THE ECONOMIC EFFECTS OF DIABETES AND SUGAR-SWEETENED BEVERAGES TAXES

"Man may be the captain of his fate, but he is also the victim of his blood sugar."

Wilfred G. Oakley (1905–68)

By

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ABSTRACT

The aim of this study is to analyse the effects of diabetes and sugar-sweetened beverages on the South African economy. The study was motivated by the prevalence of diabetes in South Africa and the cost of managing diabetes. In 2016, diabetes was the second leading cause of mortality in the country. Current studies show that more than 7% of healthcare expenditure is spent on diabetes care. Sugar-sweetened beverages have been linked to the increase in the prevalence of diabetes.

Three independent studies are conducted to investigate the link between diabetes, sugar-sweetened beverages (SSB) and the economy. Firstly, we study the impact of diabetes on labour market outcomes in South Africa using regression analysis. We achieve this through using probit models, propensity score matching and linear instrumental variable methods to account for endogeneity of diabetes. We find through the analysis that individuals with diabetes are less likely to be employed when compared to individuals without diabetes. Secondly, we investigate the economy-wide impact of diabetes using a computable general equilibrium model. We assess the impact of diabetes on GDP, household welfare and sectoral outputs. We find that diabetes reduces sectoral outputs, household consumption as well as GDP. Thirdly, we investigate the effects of sugar-sweetened beverages tax on the economy. We analyse this through simulating the effects of the tax together with the envisaged health benefits from the tax. The results of the analysis show that in the short-run poor households are negatively affected. The negative effect is however reversed in the long-run when the net health benefits of the SSB tax are considered.

Overall, the major finding of this research is that diabetes has a negative effect on the South African economy. This negative effect can however be offset by targeted tax policy interventions.

DEDICATION

I dedicate this work to all the women and men who have fallen victim to diabetes mellitus. A special dedication to my Aunt, Mokgadi Rosina Malomane who died on the 29th of January 2019 after years of battling diabetes.

To my angels: Bahumi and grandparents Tshepisi and Motsatsi.

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To my siblings Mokgadi, Mmapholo, Maria, Khomotso and Emmanuel, thank you for being my cheerleaders and for believing in me. Your constant support and reminder of what is possible encouraged me to accomplish this task.

DECLARATION

I, Masedikwe Mokwape Evelyn Thsehla, declare that this research is entirely my own, and where necessary due credit has been given. This thesis is submitted in fulfilment of the requirements for the degree Doctor of Philosophy at the University of Pretoria. It has not been submitted before for my degree or examination at any other university.

Signature: ………………………….

Date: ………………………………….

SERETO

Ke nna Napjadi

Napjadi ke le gana gae,

Le gana gae la tshengwane

Le dumetša go ya bolata

Ba re o se ye bolata le pelwana

Šia pelo o ye bolata

Napjadi ke maakaretša

Akaretša meetsi a pula

Bohumi bo tšwa diatleng

Table of Contents

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

The emerging evidence linking sugar-sweetened beverages (SSB) and type II diabetes (diabetes) plus the additional need for revenues to fund health programs has led to governments worldwide to consider taxes on sugar-sweetened beverages (Brownell et al., 2009; Chriqui et al., 2013). In South Africa, the Minister of Finance announced during the 2015 budget speech a proposal to tax sugar-sweetened beverages. The World Health Organization (WHO) recommends that policy be used to influence consumption of healthy food (World Health Organization, 2004, 2008). Researchers suggests that increasing the price of unhealthy foods through taxes and/or reducing the price of foods high in nutrients that are pro-health may improve consumption of healthy food (Thow et al., 2010). SSB or soda taxes have been proposed as a means of reducing the intake of these beverages as well as a means to generate revenue that governments can use for health programs (Brownell *et al.*, 2009).

Sugar-sweetened beverages are a group of beverages that includes soda sweetened with sugar, corn syrup or other caloric sweeteners. The consumption of SSB has been linked to risks for obesity, diabetes and heart disease (V S Malik *et al.*, 2010). The WHO predicts that the rapid rise in non-communicable diseases such as diabetes has the potential to impede developmental goals such as reduction in poverty in low-income countries particularly by increasing household costs associated with health care and by increasing the number of people who cannot work due to ill health. Non-communicable diseases (NCDs) by their definitions are chronic diseases that require long term medical care which can increase household costs associated with health care (World Health Organization, 2018b).

According to economic theory, government must intervene whenever markets fail to control the sale of goods that have less merits than consumers perceive. With regards to SSBs, many consumers are not aware of the link between consumption of these beverages and the consequences of consuming these beverages (Allcott, Lockwood and Taubinsky, 2019). This imperfect information is further distorted by extensive marketing campaigns that advertise the benefits of consuming sugar-sweetened beverages. Financial “externalities” are also a motivation for taxing sugar-sweetened beverages because non-communicable diseases which are mostly chronic in nature are costly to treat which places a burden on the health care system.

As the obesity and diabetes crisis grows, calls for a tax to halt sugar consumption have become more pronounced. In order to address the obesity and diabetes epidemic, the Ministry of Finance in consultation with the Ministry of Health introduced SSB tax from April 2018. Current studies suggest that the tax will result in a decrease in consumption of sugar-sweetened beverages and decrease obesity which is a risk factor for diabetes (Manyema *et al.*, 2015).

Opponents of the introduction of tax on SSB however argue that such interventions are regressive and will disproportionately harm the poor as the low-income populations spend a high percentage of their income on food than would higher-income groups (Tamir *et al.*, 2018; Allcott, Lockwood and Taubinsky, 2019). Research however shows that low-income populations consume less healthy food than high-income populations and therefore are at higher risk of obesity and chronic NCD (Kim and Kawachi, 2006). The introduction of the tax is seen as a way of influencing consumption behaviour which might result in long-term health benefits. Furthermore, revenue generated from the tax if used for healthy food could help offset the costs that are borne by low-income consumers.

1.2 Sugar-sweetened beverages consumption

According to research, consumption of sugar (mainly through confectionery and soft drinks) and stimulants in South Africa increased from 12.7 kg/Capita/year to 16.9 kg/Capita/year (33.1%) from 1999 to 2012 (Ronquest-Ross et al., 2015) . In South Africa, the sugar sweetened beverage industry is dominated by multinational beverage companies, Coca-Cola, Danone Group and Pepsi. In 2010, the three main suppliers of beverages, had a market share of approximately sixty-five percent with other suppliers taking a little over 35% percent of the market based on sales value (Igumbor *et al.*, 2012). The Coca-Cola Company which is the biggest supplier of soft drinks commanded a market share of approximately 50%.(Hawkes, 2002) According to a report by the Beverage Association of South, the non-alcoholic beverage industry supports approximately 294 000 jobs in South Africa and contributes approximately R60 billion to South Africa's GDP (BEVSA, 2017).

Over the last few years, the SSB industry has seen a rapid increase in the volumes of beverages produced with an increase from 2 294 million litres to 4 746 million litres between the years 1998 and 2012. In 2011, the total supply of soft drinks amounted to R24 304 million with consumers in hotels, restaurants and households consuming over seventy percent of the overall total supply of the products. Between 1996 and 2010 the volume of soft drink imports from South Africa into the other SADC countries also doubled resulting in an increase in the production of these beverages (Thow *et al.*, 2015).

Statistics South Africa (StatsSA) has also shown that food and non-alcoholic beverages are the fourth largest contributor to household consumption expenditure in South Africa. The South African Income and Expenditure survey conducted in 2010 shows that lower income groups spend a high percentage of their income on food and beverages as compared to the high-income groups. The lower income groups spend 1.2 percent of their income on mineral waters, soft drinks, fruit, and vegetable juices as compared to 0.4 percent in the upper income group. In absolute terms, the lowest income decile of the population on average spends about R122 per annum on non-alcoholic beverages as to compared to R1 683 by the highest income decile. Annual household consumption of these beverages at home and in restaurants, represent 0.81 per cent of total household expenditure. The latest findings show that an increase in SSB sales by 2.4% will result in an additional 1 287 000 obese adults in South Africa by 2017 (Tugendhaft *et al.*, 2016) .

1.3 Prevalence of obesity and diabetes

Worldwide the prevalence of obesity has nearly doubled since 1975. According to the WHO, more than half a billion adults were obese in 2016 (World Health Organization, 2018c). Obesity has been shown to be a risk factor for non-communicable diseases such as coronary heart disease and type II diabetes (Malik et al., 2010). In South Africa, the prevalence of obesity has risen extensively in recent years with South Africans rated as the most obese nation in sub-Saharan Africa. In 2016, the prevalence of obesity and overweight were estimated at approximately 68% in women and 31% in men (Statistics South Africa, 2016). Parallel to the rise in obesity has been the increase in the prevalence of type II diabetes.

Diabetes is a chronic non-communicable disease that occurs when the body fails to regulate blood sugar levels or fails to utilise the insulin it produces. The World Health Organization estimate that the number of adults worldwide living with diabetes was 422 million in 2014 as compared to 108 million in 1980. In 2012, diabetes was responsible for 3.7 million deaths in the world. More than 2.2 million of these deaths were caused by cardiovascular diseases and other diseases attributable to diabetes. WHO reports that most of the deaths occurs prior to age 70 and affects mainly individuals in low- and middle-income countries (World Health Organization, 2016) .

In South Africa, an estimated 9.8% of the population was living with diabetes in 2016. Six percent of all deaths in the country were attributable to diabetes (StatsSA, 2018a). The prevalence of diabetes is reported to have grown from 4% in 2000 to 6.5% in 2011 (International Diabetes Federation, 2011). The prevalence is expected to rise to approximately 30% in 2030. According to a report by the Council for Medical Schemes, diabetes is one of the top conditions to treat with treatment expenditure amounting to approximately R11 000 per patient per month in the private sector (Council for Medical Schemes, 2015). In 2011, the IDF estimated that approximately seven percent (7%) of health expenditure was spent on diabetes among adults aged 20 – 79 years in 2010. It is estimated that the expenditure will rise by 30 -34 % in 2030 in developing countries(International Diabetes Federation, 2011).

Diabetes exacts three broad categories of economic cost to people with diabetes, their families, health systems and national economies: direct healthcare costs, indirect healthcare costs and productivity costs. The direct healthcare costs include medication, consultations as well as hospitalisation for the condition itself and for its complications. The indirect healthcare costs include other expenses such as travelling to health care facilities. Productivity costs includes the loss of earnings from mortality, morbidity and disability associated with diabetes and its complications. At the macro level, the burden of diabetes reduces life expectancy and economic productivity ultimately depleting the quality and quantity of a country's labour force. Rising mortality rates in a country may lead to reduced labour force, shortage of skills and change in the age structure of the labour force (Abegunde and Stanciole, 2006).

1.4 Taxation of sugar-sweetened beverages

The concept of taxing sugar-sweetened beverages is not new. Taxes on soft drinks taxes can be dated as far back as 1920. Several countries, such as Algeria, Belgium, Denmark, Finland, and France have since adopted beverage excise or similar taxes/fees. A number of countries, including Finland, France and Mexico, have introduced taxes in an effort to reduce consumption of sugar-sweetened beverages. These taxes vary greatly by what beverages are taxed and the time of tax imposed. Some countries tax only soft drinks, whereas others tax all sweetened beverages. Currently more than 34 states in the United States of America have implemented SSB taxes as a way to encourage the consumption of less priced healthier alternatives (Schwendicke and Stolpe, 2017). In Arkansas, Washington and West Virginia special taxes on soft drinks are imposed while; Minnesota charges sales tax on candy, chewing gum and ice cream; and Texas imposes a candy tax.

The rationale for the taxation is that the increase in the price of the SSBs will deter consumers from purchasing these beverages. It is envisaged that the proposed increase in tax on these beverages will result in an increase in average price of SSB and therefore reduce consumption. A reduced consumption will result in lower daily caloric intake and therefore lower obesity which will in turn lower incidences of Type II diabetes. Lowered incidences of type II diabetes will result in a health work force which will increase productivity. The proposed excise tax is also seen as a mechanism to increase government revenue.

1.5 Aim and objectives of the study

Investigating the link between sugar-sweetened beverages and diabetes gained momentum in the last 5 years. Current studies on SSB taxes have focused on the impact on consumption, obesity reduction and potential for revenue generation. The aim of this study is to provide policymakers with a detailed analysis of the impact of diabetes and sugar-sweetened beverages taxes on the South African economy.

Our objectives are to study:

- The impact of diabetes on labour force participation.
- The impact of diabetes on the economy.
- The impact of sugar-sweetened beverages tax on the economy.

1.6 Research methodology

We use two different research methods to analyse the impact of diabetes and sugar-sweetened beverages on the economy. Firstly, we use a regression analysis to study the effects of diabetes on labour outcomes in South Africa. Probit, propensity score matching, and linear instrumental variable models are used to analyse the effects of diabetes on labour force outcomes. We estimate the regression using propensity score matching in order to compare individuals with similar covariates which the probit model assumes to be constant. We further estimate the regression using linear instrumental variable method to account for the possible endogeneity of diabetes.

Secondly, we use a computable general equilibrium model to study the economy-wide effects of diabetes and sugar-sweetened beverage taxes. We use CGE in this study because CGE models have a number of features that make them suitable for examining "cross cutting" issues such as the impact of diseases on the economy (Arndt and Lewis, 2000; M Horridge, 2000).

We use a modified version of the University of Pretoria General Equilibrium Model (UPGEM) documented in Horridge (2000) and Bohlmann et al. (2015) for the analysis. For this study, we use a comparative-static version of the model. UPGEM is a multi-sector model that is calibrated through the construction of a balanced database. The database uses the official 2017 Supply-Use Table (SUT) of South Africa, published by Statistics South Africa, as a starting point and initial solution to the model. Forty-two industries are identified in the model and eleven occupations are identified as labour inputs. Final users of commodities include investors, four households, governments, and the rest of the world (exports).

A single central government is assumed to simplify the implementation of the model. As is standard in CGE models, UPGEM assumes a competitive economy with constant returns to scale, cost minimisation for industries and utility maximisation for households, and continuous market clearance. In addition, zero profit conditions are assumed for all industries in both the short-run and long-run. The model is solved using GEMPACK software. In solving the model, we undertake a number of simulations to study the impact of diabetes and sugar sweetened beverages on the economy. We report model results as percentage deviations of variables from a business-as-usual baseline.

1.7 Contribution of study

This study contributes to the literature in several ways. Our first contribution is in analysing the impact of diabetes on labour force outcomes in South Africa. Over the last few years a growing body of literature has developed to study the indirect cost of diabetes (Brown et al., 2005; Latif, 2009; Seuring et al., 2015). While the above studies have shown the impact of diabetes on labour force outcomes in several countries, few studies have measured the impact in low and middle-income countries such as South Africa (Lawana *et al.*, 2020). There are enough reasons to expect significant adverse effects of diabetes in South Africa as compared to other countries. In Africa, approximately 76 percent of diabetes deaths occur in people younger than 60 years, the most economically active population as compared to the global proportion of forty nine percent. The situation is further exacerbated by the prevalence of undiagnosed diabetes which is as high as forty six percent in upper-middle income (Peer et al., 2014). This study therefore adds to the current literature by showing the impact of diabetes on different labor force outcomes in South Africa by using different methodologies.

The second contribution is in modelling the impact of the diabetes on the economy through reduction in labour supply and productivity as well as increased demand for health care services. Current studies on the economic impact of diabetes use econometric techniques to model the direct costs of diabetes. Studies that show the indirect impact of diabetes on the economy are few. Those that exist do not show the economy-wide impact of the disease. We contribute to the body of literature by showing how diabetes can impact the economy through reduction in labour supply, productivity, and increased demand for healthcare services.

The third contribution is in modelling the impact of SSB tax on the economy using a detailed computable general equilibrium approach. This is achieved by constructing a suitable database for South Africa that includes a distinct sugar and beverage industry in the model's base year. Our database makes it possible to quantitatively analyse the policy's impact within the model's general equilibrium environment. Other studies have partially investigated the impact of SSB taxes on the economy by using mathematical modelling techniques (Manyema *et al.*, 2014; Basu *et al.*, 2014). Few have investigated the effects of the tax on the economy's resource allocation, sector structure and product-mix, economic growth, and income distribution have not been studied (Theron, Rossouw and Fourie, 2016). We add onto previous research by modelling the health benefits that are derived from the SSB tax through increased labour supply, and reduced demand for healthcare services. The study therefore contributes to the current discussion around the impact of SSB taxes by providing policymakers with new evidence on economic effects of SSB tax on different households in the short-run. To our knowledge, this is the first academic study to show the impact of SSB tax together with the benefits that are derived from the tax.

1.8 Outline of the study

The thesis comprises of seven chapters which includes 3 independent studies. The following is an overview of the chapters:

- **Chapter 1**

Chapter 1 introduces the topic under investigation and gives the context for the investigation. The chapter details the aim of the investigation and the contribution of the study to current discussions around the economic effects of diabetes and SSB taxes. The methods for the investigation are also introduced in this chapter.

- **Chapter 2**

Chapter 2 looks at the theory and empirical evidence on diabetes, sugar-sweetened beverages, health, and productivity. The chapter gives a background overview of health and productivity studies. Section four of the chapter reviews the literature on the impact of diabetes on productivity. This is followed by an analysis of the impact of SSB taxes on economic activity. The existing gaps that still need to be filled are also discussed followed by a conclusion of the chapter.

- **Chapter 3**

Chapter 3 presents the first independent study. The aim of this study is to estimate the impact of diabetes on labour outcomes in South Africa. We employ probit, propensity score matching and linear instrumental variable models to examine this effect and account for possible endogeneity in diabetes.

- **Chapter 4**

Chapter 4 describes the estimation strategy and the specifications for the model used to analyse the economy-wide impact of diabetes and SSB tax. In this chapter we first start by looking at the general overview of the model that we use. This is followed by the theoretical specification of the model. The development of the model database is then discussed followed by a detailed description of the model closures.

- **Chapter 5**

Chapter 5 looks at the impact of diabetes on the South African economy. Diabetes as a chronic disease has an impact on labour supply and productivity through absenteeism and presenteeism. The increased prevalence of diabetes also impacts the economy through increased demand for healthcare. We model the impact of diabetes through decrease in labour supply, labour productivity, and increased demand for healthcare.

- **Chapter 6**

Chapter 6 estimates the impact of sugar-sweetened beverages taxes on the economy. We model the impact through increased taxes on the beverage industry. We also assume that labour supply will increase and demand for healthcare will decrease due to the decrease in diabetes.

- **Chapter 7**

Chapter 7 summarises the research findings, emerging policy issues and recommendations for future research.

CHAPTER 2

SUGAR-SWEETENED BEVERAGES, DIABETES AND PRODUCTIVITY: THEORY AND LITERATURE

2.1 Introduction

The link between sugar-sweetened beverages and their impact on health has been studied extensively in the past few years (Ruanpeng et al., 2017). Consumption of SSB has been linked to obesity (BMI greater than 30) and overweight (BMI equal to or more than 25) which are risk factors for chronic conditions such as Type II diabetes (diabetes), hypertension and cardiovascular diseases (Cheungpasitporn et al., 2015; Narain et al., 2017). Chronic diseases have been shown to have a negative impact at the macro- and microeconomic level through productivity loss and expenditure on health care(World Health Organization, 2009).

The aim of this chapter is to review the link between diabetes and labour productivity and the impact of sugar sweetened beverage tax on the economy. We start the review by looking at the theory on human capital, health, and productivity in the background section. The theory on human capital is premised on the notion that an increase in a person' stock health raises his or her productivity. We include this section in order to understand how health affects productivity and the economy. We also review the different approaches that are used to estimate the economic impact of poor health in section 2.3 We then review the relationship between diabetes and economic activity as well as the methods used to measure this relationship in section 2.4. We limit the review of the relationship between diabetes and productivity to two distinct channels: the impact of diabetes on labour force participation and the effect on earnings. In section 2.5 we look at the link between SSB and health. Section 2.6 explores the evidence linking the impact of the tax on health outcomes whilst section 2.7 focuses on the impact on the economy. The emerging issues for research and gaps that this current study aims to fill are discussed in Section 2.8. The conclusion for the chapter is presented in section 2.9.

2.2 Background

Healthy workers are one of the most important economic assets for a nation. When people cannot work due to poor health, the economy is affected as poor health results in reduction in labour productivity, increased health expenditure due to illnesses and less taxes on earnings (Davis, et al., 2005 and Ramírez, 1998). The relationship between health and productivity can be dated back to Grossman's investigation on the "Demand for health". According to Grossman, (1972) health is an asset that yields an output of healthy time. Individuals inherit this asset that decreases with age and can be increased by investing in healthy habits. The Grossman model differentiates health from other forms of capital based on the theory that an increase in a person's knowledge and health increase his or her productivity while his health determines the total amount of time he can spend accumulating wealth.

Using Grossman's theory Strauss and Thomas, (1998), further show that labour supply is influenced by an array of measured health status, vector of prices for consumer (pc) goods, real wage (w); education (S); a vector of demographic (A) characteristics; the family background (B) of the individual; the local community infrastructure (I); an array of unobservable (α) variables (e.g. ability), measurement error (e_w), non-labour income (V) and the taste parameter (ξ).

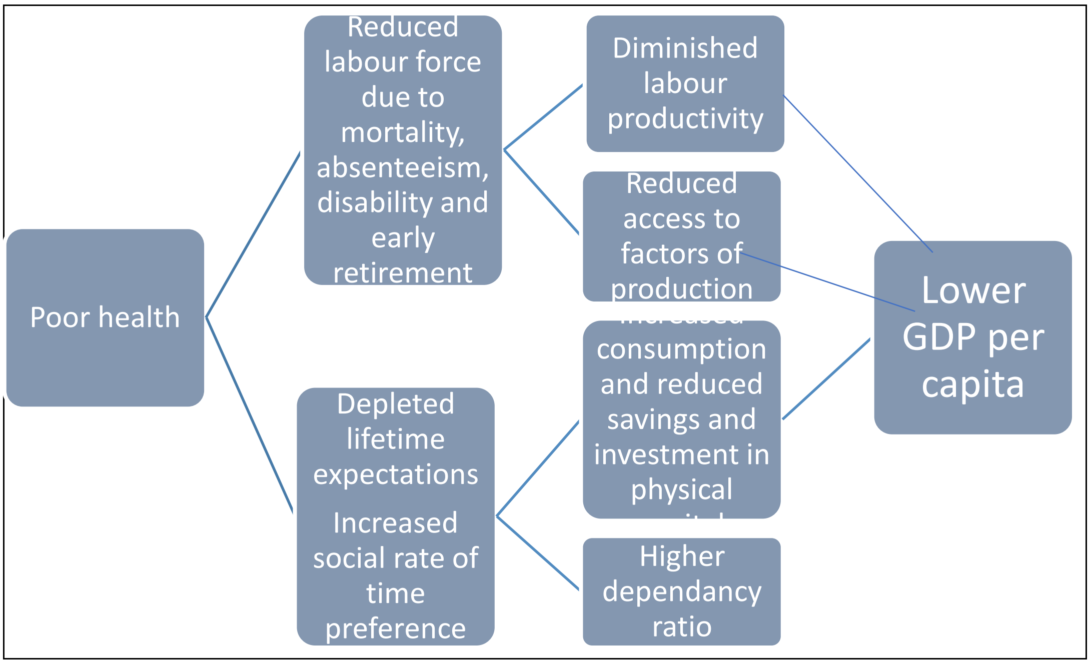
$$L = L\,(H, pc, w\,(H; S, A, B, I, \alpha, e_w), S, A, B, V, \xi) \qquad (1)$$

Bloom and Canning (2000) further identify different ways through which health can affect productivity. At the household level, they argue that healthy individuals who are physically and mentally healthy increase productivity through reduced absenteeism. Furthermore, individuals who are healthy may increase consumption in non-health goods. Healthy individuals may also choose to invest more in education and may choose to save more for retirement resulting in an increase capital stock. Poor health can however result in reduction in productivity and consumption of healthy goods through purchasing of health care services and time spent in seeking health care.

At the firm level poor health has been shown to affect the economy through reduced productivity, labour supply, earnings, investments, and capital accumulation (Tunceli *et al.*, 2009; Minor, 2011; Liu and Zhu, 2014). Reduced productivity impacts the quality of work which may negatively affect a firm's earnings and profits. A reduction in a firm's earnings can result in less investments thereby reducing future earnings and taxable income. Furthermore, firms may choose to invest in health-related services and benefits for their employees. This may result into less investments in other non-health capital thereby lowering firm outputs and ultimately national income (World Health Organization, 2009).

At the government level, poor health may reduce available government resources by increasing public health expenditures to treat illnesses. Poor health also reduces life expectancy which deprives individuals of their health and productivity ultimately reducing government's taxable income. A reduction in government's income could compel governments to increase tax rates to meet rising health care needs. An increase in taxes could result in a decrease in disposable income which in turn could depress aggregate demand, thereby limiting economic growth and reducing government's ability to invest in strategic areas. Figure 2.1 shows the link between poor health and the economy.

Figure 2. 1: The linkage between poor health and the economy (adapted from: Abegunde and Stanciole, 2006)



Globally, the burden of disease has shifted from a high prevalence of communicable diseases to a high prevalence of non-communicable (NCDs) in the 21st century. Current global estimates indicate that of the 57 million deaths that occurred worldwide in 2008, 36 million were due to chronic non-communicable diseases. Cardiovascular diseases accounted for 48% of chronic diseases deaths, cancers 21%, while asthma and obstructive pulmonary diseases accounted for 4.2 million of the deaths. Diabetes accounted for an additional 1.3 million of the deaths (World Health Organization, 2010). The World Health Organization projects that between 2010 and 2020, non-communicable diseases deaths will increase by 15% globally. In 2017, ischemic heart disease, neonatal disorders, stroke, lower respiratory infections, diarrhoea, road injuries, and chronic obstructive pulmonary disease were responsible for more than 5 million deaths worldwide. The Institute for Health Metrics and Evaluation (IHME) estimates that the burden of disability due to non-communicable diseases increased by 80% in the same year(Institute for Health Metrics and Evaluation, 2018). WHO predicts that the greatest increases in chronic diseases will be felt in the WHO regions of Africa, South-East Asia and the Eastern Mediterranean (World Health Organization, 2015).

South Africa faces a quadruple burden of disease that is characterised by a high prevalence of non-communicable diseases, maternal, new-born and child health mortality; HIV/AIDS and tuberculosis and violence and injury (Groenewald *et al.*, 2014). The burden of non-communicable diseases has increased in the past years. Between the years 2007 and 2017, non-communicable diseases such as diabetes, chronic lung diseases, and mental illness were amongst the top 10 causes of years lived with disability in the country. Whilst HIV/AIDS was the leading cause of mortality in 2017, non-communicable diseases such as ischemic heart diseases, stroke, diabetes, and chronic obstructive pulmonary disease were amongst the top 10 leading causes of mortality (Institute for Health Metrics and Evaluation, 2017).

Globally, poor health imposes large financial and economic costs on countries. The economic and financial costs due to chronic diseases have also been shown to be high in low- and middle-income countries such as South Africa. According to the World Economic Forum, cumulative economic losses due to diabetes, cardiovascular diseases, respiratory diseases, and cancer are estimated to surpass US$ 7 trillion over the period 2011-2025 (Bloom *et al.*, 2011). In South Africa it is estimated that diabetes, stroke, and coronary heart disease cost the country around R26 billion between the years 2006 and 2015. Productivity losses arising from absenteeism, presenteeism and early retirement due to ill health was estimated at 6.7% of GDP in 2015 (Hofman, 2014).

According to the World Health Organisation (WHO), a number of deaths from chronic diseases could be averted by reducing the major risk factors for NCDs. Non-communicable diseases also known as lifestyle diseases have been linked to tobacco use, physical inactivity, unhealthy diet, and the harmful use of alcohol. According to the World Health Organization, approximately 9.8 percent of the population in South Africa suffers from Diabetes (World Health Organization, 2016). The risk of developing diabetes has been shown to increase for individuals who are physically inactive, obese, and with family history of the disease (Barbara Fletcher, Gulanick and Lamendola, 2002; Pheiffer *et al.*, 2018). The strategy for reducing non-communicable diseases in South Africa includes health promotion at the community level, early diagnosis, and comprehensive management through cost-effective interventions (National Department of Health, 2013). Specific interventions include reduction in salt intake (National Department of Health, 2016), taxing of tobacco products, alcohol and sugar-sweetened beverages (National Treasury, 2019).

The sugar tax policy in South Africa was introduced in 2018 through the Health Promotion Levy on Sugary Beverages as a strategy to reduce diabetes and other lifestyle related diseases. The levy was introduced at a fixed rate of 2.1c/gram of the sugar content that exceeds 4g per 100ml of sweetened beverages. The WHO estimates that in the first year of implementation more than R3.2 billion (US$ 214 million) in revenue was generated from the tax.

As we begin to recognize the magnitude of the non-communicable disease crisis, characteristics of those affected, and the many different channels through which the epidemic impacts the economy, it is important to try to evaluate the effects of the pandemic as well as the preventative strategies on the economy. Over the years several methods have been used to estimate how poor health affects key macroeconomic variables.

2.3 Methods for estimating the effects of health on the economy.

Approaches for estimating the economic impact of poor health fall into three main categories: the cost of illness methods; microeconomic models and macroeconomic models.

(i) Cost-of-illness studies

Costs of illness studies are used in illustrating the costs of treating diseases and/or their risk factors(Jo, 2014). Cost of illness studies separate the costs of illness into three categories: direct costs, indirect costs, and intangible costs. Direct costs include the costs of labour, consumables, and other services needed to provide health care. Indirect costs seek to measure the loss of labour caused by morbidity or premature death while intangible costs measure the psychological effects of an illness.

Three different approaches are used to study the indirect costs of an illness. The first approach, the human capital measures the impact of illness through lost earnings for the patient and caregivers. Most studies measure lost output through lost earnings and lost work hours due to absenteeism. The second approach, the friction method, measures loss of productivity during the time it takes to replace a worker while the willingness-to-pay method measures the amount an individual would be willing to pay to reduce the probability of having an illness or mortality (Jo, 2014).

The human capital approach is used in most studies to measure the impact of illness on patients and caregivers. This approach is estimated using prevalence data, incidence data or econometric analyses. With an econometric approach, the difference in costs between a group with a disease and one without a disease is estimated. The costs are estimated using a mean differences approach or a multi-stage regression approach. The mean differences approach determines the incremental difference attributable to the disease between the two groups while the multi-stage regression approach compares coefficients from the regression analyses with the disease dummy variable. Most of the studies on the impact of diseases on the economy have used the cost of illness approach more than the micro- and macro-economic approach. Despite its popularity, the COI approach is rendered less suitable in estimating the economic impact of disease because of their inability to measure causality.

(ii) Microeconomic studies

Microeconomic studies have been used to measure the economic impacts of diseases and their risk factors for individuals and their households. Microeconomic approaches are used because they offer reasonable possibilities to address causality. There are several dimensions of the economic consequences of diseases at the microeconomic level. The three main types of consequences include labour supply and labour productivity effects, consumption and savings and education and human capital accumulation.

Over the years, the relationship between health and labour productivity has been studied through several strategies. The first approach for measuring the impact is through lost output due to poor health. Most studies measure lost output through lost earnings and lost work hours due to absenteeism. Nwosu and Woolard, (2017) investigates this relationship using self-reported health status on labour force participation, wage determination and wage discrimination using cross-sectional analysis from the National Income Dynamics Study (NIDS) in South Africa. Their study finds a significant impact of health on labour force participation of between 20% and 33%. The study also finds a positive and statistically significant gradients between better physical, psychological, and general health and wages among Africans and coloureds.

To measure the impact of disability on productivity, Vecchio, (2015) examines the association between labour force participation and residing with an individual with a disability and finds that staying with an individual with a mental illness reduced male propensity to participate in the labour market. Using a difference in difference and matching techniques, Gómez & Nicolás, (2006) finds that the probability of remaining in employment is reduced by 5% for individuals who suffered a health shock than those who did not suffer any health shock.

Pelkowski & Berger, (2004) also studies this relationship using data from the Health and Retirement Study to determine the impact of temporary and permanent illness on wage outcomes. Using a probit model, the results of their study shows that the impact of illness differs between females and males with the former having a larger reduction in wages whilst the latter have bigger decreases in hours worked. Whilst microeconomic studies shed light on the relationship between health and labour force participation, the studies do not capture the economy-wide impact of poor health.

(iii) Macroeconomic studies

At the macro level, regression-based econometric growth models, macroeconomic calibration models, input-output analysis and computable general equilibrium models (CGE) are used to study the macroeconomic impact of diseases (World Health Organization, 2009). Regression-based econometric models focus mainly on the impact of health on economic growth using single-country or cross-country panel data. Gallup and Sachs, (2001) uses this model to study the economic burden of malaria in several countries. Their studies show that between 1965 and 1990, countries with malaria grew by 0.4% per annuum as compared to other countries that grew by 2.3%. Other studies have also used similar approaches to study the impact of health on economic growth (McCarthy, Holger and Wu, 2000; Gyimah-Brempong and Wilson, 2004). A common theme amongst these models is their failure to control for endogeneity.

