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Essays on Dynamic Fiscal Incidence Modelling in South Africa

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With gratitude,

To my father, Koos, who taught me about the stars and relentlessly cheered me on towards them. And to my mother, Bessie, whose enduring love inspired me to reach for them.

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To my pastor, David, who discerned in obscurity, whose vision uncovered excellence, whose leadership fuels me forward.

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You are all my reasons.

With praise,

To the Lord my God, who holds the universe in His hands, who weighs and measures the heart of man. Who foreknew me. Who called me. It is done. May it glorify Your name.

SUMMARY

This thesis considers fiscal incidence modelling in South Africa. We use literature and empirical data to show that the bulk of government expenditure in South Africa is unproductive. For this reason, we suggest an alternative fiscal policy mix that focuses on a specific, productive and wealth-creative expenditure item, investments. By indirectly contributing to greater levels of investments we show that better levels of economic output and social development can be obtained.

To analyse the economic consequences of the suggested fiscal policy mix we construct a dynamic, regional computable general equilibrium model. We also add additional features to provide more accurate and detailed results. These include multiple household modelling, social accounting matrix modelling, as well as an in-depth allocation of fiscal expenditures. A policy simulation determines the fiscal incidence of keeping the government real wage bill fixed for a period of five years. Perpetual savings generated by this decision is used to increase investments via a subsidy in the construction industry.

From our results the two main contributions of our research emerge. First, the policy simulations provide a detailed analysis of an alternative fiscal policy mix and show that our mix leads to greater levels of economic and social development. By social development we specifically refer to the additional jobs that were created and the increase in real household income, spending, and savings. This fresh, evidence-based perspective on fiscal policy provides policymakers and researchers key insights about the fiscal incidence of government policies in South Africa. Second, TERM-SA provides a flexible tool for evaluating many other economic and political topics as they relate to the South African economy.

CHAPTER 1 – INTRODUCTION

1.1 Background and Literature Review

1.2.1 Social Development at the Cost of Economic Growth

Governments use fiscal policy to stimulate economic growth and social development by using fiscal policy tools like government taxes, expenditure, and borrowing (Ocran, 2011). Governments use a combination of these tools to impact the real economy and ultimately the income of individuals. This process is commonly referred to as the fiscal incidence of government policy. In South Africa (SA), as the following section will show, research and data suggest that fiscal policy is focused progressively on wealth distribution, and not wealth creation. As a result, in recent years social development has been implemented at the cost of sustainable economic growth.

In an early study on South Africa's economic history, Terreblanche (2002) explained that although South Africa was successfully democratised, social development had not yet occurred. By social development Terreblanche (2002) specifically referred to the government's ability to address issues related to poverty and inequality. He argued that the fiscal policy strategy the government used during the initial period of democracy was not appropriate for social development and yet this initial strategy was implemented until 2007/08. During the period 1994/95 to 2007/08, the South African government stabilised expenditure and used additional revenue to reduce the budget deficit and the debt burden; a process which many would consider prudent fiscal management. In fact, the debt burden was reduced from 48.3% in 1994/95 to only 26.0% in 2007/08 (Treasury, 2018). During this period spending on social development declined from 55% in 1994/95 to only 48% in 2007/08, expressed as a percentage of total expenditure (Treasury, 2018). Using an economic classification of government expenditure, we refer to spending on social development as that part of government expenditure which is spent on the compensation of civil servants and transfers made to the poor. Transfers include but are not limited to, child and old age support.

During this period, the government's spending on wealth-creative policies, i.e. spending on investments, was unfortunately also low. The term "investments" is used as a collective term to describe spending on capital assets and the term includes all types of tangible and non-tangible assets. These include, but are not limited to property, infrastructure, equipment, and software. From 1994/95 to 2007/08 the South African government spent on average 5.3% of their total budget on investments (National Treasury, 2018). There was a slight increase in the annual average rate from 2008/09 to 2017/18 when spending on investments averaged 7.8% of total spending. However, as a percentage of total spending, investments' share fell from 8.4% in 2008/09 to 6.6% in 2017/18.

There is consensus in the literature relating to government investments that the reluctance of African countries to spend sufficiently on investments is an impediment to growth. In the South African context, Fedderke, Perkins and Luiz (2006) explain that an unwillingness to spend sufficiently on investments helps to explain the decline in economic activity since 1970. Du Plessis and Smit (2006) substantiate these findings and emphasise the South African government's lack of investment spending. Economic growth between 1994/95 and 2007/08 averaged 3.54% annually and fell to an average of 1.69% between 2008/09 and 2017/18. Terreblanche (2002) intended for the government to play an even more active role in wealth redistribution and allocation of resources towards social development. After the global financial crisis of 2008, the government rapidly increased spending, a common fiscal response to external shocks (Alm & Abel, 2010). However, whilst spending on social development increased, spending on investments decreased.

After the financial crisis, the South African government increased the intensity of their redistributive policies through an expansionary fiscal scheme. Jooste, Liu and Naraidoo (2013) support fiscal expansion but conclude that fiscal policy can only be used to stimulate short-term consumption and output, and that South Africa's government should be weary not to over-extend the duration of stimulus. However, spending on social development increased from 48.0% in 2008/09 to 51.7% in 2017/18 (Treasury, 2018), later we will show how this gradual increase was in fact a and over-extension of stimulus. Also, the higher levels of capital expenditure in 2008/09 (8.4%) were gradually reduced to 6.6% in 2017/18. Increases in spending on social development during a time when revenue collections were low, resulted in substantial budget deficits and an increase in debt levels from 31.5% in 2008/09 to 53.5% in 2017/18. Because of the expansionary fiscal scheme Ocran (2011) and Inchauste, Lustig, Maboshe, Purfield and Woolard (2015) conclude that social development has indeed now occurred in SA. In fact, by using progressive taxes and spending on wealth redistributive policies, i.e. increasing governments wage bill and spending on transfers, South Africa has achieved the greatest reduction in poverty and income inequality among emerging market countries (Inchauste, et al., 2015).

Even with these improvements, SA is still among those countries with the highest levels of income inequality. Inchauste et al. (2015) note that because of the lack of economic growth, high fiscal deficits and the rising cost of debt, further social development will not be possible via redistributive policies. The South African government has overextended the period of stimulus, as Jooste et al. (2013) warned against. To continue with social development, the South African government needs to improve public service, as well as grow the economy (Inchauste, et al., 2015). Higher economic growth however, seems unlikely with SA's current redistributive policies that focus on increasing spending, rather than focusing on increasing production through wealth creative policies. The South African government's current fiscal policy strategy closely replicates the structurally constrained nature of South Africa's economy (Akanbi, 2013).

In a structurally constrained economy like South Africa's, domestic production is less than domestic demand. As a result, economic activity is driven by expenditure and not production. Under these circumstances an economy fails to achieve appropriate levels of income distribution (Akanbi, 2013); commonly referred to as the poverty trap. By using an Engle Granger two-step estimation technique, Akanbi (2013) shows that under the current supply constraints in SA, fiscal policy (especially those policies focusing on expenditure) would not be effective at stabilising the economy. Akanbi (2013) calls for a better fiscal policy mix, that would first address the structural supply constraints in the South African economy. Many of his suggestions can be considered wealth creative policies which can lead to sustained, inclusive economic growth. Amongst others, he emphasises the need for substantial increases in investments and the successful development of skills. Developing skills can lead to an increase in labour productivity. Mabugu, Robichaud, Masionnave and Chitiga (2013) use an intertemporal CGE model to draw a similar conclusion; increasing current expenditure will not have a lasting impact on economic activity. Jooste et al. (2013) supports this conclusion and further concludes that wealth creative policies will also increase the overall debt levels of SA. Financing the expansion with tax increases will help to reduce the debt burden, but it will also dampen the initial economic benefits. Mabugu et al. (2013) show that the best fiscal policy tool the South African government can use, is to increase investments. This will ensure sustainable economic growth. Even when using three types of calibrated DSGE-models, Jooste et al. (2013) show that government investment, i.e. capital expenditure, in isolation, has a greater impact on output than current expenditure or total expenditure. Wealth creative policies also help to reduce the long-term deficit and debt levels (Mabugu, et al., 2013). This is crucial in the current economic environment.

To further explain why government spending cannot lead to ongoing consumption, and output benefits, it is worthwhile to investigate the causality between economic activity (income) and government expenditure in South Africa. Ansari, Gordon and Akuamoah (1997) initially found evidence to support the Keynesian hypothesis that income growth is determined by growth in government expenditure $(G \rightarrow Y)$. However, they did not test for cointegration or causality using modern techniques like the Toda-Yamamoto procedure. Modern techniques have distinctive advantages over the residual-based Engle and Granger (1987) techniques employed by Ansari et al. (1997). Also, modern researchers have more recent data to work with, as well as a longer time-series to consider. Ziramba (2008) found bidirectional causality, ruling out the Wagner and Keynesian hypotheses. Finally, Alm and Embaye (2010) use specific techniques to overcome common restrictive modelling assumptions and found evidence to support Wagner's law $(Y \rightarrow G)$.

One simple explanation for the mixed results, which also make Wagner's law more likely, relates to the unproductiveness of the bulk of a government's expenditure. Had government expenditure been productive, more spending would increase income. Investment expenditure, which can be considered productive as it generates long-term income by raising total factor productivity, is only a relatively small share of total spending. During the period 1994/95 to 2007/08 investments averaged 5.3% of total expenditure, annually. Then, during the period 2008/09 to 2017/18 investment expenditure experienced a slight pick-up to 7.8%.

However, as we will show in the following section, the bulk of the remaining government expenditure, referred to as current expenditure, is not productive. By accepting this, Wagner's law would be preferred over the Keynesian hypothesis.

Following an economic classification of consolidated government expenditure, expenditure can be divided into investments, interest, social development, and final goods and services. By excluding investments, the remaining expenditure items can be considered current expenditure. Social development includes spending on salaries and wages of civil servants, as well as transfers to households. During 2008/09 social development averaged 55.1% of current expenditure, slightly higher than the 54.0% that was spent on social development during 1994/95 to 2007/08 (Treasury, 2018). During 2008/09 to 2017/18 the compensation of employees made up 38.0% of social development's share of current expenditure, whereas transfers to households made up 17.1%. Transfers to households facilitate the redistribution of income and mainly boost short-term expenditure on goods and services that fulfil the basic needs of households. Although transfers boost short-term consumption and production, they do not directly enhance long-term total factor productivity and therefore fuel the structurally constrained economy Akanbi (2013) referred to.

