputs with a time lag due to physiological and institutional reasons (Gujarati and Porter., 2009). The physiological reasons include inertia (force of habits), and the fact that farmers may not be certain whether a change is permanent or transitory due to imperfect information. The contractual obligations are the main institutional reason for the lag response of supply to the price of inputs. The per-capita quantity of sugar consumed in the previous year ($cons_{t-1}$) and quantity of sugar sold in the previous year ($sugar\_sales_{t-1}$) were also added in the domestic sugar demand and supply equations, respectively, because of the adaptive expectations hypothesis, which states that individuals adapt their expectations in the light of the previous periods' experiences. Therefore, the domestic quantity of sugar consumed in the current period ($cons_t$) depends on the domestic quantity of sugar consumed in the previous period ($Cons_{t-1}$). Similarly, the domestic quantity of sugar sold in the current year ($sugar\_sales_t$) depends on the domestic quantity of sugar sold in the previous year ($sugar\_sales_{t-1}$).

The log-log functional form will be used in this study for both domestic demand and supply of sugar equations. This functional form enables the direct interpretation of the estimated coefficients in terms of elasticity (Gujarati and Porter, 2009).

The empirical domestic demand and supply functions for sugar in South Africa can be expressed as follows:

$$lnQss(lnsugar\_sales_t)=\alpha_0+\alpha_1 lnexports_t+\alpha_2 lncaneprice_{t-1}+\alpha_3 lnprice_t+\alpha_4 lnsugar\_sales_{t-1}+\alpha_5 lntime\_trend_t+U_{1t} \quad (3.1)$$

$$lnQdd(lnsugar\_sales_t)=\beta_0+\beta_1 lnconst_1+\beta_2 lntotal\_population_t+\beta_3 lnprice_t+\beta_4 lndispo\_income_t+U_{2t}\ldots$$

……………………………………………………………………………………………..(3.2)

Equilibrium Condition: lnQss=lnQdd

where;

ln = natural log

t = year (1,2,3,..*n*)

$sugar\_sales_t$ = quantity(tons) of domestic sugar sold in year *t;*

$dispo\_income_t$ = real disposable income (R/caput) in year *t;*

$cons_{t-1}$ = quantity of sugar consumed (t/caput) in the previous year*;*

$total\_population_t$ = South African population size in year *t;*

$price_t$ = the real domestic price of sugar (R/tons) in year *t;*

$caneprice_{t-1}$ = the real price of sugarcane (R/tons) in the previous year*;*

$sugar\_sales_{t-1}$ = quantity(tons) of domestic sugar sales in the previous

year*;* $time\_trend_t$ = deterministic time trend-proxy for changes in technology*;*

$exports_t$ = quantity (tons) of sugar exports in year *t;*

U_{1t}, U_{2t} =model error terms

αi, βi = regression coefficients

3.4. Dynamic sugar demand and supply model

As noted in section 3.4.1, a static demand and supply model has several weaknesses, *viz*., i). It is hard to tell if the estimates are for the long-run or are for the short-run, ii). The assumption that once the equilibrium has been reached, it remains unchanged period after period is not true in economics because over time the disequilibrium may result due to different forces, such as government controls, non-profit maximizing decisions, and sticky prices.

According to Nerlove and Addison (1958:861), "the real world presents us with a curious mixture of short-run and long-run adjustments". Therefore, an econometric technique that can investigate both short-run and long-run elasticities is necessary and desirable. The dynamic demand and supply models could help in distinguishing the short-run and long-run elasticities, and it has been found to results in a significant improvement when compared with the analysis results that are based on static models (Nerlov and Addison, 1958).

3.4.1 Cointegration analysis

The first step, before estimating long run and short estimates it's to perform a cointegration test. Cointegration is defined by Gujarati and Porter (2009), as a situation in which two variables have a long-run relationship. In time-series data, two or more non-stationary variables are cointegrated if some linear combinations between them are stationary (Cross *et al.*, 2011). Under this scenario, the regression of the two variables will not be spurious.

The time series variables must have the same degree of non-stationarity if they are cointegrated, i.e., if the non-stationary process variable y and x become stationary after differencing at d times, the two variables are cointegrated, and they are said to be integrated at an order d, denoted by ***I*(d).** If variable A and variable B, become stationary at their first difference, variable A and Variable B are said to be integrated at an order 1 denoted by ***I*(1)**. The presence of cointegration between variables was tested using Johansen's maximum likelihood test, which requires all variables to be stationary at their first deference.

3.4.2 Variables causality

Cointegration indicates whether the variables have a long-run relationship or not, it does not say anything about causality between variables (Zou, 2018). The Granger causality test is a useful statistical test when assessing the direction of causality between two variables (Cross *et al*., 2011). The granger Causality test is very helpful in determining whether a time series variable is useful in forecasting another time series variable. Variable A is said to Granger Cause Variable B if the lag of a variable A can improve the forecast of variable B.

3.4.3 The Vector Error Correction Model (VECM)

The cointegration relationship between variables enables the error correction model (ECM) to be derived from the autoregressive distributed lag model (Zou, 2018). The VECM is the multivariate extension of the ECM, it is derived from the VAR model with a cointegration constraint (Guo, 2017). When there is a large range of short-term dynamic fluctuations, VECM expressions can restrict the long-term behavior of the endogenous variables and will be convergent to their cointegration relation, this is because the VECM has a cointegration constraint.

When the variables of a VAR model are cointegrated, the VAR levels can be transformed into a VECM by taking a difference operator $\Delta=1-L$. After the VAR model is transformed into the VECM model one lag is lost (Zou, 2018). The most attractive feature of a VECM is that it enables the study of short-run and long-run dynamics in the relationship between variables (Gujarati and Porter, 2009). In this regard, a VECM offers a means of obtaining consistent and yet distinct estimates for both short-run and long-run elasticities.

The VECM for the domestic sugar demand equation (3.3) and domestic sugar supply equation (3.4) was estimated as follows:

$\Delta lnsugar\_sales_t=\beta_0+\beta_1\Delta lnrealprice_{t-1}+\beta_2\Delta lndispo\_income_t+\beta_3\Delta lnpopulation_t+\beta_4\Delta lncon_{t-1}+ECtdd+e_t$ …………………………………………………………………………………..(3.3)

$\Delta lnsugar\_sales_t=\alpha_0+\alpha_1\Delta lnsugar\_sales_{t-1}+\alpha_2\Delta lnrealprce_t+\alpha_3\Delta lncaneprice_{t-1}+\alpha_4\Delta lntimetrend_t+\alpha_5\Delta exports_t+ECtss+v_t$………………………………..………..… (3.4)

Where;

Δ is a first difference operator.

ln	= natural log;
t	= year, where t=1,2, 3,..,*n;*
$sugar\_sales_t$	= quantity(tons) of domestic sugar sold in year *t;*
$sugar\_sales_{t-1}$	= quantity(tons) of domestic sugar sales in the previous year*;*
$realprice_t$	= the real domestic price of sugar (R/t) in year *t;*
total $population_t$	= South African population size in year *t;*
$real\_dispo\_income_t$	= the real average disposable income (R/caput) in year *t;*
$cane\_price_{t-1}$	= the real cost of labour (R/tons) in year *t;*
$timetrend_t$	= deterministic time trend-proxy for changes in technology*;*
$exports_t$	= quantity (tons) of sugar exports in year *t;*
ECtdd	= error correction terms for the domestic sugar demand equation;
ECtss	= error correction terms for the domestic sugar supply;

V_t , and e_t = error terms; and

α_i and β_i = regression coefficients.

3.5 Model diagnostic tests

This section discusses the diagnostic tests used in this study, i.e., multicollinearity and serial autocorrelation tests. Performing these diagnostic tests was essential to ensure the reliability of results estimated using both simultaneous equations and a VECM.

3.5.1 Multicollinearity: an overview of the problem and its detection

Multicollinearity is one of the most serious and hard to control problems in all regression analysis (Allen, 1997). Multicollinearity arises when at least two highly correlated explanatory variables are assessed simultaneously in a regression model (Sinon and Alkan, 2015). According to Gujarati and Porter (2009), three sources of multicollinearity are i). Data collection method employed, i.e., sampling over a limited range of the values taken by the regressors in the population, ii). Model specification errors, i.e., using an incorrect functional form, iii). Over determining the model, this is common when the model has more explanatory variables than the number of observations. In time-series data, multicollinearity may be caused by including regressors that share a common trend, i.e., variables that all increase or decrease over time at less or the same rate.

Multicollinearity can either be perfect or imperfect. Perfect multicollinearity is the complete violation of the OLS assumption, in this situation, the OLS estimation will fail because if two variables are perfectly correlated, it becomes impossible to vary one variable while keeping the other variable constant, hence the individual effects of the explanatory variables on the response variables cannot be separated (Allen, 1997). However, even less than perfect multicollinearity is a problem in the regression analysis if it is extreme.

Other several consequences of high multicollinearity, include precise estimation difficulties (Allen, 1997). This is because a high degree of multicollinearity results in estimates with large standard errors, which increase the likelihood of accepting the null hypothesis (larger P-values, small t-values, wide confidence intervals) concluding that the regression coefficients are not statistically significant. Furthermore, extreme multicollinearity may result in imprecise regression coefficients, i.e., regression coefficients with signs that do not corroborate with economic expectations (Tu *et al*., 2005).

Multicollinearity is a question of a degree and not of kind, moreover, since multicollinearity refers to the condition of the explanatory variables that are assumed to be non-stochastic, it is a feature of the sample and not of the population. As a result, multicollinearity is always present in the sample, therefore, one may not test for multicollinearity but rather can measure its degree (Gujarati and Porter, 2009).

Several methods are used to detect the severity of multicollinearity. However, only those applied in this study are briefly discussed in this section. These methods include i) The examination of the correlation matrix of the explanatory variables, a high and significant pair-wise correlation between two regressors above $|0.8|$, indicates that multicollinearity could be a serious problem. ii) Higher R^2 but few statistically significant regressions coefficients, implying that the model explanatory variables provide a higher degree of explaining the response variable, but at the same time, they have no meaningful relationship with a response variable. iii) Variance Inflation Factor ($VIF=1/1-R^2$) is another commonly used tool for detecting the severity of multicollinearity, the larger the VIF the more collinear the variable is. The common rule of thumb is that if a VIF is greater than 10, multicollinearity is a serious problem (Gujarati and Porter, 2009).

3.5.2 Serial autocorrelation: an overview of the problem and its detection

Autocorrelation is a situation in which the disturbance term for any observation is related to or influenced by the disturbance term of any other observation (Gjarati and Porter, 2009:440). One of the most important OLS assumptions is that there is no serial autocorrelation, i.e., the covariances and correlations between different disturbances are all equal to zero (Kiula, 2014).

This can be shown mathematically as follows:

$$Cov(u_t,u_s)=0 \text{ and } t \neq s$$

This assumption states that the disturbances u_t and u_s are independently distributed. However, if this assumption is no longer valid, then the disturbances are not pairwise independent, but pairwise autocorrelated (or serially correlated). Meaning that an error occurring at a period t may be carried over to the next period, i.e., t+1. Autocorrelation is most likely to occur in time series data (Anderson, 2015).

Some of the causes of autocorrelation include i). Variable omission, omitting some important explanatory variables during the modeling process could result in temporal autocorrelation which could generate bias parameter estimates and lead to incorrect inferences, especially if the omitted variable is correlated with variables included in the model (Cameron and Trivedi, 1998). ii). Misspecification of the model functional form, for instance, using the linear model when the original model is non-linear could also result in autocorrelation (Kiula, 2014). iii). Systematic measurement errors, for instance, if a farmer updates inventory at a given period, if a systematic error occurs, then the cumulative inventory stock will exhibit cumulated measurement errors and these errors will show up as an autocorrelated procedure.

Even though the OLS estimators remain unbiased and consistent in the presence of serial autocorrelation, however, the estimators became inefficient (Gujarati and Porter, 2009). Furthermore, the estimated variances of the regression coefficients become biased and inconsistent, therefore invalidating the hypothesis testing.

Several methods are used to detect the presence of serial autocorrelation (i.e., DW test, Runs test, a graphical examination of residuals or standardized residuals, etc.), but only the Breusch-Godfrey (BG) test used in this study is described briefly in this section. The test was developed by Breusch and Godfrey, to avoid the weaknesses of the DW test of autocorrelation (Gujarati and Porter, 2009). Compared to the DW test, the BG test is general in the sense that it allows for the following;

i) Non-stochastic regressors such as lag values of the dependent variable, i.e., regression of the following type:

$$Y_t=\beta_0+\beta_{1t}X_{1t}+\beta_{2t}X_{2t}+\ldots\ldots+\beta_{kt}X_{kt}+\gamma Y_{t-1}+u_t \quad (3.5)$$

ii) The higher-order autoregressive schemes, such as AR(1), AR(2),….AR(n).

iii) Simple or higher-order moving averages of white noise error terms.

iv) It is not dependent on the normality assumption.

v) It can be applied to regressions with a large number of lags.

3.6. The impact of the SSBs tax on the South African sugar industry

This section provides detailed information on how the impact of a SSBs tax on the revenue earned by the South African sugar industry in the domestic sugar market, the RV price received by sugarcane growers were estimated.