Macroeconomic calibration models are also used to measure the impact of health on the economy. These models are used to estimate the direct impact of health on GDP and GDP growth using microeconomic estimates. One earlier example is by Shastry and Weil, (2003) who estimate the effect of female adult survival rate and anaemia on GDP variance. Similarly Weil, (2007) shows the impact of adult survival rate on GDP variance across countries. Abegunde and Stanciole, (2006) uses a similar approach to estimate the impact of chronic diseases on economic growth in 23 countries using panel data.

Other macroeconomic approaches such as the Input–Output (I–O) analysis which uses I–O tables are also used to measure the economic impact of health. The input-output table describes the relationship between industries and their production and use of products. In an I-0 analysis, the mutual interdependence among these various industries is quantified. Developed by Wassily Leontief, the methodology has been used in other fields such as energy, transport, and environment (Ali, Bilal and Sabir, 2020; L. Liu *et al.*, 2020; Y. Liu *et al.*, 2020). Few studies apply this method in the health sector. Yamada and Imanaka, (2015) uses this approach to estimate the economic impact of all medical institutions in Japan. More recently Santos, (2020) uses this approach to examine the corona virus mitigation and suppression strategies on the workforce and their associated economic losses.

In recent years CGE models which uses I-O tables and supply-use tables have been used in a number of studies to investigate the macroeconomic impact of diseases in different countries. CGE modelling technique is used because of its ability to model economy-wide impacts of policy changes. The main advantage of CGE modelling as the name suggests focus on general equilibrium effects. According to Arndt and Lewis, (2000), CGE models have an advantage over partial equilibrium and aggregate macro approaches because *they are based on a consistent and balanced set of economy wide accounts (called a Social Accounting Matrix, or SAM), which requires (among other things) that key behavioural and accounting constraints (such as budget constraints and balance of payments equilibrium) are maintained.* Both the dynamic and static models are used to study the impact of diseases on the economy. In a static model, the equilibrium is a single data point whilst a time path to reach a steady state is computed in a dynamic model. Furthermore the static model is able to specify changes in only the exogenous variable of interest whilst the dynamic model requires specifying changes in all exogenous variables (Mark Horridge, 2000).

For the United Kingdom (UK), Smith et al., (2009), uses a static model to evaluate the economy-wide impacts of the influenza pandemic. They assume in their study that the pandemic impacts the economy through labour supply, as both the quantity and productivity of labour is reduced by illness and deaths due to the disease. The impact of mitigation policies which may reduce available labour if people keep away from work to avoid infections are also considered in their study. The results of their study show that mitigation policies in the form of school closures reduces GDP by 5.8% whilst the disease itself reduces GDP by 1.5%. The study further shows that other interventions such as staying away from work also results in a negative impact on the economy. The study, however, does not show whether the impact is the same for all sectors considering that some sectors are less labour intensive.

In a another study, Smith et al., (2009) evaluates the impact of pandemic influenza in France, Belgium, UK and The Netherlands on labour supply, inputs productivity and healthcare delivery cost using a single country static CGE model. Similar to the previous study, the analysis shows that GDP is reduced by 0.5% when the pandemic is mild and 2% for severe cases. Furthermore, mitigation policies in the form of school closure for four weeks at the peak of a pandemic is shown to cost the UK economy £27 billion. Proportional GDP estimates were recorded for France, Belgium, and Netherlands albeit greater than the UK impacts by varying factors. Domestic output, particularly in the labour-intensive sectors also suffered large losses with the least impact in the agricultural sector which suffered the largest losses in the trade.

For Australia, Verikos et al. (2010) uses a dynamic CGE model to simulate the economic effects of two influenza epidemic episodes. The authors develop a Health model (MONASH-Health) with a detailed health sector specifying 18 treatments as health sector industries in addition to the traditional industries. Four types of economic shocks are imposed on the model to simulate an H1N1 pandemic: (i) *a surge in demand for hospital and other medical services, (ii) a temporary upsurge in sick leave and school closures requiring withdrawal of parents from the labour force; (iii) some deaths with a related permanent reduction in the labour force; and (iv) temporary reductions in inbound and outbound international tourism and business travel*. The results of the study show reductions in GDP by 6.2% and employment by 4.1% with magnitude of reductions presumably larger for a severe epidemic.

For low and middle-income countries, Smith & Keogh-Brown, (2013) assesses the impact of a mild influenza pandemic on the economies of Thailand, South Africa, and Uganda. The authors simulate the impact of changes in labour supply resulting from the outbreak of the disease. The results of the study showed small impacts resulting in less than 1% GDP loss across all countries. The impact on sectors however differed across countries with the capital-intensive sectors such as the mining and extraction suffering the smallest losses due to the small contribution of labour to these sectors.

Whilst these studies have shown the impact of communicable diseases on labour productivity, few studies have modelled the impact of communicable diseases using CGE model. Verikos et al., (2013) investigates this link in Australia using a dynamic CGE model. The authors simulate the effect of reducing the prevalence of a number of chronic diseases on the economy and finds that improvements in older workers results in positive economic benefits as compared with younger workers. Furthermore, reducing chronic diseases results in improvements in GDP, employment, capital, the trade balance, real depreciation of the exchange rate due to the benefits in the trade sector.

2.4 Review of the impact of diabetes on economic activity

Over the last few years, a growing body of literature has developed to study the direct and indirect cost of diabetes. Most of the studies use the human capital approach to determine lost income and lost hours due to morbidity and mortality. Ettaro et al., (2004) assessed the global evidence on the direct and indirect cost of diabetes and found that diabetes has a large impact on the economy in different countries. In another review, Ng et al., (2014) focused on the methods used in the identified cost of illness studies and found a considerable economic burden associated with diabetes mellitus. A similar conclusion is found by Seuring et al., (2015)who shows a large economic burden of diabetes mostly in low- and middle-income countries.

2.4.1 Impact on earnings

A number of studies have investigated the impact of diabetes on earnings in several countries. The methods of analysis in these studies range from regression analysis to matching methods that adjust for the differences between people with diabetes and those without. In the United States of America, several studies have investigated the impact of diabetes on wage outcomes. The impact of diabetes in the USA ranges from $2, 221 lost earnings to lost earnings of $19,655 per year.

For the United Kingdom, Holmes et al., (2003) conducted a survey to investigate whether people with diabetes and their carers lose income. Of those who lost earnings, mean lost earnings were estimated at £13 841 (S.D. £9551) per patient and £10 960 (S.D. £6002). In Canada, Kraut et al., (2001) conducted a prospective population-based cohort study consisting of 25,554 individuals without diabetes and 608 with diabetes, of whom 242 had a complication of the disease.

Table 2. 1: Impact of diabetes on earnings outcomes.

Author	Country	Age	Dataset	Methodology	Effect on productivity outcomes	
					Males	**Females**
Holmes et al., (2003)	United Kingdom	Younger than 65	653 patients, 253 carers	Chi-square	£869 per patient, £1300 per carer	
Leijten et al., (2014)	The Netherlands	45 – 64	N=8411 Longitudinal Study on Transitions in Employment, Ability and Motivation	Generalized estimating equations	No significant effect on productivity Work ability reduced by 2% (measured by Work Ability Index)	
Liu and Zhu (2014)	China		11,095 individual-level data	Difference-in-differences model	16.3% decrease in annual income for newly diagnosed diabetes	
Collins et al., (2005)	USA	Working age	12,397 Dow full-time active employees at five locations in Michigan and Texas	Logistic regression	No significant effect on work days	
Kraut et al., (2001)	Canada	18 - 64	25,554 individuals without diabetes and 608 with diabetes	Chi-square *t* tests	With complication, earnings reduced by 72%	
Lenneman et al., (2011)	USA	More than 16	577,186 unique HRA participants	*t* tests	Lost earnings per year of $2, 221	
Vijan et al., (2004)	USA	51 – 61		Logistic regression Ordinary least squares	Lost earnings per year $6, 250	
Minor (2011)	USA	Older than 19	2006 NHIS. 35 000 households with 87 500 persons	Probit Model IV	Lost earnings per year of $2,865 (exogenous) Lost earnings per year of $19,655 (endogenous)	
Minor (2013)	USA	Older than 14	12,686 men and women	Logistic model Ordinary Least Square Fixed Effects	No general effect on wages, some evidence of wage penalty of about 18% 6-10 years after diagnosis	No strong evidence
Zondi (2015)	South Africa	Older than 18		Non-parametric test	Lost earnings of R4 019 904 per year in patients with an average wage of R2 991.	

To analyse the influence of diabetes on income, a Tobit regression model was used. They find in their study that with complications, diabetes reduces earnings by 72% of total income.

Using independent sample *t* tests, Lenneman et al., (2010) investigates this link using data from 577 186 participants and finds lost earnings of $2, 221 per year due to diabetes. In another study, Vijan & Langa, (2008) uses logistic regression to show lost earnings of $6, 250 per year for adults. Using Probit model with instrumental variable, Minor, (2011) records lost earnings per year of $2, 865 when diabetes is assumed to be and exogenous variable and lost earnings of $19, 655 when diabetes is treated as an endogenous variable.

Using a difference-in-difference model, Liu & Zhu, (2014)estimates that diabetes leads to 16.3% decrease in annual income in China. Furthermore, the impact was shown to be more significant for males and people with glycosylated haemoglobin (A1C) levels between 8.0% and 10.0% leading to a 22.0% and 28.0% decrease in annual income, respectively. In South Africa Zondi, (2015)shows that diabetes results in lost earnings of R4 019 904 per year in patients with an average wage of R2 991. The results on the impact of diabetes on earnings are summarised in table 1.

Overall, the studies show that the impact on earnings differs from country to country and within countries due to the study designs and the statistical methods used for analysis. Whilst these studies quantify the impact of diabetes on earnings, the problem of endogeneity is not addressed in the analysis. Failure to address endogeneity could result in possible bias and possible overestimation of the impact of diabetes on earnings. Bias could be introduced from unobserved illnesses, unobserved preferences, and the potential for lost earnings to increase the risk of developing diabetes.

2.4.2 Impact on labour force

A number of studies have investigated the relationship between poor health outcomes and labour force outcomes in several countries (Zhang, Zhao and Harris, 2009; Brown *et al.*, 2012; Pharr, Moonie and Bungum, 2012; Norström *et al.*, 2019). Current evidence suggests that poor health is associated with unemployment whilst healthier people are more likely to gain and retain employment. Whilst the correlation between health and employment has been well established, the causal relationship seems to work in both directions. Evidence from research shows that being employed can lead to better health in two ways. Firstly, individuals who are employed have income which provides financial means to access better healthcare, nutritious food and better sanitation which are all determinants of health (Schaller and Stevens, 2015; Zavras *et al.*, 2016). On the other side individuals who are unemployed have increased risk for mortality, physical illness, psychological stress and family breakdown (Wilson and Walker, 1993). Secondly being employed has been associated with psychological benefits such as better self-esteem and a sense of purpose and identity (Van Der Noordt *et al.*, 2014; Cottini and Ghinetti, 2018). Furthermore, having work has been shown to facilitate recovery from illness and enhance mental health (Modini *et al.*, 2016).

In recent years the impact of chronic diseases such as diabetes, hypertension and cardiovascular disease on labour outcomes has been studied (Kouwenhoven-Pasmooij *et al.*, 2016; Unmuessig *et al.*, 2016). Individuals with chronic disease have been shown to have a high probability of early retirement, and unemployment (de Boer *et al.*, 2018). A number of studies have also shown the relationship between diabetes and labour force outcomes.

A systematic review conducted by Pedron *et al.*,(2019) shows that diabetes has a negative impact on labour market participation in a number of countries. In the USA, diabetes has been shown to decrease the probability of employment by 7.5% for individuals older than 44 years (Brown 3rd, Pagan and Bastida, 2005). In Mexico, the probability of employment has been shown to decrease by 10% in males and 4.5% in females (Seuring, Goryakin and Suhrcke, 2015). Whilst these studies have investigated the impact of diabetes on labour outcomes, different methodologies are used to examine this impact. These methods cover a range of econometric techniques that includes regressing several covariates on labour outcomes and matching methods to estimate the impact of diabetes on productivity outcomes.

Whilst earlier studies assumed diabetes to be exogenous, recent studies have shown that treating diabetes as an exogenous variable might bias results (Kraut, Walld and Mustard, 2001; Latif, 2009). This might be due to the fact that diabetes may be correlated with employment in different ways. Firstly, diabetes may cause unemployment, because of its debilitating nature. Uncontrolled diabetes may result in complications, such as cardiovascular disease, nephropathy, neuropathy, retinopathy, and hearing impairment. These complications are a major cause of disability, reduced quality of life, and death. Employees with diabetes may prematurely stop working, translating into a reduction in earned income and savings (Piechota, Malkiewicz and Karwat, 2004; Wong *et al.*, 2013). Therefore, all else equal, diabetics are likely to be less productive than non-diabetics, and, therefore, less likely to be employed.

Table 2. 2: Impact of diabetes on labour outcomes

Author	Country	Age	Dataset	Methodology	Effect on employment	
					Male	Female
(Seuring, Goryakin and Suhrcke, 2015)	Mexico	15 – 44 45 – 64	Mexican Family Life Survey, 40,000 individuals	Bivariate Probit Model IV	Probability of employment 10% less	Probability of employment 4.5 % less
(Lin, 2011)	Taiwan	45 – 64	National Health Interview Survey, 30,680 sampled individuals	Bivariate Probit Model IV	Probability of employment 9% less (exogenously) Probability of employment 19 % less (endogenously)	Probability of employment 11% less (exogenously) Not significant (endogenously)
(Seuring, Serneels and Suhrcke, 2019)	Mexico	Older than 15	Longitudinal household survey	FE model	Probability of employment 5.5 pp less	Probability of employment 5.5 pp less
(Brown I I I *et al.*, 2011)	USA	35 – 64			Probability of employment 5% less (exogenously)	No significant effect
(Minor, 2011)	USA	Older than 19	2006 NHIS. 35 000 households with 87 500 persons	Probit Model IV		Probability of employment 25.2 % less (exogenously) Probability of employment 45.1% less (endogenously)
(Zhang, Zhao and Harris, 2009)	Australia	18 – 64	Australian National Health Surveys, 37,000 Australian.	Multivariate Probit model	50 – 64:11.5% points less likely to be in labour force 18 – 49: 3.9% points less likely to be in labour force	Not significant
(Latif, 2009)	Canada	15 – 64	National Population Health Survey, 49 000 respondents	Bivariate Probit model IV	Probability of working 19% less	Probability of working 17% less
	USA	51 – 61	Health and Retirement Study 7,055 employed respondents	Probit	Probability of working 7.1 percentage points less	Probability of working 4.4 percentage points less
(Brown 3rd, Pagan and Bastida, 2005)	USA	Older than 44	Border Epidemiologic Study, 1089 respondents	Bivariate Probit IV	Probability of employment 7.4% less (exogenous) Probability of employment 10.6% (endogenous)	Probability of employment 7.5 % less (exogenous) No significant effect (endogenous) Endogeneity exists
	USA	51 – 61	Longitudinal cohort study, 70,000 households,	Logistic regression Ordinary least squares	Probability of working 4.4% less	Probability of working 7.1% less
(Tunceli *et al.*, 2009)	USA	20 – 44 45 – 64	Annual household survey,	Probit models	Proportion with work limitations 3.4% higher Proportion not working 8.1%	
	Canada	18 – 64	Population based cohort study, 25,554 individuals	Logistic regression Tobit regression	Twice as likely not to be in the labour force	
Lawana et al., (2019)	South Africa	20 -64	National Income Dynamics Study	Multivariate probit model	Non-significant association with labour force participation (0.086)	Significant association with labour force participation (−0.138**)

Secondly, unemployment may cause diabetes. Diabetes is a lifestyle disease linked to the consumption of unhealthy food (Deshpande, Harris-Hayes and Schootman, 2008; Sami *et al.*, 2017). Unemployed individuals who have lower incomes are more likely to consume cheaper unhealthy food (Smed *et al.*, 2018). Consumption of cheaper unhealthy food, such as sugar sweetened beverages, has been linked to the increase in the prevalence of diabetes (Vasanti S. Malik *et al.*, 2010). Being unemployed could therefore increase one's chance of developing diabetes.

Thirdly, in any analysis, it is impossible to account for everything that might matter. Unobserved variables related to, for example, time preference or other personal traits, could be correlated with both diabetes and employment. Since those variables are not observed, an analysis ignoring that possibility could yield spurious results. For example, an unambitious individual may have a relatively low employment propensity and make unhealthy lifestyle choices.

Different methods have been used to tackle this bias that might result due to the reverse causality between diabetes and employment. Using Probit regression, with family of diabetes as instrumental variable, Tunceli et al., (2005) shows that among individuals with diabetes, the absolute probability of working was 4.4 percentage points less for women and 7.1 percentage points less for men relative to individuals without diabetes. Minor, (2011) also applies instrumental variable (IV) methods to account for other unobserved variables while Liu X (2011) addresses the endogeneity problem by making use of a difference-in-difference model. For South Africa, Lawana et al., (2019) uses recursive simultaneous equations from the multivariate probit model with simulated maximum likelihood to control for endogeneity. Overall, most of the studies show that diabetes has a negative impact on labour outcomes. The reviewed studies show a significant impact on males in different countries. For females, the impact ranged from no significant impact in Australia to 45.1 % reduction in USA. In South Africa the impact is shown to be insignificant in females. Pedron *et al.*, (2019) argues that the variation in the effect might be due to differences in the mean sample ages, modelling techniques or outcome definitions. In terms of the methodology used, most of the studies reviewed use standard regression or matching methods to estimate the impact of diabetes on labour outcomes. A common concern in the literature is however that few studies include co-morbidities, control for endogeneity and differentiate between type I and type II diabetes which might lead to an overestimation of the impact (Pedron *et al.*, 2019).

2.5 Sugar-sweetened beverage and health

The growing body of evidence on SSBs reveals that regular consumption contributes to weight gain and diseases that share obesity as a risk factor. Obesity has become a major global health challenge. In 2010, overweight and obesity were estimated to cause 3·4 million deaths worldwide. South Africa has the highest prevalence of obesity in Sub-Saharan Africa with a prevalence of 42% in women (M. Ng *et al.*, 2014). The increase in the use of sugar dense food has been associated with the increase in the prevalence of risk factors such as obesity and the increased risk for diabetes and cardiovascular diseases. The current literature shows that people who drink a lot of sugary drinks often tend to weigh more than people who do not drink sugary drinks (Vasanti S. Malik *et al.*, 2010)).

A wide range of studies have shown that SSB consumption has a positive impact on obesity. Francis et al. (2009) explores this link in a study to model the association between SSB consumption and overweight. The study found that overweight occurs frequently among 15-19-year-olds and is associated with increased consumption of sweetened beverages. High waist circumference was found to be more prevalent among females and was related to low consumption of fruits and vegetables. In Beijing, Jim et al (2012) studied the consumption of SSBs among junior high school students to explore the relationship between SSB intake and adolescents' overweight/obesity. The study comprised of 322 (46%) males and 380 (54%) females (age 11-15 y, median 13 y). The prevalence of overweight was found to be 21.1% in males and 11.6% in females. Prevalence of obesity was 22.7% in males and 10.3% in females. The study recorded that 7.7% of students consumed SSBs at least once per day.

Devona- Gutierrez et al, (2010) argues that sweetened beverage consumption increases the risk of metabolic syndrome in Mexican adults, possibly by providing excess energy and large amounts of rapidly absorbable sugars. They prove this association by studying 5240 individuals aged 20 to 70 years (mean 39.4) to study the impact of SSB. The study found that for each additional daily sweetened beverage serving consumed, participants experienced an average increase of 0.49 mmol/l in TAG and a decrease in HDL cholesterol of 0.31 mmol/l. Subjects consuming more than two servings of sweetened beverages daily were shown to have an increased risk of metabolic syndrome than those who did not consume sweetened beverages. Overweight/obesity was prevalent in 56.6 % of adults and metabolic syndrome was prevalent in 26.6 %.

Overweight and obesity are risk factors for type II diabetes. Several studies have shown that consumption of sugar sweetened beverages is associated with increased risk for diabetes (Schulze *et al.*, 2004; Odegaard *et al.*, 2010; De Koning *et al.*, 2011). Results of meta-analysis also show that individuals who consume sugar sweetened beverages increases their risk of developing diabetes (V S Malik *et al.*, 2010; Greenwood *et al.*, 2014). Wang *et al.*, (2015) further shows that this association is exacerbated by an increase in body mass index. Current evidence suggests that reducing sugars intake may help maintain a healthy body weight and possibly reduce the risk of diabetes. Drouin-Chartier *et al.*, (2019) shows that replacing one daily serving of sugary beverage with water, coffee, or tea could reduce the risk for diabetes by 2 to 10 percent. Researchers argue that increasing the price of sugar sweetened beverages could result in a decrease in their consumption (Colchero *et al.*, 2015).

2.6 SSB tax and health

The increase in the evidence linking sugar-sweetened beverages with poor health outcomes has resulted in a several studies that seek to model the impact of SSB taxes on health and economic activity. Preventative strategies in the form of SSB taxes are proposed as means to reduce obesity which is a risk factor for a number of non-communicable diseases. Approaches to estimating the impact of SSB taxes varies between microeconomic simulation and macroeconomic models. Microeconomic studies are used to measure the impacts of SSB taxes on individuals and their households. Macroeconomic models such as the computable general equilibrium models have been used to study the impact of policy change on different aspects of the economy.

In recent years, several studies have explored the impact of SSBs taxes on obesity and diabetes (Briggs *et al.*, 2013; Basu *et al.*, 2014; Manyema *et al.*, 2014; Saxena *et al.*, 2019b). Researchers argue that an increase on the price of SSBs will decrease demand for SSBs which will in turn lower the consumption of SSBs (Redondo, Hernández-Aguado and Lumbreras, 2018). Results of systematic reviews show that food taxes and subsidies are likely to be an effective intervention to improve consumption of foods that are associated with obesity and chronic disease such as diabetes (Thow *et al.*, 2010; Escobar *et al.*, 2013; Thow, Downs and Jan, 2014). In middle-income countries such as South Africa, Nakhimovsky *et al.*, (2016) indicates that taxing SSBs could reduce sugar intake enough to prevent growth in the obesity pandemic. In South Africa, Manyema *et al.*, (2014) shows that a 20% tax on SSBs would reduce over 220 000 cases of obesity in adults.

The link between SSB tax and diabetes has also been studied in recent years. SSB tax is associated with a decrease in the prevalence of diabetes in several countries. Most of the studies that estimate the impact of SSB tax on diabetes use Markov model to simulate lifetime effects of the tax. Sánchez-Romero et al., (2016) uses a computer-simulation state transition (Markov) model of Mexican adults aged 35 to 94 years to project the future impact of SSB tax on diabetes incidence. A 10% and a 20% reduction in SSB consumption was shown to result in about 189 300 fewer incidences of type 2 diabetes.

A similar approach is followed by Manyema et al., (2015) who uses a multi-state life table-based Markov model to study the impact of 20% tax on SSBs. In their study two population groups are compared, reference population that simulate the working age population in South Africa and an identical intervention population with an additional 20% tax on their SSBs. The results of their study show that 20% SSB tax reduced diabetes incident in all adults by 4.0% over a 20 years period. Saxena *et al.*, (2019) estimates that over 20 years, a 10% tax would avert 8000 premature deaths related to diabetes. Whilst these studies do estimate the effects of the tax on diabetes, their analysis fails to model the overall impact of the tax in other sectors other than health.

2.7 SSB tax and the economy

According to economic theory, government must intervene whenever markets fail to control the sale of goods that have less merits than consumers perceive. Increasing the price of unhealthy foods through taxes and/or reducing the price of foods high in nutrients that are pro-health is seen as a way to improve consumption of healthy food (Thow et al., 2010). SSB tax has been recommended as a means to reduce the consumption of sugar sweetened beverages which have been identified as a risk factor for diabetes. Allcott, Lockwood and Taubinsky, (2019) argue that such taxes are favourable if they can counteract externalities, internalities and when the tax does not disproportionally affect the poor. Proponents for the SSB tax argue that many consumers do not correctly internalise the harms of consuming SSBs as many are not aware of the link between consumption of these beverages and the health and financial consequences of consuming these beverages (Griffith, O'Connell and Smith, 2018). This imperfect information is further distorted by extensive marketing campaigns that advertise the benefits of consuming sugar-sweetened beverages. Financial "externalities" are also a motivation for taxing sugar-sweetened beverages because non-communicable diseases which are mostly chronic in nature are costly to treat which places a burden on the health care system.

Opponents of the introduction of tax on SSB however argue that such interventions are regressive and will disproportionately harm the poor as the low-income populations spend a high percentage of their income on food than would higher-income groups. Research however shows that low-income populations consume less healthy food than high-income populations and therefore are at higher risk of obesity and chronic NCD (Kim and Kawachi, 2006). The introduction of the tax is seen as a way of influencing consumption behaviour which might result in long-term health benefits. The regressivity of the tax could therefore be offset by revenue generated from the tax if used to subsidize healthy food and health care costs that are borne by the low-income groups (World Health Organization: Europe, 2015). Allcott, Lockwood and Taubinsky, (2019) however argues that the extent of this benefit depends on the price elasticity of demand of SSB and the extent to which revenue generated is used for the benefit of those who are negatively affected by the tax. In South Africa the demand for soft drinks has been shown to be price-elastic (Stacey, Tugendhaft and Hofman, 2017). Javadinasab *et al.*, (2020) also shows that in selected countries, sin taxes are used to provide sustainable health financing. Hagenaars, Jeurissen and Klazinga, (2017) argues that it is often the fiscal needs of a country than the potential to improve health that motivates policy makers to implement the SSB tax.

In recent years, several studies have attempted to model the impact of the SSB tax on the economy. The current studies are however focused on the impact of the taxes on employment and the revenue generation potential of the tax. Industry opponents on SSB tax have argued that such a tax will have a negative impact on the economy through reduction in employment (Theron, Rossouw and Fourie, 2016; Mounsey *et al.*, 2020). Powell *et al.*, (2014) shows that the declines in employment within the beverage industry is offset by new employment in government as well as other sectors of the economy. In Mexico, an introduction of the tax was shown to have no significant changes in employment in the beverage industries (Guerrero-López, Molina and Colchero, 2017).

Revenue generating potential of the SSB tax is one of the rationales for introducing the tax. Proponents of the tax argue that revenue generated from the tax could be used to subside healthy food and cover or be invested in health care programs. For South Africa, Saxena *et al.*, (2019) shows that a 10% SSB tax would raise R6 billion (US$450 million) and save government R2 billion (US$140 million) in subsidised healthcare over 20 years. Andreyeva, Chaloupka and Brownell, (2011) shows that the United States of America could generate $79 billion between 2010 and 2015 from a national penny-per-ounce tax on sugar-sweetened.
Studies that look at the economy-wide impact of the tax are limited. Macroeconomic models are used to study the economy-wide impact of taxes. To assess the impact of a 20% tax on employment in Illinois and California, Powell et al., (2014) uses a macroeconomic simulation model that account for changes in the demand for inputs into SSB. Using a 169-sector model they simulate a 20% tax also accounting for changes in SSB demand, substitution between beverages, income, and government spending of new tax revenues. Their analysis shows a decline in employment in the beverage industry which is offset by an increase of 0.06% jobs in Illinois and 0.03% in California in other sectors. Whilst the analysis shows the impact of the tax at the macroeconomic level, the effects related to health gains resulting from reduced SSB consumption is not modelled in the study.

For Vietnam, Chuc, (2014) uses a static computable general equilibrium model (CGE) model to study the impact of a 10% SSB taxes on the economy. Their model identifies 63 sectors and 30 households that are disaggregated across two regions. Data from the 2011 social accounting matrix is used to calibrate their model. The model predict that Government revenue will increase by 8.46 million while the soft drinks industry will have a revenue loss of USD 40.5 million. Other sectors are shown to have a reduction in revenue of about USD 12.1 million. The tax is also shown to have a negative impact on employment and income. Similar to Powell *et al.*, (2014) the analysis fails to account for health gains resulting from reduced SSB consumption.

In South Africa, Theron, Rossouw and Fourie, (2016), follows a similar approach by estimating the impact of SSB tax using a dynamic CGE model. Using data from the social accounting matrix, their model identifies 31 industries and products. They first simulate a baseline forecast of the economy to project the trajectory of the economy without any tax intervention. They then impose an exogenous shock on the economy using different own-price elasticity levels. Their modelling finds that an imposition of the tax shock reduces GDP growth as well as unemployment. Similar to Chuc, (2014), their analysis does not take into account the expected health benefits that might be derived from an introduction of the tax.

2.8 Emerging research issues

Two themes emerge from a review of the literature with regards to studies on diabetes and sugar-sweetened beverages. The first one is the modelling techniques used to study the impact of diabetes on labour outcomes as well as the impact of SSB on the economy. The empirical testing of the impact of SSB taxes on the economy are tilted towards the use of microsimulation techniques and epidemiological models. While microsimulation techniques have the capacity to simulate alternative policies and forecast the fiscal and distributional consequences associated with these proposed changes, they are limited by not being able to model prices, wage effects and other macroeconomic variables. Those that have attempted to investigate the impact do so with different methodological approaches. The most recent study is by Powell et al., (2014) who uses a regional economic model to study the impact of taxes on net employment in Illinois and California. While this study sheds some light as to what the impact of the SSB taxes could be on employment, impacts on other macroeconomic variables is not shown.

In South Africa, recent studies by Manyema et al., (2015, 2014), Saxena *et al.*, (2019), and Tugendhaft et al., (2016) have made notable contributions to the sugar sweetened beverage literature. Their studies however fail to show the economy-wide impact of the SSB taxes. The limitation with these studies is that findings fail to show how the taxes impact other sectors of the economy such as employment outcomes, growth, and wage impacts. With regards to the impact of diabetes on labour outcomes, most of the studies have been conducted in high income countries using econometric techniques. Only two studies use CGE model to study the economy-wide impact of diabetes. Both Theron, Rossouw and Fourie, (2016) and Chuc, (2014) however do not incorporate the expected benefits that might be derived from the tax in their model. To add value to the current discussions around diabetes and the impact of sugar-sweetened beverages we model the health benefits that are derived from the SSB tax through increased labour supply and reduced demand for healthcare services. We further show how the tax affects consumption by the different household groups.

Our study also adds to the current debates by looking at the impact of diabetes on employment, unemployment, and non-labour force participation. Previous studies have mostly focused on the effects on employment between those with diabetes and those without diabetes. We contribute to the literature by looking at the impact on the different labour outcomes.

2.9 Conclusion

The aim of this chapter was to review the relationship between diabetes and the economy as well as the economic impact of sugar-sweetened beverages. We started the chapter by looking at the theory on human capital, health, and productivity. We then reviewed the impact of diabetes on labour outcomes. Most of the studies that we reviewed were microeconomic studies that showed that diabetes has an impact on labour outcomes, earnings as well as working hours. We also reviewed the literature for evidence of the impact of SSB taxes on the economy. A review of the evidence showed that most of these studies rely on mathematical approaches to study the impact of this taxes on health and economic outcomes. Most of the studies also focused on health outcomes more than economic outcomes. We identified this as a gap that our study could fill and contribute to the current discussion on the SSB policy.

CHAPTER 3

THE IMPACT OF DIABETES ON LABOUR MARKET OUTCOMES IN SOUTH AFRICA

Abstract

This study estimates the effect of diabetes on labour market outcomes in South Africa using data from the General Household Survey (2016). We employ probit, propensity score matching and linear instrumental variable models to examine this effect and to account for possible endogeneity in diabetes. Our findings indicate that diabetes significantly reduces employment probabilities of females by five percentage points and males by four percentage points relative to those who do not have diabetes when diabetes is treated as an exogenous variable. Our results highlight the detrimental impact of diabetes on labour outcomes.

JEL classification: I15; J21

Key words: Diabetes; labour outcomes, employment

3.1 Introduction

South Africa is on the verge of a Type II diabetes mellitus (diabetes) crisis. Diabetes is one of the leading causes of mortality in the country, accounting for 5.4 percent of deaths in 2015 (StatsSA, 2014). According to the World Health Organization, approximately 9.8 percent of the population suffers from Diabetes, and the prevalence rate is expected to rise to 30 percent by the year 2030. In recognition of the substantial individual and government costs of the disease, diabetes is a 'national health priority area' in South Africa (NPC, 2012). To curb the prevalence of diabetes, the South African government adopted a policy in April 2018 to tax sugar-sweetened beverages (SSBs), on the assumption that increased SSB prices will deter consumers from purchasing these beverages, thereby reducing sugar consumption. Since the consumption of SSBs has been linked to non-communicable diseases, such as Type II Diabetes (V S Malik *et al.*, 2010; Basu *et al.*, 2014), it is further assumed that the reduction in sugar consumption will yield concomitant reductions in diabetes, or at least slow its expected rise and help reduce individual and government costs associated with the disease. Furthermore, as we describe more fully below, reductions in diabetes could also yield improvements in the labour market, which would yield additional improvements for government (increased tax revenues) and the economy.

Globally, the number of people living with diabetes and the number of deaths due to diabetes has also increased over the years. The World Health Organization estimate that the number of adults worldwide living with diabetes increased from 108 million in 1980 to 422 million in 2014. In 2012, diabetes was responsible for 1.5 million deaths in the world (World Health Organization, 2016). Most of these deaths have been recorded in low- and middle-income countries in the population group below 70 years (World Health Organization, 2016).