This logic can also be applied to the portion of government expenditure which is spent on final, not intermediary, goods and services, which are used by the South African government to produce various government services. Since 2008/09 to 2017/18 the average annual spending on goods and services was 16.7%, as a percentage of consolidated government expenditure. Also, from the abovementioned data, the largest single expenditure items in the South African government's budget is the civil servant wage bill, which averaged 38.0% of total expenditure during 2008/09 to 2017/18. However, this portion of government expenditure can also be considered unproductive. To reach this conclusion we use output per worker, a variable commonly used to estimate productiveness, to compare the productiveness of SA's civil servants to those of civil servants in other countries. Our findings suggest that government employees in SA are the third most unproductive amongst all the countries we analysed. These countries include: France, Germany, Australia, Canada, Japan, United Kingdom, Unite States of America, China, Turkey, Russia, Brazil, and South Africa.

Using the Encyclopaedia Britannica (Brogan, 2019) and the Cambridge Dictionary (2019) a standard definition of government can be expressed as:

> "entities that govern an organized community to ultimately ensure the welfare of all civilians. To do this governments use their legislature, executive, and judiciary functions to oversee, support and administer the entire economy".

Considering this definition, it would be fitting to express various government-related data in terms of the size of the economy they administer. However, we also use the total final consumption expenditure of government to express government data on a more government-specific manner. To ensure consistent measures and definitions we used GDP and final government consumption expenditure data from the IMF (International Monetary Fund, 2018) and Government Finance Statistics (GFS). These figures are expressed in terms of international purchasing power parity (PPP) dollars. Employment data was sourced from the International Labour Organization (ILO). In the end we were able to express two measures of output per worker of government employees, for various countries ranging from poor to rich. In both measures of output per worker, South Africa ranked the third lowest in terms of output per worker. Using total expenditure, and measured in international PPP$, South Africa's government output per worker in 2016 was roughly $325 000, which is only slightly higher than Russia, $302 000, and somewhat higher than Brazil $280 000. When South Africa is measured against Turkey, South Africa's developmental peer, with an output per government worker of $650 000, SA's figures look dismal. The developing world figures are significantly lower than the developed world average of $727 000.

For robustness, we also considered the productiveness of government expenditure from a functional classification viewpoint. The three largest expenditure items include education, healthcare and interest. Since 2008/09 to 2017/18 the average spend on these items were 21.1%, 12.4% and 9.4%, respectively; a combined total of 42.9%. Considering that most of the government's spending is done on current expenditure items (on average 93.7% since 1994/95), it is easy enough to assume that most of the government's debt was not accumulated to acquire assets but rather to pay for current expenditure. For this reason, we can assume that the interest payments the government make are mostly unproductive; these payments do not increase long-term total factor productivity or some other measure of productivity.

In some instances, spending on education and possibly even healthcare is wealth creative, i.e. they increase total factor productivity. However, the dismal performance of education (IEA, 2016) and healthcare (New Narrative Ltd., 2018) in SA suggest that spending on these items do not significantly contribute to productivity gains. The assumption is that a healthy, educated labour force is more productive, and therefore contribute to long-term economic growth. As a percentage of total annual expenditure, an average of 12.4% was spent on healthcare and 21.1% on education, during the 2008/09 to 2017/18 period. In terms of the quality of service produced by these two expenditure items, South Africa ranked either last, or second last in the world. Unfortunately, due to the poor quality of output in these sectors, South Africa most likely did not realise the potential productivity benefits from these expenditure items. This also helps to explain the mixed results researchers like Ansari et al. (1997), Ziramba (2008), and Alm and Embaye (2010) found when attempting to discern the relationship between national income and government expenditure in South Africa. Although there are many other studies that find similar results, we briefly consider three major studies on South Africa's education and healthcare to illustrate the lack of efficient output from these industries.

The International Association for the Evaluation of Educational Achievement (IEA) regularly conducts comparative assessments on student achievements in mathematics, sciences, and reading. IEA's Trends in International Mathematics and Science Study (TIMSS), and the Progress in International Reading Literacy Study (PIRLS) review assessments on education across more than 60 countries. In 2011 the TIMSS and PIRLS reports showed that SA ranked last in mathematics, science and reading, among all countries surveyed (IEA, 2011). In 2015 the TIMSS study showed that South Africa once again ranked last in science, but second to last in mathematics (IEA, 2015). In 2016 the PIRLS study reported that South Africa once again ranked last in reading achievements among all countries surveyed (IEA, 2016).

The Future Health Index (FHI) is commissioned annually by Philips and measures the value-based outcome of a country's healthcare system (New Narrative Ltd., 2018). Overall the index considers access to care, patient outcomes, and the ability of healthcare systems to provide satisfactory outcomes to both patients and practitioners, at optimum cost. The index therefore, also considers the size of spending on healthcare, as a percentage of GDP. According to their findings South Africa ranked last among the 16 countries analysed. South Africa's efficiency ratio score was a mere 11.09, much lower than the global average of 26.69. Even compared to our emerging peers, SA ranks worryingly low. Brazil, Russia, and China scored 22.06, 27.38, and 38.19, respectively.

Using the studies mentioned above we conclude that government expenditure in SA is not productive. For this reason, it would be difficult for expenditure to produce sustainable long-term economic growth ($G \rightarrow \mathrm{Y}$), although it may be possible to produce growth spurts in the short-term. It is, therefore, more reasonable to believe that Wagner's law ($Y \rightarrow \mathrm{G}$) is applicable to SA's economy, as suggested by Alm and Embaye (2010). These findings are further substantiated by Odhiambo (2015) who uses an auto-regressive distributed lag model (ARDL) to show that economic growth Granger-causes government spending in the long-term. From this, we can conclude that government's redistributive fiscal policies ($G \rightarrow \mathrm{Y}$) that focus on stimulating aggregate demand via social development are not conducive in producing economic growth in the long-term, like the conclusion reached by Jooste et al. (2013).

Like Akanbi (2013), Fedderke et al. (2006), and Inchauste et al. (2015), we suggest an alternative fiscal policy mix aimed at sustainable economic growth through wealth creative policies, those that focus on investment spending rather than spending on social development. Once wealth has been created, it can then again be aggressively redistributed.

1.2.2 A Fiscus for Sustainable, Inclusive Economic Growth

Research done by Fedderke et al. (2006) illustrate the importance of higher investment spending in SA. They show that investment expenditure can boost economic growth in the long run, both directly and indirectly by raising the marginal product of capital. Du Plessis and Smit (2006) draw a similar conclusion but emphasise the government's role in spending sufficiently on investment. Using an intertemporal CGE-model Mabugu et al. (2013) and Jooste et al. (2013) conclude that greater levels of current expenditure will not have a lasting impact on economic activity. These authors explain that governments who use current expenditures to boost growth in a cycle of fiscal expansion, increase the debt burden in the long run. Furthermore, although financing a fiscal expansion with tax increases will help to reduce the debt burden, it will also dampen initial economic benefits. Mabugu et al. (2013) show that the best fiscal policy tool the government can use is to increase investment expenditure. This can ensure sustainable economic growth for South Africa. Jooste et al. (2013) use three types of calibrated DSGE-models to show that in isolation, government investment has a greater impact on output than current expenditure or total expenditure. Wealth creative policies also help to reduce the long-term deficit and debt levels without forgoing some of the short-term benefits (Mabugu, et al., 2013). This is crucial in South Africa's current economic environment where the government deficit and debt levels are high.

Calderón et al. (2015) use a panel time series approach to evaluate how investments contribute to output. Specifically, their research considers the impact of power, transport and telecommunications infrastructure and shows that the long-run elasticity of output ranges between 0.07% and 0.10%. Their research makes an adjustment to correct for the effect of low productivity and corruption which is often related to government investment projects. They make this adjustment by using an investment index of physical capital, which they introduce in their long run aggregate production function. That is, rather than using government investment expenditure to determine the impact of investments on output, they used their constructed index to avoid previous shortcomings with these types of analyses. Results generated by Claderón et al. (2015) are supported by earlier meta-analysis results generated by Bom and Ligthart (2008).

After adjusting for publication bias, Bom and Ligthart's (2008) initial findings on the output elasticity of investments can be adjusted to 0.09% (Calderón, et al., 2015). It is also important to note that although the research by Calderón et al. (2015) considers 88 different countries, parameter homogeneity tests indicate that there are no significant differences between countries. In fact, using time-series analysis in a vector error-correction mechanisms (VECM) framework, Fedderke et al. (2006) found similar results for South Africa: an output elasticity between 0.06% and 0.20%. Using this information, we have adjusted our simulations in a similar fashion by allowing exogenous investment increases to occur through a subsidy in the construction industry, rather than simply increasing the government's investment expenditure. By using a tax cut (subsidy) in this manner we also comply with Akanbi (2013), who noted that tax-related fiscal policies will be more effective in South Africa's structurally constrained economy.

An alternative fiscal policy mix is needed to facilitate greater levels of inclusive, sustainable economic growth. We suggest, and will later show, that by reducing policies that focus on social development, and using the savings generated from these decisions to increase investment expenditure, the government can create an environment of inclusive, sustainable economic growth.

1.3 Aim and Contribution of Study

The aim of this study is to provide policymakers with a better fiscal policy mix that can lead to sustainable, inclusive economic growth. By using general equilibrium analysis, we investigate the proposed shift in policy from its current emphasis on social development towards economic development. More specifically, we model the impact of keeping the real wage bill of civil servants fixed for a period of five years. Savings from this initial step can then be used to reduce taxes or government's overall debt levels. However, our aim is to show how savings can be used to grow the economy sustainably, whilst considering the impact on such variables as household incomes. For this reason, savings are used to increase investments. The design and calibration of the policy simulation is discussed in the Chapters 4 and 5.

We evaluate the economic consequences of these policy-induced changes to government's fiscus by using The Enormous Regional Model of South Africa (TERM-SA), a dynamic, regional computable general equilibrium (CGE) model of South Africa. In achieving this outcome, several noteworthy contributions are made. The first of which is the MONASH-style dynamics of Dixon and Rimmer (2002) that were added to a standard TERM model which was originally built by Horridge et al. (2005) and is now adopted for South Africa's economy. The model theory of this addition is discussed in Chapter 2.