3.6.1 The impact of a sugar tax on the revenue earned by the South African sugar industry

A domestic market sugar revenue analysis was conducted for the 2016/17 and 2019/20 seasons to estimate the impact of the HPL on the revenue earned from the domestic market sugar sales. The revenue analysis was separated into two parts, *viz.*, the revenue impact of the HPL under a static demand and supply model (3SL model) consideration, the short-run and long-run revenue impact of the HPL using a dynamic demand and supply model (VECM).

The sugar notional prices used in the determination of domestic sugar revenues were estimated as a sum of the sugar import tariff and export parity price. Two notional price estimates were obtained, i.e., the sugar notional price with HPL (PwithHPL) and the sugar notional price in the absence of the HPL (PwithoutHPL).

The own-price elasticity estimates (static model and dynamic model) of domestic demand for sugar (ε_{DD}) were used to estimate the change in the domestic quantity of sugar demanded (ΔQdd) given a change in sugar notional price, under the assumption that large changes in sugar notional prices were due to the HPL. The change in the domestic sugar industry revenue due to the HPL was then estimated as a product of ΔQdd and PwithHPL.

3.6.2 The Impact of the sugar tax on the RV price received by sugarcane growers'

The HPL is expected to have a negative impact on both sugarcane millers and sugarcane growers. To determine the impact of the sugar tax on the South African sugar industry, the division of proceeds formula (illustrated in section 2.11.6), the notional price with and without the HPL, the 2019/20 domestic sugar sales value, and the 2019/20 sugar exports value were used to estimate what the 2019/20 RV price would have been in the absence of the HPL (a counterfactual) and to estimate the 2019/2020 RV price with HPL. The impact of the HPL on growers' RV price was then estimated as the percentage change in the 2019/20 RV price with the HPL from the counterfactual (i.e., the 2019/20 RV price without the HPL).

3.7 The sources of data

The study relied on the secondary time series annual data for the period 1977-2019. The data includes the domestic price of sugar, domestic sugar sales (quantity), and the quantity of sugar exports gathered from the South African Cane Growers Association (SACGA). The South African Reserve Bank (SARB) was used as a source of data for the index of consumers' disposable income per capita. The data for the variable domestic per-capita consumption of sugar, the price of sugarcane, and the South African population size were gathered from the abstract of agricultural statistics (DAFF, 2019).

The data for variable Consumer Price Index (CPI) with the base year 2010 (2010=100) gathered from the World Bank, was used to convert nominal figures into real figures, to account for the effects of inflation. The data was then used to estimate the own-price elasticities of domestic demand and domestic supply of sugar, necessary to determine the impact of the HPL on the quantity of sugar demanded by manufacturers of SSBs and revenue earned by the South African sugar industry.

3.8 Discussion and conclusion

The objective explored in this chapter was to outline and describe research methods used in this study to achieve the study objectives. The study relied more on the secondary time series data for the period 1977-2019, gathered from various data sources including DAFF, SARB, World Bank, and SACGA. From all possible methods that could have used to assess the study research objectives, the 3SLS and VECM were chosen.

The 3SLS model was chosen for static analysis because of its ability to address the endogeneity problem between price and quantity. Furthermore, it generates estimates that are more efficient when compared to other simultaneous equations techniques (i.e., 2SLS). The VECM was chosen for estimating consistent and yet distinct short-run and long-run elasticity estimates of domestic sugar demand and supply equation, this was necessary to projects the short-run and the long-run impact of the SSBs tax on the revenue earned by the South African sugar industry. Having outlined the study research methodology in this chapter, the next three chapters, i.e., chapters four, five, and six are centered on the presentations and discussions of the results of the analysis.

CHAPTER 4: ESTIMATION OF THE DOMESTIC SUGAR DEMAND AND SUPPLY

4.1 Introduction

Having outlined a suitable econometric research method for the study in chapter three, in chapter four the results of a domestic sugar demand and supply are presented. The results of the stationarity test, which is the first important step when doing a regression analysis involving the use of time-series data were reported in section 4.2. The stationarity test is essential to avoid spurious (false) regression problems, encountered when regressing a non-stationary time series variable on another non-stationary time series variable. Thereafter, the results for the model diagnostic tests, i.e., multicollinearity and serial autocorrelation were outlined and interpreted in section 4.3. Finally, the 2SLS and 3SLS regression results were outlined and interpreted in section 4.5.

4.2 Stationarity test

Before doing further analysis, the time series data need to be tested for stationarity. According to Gujarati and Porter (2009:740), “if a time series is stationary, its mean, variance, and covariance remain the same no matter at what point they are measured” a time series will tend to return to its mean and fluctuates around the mean. However, a non-stationary time series will have a time-varying mean or time-varying variance, or both.

Testing for stationarity is essential since conventional estimation procedures cannot be applied to regression models whose variables are non-stationary (Tajdin *et al.*, 2017). The non-stationary series also has a possibility of spurious regression. Spurious regression means that when regressing a time series variable on another time series variable(s), there’s a high possibility of obtaining a very high R^2 (more than 0.9) even in the absence of a meaningful relationship between two or more variables, sometimes an insignificant relationship between variables may be expected, but a regression often shows a meaningful relationship (Taidin *et al*, 2017).

The stationarity test was conducted using the Augmented Dickey-Fuller (ADF) test. The variables found non-stationary were made stationary by first differing (d), which is to subtract the previous value of the variable from its current value.

4.2.1 Stationary test results for variables at their levels

The Augmented Dickey-Fuller (ADF) test was conducted on each of the variables used in the domestic sugar demand and supply equation to check whether they are stationary or not. According to the rule of thumb, the null hypothesis implying that a time series is non-stationary is rejected in favour of an alternative hypothesis (stationary), if the critical value of an ADF test is less than the test statistic (Gujarati and Porter, 2009).

The results of the ADF test for the domestic sugar demand and supply variables at their levels (before differencing) are outlined in Table 4.1. From Table 4.1, it can be concluded that at 5% significance level variables, *viz.*, time trend ($lntime\_trend_t$), real previous period price of sugarcane ($lncane\_price_{t-1}$), previous period sugar consumption ($lncons_{t-1}$), sugar exports quantity ($lnsugarexports_t$), and real consumers' disposable income ($lndispo\_income_t$), were stationary at their levels. However, variables such as current period domestic sugar-sales ($lnsugar\_sales_t$), previous period domestic sugar-sales ($lnsugar\_sales_{t\_1}$), the real domestic price of sugar ($lnreal\_price_t$), and South African population size ($d1lnpopulation_t$) were non-stationary at their levels. All non-stationary variables were made stationary by taking their first difference.

Table 4.1: ADF test result for the domestic sugar demand and supply variables at their levels

Variable	**Critical value (5%)**	**Test Statistics**	**Conclusion**
$lnsugar\_sales_t$	-3.532	-2.868	Non-stationary
$lntimetrend_t$	-3.532	-20.487	Stationary
$lnsugarexports_t$	-3.540	-4.159	Stationary
lncane_price	-3.532	-3.928	Stationary
$lnrealprice_t$	-3.540	-1.298	Non-stationary
$Lnsugar\_sales_{t-1}$	-3.540	-1.590	Non-stationary
$lndispo\_income_t$	-3.532	-6.138	Stationary
$lncos_{t-1}$	-3.536	-4.183	Stationary
$lnpopulation_t$	-3.532	-1.132	Non-stationary

Source: Authors' own computations

4.2.2 Stationarity test results after differencing

The ADF test result for the first differenced (d1) domestic sugar supply and demand variables are outlined in Table 4.2.

Table 4.2: ADF test result for the first differenced domestic sugar demand and supply variables

Variables	**Critical Value (5%)**	**Test statistics**	**Decision**
$d1lnrealprice_t$	-4.260	-7.814	Stationary
$d1lnsugar\_sales_{t-1}$	-3.544	-6.804	Stationary
$d1lnsugar\_sales_t$	-3.540	-6.520	Stationary
$d1lnpopulation_t$	-3.536	-6.339	stationary

Source: Authors' own computations

The results show that at a 5% significance level, all variables that were nonstationary at their levels became stationary after first differencing. The stationary variables were used in the analysis to avoid the possibility of spurious results.

4.3 Multicollinearity test results

The severity of multicollinearity was diagnosed using pair-wise correlation matrices and the VIFs for both domestic sugar supply and demand equation. A pairwise correlation matrix result for the variables used in the domestic sugar supply equation is presented in Appendix C2. An asterisk (*) indicates correlation coefficients for variables with statistically significant correlations at a 95% level of statistical confidence. Generally, the significant and higher correlation (at least $|0.8|$) between two variables signals but does not guarantee a higher degree of multicollinearity between the variables (Gujarati and Porter, 2009). In appendix C2, the strength of correlation among variables is not too high (not more than $|0.8|$) to guarantee the presence of extreme multicollinearity between variables. Only the correlation between domestic sugar sales ($d1lnsales_t$) and deterministic time trend (lntimetrendt) is a little bit higher and significant at a 5% significance level (0.6552*) but it still less than $|0.8|$. The correlation coefficients for all other variables are less than 0.5.

As mentioned in section 4.3.2.1, observing correlation matrices only is necessary, but not sufficient to guarantee the presence of multicollinearity between variables, the VIFs should also be considered. The VIF results of the domestic sugar supply variables are outlined in Table 4.3.

Table 4.3: The VIF test results for the domestic sugar supply variables

Variable	VIF	1/VIF
$lntimetrend_t$	1.34	0.744
$lnrealcaneprice_t$	1.57	0.6365
$d1lnrealprice_t$	1.42	0.7025
$lnsugar\_exports_t$	1.22	0.8194
$d1lnsugar\_sales_{t-1}$	1.07	0.9320
Mean VIF	1.33	

Source: Authors' own computations

The common rule of thumb is that a VIF>10 indicates severe multicollinearity (Gujarati and Porter, 2009). All domestic sugar supply variables have a VIF that is less than 10 (VIF<10), indicating no severe multicollinearity between domestic sugar supply variables considered in this study.

The correlation matrix results for the domestic sugar demand equation are presented in Appendix C1. Based on the correlation matrix, extreme multicollinearity cannot be suspected in most variables used in the domestic sugar demand equation, as the correlation coefficients between all variables are less than eight ($>|0.8|$). Only the correlation coefficient between $lncons_{t-1}$ and $d1lnsales_t$ is a little bit high and significant (0.6484*), but it is still less than $|0.8|$. The VIF test results for the domestic sugar demand variables are outlined in Table 4.4.

Table 4.4: The VIF test result for the domestic sugar demand variables

Variable	**VIF**	**1/VIF**
$lncons_{t-1}$	1.95	0.512
$d1lntotalpopulation_t$	1.72	0.583
$d1lnrealprice_t$	1.19	0.841
$d1lnrealdisposable_t$	1.90	0.527
Mean VIF	1.69	

Source: Authors' own computations

Like the domestic sugar supply equation, there was also no evidence of extreme multicollinearity on the variables included in the domestic sugar demand equation, i.e., all variables didn't have a VIF that is greater than10.

4.4 Serial autocorrelation test results

The BG test results for both domestic sugar demand and supply equation are outlined in Table 4.5.

Table 4.5: BG test results for the domestic sugar demand and supply equation

	Lags(*p*)	Chi2	df	Prob>Chi2
domestic-sugar supply	2	0.623	2	0.7323
domestic-sugar demand	2	0.155	2	0.9254

Source: Authors' own computation

The decision criteria of the BG test conclude that if the probability value is greater than 0.05, the null hypothesis of no serial autocorrelation cannot be rejected. In this study, the probability values are 0.7323, and 0.9254, respectively for the domestic sugar supply and demand equation. This implies that the null hypothesis of no serial autocorrelation cannot be rejected, therefore, the error terms of both domestic sugar demand and supply equation are not correlated over time.

4.5. Simultaneous equation results of the domestic sugar demand and supply equation

This section presents simultaneous equations results for the domestic sugar demand and supply. The section starts by presenting the identification test results in section 4.5.1. The Hausman specification error test of endogeneity results are presented in section 4.5.2. In section 4.5.3 the justification of the 3SLS model is illustrated by comparing the standard errors of the 3SLS and 2SLS estimates. In section 4.5.4 and 4.5.5, the 3SLS model results are presented, respectively, for the domestic sugar supply and demand equation.

4.5.1 The identification test results

The domestic sugar demand equation was over-identified, using the order conditions the domestic sugar demand equation excluded five exogenous variables i.e., K-k>m-1 (4>1)-, and based on the rank conditions its determinant was non-zero. Similarly, the domestic sugar supply equation was over-identified, using the order conditions the equation excluded three exogenous variables, i.e., K-k>m-1 (3>1)-, furthermore, using the rank conditions the equation was also identified, i.e., the determinant of the matric was non-zero.