In addition to imposing large morbidity and mortality costs, diabetes and its complications impose substantial economic costs on people with diabetes and their families, as well as to health systems and national economies (Kirigia *et al.*, 2009). Diabetes exerts three broad categories of economic cost; direct healthcare costs, indirect healthcare costs and intangible costs (Jonsson, 1998). The direct healthcare costs include medications and consultations and hospitalisation for the condition, itself, and for its complications. The indirect healthcare costs include other expenses, such as travelling to health care facilities, productivity loss associated with morbidity, as well as the loss of income due to mortality, morbidity and disability associated with diabetes and its complications. The intangible costs include losses due to physical and psychological pain (Kirigia *et al.*, 2009), which is difficult to quantify.

According to the International Diabetes Federation (IDF), estimated global diabetes health care costs were at least 376 billion USD in 2010. In South Africa, the national economic burden was forecast to be 865 thousand USD in 2011. The IDF estimates that approximately seven percent of total health expenditure went to diabetes care amongst adults aged 20 – 79 in 2010. It is further estimated that expenditure will rise by 30 – 34 percent by 2030 in developing countries. In South Africa, these costs will rise to between 1.1 – 2 billion USD by 2030 (Zhang *et al.*, 2010).

Over the years, numerous studies have investigated the direct and indirect cost of diabetes. Most of the studies use the human capital approach to determine direct costs of illness, lost income and lost hours, due to morbidity and mortality. Seuring, Archangelidi and Suhrcke, (2015)'s review of the global evidence argues that the studies in low and middle-income countries mostly focus on the direct costs of the disease, whereas evidence on labour market effects remains scarce. Mutyambizi *et al.*, (2018) agree; their review of diabetes costs in Africa suggests a similar focus on the direct cost of diabetes. Globally, the impact of diabetes on labour market outcomes is primarily available for upper-income countries (Brown 3rd, Pagan and Bastida, 2005; Latif, 2009; Seuring, Goryakin and Suhrcke, 2015). Thus, there is a need to learn more about labour market effects in less developed countries that, as in the case of South Africa, have relatively high levels of diabetes.

In terms of the methodology used, most of the studies reviewed use standard regression or matching methods to estimate the impact of diabetes on labour outcomes. A common concern in the literature is however that few studies include co-morbidities, control for endogeneity and differentiate between type I and type II diabetes which might lead to an overestimation of the impact (Pedron *et al.*, 2019). Endogeneity arises when unobserved factors related to diabetes are correlated with unobserved factors influencing employment. For example, a sedentary person may be more likely to develop diabetes and be less productive (Wilmot and Idris, 2014). Although many studies employ simultaneous equation and other models to account for endogeneity, its effect remains ambiguous.

Brown *et al.* (2005) utilise data from the Border Epidemiologic Study on Aging and bivariate probit models, where family Diabetes history is used as an instrumental variable. They find that diabetes has a substantial negative effect on employment for men but not for women, while diabetes is endogenous for women, but not men. Using data from Canada's National Health Survey, Latif (2009) follows a similar approach, but is able to more finely distinguish between the possible genetic pathways. The five instrumental variables incorporate paternal diabetes (as well as having died from the disease), maternal diabetes (also, having died from it) and sibling diabetes. The results point to a significant negative impact on female employment, but no significant impact on the employment of non-white Canadians. Furthermore, assuming exogeneity results in the over-estimation of the diabetes impact on male employment. Applying instruments and methods similar to Latif (2009), Lin, (2011) uses data from Taiwan's National Health Interview Survey (NHIS) and finds that diabetes has a larger negative and significant effect on employment for men when compared to women.

The preceding research has focused exclusively on developed economies. We were only able to find studies for two other developing country. Seuring, et al. (2015) analyses data from the Mexican Family Life Survey with mother and father diabetes status as instruments. Their analysis finds that diabetes reduces employment for men (about 10 percentage points) and women (about 4.5 percentage points), although they find no indication that diabetes is endogenous. Seuring, Serneels and Suhrcke, (2016) apply fixed effects methods, finding employment reductions around 5.5 percentage points for both men and women. More recently, Lawana *et al.*, (2020) investigated the impact of lifestyle risk factors and non-communicable diseases on labour outcomes in South Africa. For their analysis, an endogenous multivariate probit model with a recursive simultaneous structure is used. Their analysis finds that diabetes has a significant negative impact on labour force participation in females whilst no effect is found in males.

As noted previously, diabetes affects about 10% of the South African population, currently, and is expected to affect close to 30% of the population within the next 15 years. Moreover, the majority of individuals with diabetes are less than 64 years of age, with the highest incidences (54%) reported between the ages of 35 and 54 years (Bertram *et al.*, 2013), the "most economically active" population in most countries, including South Africa. Furthermore, in Africa, approximately 76% of diabetes deaths occur in people younger than 60 years of age, compared to the global proportion of 49% (International Diabetes Federation, 2013). The situation is further exacerbated by the prevalence of undiagnosed diabetes, which could be as high as 46% in upper-middle income countries (Peer *et al.*, 2014). The high prevalence of diabetes is concerning, given that healthy workers are an important economic asset for a nation. When people cannot work, due to serious health problems, they cannot fully support their families, let alone a nation, because they do not generate economic output or pay taxes on earnings (Davis *et al.*, 2005). Not only that, when people are healthy, the government incurs smaller health-related expenditure, and therefore it is able to invest in education or to upgrade infrastructure, which will enhance overall economic productivity.

Given the prevalence of diabetes in the working age group (Bertram *et al.*, 2013), and its expected future prevalence, as well as other features of the South African economy, we add to the literature by investigating the effect of diabetes on different labour market outcomes using different methodologies. Whilst Lawana *et al.*, (2020) have investigated this relationship, their study focuses only on labour force participants, i.e. individuals working for pay, being unemployed but looking for a job, and discouraged from seeking work. We also control for other relevant variables (e.g. wealth status) which might influence labour market that are not included in their analysis.

Since government has introduced an SSB tax, this research also provides a pre-tax baseline estimate of the effects of diabetes on the labour market, which can be compared post-tax for policy evaluation purposes. As with previous literature, we consider the possibility that diabetes and labour market outcomes are endogenously determined. We employ two separate types of models to address this possibility – two-stage least squares and recursive bivariate probit models – incorporating genetic instrumental variables. Doing so is appropriate, since identification in the latter models requires the bivariate normality assumption to be correct, while identification in the former models does not rely on normality.

We are not the first researchers to consider health and labour market issues in South Africa. Given the rate of HIV/AIDS in the country, understandably, South African research has often focused on it (Arndt and Lewis, 2000; Young, 2005; Levinsohn *et al.*, 2011), although more recent research considers obesity (Some, Rashied and Ohonba, 2016), self-assessed poor health (Nwosu and Woolard, 2017), life-style risk factors and non-communicable diseases (Lawana *et al.*, 2020).

3.2 Methodology

3.1.1 Dataset

The present study uses the 2016 General Household Survey (GHS) conducted by Statistics South Africa. The GHS is a nationally representative household survey conducted yearly. The target population of the survey consists of all private households and residents in workers' hotels in all nine provinces of South Africa. Face-to-face interviews were conducted on a total of 25 653 households with a knowledgeable household member. Information on a wide range of demographic, social, economic and health related topics was collected. For more details related to the survey and the instrument, see StatsSA, (2016).

3.2.2 Main variables

Our main variable of interest is diabetes; thus, we make use of the diabetes variable in the survey. Diabetes is an indicator taking on the value of 1 if an individual has been diagnosed with diabetes and 0 if not. Our dependent variables of interest include employment, unemployment, and non-participants in the labour force[1] (NPLF). Employment is based on a standard definition, and is coded 1, if an individual worked for a salary, wage or any form of payment in the last week (which could include running own business), and 0, if otherwise. Unemployment is coded as 1 if an individual has not worked for a salary, wage, or any form of payment in the last week and 0 if otherwise. Non-participation in labour force (NPLF) is coded as 1 if an individual has not worked and has not being looking for employment or try to start their own business and 0 otherwise. Thus, we separately examine (i) employed vs unemployed and non-participants in labour force (ii) employed vs unemployed (iii) employed

[1] Non-participants in the labour force include individuals between the ages 15 and 65 who have not worked, looked for work or tried to start a business. The group includes full-time scholars and students, full-time homemakers, those who are retired, and those who are unable or unwilling to work)

vs NPLF, and (iv)unemployed vs employed and NPLF. In sensitivity analysis unemployed is expanded to include those who are unable and unwilling to work to align with the broad definition of unemployment.

3.2.3 Covariates

We consider a number of covariates shown to be of importance in the literature. To account for heterogeneity in the prevalence of diabetes and the impact on labour market outcomes, we analyse the data by the different gender groups. We also control for age because diabetes risk increases with age (B Fletcher, Gulanick and Lamendola, 2002; Kasiam *et al.*, 2009). Furthermore, employment rates have been shown to differ by age group in South Africa (StatsSA, 2018b). Therefore, we include individuals between the ages of 20 and 64, with age categorized into five-year bands, the 15-20 age band, the youngest, serve as our reference category.

We further include population group indicators, because diabetes prevalence often differs by ethnic group (Fletcher *et al.,* 2002; Klimenditis *et al.*, 2011). South Africa's apartheid past has led to wide differences in human capital accumulation by race (Gamede, 2017), as well as labour market access and success (Burger and Jafta, 2006); thus, population group is also expected to affect employment. Thus, population group indicators control for possible labour market discrimination, as well as possible differences in genetic susceptibility to diabetes.
The level of education is also included in our analysis since education is related to diabetes (Bachmann *et al.*, 2003; Lee et al, 2013), health seeking behaviour and labour market outcomes. In South Africa, education attainment has been shown to significantly improve employment prospects (Branson and Leibbrandt, 2013). For the analysis, we use dummy variables for primary, secondary, secondary, certificate, degree or postgraduate qualification, with 'no schooling' as the base measure of education.

We include a number of additional sociodemographic characteristics to capture their relationship with employment status and lifestyle habits which could result in Diabetes. One is marital status (using indicators for single, the reference category, married and divorced/widowed). A number of studies find increased labour force participation (perhaps employment), as well as higher earnings, for married males. However, there is decreased labour force participation (perhaps employment) and earnings for females (Ntuli, 2007). Furthermore, marital status is a risk factor for Type II Diabetes in men (Cornelis *et al.*, 2014). We also include the number of children under the age of 18 residing in the household, because child bearing increases the risk of gestational diabetes and ultimately Type II Diabetes in women (Bellamy *et al.*, 2009). In addition, studies find reduced employment for women (Troske and Voicu, 2009) compared to men (Cools, Markussen and Strom, 2017), when there are young children in the household. Further variables relate to dwelling and location. South Africa is a large and diverse country with regional socioeconomic differences, we also account for potential provincial differences in diabetes prevalence (Maier *et al.*, 2013) and employment (StatsSA, 2014) with provincial indicators; Limpopo is our reference province.

To account for socioeconomic status, we incorporate wealth in the analysis. The association between wealth and health has been studied extensively, the causal direction between wealth and health is however uncertain (Smith, 1999). In terms of diabetes, some studies show a positive association between increased wealth and diabetes prevalence (Hosseinpoor *et al.*, 2012), whilst others find an inverse relationship between wealth and prevalence (Tanaka, Gjonca and Gulliford, 2011). Wealth is also correlated with attachment to the labour force. Previous studies consider the association between wealth and labour force participation using, housing/non-housing (Amedah & Fougère, 2017; Fu, Liao, & Zhan, 2016;) inheritance (Brown, Coile and Weisbenner, 2010; Amedah and Fougère, 2017), lottery winnings (Imbens, Rubin and Sacerdote, 2001) and rental subsidies (Jacob and Ludwig, 2012) finding an negative relationship between wealth and labour supply.

We use principal components analysis to create a wealth index. For our analysis, owning a vehicle, staying in a brick house, owning household appliances such a washing machine, stove, refrigerator, or furniture, having pay television and internet access were included in the index. Based on the wealth scores, five wealth quintiles ranging from poorest to richest (poorest, poorer, middle, richer, richest) are defined.

We also include hypertension and heart disease in the analysis to control for the effects of co-morbidities which might also influence employment outcomes (Pedron *et al.*, 2019). We include hypertension and heart disease because of the high prevalence in individuals with diabetes (Nowakowska *et al.*, 2019). According to Long and Dagogo-Jack, (2011), 75% of individuals with diabetes have hypertension. These two conditions have the same risk factors and complications thereby making the existence of one a predisposition to the other. Furthermore, both conditions are more likely to lead to heart disease complications.

3.2.5 Econometric specification

Three estimation strategies are employed, probit, propensity score matching and linear instrumental variable model.

3.2.5.1 Probit model

We first estimate a probit model.

$$E_i^* = \beta D_i + \alpha X_i + \mu_i$$
$$E = 1 \; if \; E_i^* > 0$$
$$E = 0 \; if \; E_i^* \leq 0 \qquad (1)$$

where E* is a latent variable representing the i^{th} individual's propensity to be employed in the labour market. The corresponding observable binary variable E_i indicates whether or not $E_i^* > 0$; implicitly, whether or not the employment propensity is high enough to observe employment. We also consider other binary outcome comparisons from the labour market, and each model follows a similar formulation; thus, the formulation is generic, even if the discussion is specific to just one of the models we estimate.

In this analysis, an individual is employed if they worked for a salary, commission or payment in-kind, even if only for one hour in the past week. In a probit model, diabetes (D) is assumed to be exogenous; we use a similar binary indicator to represent whether the individual has diabetes (=1) or not (=0), although the indicator is based on self-reported diagnoses made by a doctor, as per the survey. We include a vector X of additional exogenous socio-characteristics, previously described. Given that diabetes is a dummy variable, we estimate the marginal effects of diabetes on the probability of being employed, which is the sample average of changes in the predicted probability of being employed across the two binary indications of Diabetes, keeping all other variables at their observed values:

$$ME = \frac{1}{n}\sum_{i=1}^{n}\left[\Phi\left(\hat{\beta}D_i + \hat{\alpha}X_i \middle| D_i = 1\right) - \Phi\left(\hat{\beta}D_i + \hat{\alpha}X_i \middle| D_i = 0\right)\right] \quad (2)$$

Where Φ is the standard normal distribution function, $\Phi\left(\hat{\beta}D_i + \hat{\alpha}X_i\right)$ is the predicted probability of being employed and n is the number of individuals in the sample. We also consider other labour market outcomes.

3.2.5.2 Propensity score matching

The marginal effects in the probit model above measures the average treatment effect on the treated, i.e. the effect of diabetes on employment for those who have diabetes. The model assumes that the impact of diabetes is constant across all individuals. Furthermore, individuals with and without diabetes are included in the estimation sample even when there are no similar individuals of the other group in terms of their values of the covariates.

To avoid the restrictions imposed by the probit model, we estimate the regression using propensity score matching. The propensity score matching consists of matching those with diabetes and those without diabetes in terms of the other covariates and then comparing the employment probability for individuals with the same diabetes propensity.

We first estimate diabetes propensity score for each individual in the sample using the estimated coefficients from the probit regression. We further assess covariates balance between those with diabetes and those without diabetes using standardized difference and the percent bias reduction. Once the two samples are matched, we then compute the average treatment effects on the treated (ATT) by matching those with and without diabetes based on their propensity score. The difference in labour outcomes between matched diabetics and non-diabetics is then computed. The ATT is obtained by averaging these differences across the m matches:

$$ATT = \frac{1}{m}\sum_{j=1}^{m}\left[Y_j^{j\in B=1} - Y_j^{j\in B=0}\right] \quad (3)$$

The nearest neighbour matching is used to analyse the difference in employment between those with and without diabetes. The method recommended by Abadie and Imbens, (2016) which takes into account that propensity scores are estimated prior to matching is used. We choose this method because traditional bootstrap methods for computing standard errors have been shown to be less sufficient (Abadie and Imbens, 2008)

3.2.5.3 Linear instrumental variable model

As noted above, probit models and propensity scores rest on the assumption that diabetes, conditional on all covariates is independent of employment. Furthermore, the models assume normality in errors, which might be unrealistic. For that reason, we also estimate the effect of diabetes on employment through two-stage least squares, using the same covariates that are used in the above models. For our analysis, we use the method proposed by Lewbel (2012) to generate instruments. This method is recommended when traditional instruments are not available or when the identified instrument is weak for identification (Lewbel, 2018). The method is used extensively in the literature including the health literature (Brown, et.al. 2014; Awaworyi, et.al. 2017;Brown, 2014; Drichoutis, et.al. 2012). The model takes the following form of a first and second stage (equation 4). Lewbel (2012) uses heteroscedasticity present in the data to generate instruments by multiplying the residuals (ε_1) from the first-stage regressions with a subset of the included exogenous variables in mean-centred form $(Z - \bar{Z}).\varepsilon_1$, where $\bar{Z}$ is a vector of the means of Z. For our analysis, all included covariates are used to construct the instruments. Instead of identifying endogenous variables in the second stage equation based on traditional exclusion criteria, the method allows for achievement of identification using higher moments (equation 4) along with some heteroscedasticity of (ε_j);

$$E_i = \beta_0 + \beta_1 D_i + \alpha_1 X_i + \mathcal{E}_1$$

$$D_i = \alpha_0 + \alpha_1 X_i + \mathcal{E}_2 \qquad (4)$$

$$E(X\mathcal{E}_1) = 0,\ E(X\mathcal{E}_2) = 0,\ Cov\,(Z, \mathcal{E}_1\,\mathcal{E}_2) = 0 \qquad (5)$$

The results of the analysis are reported in the following section.

3.3 Results

3.3.1 Socio-demographic characteristics

The data used in the analysis is described in Table 3.1. The table presents the mean and standard deviations of the analysis for individuals who do, and do not report being diagnosed with diabetes. The data shows that individuals with diabetes are more likely to be out of the

Table 3. 1: Summary statistics for individuals with and without diabetes

	Males				Females			
	Diabetes=No		Diabetes=Yes		Diabetes=No		Diabetes=Yes	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Employed	0.51	0.50	0.58	0.49	0.39	0.49	0.36	0.48
Unemployed	0.15	0.35	0.04	0.19	0.15	0.36	0.05	0.22
NPLF	0.34	0.47	0.38	0.49	0.46	0.50	0.59	0.49
Age	34.16	13.32	53.34	9.53	35.49	13.71	52.93	9.52
Age15to19	0.15	0.35	0.00	0.07	0.13	0.34	0.01	0.08
Age20to24	0.15	0.36	0.01	0.10	0.13	0.34	0.01	0.08
Age25to29	0.14	0.34	0.01	0.10	0.13	0.34	0.02	0.13
Age30to34	0.13	0.33	0.02	0.14	0.13	0.33	0.03	0.16
Age35to39	0.11	0.32	0.05	0.22	0.10	0.30	0.04	0.20
Age40to44	0.09	0.29	0.06	0.23	0.09	0.29	0.07	0.26
Age45to49	0.07	0.26	0.13	0.33	0.08	0.28	0.12	0.32
Age50to54	0.06	0.24	0.19	0.39	0.07	0.26	0.21	0.41
Age55to59	0.05	0.23	0.22	0.42	0.06	0.24	0.23	0.42
Age60to64	0.04	0.20	0.25	0.43	0.05	0.22	0.23	0.42
Children	1.42	1.67	1.14	1.47	1.98	1.83	1.73	1.76
Race								
African	0.82	0.38	0.64	0.48	0.83	0.38	0.73	0.44
Coloured	0.10	0.29	0.18	0.39	0.10	0.30	0.16	0.37
Indian	0.02	0.14	0.07	0.26	0.02	0.13	0.04	0.21
White	0.06	0.24	0.10	0.30	0.06	0.23	0.06	0.24
Marital Status								
Single	0.60	0.49	0.12	0.33	0.55	0.50	0.22	0.42
Married	0.37	0.48	0.79	0.41	0.36	0.48	0.49	0.50
Divorced	0.02	0.13	0.05	0.21	0.03	0.18	0.06	0.23
Widowed	0.01	0.11	0.04	0.20	0.06	0.24	0.23	0.42
Province								
Western cape	0.11	0.31	0.16	0.37	0.10	0.30	0.15	0.36
Eastern cape	0.12	0.33	0.16	0.36	0.13	0.34	0.18	0.39
Northern cape	0.05	0.21	0.06	0.24	0.05	0.21	0.06	0.25
Free state	0.05	0.23	0.07	0.26	0.06	0.24	0.08	0.27
Gauteng	0.24	0.43	0.24	0.43	0.23	0.42	0.17	0.38
Mpumalanga	0.08	0.27	0.06	0.24	0.08	0.28	0.05	0.22
Limpopo	0.10	0.30	0.05	0.22	0.11	0.31	0.05	0.21
Northwest	0.07	0.25	0.03	0.18	0.06	0.24	0.05	0.22
KwaZulu-Natal	0.17	0.38	0.17	0.37	0.18	0.38	0.20	0.40
Setting								
Urban	0.66	0.47	0.77	0.42	0.64	0.48	0.68	0.47
Traditional	0.30	0.46	0.18	0.38	0.33	0.47	0.29	0.46
Farms	0.04	0.21	0.05	0.21	0.04	0.19	0.02	0.15
Education level								
No schooling	0.03	0.16	0.06	0.24	0.04	0.19	0.09	0.28
Primary	0.15	0.36	0.16	0.37	0.13	0.33	0.29	0.46
Secondary	0.69	0.46	0.55	0.50	0.70	0.46	0.49	0.50
Certificate	0.06	0.25	0.12	0.32	0.07	0.25	0.06	0.24
Diploma	0.01	0.12	0.02	0.14	0.02	0.13	0.02	0.14
Bachelors	0.02	0.13	0.03	0.18	0.02	0.14	0.01	0.11
Honours	0.01	0.11	0.03	0.16	0.01	0.12	0.02	0.12
Masters	0.01	0.09	0.01	0.11	0.01	0.09	0.01	0.11
Doctorate	0.00	0.05	0.00	0.00	0.00	0.04	0.00	0.00
Other	0.01	0.12	0.02	0.13	0.01	0.10	0.01	0.11

Co-morbidities								
Hypertension	0.05	0.21	0.49	0.50	0.10	0.30	0.63	0.48
Heart disease	0.00	0.06	0.03	0.17	0.01	0.07	0.05	0.21
Wealth Status								
Poorest	0.21	0.41	0.49	0.50	0.21	0.41	0.26	0.44
Second	0.19	0.39	0.22	0.41	0.20	0.40	0.24	0.43
Middle	0.18	0.39	0.13	0.33	0.20	0.40	0.20	0.40
Fourth	0.21	0.41	0.08	0.27	0.22	0.41	0.17	0.37
Richest	0.21	0.41	0.09	0.29	0.18	0.38	0.13	0.34
Sample size	19 128		458		21379		796	

Summary statistics of study sample taken from the 2016 general household survey. Mean and standard deviation are reported at the individual level. Note: NPLF stand for non-participants in labour force Std. Dev. Stands for standard deviation.

labour force than in. If in the labour force, females with diabetes are more likely to be employed than unemployed whilst males are more likely to be unemployed. As noted at the outset and seen in this data, the average age of individuals with diabetes is shown to be high as compared to individuals without diabetes. The mean age is shown to be high in the age group 45 and above for the diabetes group as compared to the non-diabetes group in both males and females. It is also the case that individuals with diabetes have fewer children than those without, despite being, on average, older. Individuals with diabetes are also shown to have less secondary education than individuals without diabetes. With regards to the prevalence of diabetes across the different race groups, African females are more likely to have diabetes as compared to African males whilst the prevalence is shown to be higher in Coloured, Indian, and White males. Single females are shown to have a high prevalence of diabetes as compared to single males whilst married males are shown to have a high prevalence of diabetes as compared to married females. Both widowed and divorced females are shown to have a high prevalence of diabetes as compared to widowed and divorced males. Prevalence of diabetes is shown to be high in females residing in Eastern Cape, Free-State, North-West, Northern Cape and Kwazulu-Natal whilst the prevalence is high in males residing in Western Cape, Gauteng, and Mpumalanga. Individuals with diabetes are also shown to reside in urban areas than individuals without diabetes in both males and females. Individuals with diabetes are also likely to have hypertension and heart disease as compared to individuals without diabetes. Individuals with diabetes are also shown to be poor than individuals without diabetes in both males and females.

3.3.2 Probit results

Table 3.2 presents probit estimates of the relationship between diabetes and several different labour market participation outcomes, such as employment versus unemployment and non-participants in labour force, employment versus non-participants in labour force and unemployment versus employment. The estimates themselves are not particularly meaningful; thus, we present the marginal effects estimates here. The results, as expected, mimic the descriptive statistics. Individuals with diabetes are less likely to be employed than individuals without diabetes. Diabetes reduces employment probabilities of males by 4 percentage points relative to the unemployed and non-participants in the labour force. The probability is reduced by 5 percentage points in females. The results of the other covariates are as expected in both males and females. Age increases the probability of employment in both groups and all age groups are more likely to be employed than the reference age group of 15-19. The number of children in the household seems to reduce employment in both males and females. The probability of employment for Indian females with diabetes is reduced as compared to African females whilst the probability of employment increases for Indian males.

Table 3. 2: The impact of diabetes on various labour market participation outcomes: probit

	Male		**Female**	
	M.E		**M.E**	
Diabetes effect on employment relative to unemployed and NPLF	-0.04*	(0.02)	-0.05**	(0.02)
N	19586		22175	
Diabetes effect on employment relative unemployment	0.04	(0.03)	0.01	(0.03)
N	12916		11873	
Diabetes effect on employment relative NPLF	-0.05**	(0.02)	-0.06***	(0.02)
N	16749		18862	
Diabetes effect on unemployment (narrow)	-0.05	(0.02)	-0.02	(0.02)
N	19586		22175	
Diabetes effect on unemployment (broad)	0.04*	(0.02)	0.05**	(0.02)
N	129 16		118 73	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes. NPLF stand for non-participants in labour force. N stands for sample size. M.E stands for marginal effects. Standard errors (SE) are in parentheses. Explanatory variables such as age, children, dwelling, province, wealth education level, marital status, are included in the full sample regression model. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.01

Being married seem to reduce employment probabilities of females while the probability of employment increase by 2 percentage points in males. As expected, education, especially a completed honours qualification, increases the probability of employment in both males and females. Having hypertension and heart disease is shown to reduce the probability of employment in both males and females. The probability of employment is reduced by 17 percentage points in males with heart disease. Coming from a second, middle and fourth wealth quintile is shown to reduce the probability of employment in males as compared to individuals in the richest quintile. For females in all wealth quintile, the probability of employment seems to increase as compared to females in the richest quintile.

We further analysed the impact of diabetes on employment when non-participants in the labour force are removed from the analysis. Individuals with diabetes are shown to be more likely to be employed which is counterintuitive as one would expect a decrease in the probability of employment. When the effects of diabetes on employment relative to non-participation in the labour force is analysed, the results show a significant reduction in employment probability in both male and female. For sensitivity analysis we estimated the effect of diabetes on unemployment. The effect is shown to be positive and significant in both male and female when analysis is based on broad unemployment. Full results for the remaining covariates are presented in Appendix for chapter 3.

3.3.3 Propensity score matching results

The results for the propensity score matching are presented in table 3.3. Similar to the probit model, the analysis shows a reduction in employment in both males and females with diabetes. Whilst probit results showed results which are not significant when those who are non-participants in the labour force are excluded from the analysis, the analysis showed a significant increase in males. When those who are unemployed are removed from the analysis the effect is shown to be significant in both males (7 percentage points) and females (8 percentage points). The slightly high effect of the propensity score matching may be due to the comparability in terms of the baseline covariates between the two groups. Examining the effect on unemployment shows that the effect is negative and insignificant in both male and female. Similar to probit, positive and significant effect is shown on unemployment when the broad unemployment is considered.

Table 3. 3: The impact of diabetes on various labour market participation outcomes: propensity score matching

	Male		Female	
Diabetes effect on employment relative to unemployed and NPLF	-0.06**	(0.03)	-0.05*	(0.02)
N	19 586		22175	
Diabetes effect on employment relative unemployment	0.04**	(0.02)	0.02	(0.03)
N	12916		11873	
Diabetes effect on employment relative NPLF	-0.07**	(0.03)	-0.08***	(0.02)
N	16749		18862	
Diabetes effect on unemployment (narrow)	-0.01	(0.01)	-0.02	(0.01)
N	19586		22175	
Diabetes effect on unemployment (broad)	0.06**	(0.03)	0.04	(0.02)
N	19586		22175	

Notes: This table shows the effects of diabetes on various labour market participation outcomes using the nearest neighbour matching method. NPLF stands for non-participants in labour force. Standard errors in parenthesis. Explanatory variables such as age, children, dwelling, province, wealth education level, marital status, are included in the full sample regression model.

3.3.4 Linear instrumental variable results

Table 3.4 presents the results of the Lewbel instrumental variable model. Similar to the probit estimation and propensity score matching, the Lewbel model shows that males and females with diabetes are less likely to be employed than those without diabetes. Comparing the Lewbel results to the probit, we find that the results are similar. The results turn to be slightly less in males when we exclude the non-participants in the labour force. The results are however insignificant. The results of the analysis also show that the null hypothesis of weak instruments and under identification is rejected. The Sargan test also does not reject the null hypothesis of instruments uncorrelated with the error term suggesting exogeneity of diabetes. The full results of the first and second equation are reported in appendix C.

Table 3. 4: The impact of diabetes on various labour market participation outcomes: linear instrumental variable

	Male		Female	
Diabetes effect on employment relative to unemployment and NPLF	-0.05*	(0.02)	-0.05**	(0.02)
χ 2 (H0: under identification)	572.57		1079	
p-value	(0.00)		(0.00)	
F stat (H0: weak instruments)	780.21		877.41	
Sargan (H0: valid instrument)	62.36		51.33	
P-value	(0.02)		(0.13)	
N	195 86		22175	
Diabetes effect on employment relative unemployment	0.00	(0.02)	0.01	(0.02)
χ 2 (H0: under identification)	336.40		394.80	
p-value	(0.00)		(0.00)	
F stat (H0: weak instruments)	338.9		191.83	
p-value	(0.00)		(0.00)	
Sargan (H0: valid instrument)	42.05		31.96	
P-value	(0.43)		(0.84)	
N	129 16		118 73	
Diabetes effect on employment relative to NPLF	-0.06*	(0.02)	-0.06***	(0.02)
χ 2 (H0: under identification)	556		1039.24	
p-value	(0.00)		(0.00)	
F stat (H0: weak instruments)	680.44		863.14	
p-value	(0.00)		(0.00)	
Sargan (H0: valid instrument)	59.66		50.43	
P-value	(0.03)		(0.15)	
N	167 49		18862	
Diabetes effect on unemployment (narrow)	-0.00	(0.01)	-0.01	(0.01)
χ 2 (H0: under identification)	572.57		1079.17	
p-value	(0.00)		(0.00)	
F stat (H0: weak instruments)	780.21		877.40	
p-value	(0.00)		(0.00)	
Sargan (H0: valid instrument)	51.10		44.94	
P-value	(0.13)		(0.31)	
N	195 86		22 175	
Diabetes on unemployment (broad)	0.05*	(0.02)	0.06**	(0.03)
χ 2 (H0: under identification)	572.57		1079.17	
p-value	(0.00)		(0.00)	
F stat (H0: weak instruments)	780.21		877.40	
p-value	(0.00)		(0.00)	
Sargan (H0: valid instrument)	62.36		51.33	
P-value	(0.43)		(0.13)	
N	195 86		22 175	

Note: This table shows the effects of diabetes on various labour market participation outcomes using the Lewbel instrumental variable model. NPLF stand for non-participants in labour force. N stands for sample size. Standard errors are in parentheses. Explanatory variables such as age, children, dwelling, province, wealth education level, marital status, are included in the full sample regression model. Marginal effects; * p< 0.1, ** p<0.05, *** p<0.01

3.4 Conclusion

Poor health has a negative impact on economic output as individuals who cannot work due to their health status cannot generate economic output or pay taxes on earnings (Davis, Karen; Collins, Sara R; Doty, Michelle M; Ho, Alice; Holmgren, Alyssa, 2005). Furthermore, poor health can have macroeconomic impacts via increased health expenditures, labour and productivity losses and reduced investment in human and physical capital formation (World Health Organization, 2009). The focus of this paper was on understanding the impact of diabetes on labour force participation in South Africa using several models.

We estimated the impact on a number of different labour market participation outcomes, such as employment vs unemployment and non-labour market participation, employment vs unemployment and employment vs non-labour market participation. For robustness check we also estimated the impact of diabetes on unemployment. Using a probit model and propensity score matching method, the analysis shows that individuals with diabetes have less chances of being employed as compared to individuals without diabetes. Our analysis is similar to earlier studies that have shown the negative impact of diabetes in Mexico (Seuring et. al., 2015), Canada (Latif, 2009) and the United States (Brown et al., 2005). Lawana *et al.*, (2020) also reports the negative impact of diabetes on labour force participation in South Africa for both males and females using a different dataset. Their results are however shown to be statistically significant for females only.