A major contribution is the construction of a suitable regional database that can accurately portray the South African economy, its regions, fiscal policies, and household consumption patterns. To construct a more accurate representation of the government accounts we used the most detailed national and regional expenditure data available; as far as we are aware this is the first use of such detailed data in macro-economic policy modelling in South Africa. Unlike standard CGE models, TERM-SA also considers three different types of government industries. Instead of only modelling one government industry, often the case in macro-economic models, TERM-SA differentiates between three government industries: education, health, and general government services. To produce detailed results on different types of households, their incomes, occupations and consumption patterns, we add multiple household modelling in TERM-SA. Furthermore, to better illustrate how factor incomes, tax revenues, and interest on outstanding debt accrue to households, government and enterprises, TERM-SA includes Social Accounting Matrix (SAM) modelling capabilities. These additions allow TERM-SA to better illustrate the link between producers and users in the South African economy. By combining the model theory with accurate data, TERM-South Africa is capable of quantitatively analysing our policy questions within the model's general equilibrium environment. The model database is discussed in Chapter 3.

Our final contribution is the policy simulation and interpretation of results. Based on advanced methodology, we provide policymakers with fresh analysis and evidence to consider. After developing a suitable model closure and constructing a plausible baseline, we interpret the economic impact of the suggested changes to government's fiscal policy mix, as deviations away from the baseline forecast. This simulation helps to explain the South African government's role in sustainable, inclusive economic growth. The simulations are discussed and analysed in Chapter 5.

As our initial assessment showed (as discussed in the preceding section) the government's current redistribution strategy focusing on social development is not effective in producing sustainable, inclusive economic growth. We furthermore model controversial policy issues such as keeping the government's real wage bill fixed over a five-year period. However, it must be understood that our aim is to provide fresh evidence and analysis to policymakers, and not to deter from the progress that has been made to date. Taking this into consideration, we believe that this study has the potential to make a valuable contribution to the literature on fiscal policy and its role in creating sustainable, inclusive economic growth in South Africa.

In Chapter 2 we discuss the theoretical structure of TERM-SA by providing a detailed description of the flows database, production structure, and sourcing mechanisms used in our model. Chapter 2 also provides an explanation on how the dynamic extensions in TERM-SA work and provides the theoretical framework for multiple household modelling in TERM-SA. Finally, we discuss the SAM extension that has been added to TERM-SA to capture various behavioural equations that are often excluded from MONASH-style CGE models.

Chapter 3 looks at TERM-SA's database, how we use a National Input-Output database, adjust for specific industries, and add regionality. In Chapter 3 we also discuss the SAM-database and provide illustrations to explain the addition of new behavioural equations. The final section of this chapter explains how the model database is calibrated.

In Chapter 4 we discuss the model closures that will be used in our policy analysis by providing a stylised representation of TERM-SA. Specifically, we explain how the forecast (baseline) and policy closures are set up to facilitate the analyses of an alternative fiscal policy mix.

In Chapter 5 we introduce our simulation by first explaining our baseline findings. From here we interpret our policy shocks and simulation results. Finally, we provide concluding remarks for this thesis and provide suggestions for possible future research.

CHAPTER 2 – MODEL THEORY

2.1 Introduction

Chapter 2 sets out a detailed explanation of TERM-SA's theoretical structure. First, we provide an overview of TERM-SA and how our model is built on the core principles of CGE-models, those of ORANI (Dixon, Parmenter, Sutton and Vincent, 1982) and TERM (Horridge, et al., 2005). A detailed account of the core principles is illustrated by TERM-SA's flow database, production structure and sourcing mechanisms. Then, we focus on explaining the dynamic extension that was added to the core CGE principles. These include capital accumulation, lagged wages, and government debt accumulation. TERM-SA also allows for multiple household modelling, which is elaborated on. Finally, we provide the theoretical background to TERM-SA's SAM extension. In addition to multiple households, this SAM extension added to the more standard regional, dynamic CGE-model, is what differentiates TERM-SA. These additions allow TERM-SA to better illustrate the link between producers and users throughout the rest of the economy.

2.2 Theoretical Structure of TERM-SA

2.2.1 Overview of TERM-SA

TERM-SA is a multi-regional, dynamic, computable general equilibrium (CGE) model of the South African economy. Its theoretical structure follows that of the bottom-up TERM (The Enormous Regional Model) developed by Horrdige et al. (2005), based on the ORANI model (Dixon, et al., 1982). By representing the South African economy in a bottom-up manner, each region has its own behavioural equations, input-output database and inter-regional trade matrices.

TERM-SA consists of a linearized system of theoretical equations that describe the behaviour of economic participants[1]. Main equations include the regional and inter-regional industry demands for intermediate inputs and primary factors. Typically, in CGE-models like TERM-SA, industries minimise the cost of production for a given level of output subject to a constant elasticity of substitution production function. Industries do this by optimising their mix of labour, capital and intermediary commodities. TERM-SA differs from national, single-region models, in that each commodity is produced by an industry or multiple industries in each region. Although TERM-SA allows regional industries to produce more than one commodity, each regional industry produces mainly one commodity.

Investment activity, which is affected by changes in the rates of return, produces sector-specific units of capital in each region (Wittwer, Vere, Jones and Griffith, 2005). As industries decide to source capital from cheaper regions, the investment response allows for regional capital mobility. Varying rates of return cause year-on-year adjustments in capital stock. The national labour supply is determined by demographic factors and is also assumed mobile between regions. This mobility is imperfect and is achieved in policy simulations by allowing for regional differences in real wages in both the short- and long-term. By introducing regional mobility to capital and labour, each region's stock of productive resources reflects regional labour markets and relative rates of return (Wittwer, et al., 2005). In the short-term, wages are assumed sticky on a regional level to allow initial labour market adjustments to come more from regional employment, than from regional wages. Wittwer, et al. (2005) also explain that regional wages can differ from national wages in the long-term. In doing so, not all long-term adjustments are facilitated by inter-regional labour movements.

The level of output in TERM-SA is based on final user demand, which reflects the prices of commodities and incomes of users. Final users of commodities include: households, investors, government and exporters. Like standard CGE-models, basic government demand, as well as direct and indirect taxation, are recognised in TERM-SA. Subject to their budget constraints, each regional household-type maximises utility through a Klein-Rubin utility function, as

[1] Theoretical equations are described in detail in Dixon and Rimmer (2002). It is important to note that regionality does not change the underlying theory of behavioural equations.

explained in Dixon et al. (1982) and Dixon and Rimmer (2002)[2]. Unlike ORANI-based national models, with a single government and representative household, TERM-SA has a government and multiple households in each region.

Originally, we intended to extend TERM-SA's modelling capabilities beyond the normal national government accounts to include additional government accounts, like Honkatukia (2013). We decided against this, in favour of adding more depth to the government data available in SA's National Accounts, to ultimately increase the accuracy of our simulation results. Some of the main reasons why we decided against the inclusion of additional government accounts include:

- On a provincial government level annual budget deficits or surpluses are written off and added to national government debt. Also, large net-interest payments are made by the national government, not by local authorities;
- Most of the spending is done by the national government, either directly through various national departments in each province, or indirectly through transfers that are made to provinces;
- The largest share of government revenue is sourced on a national level, and not by provinces; and
- The bulk of revenue provinces receive is through transfers from the national government.

By implementing multiple-household modelling like PHILGEM (Corong & Horridge, 2012) and INDOTERM (Horridge & Wittwer, 2006), TERM-SA is better suited to measure the impact of different economic policies and the fiscal incidence of government policies on different types of households in SA. However, unlike these models TERM-SA also allows for a dynamic long-term analysis of the impact of various policies on different household types.

Standard ORANI pricing equations form part of TERM-SA's theoretical core and are based on the premise that pure profits are zero, which imply that markets are competitive. Consistent

[2] A brief derivation of the Klein-Rubin utility function is provided in Appendix B4.

with South Africa being a small, open economy, import prices are exogenously determined (taken from the rest of the world). Export demand is inversely related to its price, denominated in a foreign currency. Like other CGE-models, market clearing conditions are also set up in TERM-SA. Other core equations, often associated with ORANI, describe items such as GDP, aggregate employment and the consumer price index.

In addition to the core CGE-equations of ORANI, TERM-SA also includes equations to allow year-on-year simulations. Originally developed by Dixon and Rimmer (2002), in their single-region Australian MONASH model, dynamics was later adopted for regional models by Wittwer et al. (2005). In TERM-SA, three main dynamic intertemporal links allow year-on-year simulations: capital accumulation, a lagged wage adjustment process, and government debt accumulation. Including social accounting matrix modelling (SAM-modelling) is another useful addition to the core theoretical structure of TERM-SA (Corong & Horridge, 2012). By including this extension, TERM-SA can model the link between producers and the rest of the economy in more detail.

We used GEMPACK software, developed by Harrison and Pearson (1996), to solve all the equations that were implemented on the 2012 regional input-output database of SA (Statistics South Africa, 2017). However, before the database was first updated using 2013 GDP figures (Statistics South Africa, 2018). For the purposes of this study we will only discuss the database in more detail in Chapter 3. After TERM-SA was successfully set up, it was tested for both real and nominal homogeneity, and passed both these initial tests.

2.2.2 The TERM-SA Structure

TERM models like TERM-SA can accommodate high dimensional data by employing various data generating and dimensionality reducing techniques[3]. One of these techniques includes the assumption that all regional users who source commodities from different regions, do so according to common properties (Stofberg & van Heerden, 2015). Figure 2A[4] from Horridge

[3] These are explained in more detail in Horridge (2011).
[4] It should be noted that there is a consistent link between the flows database illustrated in Figure 2A, the National I-O table illustrated by Table 2B, and the national SAM database illustrated by Table 3A. However, the

et al. (2005) reflects the Input-Output (I-O) database used by TERM-SA. It reveals the basic structure of TERM-SA and is key to its efficiency. The rectangles indicate flow matrices, and core matrices are typed in bold; these matrices are used as input data to estimate other matrices used by the model. The dimensions of the matrices are indicated by indices (c, s, i, m, etc.) which correspond to the following sets:

Table 2A: Main Sets of TERM-SA

Index	Short Name	Description	Size
s	SRC	Domestic or imported sources (DOM, IMP)	2
m	MAR	Margins levied on commodities	2
c	COM	Commodities[5]	30
i	IND	Industries[5]	30
o	OCC	Skills (occupation)[6]	11
h	HOU	Households	12
d	DST	Regions of use (Destination)[7]	9
r	ORG	Regions of origin	9
p	PRD	Regions of margin production	9
f	$FINDEM$	Final demanders (HOU, INV, GOV, EXP)	4
u	$USER$	Users = IND, $FINDEM$, $STOCKS$	6

Each flow-variable is expressed by a price and quantity variable. The number of variables and equations follow a very specific set of requirements (Horridge, et al., 2005) to ensure that the model can be solved.