4.5.2 Hausman specification error test of endogeneity

Before one may discard OLS in favour of 2SLS or 3SLS, there must be a statistical justification for that. It is justified to use instrumental variable techniques (3SLS and 2SLS), in the presence of endogeneity, because the OLS method would produce estimates that are both inefficient and inconsistent (Gujarati and Porter, 2009). However, if there is no endogeneity, using the OLS will generate estimates that are both consistent and efficient, in this case using the instrumental variable techniques would result in estimates that are consistent but not efficient. The simultaneity problem arises because some of the regressors are endogenous and are, therefore, likely to be correlated with the disturbance or error term. The test of simultaneity is, therefore, a test of whether an endogenous regressor is correlated with an error term.

The Hausman specification error test was used to test the presence of endogeneity on the domestic sugar demand and supply equations separately. The Hausman specification error test was conducted by regressing the variable suspected to be endogenous against residuals of the equation. A statistically significant residual coefficient indicates that a regressand is endogenous (correlated with an error term), favoring the use of the 2SLS or 3SLS method instead of OLS. However, the insignificant residual coefficients indicate that a regressend is not endogenous, favouring the use of OLS instead of the 2SLS or 3SLS method.

In this study, the Hausman specification error test was conducted by estimating the following regressions:

Domestic sugar demand equation;

$\text{lnreal-price}_t = \beta_0 + \beta_1 \text{lnreal-priceHat} + \beta_2 \ln V_t$……………..……(4.1)

Domestic sugar supply equation;

$\text{lnreal-price}_t = \alpha_0 + \alpha_1 \text{lnreal-priceHat} + \alpha_2 \ln U_t$…………..……(4.2)

where: Real_price_t : is the real domestic price of sugar at time *t*

Real_priceHat : instrumental variable for the domestic price of sugar at time *t*

V_t : residuals for the domestic sugar demand equation at time *t*

U_t : residuals for the domestic sugar supply equation at time *t*

The Hausman specification error test of endogeneity results for the domestic sugar demand equation are presented in Table 4.6.

Table 4.6: Results of the Hausman Specification Error Test of Endogeneity for the Domestic Sugar Demand Equation.

d1lnreal-price	coefficient	Std.Err	P-value
d1lnreal-priceHat	0.144	0.212	0.504
V_t	1.53	0.658	0.028
cons	0.006	0.010	0.589

Source: Authors' own computations

The domestic sugar demand equation residuals (V_t) were statistically significant at a 1% significance level. Therefore, there is sufficient evidence to conclude that there is endogeneity in the domestic sugar demand equation. As a result, either 2SLS or 3SLS could be used instead of OLS to obtain estimates that are both consistent and efficient (Koutsoyiannis, 1977).

The Hausman specification error test of endogeneity results for the domestic sugar supply equation are presented in Table 4.7.

Table 4.7: Result of the Hausman specification error test of endogeneity for the domestic sugar supply equation

$d1lnreal\text{-}price_t$	Coeff	Std. Error	P-value
d1lnreal-priceHat	0.277	0.166	0.106
U_t	1.159*	0.599	0.063
cons	0.005	0.009	0.608

*Significant at the 10 % significance level

Source: Authors' own computation

The residuals of the domestic sugar supply equation (U_t) were statistically significant at a 10% significance level. Therefore, like the domestic sugar demand equation, there is sufficient evidence to conclude that endogeneity is present in the domestic sugar supply equation. Therefore, either 2SLS or 3SLS regression could be used to produce estimates that are more efficient and consistent.

4.5.3 Justification of the 3SLS regression model

The comparison of efficiency gains between the 2SLS and 3SLS estimates is presented in Table 4.8.

Table 4.8: Comparison of efficiency gains between 3SLS and 2SLS

	2SLS Regression			3SLS Regression		
	Coeff	**Std.Err**	**P>t**	**coeff**	**Std. Err**	**p>t**
Sugar Supply						
d1lnrealprice$_t$	1.019***	0.213	0.000	0.838***	0.186	0.000
d1lnsugar_sales$_{t-1}$	0.37*	0.199	0.061	0.246	0.185	0.182
d1nsugar_exports$_t$	0.137	0.121	0.260	0.069	0.109	0.528
lncaneprice$_{t-1}$	-0.074***	0.0195	0.001	-0.059***	0.018	0.001
lntimetrend$_t$	0.105***	0.032	0.001	0.106***	0.033	0.001
cons	7.882	0.308	0.000	7.687	0.289	0.000
Sugar demand						
d1lnrealprice$_t$	-3.766	3.639	0.301	-2.652***	0.768	0.001
lncons$_{t-1}$	0.41***	0.148	0.005	0.4201***	0.079	0.000
d1lntotal_polation$_t$	0.115	0.483	0.24	0.087**	0.156	0.577
lndispos_income$_t$	0.403**	0.165	0.011	0.364***	0.109	0.001
Cons	0.819	3.596	0.23	0.982	1.301	0.450

***, ** refer to 1 % and 5 % levels of significance, respectively

Source: Authors' own computations

All the standard errors generated by the 3SLS model are smaller when compared to those generated by the 2SLS model. Therefore, 3SLS estimates were estimated to be more efficient than the 2SLS estimates, hence, the analysis in this study were based on the 3SLS regression results.

4.5.4 The domestic sugar supply equation results

The results of the domestic sugar supply equation are outlined in Table 4.9.

Table 4.9: Three-Stage Least Squares (3SLS) results for the domestic sugar supply equations in South Africa

Variable	Coefficient	Std. Err	Z	P>z
$d1lnprice_t$	0.838***	0.186	4.51	0.000
$lncaneprice_{t-1}$	-0.059***	0.018	-3.32	0.001
$lntimetrend_t$	0.106***	0.033	3.21	0.001
$d1lnsugar\_sales_{t-1}$	0.246	0.185	1.33	0.182
$d1lnsugar\_exports_t$	0.069	0.109	0.63	0.528
Cons	7.687	0.289	26.56	0..000

$R^2 = 0.665$

P = 0.000 (statistically significant at the 1 % level).

*** refer to 1 % level of significance.

Source: Authors' own computations

The domestic sugar supply equation is significant at a 1% significance level, i.e., its probability value (p) is equal to zero (p=0.000). Furthermore, the model offers a reasonable degree of explanation for the domestic sugar supply equation. The variables included in the domestic sugar supply equation explain about 66.5% of the variations in the natural log of domestic sugar sales (R^2=66.5%).

Sixty percent of the variable coefficients (the real domestic price of sugar, lag real cane producer price, and previous period domestic sugar sales) were found to significantly influence the domestic sugar supply in South Africa. The variable coefficient for the real domestic price of sugar ($d1lnrealprice_t$) was estimated positive and significant at a 1% significance level. The coefficient was estimated to be 0.837, meaning that a 1% increase in the real domestic price of sugar would increase the domestic quantity of sugar sales by 0.837%, which indicates that the domestic supply of sugar is relatively own-price inelastic. This is not surprising because the domestic market is an ideal market for the domestic sugar industry since it is more lucrative than the export market (Kohler, 2016), due to tariff protection afforded by ITAC to the South African sugar industry. Furthermore, the price of sugar realized from the world market is typically lower than the local price of sugar because of many sugar-producing countries benefiting from production subsidies and other forms of government support (Kadwa, 2018). Therefore, South African sugar producers would always aim to sell more in the domestic market than the export market.

The variable coefficient for the deterministic time trend ($d1lntime\_trend_t$), i.e., a proxy for the impact of changes in technology- was estimated to be 0.106 and statistically significant at a 1% significance level. This implies that over the period 1977-2019 technological advancements in the production of sugar have led to an increase in the domestic sales of sugar. This is according to a priori expectations, because, over time, there has been an introduction of many new varieties of cane, better harvesting methods, and more efficient irrigation systems, offsetting the negative impact of declining soil quality in sugarcane and, hence sugar production (Goga, 2013).

The variable coefficient for the sugar exports ($d1lnexports_t$) was estimated to be 0.0686 but not significantly different from zero at a 5% level of statistical confidence. The insignificance of this coefficient does make economic sense because the local sugar market takes priority, due to price discrimination which was explained in detail in section 2.11.6.

The variable coefficient for the domestic sugar sales in the previous period ($d1lnsugar\_sales_{t-1}$) was estimated to be positive but not statistically significant. The variable coefficient was estimated to be 0.246, although the variable coefficient sign is in line with the adaptive expectations' hypothesis, which stipulates that people form their expectations about what will happen in the future based on what happened in the past, implying that the current supply of sugar depends on the previous period supply of sugar (Willis, 1980). However, it is not significant, the possible explanation for this outcome could be the fact that over the recent years there's been no stable domestic supply of sugar by the South African sugar industry, due to challenges such as the oversupply of cheap sugar imports (reducing the domestic sugar industry market share), resulting from inadequate tariff protection of the South African sugar industry. Furthermore, the newly implemented HPL has reduced the local demand for sugar and caused South Africa to supply almost one million tons of sugar to the export market during the 2019/20 season (SACGA, 2019).

The variable coefficient for the previous period's real sugarcane producer price ($lncaneprice_{t-1}$) was estimated to be -0.059 and highly significant at a 1% significant level. This coefficient makes economic sense because sugar is derived from sugarcane (sugarcane is the main input in the production of sugar). Therefore, an increase in the previous period's real price of sugarcane is expected to significantly increase sugar input cost, thereby reducing the quantity of sugar produced and sold in the domestic sugar market.

4.5.5 The domestic sugar demand equation results

The 3SLS regression results of the domestic sugar demand equation are outlined in Table 4.10.

Table 4.10: Three-Stage Least Squares (3SLS) results for the domestic sugar demand equations in South Africa

Variable	Coefficient	Standard Error	Z	P>z
d1lnrealprice$_t$	-2.652***	0.768	-3.45	0.001
lncons$_{t-1}$	0.420***	0.079	5.28	0.000
d1population$_t$	0.087	0.156	0.56	0.577
lndispos_income$_t$	0.364***	0.109	3.33	0.001
Cons	0.982	1.301	0.75	0.450

R^2 = 0.608

P = 0.000 (statistically significant at the 1 % level).

*** refer to 1 % level of significance.

Source: Authors' own computations

The domestic sugar demand equation is overall statistically significant, i.e., the p-value for the domestic sugar demand equation is equal to zero (P=0.000). In comparison to the domestic sugar supply equation, the explanatory variables included in the domestic sugar demand equation offer a reasonable but relatively smaller degree of explanation for the changes in the quantity of domestic sugar demanded. The explanatory variables included in the domestic sugar demand equation explain about 60.8% of the variations in the domestic sugar demand.

Except for the variable representing the South African population size ($d1lnpopulation_t$) all variables included in the domestic sugar demand equation were found to significantly influence the domestic demand for sugar. The variable coefficient for the previous period sugar consumption ($lncons_{t-1}$) was estimated to be 0.420 and statistically significant at a 1% level of significance. The sign of the variable coefficient corroborates the adaptive expectations hypothesis, which states that consumers make current consumption decisions based on their previous period consumption, hence high sugar consumption in the previous period should be associated with high sugar consumption in the current period.

The variable for the total South African population size ($d1lntotal\_population_t$) was estimated to be 0.087 but not statistically different from zero. The sign of this variable is according to a priori expectation because long-term population growth and growth in real income per capita will increase the local demand for sugar (i.e., more people would demand sugar, sugar-containing foods, and beverages, etc.). The insignificant of this variable may be attributable to some demand influencing variables that are not included in the model due to data limitations, i.e., the price of sugar substitutes and complements.

The variable coefficient of the real domestic price of sugar ($d1lnrealprice_t$) in South Africa was estimated to be -2.652 and highly significant at a 1% significance level. This implies that a 1% increase in the real domestic price of sugar will reduce the quantity of sugar demanded by 2.652%. This estimate is greater than one in absolute terms, implying that the domestic demand for cane sugar in South Africa is relatively own-price elastic. This was expected because over time there's been an introduction of various cane-sugar substitutes including honey, stevia, fruit concentrates, coconut sugar, etc.

The variable coefficient for the real disposable income ($lndispo\_income_t$) was estimated to be 0.364 and significant at a 1% level of significance. This implies that the demand for cane sugar is relatively income inelastic. This was expected under an assumption that sugar is a normal good in South Africa, therefore, an increase in consumers' real disposable income, should mean more spending on sugar including cane sugar. Engel's law also stipulates that an increase in consumer's real disposable income, increases the absolute income they spend on food (including sugar), but the proportion of income spent on food decreases (Clements and Si, 2017). Furthermore, the demand for sugar in South Africa was not expected to be highly income elastic, because consumers tend to spend a smaller proportion of their income on sugar since sugar constitutes an insignificant proportion of peoples' daily diet.

4.6 Discussion and conclusion

The objective of this chapter was to present the empirical results of the static demand and supply model (3SLS). The variables used in this study were all stationary, variables that appeared to be non-stationary at their level were transformed to became stationary by taking their first difference. This was essential to avoid the problem of spurious results, which is often encountered when regressing a non-stationary time series variable on another non-stationary time series variable. The model diagnostic tests also confirmed that the data used in this study is free from multicollinearity and serial autocorrelation problem.

The coefficients for the variable of interest, i.e., the own-price elasticity of domestic demand for sugar in South Africa was estimated to be -2.652, indicating that the domestic demand for sugar in South Africa is relatively own-price elastic. The own-price elasticity of domestic sugar supply on the other hand was estimated to be 0.837, indicating that the domestic supply of sugar is relatively own-price inelastic.