Previous research has also shown that the effect of diabetes on employment varies by gender with the impact being shown to be exogenous for females and endogenous for males (Brown 3rd, Pagan and Bastida, 2005; Latif, 2009). For Mexico, diabetes is shown to be exogenous for both male and female (Seuring, Goryakin and Suhrcke, 2015). Our analysis shows similar effects in both male and females indicating that being employed does not increase the risk of having diabetes. We further estimated the impact of diabetes on unemployment to test the sensitivity of the model. The results show that diabetes increases broad unemployment significantly in both male and female. Negative results and insignificant results are shown when narrow unemployment is estimated highlighting how focusing on narrow unemployment underestimates the impact of diabetes.

Our analysis also revealed that that males in the second, middle and fourth wealth quintile are less likely to be employed than those in the richest quintile. For females in all wealth quintile, the probability of employment seems to increase as compared to females in the richest quintile. Similar results are reported by Seuring, Goryakin and Suhrcke, (2015) who argue that the difference between males and females could be due to the difference in the physical demand placed on males in jobs as compared to less strenuous jobs for females. The same seems to be true for males in the richest quartile who are more likely to continue working due to having positions that are less likely to be physically demanding. The probability of employment is shown to further decrease with co-morbidities especially in males with heart disease.

In terms of policy implications, the most important result of this study is that diabetes could be a serious hindrance to employment opportunities in South Africa. This is likely to arise because diabetes is an incapacitating health condition (Westaway, Rheeder and Gumede, 2001; Shim *et al.*, 2012). The disease can however be prevented through diet control and control of overweight and obesity (Olokoba, Obateru and Olokoba, 2012). In South Africa, the strategy for the prevention of non-communicable diseases such as diabetes include promotion of healthy diets, early diagnosis and management and monitoring, surveillance, and research (National Department of Health, 2013). As part of the prevention strategy for diabetes, sugar-sweetened beverage tax was introduced in 2016 to reduce the risk of developing diabetes. Opponents to the sugar tax have however argued that the tax will reduce employment in the relevant sectors. Our analysis shows that inaction on the diabetes epidemic will result in significant negative impacts on the quantity of the labour force in South Africa. The recent introduction of the SSB tax, health education and employee wellness programmes on diabetes could reduce the adverse impact on employment and work productivity and potentially abate losses in income.

A few limitations have been identified. This study uses survey data which collects self-reported information on diabetes, which might have caused some attenuation bias in our estimated parameters. In addition, we could not differentiate between type I and type II diabetes as the survey does not distinguish the two. Padoa, (2011) estimates that less than 10% of the diabetes cases is type I. The analysis is also based on cross-sectional data which limits the inclusion of unobserved time-invariant heterogeneity. Nonetheless, this dataset was the most suitable as it provided us with an array of demographic and socioeconomic information that have been shown to affect employment probability.

In summary, the contribution of this paper is in analysing the impact of diabetes on different labour market outcomes in a region were diabetes is the second leading cause of death. Going forward, it will be worthwhile for future research to investigate the impact of diabetes on other macroeconomic variables such as the gross domestic product, trade, and consumption to determine the economy-wide impact.

CHAPTER 4

MODEL SPECIFICATION AND ESTIMATION STRATEGY FOR ECONOMY-WIDE IMPACT OF DIABETES AND SUGAR SWEETENED BEVERAGE TAX

4.1 Introduction

In this chapter we describe the model used to estimate the economy-wide impact of diabetes and sugar sweetened beverage tax. A modified version of the University of Pretoria General Equilibrium Model (UPGEM) is used. UPGEM is a detailed CGE model of the South African economy based on ORANI, a multi-sectoral model of the Australian economy that was developed by Peter Dixon and colleagues at the Centre of Policy Study and IMPACT Project, building on the ground-breaking work of Johansen (1960). Like ORANI, UPGEM is a comparative-static, multi-sectoral model exhibiting neoclassical assumptions which govern the behaviour of the model's economic agents.

We use CGE model in this study because it is an empirical approach of general equilibrium analysis with a number of features that makes the model suitable for examining "cross cutting" issues such as the impact of diseases on the economy (Arndt and Lewis, 2000; M Horridge, 2000). Furthermore, CGE models provide industry disaggregation and the behaviours of economic agents in a quantitative description of the whole economy.

The modelling framework is based on four basic tasks: derivation and description of the model's theoretical structure, calibration, simulation design and solution and interpretation of results (Adams, 2005). GEMPACK software is used to formulate and solve the model. This chapter will focus on the derivation, description of the model's theoretical structure and the calibration of the model database.

4.2 Model theory and specification

We use a modified version of UPGEM documented in Horridge (2000) and Bohlmann et al. (2015) for the analysis. For this study, we use a comparative-static version of the model. UPGEM is a multi-sector model that assumes an economy that is perfectly competitive with constant returns to scale production function, cost minimisation by industries, utility maximisation by households, and continuous market clearance. The model further assumes zero profit conditions for all industries in the long-run.

The model allows each industry to produce several commodities with primary factors of production. Production starts with different types of labour which are combined substitution production function (CES). Capital, Labour and land are also combined using CES to produce composite primary factors. Each commodity composite (which is a function of a domestic good and the imported equivalent) is then combined with the primary-factor composite and 'other costs' using a Leontief production function to produce sector output. All industries in the model share this common production structure, with input proportions and behavioural parameters varying between industries (see figure 4.1).

Each industry in the model minimises cost subject to given input prices using constant returns to scale production function. Households maximise a Klein-Rubin utility function subject to their budget constraint. The demand and supply equations are derived from the solutions to the optimisation problems which are assumed to underlie the behaviour or private sector agents. Units of new industry-specific capital are constructed as cost-minimising combinations of domestic and imported commodities. Substitution between different commodities is modelled using the Armington CES assumptions. The price of imports is exogenously determined, consistent with the assumption of South Africa being a small open economy. Government consumption is set to be exogenous and the details of direct and indirect taxation are also recognised in the model.

Linearised system of equations is then used to explain the theory underlying the behaviour of participants in the economy. This system of equations describes sector demands for primary factors and intermediate inputs; final household, investment, government and foreign demand for commodities; pricing in the economy which sets pure profits from all activities to zero; market clearing equations for various primary factors and commodities and miscellaneous or definitional items such as GDP, aggregate employment and the consumer price index (M Horridge, 2000).

To explain the key macroeconomic relationships in the UPGEM model a simplified system of equations referred to as the back-of-the-envelope model is used. The back of the envelope (BOTE) model is designed to present and explain the core elements contained in the large and often complex CGE models. Table 4.1 below is a representation of the UPGEM model using the back of the envelope model. A BOTE model simplifies the large-scale model to gain insight on model results.

Table 4. 1: Back of the envelope model

GDP	= C + I + G + (X-M)	(1)
GDP	= A*f (K, L)	(2)
C	= APC*HINC	(3)
C / G	= R_CG	(4)
M	= f (GDP, TofT, TWS)	(5)
TofT	= f(X, F_X)	(6)
I	= f (RoR, F_I)	(7)
R_IK	= I / K	(8)
CPI	= f (PY, TofT)	(9)
K/L	= f (RP_L/RP_K)	(10)
RoR	= f (K/L, TofT, A)	(11)
RW	= f (K/L, TofT, A)	(12)
RP_L	= RW*f (1/TOT, 1/1+T)	(13)
RP_K	= ROR* f (1/TOT, 1/1+T)	(14)

Equation (1) in table 4.1 shows the relationship between GDP, private consumption, investments, government, imports and exports from the expenditure side. Household consumption in South Africa contributes around 60 percent to GDP followed by investment and government expenditure each contributing approximately 20 percent. The relationship between GDP from the supply side to inputs of capital, labour, and primary factor augmenting technical change is shown in equation 2.

Equation (3) relates household consumption to household disposable income via the average propensity to consume. Equation (4) defines the ratio of private to public consumption while equation (5) relates imports (M) to the level of GDP, the terms of trade, and an import/domestic preferences twist variable. The terms of trade (TofT) is defined in (6) as the foreign-currency price of domestically produced exports relative to the price of imports. In equation (7) investment expenditure is defined as a function of the rate of return on capital and the demand shift variable. The investment-capital ratio is defined in equation (8) as a function of investment expenditure over capital stock.

Table 4. 2: Description of Variables

A	Primary-factor augmenting technical change
APC	Average propensity to consume
C	Real private household expenditure
CPI	Consumer price index
F_I, F_X	Shift in investment; Shift in export demand schedule
G	Real government expenditure
GDP	Real gross domestic product
I	Real investment expenditure
K	Capital stock
L	Labour
RoR	Rate of return on capital
R	Interest rate on net foreign liabilities
R_CG	Ratio of private to public consumption
R_IK	Capital growth rate (I/K ratio)
RP_L	Real price of labour
RP_K	Real price of capital
RW	Real Wages
TofT	Terms of trade
TWS	Cost-neutral import/domestic preference twist
X, M	Export volumes; Import volumes

The consumer price index is determined in equation (9) as a function of the price of domestically produced goods and the terms of trade. Equation (10) shows the relationship between relative factor inputs and relative factor prices. The real price of labour is defined as the nominal wage rate relative to the price of GDP at factor cost (the price of output). The real price of capital is defined as the nominal rental on capital relative to the price of GDP at factor cost. An increase in the real price of labour relative to the real price of capital will cause an increase in the capital intensity of the economy. With perfect competition, the real price of labour is equivalent to the marginal product of labour and the real price of capital is equivalent to the marginal product of capital.

The rate of return on capital is determined in equation (11) as a function of capital to labour ratio, the terms of trade and the primary factor augmenting technical change. To determine (11) we assume that the rate of return on capital (RoR) can be expressed as the factor payment to capital relative to the price index for new investments [Q/PI]. We then assume Q is determined by the value of the marginal product of capital, written as [MPK*PY]. Equation (11) is then summarised through MPK which a function of the K/L ratio and technical change is, and [PY/PI] a function of the terms of trade. In a similar manner, real wage is determined in equation (12) as a function of the capital labour ratio, the terms of trade and the technical change.

The real price of labour is defined in equation (13) as a function of the real wage multiplied by the inverse of the terms of trade, and one plus the ad valorem rate of indirect taxes less subsidies. Equation (14) defines the real price of capital similar to equation (13) as a function of the rate of return on capital multiplied by the inverse of the terms of trade, and one plus the ad valorem rate of indirect taxes less subsidies.

4.3 Development of the model database

The UPGEM was used as a base for building our model of analysis. We calibrate the model through construction of a balanced database and evaluation of the coefficients and parameters that serves as the initial solution to the model. The database is constructed using the official 2017 Supply-Use Table (SUT) of South Africa, published by Statistics South Africa, as a starting point and initial solution to the model. The SUT distinguishes between 62 industries and 104 services. For our analysis, we expand the UPGEM by aggregating the 62 industries to 42 industries (see Appendix C) while the 104 commodities are similarly aggregated to 42 commodities. Furthermore, the beverage and sugar industry are maintained as a separate industry from the rest of food manufacturing for the purpose of our analysis.

Each of the 42 industries are allowed to produce only one corresponding product. Eleven occupations are identified as labour inputs. Final users of commodities include investors, households, governments, and exporters. For our analysis, we disaggregate households into four groups. Using data from the 2011 social accounting matrix (SAM), households are disaggregated across products based on the expenditure shares and across income classes using shares from the living conditions survey. Four household groups are then identified ranging from poor to rich. A single central government is assumed to simplify the implementation of the model.

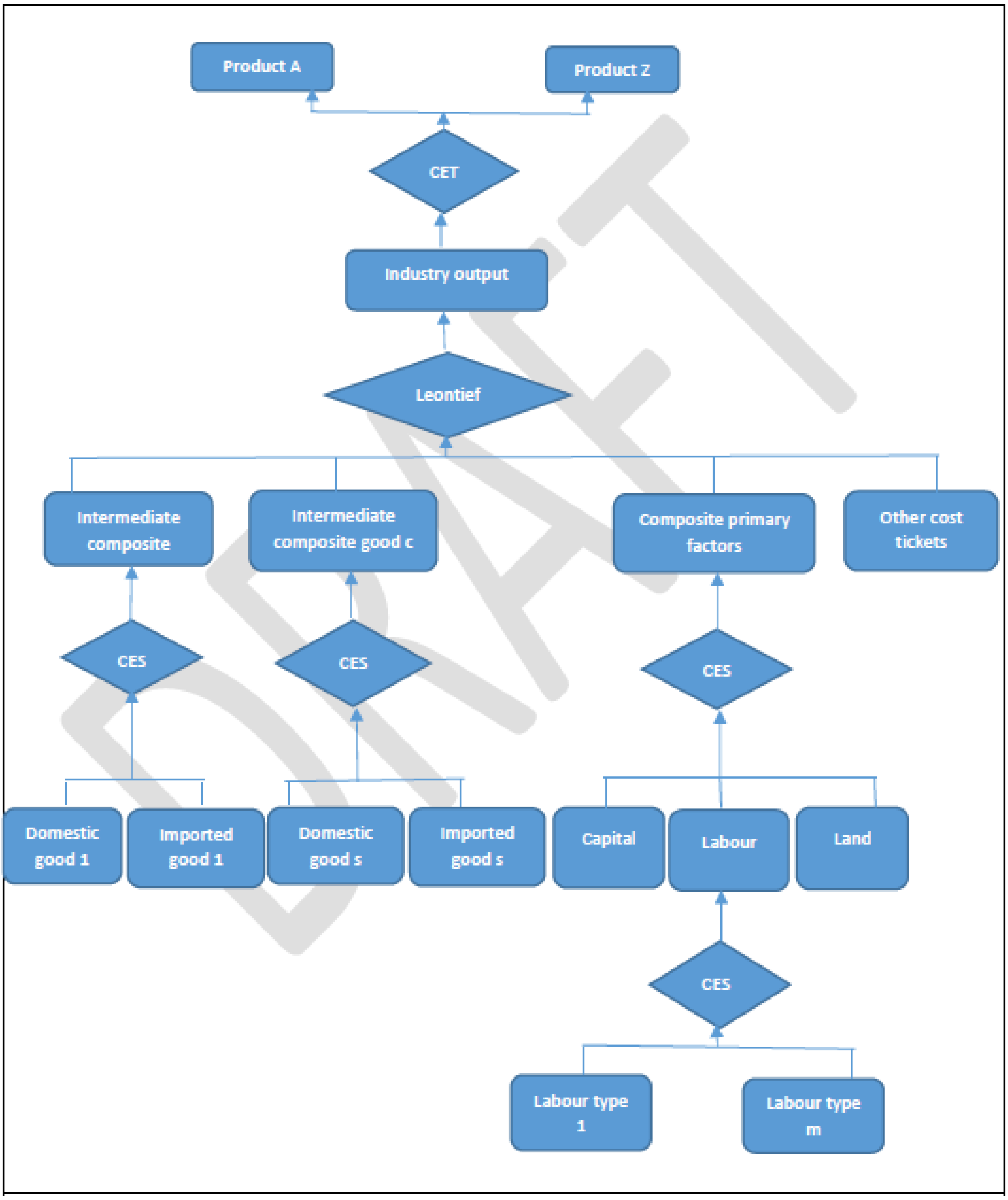
The commodities in the model are obtained locally or imported. The commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export column. The domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes payable on the purchases are captured in the model as well as the primary factors of production: labour (divided into O occupations), fixed capital, and agricultural land. Production taxes are also included in the model as output taxes or subsidies that are not user specific. Miscellaneous taxes such as municipal taxes or charges are captured in the 'other costs' column.

The basic structure of the model's database is depicted in Figure 4.2. The database is made up of two parts: an absorption matrix and a joint production matrix. Row one in the absorption matrix captures the basic flows of commodities to producers, investors, households, exports, government consumption and inventory accumulation. Basic prices of commodities are used in this row. V1BAS and V2BAS have industries dimension (IND). V1BAS is defined as the value of good I from source s used by industry j as an input to the current production while V2BAS is the value used to create capital for industry j. Row two in the absorption matrix is the margin matrices. These are the quantities of retail and wholesale services or transport needed to deliver each basic flow to the user. For example, V3MAR (c, s, m) is the value of margin type m used to deliver commodity type c from source s to households (user 3). The model assumes that margin services are domestically produced and are valued at basic prices. The third column is the sales tax matrices that are charged on the corresponding basic flows. Positive values indicate collections of indirect taxes while negative values subsidies associated with each of the flows. The fourth row is the value of the purchases for producers, investors, households, exports, government, and inventories. These values are obtained by summing the basic values, the margins, and the taxes for the respective

V1LAB captures payments for labour by occupation or skill group. Payments by industries for the use of capital and land are captured in V1CAP while collections of net taxes on production are captured in V1PTX. The value of V1CAP is represented by the gross operating surplus (GOS) within the system of national accounting. The GOS is the value of gross output or sales minus the cost of intermediate goods and services to give gross value added and less compensation of employees. In the UPGEM database this value is calculated as the value of total sales (MAKE) less intermediate input costs (V1PUR), minus labour input costs (V1LAB), minus production taxes (V1PTX), minus other costs (V1OCT). V1OCT is included to capture other industry costs not classified elsewhere.

From the supply table the joint production matrix, MAKE is formed. The MAKE matrix captures the output of commodity c by industry i, valued in basic prices. The content of the matrix is equivalent to the supply table. Tariff revenue by imported commodities is captured in the V0TAR vector. The assumption of quantity demand equals to quantity supplied are met by making sure that the values of the MAKE matrix equal to the values of the industry inputs. For example, the sugar column of MAKE must be equal to the sugar column sum of V1BAS, V1MAR, V1TAX, V1LAB, V1CAP and V1PTX. The row sums of MAKE must also be identical to basic values of demands for domestic commodities.

Figure 4. 1: Nested production function



Source: Adapted from Horridge (2000)

Figure 4. 2: Stylized Representation of a CGE Model Database

		Absorption Matrix						
		1	2	3	4	5	6	
		Producers	Investors	Households	Export	Government	Inventories	
	Dimension	← IND →	← IND →	← HOU →	← 1 →	← 1 →	← 1 →	
Basic Flows	COMxSRC ↕	V1BAS ("dom") V1BAS ("imp")	V2BAS ("dom") V2BAS ("imp")	V3BAS ("dom") V3BAS ("imp")	V4BAS ("dom") V4BAS ("imp")	V5BAS ("dom") V5BAS ("imp")	V6BAS ("dom") V6BAS ("imp")	DOM IMP
Margins	COMxSRCxMAR ↕	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	zero	MARUSE
Indirect Taxes	COMxSRC ↕	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	zero	TLSP
BAS+MAR+TAX equal PUR Values	COM ↕	V1PUR USE TABLE	V2PUR INVESTMENT	V3PUR CONSUMPTION	V4PUR EXPORTS	V5PUR GOVERNMENT	V6PUR INVENTORIES	INDUSTRY plus FINAL DEMAND
Labour Inputs	OCC ↕	V1LAB						
Capital Rentals	1 ↕	V1CAP						
Land Rentals	1 ↕	V1LND part of V1CAP						
Production Taxe	1 ↕	V1PTX						
Other Costs	1 ↕	V1OCT part of COSTS						
		INDUSTRY COSTS						

COM = number of commodities ; IND = number of industries ; SRC = ("dom", "imp")
MAR = commodities used as margins ; OCC = occupation types

	MAKE MATRIX
Dimension	← IND →
COM ↕	SUPPLY TABLE incl MARSUP

	IMPORT DUTIES
Dimension	← 1 →
COM ↕	V0TAR

Source: Adapted from Horridge (2000)

4.4 Development of the model closure

Computable general equilibrium models such as the one specified are very large and contain a number of equations and variables. For the model to be valid, the number of endogenous variables must equal to the number of equations. This is achieved by treating the variables that are not explained by the equations in the model as exogenous. A choice of which variables to be made exogenous versus endogenous is called the “model closure”. The selection of the exogenous variables is determined by the economic environment in which the model is run and the time frame (short-run versus long-run) under which economic variables are allowed to adjust to a new equilibrium after the shock. The time frame assumption determines how different factor markets such as labour and capital are modelled. For our analysis we assume both the short-run and long-run closure.

For the long-run, from the income side of GDP, labour supply /aggregate employment and the gross rate of return on capital is exogenised. Consequently, capital stock at aggregate industry levels is allowed to adjust so a fixed rate of return on capital is maintained and the real wages adjusts to reflect changes in demand for the fixed aggregate labour. By absorbing any demand-side pressure via changes in real wages, the labour market is allowed to clear.

From the expenditure side of GDP, we endogenise household consumption, government expenditure and imports. In order for these variables to become endogenous we exogenise the average propensity to consume (APC) and the ratio of private to public consumption (R_CG) and the import/domestic preference twist (TWS) variables with household consumption, investment expenditure, government expenditure as well as imports. Exports are also endogenised by fixing the technical change. The terms of trade is also made exogenous by making the export demand shifter endogenous. With regards to the monetary variables, the consumer price index remains exogenous in order for us order to determine the absolute price level in the model.

In the full model we impose budget neutrality for policy simulations involving government, that is, we allow no change to public sector debt as a result of the policy. To achieve this result, we let consumption taxes adjust to compensate for the change in government finances. Finally, all tax rate variables are exogenised and the tax rate on the sales of SSB can be shocked to determine the effect of such a shock on the South African economy.
Table 4.3 below is a summary of the policy closure for the long-run closure.

Table 4. 3: Long-run closure

Endogenous variables	Exogenous variables
Gross domestic product (GDP)	Employment (E)
Household consumption (C)	Rates of return (RoR)
Investment expenditure (I)	Average propensity to consume (APC)
Government expenditure (G)	Investment demand shifter (F_I)
Imports (M)	Ratio of private to public consumption (R_CG)
Real Wages (RW)	Technical change (A)
Capital Stock (K)	Exports (X)
Import/domestic preference twist (TWS)	Terms of trade (ToT)
Export demand shifter (F_X)	Consumer price index (CPI)
Ratio of investment to capital (R_IK)	
Domestic price index (PY)	

For the short-run, from the income side of GDP, aggregate employment and the gross rate of return on capital becomes endogenous whilst real wages becomes exogeneous. Capital stock at aggregate industry levels is exogenised to allow industry specific return on capital. From the expenditure side of GDP, we exogenise household consumption, government expenditure and exports. In order for these variables to become exogenous we endogenise the average propensity to consume (APC) and the ratio of private to public consumption (R_CG) and the import/domestic preference twist (TWS). Exports also become exogenous by allowing technical change to adjust. The terms of trade is also allowed to change by making the export demand shifter exogenous.

Table 4. 4: Short-run closure

Endogenous variables	Exogenous variables
Employment (E)	Real Wages (RW)
Rates of return (RoR)	Household consumption (C)
Average propensity to consume (APC)	Investment expenditure (I)
Investment demand shifter (F_I)	Government expenditure (G)
Ratio of private to public consumption (R_CG)	Capital Stock (K)
Technical change (A)	Import/domestic preference twist (TWS)
Terms of trade (ToT)	Export demand shifter (F_X)
Consumer price index (CPI)	Ratio of investment to capital (R_IK)
Imports (M)	Domestic price index (PY)
	Exports (X)

4.5 Conclusion

In this chapter, we described the theoretical structure, the database, model closure and the stylized approach for interpreting the results of the UPGEM model. The model that we use is a static CGE model of the South African economy whose theoretical foundations are based on the ORANI model. We constructed the model's database using 2017 as the base year. In the first section, we set out the basic input-output structure of the model database and described the key aggregates for the South African economy in the base year. We then described the model closures. The stylized model was also discussed in this chapter in order to help with interpretation of the results of the model in chapters that follow.

CHAPTER 5

THE IMPACT OF DIABETES ON THE SOUTH AFRICAN ECONOMY

Abstract

Diabetes is the second leading cause of mortality in South Africa. This paper provides a quantitative assessment of the economy-wide impact of diabetes in South Africa using a multi-sector Computable General Equilibrium (CGE) model of the South African economy. The simulation results indicate that the decrease in labour supply and productivity, and increased demand for health care services due to diabetes leads to negative economic outcomes. Our results indicate that diabetes reduces GDP by 0.64% from the baseline. The results of the simulation further show that all sectors tend to contract due to the impact of diabetes. These insights highlight the importance of using detailed models to study the economy-wide impact of diseases. This results allows stakeholders to recognise the importance of developing appropriate policy-level responses.

JEL classification: I12, I15

KEYWORDS: Diabetes, productivity, labour supply, employment

5.1 Introduction

Type II Diabetes Mellitus (diabetes) is one of the leading causes of morbidity and mortality worldwide (World Health Organization, 2018d). In 2012, diabetes was responsible for 3.7 million deaths in the world (World Health Organization, 2018a). In South Africa diabetes is the second leading cause of mortality (StatsSA, 2018a). In 2016, an estimated 9.8% of the population was living with the disease whilst six percent of all deaths were attributable to the disease. The prevalence of diabetes is reported to have grown from 4% in 2000 to 6.5% in 2011. The prevalence is expected to rise to approximately 30% in 2030 (International Diabetes Federation, 2013).

Diabetes and its complications has been shown to have an economic impact on people with diabetes and their families, and to health systems and national economies through direct medical costs and indirect costs (Sorensen et al., 2016). The indirect costs include lost productivity from mortality, morbidity and disability associated with diabetes and its complications. The World Health Organization predicts that lost work days, restricted activity days, lower productivity at work, mortality and permanent disability was responsible for net losses in national income from diabetes and cardiovascular disease of ID557.7 billion in China, ID303.2 billion in the Russian Federation, ID236.6 billion in India, ID49.2 billion in Brazil and ID2.5 billion in Tanzania between the years 2005 and 2015 (World Health Organization, 2005).

The direct cost for treating diabetes is also significant. In South Africa, the national economic burden was estimated to be 865,095 USD in 2011 (Zhang et al., 2010). According to a report by the Council for Medical Schemes, diabetes is one of the top conditions to treat with treatment expenditure amounting to approximately 915 USD (approx. R11,000) per patient per month in the private sector (Council for Medical Schemes, 2015). In 2018, the total direct cost for patient with treated for diabetes were estimated at over R2.7 billion (Erzse *et al.*, 2019). It is estimated that the expenditure will rise by 30-34% in 2030 in developing countries. These costs will amount to between 1.1 to 2.0 billion USD in 2030 (Zhang et al., 2010).

The high prevalence of diabetes is concerning, given that healthy workers are an important economic asset for any nation. When people cannot work due to serious health problems, they cannot fully support their families, let alone nation, because they do not generate economic output or pay taxes on earnings. Moreover, when people are healthy, the government incurs smaller health-related public expenditures. The associated opportunity cost can easily be viewed through the lens of increased investment in other critical areas such as education or infrastructure, both of which will further enhance overall economic productivity.

Over the years a number of studies have investigated the impact of diabetes on the economy. The vast majority of the literature on the economic impact of diabetes focuses on the direct impact such as consultations, hospitalisation and cost of medication and the indirect impact associated with absenteeism and mortality. Seuring et al., (2015) conducted a literature review on the cost of diabetes and found that approximately half of the studies reviewed estimated both the overall direct and indirect costs of diabetes. These studies make use of microeconomic models to analyse the impact at individual levels. Amongst the reviewed studies, the authors further find that the societal perspective was the most commonly used method followed by the healthcare system and third-party payer perspective. In addition, most of the studies reviewed employed a retrospective and prevalence-based study design. Whilst these studies attempt to show the direct and indirect impact of diabetes, one notable limitation in the literature is the lack of consideration of economy-wide impacts.

In this paper, we examine how diabetes mellitus impacts the economy through loss in labour supply, productivity, and increased government demand for health care. At the household level, diabetes has been shown to have a negative impact on labour productivity through presenteeism, absenteeism and mortality due to diabetes and its complications (Seuring & Archangelidi, et al., 2015). At the firm level, productivity costs include the loss of earnings from mortality, morbidity and disability associated with diabetes and its complications. At the government level, diabetes has also been shown to increase health care expenditure due to increased demand for health care services (World Health Organization, 2009). We therefore estimate how key economic variables such as GDP, consumption, wage rates and the consumer price index change as labour productivity and demand for health care changes, as a result of diabetes. To conduct our quantitative analysis, we use a comparative-static multi-sector general equilibrium model (CGE) to investigate the long-term effects of diabetes on the South African economy. Three different scenarios are modelled simultaneously: a four percent decrease in labour supply, a one percent decrease in labour productivity and a one percent increase in government expenditure.

Our study contributes to the body of literature in several ways. The first contribution is in the use of a detailed general equilibrium model to quantify the economic burden of diabetes. Most studies on the cost of diabetes employ microeconomic or partial equilibrium models to estimate the economic burden of the disease. Such models however do not investigate the effects of the disease on other sectors of the economy. Our analysis shows how diabetes affects the different sectors of the economy as well as other macroeconomic variables. We achieve this using the CGE methodology which can show the economy-wide shocks of diabetes.

Our second contribution relates to the policy shocks that we are investigating. Most studies on the cost of diabetes measure only the direct impact of diabetes on the economy. Even for studies that measure both the direct and indirect impact of the disease, the use of microeconomic models limits their analysis to individual levels. For our analysis, we investigate the indirect cost of diabetes at the macroeconomic level through reduced labour supply and productivity and directly through increased demand for healthcare services. Our analysis contributes to the literature by showing how the direct and indirect costs of diabetes affects the different sectors of the economy.

Thirdly, most macroeconomic studies on the economic impact of diabetes are undertaken in developed or upper-middle income countries. This is despite the fact that diabetes affects mostly the working population in lower and middle-income countries in the African content (Mutyambizi *et al.*, 2018). Given the high prevalence of diabetes and the amount spent on healthcare in South Africa, policy makers are likely to have an interest in the impact of the disease on the economy. Our analysis will therefore present a picture of the potential economy-wide effects of the disease in a different setting where the epidemiological and economic profiles differ.

The rest of the paper is outlined as follows: section 5.2 describes the methodology that we use to estimate the impact of diabetes. The results of the analysis are presented in section 5.3 whilst section 5.4 discusses the findings and concludes.

5.2 Model and methodology

5.2.1 Economic Model

We use a modified version of the University of Pretoria General Equilibrium Model (UPGEM) documented in Horridge (2000) and Bohlmann et al. (2015) for the analysis. For this study, we use a comparative-static version of the model. UPGEM is a multi-sector model that assumes a perfectly competitive economy with constant returns to scale, cost minimisation for industries and utility maximisation for households, and continuous market clearance. In addition, zero profit conditions are assumed for all industries in the long-run.

The model also allows each sector to produce several commodities, starting with composite labour which is a CES aggregate of occupational labour types. Capital, labour and land are combined together using constant elasticity of substitution production function (CES) to produce composite primary factors. Domestic goods and the imported equivalent are combined to produce commodity composite. Primary-factor composite, commodity composites, and 'other costs' are combined using a Leontief production function to produce sector output. All industries in the model share this common production structure, with input proportions and behavioural parameters varying between industries.

A linearised system of equations describes the theory underlying the behaviour of participants in the economy. This system of equations contains equations describing sector demands for primary factors and intermediate inputs; final household, investment, government and foreign demand for commodities; pricing in the economy which sets pure profits from all activities to zero; market clearing equations for various primary factors and commodities and miscellaneous or definitional items such as GDP, aggregate employment and the consumer price index (M Horridge, 2000).

5.2.2 Database

The model is calibrated through construction of a balanced database and evaluation of the coefficients and parameters that serves as the initial solution to the model. The database uses the official 2017 Supply Use Table (SUT) of South Africa, published by Statistics South Africa, as a starting point and initial solution to the model. The SUT originally distinguishes between 62 industries and 104 services. For this study, the 62 industries are aggregated to 42 industries (see Appendix C) while the 104 commodities are similarly aggregated to 42 commodities. The sugar sweetened beverage industry is maintained as a separate industry from the rest of food manufacturing. Each of the 42 industries is allowed to produce only one corresponding product. Eleven occupations are identified as labour inputs. Final users of commodities include investors, households, governments, and exporters. A single representative household and central government is assumed to simplify the implementation of the model.

5.2.3 Model closure

For the model to be valid, the number of endogenous variables must equal to the number of equations in the model. The selection of the exogenous variables is determined by the economic environment in which the model is run and the time frame (short-run versus long-run) under which economic variables are allowed to adjust to a new equilibrium after the shock. The time frame assumption determines how different factor markets such as labour and capital are modelled. For our analysis, we set up the UPGEM model's policy closure to reflect a long-run closure time horizon.

From the income side of GDP, labour supply /aggregate employment and the gross rate of return on capital is exogenous. Consequently, capital stock at aggregate industry levels is allowed to adjust so a fixed rate of return on capital is maintained. Real wages adjust since wage contracts are periodically renegotiated. By absorbing any demand-side pressure via changes in real wages, the labour market is allowed to clear. From the expenditure side of GDP, household consumption, government expenditure and imports are endogenous. The terms of trade is also made exogenous by making the export demand shifter endogenous. Exports are determined as a residual to balance GDP from the expenditure side with GDP from the income side.

5.2.4 Scenario

We design three different scenarios to capture the impact of diabetes on the economy. The impact of diabetes is modelled as (i) a reduction in employment, (ii) a reduction in labour productivity and (iii) an increase in demand and subsequent provision for healthcare services by government. To portray a complete picture of the impacts of diabetes on the economy, we first run the simulations individually.