Matrices in Figure 2A illustrate flow values according to the following pricing methods:

1. Basic prices = output prices for domestic commodities or CIF prices for imports.
2. Delivered prices = basic prices + margins.
3. Purchaser's prices = basic prices + margins + net-taxes = delivered prices + net-taxes.

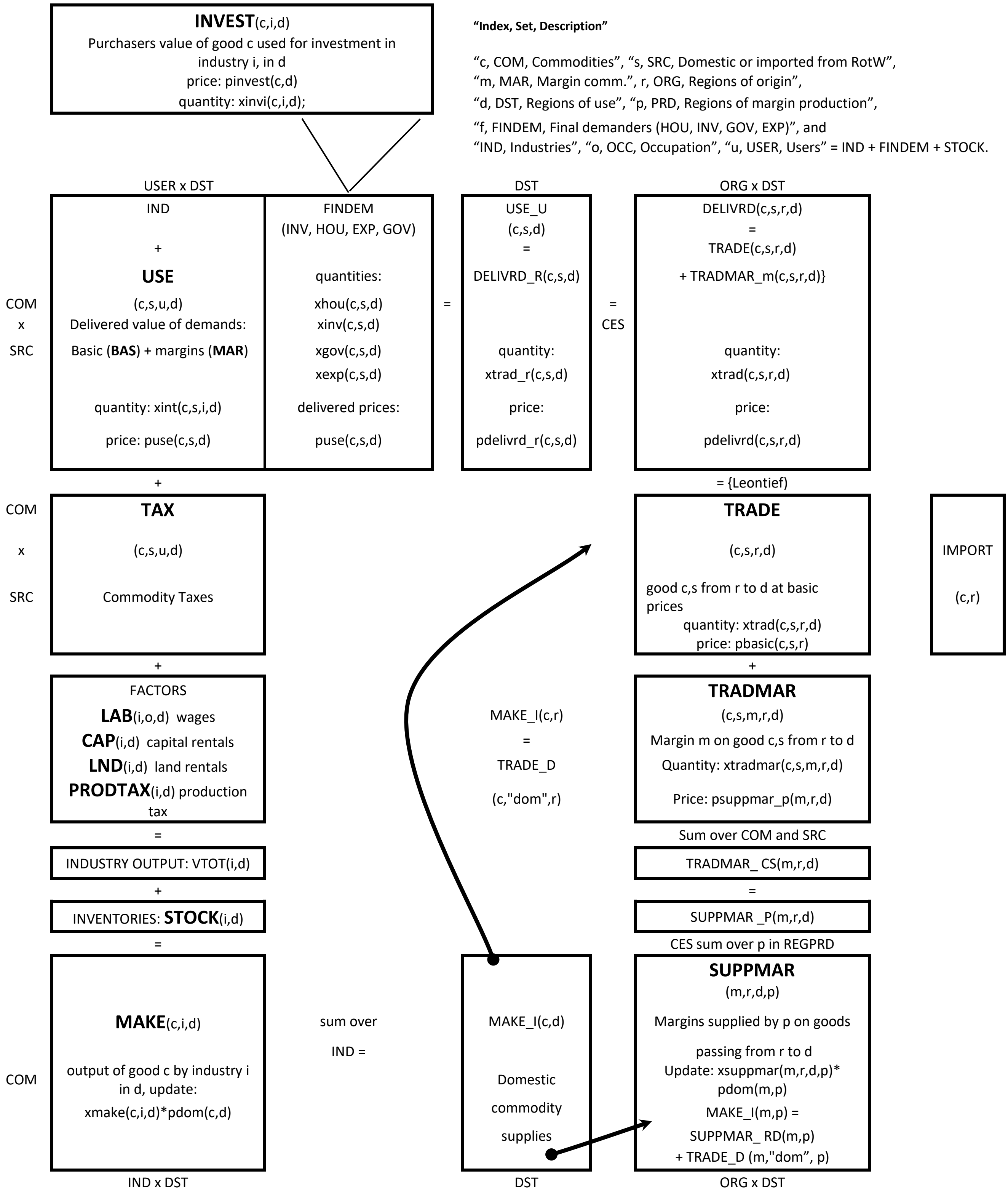
flows database includes regionality. Chapter 3 provides a detailed description of how these different databases were used to create the database used by TERM-SA. For consistency we applied similar code names between the different databases.

[5] A full list of the different commodities and their corresponding industries are supplied in Appendix A-1.

[6] A full list of occupations is supplied in Appendix A-2.

[7] A full list of regions is supplied in Appendix A-3.

Figure 2A: TERM-SA's Flows Database



Matrices on the left of Figure 2A refer to the regional input-output database. On the top-left TERM-SA's USE-matrix is illustrated by $USE(c,s,u,d)$, and represents those commodities that are used by various users in the South African economy. The USE-matrix consists of the delivered prices of each domestically supplied or imported (s in SRC) commodity (c in COM), that flows towards its destination region (d in DST) for each user. Users include industries (IND), change in inventories ($STOCK$) and four final demanders of commodities: households (HOU), investors (INV), government (GOV), and exporters (EXP). TERM-SA specifically distinguishes between these final demanders of commodities on a regional and national level. The TAX-matrix supplies information about commodity tax revenues and contains an element corresponding to each element of the USE-matrix. By combining the TAX-matrix with primary factor costs (labour, capital and land) and production-tax matrices, the total cost of production (or value of output) for each regional industry can be calculated (Horridge, et al., 2005). Concerning inventory ($STOCK$) in TERM-SA, we assume that there are no imported inventories. Also, inventories in domestic output is only regarded from an industry's output perspective and are not commodity-specific. We imply then that each industry shares the same inventory changes among all commodity types.

Regional sourcing is expressed on the right-side of Figure 2A. The $TRADE$-matrix shows trade flows between provinces (regions) in South Africa, but also between provinces and the rest of the world. The matrix consists of those commodities traded (c), the source region from where each commodity is traded (r in ORG), and a destination region to where each commodity is traded to (d), for both imported and domestically supplied commodities (s). The $IMPORT$-matrix contains the total amount of imports at each harbour and airport and is summed over all destinations (d) of the imported (imp in SRC) portion of the $TRADE$-matrix. The diagonal of the $TRADE$-matrix therefore, represents commodities that are produced and consumed in the same region, so that $r = d$. A good example of these types of commodities in TERM-SA are transport services. Of regionally produced transport services 81% is consumed in the region of production. For TERM-SA to calculate commodity output flows between origin and destination regions, a $DELIVRD$-matrix is calculated. This $DELIVRD$-matrix is calculated by summing over $TRADE$ and $TRADEMAR$-matrices.

The $TRADEMAR$-matrix shows those margins (m) used to facilitate the trade and flow (transport) of commodities between users (u) in various regions (d). $SUPPMAR$ reports the production of margins and assumes common proportionality. Horridge et al. (2005) imply that according to this, margins are not commodity and source dependant; the same proportion of margin (m) is produced in each region (p) and used in a similar way by all users who transport any commodity (c) from one region (r) to another (d). Users (u) in turn, demand margins according to a CES-type function from those regions (p) that produce them (Horridge, et al., 2005).

TERM-SA assumes that all users (u) of a given commodity (c, s) in a given region (d) have the same sourcing (r) mix. In effect, TERM-SA assumes there is a broker who decides on behalf of all users where supplies will be sourced from. Supply proportions in turn, are decided by an Armington elasticity: the matrix $DELIVRD\_R$ is a CES composite (over r in ORG) of the $DELIVRD$-matrix.

The arrow that shows a link between the $MAKE\_I$-matrix and the $TRADE$ and $SUPPMAR$-matrices, points towards a reconciliation between the demand and supply of local commodities in the database. To fulfil the requirements of reconciliation, certain margin-commodity and non-margin commodity assumptions must be met (Horridge, et al., 2005). Particularly, in the case of non-margin commodities, Horridge et al. (2005) explain that the summed-up part of domestically traded commodities in the $TRADE$-matrix must equal the corresponding element in the $MAKE\_I$-matrix; demand must equal supply.

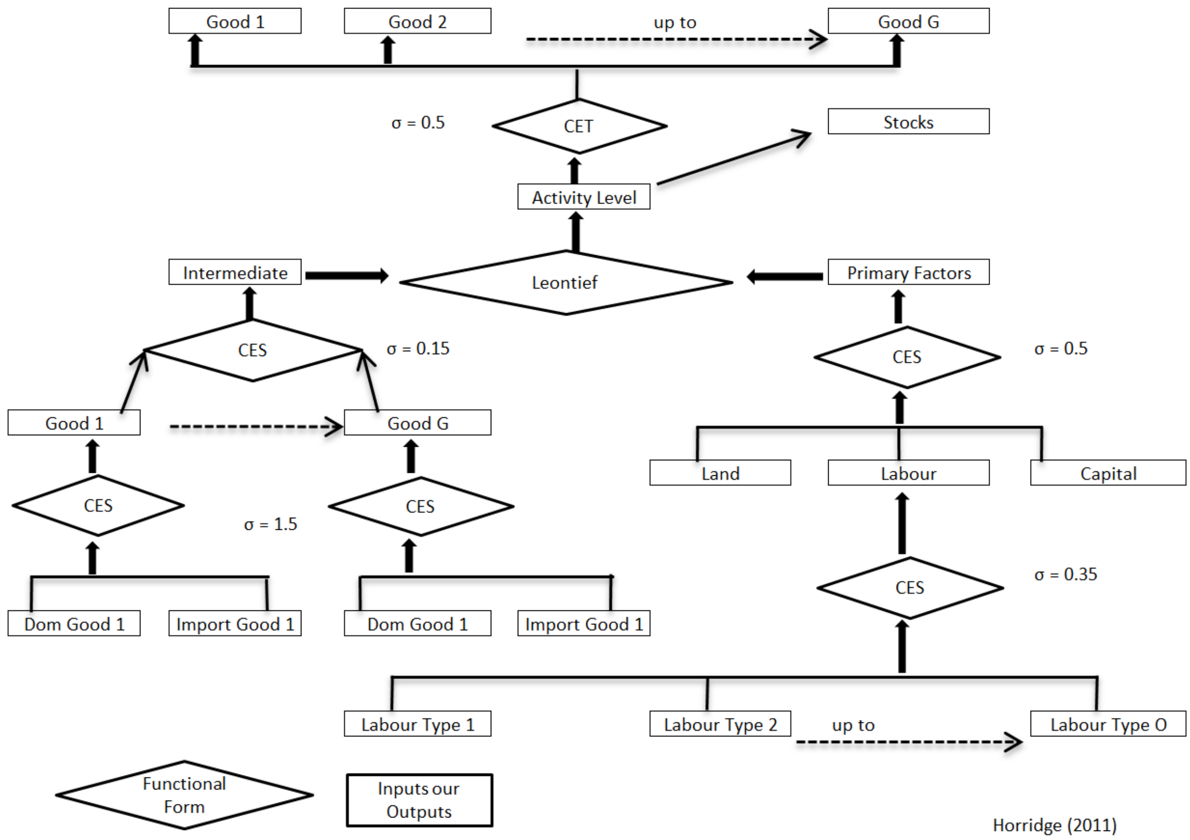
Horridge et al. (2005) also emphasise that the $INVEST$matrix in TERM models can disaggregate investment into an industry and commodity level, for each region. By doing so, TERM models like TERM-SA offer a unique opportunity to compare how different industries, in different regions distinguish the commodity composition of investment; as an example we might expect the farming industry in South Africa to use more machinery and less construction. Detailed household purchasing data ($HOUPUR$-matrix), also allows us to distinguish 12 household types, each with unique budget shares and preferences. These household types are differentiated based on their income and expenditure levels, following the definitions of South Africa's income and expenditure surveys (Statistics South Africa, 2012). In TERM-SA we start with a ten-decile distribution of household income and expenditure. However, we then split the poorest and richest deciles into ventiles.