The major weakness of the 3SLS regression model was the inability to distinguish between short-run and long-run estimates. The VECM was then used to address the drawback of the 3SLS model. Estimating short-run and long-run elasticity estimates is essential for projecting the short-run and long-run impact of a policy. In chapter five the results of a VECM for the short-run and the long-run elasticity estimates of domestic sugar demand and supply are presented and discussed.

CHAPTER 5: THE SHORT-RUN AND LONG-RUN ELASTICITY ESTIMATES OF DOMESTIC SUGAR DEMAND AND SUPPLY

5.1 Introduction

The short-run and long-run elasticity estimates of the domestic sugar demand and supply variables are presented and discussed in this chapter. The chapter starts by presenting and discussing Johansen's cointegration test results used to assess whether the domestic sugar demand and supply variables have a long-run relationship in section 5.2. In section 5.3 the Wald test for Granger causality results are presented and discussed for the domestic sugar demand and supply variables. Thereafter, the short-run and long-run estimates of the VECM are presented and discussed in section 5.4. Finally, in section 5.5 the VECM validity tests for both domestic sugar demand and supply equations are performed using the serial autocorrelation test, heteroskedasticity test, and residuals normality test.

5.2 Cointegration test results for the domestic sugar demand and supply equation

Appendix H shows the results of Johansen's cointegration test, separately for the domestic sugar demand and supply variables. One of the key assumptions of Johanson's cointegration test is that the nonstationary level variables should be stationary at their first difference, indeed all nonstationary variables were found in section 4.2.2 to be stationary at their first difference, i.e., integrated at an order 1 ***I* (1).**

In the domestic sugar supply equation, there are more than three cointegration relationships between variables. This is confirmed by the trace statistic and the maximum eigenvalue statistics, i.e., before rank four both trace statistics and maximum eigenvalue statistics are greater than their

5% critical values, but from rank four onward both trace and eigenvalue statistics are less than their 5% critical values. However, unlike the domestic sugar supply variables, there are more than two cointegration relationships between domestic sugar demand variables. Therefore, there is a long-run relationship between domestic sugar demand and supply variables used in this study, justifying the use of a VECM instead of a VAR model (Andrei and Andrei, 2014).

5.3 The Granger causality test results of the domestic sugar demand and supply equation

The Wald test for Granger causality results for the domestic sugar demand equation is summarized in Table 5.1.

Table 5.1: Domestic sugar demand equation Wald test for Granger causality results

Equation	Excluded	Chi2	df	Prob>chi2
$d1lnsuga\_sales_t$	$d1lnrealprice_t$	31.447	2	0.000
$d1lnrealprice_t$	$d1lnsugar\_sales_t$	10.316	2	0.006
$d1lnsugar\_sales_t$	$lncos_{t-1}$	18.429	2	0.000
$d1lnsugar\_sales_t$	$d1lntotalpopulation_t$	22.673	2	0.000
$d1lnsugar\_sales_t$	$lnreal\_dispincome_t$	6.4218	2	0.000
	ALL	383.03	7	0.000

Source; Authors' own computations.

The Wald test decision criteria state that if the probability value between two variables is less than 5%, the null hypothesis of no Granger causality between two variables should be rejected, i.e., the probability value for the domestic sugar sales ($d1lnsales_t$) and real domestic price of sugar

($d1lnrealprice_t$) is 0.000, hence there is sufficient evidence to reject the null hypothesis, and thus $d1lnrealprice_t$ granger cause $d1lnsugarsales_t$. The P-values of all variables excluded (the real domestic price of sugar, domestic sugar consumption in the previous year, population size, and real disposable income) against domestic sugar sales in the domestic sugar demand equation were less than 5%, implying that all variables included in the domestic sugar demand equation granger cause the domestic sugar purchases.

The results of the Wald test of Granger causality for the domestic sugar supply equation are presented in Table 5.2.

Table 5.2: Domestic sugar supply equation Granger causality Wald test results

Equation	Excluded	Chi2	df	Prob>chi2
$d1lnsugar\_sales_t$	$d1lnrealprice_t$	4.8954	2	0.006
$d1lnsugar\_sales_t$	$lntimetrend_t$	0.3176	2	0.853
$d1lnsugar\_sales_t$	$d1lnsugar\_sales_{t-1}$	10.118	2	0.006
$d1lnsugar\_sales_t$	$d1lnsugar\_exports_t$	19.502	2	0.000
	ALL	6.837	8	0.000

Source: Authors' own computations

The probability values indicate that all variables included in the equation except for the deterministic time trend ($lntimetrend_t$), granger cause the domestic quantity of sugar sales ($d1lnsugar\_sales_t$), i.e., their probability values are less than 5%.

5.4 The short-run and long-run elasticity estimates of domestic sugar demand and supply equation

The presence of a cointegration relationship between variables used in this study suggests that the VECM could be used to separate the short-run and the long-run responses of domestic sugar demand and supply to price and non-price factors. The instrumental variable for the price (d1lnrealpriceHat) was used since there is endogeneity between the real domestic price and the quantity of sugar sold and purchased in the domestic sugar market.

5.4.1 The optimal lag length selection

To determine the model optimal lag length, the Akaike's information criteria (AIC) was used. The results for selecting the optimal lag length are outlined in Table 5.3. The AIC results imply that the model has one optimal lag length (the lowest value of the AIC occurs at lag one).

Table 5.3: The model optimal lag length selection

lag	L1	LR	df	p	AIC	HQIC	SBIC
0	-1006.5				54.6223	54.6837	54.7964
1	-900.4	212.05	16	0.000	49.756*	50.063*	50.6268*
2	-879.57	5.8322	16	0.990	50.4632	51.0158	52.0306
3	-880.28	34.576*	16	0.005	50.3936	51.1918	52.6576
4	-870.52	19.519	16	0.243	50.7309	51.7747	53.6915

*indicates the lowest critical value of a given criteria

Source: Authors' own computations

5.4.2 The short-run elasticity estimates of domestic sugar demand and supply equations

The short-run elasticities of domestic sugar demand and supply various price and non-price factors included in this study are presented in Table 5.4.

Table 5.4: Short-run estimates of the VECM for the domestic sugar demand and supply

Variable	Coefficient	Standard Error	P-Value
Domestic sugar demand equation			
d1lnrealpriceHat	-0.3011*	0.164	0.067
$lndispo\_income_t$	0.017	0.023	0.464
$lncons_{t-1}$	0.936***	0.032	0.000
$d1lntotal\_population_t$	-0.744	1.357	0.584
Cons	0.623	0.264	0.018
Domestic Sugar Supply Equation			
d1lnrealpriceHat	0.762***	0.227	0.001
$lnsugar\_exports_t$	-0.162	0.122	0.185
$lncaneprice_{t-1}$	-0.188**	0.089	0.036
$lntimetred_t$	0.145	0.185	0.434
$d1lnsugar\_sales_{t-1}$	0.323**	0.145	0.026
Cons	5.097	1.956	0.009

***, **, * refer to 1 %, 5% and 10 % levels of significance, respectively.

Source: Authors' own computations

For the domestic sugar demand equation, half of the estimated variable coefficients were statistically significant in the short run. The variables that were found significant include an instrumental variable for the price (d1lnrealpriceHat) and consumption of sugar in the previous period ($d1lncons_{t-1}$).

The coefficient of the price instrumental variable (d1lnrealPriceHat) was estimated to be -0.301 and statistically significant at the 10% level of significance. This implies that in the short-run, the domestic demand for sugar in South Africa is relatively own-price inelastic, with the short-run own-price elasticity of demand being equal to -0.301. Therefore, in the short run, a 1% increase in the real domestic price of sugar will reduce the quantity of sugar demanded in the local market by 0.301%, *ceteris paribus*. This is consistent with economic theory because in the short-run consumers do not respond instantaneously to price changes, for many reasons including search cost, consumers' unlikeliness to notice price changes immediately, habitual patterns of behavior of consumers, and consumers' uncertainties about future price changes (Tomek and Kaiser, 2014).

The coefficient for the previous period consumption of sugar ($lncons_{t-1}$), was estimated to be 0.936 and statistically different from zero at the 1% significance level. The sign of this variable coefficient corroborates with the adaptive expectations' hypothesis, which states that consumers make current consumption decisions based on their previous period consumption experiences. Therefore, the domestic consumption of sugar in the previous period is expected to be positively related to the domestic consumption of sugar in the current period. The variable coefficients that indicate changes in consumers' real disposable income ($lndispo\_income_t$) and South African population size ($d1lntotal\_population_t$) do not significantly influence the domestic consumption of sugar in the short run.

For the domestic sugar supply equation, several variables were also found to significantly influence the domestic quantity of sugar sold in the short run, these variables include the instrumental variable for the real domestic price of sugar (d1lnrealpriceHat) and the previous period's real price of sugarcane (lncaneprice_{t-1}). The instrumental variable for the real domestic price of sugar (d1lnrealpriceHat) was statically significant at a 1% significance level. This variable was estimated to be 0.762, implying that in the short-run the domestic supply of sugar in South Africa is relatively own-price inelastic. Therefore, in the short run, a 1% increase in the real domestic price of sugar, will increase the quantity of sugar supplied in the domestic sugar market by 0.762%, *ceteris paribus*. This was expected because the supply response may be relatively small in the short-run due to the medium-term nature of the sugarcane crop (a major input in the production of sugar), i.e., sugarcane is typically replanted every ten years, in other areas a time lag from planting sugarcane to harvest can be 24 months (Zhou, 2013). Moreover, there are many competing uses for land suitable for sugarcane production, for instance, orchards crop (macadamia nuts, avocado, mango, etc.) or other medium-term crops (e.g., forestry).

The coefficient for the previous period's real producer price of sugarcane ($\text{lncane\_price}_{t-1}$), was estimated negative and statistically different from zero at the 5% significance level. This variable corroborates with the economic theory of an inverse relationship between the supply of a commodity and its cost of production (Daly and Farley, 2004). This is because sugarcane is the key input in sugar production with no substitute for sugar mills in SA. Therefore, a decrease in the quantity of sugarcane demanded by the sugar millers' (due to an increase in the real price of sugarcane) will lead to a decrease in the quantity of sugar produced.

The variable coefficient for the previous period domestic sugar sales ($d1lnsugar\_sales_{t-1}$) was estimated to be 0.325 and significant at a 5% level of significance. The variable coefficient conforms to the adaptive expectations hypothesis.

The variable coefficient for the deterministic time trend (lntimetrend) (a proxy for technological advancement) was estimated to be 1.45, but not statistically different from zero. Although technological improvements enable firms to produce more output with the same quantity of resources (Tomek and Kaizer, 2014), a statistically insignificant time trend was expected in the short run. This is because more time is required to develop or adopt new technologies (i.e., discovering and projecting the net benefit of new technologies through research may take time) and for technology to have a meaningful impact in production (i.e., possible need for reskilling labour to better handle technology). Research by (Gibson, 2016), also indicated that declining soil quality (e.g., soil acidification, soil compaction, etc.) is another factor, that tends to partially offset the effects of technological advancement on sugarcane yield. Therefore, in the short run, declining soil fertility is likely to elicit a zero-sugar supply response to advances in sugar production methods.

5.4.3 The long-run elasticity estimates of domestic sugar demand and supply variables

The results of the long-run elasticity estimate of both domestic sugar demand and supply are presented in Table 5.5.

Table 5.5: Long-run estimates of the VECM for the domestic sugar demand and supply equations

Variable	Coefficient	Standard error	P-value
Domestic sugar demand equation			
d1lnrealpriceHat	-2.243*	1.304	0.086
$lndispo\_income_t$	0.688***	0.047	0.000
$d1lnpopulation_t$	-0.0145	0.069	0.835
$lncons_{t-1}$	0.038***	0.007	0.000
ECt_1	-0.319**	0.096	0.001
Domestic sugar supply equation			
d1lnrealpriceHat	1.809***	0.215	0.000
$1nsugar\_exports_t$	0.339	0.239	0.156
$lnrealcane\_price_t$	-5.867***	0.451	0.000
$lntime\_trend_t$	0.217***	0.056	0.000
ECt_2	-0.942***	0.341	0.006

***, **, * refer to 1 %, 5 % and 10 % levels of significance, respectively.

Source: Authors' own computations

Both domestic sugar demand and supply equations were significant at a 1% significance level, i.e., their P-values are equal to 0.000. The own-price elasticity of domestic sugar demand (d1lnreal_priceHat) was estimated to be -2.243 and significance at 1% significance level, implying that in the long run, a 10% increase in the real domestic price of sugar will reduce the quantity of sugar demanded in the domestic sugar market by 2.243%, *ceteris paribus*. This implies that the domestic demand for sugar in South Africa is relatively own-price elastic in the long run. This was expected because, in the long run, consumers and manufacturers of sugar-containing goods, e.g., SSBs, have time to adjust to a change in price. As a result, they may discover new substitutes for sugar (Subotnik, 1974). Consumers of sugar and Manufacturers of SSBs are already substituting sugar with artificial sweeteners, i.e., Stevia, xylitol, honey, molluscs, syrup, etc.