Table 5. 1: Simulation scenarios

Scenario	**Specification of shocks**	**Variable**	**Reference**
(i) Reduction in employment due to diabetes mortality	0.1 %	Employment (employ_i)	
(ii) Reduction in productivity due to absenteeism	0.6 %	Labour-augmenting technical change (a1lab_o)	(Bommer *et al.*, 2017)
(iii) Increase in demand for health care due to diabetes	1.6 %	Household consumption shift (a3_s)	(Erzse *et al.*, 2019)

Notes: This table shows the different scenarios that were modelled and the magnitude of the shocks that were applied to the different variables.

5.2.4.1 Decrease in employment

Our first scenario captures the effect of diabetes on the economy through reduction in employment. Diabetes is one of the leading causes of mortality in South Africa. Poor health or mortality has a negative impact on the economy through reduction in labour supply. Diabetes has been shown to affect the working age population. In 2017, more than 37 million South Africans formed part of the working-age population. In the same year, more than 22 million individuals formed part of the labour force. Mortality due to diabetes was estimated at 25 336. Given that diabetes affects the working age population we assume that the labour force will decrease by 25 336. This therefore results in a 0.1[2] percent decrease in the labour force. We then assume that since the employment rate has been stagnant in South Africa, the

[2] Labour force without diabetes: (16127 + 6177)/37485 = 0.595011338
Labour force with diabetes: (16127 + 6177)/37459 = 0.595424331
Change in labour force=0.1

decrease in the labour force will decrease employment probability by the same rate. The impact of diabetes on employment is therefore introduced in the model as an exogenous shock to the aggregate employment variable (employ_i). Based on this estimates employment in the model is assumed to decrease by 0.1 % per annum. Similar estimates are shown in chapter 3 where diabetes is shown to decrease the employment probabilities by 0.05 and 0.04 (average 0.1) for male and female, respectively.

Table 5. 2: **Labour market overview**

Labour Market Aggregates (Thousands)	**2015 (Q2)**	**2016 (Q2)**	**2017(Q2)**
Working Age Population	36 224	36 875	37 485
Employment	15 685	15 585	16 127
Unemployment	5 231	5 635	6 177
Labour force	20 917	21 220	22 305

5.2.4.2 Decrease in labour productivity

Literature on health and human capital shows a positive relationship between health and worker productivity. The second scenario captures the effect of diabetes on the economy when labour productivity is reduced due to diabetes. We model the impact on labour productivity because diabetes has been shown to have an impact on reduced number of days at work due to illness. The labour productivity shock is introduced in the model via the factor-specific productivity equation. We therefore impose an annual reduction in labour productivity due to diabetes. Based on findings by Bommer *et al.*, (2017) diabetes prevalence is assumed to decrease labour productivity by 0.6% in low and middle income countries. The shock is therefore introduced in the model as a 0.6% decrease in labour productivity to all industries.

5.2.4.3 Increase in demand for healthcare

The third scenario is the impact of diabetes on the economy through increased demand for health care. Diabetes is a chronic illness that requires long-term healthcare and hospitalisation for complications. South Africa currently spends approximately 14% of government expenditure on health care. In 2017, approximately R170 billion was allocated to healthcare. According to Saxena et.al (2019), diabetes cost the South African government R2.7 billion. We therefore introduced as an annual increase of 1.6%[3] in government demand for health care. The shocks to government demand for health indicates that health care expenditure increase as the prevalence of diabetes increases.

5.2.4.4 Sensitivity analysis

We further conduct a sensitivity analysis to test if the model is robust enough to changes in the input parameters. We test the model using the capital-labour substitution elasticity. In CGE modelling, the capital-labour substitution elasticities are important for determining the sensitivity of industry's demand for capital and labour when there are changes in their relative prices. An elasticity of 0.3 is used in our baseline. To test the sensitivity of our model to changes in elasticity levels we conduct two simulations. Based on the literature, for the first simulation we simulate capital-labour substitution of 0.6. In the second simulation we simulate a labour substitution elasticity of 0.15 (De Wet, 2003).

5.3 Results

The results of the impact of diabetes are interpreted in this section. The results are interpreted using the BOTE model discussed in chapter 4. According to Adams, (2005), interpretation is concerned with explaining in a logical sequence the projections from a model. The effects on macroeconomic variables such as gross domestic product, consumer price index and household consumption are presented first. This is followed by sectoral level results which show how different sectors perform when the effects of diabetes are modelled.

5.3.1 Macroeconomic impact

The results of the main macroeconomic variables are presented in table 5.3. The analysis shows that reduction in labour supply, productivity, and increased demand for health care due to diabetes have a negative impact on the economy of South Africa. The decrease in labour supply due to diabetes increases the real price of labour which increases real wages[4]. The increase in the real price of labour relative to the real price of capital cause an increase

[3] Demand increase = R2.7 billion/R170 billion; = 1.6%

[4] RW = f (K/L, TofT, A)

in the capital intensity of the economy and a decrease in the labour intensity of the economy. The decrease in the variable factor of production consequently result in a decline in gross domestic product at factor costs[5]. These results could explain the 0.64% decrease in GDP relative to the baseline when all scenarios are run simultaneously.

Table 5. 3: Results of the main macroeconomic variables.

Variables	Decreased Labour supply	Decreased Productivity	Increased Government demand	Total impact
Consumer price index (CPI)	0.02	0.10	0.00	0.12
Real Wages	0.02	-0.48	0.00	-0.46
Terms of Trade	0.02	0.12	0.00	0.14
Real GDP	-0.10	-0.58	-0.01	-0.64
Household Consumption	-0.09	-0.54	-0.00	-0.73
Investment	-0.10	-0.57	-0.02	-0.68
Export volume	-0.08	-0.48	-0.01	-0.57
Import volume	-0.06	-0.36	-0.01	-0.43

On the expenditure side, diminished productivity and labour supply increases the aggregate price level and thus reduce aggregate real household consumption. Furthermore, reduction in productivity results in less exports and imports which weakens trade thereby diminishing the balance of trade. The decrease in net exports volume is from higher export prices and a real appreciation of the exchange rate leading to an increase in the trade balance. The consumer price index increases as the price of locally produced goods increases due to diminished productivity and labour[6]. The decline in exports, household consumption and investment could explain the reduction in GDP from the expenditure side[7].

5.3.2 *Sectoral impact*

Table 5.4 shows the percentage changes in sector outputs in response to the different scenarios. The results of the simulation show that all sectors tend to contract due to the impact of diabetes on labour supply, productivity, and demand for healthcare expenditure. Decrease in labour productivity is shown to have the highest impact on sector output as

[5] GDP = A*f (K, L)
[6] CPI = f (PY, TofT)
[7] GDP = C + I + G + (X-M)

Table 5. 4: Results of the impact of diabetes on sector output.

Sector	Decreased labour supply	Decreased Productivity	Increased Government demand	Total Output
1 Field crop	-0.16	-0.49	-0.02	-0.59
2 Fruit and veg	-0.17	-0.50	-0.02	-0.60
3 Livestock	-0.18	-0.54	-0.02	-0.65
4 Forestry	-0.20	-0.59	-0.02	-0.71
5 Fishing	-0.18	-0.54	-0.02	-0.65
6 Coal	-0.17	-0.51	-0.02	-0.61
7 Metal ore	-0.18	-0.53	-0.01	-0.63
8 Other mining	-0.19	-0.58	-0.02	-0.69
9 Meat	-0.19	-0.56	-0.02	-0.68
10 Dairy	-0.17	-0.50	-0.02	-0.60
11 Grain	-0.19	-0.55	-0.02	-0.67
12 Bakery	-0.18	-0.54	-0.02	-0.65
13 Sugar	-0.18	-0.55	-0.02	-0.66
14 Cocoa	-0.20	-0.59	-0.02	-0.71
15 Other food	-0.19	-0.58	-0.02	-0.69
16 Beverage	-0.18	-0.54	-0.02	-0.65
17 Soft drink	-0.19	-0.57	-0.02	-0.68
18 Tobacco	-0.18	-0.54	-0.02	-0.65
19 Textile and footwear	-0.21	-0.62	-0.02	-0.75
20 Wood and paper	-0.21	-0.61	-0.02	-0.73
21 Petroleum and refinery	-0.18	-0.55	-0.02	-0.65
22 Other chemical	-0.22	-0.65	-0.02	-0.77
23 Non-metal	-0.21	-0.61	-0.02	-0.73
24 Iron steel	-0.21	-0.63	-0.02	-0.75
25 Electrical machinery	-0.23	-0.70	-0.02	-0.84
26 Radio and Television	-0.26	-0.79	-0.02	-0.93
27 Transport equipment	-0.21	-0.62	-0.02	-0.74
28 Other manufacturing	-0.21	-0.63	-0.02	-0.76
29 Electricity and gas	-0.19	-0.57	-0.02	-0.68
30 Water	-0.19	-0.56	-0.02	-0.67
31 Construction	-0.19	-0.57	-0.02	-0.68
32 Trade	-0.21	-0.63	-0.02	-0.75
33 Accommodation	-0.21	-0.62	-0.02	-0.74
34 Transport services	-0.20	-0.58	-0.02	-0.70
35 Post and communication	-0.21	-0.62	-0.01	-0.74
36 Finance	-0.20	-0.59	-0.02	-0.71
37 Real estate	-0.19	-0.57	-0.02	-0.68
38 Other business	-0.21	-0.61	-0.01	-0.73
39 General government	-0.18	-1.08	0.05	-0.59
40 Education	-0.19	-1.12	-0.02	-0.68
41 Health	-0.19	-1.13	-0.02	-0.68
42 Other services	-0.20	-1.17	-0.02	-0.71

compared to the scenario whereby labour supply is decreased, and government demand is increased. General government, education, health, and other services sectors are shown to be the hardest hit when productivity is reduced.

5.3.3 Effects on household consumption

The increase in the prevalence of diabetes will have disproportionate impact on those who are sick and need access to health care services. The result of the simulation show that household basic demand decreases with the decrease in labour supply and productivity. Real household consumption records a decline of 0.09% and 0.54% for the decreased labour supply and decreased productivity scenarios, underscoring the welfare impact of diabetes on households. The decline in household is slightly less than that of real GDP because the potential decline in household consumption was bettered by gains in the terms of trade of 0.14% when all scenarios are modelled simultaneously. This is also due to the ability of households to substitute between domestically produced output with less priced imported versions. The interaction of this income and substitution effect is highlighted by the result for aggregate import volumes which declines by 0.43% relative to the baseline. The terms of trade improve due to the increase of domestic prices, resulting in a decline in export volume by 0.57%.

With real GDP and consumption falling by between 0.64% and 0.73% respectively, our prediction is that imports should also fall by approximately the same amount to reflect the impact of diabetes in weakening domestic demand. The net results however show a fall in imports by 0.43% mainly due to household and sector demands switching away from expensive domestic goods to cheaper versions as predicted by Armington nests in the theoretical structure of industry and household demand.

5.3.4 Decomposition analysis

The results of the Fan decomposition analysis of the impact of diabetes (all scenarios) on sector output are presented in table 5.5. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share, and export effect to industry-level output change. The local market contribution largely explains the reduction in overall

Table 5. 5: Effects of diabetes on the shares of industry output.

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.54	-0.01	-0.04	-0.59
2 Fruit and veg	-0.53	-0.01	-0.06	-0.60
3 Livestock	-0.64	-0.00	-0.01	-0.65
4 Forestry	-0.70	-0.00	-0.01	-0.71
5 Fishing	-0.52	-0.00	-0.12	-0.65
6 Coal	-0.38	-0.01	-0.22	-0.61
7 Metal ore	-0.12	-0.00	-0.51	-0.63
8 Other mining	-0.19	-0.09	-0.41	-0.69
9 Meat	-0.54	-0.06	-0.08	-0.68
10 Dairy	-0.55	-0.01	-0.05	-0.60
11 Grain	-0.59	-0.03	-0.05	-0.67
12 Bakery	-0.64	-0.00	-0.00	-0.65
13 Sugar	-0.60	-0.02	-0.04	-0.66
14 Cocoa	-0.63	-0.06	-0.02	-0.71
15 Other food	-0.52	-0.06	-0.11	-0.69
16 Beverage	-0.45	-0.01	-0.18	-0.65
17 Soft drink	-0.59	-0.01	-0.08	-0.68
18 Tobacco	-0.47	-0.03	-0.16	-0.65
19 Textile and footwear	-0.52	-0.12	-0.10	-0.75
20 Wood and paper	-0.63	-0.04	-0.06	-0.73
21 Petroleum and refinery	-0.51	-0.07	-0.07	-0.65
22 Other chemical	-0.50	-0.13	-0.14	-0.77
23 Non-metal	-0.63	-0.08	-0.03	-0.73
24 Iron steel	-0.41	-0.12	-0.21	-0.75
25 Electrical machinery	-0.61	-0.19	-0.03	-0.84
26 Radio and Television	-0.61	-0.27	-0.06	-0.93
27 Transport equipment	-0.45	-0.15	-0.14	-0.74
28 Other manufacturing	-0.47	-0.11	-0.17	-0.76
29 Electricity and gas	-0.67	-0.00	-0.01	-0.68
30 Water	-0.67	0.00	-0.00	-0.67
31 Construction	-0.68	-0.00	-0.00	-0.68
32 Trade	-0.72	-0.00	-0.02	-0.75
33 Accommodation	-0.55	-0.09	-0.09	-0.74
34 Transport services	-0.57	-0.04	-0.09	-0.70
35 Post and communication	-0.64	-0.06	-0.04	-0.74
36 Finance	-0.67	-0.01	-0.03	-0.71
37 Real estate	-0.67	-0.00	-0.01	-0.68
38 Other business	-0.65	-0.03	-0.05	-0.73
39 General government	-0.59	-0.00	0.00	-0.59
40 Education	-0.68	-0.00	0.00	-0.68
41 Health	-0.65	-0.01	-0.02	-0.68
42 Other services	-0.63	-0.03	-0.06	-0.71

Notes: Fan decomposition analysis when all scenarios are modelled together.

output for all the sectors while the domestic share effect explains a shift from the imported to the domestically produced. The results of the analysis show that diabetes, has a negative impact on overall output in all sectors of the economy. The results show a decline in all sectors when all the scenarios are modelled simultaneously. In terms of a shift from the usage of local output from domestic to imported, the analysis shows that diabetes induces a decline in the usage of now relatively more expensive local output, thereby increasing the imported share of commodities used. The demand for locally produced output declines, with the largest decline being for the radio & television output when all scenarios are run simultaneously. This is partially explained by the cost of the intermediate radio and TV inputs as well as output declines which the radio & television and manufacturing sector has to content within the production of its final outputs. Results of the other scenarios are presented in appendix for chapter 5.

5.3.4 Sensitivity analysis

Results of the sensitivity analysis are shown in table 5.7. The analysis shows that the use of high elasticity of substitution for the primary factors of productions increases GDP from the expenditure side even when employment and productivity are decreased. When the elasticities are reduced, the results are similar to that of the baseline. The results of the sensitivity analysis are intuitive as one would expect that with high elasticities industries would move away from labour to other factors of production as labour becomes more expensive relative to the other primary inputs. With low elasticity level, real GDP would decrease as labour decreases. The analysis therefore shows that the model is sensitive to changes in input parameters.

Table 5. 6: Sensitivity analysis: impact of different capital-labour substitution elasticities on key macroeconomic variables

Variables	High elasticities	Low elasticities
Consumer price index (CPI)	-0.26	0.12
Real Wages	1.89	-0.46
Terms of Trade	-0.20	0.14
Real GDP	1.12	-0.68
Household Consumption	1.21	-0.64
Investment	0.40	-0.68
Exports volume	0.83	-0.57
Imports volume	0.61	-0.43

5.4 Conclusion

Diabetes is the second leading cause of mortality in South Africa and a serious socio-economic concern. The main objective of this paper was to evaluate the economy-wide impact of diabetes in South Africa. Using a computable general equilibrium model, we estimate the impact through productivity loss, labour supply and increase in demand for health care services. We run three simulations based on previous studies that have assessed the impact of diabetes on the different economic and health outcomes.

In scenario 1 we assume that mortality due to diabetes will reduce labour supply. We find in our analysis that when labour supply is reduced, household consumption is negatively affected whilst real wages increase. When real wages increase the cost of domestic production and, hence, domestic price levels increase. Higher domestic prices decrease demand for exports and import-competing domestic goods at the initial real exchange rate. The consumer price index also increases to reflect the increase in domestic prices. The fall in level of exports and household consumption result in a 0.10% reduction in GDP relative to the baseline.

In scenario 2 we simulated a 0.6% productivity loss due to diabetes. We find in the analysis that reduction in labour productivity reduces household consumption, investment and ultimately GDP by 0.58% relative to the baseline. The decrease in outputs results in lower real wages. CPI also increases to reflect the increase in the cost of production. When increased demand for government services is simulated in scenario 3, similar trends of less magnitude are shown observed. When all scenarios are modelled simultaneously, GDP is shown to decrease by 0.64%. Furthermore, investment, household consumption and trade are negatively affected by the prevalence of diabetes. Furthermore, all sectoral outputs decrease due to reduced productivity and labour supply.

This study shows that diabetes has a negative effect on the economy of South Africa. The results indicate that reduced labour supply due to diabetes has the highest impact on the economy that results in approximately 0.64 % reduction in GDP. In recent years, a number of studies have shown the direct cost of diabetes in low- and middle-income countries (Seuring, Archangelidi and Suhrcke, 2015). In South Africa Erzse *et al.*, (2019) estimates this cost to be approximately R2.7 billion in the public sector. Whilst a number of studies have shown the direct cost of diabetes, few have shown the economy-wide impact of diabetes.

The results of this study indicate the importance of using macroeconomic models to capture the 'ripple effect' of events through different sectors. Whilst several studies have shown the economic impact of diabetes, the use of traditional economic evaluation (human capital approach) limits the impact to individual level as these models work within a partial equilibrium framework. These models work under the premise that changes within a sector can be isolated from other sectors, and thus, results in analysis that is limited. Macro-based studies such as the CGE model have greater sectoral specificity and sensitivity and so complement the forms of analysis as presented here. Moreover, the results from this study present critical lessons on the impact of chronic diseases. The results show that diabetes is not just a health issue but also an economic issue that generates massive economic loss through reduced labour supply, productivity, and increased demand for health care. The analysis shows how the indirect consequences of diabetes can have massive impact on the economy. This paper further illustrates the value of considering the economy-wide impacts of diseases on a country.

CHAPTER 6

ECONOMIC EFFECTS OF SUGAR-SWEETENED BEVERAGES TAXES IN SOUTH AFRICA

Abstract

The consumption of sugar-sweetened beverages has risen sharply in South Africa over the past few years. Current research shows that sugar-sweetened beverages increase the prevalence of obesity, which is a risk factor for diabetes. We estimate the short-run and long-run impact of a tax on sugar-sweetened beverages on the economy using a computable general equilibrium model. Three different scenarios are modelled: a 10% increase in sugar sweetened beverage tax, a 0.04% increase in labour supply, and a 1.2% reduction in government expenditure. When a 10% sugar tax is modelled in isolation, the analysis shows that the tax will reduce GDP by 0.01% in the short-run. However, the impact is reversed when the derived benefits are modelled simultaneously with the tax. The analysis therefore shows the importance of modelling the impact of policy changes together with the expected changes that might occur due to the policy change.

JEL classification: I12, I15

KEYWORDS: Computable general equilibrium, sugar-sweetened beverages, productivity, tax

6.1 Introduction

The South African government has adopted a policy to tax sugar-sweetened beverages (SSBs). The policy came into effect from the 1st of April 2018. The rationale for the taxation is that the increase in the price of the SSBs will deter consumers from purchasing these beverages and therefore reduce consumption of sugar. Consumption of sugar-sweetened beverages in South Africa has increased over the past few years. Consumption of SSB increased by 69 % between the years 1999 and 2012 (Ronquest-Ross et al., 2015). According to Euromonitor, off-trade sales of soft drinks grew from 3 620 in 2008 to 4 206 million liters in 2013 (Euromonitor, 2013).

The consumption of sugar-sweetened beverages has been linked to non-communicable diseases such as type II diabetes and metabolic syndrome (V S Malik *et al.*, 2010; Basu *et al.*, 2014). The number of new cases and the prevalence of diabetes have been steadily increasing over the past decades (Murray *et al.*, 2012). According to the World Health Organization, in 2012, diabetes was responsible for 3.7 million deaths in the world, 2.2 million of these deaths were caused by cardiovascular diseases and other diseases attributable to diabetes (World Health Organization, 2016).

The link between the increase in the consumption of sugar-sweetened beverages and obesity which is a risk factor for diabetes and metabolic syndrome has resulted in governments world-wide to consider taxing sugar-sweetened beverage (Jou and Techakehakij, 2012). The introduction of the tax is seen as a way of influencing consumption behaviour which might result in long-term health benefits (Wright et al., 2017). Furthermore, the revenue generated from the tax can be used to subside healthier alternatives and educational programs (Franck, Grandi and Eisenberg, 2013).

The rationale for the taxation is that the increase in the price of the SSBs will deter consumers from purchasing these beverages. It is envisaged that the proposed increase in tax on these beverages will result in an increase in average price of SSB and therefore reduce consumption. A reduced consumption will result in lower daily caloric intake and therefore lower obesity which will in turn lower incidences of Type II diabetes. Lowered incidences of type II diabetes will result in a health work force which will increase productivity. The tax is also seen as a mechanism to increase government revenue.

Allcott, Lockwood and Taubinsky, (2019) argue that taxing SSB is favourable when the tax is able to counteract externalities and internalities due to the consumptions of the SSB and when the tax is not regressive. With regards to the SSB tax, proponents for the tax argue that many consumers are not aware of the link between consumption of these beverages and the health and financial consequences of consuming these beverages (Griffith, O'Connell and Smith, 2018). This imperfect information is further distorted by extensive marketing campaigns that advertise the benefits of consuming sugar-sweetened beverages. Financial "externalities" are also a motivation for taxing sugar-sweetened beverages because non-communicable diseases which are mostly chronic in nature are costly to treat which places a burden on the health care system.

Whilst SSBs taxes have been advocated for a means to reduce consumption and the prevalence of non-communicable diseases, the counterargument is that such taxes are regressive and will impact negatively on the poor as the low-income group spend a high percentage of their income on food (Nnoaham *et al.*, 2009). Furthermore, the SSB industry has argued that the SSB taxes will result in reductions in employment in the SSB sector and other relevant sectors (BEVSA, 2017). Research however shows that low-income populations consume less healthy food than high-income populations and therefore are at higher risk of obesity and chronic NCDs (Kim and Kawachi, 2006). Advocates of the use of SSB taxes argue that taxes are efficient instruments not only for reducing sugar consumption but for generating revenue that could benefit the economy (Roache and Gostin, 2017).

In the past few years, a number of studies have demonstrated that increased taxes can reduce the consumption of sugar-sweetened beverages and the prevalence of obesity (Andreyeva et al., 2011; Manyema et al., 2015). Whilst these studies have shown the impact of sugar-sweetened beverages on health, measures to introduce taxes faces opposition as these taxes could have negative impact on the economy. Opponents to these taxes argue that such taxes will have a negative impact to the economy through reduction in employment. Currently, few studies have shown the economy-wide effects of introducing the sugar sweetened beverage taxes. For South Africa, Theron, Rossouw and Fourie, (2016) have analysed the impact of the tax using a dynamic computable general equilibrium model.

We build on previous research by investigating the impact of the current 10% SSB tax on the South African economy using a static model. The static model has been used extensively in the other fields to measure the impact of a policy change on the economy (Oh, Yoo and Kim, 2020). Our choice of model is based on the ability of the static model to specify changes in only the exogenous variable of interest whilst the dynamic model requires specifying changes in all exogenous variables (Mark Horridge, 2000). Furthermore, our analysis differ from Theron, Rossouw and Fourie, (2016) who model chances in own-price elasticities whilst we model tax change to the SSB industry.

The current study therefore contributes to the literature in several ways. Firstly, this study shows how the sugar-sweetened beverages taxes will impact real household consumption and macroeconomic variables such as employment, consumption, and real wages in the short-run using a static model. Secondly, we show the impact of the tax on different households. We achieve this by disaggregating households into four categories ranging from the poor to the rich.

In addition to modelling the economic impact of the taxes, we model the impact of an increase in labour supply and productivity and a reduction in health care expenditure due to the impact of the tax in the long-run. The adverse effects of sugar-sweetened beverages have become central to the debate on its impact on health, however, the policy discussions do not seem to be paying much attention to the long-term impact of sugar-sweetened beverages on the economy. In fact, most of the existing studies on sugar-sweetened beverages have focused mostly on the health impact. This is so even though sugar sweetened beverage industry contributes over 16 billion to the South African economy (BEVSA, 2017). This study shows the economy-wide impact of the policy change.

We include this analysis because the demand for SSB has been shown to be sufficiently price elastic such that a significant reduction in consumption may result from a tax (Stacey, Tugendhaft and Hofman, 2017). Furthermore, current studies show that the sugar taxes will reduce consumption of sugar-sweetened beverages which will in turn reduce obesity which is a risk factor for diabetes (Manyema *et al.*, 2015). We therefore assume that decreasing the prevalence of diabetes will increase labour supply and a productivity. We also model the impact of the policy change on health care expenditure since government spends a significant amount of health expenditure on diabetes. We therefore assume that the decrease in diabetes will also reduce government demand for health care. The second contribution is therefore in modelling the expected changes in the economy due to the reduction in diabetes subsequent to the introduction of the SSB tax.

For our analysis, we use a general equilibrium model to investigates the short-run and long-run effects of the proposed sugar sweetened beverage tax on SSB consumption, employment in the SSB sector and related sectors as well as the impact on other macroeconomic variables. Four different scenarios are modelled: a 10 percent increase in sugar sweetened beverage tax, a 0.05 percent increase in labour supply, a 0.2 percent increase in labour productivity and a 1.2 percent reduction in government expenditure.

The remainder of the paper is organised as follows; section 6.2 reviews the literature, section 6.3 outlines the model and method of analysis, section 6.4 presents the simulation scenarios, section 6.5 discusses the simulation results with special reference to the macro-economy, industrial sectors and households. Concluding remarks are made in Section 6.6.

6.2 Previous studies

In the past few years, a number of studies have demonstrated that increased taxes can reduce the consumption of sugar-sweetened beverages and the prevalence of obesity (Andreyeva et al., 2011; Manyema et al., 2015). Whilst these studies have shown the impact of sugar-sweetened beverages on health, measures to introduce taxes faces opposition as these taxes could have negative impact on the economy. Opponents to these taxes argue that such taxes will have a negative impact to the economy through reduction in employment. Currently, few studies have shown the economy-wide effects of introducing the sugar sweetened beverage taxes. In this section we highlight the existing literature on the economic effects of the sugar sweetened beverage tax.

Andreyeva et al., (2011) use United States Census population projections from 2007 to 2015 to construct a model to project the impact of penny-per-ounce tax on beverage consumption and tax revenues. Their results showed that a national penny-per-ounce tax on sugar-sweetened beverages could generate new tax revenue of $79 billion between the years 2010 and 2015 and reduce daily per capita caloric intake from sugar-sweetened beverages from the current 190–200 calories to 145–150 calories.

In another study, Wang *et al.*, (2012) uses a state-transition computer model to evaluate the impact of a 1 cent per ounce tax on beverages sweetened with sweeteners such as sugar and syrup in New York. The study showed that an excise tax will generate tax revenue close to $1 billion each year for the State. For South Africa Manyema *et al.*, (2015), uses a proportional multi-state life table-based Markov model to estimate the effect of a 20% tax on Type II Diabetes. Their analysis shows that cumulatively over twenty years, approximately 21 000 adult death due to diabetes may be averted and over ZAR10 billion (USD 860 million) in healthcare expenditure could be saved.

For Australia, Basu *et al.*, (2017) uses a Markov cohort models to estimate the health impact of a SSB tax across different socioeconomic groups. Their study finds that a 20% tax would lead to gains in health adjusted life years and healthcare cost savings of AU$ 1, 733 million. In another study, Nomaguchi *et al.*, (2017) finds that an additional 20% tax on SSBs results into productivity gains of AU$751 million for the working-age population and reduction in healthcare costs of AU$425 million.

Chuc, (2014) uses a static computable general equilibrium model (CGE) model to study the impact of a 10% SSB taxes on the economy. The model predict that Government revenue will increase by 8.46 million while the soft drinks industry will have a revenue loss of USD 40.5 million. Other sectors are shown to have a reduction in revenue of about USD 12.1 million. The tax is also shown to have a negative impact on employment and income. The cost of running a system of excise tax collection was also one of the negative impacts recorded by the study. In South Africa, Theron, Rossouw and Fourie, (2016) have studied the impact of a SSB tax using a dynamic CGE model. For their analysis, a tax shock is applied using own-price elasticity levels. Using three different elasticity values, (-0.79, -0.97 and 1.30) to model the potential impact of the tax (equivalent to 25.1% increase in price in SSB sector) they find that increased prices due to the tax reduces GDP, employment and outputs in the SSB sector and other related sectors. Their study however does not consider the health benefits that might be derived from the introduction of the tax.

Whilst the above studies have investigated the effects of diabetes on the economy, the studies are limited in that they do not capture the subsequent health gains that might arise due to the imposition of the tax. Furthermore, these studies do not show how different household groups are affected by the tax. Our analysis employs a static CGE model to examine the economy-wide impact of the tax and the health benefits that might be accumulated as a result of the taxes. We further show the distributional impact of the tax among poor and rich households by analysing the short-term effects of the tax.

6.3 Model and methodology

6.3.1 Conceptual framework

Figure 6.1 depicts the conceptual framework for our analysis. We start by assuming that the increase in tax on the SSB beverages will result in an increase in average price of the beverages. In South Africa, Stacey, et.al has shown that SSBs are price elastic(Stacey, Tugendhaft and Hofman, 2017). Furthermore, Teng et.al (2019) has shown that a 10% SSB tax will reduce beverage purchases and dietary intake of about 10.0% (Teng *et al.*, 2019). We therefore assume that an increase in prices will result in a decrease in consumption. A reduced consumption will result in lower daily caloric intake and therefore lower obesity which will in turn lower medical costs because of the lowered incidences of Type II diabetes (Manyema *et al.*, 2015). Because diabetes reduces labour supply and productivity(Lavigne *et al.*, 2003; Krstovic-Spremo *et al.*, 2014; Magliano *et al.*, 2018), we assume that the reduction in the incidence of diabetes will also increase labour supply due to reduced mortality and morbidity.

6.3.2 Model

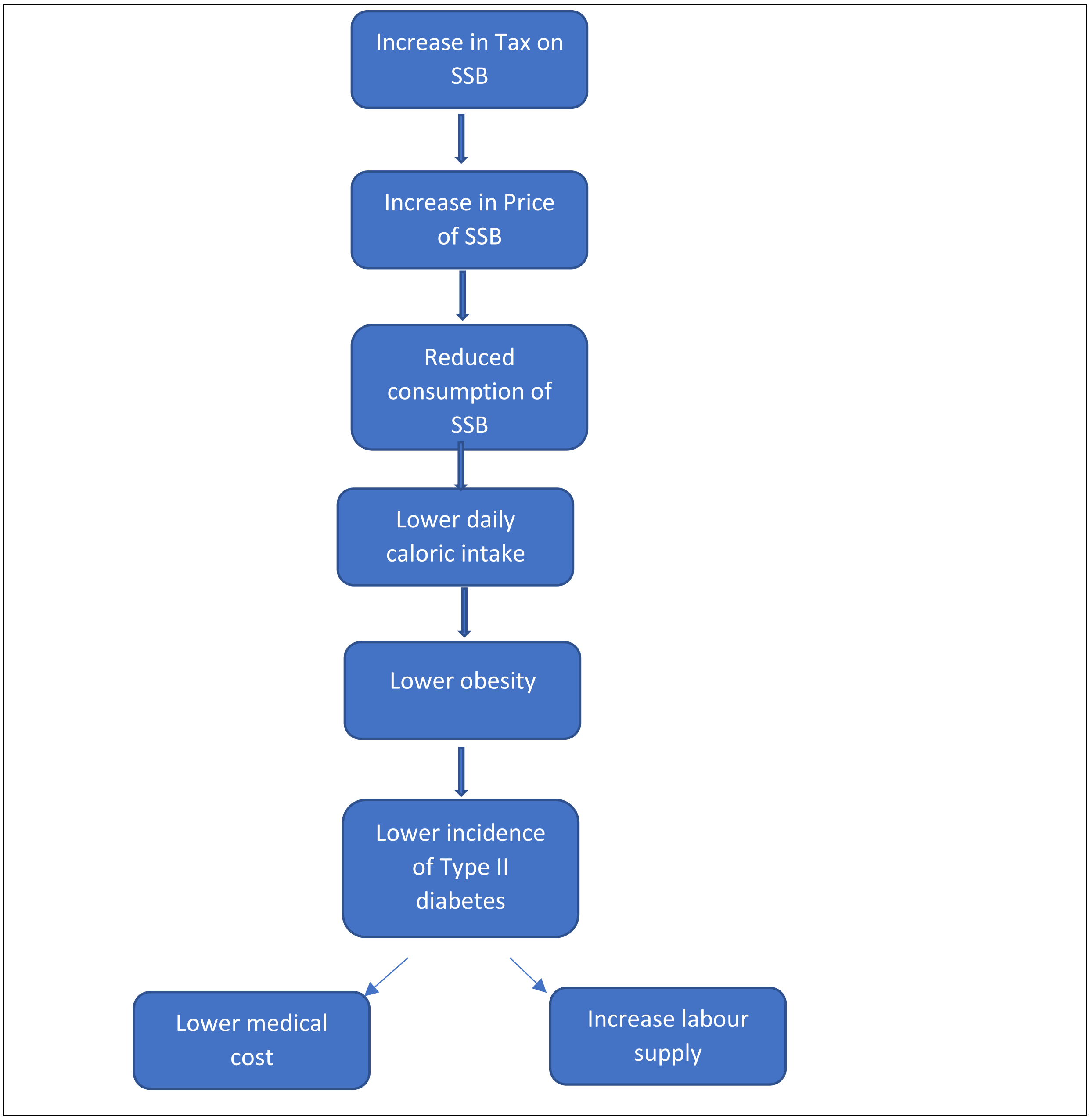
A modified version of the University of Pretoria General Equilibrium Model (UPGEM) was used for the analysis. UPGEM is a multi-sector model that also allows each sector to produce several commodities using eleven different types of labour, capital, and land. In this model, production of commodities starts with different types of labour that are combined by a constant elasticity of substitution (CES) production function. This is followed by the aggregation of labour, capital and land using CES to produce composite primary factors. Domestic goods and the imported equivalent are also combined using CES to produce commodity composite. Primary-factor composite, commodity composites, and 'other costs' are combined using a Leontief production function to produce sector output. A perfectly competitive economy with constant returns to scale, cost minimisation for industries and utility maximisation for households, and continuous market clearance are assumed. Zero profit conditions are also assumed for all industries.