One shortcoming of standard TERM models is their inability to illustrate how factor incomes and tax revenues accrue to households and government (Horridge, et al., 2005). To address this issue, TERM-SA follows the example set by Corong and Horridge (2012) and includes a Social Accounting Matrix (SAM) extension; this extension will be explained in detail in Section 2.5.

2.2.3 Industry Production in TERM-SA

Like standard CGE-models, industries in TERM-SA decide which commodities to produce through a process illustrated by Figure 2B (Horridge, 2011). Each industry chooses a cost-minimising combination of intermediate commodities and primary factor inputs (land, capital and labour). These decisions are subject to the industry's production function which is structured by a series of constant elasticity of substitution (CES) nesting assumptions (Horridge, 2011).

Figure 2B: The TERM-SA Production Structure



The area above the “Activity Level” in Figure 2B represents each industry’s supply of commodities. The decision on which commodity to produce, follows a constant elasticity of transformation (CET) function. Horridge (2011) assumes a common CET value of $\sigma = 0.5$. Industry inputs are transformed into industry outputs, which in turn, are calibrated from the $MAKE$-matrix in Figure 2A.

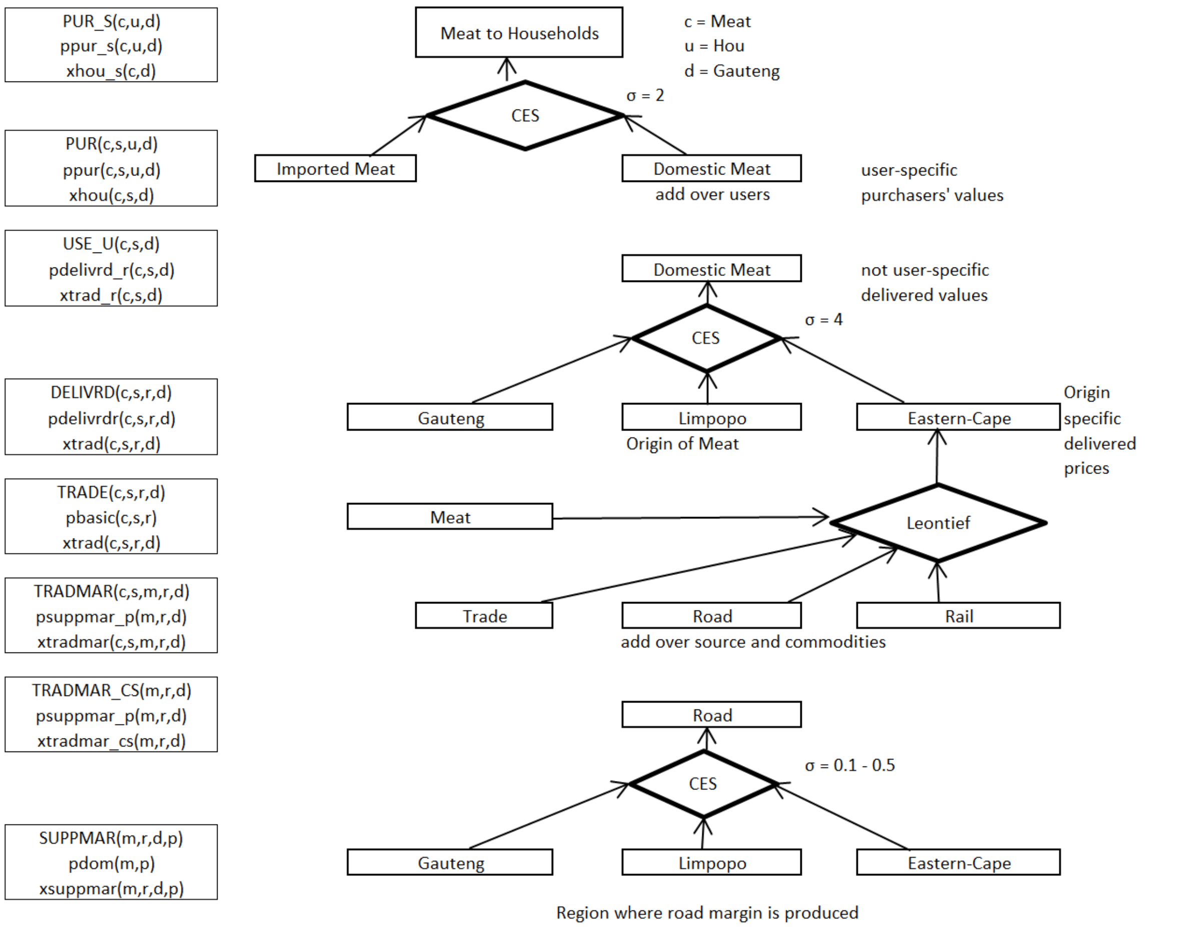
The area below the “Activity Level” corresponds to those inputs that are used by each industry to produce the commodity they decide to supply. Industries produce commodities by combining a fixed proportion (Leontief-type specification) of two high-level aggregates: intermediate commodities and primary factors. Intermediate inputs that are used by industries in the industry’s production processes are chosen based on a CES-specification; where CES is assumed $\sigma = 0.15$ (Horridge, 2011). Each commodity is also either sourced domestically or abroad, based on a CES-type decision; here, $\sigma = 1.5$ (Horridge, 2011). A more detailed description of the sourcing mechanisms of TERM-SA will be provided in Section 2.2.4. When choosing between primary factors (land, labour, and capital) a CES-specification is also used; in this instance Horridge (2011) assumes $\sigma = 0.5$. Finally, the choice of which level of skilled workers to employ is also based on a CES-specification; where $\sigma = 0.35$.

2.2.4 Sourcing Mechanisms in TERM-SA

Horridge et al. (2005) give a complete description of the sourcing mechanisms used in the South African version of TERM, called TERM-SA. They use Figure 2C to illustrate TERM’s substitution, and the accommodating data-sourcing abilities. Together, Figures 2A, 2B and 2C indicate the innovative nature of TERM models. In Figure 2C, adopted from (Stofberg and van Heerden, 2015), a simple example of red meat demanded by households in Gauteng from the Eastern Cape is used to illustrate TERM-SA’s sourcing mechanisms. In a similar manner these mechanisms can be applied to each of TERM-SA’s 30 commodities (COM), for each of the 30 industries (IND) and five users (USR), between each of the nine provinces (ORG and DST), to ultimately facilitate regional economic modelling in TERM-SA.

The text boxes on the left of Figure 2C link this figure to Figure 2A as each uppercase variable indicates the flow associated with a specific nesting system. These boxes correspond to the level of decision making in the economy; although in this example a single user (households) in a single region (Gauteng) decides to source a single commodity (meat). Important in TERM-SA's mechanics is the price (p) and quantity (x) variables associated with each flow, also indicated in each box of Figure 2C. Subscripts define a certain matrix and indicate an additional level of dimensionality.

Figure 2C: TERM's Sourcing Mechanisms



Horridge (2011)

From the top, a household in Gauteng decides to source meat domestically (dom in SRC) or abroad (imp in SRC) through a CES-type specification[8]. Following the guidelines in Horridge et al. (2005) elasticities have been awarded to each sourcing decision made by users in South Africa. In this instance, the decision between domestic or imported meat is $\sigma = 2$. Commodity demand is guided by user-specific prices, sourced from the PUR-matrix (a summation of the

[8] A detailed derivation of the CES function is provided in Appendix B3.

TAX and USE-matrices of Figure 2A). After the household in Gauteng decides to source their meat domestically, the household must decide from which province (DST) in South Africa to buy the meat from. This decision is guided by the value of delivered prices (basic prices + margin costs) through a CES-type specification; $\sigma = 4$. Delivered prices imply that even if meat producers keep prices fixed, a change in some other cost will affect regional market shares (Stofberg and van Heerden, 2015).

Aggregate regional demand, USE_U, can be obtained by summing demand over the users in each region. Horridge et al. (2005) suggest that household decisions on this level are best represented by an elasticity of four, $\sigma = 4$, as the model assumes that wholesalers, and not final demanders, decide where the meat would be sourced from. Common proportionality once again implies that the proportion of meat sourced from the Eastern Cape is the same for all users in Gauteng. This assumption allows regions with lower production costs to increase production costs in order to increase their market share (Horridge, et al., 2005).

The delivered price that a household in Gauteng pays after deciding to source meat from the Eastern Cape is indicated as a Leontief-type specification. This indicates how the delivered price consists of a fixed portion of the basic and margin costs of meat, in the second last step of Figure 2C Horridge et al. (2005) add that origin-destination pairs, which are far apart, heavy or bulky, have higher transport costs. This causes margin costs to have a greater share of the delivered price than subsequent commodity pairs which are closer together, consist of smaller packages, or are lighter in tonnes to transfer.