The coefficient of the instrumental variable for the price (d1lnreal-priceHat) on the domestic sugar supply equation was estimated to be 1.809 and is statistically significant at a 1% significance level. This implies that a 1% increase in the real domestic price of sugar will increase the quantity of sugar supplied by 1.809% in the long-run, *ceteris paribus*. This was expected because over time producers of sugar can change their mix of enterprises in their farm plans, making the long-run domestic supply of sugar to be relatively more responsive to own-price changes. This could be supported by the fact that South African sugarcane producers are already diversifying towards other land uses including various long-term crops (macadamia nuts, avocado, etc.), in response to challenges facing the South African sugar industry (HPL, the cheap sugar imports, rising input cost) (BFAP, 2018).

The variable coefficient of the real disposable income ($lnrealdisp\_income_t$) was estimated to be 0.688 and significant at a 1% significance level. This variable coefficient represents the income elasticity of domestic demand for sugar in South Africa. Therefore, a 1% increase in average consumers' real disposable income will increase the domestic demand for sugar by 0.688%, *ceteris paribus*. This implies that the domestic demand for sugar in South Africa is relatively income inelastic in the long run, this was expected because sugar is a necessity good and it constitutes a small portion of consumers' everyday diet, therefore, consumers tend to continue purchasing nearly the same quantity of sugar even when their income level changes.

The variable coefficient for the previous period domestic consumption ($lncos_{t-1}$) of sugar was estimated to be 0.038 and highly significant at a 1% significance level. This outcome is consistent with the adaptive expectation hypothesis.

The variable coefficient for the South African population size was estimated to be -0.014 and not statistically different from zero. This was not expected because a long-term growth in population, with a growth in real income per capita, is expected to increase the demand for sugar. The missing key demand explanatory variables such as the price of sugar substitutes or complements due to data limitations could be responsible for this outcome.

The variable coefficient for the error correction term (ECt_1) indicates the speed of adjustment towards the long-run equilibrium for the domestic sugar demand equation. The variable coefficient has an expected negative sign and is significant at a 1% significant level. The ECt_1 was estimated to be -0.319, implying that 31.9% of the disequilibrium in domestic sugar demand is corrected per annum, i.e., the distortions in the domestic sugar demand from the long-run equilibrium are corrected by 31.9% per annum.

The variable coefficient for sugar exports ($d1lnexports_t$) was estimated to be 0.339 and not statistically significant. This was expected because increasing local sugar sales is the main priority for the South African sugar industry since the local market prices tend to exceed prices on the export market. The reasons for this were explained in section 2.11.6.

The variable coefficient of the deterministic time trend was estimated to be 0.217 and significant at a 1% significance level, implying that improvement in sugar production technology has been increasing domestic sugar sales. This is in contrast with the short-run estimate which was insignificant. This was expected because, over the past decades, there has been an introduction of new sugarcane varieties, an introduction of advanced sugarcane irrigation and harvesting methods, which are likely to outweigh the negative impact of soil degradation in sugar production (Mahmood, 2013).

The variable coefficient for the real price of sugarcane in the previous period was estimated to be -5.867 and significant at a 1% significance level. This was expected since sugarcane is the key input in the production of sugar. An increase in the real price per ton of sugarcane is expected to reduce the quantity of sugarcane demanded by South African sugar producers in the long run, which will, in turn, reduce the quantity of sugar produced and available to be sold in the domestic sugar market.

The variable coefficient for the error correction term (ECt_2) indicates the speed of adjustment towards the long-run equilibrium for the domestic sugar supply equation. The ECt_2 was estimated to be -0.942 and significant at a 1% significance level. The coefficient is negative and statistically significant as expected. This implies that 94.2% of the disequilibrium in domestic sugar supply is corrected per annum.

5.5. The VECM validity tests

The validity of a VECM gets proved by the tests applied to residuals. The model residuals must be normally distributed with no serial autocorrelation and be homoscedastic (Taghvae *et al*, 2015). When the residuals of a VECM possess this characteristic, the results predicted by a VECM can be used for analysis and forecasting. In this section, the results of the model validity test are presented.

5.5.1 The test of residual serial autocorrelation

The results of residual serial autocorrelation were discussed in section 4.4. Using the BG test, autocorrelation was not found on both domestic sugar demand and domestic sugar supply residuals. Therefore, based on the results of serial autocorrelation, it can be concluded that the results of a VECM both domestic sugar demand and supply are reliable, and hence they could be used for analyzing and forecasting.

5.5.2 The residuals normality tests

The distribution of domestic sugar supply residuals using the bar graph is presented in Figure 5.1. The bar graph seems normally distributed (i.e., it is not skewed in any direction), the domestic sugar supply residuals, therefore, seem to satisfy the normality assumption.

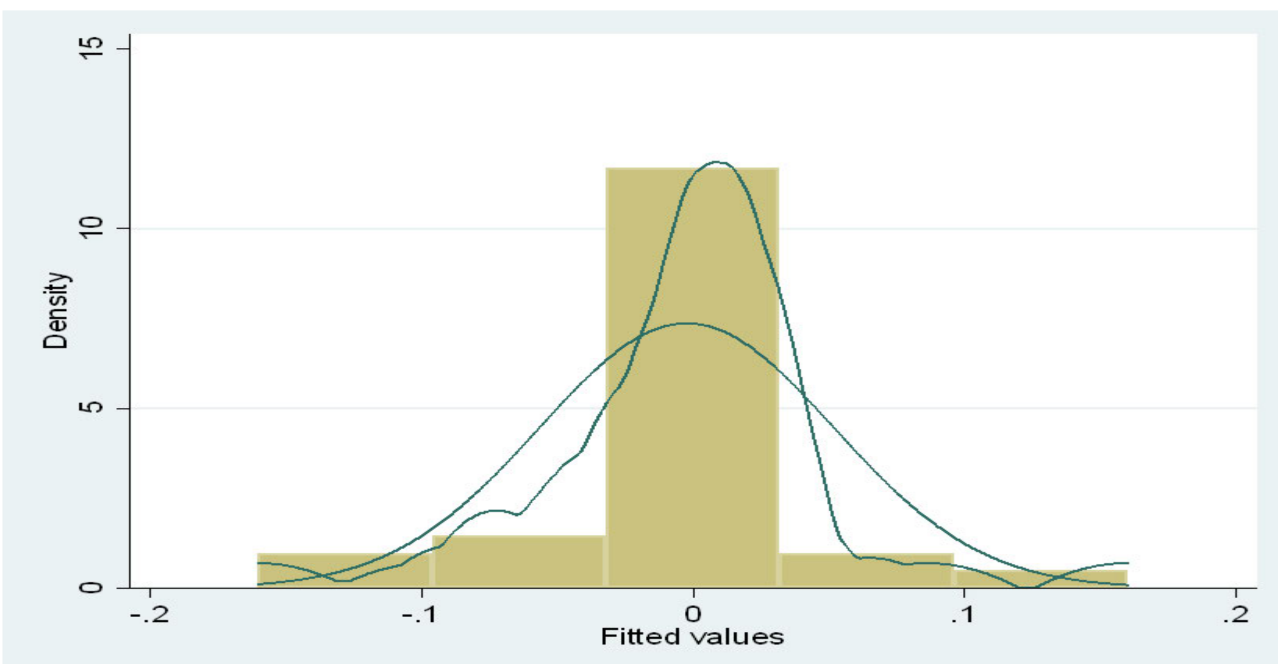


Figure 5.1: Bar-graph of the distribution of the sugar-supply residuals (Authors' own computations)

To be more certain that domestic sugar supply residuals are normally distributed, the commonly used Jarque-Bera (JB) normality test was conducted. The JB normality test results for domestic sugar supply residuals are outlined in Table 5.6.

Table 5.6: Jarque-Bera normality test of results for domestic sugar supply equation residuals

Variable	Chi(2)	Prob>chi(2)
Supply residuals	1.348	0.5097

Source: Authors' own computations

Since the P-value (0.5097) of the JB test is greater than 5%, there is sufficient evidence to conclude that the residuals of the domestic sugar supply equations are normally distributed. Therefore, based on the JB test of normality, the estimates of the VECM for the domestic sugar supply equation are reliable and could be used for forecasting.

The bar graph showing the distribution of domestic sugar demand residual distribution is presented in Figure 5.2. The bar graph seems to be normally distributed but it's not highly convincing. Using a more formal test could help in this circumstance, e.g., the JB normality test.

Figure 5.2: Bar-graph of the domestic sugar demand residuals distribution (Authors' own computations)

The JB normality test was conducted for better clarity on the distribution of domestic sugar demand equation residuals. The results are presented in Table 5.7.

Table 5.7: Jarque-Bera normality test results for domestic sugar demand equation residuals

variable	**chi2(2)**	**Prob>chi2**
Demand residuals	3.644	0.1617

Source: Authors' own computations

Table 5.7 shows that the P-value (0.1617) of the JB normality test for the residuals of the domestic sugar demand equation is greater than 5%. This implies that the residuals of the domestic sugar demand equation are normally distributed. Based on the JB normality test, the VECM estimates of the domestic sugar demand equation are reliable, hence they can be used for analysis and forecasting.

5.5.3 The Heteroskedasticity test results

The White test for heteroskedasticity was used on both domestic sugar demand and supply equation to test whether the domestic sugar demand and supply residuals are homoscedastic (same finite variance). The White test results for both domestic sugar demand and supply equation are outlined in Table 5.8

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Table 5.8: White's heteroscedasticity test results for both domestic sugar demand and supply residuals

Equation	Chi2	P-value
Sugar demand	9.87	0.7717
Sugar supply	27.39	0.1247

Source: Authors' own computation

Since the P-values of the white's test are greater than 5% on both domestic sugar demand (0.7717) and domestic sugar supply (0.1247), there's sufficient evidence to conclude that the domestic sugar demand and supply residuals are Homoscedastic, justifying the use of a VECM for forecasting and analysis.

5.6 Discussion and conclusion

The objective of this chapter was to present the short-run and long-run elasticity estimates of domestic sugar demand and supply variables. This was essential to project the short-run and long-run impact of a SSBs tax on the revenue earned by the South African sugar industry in the local sugar market. The model validity tests (i.e., residuals normality test, heteroscedasticity test, and serial autocorrelations test), confirmed that the results of a VECM are reliable, hence they can be used for future forecasting and predictions.

The variables of interest, i.e., the short-run and long-run own-price elasticity estimates of domestic sugar demand were estimated to be -0.301, and -2.243, respectively. Therefore, in the short-run consumers of sugar are relatively less responsive to changes in the real price of sugar, due to many reasons including, consumers' unlikeness to notice price changes immediately, habitual behavioral patterns of consumers, and consumers' uncertainties on whether price changes are transitory or permanent. However, in the long run, consumers' will be relatively more responsive to sugar price changes because they will have enough time to discover other substitutes for sugar. Having estimated the own-price elasticity estimates of domestic sugar demand in chapters four and five, the impact of the SSBs tax on the South African sugar industry is estimated in chapter six using the estimated own-price elasticity estimates of domestic sugar demand.

CHAPTER 6: THE IMPACT OF THE SSBs TAX ON THE SOUTH AFRICAN SUGAR INDUSTRY

6.1 Introduction

The results of the impact of the SSB tax on the South African sugar industry based on the results presented in chapter four and chapter five are discussed in this chapter. The chapter starts by providing estimates of sugar notional prices for 2016/17, and 2019/20 seasons as the sum of the sugar export tariff and sugar export parity price. Secondly, the estimates of the own-price elasticity of domestic sugar demand are used to project the impact of the SSB tax on the revenue earned by the domestic sugar industry, under the consideration of a static demand and supply model (3SLS), as well as under the consideration of the dynamic demand and supply model (VECM). Lastly, the South African sugar industry division of proceeds formula was used to project the impact of the SSB tax on the RV price received by sugarcane growers.

6.2 The impact of a sugar tax on the revenue earned by the South African sugar industry

The sugar notional prices were estimated at R8719.96/t and R9108/t, respectively for the 2016/17 and 2019/20 seasons. The 2016/17 season was used to denote the year before the implementation of the HPL, the choice for using the 2016/17 season instead of the 2017/18 season, was the large sugar imports volumes (more than 500 000 tons) during the 2017/18 season which substantially reduced the domestic sales of sugar, as the South African sugar industry had to export large quantities of sugar, due to the loss in the domestic market share. Using the own-price elasticity estimates of domestic demand for sugar and sugar notional price estimates, the impact of the SSBs tax on the South African sugar industry’s domestic revenue was estimated as follows:

i) **The impact of the HPL on the revenue earned by the sugar industry in the domestic sugar market using the static demand and supply model (3SLS model)**

From the ε_{DD} the estimate of -2.652, the quantity of sugar sold in the domestic sugar market was estimated to have decreased by 184 169 tons. The change in domestic sugar revenue was then estimated as a product of ΔQdd*PwithHPL, and it was estimated to have decreased by R1.68 billion.

ii) **The Short-run and long-run impact of the HPL on the revenue earned by the sugar industry in the domestic sugar market using the dynamic demand and supply model (VECM)**

From the short-run ε_{DD} estimate of -0.301, the quantity of sugar sold in the domestic sugar market was estimated to have decreased by 20 901 tons in the short run, causing an estimated domestic market sugar revenue loss of about R190 million in the short run.