Linearised system of equations are used to describe sector demands for primary factors and intermediate inputs; households, investment, government and foreign demand for commodities; pricing in the economy which sets pure profits from all activities to zero; market clearing equations for various primary factors and commodities and miscellaneous or definitional items such as GDP, aggregate employment and the consumer price index (M Horridge, 2000).

6.3.3 Database

The core database is constructed using the official 2017 supply use table of South Africa, published by Statistics South Africa. For the purposes of this analysis, the 62 industries and 104 services in the supply use table are aggregated to form 42 industries and 42 commodities. In addition, the beverage industry is disaggregated from the food industry to allow for the simulation of the tax policy. Each of the 42 industries are allowed to produce only one output. Eleven occupations are used as labour inputs. Final users of commodities include investors, households, governments, and exporters. For the short-run model, four household groups are identified ranging from poor to rich. A single central government is assumed to simplify the model.

Figure 6. 1: Conceptual framework for modelling the effects of the sugar-sweetened beverage tax on the economy.



6.3.4 Model closure

The model closure is informed by the economic environment in which the model is run and the time frame (short-run versus long-run) under which economic variables are allowed to adjust to a new equilibrium after the shock. For our analysis, we set up the UPGEM model's policy closure to reflect both the short-run and the long-run closure time horizon. Under the short-run, capital stock in each sector, aggregate investment, technological changes, GDP from the expenditure side and tax rates are exogenous whilst aggregate employment, return on capital and the trade balance are allowed to adjust. We also set the trade balance to be endogenous under the short-run.

Under the long-run labour supply and the gross rate of return on capital are exogenous. As a result, capital stock at aggregate industry levels is allowed to adjust so that a fixed rate of return on capital is maintained. Real wages adjust since wage contracts are periodically renegotiated. Consequently, the labour market is allowed to clear by absorbing any demand-side pressure via changes in real wages. From the expenditure side of GDP, household consumption, government expenditure and imports are fixed. The terms of trade is allowed to adjust by fixing the export demand shifter. Exports are determined as a residual to balance GDP from the expenditure side with GDP from the income side.

6.4 Simulations

Three different scenarios are simulated in this analysis to measure the effects of the sugar-sweetened beverages tax on the economy. The first simulation captures the impact of a SSB tax in the short-run. Simulation 2 and 3 captures the effects of reduction in diabetes after the implementation of the tax in the long-run. In the short-run, the tax scenario is simulated independently. In the long-run, the different scenarios are modelled simultaneously.

6.4.1 Sugar-sweetened beverages tax

The first shock simulates the introduction of a sugar sweetened beverage tax. The Ministry of Finance published a draft bill on "Rates and Monetary Amounts" which stipulates that sugar-sweetened beverages will be levied by 2.1c/gram of the sugar content that exceeds 4g/100ml. The shock is therefore introduced in the model as a 10%[8] increase in taxes to the sugar beverage industry. That is the sales tax on soft drinks is increased by 10%. This policy shock is calibrated to produce an increase in sugar sweetened beverage tax in South Africa in the short-run.

[8] National Treasury estimate that a 2,29c/gram = 20% tax increase; 2.2c will there equal to 10% tax increase.

Table 6. 1: Simulation scenarios

Scenario	Specification of shocks	Variable	Reference
Increase in SSB Tax	10%	General sales tax shifter *(f0tax_s)*	
Increase in labour supply	0.04%	Employment (employ_i)	(Saxena *et al.*, 2019a)
Reduction in demand for Health	1.2%	Household consumption shift (a3_s)	

6.4.2 Increase in employment

We assume that the probability of employment increases due to a decrease in morbidity and mortality after the tax is introduced. Employment is represented in the UPGEM model as a factor of production for each sector. The second shock that is simulated is an increase in employment due to a decrease in the prevalence of diabetes. According to Saxena *et al.*, 2019a) a 10% tax could avert 8000 diabetes related deaths. Since diabetes affects the working age population, we assume that the 8000 deaths are averted in the working age population. In 2017, 22 05 1070 individuals formed part of the labour force. Of this, 16 171 028 (73%) were employed. We therefore assume that as the labour force increases, employment probabilities will increase by the same rate. We therefore model this impact as an increase in employment by 0.04[9]%.

6.4.3 Decrease in Health care expenditure

South Africa spends about 8% of Gross Domestic Product (GDP) on health per annum. Healthcare expenditure accounts for approximately 14% of government expenditure. The International Diabetes Federation estimates that approximately 7% of health expenditure is spent on Diabetes. According to Erze, et.al (2019) approximately R2 billion healthcare costs could be saved due to an introduction of the SSB taxes over 20 years. The fourth shock that we simulate is a decrease in health care expenditure due to a decrease in the demand for diabetes healthcare services. The shock is therefore introduced in the model as a 1.2%[10] decrease in demand for healthcare by government in the long-run.

[9] Labour force= (2205970 (with tax) – 22051070(without tax))/22051070 = 0.04%
[10] Demand for healthcare= R2 billion/R170billion; = 1.2%

6.4.4 Sensitivity analysis

We further conduct sensitivity analysis to test the robustness of our model to changes in shocks and input parameters. We test the model's sensitivity to changes in different tax scenarios. We conduct two sensitivity analysis tests: a 20% SSB tax and a 5% SSB tax. The first simulation is therefore a 20% increase in SSB tax in the SSB industry. The increase is based on the initial studies which recommended an introduction of a 20% tax increase to the SSB industry (Manyema *et al.*, 2015). We therefore model this increase to illustrate the sensitivity of household demands to increase in the SSB tax. In addition, we test the sensitivity of the model to a 5% increase in the SSB tax.

6.5 Results

The results of the impact of sugar sweetened beverage tax simulation are interpreted in this section. We report on the results of the main macroeconomic variables, the effects on different sectors, the effects on households and the FAN decomposition.

6.5.1 Macroeconomic level

The main macroeconomic variables from the income and expenditure side of GDP are presented in table 6.2. The results of the analysis show that the impact of the sugar sweetened beverage tax on GDP is minimal in the short-run. With the imposition of the SSB tax, export prices rise relative to import prices, leading to an improvement in the terms of trade. The increase in the SSB tax, increase the aggregate price level and thus reduce household consumption and increase the consumer price index. The decrease in demand for goods decrease productivity levels which in turn result in a decline in real wages by 0.11 percent. The decline in household consumption, and level of exports contribute to the minimal reduction in GDP on the expenditure side[11].

[11] GDP = C + I + G + (X-M)

Table 6. 2: Results of main macroeconomic variables (% change deviation from BAU)

	Short-run	Long-run	
Variables	**10% Tax**	**10% Tax + employment**	**10% Tax + employment + health expenditure**
Consumer price index (CPI)	0.02	0.05	0.05
Real wage rate	-0.11	-0.19	-0.19
Terms of Trade	0.01	-0.00	-0.00
Real GDP	-0.01	0.02	0.02
Aggregate real investment	-	0.02	0.02
Consumption	-0.01	0.01	0.02
Export volume	-0.03	0.01	0.02
Import volumes	-0.04	0.01	0.01

BAU: business as usual

In the long-run the results of the SSB tax are offset by improvements in labour supply due to the decline in diabetes. As expected, the increase in employment in scenario 2 results in a decline in real wages. Household consumption increases due to more people being employed. From the expenditure side GDP also increases as a result of an increase in consumption, investments as well as the volume of exports. Similar results are observed when government demand for services is reduced due to reduction in demand for diabetes healthcare services. The tax however increases the price of locally produced goods which in turn increase the consumer price index[12].

6.5.2 *Effects on different sectors*

Table 6.3 shows the percentage changes in sector outputs in response to the SSB tax scenarios. The results of the simulation show that outputs tend to contract due to introduction of the SSB tax in selected sectors in the short-run. As can be expected the hardest hit sector is the soft-drinks sector which contracts by 3.18 percent. The accommodation sector also contracts followed by the sugar sector. The contraction in the accommodation sector is also expected as the sector is the biggest consumer of soft drinks. The sugar sector also contracts as the sugar sweetened beverage sector uses their inputs to produce the beverages.

[12] CPI = f (PY, TofT)

Table 6. 3: Short-run and long-run effects of SSB tax on different sectors

Sector	10% tax	10% Tax + employment	10% Tax + employment + health expenditure
1 Field crop	0.01	0.03	0.03
2 Fruit and veg	-0.01	-0.05	-0.04
3 Livestock	0.00	0.01	0.02
4 Forestry	0.02	0.06	0.06
5 Fishing	0.01	0.03	0.04
6 Coal	0.01	0.09	0.09
7 Metal ore	0.03	0.25	0.26
8 Other mining	0.02	0.19	0.19
9 Meat	0.01	0.00	0.01
10 Dairy	0.02	0.05	0.05
11 Grain	0.02	0.08	0.09
12 Bakery	0.01	0.02	0.03
13 Sugar	-0.13	-0.29	-0.29
14 Cocoa	-0.03	0.00	0.01
15 Other food	0.03	0.06	0.07
16 Beverage	0.04	0.12	0.13
17 Soft drink	-3.18	-5.06	-5.06
18 Tobacco	0.01	-0.23	-0.22
19 Textile and footwear	0.07	0.15	0.16
20 Wood and paper	0.02	0.05	0.06
21 Petroleum and refinery	0.02	0.09	0.09
22 Other chemical	0.06	0.13	0.14
23 Non-metal	-0.02	-0.06	-0.05
24 Iron steel	0.07	0.19	0.19
25 Electrical machinery	0.06	0.12	0.13
26 Radio and Television	0.05	0.17	0.18
27 Transport equipment	0.07	0.15	0.16
28 Other manufacturing	0.02	0.15	0.16
29 Electricity and gas	0.01	0.08	0.09
30 Water	-0.03	-0.08	-0.07
31 Construction	0.00	0.01	0.02
32 Trade	-0.00	0.03	0.04
33 Accommodation	-0.28	-1.82	-1.81
34 Transport services	0.00	0.02	0.02
35 Post and communication	0.01	0.05	0.05
36 Finance	0.02	0.07	0.08
37 Real estate	0.01	0.03	0.04
38 Other business	0.02	0.06	0.06
39 General government	0.00	0.02	0.00
40 Education	0.01	0.09	0.09
41 Health	0.02	0.07	0.07
42 Other services	-0.02	0.00	0.01

Column 2 further shows how an increase in labour supply due to a decline in the prevalence of diabetes will affect sector outputs in the long-run. The result indicates that an increase in labour supply lead to a significant positive response in most sectors. The soft-drinks sector remains the hardest hit in the long-run followed by the accommodation and sugar sectors. Similar increases are observed when health expenditure declines due to less demand for health care services.

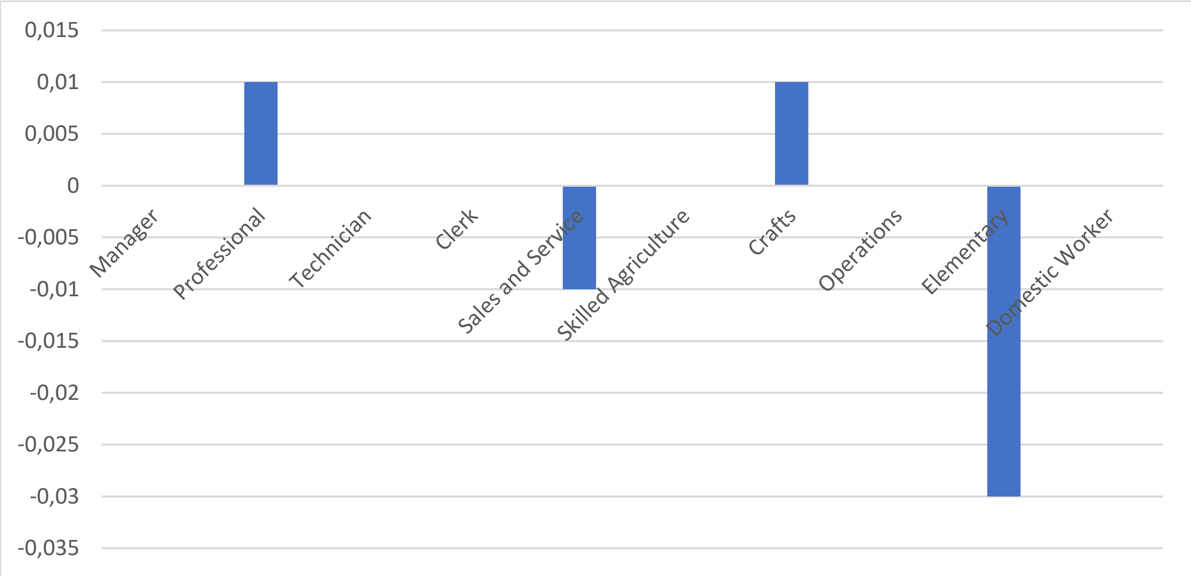
6.5.3 Effects on households

The increased prices of sugar-sweetened beverages due to the tax will have a disproportionate impact on those who consume the beverages. The exact impact of SSB tax on prices depends on many factors and may change as new production practices evolve such as substitution towards less sugary beverages. Households may also experience income reductions with a decrease in the price of factors of production on which their income is mainly relied. The changes in prices of commodities and income will ultimately reduce disposable income which results in decrease in demand for commodities. The result of the simulation shows that in the short-run the tax will have a disproportionate effect on real household consumption. Real household consumption is shown to decrease by 0.02 for the poor and 0.01 for the middle household group. The tax is shown to have no effect on the high-income household group.

Domestic basic demand is shown to decrease for soft-drinks, hotels, accommodation, and other services with the introduction of the tax policy. The demand for soft drinks by households decrease by 2.3 percent while the demand for accommodations services decrease by 0.4 percent. The demand for imports decreases in all sectors due to the imposition of the tax. The negative impact of the tax on demand for soft-drinks and accommodation services is however reversed when improvements in labour supply, productivity and reduction in government expenditure are introduced in the model.

Concerns regarding the negative effects of SSB taxation have been raised with regards to the negative impact of the tax burden on employment losses. The tax burden is expected to induce production changes throughout the economy which will have an impact on the variable factors of production. The results of the simulation show that a demand for skilled labour categories such as managers, technicians, clerks, and operators are not affected by the imposition of the tax. Professionals and crafts are shown to benefit from the SSB taxes while sales and elementary contract due to the policy. Employment loss is however reversed with gains over 3 percent in all occupational groups with improvements in labour supply and reduced demand for health care services. Figures 6.2 illustrate the effects of the tax change on different occupational groups.

Figure 6. 2: Employment effects of SSB taxes



6.5.4 Fan decomposition

The results of the Fan decomposition analysis of the impact of sugar-sweetened beverages taxes on selected industry output are presented in table 6.4. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share, and export effect to output change. The local market contribution largely explains the reduction in overall output for all the industries while the domestic share effect explains a shift from the imported to the domestically produced. The export effect shows an increase in exports of commodities. Table 6.4 gives a breakdown of the changes in shares in total output for key sectors. Simulation 1 and 3 are depicted in the table. For simulation 1, few sectors registered a decline in exports demand due to the SSB tax that is imposed on the soft-drinks sector. Several sectors registered a decline in overall output.

Table 6. 4: Effect of SSB tax on the shares of industry output: fan decomposition

Scenario 1: SSB Tax	**Local Market**	**Domestic Share**	**Export**	**Total**
Field crop	-0.01	0.00	0.02	0.01
Fruit and veg	-0.07	0.01	0.05	-0.01
Livestock	-0.01	0.00	0.01	0.00
Bakery	0.01	0.00	0.00	0.01
Sugar	-0.20	0.02	0.05	-0.13
Cocoa	-0.02	-0.01	-0.00	-0.03
Other food	-0.01	0.01	0.02	0.03
Beverage	0.00	0.00	0.03	0.04
Soft drink	-0.86	0.24	-2.56	-3.18
Tobacco	-0.05	0.01	0.05	0.01
Transport equipment	0.00	0.04	0.03	0.07
Other manufacturing	0.01	0.01	0.01	0.02
Electricity and gas	0.01	-0.00	0.00	0.01
Water	-0.03	-0.00	0.00	-0.03
Construction	0.00	0.00	0.00	0.00
Trade	-0.00	0.00	0.00	-0.00
Accommodation	-0.03	-0.13	-0.12	-0.28
Transport services	0.00	0.00	0.00	0.00
General government	0.00	0.00	0.00	0.00
Education	0.01	-0.00	0.00	0.01
Health	0.01	0.00	0.00	0.02
Other services	-0.02	-0.01	0.01	-0.02
Scenario 3: SSB tax, employment, health expenditure				
Field crop	-0.01	0.01	0.04	0.04
Fruit and veg	-0.10	0.01	0.05	-0.04
Livestock	0.01	0.00	0.01	0.02
Bakery	0.04	0.00	0.00	0.04
Sugar	-0.34	0.01	0.02	-0.31
Cocoa	-0.02	0.03	0.01	0.02
Other food	0.02	0.02	0.04	0.07
Beverages	0.05	0.01	0.08	0.14
Soft drink	-2.09	0.12	-3.64	-5.61
Tobacco	-0.31	0.01	0.07	-0.23
Transport equipment	0.03	0.06	0.06	0.16
Other manufacturing	0.05	0.04	0.07	0.16
Electricity and gas	0.09	0.00	0.00	0.10
Water	-0.07	0.00	0.00	-0.07
Construction	0.02	0.00	0.00	0.02
Trade	0.03	0.00	0.01	0.04
Accommodation	-0.26	-0.85	-0.82	-1.93
Transport services	0.04	-0.00	-0.01	0.02
General government	0.00	0.00	0	0.00
Education	0.13	0.00	0	0.13
Health	0.08	0.01	0.01	0.09
Other services	-0.00	-0.02	0.02	0.00

As can be expected, the soft-drink registered the highest impact followed by the sugar sector. Relevant sectors in the production and consumption. In terms of a shift from the usage of local output from domestic to imported, the analysis shows that SSB tax induces an increase in the usage of local output.

Tobacco, transport and manufacturing record an increase in both share of demand for domestic outputs and exports thus leading to an overall increase in total output despite the tax. In the long-run, the negative effect of the tax is however revised some sectors when the SSB tax is modelled simultaneously with increased labour supply and productivity as well as decreased demand for health care services. Scenario 3 shows an increase in the local market share of output in sectors, with local market accounting for the largest share of changes in industry output (see appendix for chapter 6).

6.5.5 Sensitivity analysis

Results of the sensitivity analysis for a 20% increase in the SSB tax are shown in table 6.5. The analysis shows that in the short-run, a 20% increase in the tax will result in reduction in household consumption due to an increase in prices.

Table 6. 5: Sensitivity analysis for a 20% increase in SSB tax

	Short-run	Long-run
Variables	**20% Tax**	**20% Tax + employment + health expenditure**
Consumer price index (CPI)	0.05	0.11
Real wage rate	-0.21	-0.37
Terms of Trade	0.02	-0.00
Real GDP	-0.01	-0.01
Aggregate real investment	-	-0.01
Consumption	-0.03	-0.01
Export volume	-0.06	0.01
Import volumes	-0.07	0.01

Similar to the introduction of a 10% tax in the long-run, the increase in labour result in a decline in real wages by 0.37 percent. The decline in household consumption, and investment reduces GDP on the expenditure side. In the long-run the tax is shown to decrease GDP by

0.01 percent due to the decline in aggregate investment and household consumption. Results of 5% tax increase in the SSB tax are presented in the appendix for chapter 6.

6.6 Conclusion

The main aim of this paper was to evaluate the impact of a tax on sugar-sweetened beverages in South Africa using a computable general equilibrium model. We modelled four scenarios in our analysis to see how the economy is impacted when a SSB tax is imposed and when the health benefits of imposing the tax are modelled simultaneously. Our first scenario modelled the impact of a 10 percent increase in sugar-sweetened beverages tax in the short-run. Our second scenario modelled the impact of the tax together with an increase in labour supply in the long-run. Our third scenario modelled the impact of reduced government expenditure due to reduction in demand for diabetes health care services.

The results show that SSB tax has a negative impact on the economy in the short-run when tax is modelled individually without considering the benefits of introducing the tax. In the short-run, an introduction of the tax increase prices which in turn reduces household consumption and export volumes. Furthermore, outputs in sectors linked to the soft-drinks industry decrease due to the imposition of the tax. This however results in a low impact on the gross domestic product. Similar results are shown by Theron, Rossouw and Fourie, (2016) who argue that this could be as a due to increased consumption in other sectors. For Vietnam Chuc, (2014) shows that a 10% excise tax will result in a reduction of GDP by 0.01 percent. Similar results are shown in the short-run when a 20% tax is modelled to test the robustness of the model. The negative results are however reversed when the net benefits from the tax is modelled simultaneously.

Opponents of the tax have also argued that the tax will disproportionally affect the low-income groups and also reduce labour supply. Our analysis shows that in the short-run, the poorest households suffer the most impact followed by the middle-income households. The tax is shown to have no impact on the high-income households. Whilst our analysis shows that poor households are negatively affected by the tax in the short-run, this negative effect could be offset by investing the revenue generated from the tax in healthcare programmes to cover costs that are borne by low-income earners (Nakhimovsky *et al.*, 2016). Furthermore, the negative impact of the tax is reversed in the long-run when the health benefits of the tax is modelled simultaneously. Assuming that in the long-run the SSB tax will reduce SSB consumption which will in turn reduce diabetes which will consequently increase labour supply, the analysis shows a positive impact on GDP. Modelling these scenarios results in an increase in household consumption and investment in the economy.

The results from this study present critical lessons on the impact of the tax on the economy. The analysis shows that modelling the impact of the tax alone results in a negative impact on the economy in the short-run. The analysis shows that including the benefits that might be derived from tax reverses the negative impact of the tax in the long-run. The analysis therefore shows that government interventions such as the SSB tax could benefit the economy in the long-run. This paper therefore illustrates the value of considering the macroeconomic impact of policy interventions together with the resulting benefits of such interventions the so called “double-dividend” when conducting economic impact studies.

CHAPTER 7

SUMMARY AND CONCLUSION

7.1 Introduction

This chapter presents a summary of the study, the major findings and important policy implications. The purpose of the study was to analyse the effects of diabetes and sugar-sweetened beverage tax on the economy. This is performed through the application of various methods to determine the effects on key macroeconomic variables in the economy.

7.2 Summary of main findings

The major finding of this research is that diabetes has a negative effect on the economy of South Africa. In chapter 3 we estimated we estimated the impact of diabetes on a number of different labour market participation outcomes, such as employment vs unemployment and non-labour force participation, employment vs unemployment and employment vs non-labour force participation. Using a probit model and propensity score matching method, the analysis shows that individuals with diabetes have less chances of being employed as compared to individuals without diabetes. We further estimated the impact of diabetes on employment by removing non-participants in the labour force from the analysis. Diabetes is shown to increase employment which is counterintuitive as one would expect a negative impact. Similar insignificant results are shown when we estimate the effects of diabetes on unemployment. When the unemployed are removed from the analysis, the results are as expected showing a significant negative impact on diabetes in both males and females. Our analysis also revealed that that males in the second, middle and fourth wealth quintile are less likely to be employed than those in the richest quintile. For females in all wealth quintile, the probability of employment seems to increase as compared to females in the richest quintile.

In chapter 5, we estimated the effects of diabetes on key macroeconomic and microeconomic variables in South Africa using a computable general equilibrium model. We estimated the impact through productivity loss, labour supply and increase in demand for health care services. Three scenarios were simulated. In scenario 1 we assume that mortality due to diabetes will reduce labour supply. Our analysis shows that when labour supply is reduced, household consumption decreases whilst real wages increase. When real wages increase the cost of domestic production leading to increase domestic price levels. Higher domestic prices decrease demand for exports and import-competing domestic goods. The consumer price index also increases to reflect the increase in domestic prices. The fall in level of exports and household consumption result in a 0.19% reduction in GDP relative to the baseline.

In scenario 2 we simulated a 0.6% productivity loss due to diabetes. We find in the analysis that reduction in labour productivity reduces household consumption, investment and ultimately GDP by 1.2% relative to the baseline. Furthermore, investment, household consumption and trade are negatively affected by the prevalence of diabetes. Furthermore, all sectoral outputs decrease due to reduced productivity and labour supply. When increased demand for government services is simulated in scenario 3, similar trends but of less magnitude are shown observed. When all scenarios are modelled simultaneously, GDP is shown to decrease by 0.78%.

In Chapter 6 the impact of SSB tax on the economy in the short- and long-run was investigated. The analysis was underpinned by the SSB tax which was implemented in 2018. In the short-run the impact of the tax on GDP was lower than expected. With the imposition of the SSB tax, export prices rise relative to import prices, leading to an improvement in the terms of trade. The decrease in demand for goods decrease productivity levels which in turn result in a decline in real wages by 0.11 percent. The increase in the SSB tax, increase the aggregate price level and thus reduce household consumption. The poorest households suffer the most impact followed by the middle-income households. The tax is shown to have no impact on the high-income households. The decline in household consumption, and level of exports contribute to the minimal reduction in GDP on the expenditure side.

In the long-run the results of the SSB tax are offset by improvements in labour supply and productivity due to the decline in diabetes. As expected, the increase in employment in scenario 2 results in a decline in real wages. With more people employed household consumption increases which results in an increase the in the consumer price index. From the expenditure side GDP also increases as a result of an increase in consumption, investments as well as the volume of exports. When productivity improves due to the effect of the tax on diabetes, aggregate price level decreases and thus improve aggregate real household consumption. The decrease in aggregate price reduces export price relative to import prices resulting in the weakening of the trade balance. Similar results are observed when government demand for services is reduced due to reduction in demand for diabetes healthcare services. The negative impact of the tax is therefore reversed when the health benefits of the tax is modelled simultaneously.

7.3 Policy implications

In terms of policy implications, the most important result of this study is that diabetes could be a serious hindrance to economic growth in South Africa. This is likely to arise because diabetes is an incapacitating health condition (Shim et al., 2012; Westaway et al., 2001) that results in reduced labour supply. The disease can however be prevented through diet control and control of overweight and obesity (Olokoba et al., 2012).

In South Africa, the sugar tax was implemented as a way to reduce consumption of SSB. Researchers however argue that such a tax is only effective when it does not disproportionally affect the poor and it is high enough to counteract externalities and internalities that may arise due to the consumption of the SSB (Allcott, Lockwood and Taubinsky, 2019). Whilst our analysis shows that poor households are negatively affected by the tax in the short-run, this negative effect could be offset by investing the revenue generated from the tax in healthcare programmes to cover costs that are borne by low-income earners (Nakhimovsky *et al.*, 2016). Furthermore, because the low-income groups have been shown to consume unhealthy foods, government could subsidize healthier alternatives to increase consumption of healthier alternatives in the low-income groups.

Other preventative strategies should also be considered as the tax alone cannot lead to full reduction of the obesity and diabetes epidemic (Nakhimovsky *et al.*, 2016). The strategy for reducing the epidemic in South Africa includes health promotion at the community level, early diagnosis, and comprehensive management through cost-effective interventions (National Department of Health, 2013). Given the high prevalence of undiagnosed diabetes in South

Africa, interventions that aim at screening high risk individuals, health education and employee wellness programmes could also help reduce the economic burden of diabetes. Given that diabetes affects the most economically active group, firms should also invest in employee wellness programmes to help educate employees about diabetes and other chronic illnesses that might have an impact on productivity. Given that uncontrolled diabetes can result in costly complications, government should invest in health care services to manage and slow the progression of the disease.

7.3 Suggestions for further research

The study has addressed the major objective of this research which was to investigate the impact of diabetes and SSB tax on the economy. Whilst this has been achieved, there are several interesting questions that future studies can address. In terms of analysing economy-wide impact of diabetes and SSB tax, future studies can analyse the impact of the tax taking into account the health benefits of such a tax in a dynamic setting. The dynamic model will enable projecting of health benefits of such a tax on the economy.

7.4 Conclusion

South Africa is on the brink of diabetes crisis. Diabetes is the second leading cause of death in the country. Labour outcomes, GDP, household consumption, trade and industry outputs are impacted negatively by diabetes. The results of this study show how the recently introduced tax has the potential to benefit the economy when the health benefits are considered in macroeconomic models. Knowledge of the potential economic consequences of both diabetes and the SSB tax can help policymakers in making decisions that are evidence-based.