The bottom part of Figure 2C indicates the sourcing mechanism of road margins. The elasticity of these margins falls between 0.1 and 0.5 to allow for price competitiveness, and applies equally to the origin, destination and transit regions (Horridge, et al., 2005). A large elasticity of 0.5 is suitable for transport margins that can easily be relocated to cheaper regions; these include, but are not limited to, trucking services. A smaller elasticity of 0.1 fits the margin services that are demanded from the origin of production to reduce transport costs; a good example would be retail services.

2.2.5 Other TERM-SA Features

Horridge at al. (2005) conclude that the remaining features of TERM models like TERM-SA descend from ORANI and are therefore common to most other CGE-models[9]. Except for industry production, which was elaborated on in a Section 2.2.3, exports from regional ports to the rest of the world face a constant elasticity of demand (Horridge, et al., 2005). Household demand follows a linear expenditure system, while investment demand is exogenous. We follow the guidelines of standard CGE-models and exogenise government demand. A variety of closures are possible by using TERM-SA, like those elaborated on in Horridge et al. (2005). In the short-term we might exogenise industry capital stock and land endowments but allow labour to be mobile between industries within a specific region whilst only partially mobile between regions. On a regional level TERM-SA can also link household consumption to regional factor incomes.

Another feature of regional models like TERM-SA is the ability to apply macro closures on a national and/or regional level. Horridge (2011) uses the example of imposing a balance of trade constraint on a national level but allowing trade to be unconstrained on a regional level. TERM-SA can then force regional consumption to follow wage income and use an adjusting consumption variable to satisfy the national trade constraint. Another example includes allowing regional government spending to follow the region's GDP but fixing the national government expenditure to a specific level. In Chapter 5 we will explore specific shocks that have been applied to TERM-SA.

2.3 TERM-SA Dynamic Extensions

Three main dynamic inter-temporal links between successive years have been incorporated into TERM-SA: capital accumulation, a lagged wage adjustment process, and government debt accumulation. Single-region dynamic modelling is well documented in Dixon and Rimmer

[9] These features are explained in detail in Dixon et al. (1982) and elaborated on in Dixon and Rimmer (2002).

(2002) and was later adopted for multi-regional models, like TERM-SA, in Wittwer et al. (2005).

2.3.1 Capital Accumulation in TERM-SA

To facilitate recursive-dynamic modelling, a regional industry's capital stock must be allowed to adjust over time according to the level of investment in that regional industry (Dixon & Rimmer, 2002). Capital in industry (j) in a given region (r) accumulates in TERM-SA according to:

$$K_{j,r}(t+1) = \left(1 - D_{j,r}\right) * K_{j,r}(t) + I_{j,r}(t) \qquad (2.3.A)$$

where:

- $K_{j,r}(t)$ is the start of year capital stock of year t, for industry j in region r.
- $K_{j,r}(t+1)$ is the end of year capital stock of year t, for industry j in region r.
- $I_{j,r}(t)$ is the investment that occurred in industry j in region r during year t.
- $D_{j,r}$ is a parameter used for the rate of depreciation in industry j in region r.

For year t computations, $K_{j,r}(t)$ is set exogenously to reflect industry j's end-of-year capital in year $t-1$.

By discarding time subscripts, it can further be shown that:

$$EROR_{j,r} = EEQROR_{j,r} + DISEQ_{j,r} \qquad (2.3.B)$$

where:

- $EROR_{j,r}$ is the expected rate of return which capital owners in industry j in region r will receive in year t.
- $EEQROR_{j,r}$ is the expected equilibrium rate of return. This is the rate that is required to indefinitely sustain the current rate of capital growth in industry j in region r.

- $DISEQ_{j,r}$ is a measure of the disequilibrium in the current expected rate of return of industry j in region r.

Following MONASH-dynamics (Dixon & Rimmer, 2002), the expected equilibrium rate of return of TERM-SA is an inverse-logistic function, as illustrated by the AA' curve in Figure 2D (Dixon and Rimmer, 2002)[10]:

$$EEQROR_{j,r} = RORN_{j,r} + (1/C_{j,r}) * [\ln(K\_GR_{j,r} - K\_GR\_MIN_{j,r}) - \ln(K\_GR\_MAX_{j,r} - K\_GR_{j,r}) - \ln(TREND_{j,r} - K\_GR\_MIN_{j,r}) + \ln(K\_GR\_MAX_{j,r} - TREND_{j,r})] \quad (2.3.C)$$

where:

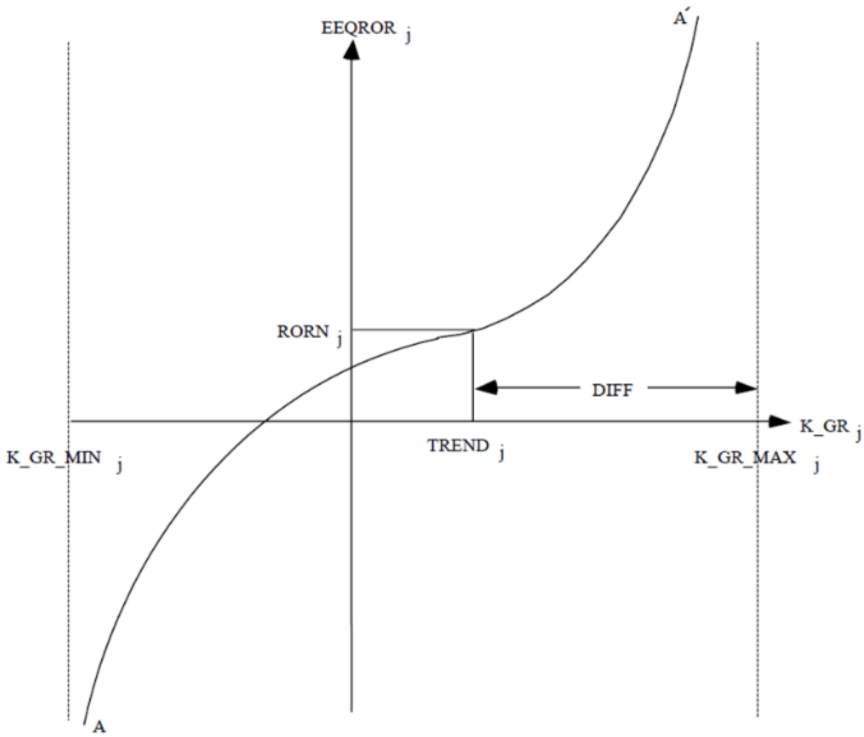
- $K\_GR_{j,r}$ is the capital growth rate of industry j in region r during year t, that is: $[K_{j,r}(t+1)/K_{j,r}(t) - 1]$.
- $K\_GR\_MIN_{j,r}$ is the minimum possible capital growth rate and is set equal to the negative of the rate of depreciation $D_{j,r}$ in (2.3.1), for each industry and region j,r.
- $TREND_{j,r}$ is each industry and region's normal capital growth rate, as observed over a given historical period.
- $K\_GR\_MAX_{j,r}$ is the maximum achievable capital growth rate of industry and region j,r. This rate is obtained by adding $DIFF$ in Figure 2D to $TREND_{j,r}$. TERM-SA follows the guidelines of MONASH (Dixon & Rimmer, 2002) and assumes a $DIFF$ value of 7%. Therefore, if the historically based $TREND_{j,r}$ rate is assumed 7.5% in South Africa, then we impose an upper limit on the simulated capital growth rate of 14.5%, during any year t.
- $C_{j,r}$ is a positive parameter that controls the sensitivity of industry j's equilibrium expected rate of return to variations in its capital growth rate.
- $RORN_{j,r}$ is the historical normal rate of return for a specific industry and region, j,r. For each industry and region, $RORN_{j,r}$ is therefore, an estimate of the average rate of

[10] Shift variables are included in the model code of TERM-SA that allow modelers to vertically shift the AA' curves of Figure 2D. This is a useful feature for forecast simulations and is employed if modelers have access to external information about either investment by industry, region, or about aggregate investment.

return that applies over the historical period in which $TREND_{j,r}$ is the average annual capital growth rate.

To better explain equation (2.3.C), Dixon and Rimmer (2002) start by assuming that $DISEQ_{j,r}$ in equation (2.3.C) is zero. By doing this it implies that industry j in region r must have an expected rate of return $EROR_{j,r}$ equal to $RORN_{j,r}$, to attract sufficient investment in year t, to ultimately achieve the historical trend capital growth rate, $TREND_{j,r}$. For an industry to attract sufficient investment in year t, to have its capital growth exceed (fall short of) trend growth $TREND_{j,r}$, its expected rate of return $EROR_{j,r}$ must exceed (be less than) the historical normal rate of return $RORN_{j,r}$.

Figure 2D: The Equilibrium Expected Rates of Return



Dixon and Rimmer (2002)

$C_{j,r}$ controls the sensitivity of industry j's capital growth, $K\_GR_{j,r}$, to variations in its equilibrium expected rate of return $EEQROR_{j,r}$ (Dixon & Rimmer, 2002). To choose the correct parameter value for $C_{j,r}$ it is therefore important to consider its derivation from equation (2.3.3), where:

$$C_{j,r} = \left[\frac{\partial EEQROR_{j,r}}{\partial K\_GR} \bigg|_{K_{GR_{j,r}} = TREND_{j,r}} \right]^{-1} * \frac{K\_GR\_MAX_{j,r} - K\_GR\_MIN_{j,r}}{(K\_GR\_MAX_{j,r} - TREND_{j,r}) * (TREND_{j,r} - K\_GR\_MIN_{j,r})}$$

(2.3.D)

By assigning a value to the slope of the AA' curve in Figure 2D somewhere in the region of $K\_GR_{j,r} = TREND_{jr}$ we can use formula (2.3.4) to evaluate appropriate values for $C_{j,r}$. Unfortunately, we do not have industry-specific data to allow assigning such a value. As a result, we had to obtain average estimates of the sensitivity of capital growth to variations, over all industries in a specific region, in expected rates of return. These estimates are indicated by the variable $SENS\_C$ in formula (2.3.5). In doing so $C_{j,r}$ can be calculated in formula (2.3.4) by using:

$$\left[\frac{\partial EEQROR_{j,r}}{\partial K\_GR_j} \bigg|_{K_{GR_{j,r}} = TREND_{j,r}} \right]^{-1} = SENS\_C \qquad (2.3.E)$$

From here, we can return to the RHS of equation (2.3.2). $DISEQ_{j,r}$ in year $t-1$ will usually be non-zero (Dixon & Rimmer, 2002). Expected rate of returns and capital growth data for year $t-1$ (observed or simulated), will usually not give a point on industry j's AA' curve. Dixon and Rimmer (2002) therefore, assume that disequilibrium disappears over time according to the following schedule:

$$DISEQ_{j,r} = (1 - \Phi_{j,r}) * DISEQ\_B_{j,r} \qquad (2.3.F)$$

where:

- $DISEQ_{j,r}$ and $DISEQ\_B_{j,r}$ are the errors between a regional industry's expected rate of return and the expected equilibrium rate of return, in year t and year $t-1$.
- $\Phi_{j,r}$ is a parameter that satisfies $0 < \Phi_{j,r} < 1$. $\Phi_{j,r}$ is commonly used as 0.5 (Dixon & Rimmer, 2002).