Using the long-run ε_{DD} estimate of -2.243, the domestic quantity of sugar sales was estimated to have decreased by 154 917 tons in the long run, causing a revenue loss of about R1.41 billion in the long run.

6.3 The estimated impact of the HPL on the RV price

From the sugar industry division of proceeds formula (illustrated in section 2.11.6), the 2019/20 RV price with (counterfactual) and without HPL were estimated to be R3932 and R4329, respectively. To estimate the impact of the HPL on the RV price received by growers during the 2019/20 season, a percentage change in the RV price as a result of the HPL was calculated against the counterfactual (i.e., RV price without HPL). The RV price received by growers during the

2019/20 season was estimated to be 9.167% lower than what it could have been in the absence of the HPL.

6.4 The Sensitivity analysis

The purpose of this section is to project the impact on the revenue earned by the South African sugar industry and the RV price received by sugarcane growers if for any reason the HPL was to increase by 20% to ZAR 0.0299 per gram of sugar contained in each SSB (i.e., the initial tax proposition). This is necessary given the ongoing suggestions by the organizations that are in support of the HPL such as, HEALA, ADSA, etc., for government to increase a SSB tax to the initial tax proposition of 20% (ADSA, 2020 and HEALA, 2020). Their major concern is that a 10% tax has been less successful at reducing the consumption of SSBs as it generated revenue that is higher by R1.32 billion when compared to the initial revenue projections of about R1.9 billion.

Based on an assumption that doubling the rate of increase in the sugar tax (i.e., from 10% to 20%) would also double the rate of increase in the sugar notional price, *ceteris paribus*, the notional price with a 20% tax was estimated to be R9496.04/t. The sensitivity analysis results for the possible impact of a 20% SSBs tax on the domestic sugar industry revenue are presented in Table 6.1. Based on a consideration of a 3SLS (static demand), own-price elasticity of domestic sugar demand estimate (-2.652), a 20% tax on SSBs is expected to reduce the quantity of sugar demanded in the domestic sugar market by 361 198 tones, causing a revenue loss of about R3.4 billion. Employing a VECM short-run own-price elasticity of domestic demand for sugar (-0.301), a 20% tax on SSBs is expected to reduce the quantity of sugar demanded in the domestic sugar market by 41 1131 tons in the short run, causing a revenue loss of about R390 million in the short-run. Using the VECM long-run own-price elasticity estimate of domestic demand for sugar (-2.243), a 20% tax on SSBs is expected to reduce the quantity of sugar demanded by 306 380 tons, causing a domestic sugar revenue loss of about R3 billion in the long run.

Table 6.1: The Sensitivity analysis results of a 20% SSBs tax impact on domestic sugar industry revenue

Own price elasticities of domestic sugar demand	**Change in quantity demand (tons)**	**Change in revenue (R)**
3SLS estimate (-2.652)	-361 198	-R3.4 billion
VEM short-run estimate (-0.301)	-41 1131	-R390 million
VECM long-run estimate (-2.243)	-306 380	-R3 billion

Source: Authors' own computations

The results of the sensitivity analysis for the expected impact of a 20% SSB tax on the RV price received by sugarcane growers are presented in Table 6.2.

Table 6.2: The sensitivity analysis of a 10% and 20% SSBs tax on the RV price

Tax rate	**Counterfactual 2019/20 RV price**	**2019/20 RV Price**	**The change in RV price**
10% tax rate	R4329	R3932	-9.167%
20% tax rate	R4644	4644	-12.545%

Source: Authors' own computations

Results show that a 20% tax on SSBs will reduce the 2019/20 RV price paid to growers by 12.545% compared to the RV price they could have received if there was no SSBs tax. This is

3.378% higher than an expected decline in the 2019/20 RV price under consideration of a 10% SSBs tax.

6.5 Discussion and conclusion

The important insights regarding the impacts of the SSBs tax on the financial position of the sugarcane growers and millers were presented in this chapter. To achieve this objective, the impact of the SSBs tax on the revenue earned by the sugar industry from the local sugar market and the impact of the SSBs tax on the RV price received by sugarcane growers were estimated.

The SSBs tax was estimated to have caused a considerable impact on the sugar industry, as under consideration of a static model (3SLS model) own-price elasticity estimate of domestic sugar demand, the SSBs tax was estimated to have reduced the domestic sugar revenue by R1.68 billion since the onset of the SSBs tax. Furthermore, using the VECM short-run and long-run own-price elasticity estimates of domestic sugar demand, the revenue earned by the domestic sugar industry was estimated to have decreased by R190 million and R1.41 billion, respectively in the short-run and long run. Using the division of proceeds formula, the RV price received by sugarcane growers' during the 2019/20 season was estimated to be lower by 9.167% when compared to the RV price that growers could have received if there was no SSBs tax.

The sensitivity analysis showed that an increase in the tax rate to the initial tax proposition, i.e., 20% would exacerbate the negative impacts of the SSBs tax, since the domestic sugar revenue will be reduced by an extra R390 million and R3 billion in the short-run and long-run, respectively. Therefore, if the government follows recommendations from health organizations (ADSA, HEALA, etc.) and increases the sugar tax to the initial proposition of 20%, both sugarcane growers' and sugarcane millers' will be worse off thereby, increasing the estimated job losses even further.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Recap of the research objectives and methodology

The general objective of this study was to investigate the impact of a SSB tax on the South African sugar industry. This was necessary because, from the onset of the SSB tax implementation, most of the grey literature has been written or commissioned by players' parties with a vested interest in the HPL (e.g., manufacturers of SSBs, the local sugar industry, and the South African government), and they may be biased.

To achieve this general objective, the following specific objectives were explained (1) evaluation of the price and non-price factors affecting domestic demand and supply of sugar in South Africa, (2) estimation of the impact of the SSBs tax on the quantity of sugar demanded in the domestic sugar market (3) estimation of the impact of the SSB tax on the South African sugar industry in terms of the RV price received by sugarcane growers' and the revenue generated from the domestic sugar market.

The analytical and empirical approaches used to achieve the above objectives were Three-Stage Least Squares (3SLS) regression and Vector Error Correction Model (VECM). The study relied on the secondary time series data for the period 1977-2019, gathered from the South African Cane Growers Association (SACGA), South African Reserve Bank (SARB), Department of Agriculture Forestry and Fisheries (DAFF), and World Bank. The chapter outlines the conclusions drawn from the study, moreover, the chapter recommends possible policy strategies as well as directions for further research.

7.2 Conclusions and recommendations

The results from the static demand and supply model (3SLS model), revealed that the factors influencing the domestic sugar supply response in South Africa include the real domestic price of sugar, deterministic time trend, and previous period real price of sugarcane, while the factors influencing the domestic sugar demand response include the real domestic price of sugar, previous period sugar consumption, and real disposable income. Most importantly, the own-price elasticity estimates of domestic sugar demand and supply were estimated to be -2.652 and 0.838, respectively, implying that the domestic sugar demand is relatively own-price elastic, whereas the domestic sugar supply is relatively own price-inelastic.

With the 3SLS model, it was difficult to indicate whether the estimates are for the short-run or the long-run period. The VECM was then used to obtain consistent and yet distinct long-run and short-run estimates of both domestic sugar demand and supply equation, this is essential when assessing the effects of a policy on the economy. Using the VECM, in the short-run, the own-price elasticity estimates of domestic sugar demand and supply were estimated to be -0.301 and 0.762, respectively. Implying that in the short run both domestic sugar demand and supply in South Africa are relatively less responsive to their own-price changes.

The long-run own-price elasticity estimates of the domestic sugar demand and supply were estimated to be -2.243, and 1.809, respectively. Implying that both domestic sugar demand and supply are relatively own-price elastic in the long run. The long-run absolute own-price elasticity estimates of domestic sugar demand and supply were larger than the short-run estimates because in the long run producers and consumers have more time to respond to price changes.

Lastly, the impact of the SSBs tax on the domestic sugar market revenue earned by the South African sugar industry was analyzed using the sugar notional price estimates (estimated as the sum of the sugar export parity price and sugar import tariff) and own-price elasticity estimates of domestic sugar demand. Using a 3SLS model, the SSBs tax was estimated to have reduced the quantity of sugar demanded in the domestic sugar market by 184 169 tons, resulting in the domestic revenue loss of about R1.68 billion.

Using a VECM, in the short run, the SSBs tax was estimated to have reduced the quantity of sugar demanded in the domestic sugar market by 20 901 tons, resulting in the domestic revenue loss of about R190 million. In the long run, the SSBs tax was estimated to reduce the quantity of sugar demanded in the domestic sugar market by 154 917tons, resulting in a domestic revenue loss of about R1.41 billion.

The reduction in revenue was smaller in the long run than in the short-run, because consumers are less responsive to price changes in the short run. Therefore, it's likely that the consumption of SSBs changed slightly, during the early months of the tax imposition due to several possible reasons (including, consumers' unlikeliness to notice price changes immediately, habitual behavioral patterns of consumers, and consumers' uncertainty about future price changes), and hence the domestic demand for sugar by the manufactures of SSBs didn't decrease significantly, leading to a smaller reduction on the revenue earned from domestic sugar sales in the short-run compared to the long-run.

The study also assessed the impact of the HPL on sugarcane growers, by estimating the impact of the HPL on the RV price received by sugarcane growers' during the 2019/20 season. Using the sugar industry division of proceeds formula. The RV price received by sugarcane growers 'during the 2019/20 season was estimated to be lower by 9.167% when compared to the RV price that sugarcane growers could have received if there was no HPL. A reduction in the RV price induced by the HPL is expected to cause large-scale sugarcane growers to increase the size of their operation (i.e., to maintain the same level of revenue given a reduction in the RV price). This, however, will be most detrimental to the liquidity and profitability of relatively smaller and less diversified farms, and especially small-scale growers who can't easily expand their farming operations due to resource limitations.

The sugar tax is indeed amongst factors that are causing a considerable reduction in the South African sugar industry returns and its contribution to the country's GDP. However, despite the negative impact of the SSBs tax, it is likely that in the short run two or more mills will cease to operate, therefore, reducing the supply of sugarcane and sugar (including sugar exports) and restore the RV price. However, in the long run, the mill closures are less likely to occur, as the benefits of a mill closure by one miller will be accrued by a competitor.

The significant negative impacts of a sugar tax on the South African sugar industry suggest the need for the South African sugar industry to invest more in other alternative income streams, which may be deemed necessary in ensuring its long-term sustainability. The South African sugar industry stakeholders are already exploring to diversify the sugar industry income streams by expanding the production of biofuels including ethanol production from sugarcane, electricity co-generation from bagasse, and biochemical feedstock's, amongst other things as the diversification plan that could help the SA sugar industry to remain profitable and sustainable. The South African government is, therefore, recommended to support the South African sugar industry with legislation that will allow the generation of revenue from these alternative by-products, especially those that promote the use of ethanol-blended petroleum and enable sugar mills to sell electricity from co-generation. The South African sugar industry cannot undertake much of this possible diversification without government intervention, because the energy and chemical sectors in South Africa are highly regulated.

The other major challenge facing the South African sugar industry is the over-supply of cheap sugar imports, which causes the South African sugar industry to export a relatively large quantity of sugar at prices that are generally below even the industry cost of production. This study, therefore, recommends DTI to ensure that the tariff protection is always in place and it provides sufficient protection to the South African sugar industry, opposite to the 2017/2018 season scenario whereby the disagreements between DTI and the South African sugar industry in terms of increasing tariff protection led to a zero Rand duty being applied on sugar imports for seven weeks between July and September 2017. In this regard, the study further recommends the DTI to review a zero-duty applied on sugar imports from countries in the SADC region. This is because the SADC countries' sugar imports, particularly sugar imports from Eswatini have an adverse effect on the South African sugar industry by reducing its local market share.

7.3. Limitations of the study and suggestion for further research

Due to data limitations and time constraints, the scope of the analysis was limited to the impact of the HPL on the South African sugar industry. There is potential for future research to investigate the impact of the tax on other sectors of the economy, i.e., the manufactures of SSBs.

Furthermore, the study only assessed the revenue implications of the tax on the South African sugar industry. There is also a potential for future research to investigate other impacts of the SSBs tax on the sugar industry, e.g., the impact on employment and the impact on the financial viability of small-scale sugarcane farms.