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Appendix for Chapter 3

Appendix A: Probit results

Table A1: The impact of various factors on diabetes

	Male		Female	
Age	0.00***	(0.00)	0.00***	(0.00)
Age20to24	0.00	(0.01)	-0.01	(0.01)
Age25to29	-0.01	(0.01)	0.00	(0.01)
Age30to34	-0.01	(0.01)	0.00	(0.01)
Age35to39	-0.00	(0.01)	0.00	(0.01)
Age40to44	-0.00	(0.01)	0.01	(0.01)
Age45to49	0.00	(0.01)	0.01	(0.01)
Age50to54	0.00	(0.01)	0.02*	(0.01)
Age55to59	-0.00	(0.01)	0.01	(0.01)
Age60to64	-0.00	(0.01)	0.00	(0.01)
Children	-0.00	(0.00)	0.00	(0.00)
Coloured	0.01	(0.00)	0.01	(0.00)
Indian	0.00	(0.00)	0.021**	(0.01)
White	-0.01***	(0.00)	-0.00	(0.01)
Married	0.01**	(0.00)	0.01*	(0.00)
Divorced	0.01	(0.01)	-0.00	(0.01)
Widowed	0.00	(0.01)	0.01*	(0.00)
Western cape	0.01	(0.01)	0.03***	(0.01)
Eastern cape	0.01**	(0.00)	0.03***	(0.01)
Northern cape	0.00	(0.01)	0.02*	(0.01)
Free state	0.01	(0.01)	0.02***	(0.01)
Gauteng	0.00	(0.00)	0.01*	(0.01)
Mpumalanga	0.00	(0.01)	0.01	(0.01)
Northwest	-0.00	(0.01)	0.01	(0.01)
KwaZulu-Natal	0.01*	(0.00)	0.03***	(0.01)
Urban	-0.00	(0.00)	0.01	(0.01)
Traditions	-0.00	(0.01)	0.02*	(0.01)
Primary	-0.00	(0.00)	0.01	(0.00)
Secondary	0.00	(0.00)	0.00	(0.00)
Certificate	0.01	(0.01)	0.01	(0.01)
Diploma	-0.01	(0.01)	0.00	(0.01)
Bachelors	0.00	(0.01)	-0.01	(0.01)
Honours	-0.00	(0.01)	0.00	(0.01)
Masters	-0.00	(0.01)	0.01	(0.01)
Doctorate	0	(.)	0	(.)
Other	0.00	(0.01)	0.01	(0.01)
Hypertension	0.03***	(0.00)	0.05***	(0.00)
Heart disease	0.01	(0.01)	0.02**	(0.01)
Poorest	0.02***	(0.00)	0.01*	(0.00)
Second	0.01**	(0.00)	0.01*	(0.00)
Middle	0.01	(0.00)	0.01	(0.00)
Fourth	-0.00	(0.00)	-0.00	(0.00)
Sample size	19547		22137	

Notes: This table shows the marginal effects of various factors on diabetes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. NPLF stand for non-participants in labour force. N stands for sample size. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.01

Table A2: The impact of Diabetes on employment relative to uemployment and NPLF

	Male		Female	
Diabetes	-0.04*	(0.02)	-0.05**	(0.02)
Age	0.00***	(0.00)	0.01***	(0.00)
Age20to24	0.29***	(0.01)	0.31***	(0.02)
Age25to29	0.44***	(0.01)	0.46***	(0.02)
Age30to34	0.47***	(0.01)	0.53***	(0.02)
Age35to39	0.48***	(0.02)	0.56***	(0.02)
Age40to44	0.44***	(0.02)	0.56***	(0.02)
Age45to49	0.40***	(0.02)	0.54***	(0.02)
Age50to54	0.36***	(0.03)	0.47***	(0.03)
Age55to59	0.28***	(0.03)	0.40***	(0.03)
Age60to64	0.07*	(0.03)	0.15***	(0.03)
Children	-0.04***	(0.00)	-0.03***	(0.00)
Coloured	-0.02	(0.01)	-0.00	(0.01)
Indian	0.05*	(0.02)	-0.08***	(0.02)
White	0.07***	(0.01)	0.02	(0.01)
Married	0.23***	(0.01)	-0.03***	(0.01)
Divorced	0.14***	(0.02)	0.05**	(0.02)
Widowed	0.11***	(0.02)	0.03**	(0.01)
Western Cape	0.02	(0.01)	0.06***	(0.01)
Eastern Cape	-0.05***	(0.01)	0.01	(0.01)
Northern Cape	-0.04*	(0.02)	0.01	(0.02)
Free state	-0.07***	(0.02)	-0.03	(0.02)
Gauteng	-0.02	(0.01)	0.01	(0.01)
Mpumalanga	0.03	(0.01)	0.03	(0.01)
Northwest	-0.00	(0.01)	-0.01	(0.01)
KwaZulu-Natal	-0.02*	(0.01)	0.023*	(0.01)
Urban	-0.14***	(0.02)	-0.08***	(0.02)
Traditions	-0.25***	(0.02)	-0.17***	(0.02)
Primary	0.02	(0.02)	0.022	(0.02)
Secondary	0.053**	(0.02)	0.09***	(0.02)
Certificate	0.11***	(0.02)	0.21***	(0.02)
Diploma	0.18***	(0.03)	0.28***	(0.03)
Bachelors	0.21***	(0.03)	0.35***	(0.03)
Honours	0.22***	(0.04)	0.40***	(0.03)
Masters	0.22***	(0.04)	0.31***	(0.04)
Doctorate	0.24*	(0.10)	0.30***	(0.07)
Other	0.10***	(0.03)	0.20***	(0.03)
Hypertension	-0.04**	(0.01)	-0.03***	(0.01)
Heart disease	-0.17***	(0.04)	-0.09*	(0.04)
Poorest	0.01	(0.01)	0.09***	(0.01)
Second	-0.03**	(0.01)	0.04***	(0.01)
Middle	-0.04***	(0.01)	0.03**	(0.01)
Fourth	-0.02*	(0.01)	0.03**	(0.01)
Sample size	19586		22175	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.01

Table A3: The impact of diabetes on employment relative to unemployment

	Male		Female	
Diabetes	0.04	(0.03)	0.01	(0.03)
Age	0.01***	(0.00)	0.01***	(0.00)
Age20to24	0.04*	(0.02)	0.06*	(0.03)
Age25to29	0.09***	(0.02)	0.10**	(0.03)
Age30to34	0.09**	(0.03)	0.12**	(0.04)
Age35to39	0.06*	(0.03)	0.10*	(0.05)
Age40to44	0.02	(0.04)	0.06	(0.06)
Age45to49	-0.04	(0.05)	0.01	(0.07)
Age50to54	-0.07	(0.05)	-0.03	(0.08)
Age55to59	-0.09	(0.06)	-0.04	(0.09)
Age60to64	-0.06	(0.07)	-0.04	(0.11)
Children	-0.03***	(0.00)	-0.03***	(0.00)
Coloured	0.01	(0.01)	0.05**	(0.02)
Indian	0.10***	(0.03)	0.10*	(0.04)
White	0.12***	(0.02)	0.14***	(0.03)
Married	0.17***	(0.01)	0.023**	(0.01)
Divorced	0.098***	(0.03)	0.05	(0.02)
Widowed	0.13***	(0.04)	0.07***	(0.02)
Western Cape	-0.06**	(0.02)	-0.04	(0.02)
Eastern Cape	-0.11***	(0.02)	-0.03	(0.02)
Northern Cape	-0.13***	(0.02)	-0.07**	(0.02)
Free state	-0.16***	(0.02)	-0.14***	(0.02)
Gauteng	-0.13***	(0.02)	-0.12***	(0.02)
Mpumalanga	-0.12***	(0.02)	-0.13***	(0.02)
Northwest	-0.11***	(0.02)	-0.09***	(0.02)
KwaZulu-Natal	-0.11***	(0.02)	-0.07***	(0.02)
Urban	-0.13***	(0.02)	-0.10***	(0.02)
Traditions	-0.17***	(0.02)	-0.13***	(0.02)
Primary	-0.02	(0.03)	0.03	(0.03)
Secondary	-0.02	(0.03)	0.04	(0.03)
Certificate	0.01	(0.03)	0.11***	(0.03)
Diploma	0.11**	(0.04)	0.19***	(0.04)
Bachelors	0.11**	(0.04)	0.24***	(0.04)
Honours	0.18**	(0.06)	0.32***	(0.05)
Masters	0.10	(0.05)	0.16**	(0.05)
Doctorate	0.11	(0.12)	0.14	(0.08)
Other	0.04	(0.04)	0.12**	(0.04)
Hypertension	-0.02	(0.02)	0.01	(0.01)
Heart disease	-0.08	(0.07)	0.11	(0.08)
Poorest	0.03**	(0.01)	0.14***	(0.01)
Second	-0.03**	(0.01)	0.04**	(0.01)
Middle	-0.04***	(0.01)	0.03*	(0.01)
Fourth	-0.02*	(0.01)	0.03*	(0.01)
Sample size	12916		11873	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Table A4: The impact of diabetes on employment relative to non-participants in labour force

	Male		Female	
Diabetes	-0.05**	(0.02)	-0.06***	(0.02)
Age	0.00***	(0.00)	0.01***	(0.00)
Age20to24	0.30***	(0.01)	0.36***	(0.02)
Age25to29	0.47***	(0.01)	0.54***	(0.02)
Age30to34	0.49***	(0.01)	0.60***	(0.02)
Age35to39	0.49***	(0.01)	0.62***	(0.02)
Age40to44	0.44***	(0.02)	0.61***	(0.02)
Age45to49	0.40***	(0.02)	0.58***	(0.02)
Age50to54	0.33***	(0.02)	0.49***	(0.03)
Age55to59	0.25***	(0.02)	0.41***	(0.03)
Age60to64	0.06*	(0.03)	0.15***	(0.04)
Children	-0.03***	(0.00)	-0.03***	(0.00)
Coloured	-0.03**	(0.01)	-0.03**	(0.01)
Indian	0.00	(0.02)	-0.12***	(0.02)
White	0.03	(0.01)	-0.02	(0.01)
Married	0.20***	(0.01)	-0.05***	(0.01)
Divorced	0.12***	(0.02)	0.03	(0.02)
Widowed	0.09***	(0.02)	0.02	(0.01)
Western Cape	0.05***	(0.01)	0.09***	(0.02)
Eastern Cape	-0.01	(0.01)	0.02	(0.01)
Northern Cape	0.02	(0.02)	0.03	(0.02)
Free state	-0.01	(0.01)	0.01	(0.02)
Gauteng	0.04***	(0.01)	0.06***	(0.01)
Mpumalanga	0.10***	(0.01)	0.09***	(0.01)
Northwest	0.05***	(0.01)	0.02	(0.01)
KwaZulu-Natal	0.02	(0.01)	0.05***	(0.01)
urban	-0.10***	(0.02)	-0.06***	(0.02)
traditions	-0.22***	(0.02)	-0.17***	(0.02)
Primary	0.03	(0.02)	0.02	(0.02)
Secondary	0.08***	(0.02)	0.10***	(0.02)
Certificate	0.14***	(0.02)	0.24***	(0.02)
Diploma	0.17***	(0.03)	0.29***	(0.03)
Bachelors	0.20***	(0.03)	0.35***	(0.03)
Honours	0.18***	(0.03)	0.39***	(0.03)
Masters	0.23***	(0.05)	0.33***	(0.04)
Doctorate	0.25**	(0.10)	0.33***	(0.08)
Other	0.10***	(0.03)	0.21***	(0.03)
Hypertension	-0.04***	(0.01)	-0.04***	(0.01)
Heart disease	-0.16***	(0.04)	-0.11**	(0.04)
Poorest	-0.02	(0.01)	0.06***	(0.01)
Second	-0.02*	(0.01)	0.05***	(0.01)
Middle	-0.03***	(0.01)	0.03**	(0.01)
Fourth	-0.02	(0.01)	0.03**	(0.01)
Sample size	16749		18862	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Table A5: The impact of diabetes on unemployment (narrow)

	Male		Female	
Diabetes	-0.05	(0.02)	-0.02	(0.02)
Age	0.00*	(0.00)	-0.00	(0.00)
Age20to24	0.19***	(0.01)	0.20***	(0.01)
Age25to29	0.19***	(0.01)	0.23***	(0.01)
Age30to34	0.15***	(0.01)	0.19***	(0.01)
Age35to39	0.13***	(0.01)	0.18***	(0.02)
Age40to44	0.12***	(0.02)	0.17***	(0.02)
Age45to49	0.13***	(0.02)	0.15***	(0.02)
Age50to54	0.09***	(0.02)	0.12***	(0.02)
Age55to59	0.06*	(0.02)	0.067*	(0.03)
Age60to64	-0.06	(0.03)	-0.04	(0.04)
Children	0.01***	(0.00)	0.01***	(0.00)
Coloured	-0.00	(0.01)	-0.02*	(0.01)
Indian	-0.08***	(0.02)	-0.09***	(0.02)
White	-0.09***	(0.02)	-0.11***	(0.02)
Married	-0.10***	(0.01)	-0.03***	(0.01)
Divorced	-0.05**	(0.02)	-0.03*	(0.02)
Widowed	-0.09**	(0.03)	-0.04**	(0.01)
Western Cape	0.07***	(0.01)	0.07***	(0.01)
Eastern Cape	0.09***	(0.01)	0.03***	(0.01)
Northern Cape	0.14***	(0.01)	0.08***	(0.01)
Free state	0.13***	(0.01)	0.11***	(0.01)
Gauteng	0.13***	(0.01)	0.12***	(0.01)
Mpumalanga	0.13***	(0.01)	0.13***	(0.01)
Northwest	0.12***	(0.01)	0.08***	(0.01)
KwaZulu-Natal	0.11***	(0.01)	0.09***	(0.01)
Urban	0.08***	(0.01)	0.06***	(0.01)
Traditions	0.07***	(0.01)	0.027*	(0.01)
Primary	0.05*	(0.02)	-0.01	(0.02)
Secondary	0.06**	(0.02)	0.01	(0.02)
Certificate	0.04	(0.02)	-0.00	(0.02)
Diploma	-0.04	(0.03)	-0.07*	(0.03)
Bachelors	-0.02	(0.03)	-0.09**	(0.03)
Honours	-0.09*	(0.04)	-0.15***	(0.04)
Masters	-0.02	(0.04)	-0.05	(0.04)
Doctorate	-0.04	(0.09)	-0.02	(0.06)
Other	0.01	(0.03)	-0.03	(0.03)
Hypertension	0.00	(0.01)	-0.02	(0.01)
Heart disease	-0.01	(0.05)	-0.13**	(0.05)
Poorest	-0.04***	(0.01)	-0.08***	(0.01)
Second	0.02**	(0.01)	-0.01	(0.01)
Middle	0.02**	(0.01)	-0.01	(0.01)
Fourth	0.01	(0.01)	-0.01	(0.01)
Sample size	19586		22175	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Table A6: The impact of diabetes on unemployment (broad)

	Male		Female	
Diabetes	0.038*	(0.02)	0.051**	(0.02)
Age	-0.0027***	(0.00)	-0.0050***	(0.00)
Age20to24	-0.29***	(0.01)	-0.31***	(0.02)
Age25to29	-0.44***	(0.01)	-0.46***	(0.02)
Age30to34	-0.47***	(0.01)	-0.53***	(0.02)
Age35to39	-0.48***	(0.02)	-0.56***	(0.02)
Age40to44	-0.44***	(0.02)	-0.56***	(0.02)
Age45to49	-0.40***	(0.02)	-0.54***	(0.02)
Age50to54	-0.36***	(0.03)	-0.47***	(0.03)
Age55to59	-0.28***	(0.03)	-0.40***	(0.03)
Age60to64	-0.071*	(0.03)	-0.15***	(0.03)
Children	0.035***	(0.00)	0.028***	(0.00)
Coloured	0.019	(0.01)	0.0082	(0.01)
Indian	-0.046*	(0.02)	0.084***	(0.02)
White	-0.070***	(0.01)	-0.018	(0.01)
Married	-0.23***	(0.01)	0.030***	(0.01)
Divorced	-0.14***	(0.02)	-0.047**	(0.02)
Widowed	-0.11***	(0.02)	-0.033**	(0.01)
Western Cape	-0.020	(0.01)	-0.058***	(0.01)
Eastern Cape	0.045***	(0.01)	-0.0061	(0.01)
Northern Cape	0.035*	(0.02)	-0.0080	(0.02)
Free State	0.066***	(0.02)	0.030	(0.02)
Gauteng	0.020	(0.01)	-0.0096	(0.01)
Mpumalanga	-0.025	(0.01)	-0.026	(0.01)
Northwest	0.0038	(0.01)	0.0085	(0.01)
KwaZulu-Natal	0.025*	(0.01)	-0.023*	(0.01)
urban	0.14***	(0.02)	0.078***	(0.02)
traditions	0.25***	(0.02)	0.17***	(0.02)
Primary	-0.020	(0.02)	-0.022	(0.02)
Secondary	-0.053**	(0.02)	-0.086***	(0.02)
Certificate	-0.11***	(0.02)	-0.21***	(0.02)
Diploma	-0.18***	(0.03)	-0.28***	(0.03)
Bachelors	-0.21***	(0.03)	-0.35***	(0.03)
Honours	-0.22***	(0.04)	-0.40***	(0.03)
Masters	-0.22***	(0.04)	-0.31***	(0.04)
Doctorate	-0.24*	(0.10)	-0.30***	(0.07)
Other	-0.099***	(0.03)	-0.20***	(0.03)
Hypertension	0.042**	(0.01)	0.032***	(0.01)
Heartdisease	0.17***	(0.04)	0.090*	(0.04)
Poorest	-0.014	(0.01)	-0.094***	(0.01)
Second	0.028**	(0.01)	-0.043***	(0.01)
Middle	0.042***	(0.01)	-0.029**	(0.01)
Fourth	0.019*	(0.01)	-0.030**	(0.01)
N	19586		22175	

Notes: This table shows the marginal effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.2 and includes the results of other explanatory variables. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Appendix C: LINEAR INSTRUMENTAL VARIABLE

TableC1: Impact of diabetes on employment relative to employment and NPLF

	Male				Female			
	(1)		(2)		(1)		(2)	
Diabetes			-0.05*	(0.02)			-0.06**	(0.02)
Age	0.00***	(0.00)	-0.00	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Age20to24	-0.01***	(0.00)	0.19***	(0.01)	-0.01***	(0.00)	0.12***	(0.01)
Age25to29	-0.02***	(0.00)	0.40***	(0.01)	-0.02***	(0.00)	0.29***	(0.01)
Age30to34	-0.03***	(0.00)	0.46***	(0.01)	-0.02***	(0.00)	0.40***	(0.01)
Age35to39	-0.04***	(0.00)	0.48***	(0.02)	-0.03***	(0.00)	0.46***	(0.01)
Age40to44	-0.05***	(0.00)	0.46***	(0.02)	-0.03***	(0.00)	0.48***	(0.02)
Age45to49	-0.04***	(0.00)	0.43***	(0.02)	-0.03***	(0.00)	0.48***	(0.02)
Age50to54	-0.04***	(0.00)	0.40***	(0.03)	-0.01**	(0.00)	0.41***	(0.02)
Age55to59	-0.03***	(0.00)	0.33***	(0.03)	0.00	(0.00)	0.34***	(0.02)
Age60to64	-0.01***	(0.00)	0.08*	(0.03)	0.00	(0.00)	0.10***	(0.02)
Children	0.00	(0.00)	-0.04***	(0.00)	0.00	(0.00)	-0.03***	(0.00)
Coloured	0.00	(0.00)	-0.02	(0.01)	0.00*	(0.00)	-0.01	(0.01)
Indian	0.01***	(0.00)	0.05*	(0.02)	0.02***	(0.00)	-0.09***	(0.02)
White	-0.01***	(0.00)	0.06***	(0.01)	0.00	(0.00)	0.02	(0.01)
Married	0.01***	(0.00)	0.27***	(0.01)	0.00***	(0.00)	-0.03***	(0.01)
Divorced	0.01**	(0.00)	0.17***	(0.02)	-0.01***	(0.00)	0.06***	(0.02)
Widowed	-0.02***	(0.00)	0.13***	(0.03)	0.02***	(0.00)	0.04*	(0.01)
Western Cape	0.00	(0.00)	0.03	(0.01)	0.01**	(0.00)	0.06***	(0.01)
Eastern Cape	0.00	(0.00)	-0.05***	(0.01)	0.00**	(0.00)	0.01	(0.01)
Northern Cape	0.00**	(0.00)	-0.04*	(0.02)	0.00	(0.00)	0.01	(0.02)
Free state	0.00	(0.00)	-0.06***	(0.02)	0.01**	(0.00)	-0.03*	(0.02)
Gauteng	0.00	(0.00)	-0.02	(0.01)	0.00	(0.00)	0.01	(0.01)
Mpumalanga	0.00	(0.00)	0.023	(0.01)	0.00	(0.00)	0.02	(0.01)
Northwest	0.00	(0.00)	-0.00	(0.01)	0.00	(0.00)	-0.01	(0.01)
KwaZulu-Natal	0.00	(0.00)	-0.02*	(0.01)	0.00*	(0.00)	0.02*	(0.01)
urban	0.00	(0.00)	-0.13***	(0.01)	0.00**	(0.00)	-0.09***	(0.02)
traditions	0.00	(0.00)	-0.25***	(0.01)	0.00**	(0.00)	-0.18***	(0.02)
Primary	0.01**	(0.00)	0.03	(0.02)	0.02***	(0.00)	0.03	(0.02)
Secondary	0.01**	(0.00)	0.07***	(0.02)	0.01***	(0.00)	0.10***	(0.02)
Certificate	0.01***	(0.00)	0.14***	(0.02)	0.02***	(0.00)	0.25***	(0.02)
Diploma	0.00	(0.00)	0.20***	(0.03)	0.01***	(0.00)	0.33***	(0.03)
Bachelors	0.01**	(0.00)	0.22***	(0.03)	0.01*	0.01	0.39***	(0.02)
Honours	0.01*	(0.00)	0.22***	(0.03)	0.01***	(0.00)	0.43***	(0.02)
Masters	0.01**	(0.00)	0.22***	(0.03)	0.02***	(0.00)	0.35***	(0.03)
Doctorate	-0.02**	0.01	0.23***	(0.05)	-0.01	0.02	0.35***	(0.06)
Other	0.01	(0.00)	0.12***	(0.03)	0.01***	(0.00)	0.23***	(0.04)
Hypertension	0.14***	(0.00)	-0.04**	(0.01)	0.13***	(0.00)	-0.04**	(0.01)
Heart disease	0.0***	(0.01)	-0.20***	(0.05)	0.09***	0.01	-0.09**	(0.03)
Poorest	0.01***	(0.00)	-0.00	(0.01)	0.00	(0.00)	0.09***	(0.01)
Second	0.00**	(0.00)	-0.04***	(0.01)	0.00	(0.00)	0.04***	(0.01)
Middle	0.00	(0.00)	-0.05***	(0.01)	0.00	(0.00)	0.02*	(0.01)
Fourth	0.00	(0.00)	-0.02*	(0.01)	0.00	(0.00)	0.02**	(0.01)
Sample size	195 86				22 175			

Notes: This table shows effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.5. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

TableC2: Impact of diabetes on employment relative unemployment

	Male				Female			
	(1)		(2)		(1)		(2)	
Diabetes			0.00	(0.02)			0.01	(0.02)
Age	0.00**	(0.00)	0.01***	(0.00)	0.00***	(0.00)	0.01***	(0.00)
Age20to24	0.00	(0.00)	0.10***	(0.03)	-0.02**	(0.01)	0.11***	(0.03)
Age25to29	-0.01	(0.00)	0.19***	(0.02)	-0.03***	(0.01)	0.18***	(0.03)
Age30to34	-0.01**	(0.00)	0.20***	(0.02)	-0.04***	(0.01)	0.23***	(0.03)
Age35to39	-0.01*	(0.01)	0.18***	(0.02)	-0.05***	(0.01)	0.22***	(0.03)
Age40to44	-0.01*	(0.01)	0.14***	(0.02)	-0.05***	(0.01)	0.18***	(0.03)
Age45to49	0.00	(0.01)	0.07**	(0.03)	-0.06***	(0.01)	0.13***	(0.04)
Age50to54	0.01	(0.01)	0.05	(0.03)	-0.03**	(0.01)	0.08	(0.04)
Age55to59	0.02*	(0.01)	0.011	(0.03)	-0.06***	(0.02)	0.04	(0.05)
Age60to64	0.07***	(0.01)	-0.00	(0.03)	-0.08***	(0.02)	-0.00	(0.05)
Children	0.00	(0.00)	-0.04***	(0.00)	0.00	(0.00)	-0.03***	(0.00)
Coloured	0.00	(0.00)	0.02	(0.01)	0.00	(0.00)	0.05**	(0.01)
Indian	0.00	(0.00)	0.07***	(0.02)	0.00	(0.01)	0.07**	(0.02)
White	-0.01***	(0.00)	0.04***	(0.01)	0.00	(0.00)	0.05***	(0.01)
Married	0.00**	(0.00)	0.18***	(0.01)	0.00**	(0.00)	0.02*	(0.01)
Divorced	0.01***	(0.00)	0.12***	(0.02)	0.00	(0.00)	0.04*	(0.02)
Widowed	-0.01**	(0.00)	0.14***	(0.03)	0.00	(0.00)	0.08***	(0.02)
Western Cape	0.00	(0.00)	-0.05***	(0.01)	0.01**	(0.00)	-0.05*	(0.02)
Eastern Cape	0.00	(0.00)	-0.10***	(0.02)	0.01**	(0.00)	-0.04*	(0.02)
Northern Cape	0.00	(0.00)	-0.12***	(0.02)	0.00	(0.00)	-0.08***	(0.02)
Free state	0.00	(0.00)	-0.14***	(0.02)	0.01**	(0.00)	-0.15***	(0.02)
Gauteng	0.00	(0.00)	-0.12***	(0.01)	0.00	(0.00)	-0.12***	(0.02)
Mpumalanga	0.01	(0.00)	-0.10***	(0.02)	0.00	(0.00)	-0.14***	(0.02)
Northwest	0.00	(0.00)	-0.10***	(0.02)	0.00	(0.00)	-0.10***	(0.02)
KwaZulu-Natal	0.00	(0.00)	-0.11***	(0.01)	0.00	(0.00)	-0.07***	(0.02)
Urban	0.00	(0.00)	-0.09***	(0.01)	0.00	(0.00)	-0.10***	(0.02)
Traditions	-0.01	(0.00)	-0.14***	(0.01)	0.00	(0.00)	-0.12***	(0.02)
Primary	0.01***	(0.00)	-0.02	(0.02)	0.00	(0.00)	0.015	(0.03)
Secondary	0.01***	(0.00)	-0.03	(0.02)	0.00	(0.00)	0.01	(0.03)
Certificate	0.02***	(0.00)	0.00	(0.02)	0.01	(0.00)	0.07**	(0.03)
Diploma	0.01**	(0.01)	0.04	(0.03)	0.00	(0.00)	0.10***	(0.03)
Bachelors	0.02***	(0.00)	0.05	(0.02)	0.00	(0.01)	0.13***	(0.03)
Honours	0.02***	(0.00)	0.05*	(0.02)	0.00	(0.00)	0.14***	(0.03)
Masters	0.02***	(0.00)	0.04	(0.03)	0.00	(0.01)	0.09**	(0.03)
Doctorate	-0.01	(0.01)	0.01	(0.04)	-0.01	(0.04)	0.04	(0.04)
Other	0.02**	(0.00)	0.03	(0.03)	0.00	(0.01)	0.09*	(0.04)
Hypertension	0.11**	(0.00)	-0.01	(0.01)	0.09**	(0.00)	0.01	(0.01)
Heart disease	0.12**	(0.02)	-0.07	(0.05)	0.11***	(0.04)	0.07	(0.04)
Poorest	0.01**	(0.00)	0.02	(0.01)	0.00	(0.00)	0.14***	(0.02)
Second	0.00	(0.00)	-0.04**	(0.01)	0.00	(0.00)	0.05***	(0.01)
Middle	0.00	(0.00)	-0.05***	(0.01)	0.00	(0.00)	0.04**	(0.01)
Fourth	0.00	(0.00)	-0.03*	(0.01)	0.00	(0.00)	0.04**	(0.01)
Sample size	129 16				118 73			

Notes: This table shows effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.5. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.01

TableC3: Impact of diabetes on employment relative to non-participants in labour force

	Male				Female			
	(1)		(2)		(1)		(2)	
Diabetes			-0.06*	(0.02)			-0.06***	(0.02)
Age	0.00***	(0.00)	0.00	(0.00)	0.00***	(0.00)	0.00***	(0.00)
Age20to24	-0.01***	(0.00)	0.28***	(0.01)	-0.01***	(0.00)	0.18***	(0.01)
Age25to29	-0.02***	(0.00)	0.56***	(0.01)	-0.02***	(0.00)	0.42***	(0.01)
Age30to34	-0.03***	(0.00)	0.59***	(0.01)	-0.02***	(0.00)	0.52***	(0.01)
Age35to39	-0.04***	(0.00)	0.59***	(0.02)	-0.03***	(0.00)	0.56***	(0.01)
Age40to44	-0.05***	(0.00)	0.55***	(0.02)	-0.03***	(0.00)	0.57***	(0.02)
Age45to49	-0.04***	(0.00)	0.53***	(0.02)	-0.03***	(0.00)	0.55***	(0.02)
Age50to54	-0.04***	(0.00)	0.46***	(0.03)	-0.01***	(0.00)	0.46***	(0.02)
Age55to59	-0.03***	(0.00)	0.37***	(0.03)	0.00	(0.00)	0.37***	(0.02)
Age60to64	-0.02***	(0.00)	0.09*	(0.03)	0.00	(0.00)	0.11***	(0.02)
Children	0.00	(0.00)	-0.03***	(0.00)	0.00	(0.00)	-0.03***	(0.00)
Coloured	0.00	(0.00)	-0.03**	(0.01)	0.00*	(0.00)	-0.04**	(0.01)
Indian	0.01***	(0.00)	0.01	(0.02)	0.02***	(0.00)	-0.13***	(0.02)
White	-0.01***	(0.00)	0.02*	(0.01)	0.00	(0.00)	-0.02	(0.01)
Married	0.01***	(0.00)	0.22***	(0.01)	0.01***	(0.00)	-0.06***	(0.01)
Divorced	0.01**	(0.00)	0.13***	(0.02)	-0.01***	(0.00)	0.04*	(0.02)
Widowed	-0.02***	(0.00)	0.08**	(0.03)	0.02***	(0.00)	0.015	(0.01)
Western cape	0.00	(0.00)	0.06***	(0.01)	0.01**	(0.00)	0.10***	(0.02)
Eastern Cape	0.00	(0.00)	-0.02	(0.01)	0.00	(0.00)	0.01	(0.01)
Northern Cape	0.00**	(0.00)	0.02	(0.02)	0.00	(0.00)	0.03	(0.02)
Free state	0.00	(0.00)	-0.01	(0.02)	0.01**	(0.00)	0.01	(0.02)
Gauteng	0.00	(0.00)	0.04***	(0.01)	0.00	(0.00)	0.06***	(0.01)
Mpumalanga	0.00	(0.00)	0.09***	(0.01)	0.00	(0.00)	0.09***	(0.01)
Northwest	0.00	(0.00)	0.05***	(0.01)	0.00	(0.00)	0.01	(0.01)
KwaZulu-Natal	0.00	(0.00)	0.02	(0.01)	0.00	(0.00)	0.05***	(0.01)
Urban	0.00	(0.00)	-0.09***	(0.01)	0.00**	(0.00)	-0.07***	(0.02)
Traditions	0.00	(0.00)	-0.23***	(0.01)	0.01**	(0.00)	-0.19***	(0.02)
Primary	0.01**	(0.00)	0.06**	(0.02)	0.02***	(0.00)	0.025	(0.02)
Secondary	0.01	(0.00)	0.11***	(0.02)	0.02***	(0.00)	0.12***	(0.02)
Certificate	0.02	(0.00)	0.19***	(0.02)	0.02***	(0.00)	0.28***	(0.02)
Diploma	0.00	(0.00)	0.20***	(0.03)	0.02***	(0.00)	0.33***	(0.03)
Bachelors	0.01**	(0.00)	0.23***	(0.03)	0.01**	0.01	0.38***	(0.02)
Honours	0.01	(0.00)	0.20***	(0.03)	0.01***	(0.00)	0.40***	(0.02)
Masters	0.01	(0.01)	0.23***	(0.03)	0.02***	(0.00)	0.35***	(0.03)
Doctorate	-0.03	(0.01)	0.26***	(0.05)	-0.01	0.02	0.36***	(0.06)
Other	0.01	(0.00)	0.14***	(0.03)	0.01**	(0.00)	0.24***	(0.04)
Hypertension	0.14***	(0.00)	-0.04**	(0.01)	0.13***	(0.00)	-0.05***	(0.01)
Heart disease	0.05***	(0.01)	-0.21***	(0.05)	0.07***	(0.01)	-0.12***	(0.04)
Poorest	0.01***	(0.00)	-0.03*	(0.01)	0.00	(0.00)	0.06***	(0.01)
Second	0.00**	(0.00)	-0.03**	(0.01)	0.00	(0.00)	0.04***	(0.01)
Middle	0.00	(0.00)	-0.04***	(0.01)	0.00	(0.00)	0.03*	(0.01)
Fourth	0.00**	(0.00)	-0.02*	(0.01)	0.00	(0.00)	0.02*	(0.01)
Sample	167 49				188 62			

Notes: This table shows effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.5. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.01

Table C4: Impact of diabetes on unemployment(narrow) relative to employment and NPLF

	Male				Female			
	(1)		(2)		(1)		(2)	
Diabetes			-0.00	(0.01)			-0.01	(0.01)
Age	0.00***	(0.00)	0.00***	(0.00)	0.00***	(0.00)	0.00**	(0.00)
Age20to24	-0.01***	(0.00)	0.20***	(0.01)	-0.01***	(0.00)	0.20***	(0.01)
Age25to29	-0.02***	(0.00)	0.19***	(0.01)	-0.02***	(0.00)	0.23***	(0.01)
Age30to34	-0.03***	(0.00)	0.14***	(0.01)	-0.02***	(0.00)	0.16***	(0.01)
Age35to39	-0.04***	(0.00)	0.11***	(0.01)	-0.03***	(0.00)	0.12***	(0.01)
Age40to44	-0.05***	(0.00)	0.10***	(0.01)	-0.03***	(0.00)	0.10***	(0.01)
Age45to49	-0.04***	(0.00)	0.10***	(0.01)	-0.03***	(0.00)	0.08***	(0.01)
Age50to54	-0.04***	(0.00)	0.06***	(0.01)	-0.01**	(0.00)	0.06***	(0.01)
Age55to59	-0.03***	(0.00)	0.04**	(0.01)	0.00	(0.00)	0.03**	(0.01)
Age60to64	-0.01***	(0.00)	-0.01	(0.01)	0.00	(0.00)	-0.00	(0.01)
Children	0.00	(0.00)	0.01***	(0.00)	0.00	(0.00)	0.01***	(0.00)
Coloured	0.00	(0.00)	-0.00	(0.01)	0.00*	(0.00)	-0.03**	(0.01)
Indian	0.01***	(0.00)	-0.06***	(0.01)	0.02***	(0.00)	-0.06***	(0.01)
White	-0.01***	(0.00)	-0.04***	(0.01)	0.00	(0.00)	-0.05***	(0.01)
Married	0.01***	(0.00)	-0.11***	(0.01)	0.00***	(0.00)	-0.04***	(0.01)
Divorced	0.01**	(0.00)	-0.07***	(0.02)	-0.01***	(0.00)	-0.04***	(0.01)
Widowed	-0.02**	(0.00)	-0.09***	(0.02)	0.02***	(0.00)	-0.04***	(0.01)
Western Cape	0.00	(0.00)	0.06***	(0.01)	0.01**	(0.00)	0.07***	(0.01)
Eastern Cape	0.00	(0.00)	0.07***	(0.01)	0.00*	(0.00)	0.03***	(0.01)
Northern Cape	0.00**	(0.00)	0.12***	(0.01)	0.00	(0.00)	0.07***	(0.01)
Free state	0.00	(0.00)	0.11***	(0.01)	0.01**	(0.00)	0.10***	(0.01)
Gauteng	0.00	(0.00)	0.10***	(0.01)	0.00	(0.00)	0.11***	(0.01)
Mpumalanga	0.00	(0.00)	0.11***	(0.01)	0.00	(0.00)	0.13***	(0.01)
Northwest	0.00	(0.00)	0.10***	(0.01)	0.00	(0.00)	0.07***	(0.01)
KwaZulu-Natal	0.00	(0.00)	0.10***	(0.01)	0.00*	(0.00)	0.08***	(0.01)
urban	0.00	(0.00)	0.06***	(0.01)	0.00**	(0.00)	0.05***	(0.01)
traditions	0.00	(0.00)	0.05***	(0.01)	0.00**	(0.00)	0.02	(0.01)
Primary	0.01**	(0.00)	0.04**	(0.01)	0.02***	(0.00)	-0.00	(0.01)
Secondary	0.01**	(0.00)	0.05***	(0.01)	0.01***	(0.00)	0.022*	(0.01)
Certificate	0.01***	(0.00)	0.04**	(0.02)	0.02***	(0.00)	0.01	(0.01)
Diploma	0.00	(0.00)	-0.00	(0.02)	0.01***	(0.00)	-0.03	(0.02)
Bachelors	0.01***	(0.00)	0.01	(0.02)	0.01	0.01	-0.05**	(0.02)
Honours	0.01*	(0.00)	-0.01	(0.02)	0.01***	(0.00)	-0.06***	(0.01)
Masters	0.01**	(0.00)	0.00	(0.02)	0.02***	(0.00)	-0.02	(0.02)
Doctorate	-0.02**	0.01	0.023	(0.03)	-0.01	(0.02)	0.01	(0.04)
Other	0.01*	(0.00)	0.01	(0.02)	0.01***	(0.00)	-0.02	(0.02)
Hypertension	0.14***	(0.00)	-0.00	(0.01)	0.13***	(0.00)	-0.02*	(0.01)
Heart disease	0.06***	(0.01)	0.00	(0.03)	0.09	(0.01)	-0.06***	(0.01)
Poorest	0.01***	(0.00)	-0.028**	(0.01)	0.00	(0.00)	-0.08**	(0.01)
Second	0.00**	(0.00)	0.026**	(0.01)	0.00	(0.00)	-0.01	(0.01)
Middle	0.00	(0.00)	0.026**	(0.01)	0.00	(0.00)	-0.01	(0.01)
Fourth	0.00**	(0.00)	0.016*	(0.01)	0.00	(0.00)	-0.01	(0.01)
Sample size			195 86				22 175	