2.3.2 Rates of Return in TERM-SA, Static and Forward-looking

For each regional industry j the present value (PV) of a unit of capital in year t, is given by:

$$PV_{j,r}(t) = -\prod_{j,r}(t) + [Q_{j,r}(t+1) * (1 - T_{t+1}) + \prod_{j,r}(t+1) * (1 - D_{j,r}) + T_{t+1} * \prod_{j,r}(t+1) * D_{j,r}]/[1 + INT_t * (1 - T_{t+1})] \quad (2.3.G)$$

where:

- $\prod_{j,r}(t)$ is the regional industry j, r's cost of buying or constructing a unit of capital in year t.
- $Q_{j,r}(t+1)$ is the regional industry's rental rate, or the cost of using, capital in year $t+1$.
- $D_{j,r}$ is the regional industry's rate of depreciation.
- T_{t+1} is the income-tax rate of year $t+1$.
- INT_t is the nominal rate in year t.

Dixon and Rimmer (2002) mention that equation (2.3.7) illustrates three benefits capital owners receive for buying or constructing capital in year $t+1$. First, capital generates post-tax rentals to the value of $Q_{j,r}(t+1) * (1 - T_{t+1})$. Second, capital can be sold at the depreciated value of $\prod_{j,r}(t+1) *_{j,r}$. Finally, capital yields a tax deduction to the value of $(T_{t+1}) * (\prod_{j,r}(t+1) * D_{j,r})$. The PV of these three benefits for year t can be calculated by discounting the tax-adjusted interest rate as follows: $[INT_t * (1 - T_{t+1})]$.

Equation (2.3.7) can then be converted into an actual rate of return formula, $ACT\_ROR_{j,r}(t)$, by dividing both sides with $\prod_{j,r}(t)$ (Dixon & Rimmer, 2002):

$$ACT_{ROR_{j,r}}(t) = -1 + [(1 - T_{t+1}) * Q_{j,r}(t+1)/\prod_{j,r}(t) + (1 - D_{j,r}) * \prod_{j,r}(t+1)/\prod_{j,r}(t) + T_{t+1} * D_{j,r} * \prod_{j,r}(t+1)/\prod_{j,r}(t)]/[1 + INT_t * (1 - T_{t+1})] \quad (2.3.H)$$

This actual rate of return of capital in industry j during year t is defined as the PV of an investment of one rand. Expected, rather than actual rates for return, determine capital growth and investment in TERM-SA. We therefore assume that capital growth and investment in year t depend on the expectations concerning $ACT\_ROR_{j,r}(t)$. Like MONASH, in Dixon and Rimmer (2002), TERM-SA allows us to specify rates of return according to static or forward-looking expectations. The following section will briefly elaborate on the static approach[11].

Following static expectations, we assume that investors expect no change in the tax rate, so that $T_{t+1} = T_t$. It is further assumed that rental rates ($Q_{j,r}$) and asset prices ($\prod_{j,r}$) will increase by the current rate of inflation (INF). The expectation of $ACT\_ROR_{j,r}(t)$ can then be expressed as:

$$ROR\_SE_{j,r}(t) = -1 + [(1 - T_t) * Q_{j,r}(t)/\prod_{j,r} + (1 - D_{j,r}) + T_t * D_{j,r}]/(1 + R\_INT\_PT\_SE_{t,r}) \qquad (2.3.I)$$

where:

- $ROR\_SE_{j,r}(t)$ is the regional expected rate of return for industry j in year t under the static expectations specification.
- $R\_INT\_PT\_SE_{t,r}$ is the regional static expectation of the real post-tax interest rate, which can be defined by:

$$1 + R\_INT\_PT\_SE_{t,r} = [1 + INT_t * (1 - T_t)]/[1 + INF_t] \qquad (2.3.J)$$

2.3.3 Lagged Wages in TERM-SA

MONASH-style wage dynamics, as adopted in TERM-SA, offer a unique approach amongst economic models for estimating the impact of economic shocks on real wages and employment (Dixon & Rimmer, 2002). Instead of having to choose between flexible real wages and sticky employment (typical of short-term modelling), or sticky wages with flexible employment (typical of long-term modelling), TERM-SA can simulate an in-between point, or

[11] A detailed description of the forward-looking approach is given in Dixon and Rimmer (2002).

partial adjustment. In TERM-SA's approach real wages can be assumed fixed in the short-term, generating gains in aggregate employment, but flexible in the longer-term, which generate gains in real wages. This process is achieved by assuming that deviations in real wages change at a rate proportional to the difference between the forecasted national employment and its base case values (Dixon & Rimmer, 2002). The rate of proportionality is chosen at levels consistent with conventional macro-economic modelling so that employment effects that occur after some economic shock, are mostly eliminated after five years. In these instances, the non-accelerating inflation rate of unemployment (NAIRU) is either exogenous or weakly dependant on the real wage rate (Dixon & Rimmer, 2002). The application of this theory can be expressed as:

$$\left\{\frac{W^p(t)}{W^f(t)} - 1\right\} = \left\{\frac{W^p(t-1)}{W^f(t-1)} - 1\right\} + \alpha\left\{\frac{E^p(t)}{E^f(t)} - 1\right\} \qquad (2.3.K)$$

where:

- $W^P(t)$ is the real before-tax wage rate of the policy simulation.
- $W^f(t)$ is the real before tax wage rate of the forecasted simulation, during year t.
- α, is a coefficient greater than zero.
- $E^P(t)$ and $E^f(t)$ express aggregate employment in the policy and forecast simulations during year t.
- $\left\{\frac{W^p(t)}{W^f(t)} - 1\right\}$ is the proportional deviation of the forecasted real wage rate from its base-forecast in year t.
- $\left\{\frac{W^p(t-1)}{W^f(t-1)} - 1\right\}$ is the proportional deviation during $t-1$, which is brought forward into the current year t.
- $\left\{\frac{E^p(t)}{E^f(t)} - 1\right\}$ is the proportional deviation of the forecasted level of national employment from its base-forecast during year t.

Four steps are completed in TERM-SA to capture deviations between forecasted policy variables and their base values to adjust those deviations back to baseline values. First, TERM-SA uses the estimated core model results of percentage changes in real wages and employment. These values are then transferred from the baseline simulation to the forecasted policy simulation. Lagged deviations in the wage and employment rates, which have been brought forward into year t, are then calculated. Finally, the deviation in the real wage rate which is required to adjust the forecasted value back to its baseline value, is estimated.

2.3.4 Government Debt Accumulation in TERM-SA

Following MONASH-dynamics of Dixon and Rimmer (2002), a final inter-temporal link which has been included in TERM-SA, is government debt accumulation[12]. Government debt at the end of year t, GD_{t+1}, equals government debt at the start of year t, GD_t, plus the deficit, $GDef_t$, realised during year t[13]:

$$GD_{t+1} = GD_t + GDef_t \tag{2.3.L}$$

where it can be shown that the government deficit is obtained by subtracting total expenditure, $VEXPGOV_t$, in year t, from total revenue, $VINCGOV_t$, during year t[14]:

$$GDef_t = VINCGOV \ - VEXPGOV_t \tag{2.3.M}$$

Net-interest payments are estimated by applying an interest rate to the total outstanding public-sector debt at the beginning of each year t. These, and other payments are captured in government's $VEXPGOV_t$-equation. The recipients of these interest payments are households and enterprises; this will be explained in more detail in Section 2.5.2 and 2.5.3. It is worthwhile to explain that although debt will follow figures that resemble data from South Africa's National Treasury (Treasury, 2018) interest payments will not match exactly, because we assume inflation is zero. More about this will be explained in Section 5.2.3. By implication TERM-SA models real, and not nominal interest rates. Consequently, interest payments will

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[12] It is important to note that government debt is not modelled on a regional basis in TERM-SA. This is done because provinces (regions) in South Africa do not accumulate debt, only the national government accumulates debt.

[13] Following the guidelines of MONASH (Dixon & Rimmer, 2002) a control equation has been added to ensure that government debt at the start of year t equals debt at the end of year $t-1$.

[14] A detailed description of total government revenue and expenditure will be provided in Section 2.5 on the SAM-Extension.

appear less in level's (absolute) term; after real interest rates have been multiplied with outstanding debt. However, it should be noted that although debt accumulation differs in absolute terms it does not differ in terms of deviation away from the baseline, which we are more concerned about in TERM-SA.

2.3.5 Accumulation of Net Foreign Liabilities in TERM-SA

Estimating the accumulation of net foreign liabilities (assets minus liabilities) over time, follows a similar approach to other dynamic models, explained in detail in Dixon and Rimmer (2002). Net foreign liabilities (NFL) at the end of year t, is equal to the sum of NFL at the start of year t, and the additional liabilities accrued during that year. Additional assets and/or liabilities that were accrued during a particular year t, are expressed in the balance on the current account (CAD). Later, in Section 2.5.8, equation (2.5.P) will express the CAD as $VSAVROW$, the savings generated by foreigners on net flows between South Africa and the rest of the world.

NFL during year t, can therefore be expressed as:

$$NFL_{t+1} = NFL_t + CAD_t \tag{2.3.N}$$

It is also worth noting that the CAD can be expressed as the difference between savings and investments during a particular year (Dixon & Rimmer, 2002). Table 2B in Section 2.5 will show that this difference is the savings generated by foreigners, who are also referred to as the rest of the world. In the case where savings are less than investments, as is often the case in South Africa who has an average CAD deficit of 3.8% between 2009 and 2018 (South African Reserve Bank, 2018), a country becomes a net borrower from the rest of the world.

Some important assumptions are made with respect to the CAD in TERM-SA. First, the South African Reserve Bank's definition and expression of the CAD is followed (South African Reserve Bank, 2018). Second, all foreign assets liabilities are assumed to be repayable in South African Rands, after the necessary exchange adjustments have been made. Finally, interest payments are calculated by applying an interest rate on the total outstanding net foreign liabilities at the beginning of each period. This rate was initially estimated using data from the SARB (South African Reserve Bank, 2018).