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APPENDICES

Appendix A

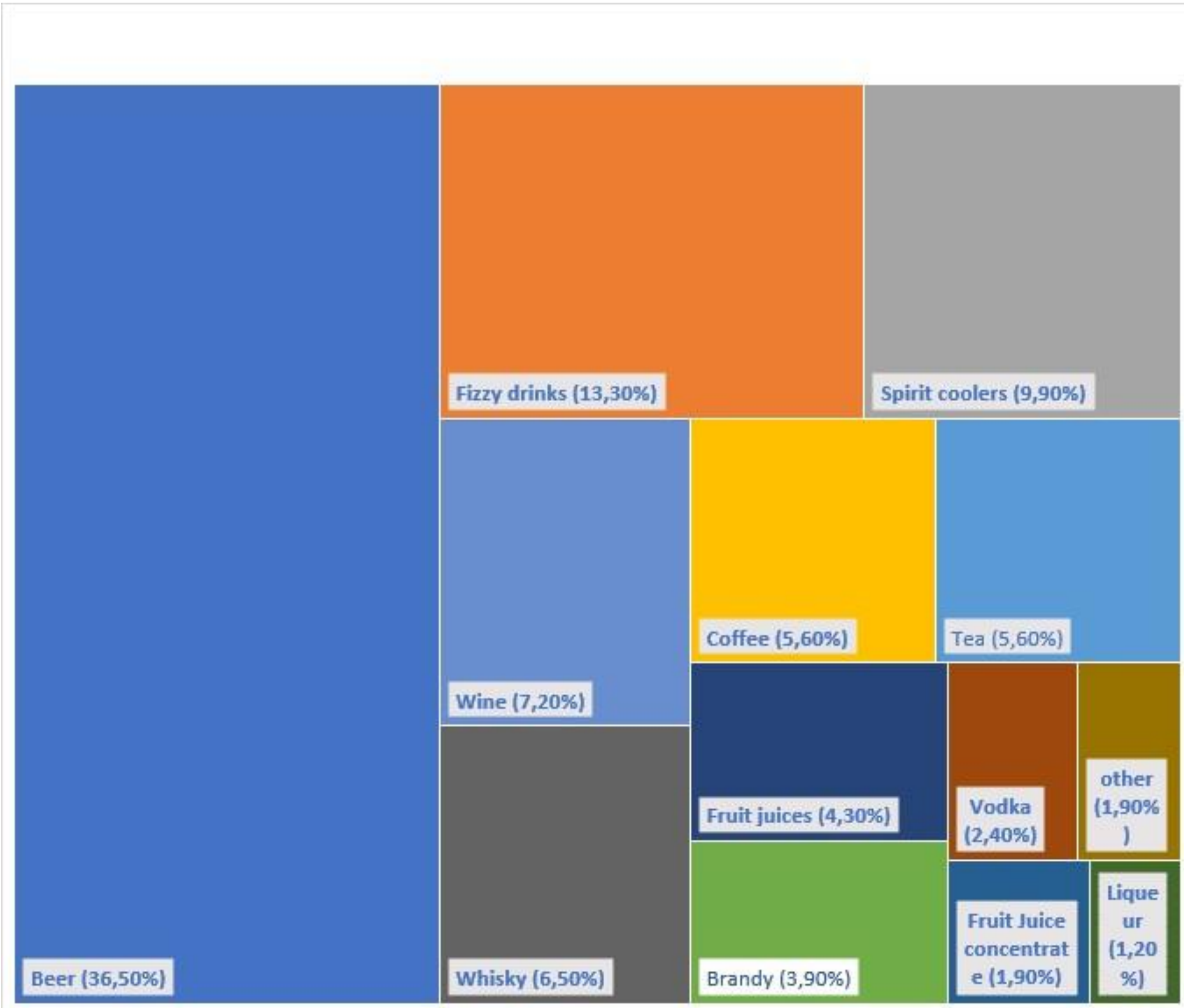

Figure A1: Percentage Breakdown of Total Household Expenditure on Beverages in South Africa (STATSA ,2019)

Appendix B: ADF stationary test results

Appendix B1: ADF stationarity test results for the domestic sugar demand and supply variables at their levels

- $lnsugar\_sales_t$

```
. dfuller lnSugarsales1000t, trend regress lags(0)

Dickey-Fuller test for unit root                   Number of obs   =        42
```

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.868	-4.224	-3.532	-3.199

MacKinnon approximate p-value for Z(t) = 0.1731

D.lnSu~1000t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnSuga~1000t						
L1.	-.3420924	.1192807	-2.87	0.007	-.5833603	-.1008244
_trend	.0018249	.001172	1.56	0.128	-.0005456	.0041954
_cons	2.426005	.8412256	2.88	0.006	.7244661	4.127545

- $lnsugar\_sales_{t-1}$

Dickey-Fuller test for unit root   Number of obs   =   41

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.696	-4.233	-3.536	-3.202

MacKinnon approximate p-value for Z(t) = 0.2376

D.lnsugar_~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnsugar_sa~1						
L1.	-.3291606	.1220727	-2.70	0.010	-.5762838	-.0820374
_trend	.0015885	.0012425	1.28	0.209	-.0009267	.0041038
_cons	2.337057	.8602915	2.72	0.010	.5954883	4.078626

- $lntimetrend_t$

Dickey-Fuller test for unit root   Number of obs   =   42

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-20.487	-4.224	-3.532	-3.199

MacKinnon approximate p-value for Z(t) = 0.0000

D.lnTimetr~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnTimetren~t						
L1.	-.2462372	.012019	-20.49	0.000	-.2705479	-.2219266
_trend	.0094746	.0008592	11.03	0.000	.0077367	.0112125
_cons	.5763204	.0189424	30.42	0.000	.5380058	.6146351

- $lnsugar\_exports_t$

Dickey-Fuller test for unit root — Number of obs = 40

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-4.154	-4.242	-3.540	-3.204

MacKinnon approximate p-value for Z(t) = 0.0053

D.lnSugarE~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnSugarExp~s						
L1.	-.703103	.1692684	-4.15	0.000	-1.046073	-.3601327
_trend	-.026536	.0140938	-1.88	0.068	-.0550928	.0020207
_cons	9.863002	2.394671	4.12	0.000	5.010937	14.71507

- $lnreal\_domesticprice_t$

Dickey-Fuller test for unit root — Number of obs = 40

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-1.298	-4.242	-3.540	-3.204

MacKinnon approximate p-value for Z(t) = 0.8885

D.lnRealDo~t	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnRealDome~t						
L1.	-.1044316	.0804652	-1.30	0.202	-.2674697	.0586065
_trend	-.0001173	.0008677	-0.14	0.893	-.0018754	.0016408
_cons	.4321076	.3348995	1.29	0.205	-.2464632	1.110678

- lndispo_income$_t$

Dickey-Fuller test for unit root Number of obs = 42

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-6.138	-4.224	-3.532	-3.199

MacKinnon approximate p-value for Z(t) = 0.0000

D.lnRealDi~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnRealDisp~e						
L1.	-.9838547	.1602811	-6.14	0.000	-1.308054	-.6596556
_trend	.0027383	.0188044	0.15	0.885	-.0352973	.0407739
_cons	5.372891	.993265	5.41	0.000	3.363823	7.381959

- lncons$_{t-1}$

Dickey-Fuller test for unit root Number of obs = 41

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.183	-4.233	-3.536	-3.202

MacKinnon approximate p-value for Z(t) = 0.0048

D.lnconst_1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnconst_1						
L1.	-.6003999	.1435404	-4.18	0.000	-.8909821	-.3098176
_trend	-.0013045	.0012704	-1.03	0.311	-.0038763	.0012673
_cons	2.149479	.5199659	4.13	0.000	1.096863	3.202095

- $lntotalpopulation_t$

Dickey-Fuller test for unit root Number of obs = 42

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-1.132	-4.224	-3.532	-3.199

MacKinnon approximate p-value for Z(t) = 0.9236

D.lnTotalP~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnTotalPop~n						
L1.	-.068736	.060745	-1.13	0.265	-.1916043	.0541323
_trend	.0011207	.0014398	0.78	0.441	-.0017916	.0040329
_cons	.725237	.6120125	1.19	0.243	-.5126752	1.963149

□

Appendix B2: ADF stationarity test results for the first differenced domestic sugar demand and supply variables

- d1lnsugar_sales$_{t-1}$

Dickey-Fuller test for unit root Number of obs = 40

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-6.520	-4.242	-3.540	-3.204

MacKinnon approximate p-value for Z(t) = 0.0000

D.d1lnSuga~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d1lnSugars~1						
L1.	-1.139415	.1747679	-6.52	0.000	-1.493529	-.7853018
_trend	-.0010282	.0010829	-0.95	0.349	-.0032223	.0011659
_cons	.0281517	.0253935	1.11	0.275	-.0233005	.0796038

- d1lnTotalpopulation

```
Dickey-Fuller test for unit root                   Number of obs   =        41

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -6.339            -4.233            -3.536            -3.202
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000

------------------------------------------------------------------------------
D.d1lnTota~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
d1lnTotalP~n |
         L1. |  -1.026618   .1619405    -6.34   0.000    -1.354449   -.6987865
      _trend |  -.0005184    .000333    -1.56   0.128    -.0011927    .0001558
       _cons |   .0341258   .0094335     3.62   0.001     .0150286     .053223
------------------------------------------------------------------------------
```

- d1lnsugar_sales$_{t-1}$

```
. dfuller d1lnSugar_Salest_1, trend regress lags(0)

Dickey-Fuller test for unit root                   Number of obs   =        39

                               ---------- Interpolated Dickey-Fuller
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value

 Z(t)             -6.804            -4.251            -3.544            -3.206

MacKinnon approximate p-value for Z(t) = 0.0000
```

D.d1lnSuga~1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
d1lnSugar_~1						
L1.	-1.109708	.1630912	-6.80	0.000	-1.440473	-.7789441
_trend	-.0017084	.0010209	-1.67	0.103	-.0037788	.0003621
_cons	.0371616	.0233988	1.59	0.121	-.0102932	.0846165

Appendix C : Correlation metrics results

Appendix C1: Domestic sugar demand equation pairwise correlation matrix results

	d1lnSa~t	lndisp~t	d1lnpo~n	lncons~1	d1lnre~e
d1lnSalest	1.0000				
lndispo_in~t	-0.2001	1.0000			
d1lnpopula~n	-0.4551*	0.5240*	1.0000		
lnconst_1	0.6484*	-0.5502*	-0.4811*	1.0000	
d1lnrealpr~e	0.2668	-0.1113	-0.1332	-0.2057	1.0000

Appendix C2: Domestic sugar supply equation pairwise correlation matrix results

	d1lnSa~t	lncane~1	lnTime~t	lnsuga~s	d1lnSu..	d1lnre~e
d1lnSalest	1.0000					
lncanepric~1	-0.0110	1.0000				
lnTimetren~t	0.6853*	-0.2415	1.0000			
lnsugar_ex~s	0.3593	-0.1393	0.2723	1.0000		
d1lnSugars~1	0.2216	0.4265*	-0.1641	0.2112	1.0000	
d1lnrealpr~e	0.2668	0.3818*	-0.1561	-0.0393	-0.0666	1.0000

Appendix D: The Variance Inflation Factors

Appendix D1: The domestic sugar demand equation Variance Inflation Factor

Variable	VIF	1/VIF
lnconst_1	1.95	0.511995
lndispo_in~t	1.90	0.526604
d1lnpopula~n	1.72	0.582841
d1lnrealpr~e	1.19	0.841238
Mean VIF	1.69	

Appendix D2: The domestic sugar supply equation Variance Inflation Factor

. vif

Variable	VIF	1/VIF
lncanepric~1	1.57	0.636501
d1lnrealpr~e	1.42	0.702466
lnTimetren~t	1.34	0.744931
lnsugar_ex~s	1.22	0.819438
d1lnSugars~1	1.07	0.932007
Mean VIF	1.33	

Appendix E: BG test of autocorrelation results

Appendix E1: BG test results for the domestic sugar demand equation

```
. estat bgodfrey, lag(2)

Number of gaps in sample:  2

Breusch-Godfrey LM test for autocorrelation
```

lags(*p*)	chi2	df	Prob > chi2
2	0.155	2	0.9254

```
                    H0: no serial correlation
```

Appendix E2: BG test results for the domestic sugar supply equation

```
. estat bgodfrey, lag(2)

Number of gaps in sample:  2

Breusch-Godfrey LM test for autocorrelation
```

lags(*p*)	chi2	df	Prob > chi2
2	0.623	2	0.7323

```
                    H0: no serial correlation
```

Appendix F: The 3SLS regression results

Three-stage least-squares regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
Qss	24	5	.062984	0.6651	41.71	0.0000
QDD	24	4	.0681693	0.6077	32.48	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Qss						
lncanepricet_1	-.0591525	.0178386	-3.32	0.001	-.0941155	-.0241896
lnTimetrendTt	.1057083	.0329747	3.21	0.001	.041079	.1703375
lnsugar_exports	.0686971	.1089252	0.63	0.528	-.1447925	.2821866
d1lnSugarsalest_1	.2464956	.1847791	1.33	0.182	-.1156648	.6086561
d1lnrealprice	.8378144	.1856481	4.51	0.000	.4739509	1.201678
_cons	7.686804	.2894308	26.56	0.000	7.11953	8.254078
QDD						
lndispo_incomet	.3644401	.1095483	3.33	0.001	.1497293	.5791508
d1lnpopulation	.0869229	.1559166	0.56	0.577	-.218668	.3925139
lnconst_1	.4201267	.0796403	5.28	0.000	.2640345	.5762189
d1lnRealDomesticMar~at	-2.65244	.7681298	-3.45	0.001	-4.157947	-1.146933
_cons	.9819978	1.301348	0.75	0.450	-1.568598	3.532593

Endogenous variables: d1lnSalest d1lnRealDomesticMarketPicet
Exogenous variables: lncanepricet_1 lnTimetrendTt lnsugar_exports
d1lnSugarsalest_1 d1lnrealprice lndispo_incomet d1lnpopulation
lnconst_1 d1lnRealDomesticMarketPicetHat

Appendix G: Johaneson cointergration test results.