Notes: This table shows effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.5. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Table C5: Impact of diabetes on unemployment (broad) relative to employment and NPLF

	Male				Female			
	(1)		(2)		(1)		(2)	
Diabetes			0.05*	(0.02)			0.06**	(0.02)
Age	0.00***	(0.00)	0.00	(0.00)	0.00***	(0.00)	-0.00***	(0.00)
Age20to24	-0.01***	(0.00)	-0.19***	(0.01)	-0.01***	(0.00)	-0.12***	(0.01)
Age25to29	-0.02***	(0.00)	-0.40***	(0.01)	-0.02***	(0.00)	-0.29***	(0.01)
Age30to34	-0.03***	(0.00)	-0.46***	(0.01)	-0.02***	(0.00)	-0.40***	(0.01)
Age35to39	-0.04***	(0.00)	-0.48***	(0.02)	-0.03***	(0.00)	-0.46***	(0.01)
Age40to44	-0.05***	(0.00)	-0.46***	(0.02)	-0.03***	(0.00)	-0.48***	(0.02)
Age45to49	-0.04***	(0.00)	-0.43***	(0.02)	-0.03***	(0.00)	-0.48***	(0.02)
Age50to54	-0.04***	(0.00)	-0.40***	(0.03)	-0.01*	(0.00)	-0.41***	(0.02)
Age55to59	-0.03***	(0.00)	-0.33***	(0.03)	0.00	(0.00)	-0.34***	(0.02)
Age60to64	-0.01***	(0.00)	-0.08*	(0.03)	0.00	(0.00)	-0.10***	(0.02)
Children	0.00	(0.00)	0.04***	(0.00)	0.00	(0.00)	0.03***	(0.00)
Coloured	0.00	(0.00)	0.02	(0.01)	0.00	(0.00)	0.01	(0.01)
Indian	0.01***	(0.00)	-0.05*	(0.02)	0.02***	(0.00)	0.09***	(0.02)
White	-0.01***	(0.00)	-0.06***	(0.01)	0.00	(0.00)	-0.02	(0.01)
Married	0.01***	(0.00)	-0.27***	(0.01)	0.00***	(0.00)	0.03***	(0.01)
Divorced	0.01**	(0.00)	-0.17***	(0.02)	-0.01***	(0.00)	-0.06***	(0.02)
Widowed	-0.02***	(0.00)	-0.13***	(0.03)	0.02***	(0.00)	-0.04*	(0.01)
Western Cape	0.00	(0.00)	-0.03	(0.01)	0.01	(0.00)	-0.06***	(0.01)
Eastern Cape	0.00	(0.00)	0.05***	(0.01)	0.00	(0.00)	-0.01	(0.01)
Northern Cape	0.00**	(0.00)	0.04*	(0.02)	0.00	(0.00)	-0.01	(0.02)
Free state	0.00	(0.00)	0.06***	(0.02)	0.01*	(0.00)	0.03*	(0.02)
Gauteng	0.00	(0.00)	0.02	(0.01)	0.00	(0.00)	-0.01	(0.01)
Mpumalanga	0.00	(0.00)	-0.02	(0.01)	0.00	(0.00)	-0.02	(0.01)
Northwest	0.00	(0.00)	0.00	(0.01)	0.00	(0.00)	0.01	(0.01)
KwaZulu-Natal	0.00	(0.00)	0.02*	(0.01)	0.00	(0.00)	-0.02*	(0.01)
Urban	0.00	(0.00)	0.13***	(0.01)	0.00	(0.00)	0.09***	(0.02)
Traditions	0.00	(0.00)	0.25***	(0.01)	0.00*	(0.00)	0.18***	(0.02)
Primary	0.01**	(0.00)	-0.03	(0.02)	0.02***	(0.00)	-0.03	(0.02)
Secondary	0.01**	(0.00)	-0.07***	(0.02)	0.01***	(0.00)	-0.10***	(0.02)
Certificate	0.01***	(0.00)	-0.14***	(0.02)	0.02***	(0.00)	-0.25***	(0.02)
Diploma	0.00	(0.00)	-0.20***	(0.03)	0.01***	(0.00)	-0.33***	(0.03)
Bachelors	0.01***	(0.00)	-0.22***	(0.03)	0.01	0.01	-0.39***	(0.02)
Honours	0.01*	(0.00)	-0.22***	(0.03)	0.01***	(0.00)	-0.43***	(0.02)
Masters	0.01**	(0.00)	-0.22***	(0.03)	0.02***	(0.00)	-0.35***	(0.03)
Doctorate	-0.02**	(0.01)	-0.23***	(0.05)	-0.01	(0.02)	-0.35***	(0.06)
Other	0.01*	(0.00)	-0.12***	(0.03)	0.01***	(0.00)	-0.23***	(0.04)
Hypertension	0.14***	(0.00)	0.042**	(0.01)	0.13***	(0.00)	0.04**	(0.01)
Heart disease	0.06***	(0.01)	0.20***	(0.05)	0.09***	(0.01)	0.09**	(0.03)
Poorest	0.01***	(0.00)	0.00	(0.01)	0.00	(0.00)	-0.09***	(0.01)
Second	0.00*	(0.00)	0.04***	(0.01)	0.00	(0.00)	-0.04***	(0.01)
Middle	0.00	(0.00)	0.05***	(0.01)	0.00	(0.00)	-0.02*	(0.01)
Fourth	0.00**	(0.00)	0.02*	(0.01)	0.00	(0.00)	-0.02**	(0.01)
Sample size			12916				11873	

Notes: This table shows effects of diabetes on various labour market participation outcomes reported in chapter 3. This table is an expansion of table 3.5. Standard errors are in parentheses. Marginal effects; * p< 0.1 ** p<0.05 *** p<0.001

Appendix for Chapter 4

Appendix D: Composition of the forty-two industries

IND42	SIC 3.0	Description of Economic Activity from Standard Industrial Classification 3.0
1 Field crop	11	I0101: Growing of cereal grains including rice, wheat, maize and sugar cane, and other field crops [SIC 1111]
2 Fruit and veg	11	I0102: Growing of vegetables, horticultural and nursery products [SIC 1112]; Growing of fruit, nuts, beverage, and spice crops including growing of grapes and manufacture of wine at the same location [SIC 1113]
3 Livestock	11	I0103: Farming of live animals including dairy farming [SIC 112]; Mixed farming [SIC 113]; Other agricultural services [SIC 114]; Hunting and related services [SIC 115]; Production of organic fertilizer such as compost [SIC 116]
4 Forestry	12	I0104: Forestry, logging and related services [SIC 12]
5 Fishing	13	I0105: Fishing, operation of fish hatcheries and fish farms [SIC 13]
6 Coal	21	I0206: Mining of coal and lignite [SIC 21]
7 Metal ore	22	I0207: Extraction of crude petroleum and natural gas including services incidental to oil and gas extraction [SIC 22]
	23	I0208: Mining of gold and uranium ore [SIC 23]
	24	I0209: Mining of iron ore and other non-ferrous metals including PGMs [SIC 24]
8 Other mining	25	I0210: Other mining and quarrying including diamonds [SIC 25]; Other service activities incidental to mining of minerals [SIC 29]
9 Meat	30	I0311: Manufacture, processing, and preservation of meat [SIC 3011]
	30	I0312: Manufacture, processing and preservation of fish [SIC 3012]
	30	I0313: Manufacture, processing and preservation of fruit and vegetables [SIC 3013]
	30	I0314: Manufacture, processing and preservation of oils and fats [SIC 3014]
10 Dairy	30	I0315: Manufacture of dairy products including milk, butter, cheese, and yoghurt [SIC 302]
11 Grain	30	I0316: Manufacture of grain mill products, starches and starch products and prepared animal feeds [SIC 303]
12 Bakery	30	I0317: Manufacture of bakery products [SIC 3041]
13 Sugar	30	I0318: Manufacture of sugar [SIC 3042]
14 Cocoa	30	I0319: Manufacture of cocoa and chocolate products [SIC 3043]
15 Other Food	30	I0320: Manufacture of other food products nec including pastas and coffee [SIC 3044-3049]
16 Beverage	30	I0321: Manufacture of alcoholic beverages [SIC 3051-3052]
17 Soft drink	30	I0322: Manufacture of soft drinks and mineral water [SIC 3053]
18 Tobacco	30	I0323: Manufacture of tobacco products [SIC 306]
19 Textile and footwear	31	I0324: Manufacture of textiles and clothing apparel [SIC 311-315]
	31	I0325: Manufacture, tanning and dressing of leather and leather goods [SIC 316]
	31	I0326: Manufacture of footwear products [SIC 317]
20 Wood and paper	32	I0327: Manufacture of wood and wood products [SIC 321-322]
	32	I0328: Manufacture of paper and paper products [SIC 323]; Publishing [SIC 324]; Printing and services related to printing [SIC 325]; Reproduction of recorded media [SIC 326]
21 Petroleum and refinery	33	I0329: Manufacture of coke oven products [SIC 331]; Manufacture of refined petroleum products [SIC 332]

22 Other chemicals	33	I0330: Manufacture and processing of nuclear fuel [SIC 333]; Manufacture of basic chemicals and other chemical products including pesticides, paints, and pharmaceuticals [SIC 334-335]; Manufacture of man-made fibres [SIC 336]
	33	I0331: Manufacture of rubber products including tyres and tubes [SIC 337]
	33	I0332: Manufacture of plastic products [SIC 338]
23 Non-metal	34	I0333: Manufacture of glass products [SIC 341]
	34	I0334: Manufacture of other non-metallic mineral products including ceramic and cement [SIC 342]
24 Iron steel	35	I0335: Manufacture of basic iron and steel (SIC 351]; Casting of iron and steel and other non-ferrous metals [SIC 353]
	35	I0336: Manufacture of basic precious and non-ferrous metals including gold, silver, PGMs and alumina [SIC 352]
	35	I0337: Manufacture of structural and fabricated metal products [SIC 354-355]; Manufacture of general and special purpose machinery [SIC 356-357]; Manufacture of household appliances and office and computing machinery [SIC 358-359]
25 Electrical machinery	36	I0338: Manufacture of electrical machinery and apparatus including electric motors, insulated wire and cables, primary batteries, and lighting equipment [SIC 36]
26 Radio and Television	37	I0339: Manufacture of radio, television, and communication equipment [SIC 371-373]
	37	I0340: Manufacture of medical appliances and instruments [SIC 374]; Manufacture of optical instruments and photographic equipment [SIC 375]; Manufacture of watches and clocks [SIC 376]
27 Transport equipment	38	I0341: Manufacture of motor vehicles [SIC 381]; Manufacture of bodies for motor vehicles and trailers [SIC 382]; Manufacture of parts and accessories for motor vehicles [SIC 383]
	38	I0342: Manufacture of other transport equipment including boats, trains, aircraft and motorcycles and bicycles [SIC 384-387]
28 Other manufacturing	39	I0343: Manufacture of furniture [SIC 391]; Manufacture of other product groups nec including jewellery, sporting goods, and toys [SIC 392]; Recycling of metal and non-metal waste and scrap [SIC 395]
29 Electricity and gas	41	I0444: Generation of electricity from coal [SIC 41]
	41	I0445: Generation of electricity from nuclear power [SIC 41]
	41	I0446: Generation of electricity from other sources including gas, hydro and renewables [SIC 41]
	41	I0447: Distribution of electricity and gas, steam, and hot water supply [SIC 41]
30 Water	42	I0448: Collection, purification and distribution of water [SIC 42]
31 Construction	50	I0549: Construction and construction related services [SIC 50]
32 Trade	61	I0650: Wholesale and commission trade [SIC 61]
	62	I0651: Retail trade and repair of personal and household goods [SIC 62]
	63	I0652: Sale, maintenance and repair of motor vehicles and retail trade in automotive fuel [SIC 63]
33 Accommodation	64	I0653: Hotels and other short-stay accommodation [SIC 641]; Restaurants and bars [SIC 642]
34 Transport services	71	I0754: Land transport including using passenger and freight services via road and rail [SIC 71]
	72	I0755: Water transport services [SIC 72]
	73	I0756: Air transport including using passenger and freight services [SIC 73]

	74	I0757: Supporting transport activities including cargo handling, storage and warehousing, activities of travel agencies [SIC 74]
35 Post and communication	75	I0758: Post and telecommunication services [SIC 75]
36 Finance	81	I0859: Financial intermediation services [SIC 81]
	82	I0860: Insurance, medical aid, and pension funding services [SIC 82]
	83	I0861: Other financial services [SIC 83]
37 Real estate	84	I0862: Real estate activities including buying, selling, renting, managing, and developing of residential dwellings and non-residential buildings [SIC 84]
38 Other business	85	I0863: Renting of machinery and equipment including agricultural, construction, transport, and personal equipment [SIC 85]
	86	I0864: Computer and related activities [SIC 86]
	87	I0865: Research and development [SIC 87]
	88	I0866: Other business service activities [SIC 88]
39 General government	91	I0967: Public administration and defence activities by general government [SIC 91]
	94	I0970: Sanitation activities, sewage, and refuse disposal [SIC 94]
40 Education	92	I1068: Private education services [SIC 92]
41 Health	93	I1069: Private health and social work services including hospital, medical, dental, veterinary activities, and day care centres [SIC 93]
42 Other services	95-99	I1071: Other services including activities of professional organisations and trade unions [SIC 95]; Recreational, cultural, and sporting activities [SIC 96]; Other service activities including laundry and hairdressing [SIC 99]

Notes: This table shows the composition of the 42 industries used to develop the database for the computable general equilibrium model. The database uses the official 2011 Supply-Use Table (SUT) of South Africa, published by Statistics South Africa, as a starting point and initial solution to the model. The SUT distinguishes between 62 industries and 104 services. For our analysis, the 62 industries are aggregated to 42 industries.

Appendix for Chapter 5

Table E1: Results of the impact of diabetes on sector output.

Sector	Decreased labour supply	Decreased productivity	Increased demand for government services
1 Field crop	-0.08	-0.49	-0.02
2 Fruit and veg	-0.08	-0.50	-0.02
3 Livestock	-0.09	-0.54	-0.02
4 Forestry	-0.10	-0.59	-0.02
5 Fishing	-0.09	-0.54	-0.02
6 Coal	-0.09	-0.51	-0.02
7 Metal ore	-0.09	-0.53	-0.01
8 Other mining	-0.10	-0.58	-0.02
9 Meat	-0.09	-0.56	-0.02
10 Dairy	-0.08	-0.50	-0.02
11 Grain	-0.09	-0.55	-0.02
12 Bakery	-0.09	-0.54	-0.02
13 Sugar	-0.09	-0.55	-0.02
14 Cocoa	-0.10	-0.59	-0.02
15 Other food	-0.10	-0.58	-0.02
16 Beverage	-0.09	-0.54	-0.02
17 Soft drink	-0.10	-0.57	-0.02
18 Tobacco	-0.09	-0.54	-0.02
19 Textile and footwear	-0.10	-0.62	-0.02
20 Wood and paper	-0.10	-0.61	-0.02
21 Petroleum and refinery	-0.09	-0.55	-0.02
22 Other chemical	-0.11	-0.65	-0.02
23 Non-metal	-0.10	-0.61	-0.02
24 Iron steel	-0.11	-0.63	-0.02
25 Electrical machinery	-0.12	-0.70	-0.02
26 Radio and Television	-0.13	-0.79	-0.02
27 Transport equipment	-0.10	-0.62	-0.02
28 Other manufacturing	-0.11	-0.63	-0.02
29 Electricity and gas	-0.10	-0.57	-0.02
30 Water	-0.09	-0.56	-0.02
31 Construction	-0.10	-0.57	-0.02
32 Trade	-0.10	-0.63	-0.02
33 Accommodation	-0.10	-0.62	-0.02
34 Transport services	-0.10	-0.58	-0.02
35 Post and communication	-0.10	-0.62	-0.01
36 Finance	-0.10	-0.59	-0.02
37 Real estate	-0.10	-0.57	-0.02
38 Other business	-0.10	-0.61	-0.01
39 General government	-0.09	-0.54	0.05
40 Education	-0.09	-0.56	-0.02
41 Health	-0.10	-0.57	-0.02
42 Other services	-0.10	-0.59	-0.02

Notes: This table shows the results of sector output under the different scenarios discussed in chapter 5.

Table E2: Effect of decreased labour supply on the shares of industry output

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.15	-0.00	-0.01	-0.16
2 Fruit and veg	-0.15	-0.00	-0.02	-0.17
3 Livestock	-0.18	-0.00	-0.00	-0.18
4 Forestry	-0.20	-0.00	-0.00	-0.20
5 Fishing	-0.15	-0.00	-0.03	-0.18
6 Coal	-0.11	-0.00	-0.06	-0.17
7 Metal ore	-0.03	-0.00	-0.14	-0.18
8 Other mining	-0.05	-0.02	-0.12	-0.19
9 Meat	-0.15	-0.02	-0.02	-0.19
10 Dairy	-0.15	-0.00	-0.01	-0.17
11 Grain	-0.16	-0.01	-0.01	-0.19
12 Bakery	-0.18	-0.00	-0.00	-0.18
13 Sugar	-0.17	-0.01	-0.01	-0.18
14 Cocoa	-0.18	-0.02	-0.01	-0.20
15 Other food	-0.15	-0.02	-0.03	-0.19
16 Beverage	-0.13	-0.00	-0.05	-0.18
17 Soft drink	-0.17	-0.00	-0.02	-0.19
18 Tobacco	-0.13	-0.01	-0.04	-0.18
19 Textile and footwear	-0.15	-0.04	-0.03	-0.21
20 Wood and paper	-0.18	-0.01	-0.02	-0.21
21 Petroleum and refinery	-0.14	-0.02	-0.02	-0.18
22 Other chemicals	-0.14	-0.04	-0.04	-0.22
23 Non-metal	-0.18	-0.02	-0.01	-0.21
24 Iron steel	-0.12	-0.03	-0.06	-0.21
25 Electrical machinery	-0.17	-0.05	-0.01	-0.23
26 Radio and Television	-0.17	-0.07	-0.02	-0.26
27 Transport equipment	-0.13	-0.04	-0.04	-0.21
28 Other manufacturing	-0.13	-0.03	-0.05	-0.21
29 Electricity and gas	-0.19	-0.00	-0.00	-0.19
30 Water	-0.19	-0.00	-0.00	-0.19
31 Construction	-0.19	-0.00	-0.00	-0.19
32 Trade	-0.20	-0.00	-0.01	-0.21
33 Accommodation	-0.15	-0.03	-0.03	-0.21
34 Transport services	-0.16	-0.01	-0.02	-0.20
35 Post and communication	-0.18	-0.02	-0.01	-0.21
36 Finance	-0.19	-0.00	-0.01	-0.20
37 Real estate	-0.19	-0.00	-0.00	-0.19
38 Other business	-0.18	-0.01	-0.01	-0.21
39 General government	-0.18	-0.00	0.00	-0.18
40 Education	-0.19	-0.00	0.00	-0.19
41 Health	-0.18	-0.00	-0.00	-0.19
42 Other services	-0.18	-0.01	-0.02	-0.20

Notes: This table shows the results of the Fan decomposition analysis of the impact of labour supply on industry output. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share, and export effect to industry-level output change.

Table E3: Effect of decreased labour supply on the shares of industry output

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.44	-0.01	-0.04	-0.49
2 Fruit and veg	-0.44	-0.01	-0.05	-0.50
3 Livestock	-0.53	-0.00	-0.01	-0.54
4 Forestry	-0.59	-0.00	-0.00	-0.59
5 Fishing	-0.43	-0.00	-0.10	-0.54
6 Coal	-0.32	-0.01	-0.18	-0.51
7 Metal ore	-0.10	-0.00	-0.42	-0.53
8 Other mining	-0.16	-0.07	-0.34	-0.58
9 Meat	-0.45	-0.05	-0.06	-0.56
10 Dairy	-0.45	-0.01	-0.04	-0.50
11 Grain	-0.49	-0.02	-0.04	-0.55
12 Bakery	-0.53	-0.00	-0.00	-0.54
13 Sugar	-0.50	-0.02	-0.03	-0.55
14 Cocoa	-0.52	-0.05	-0.02	-0.59
15 Other food	-0.43	-0.05	-0.09	-0.58
16 Beverage	-0.37	-0.01	-0.15	-0.54
17 Soft drink	-0.49	-0.01	-0.07	-0.57
18 Tobacco	-0.39	-0.02	-0.13	-0.54
19 Textile and footwear	-0.43	-0.10	-0.08	-0.62
20 Wood and paper	-0.52	-0.04	-0.05	-0.61
21 Petroleum and refinery	-0.43	-0.06	-0.06	-0.55
22 Other chemicals	-0.42	-0.11	-0.12	-0.65
23 Non-metal	-0.52	-0.07	-0.02	-0.61
24 Iron steel	-0.34	-0.10	-0.18	-0.63
25 Electrical machinery	-0.51	-0.16	-0.03	-0.70
26 Radio and Television	-0.51	-0.22	-0.05	-0.79
27 Transport equipment	-0.38	-0.12	-0.12	-0.62
28 Other manufacturing	-0.39	-0.10	-0.14	-0.63
29 Electricity and gas	-0.56	-0.00	-0.01	-0.57
30 Water	-0.56	-0.00	-0.00	-0.56
31 Construction	-0.57	-0.00	-0.00	-0.57
32 Trade	-0.61	-0.00	-0.02	-0.63
33 Accommodation	-0.46	-0.08	-0.08	-0.62
34 Transport services	-0.47	-0.04	-0.07	-0.58
35 Post and communication	-0.54	-0.05	-0.04	-0.62
36 Finance	-0.56	-0.01	-0.03	-0.59
37 Real estate	-0.56	-0.00	-0.00	-0.57
38 Other business	-0.55	-0.02	-0.04	-0.61
39 General government	-0.54	-0.00	0.00	-0.54
40 Education	-0.56	-0.00	0.00	-0.56
41 Health	-0.54	-0.01	-0.01	-0.57
42 Other services	-0.52	-0.02	-0.05	-0.59

Notes: This table shows the results of the Fan decomposition analysis of the impact of labour productivity on industry output. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share, and export effect to industry-level output change.

Table E4: Effect of increased demand for health services on the shares of industry output

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.02	-0.00	-0.00	-0.02
2 Fruit and veg	-0.02	-0.00	-0.00	-0.02
3 Livestock	-0.02	-0.00	-0.00	-0.02
4 Forestry	-0.02	-0.00	-0.00	-0.02
5 Fishing	-0.02	-0.00	-0.00	-0.02
6 Coal	-0.01	-0.00	-0.01	-0.02
7 Metal ore	-0.00	-0.00	-0.01	-0.01
8 Other mining	-0.00	-0.00	-0.01	-0.02
9 Meat	-0.02	-0.00	-0.00	-0.02
10 Dairy	-0.02	-0.00	-0.00	-0.02
11 Grain	-0.02	-0.00	-0.00	-0.02
12 Bakery	-0.02	-0.00	-0.00	-0.02
13 Sugar	-0.02	-0.00	-0.00	-0.02
14 Cocoa	-0.02	-0.00	-0.00	-0.02
15 Other food	-0.02	-0.00	-0.00	-0.02
16 Beverage	-0.02	-0.00	-0.00	-0.02
17 Soft drink	-0.02	-0.00	-0.00	-0.02
18 Tobacco	-0.01	-0.00	-0.00	-0.02
19 Textile and footwear	-0.02	-0.00	-0.00	-0.02
20 Wood and paper	-0.01	-0.00	-0.00	-0.02
21 Petroleum and refinery	-0.01	-0.00	-0.00	-0.02
22 Other chemicals	-0.01	-0.00	-0.00	-0.02
23 Non-metal	-0.02	-0.00	-0.00	-0.02
24 Iron steel	-0.01	-0.00	-0.00	-0.02
25 Electrical machinery	-0.01	-0.00	-0.00	-0.02
26 Radio and Television	-0.01	-0.01	-0.00	-0.02
27 Transport equipment	-0.01	-0.00	-0.00	-0.02
28 Other manufacturing	-0.01	-0.00	-0.00	-0.02
29 Electricity and gas	-0.02	-0.00	-0.00	-0.02
30 Water	-0.02	-0.00	-0.00	-0.02
31 Construction	-0.02	-0.00	-0.00	-0.02
32 Trade	-0.02	-0.00	-0.00	-0.02
33 Accommodation	-0.02	-0.00	-0.00	-0.02
34 Transport services	-0.02	-0.00	-0.00	-0.02
35 Post and communication	-0.01	-0.00	-0.00	-0.01
36 Finance	-0.02	-0.00	-0.00	-0.02
37 Real estate	-0.02	-0.00	-0.00	-0.02
38 Other business	-0.01	-0.00	-0.00	-0.01
39 General government	0.05	-0.00	0.00	0.05
40 Education	-0.02	-0.00	0.00	-0.02
41 Health	-0.02	-0.00	-0.00	-0.02
42 Other services	-0.02	-0.00	-0.00	-0.02

Notes: This table shows the results of the Fan decomposition analysis of the impact of increased demand for government services on industry output. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share and export effect to industry-level output change.

Appendix for Chapter 6

Table F1: Effect of SSB tax and increase labour supply on the shares of industry output

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.06	0.02	0.07	0.03
2 Fruit and veg	-0.20	0.02	0.09	-0.10
3 Livestock	-0.02	0.00	0.01	-0.01
4 Forestry	0.07	0.00	0.01	0.08
5 Fishing	-0.07	0.00	0.10	0.04
6 Coal	0.07	0.00	0.06	0.14
7 Metal ore	0.05	0.00	0.40	0.45
8 Other mining	0.02	0.06	0.24	0.33
9 Meat	-0.14	0.05	0.07	-0.01
10 Dairy	0.02	0.01	0.04	0.06
11 Grain	0.05	0.03	0.04	0.12
12 Bakery	-0.00	0.00	0.00	0.01
13 Sugar	-0.59	0.02	0.04	-0.54
14 Cocoa	-0.10	0.05	0.02	-0.03
15 Other food	-0.02	0.04	0.06	0.08
16 Beverage	0.04	0.01	0.15	0.20
17 Soft drink	-2.96	0.21	-6.19	-8.94
18 Tobacco	-0.62	0.02	0.12	-0.48
19 Textile and footwear	0.07	0.10	0.08	0.26
20 Wood and paper	-0.00	0.03	0.05	0.08
21 Petroleum and refinery	0.03	0.05	0.05	0.14
22 Other chemicals	0.01	0.10	0.11	0.22
23 Non-metal	-0.21	0.06	0.02	-0.12
24 Iron steel	0.07	0.09	0.17	0.33
25 Electrical machinery	0.03	0.15	0.03	0.20
26 Radio and Television	0.05	0.19	0.05	0.29
27 Transport equipment	0.03	0.11	0.11	0.25
28 Other manufacturing	0.06	0.07	0.13	0.26
29 Electricity and gas	0.12	0.00	0.01	0.12
30 Water	-0.15	0.00	0.00	-0.15
31 Construction	-0.00	0.00	0.00	0.00
32 Trade	0.03	0.00	0.01	0.05
33 Accommodation	-0.32	-1.71	-1.59	-3.62
34 Transport services	0.03	-0.01	-0.02	-0.01
35 Post and communication	-0.01	0.04	0.03	0.06
36 Finance	0.07	0.01	0.02	0.10
37 Real estate	0.03	0.00	0.00	0.04
38 Other business	0.03	0.02	0.03	0.08
39 General government	0.01	-0.00	0.00	0.01
40 Education	0.14	-0.00	0.00	0.14
41 Health	0.08	0.01	0.01	0.10
42 Other services	-0.03	-0.03	0.03	-0.03

Notes: This table shows the results of the Fan decomposition analysis of the impact of the SSB tax together with increased labour supply on industry output. The purpose of the Fan decomposition is to show the relative magnitudes of the local market, domestic share and export effect to industry-level output change.

Table F2: Effect of SSB tax. increase labour supply. and government demand on the shares of industry output.

Sector	1 Local Market	2 Domestic Share	3 Export	4 Total
1 Field crop	-0.01	0.01	0.04	0.04
2 Fruit and veg	-0.10	0.01	0.05	-0.04
3 Livestock	0.01	0.00	0.01	0.02
4 Forestry	0.06	0.00	0.00	0.07
5 Fishing	-0.01	0.00	0.06	0.05
6 Coal	0.05	0.00	0.04	0.10
7 Metal ore	0.03	0.00	0.23	0.26
8 Other mining	0.02	0.03	0.14	0.19
9 Meat	-0.06	0.03	0.04	0.02
10 Dairy	0.04	0.00	0.02	0.07
11 Grain	0.06	0.01	0.02	0.10
12 Bakery	0.04	0.00	0.00	0.04
13 Sugar	-0.34	0.01	0.02	-0.31
14 Cocoa	-0.02	0.03	0.01	0.02
15 Other food	0.02	0.02	0.04	0.07
16 Beverage	0.05	0.01	0.08	0.14
17 Soft drink	-2.09	0.12	-3.64	-5.61
18 Tobacco	-0.31	0.01	0.07	-0.23
19 Textile and footwear	0.06	0.06	0.05	0.17
20 Wood and paper	0.01	0.02	0.03	0.06
21 Petroleum and refinery	0.04	0.03	0.03	0.10
22 Other chemicals	0.02	0.06	0.06	0.14
23 Non-metal	-0.11	0.04	0.01	-0.06
24 Iron steel	0.05	0.05	0.09	0.19
25 Electrical machinery	0.03	0.08	0.01	0.13
26 Radio and Television	0.05	0.11	0.03	0.18
27 Transport equipment	0.03	0.06	0.06	0.16
28 Other manufacturing	0.05	0.04	0.07	0.16
29 Electricity and gas	0.09	0.00	0.00	0.10
30 Water	-0.07	0.00	0.00	-0.07
31 Construction	0.02	0.00	0.00	0.02
32 Trade	0.03	0.00	0.01	0.04
33 Accommodation	-0.26	-0.85	-0.82	-1.93
34 Transport services	0.04	-0.00	-0.01	0.02
35 Post and communication	0.02	0.02	0.02	0.06
36 Finance	0.07	0.01	0.01	0.09
37 Real estate	0.05	0.00	0.00	0.05
38 Other business	0.04	0.01	0.02	0.07
39 General government	0.00	0.00	0	0.00
40 Education	0.13	0.00	0	0.13
41 Health	0.08	0.01	0.01	0.09
42 Other services	-0.00	-0.02	0.02	0.00

Notes: This table shows the results of the Fan decomposition analysis of the effects of the SSB tax. increased labour supply. increased productivity and decreased government demand for healthcare on industry output. The purpose of the Fan decomposition is to show the relative magnitudes of the local market. domestic share and export effect to industry-level output change.

Table F3: Sensitivity analysis

	Short-Run		Long-Run
Variables	**5% Tax**	**5% Tax + employment**	**5% Tax + employment + health expenditure**
Consumer price index (CPI)	0.01	0.02	0.02
Real wage rate	-0.06	-0.10	-0.10
Terms of Trade	0.00	-0.00	-0.01
Real GDP	-0.00	0.01	0.03
Aggregate real investment	-	0.01	0.03
Consumption	-0.00	0.01	0.03
Export volume	-0.02	0.01	0.02
Import volumes	-0.02	0.01	0.02

Notes: Results of sensitivity analysis when the baseline shocks are reduced by 50%