Appendix GI: Domestic sugar supply equation

```
. vecrank lnSalest lncanepricet_1 lnTimetrendTt lnsugar_exports lnSalest_1 lnpricet,
> trend(constant) max

                    Johansen tests for cointegration
Trend: constant                                        Number of obs =      39
Sample:  1979 - 2017                                            Lags =       2
```

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	42	190.94501	.	303.1463	94.15
1	53	291.66583	0.99429	101.7047	68.52
2	62	311.29752	0.63460	62.4413	47.21
3	69	328.13183	0.57823	28.7727*	29.68
4	74	336.52051	0.34961	11.9953	15.41
5	77	342.45855	0.26252	0.1192	3.76
6	78	342.51817	0.00305		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	42	190.94501	.	201.4416	39.37
1	53	291.66583	0.99429	39.2634	33.46
2	62	311.29752	0.63460	33.6686	27.07
3	69	328.13183	0.57823	16.7774	20.97
4	74	336.52051	0.34961	11.8761	14.07
5	77	342.45855	0.26252	0.1192	3.76
6	78	342.51817	0.00305		

Appendix G2: Domestic sugar demand equation

```
. vecrank lnSalest lnpopulation lnpricet lnconst_1 lnRealDisposibleincome , trend(con
> stant) max

                     Johansen tests for cointegration
Trend: constant                                         Number of obs =      39
Sample:  1979 - 2017                                             Lags =       2
```

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	30	65.760987	.	76.9295	68.52
1	39	80.430805	0.52872	47.5898	47.21
2	46	92.092638	0.45011	24.2662*	29.68
3	51	101.00871	0.36697	6.4340	15.41
4	54	103.65539	0.12692	1.1407	3.76
5	55	104.22572	0.02882		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	30	65.760987	.	29.3396	33.46
1	39	80.430805	0.52872	23.3237	27.07
2	46	92.092638	0.45011	17.8321	20.97
3	51	101.00871	0.36697	5.2934	14.07
4	54	103.65539	0.12692	1.1407	3.76
5	55	104.22572	0.02882		

Appendix H: Granger causality Wald test results

Appendix H1: Domestic sugar demand equation Granger causality test results

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
d1lnSalest	d1lnRealPrice	31.447	2	0.000
d1lnSalest	lnConst_1	18.429	2	0.000
d1lnSalest	d1lntotal_polat~n	22.673	1	0.000
d1lnSalest	lnReal_dispos_n~e	6.4218	2	0.040
d1lnSalest	ALL	383.03	7	0.000
d1lnRealPrice	d1lnSalest	10.316	2	0.006
d1lnRealPrice	lnConst_1	44.02	2	0.000
d1lnRealPrice	d1lntotal_polat~n	2.4251	1	0.119
d1lnRealPrice	lnReal_dispos_n~e	.63326	2	0.729
d1lnRealPrice	ALL	107.73	7	0.000
lnConst_1	d1lnSalest	7.6832	2	0.021
lnConst_1	d1lnRealPrice	29.238	2	0.000
lnConst_1	d1lntotal_polat~n	15.061	1	0.000
lnConst_1	lnReal_dispos_n~e	.11509	2	0.944
lnConst_1	ALL	145.91	7	0.000
d1lntotal_polat~n	d1lnSalest	1.673	2	0.433
d1lntotal_polat~n	d1lnRealPrice	5.0138	2	0.082
d1lntotal_polat~n	lnConst_1	8.1995	2	0.017
d1lntotal_polat~n	lnReal_dispos_n~e	16.817	2	0.000
d1lntotal_polat~n	ALL	155.54	8	0.000
lnReal_dispos_n~e	d1lnSalest	1.673	2	0.433

lnReal_dispos_n~e	5.0138	2	0.082
d1lnRealPrice			
lnReal_dispos_n~e	8.1995	2	0.017
lnConst_1			
lnReal_dispos_n~e	.6137	1	0.433
d1lntotal_polat~n			
lnReal_dispos_n~e	66.416	7	0.000
ALL			

Appendix H2: Domestic sugar supply equation Granger causality test results

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
d1lnSugarSalest	d1lnrealPricet	4.8954	2	0.086
d1lnSugarSalest	d1Sugar_salest_1	10.118	2	0.006
d1lnSugarSalest	lnTimetrendTt	.3176	2	0.853
d1lnSugarSalest	lnSugarExports	19.502	2	0.000
d1lnSugarSalest	ALL	31.148	8	0.000
d1lnrealPricet	d1lnSugarSalest	.35348	2	0.838
d1lnrealPricet	d1Sugar_salest_1	1.7327	2	0.420
d1lnrealPricet	lnTimetrendTt	4.0155	2	0.134
d1lnrealPricet	lnSugarExports	1.0737	2	0.585
d1lnrealPricet	ALL	6.8368	8	0.554
d1Sugar_salest_1	d1lnSugarSalest	.77822	2	0.678
d1Sugar_salest_1	d1lnrealPricet	.91052	2	0.634
d1Sugar_salest_1	lnTimetrendTt	2.8778	2	0.237
d1Sugar_salest_1	lnSugarExports	.56656	2	0.753
d1Sugar_salest_1	ALL	5.1642	8	0.740
lnTimetrendTt	d1lnSugarSalest	4.5496	2	0.103
lnTimetrendTt	d1lnrealPricet	.35242	2	0.838
lnTimetrendTt	d1Sugar_salest_1	17.772	2	0.000
lnTimetrendTt	lnSugarExports	8.8825	2	0.012
lnTimetrendTt	ALL	31.415	8	0.000
lnSugarExports	d1lnSugarSalest	6.7797	2	0.034
lnSugarExports	d1lnrealPricet	10.197	2	0.006
lnSugarExports	d1Sugar_salest_1	1.0811	2	0.582
lnSugarExports	lnTimetrendTt	5.8418	2	0.054
lnSugarExports	ALL	26.189	8	0.001

.

Appendix I : The VECM results

Appendix I1 : The VECM optimal lag length selection

Selection-order criteria
Sample: 1981 - 2017 Number of obs = 37

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1006.51				6.2e+18	54.6223	54.6837	54.7964
1	-900.486	212.05	16	0.000	4.8e+16*	49.756*	50.063*	50.6268*
2	-897.57	5.8322	16	0.990	1.0e+17	50.4632	51.0158	52.0306
3	-880.282	34.576*	16	0.005	1.0e+17	50.3936	51.1918	52.6576
4	-870.522	19.519	16	0.243	1.7e+17	50.7309	51.7747	53.6915

Endogenous: d1lnsugar_salest d1lnrealDomesticMarketPicet d1totalPopulationt lnrealdispos_incomet
Exogenous: _cons

Appendix I2: The domestic sugar demand equation short-run elasticities

Equation	Parms	RMSE	R-sq	chi2	P>chi2
lnconst	5	.219433	0.9588	953.2706	0.0000
d1lnpricetHat	5	.126247	0.6803	87.2455	0.0000
d1lnTotalPopul~n	5	.024959	0.0855	3.832811	0.4291
lnRealDisposib~e	5	1.47614	0.0786	3.498895	0.4780

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnconst						
lnconst L1	.9360391	.0319168	29.33	0.000	.8734834	.9985949
d1lnpricetHat L1.	-.3011439	.1643065	-1.83	0.067	-.6231787	.0208908
d1lnTotalPopulat~n L1.	-.7436351	1.3573	-0.55	0.584	-3.403894	1.916623
lnRealDisposible~e L1	.0170374	.0232874	0.73	0.464	-.028605	.0626798
_cons	.623429	.2635062	2.37	0.018	.1069664	1.139892

Appendix I3: The domestic sugar demand equation long-run elasticities

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	5	240.123	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
lnCost	1	.	.	.	.	.
lnConst_1	.0382953	.0070998	5.39	0.000	.0243799	.0522107
d1lnpopulationt	-.0144853	.0693568	-0.21	0.835	-.1504221	.1214516
ECt1	-.3196534	.0956389	-3.34	0.001	-.5071021	-.1322046
lndispo_incomet	.6883436	.0472242	14.58	0.000	.595786	.7809013
d1lnreal_pricetHat	-2.242707	1.304257	-1.72	0.086	-4.799005	.31359
_cons	-12.55711	.	.	.	.	.

Appendix I4: The domestic sugar supply equation short-run elasticities

Equation	Parms	RMSE	R-sq	chi2	P>chi2
d1lnsugar_sales	7	.130927	0.9654	1087.309	0.0000
lnCaneproducer~e	7	.133999	0.9849	2544.805	0.0000
d1lnrealpriceHat	7	.014186	0.9996	108588.3	0.0000
lnsugar_exports	7	.166481	0.1938	9.373399	0.1536
lnTimetrendTt	7	.124425	0.4148	27.63942	0.0001
d1lnsug_salest	7	.15248	0.8487	218.6838	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
d1lnsugar_sales						
d1lnsugar_sales						
L1.	.3234246	.1453852	2.22	0.026	.0384749	.6083743
lnCaneproducerprice						
L1.	-.1877516	.0897355	-2.09	0.036	-.36363	-.0118732
d1lnrealpriceHat						
L1.	.7622743	.2272885	3.35	0.001	.3167969	1.207752
lnsugar_exports						
L1.	-.162362	.122375	-1.33	0.185	-.4022125	.0774885
lnTimetrendTt						
L1.	.1447199	.1848613	0.78	0.434	-.2176016	.5070414
d1lnsug_salest						
L1.	-.0359247	.1042848	-0.34	0.730	-.2403192	.1684698
_cons	5.09687	1.955558	2.61	0.009	1.264047	8.929694

Appendix I5: The domestic sugar supply equation long-run elasticities

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
d1lnSugar_salest	1	.	.	.	.	.
lntimetrendt	.2174121	.0556046	3.91	0.000	.1084292	.3263951
lnsugar_exports	.3385069	.238726	1.42	0.156	-.1293875	.8064012
ECT2	-.9419315	.3406932	-2.76	0.006	-1.609678	-.274185
d1lnrealpriceHat	1.809031	.2147986	8.42	0.000	1.388033	2.230028
lnrealcane_pricet	-5.867473	.4509689	-13.01	0.000	-6.751356	-4.98359
_cons	9.827245	.	.	.	.	.

Appendix J : Normality test results

Appendix J1: Jarque-Bera normality test results for sugar demand equation

```
Jarque-Bera normality test:  3.644 Chi(2)  .1617
Jarque-Bera test for Ho: normality:
```

Appendix J2: Jarque-Bera normality test results for sugar supply equation

```
Jarque-Bera normality test:  1.348 Chi(2)  .5097
Jarque-Bera test for Ho: normality:
```

Appendix K: Heteroskedasticity test results

Appendix K1: White's test heteroscedasticity results for domestic sugar demand residuals

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(14)      =     9.87
         Prob > chi2   =   0.7719

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	9.87	14	0.7719
Skewness	2.12	4	0.7130
Kurtosis	4.08	1	0.0433
Total	16.07	19	0.6525

Appendix K2: White's test heteroscedasticity results for domestic sugar supply equation residuals

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(20)      =     27.39
         Prob > chi2   =    0.1247

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	27.39	20	0.1247
Skewness	19.79	5	0.0014
Kurtosis	0.13	1	0.7175
Total	47.31	26	0.0065

Appendix L : Hausman specification error test of endogeneity

Appendix L1: Hausman specification error test of endogenety for the domestic sugar demand equation

```
. regress d1lnRealPricet d1lnRealPricetHat vt
```

Source	SS	df	MS
Model	.043021422	2	.021510711
Residual	.046071668	29	.001588678
Total	.08909309	31	.002873971

Number of obs	=	32
F(2, 29)	=	13.54
Prob > F	=	0.0001
R-squared	=	0.4829
Adj R-squared	=	0.4472
Root MSE	=	.03986

d1lnRealPricet	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d1lnRealPricetHat	.1446081	.1356137	1.07	0.295	-.1327531	.4219694
vt	3.940208	.8339148	4.72	0.000	2.234661	5.645755
_cons	.0055234	.007058	0.78	0.440	-.0089119	.0199587

Appendix L2: Hausman specification error test of endogeneity for the domestic supply equation

```
. regress d1lnRealPricet d1lnRealPricetHat  Ut
```

Source	SS	df	MS
Model	.01686736	2	.00843368
Residual	.072225729	29	.002490542
Total	.08909309	31	.002873971

Number of obs	=	32
F(2, 29)	=	3.39
Prob > F	=	0.0477
R-squared	=	0.1893
Adj R-squared	=	0.1334
Root MSE	=	.04991

d1lnRealPricet	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d1lnRealPricetHat	.2765454	.1655897	1.67	0.106	-.0621236	.6152143
Ut	1.159444	.5995719	1.93	0.063	-.0668181	2.385706
_cons	.004571	.0088323	0.52	0.609	-.0134932	.0226351