2.4 Multiple Household Modelling

Unlike standard macro-economic models with a single representative household, TERM-SA allows for multiple household modelling. Allowing for such modelling, TERM-SA is better able to determine the fiscal incidence of policies on different household types. This is an important addition because of the high levels of income inequality in South Africa. In fact, compared to other countries, inequality in SA is often among the highest in the world (Alvaredo, Chancel, Piketty, Saez & Zucman, 2018). Any policy changes made to South Africa's economy should be viewed in terms of their impact on the real incomes of different household types.

TERM-SA includes a regional, multiple-household extension to effectively measure the impact of economic policies on South African households and their disposable incomes. Single region models like MONASH (Dixon & Rimmer, 2002) are often limited to a single household that represents all households in the economy. In regional models like TERM (Horridge, et al., 2005) each region has its own representative household. However, following models like the static, but regional INDOTERM (Horridge & Wittwer, 2006) or dynamic, regional USAGE-TERM (Wittwer, 2017), TERM-SA includes multiple households in multiple regions.

TERM-SA distinguishes between 12 household types; the first and last deciles have been split into ventiles. This addition applies the core ORANI household behavioural equations (Dixon, et al., 1982) to each type of household in each region. Each regional household-type can then maximise their own Klein-Rubin utility function, subject to their own budget constraints and individual preferences.

By using 2011 regional Income and Expenditure (IES) data from StatsSA (Statistics South Africa, 2012), which was pre-built and provided by Quantec[15], TERM-SA allows household modelling for 12 household-types in each region (province) of SA. Households are divided into groups based on their total income and spending, according to IES-data[16]. The first and last decile groups have been split in two ventiles, which ultimately allow us to express South African households from the poorest 5% to the wealthiest 5%.

An illustrative example of higher maize prices in SA illustrates the benefits of TERM-SA's multiple household modelling. On the one end, higher maize prices increase the cost of living of poor households because maize is a comparatively large portion of their living costs. On the other end higher maize prices also increase agricultural incomes in maize producing regions. However, many of the poorest households earn wages in these areas. The net effect of this scenario, whether it is beneficial or not to the poorest households, can be estimated by TERM-SA. This illustrative example emphasises the importance of multiple-household modelling in lower to middle-income countries where poverty is abundant and income distribution unequal. Single representative households, national or regional, cannot capture the impact of policies or other external shocks (like a drought) on the poorest households in a specific country.

2.5 The SAM-extension

Following the example of PHILGEM (Corong & Horridge, 2012), TERM-SA includes additional behavioural equations to allow social accounting matrix modelling (SAM-modelling) of the South African economy. By drawing on supplementary SAM-data TERM-SA can overcome the inability of standard MONASH-style CGE-models and illustrate how factor incomes, tax revenues, and interest on outstanding debt accrue to households, government and enterprises. TERM-SA is therefore better able to illustrate the link between producers and the

[15] Quantec is a consultancy providing economic and financial data, country intelligence and quantitative analytical software: https://www.quantec.co.za/.
[16] The complete household-split process will be explained in detail in the Chapter 5.

rest of the economy. Previous South African SAM-models, like IDCGEM Coetzee, Kwarada, Naude and Swanepoel (1997) and the simplified PEKGEM (Centre of Policy Studies, n.d.), also included some parts of SAM-modelling. However, IDCGEM does not include dynamics like PEKGEM or TERM-SA. Neither PEKGEM or IDCGEM allow multiple-household modelling or include SAM-based behavioural equations for enterprises, and both are based on SA's outdated 1995 SAM-database. These shortcomings have all been addressed by TERM-SA.

The following Sections, 2.5.1 to 2.5.9, will consider the additional SAM-based behavioural equations that have been added to TERM-SA. Naming of SAM-related data conform to SAM-conventions, this implies that flows are named based on the row (income) and column (expenditure) where the data is sourced. As an example, $VGOVGOS$ refers to the government income from gross operating surplus. Similarly, $VTAXENT$ specifies the direct income tax paid by enterprises. SAM-related datapoints are illustrated as shaded blocks in Table 2B. Those blocks that are not shaded represent data from TERM-SA's core databases, the standard CGE-database that were elaborated on earlier in Chapter 2. To ensure consistency between core, SAM and regional (flows) databases, we've adopted similar naming conventions between these databases. This is illustrated in Figure 2A and later in Table 2B and 3A. Each row reflects the income of a specific source, which drives expenditure in the corresponding column. A detailed description of each equation, variable and coefficient, is available in Corong and Horridge (2012). The following section will only include key equations and their descriptions. An important addition that was made to TERM-SA is addition of gross operating surplus earned by foreigners, which will impact on net transfers and net foreign liabilities, as well as certain debt dynamics and interest payments on both government debt and foreign liabilities.

Table 2B: TERM-SA SAM-Database

		1 Industries	2 Domestic Commodities	3 Imported Commodities	4 Labour	5 Capital	6 Production Taxes	7 Commodity Tax	8 Tariff	9 Direct Tax	10 Households	11 Enterprises	12 Government	13 Government Investment	14 Private Investment	15 Inventories	16 Rest of the World	17 Total
	Dimension	IND	COM	COM	OCC	CAP	PRODTAX = 1	1	COM	1	HOU	ENT =1	GOV = 1	IND	IND	IND	1	1
1 Industries	IND		MAKE(c,i)															Sales
2 Domestic Commodities	COM	BAS(c,d,IND) + MAR(c,d,IND)									BAS(c,d,HOU) + MAR(c,d,HOU)		BAS(c,d,GOV) + MAR(c,d,GOV)	BAS(c,d,INV) + MAR(c,d,INV)	BAS(c,d,INV) + MAR(c,d,INV)	BAS(c,d,STOCK) + MAR(c,d,STOCK)	BAS(c,d,EXP) + MAR(c,d,EXP)	Demand for Domestic Commodities
3 Imported Commodities	COM	BAS(c,i,IND)									BAS(c,i,HOU)		BAS(c,i,GOV)	BAS(c,i,INV)	BAS(c,i,INV)	BAS(c,i,STOCK)	BAS(c,i,EXP)	Demand for Imported Commodities
4 Labour	OCC	LAB(i,o)																Wage Income
5 Capital + LND	CAP	CAP(i) + LND(i)																Capital Income
6 Production Taxes	1	PRODTAX + OCT																Production Tax
7 Commodity Tax	1	TAX(c,s,IND)									TAX(c,s,HOU)		TAX(c,s,GOV)	TAX(c,s,INV)	TAX(c,s,INV)		TAX(c,s,EXP)	Commodity Tax
8 Tariff	COM			TAR(c)														Tariff
9 Direct Tax	1										VTAXHOU	VTAXENT						Income Tax
10 Households	HOU				LAB_I	VHOUGOS						VHOUENT	VHOUGOV				VHOUROW	Household Income
11 Enterprises	1					VENTGOS					VENTHOU		VENTGOV				VENTROW	Enterprises Income
12 Government	1					VGOVGOS	PRODTAX + OCT	TAX_csu	TAR(c)	VTAXHOU + VTAXENT	VGOVHOU	VGOVENT					VGOVROW	Government Income
13 Government Investment	1												VGOVINV_I					Government Investment
14 Savings	1										VSAVHOU	VSAVENT	VSAVGOV				VSAVROW	Savings
15 Stocks	IND														STOCK(IND)			Stocks
16 Rest of the World	1			BAS_csu* - TAR_c		VROWGOS					VROWHOU	VROWENT	VROWGOV					Foreign Exchange Receipts
17 Total	1	Output	Supply of Domestic Commodities	Supply of Imported Commodities	Wage Costs	Cost of Capital	Production Tax	Commodity Tax	Tariff	Income Tax	Household Expenditure	Enterprises Expenditure	Government Expenditure	Government Investment	Private Investment	Inventories	Foreign Exchange Receipts	

Note: BAS_csu is a summation of the BAS-matrix over the commodity, source, and user dimensions. Shaded cells indicate additional data from the SAM-database (i.e. not found in the core national CGE database). Legend: IND – number of industries (30); COM – number of commodities (30); OCC – number of occupations (11), CAP – types of Capital; HOU – number of households (12).

2.5.1 Gross Operating Surplus

The total gross operating surplus ($VGOS$) produced annually in South Africa's economy is obtained by summing the capital (CAP_I) and land (LND_I) rentals:

$$VGOS = CAP\_I + LND\_I; \tag{2.5.A}$$

Income derived from GOS (row 5) are allocated to households, enterprises, government and the rest of the world (column 5) according to SAM-data weightings. Using the TABLO code in which TERM-SA is coded, the following equation from Corong and Horridge (2012), measures the nominal percentage change in total GOS:

$$VGOS * wgos = CAP\_I * w1cap\_i + LND\_I * w1lnd\_i; \tag{2.5.B}$$

Each specific user's income from GOS is assumed to follow a weighted percentage of the previous equation.

2.5.2 Enterprises Account

The enterprises account represents all public and private corporations (including financial and non-financial corporations) in South Africa. Enterprises in SA receive an income ($VENT$, the sum of row 11) from factors ($VENTGOS$), households ($VENTHOU_{HOU}$), the rest of the world ($VENTROW$), and from the government ($VENTGOV$):

$$VENT = VENTGOS + VENTHOU_{HOU} + VENTROW + VENTGOV \tag{2.5.C}$$

Payments made to enterprises from various household-types (poorest to richest) in SA include property income payments and secondary distribution of incomes. Van Seventer, Hartley, Gabriel and Davies (2016) explain that the secondary distribution of income includes: interest on mortgage bonds, certain private contributions to pensions, as well as employer contributions to pensions.

It is therefore, reasonable to assume that the percentage change in these payments follow the percentage change in GOS earned by households. Another default assumption is that the percentage change in income received from the rest of the world, follows the growth rate of the South African economy. It is however, important to note that these default assumptions used by Corong and Horridge (2012) can be altered to fit the modelers' requirements.

Payments from government to enterprises is expressed by equation (2.5.D). Property income payments and the secondary distribution of incomes that are made from government to enterprises are represented by GOV_TR_ENT in equation (2.5.D). In addition to these payments, TERM-SA's dynamic extension of debt accumulation captures the flow of interest payments on outstanding government debt (GOV_INT_ENT). This addition is unique to TERM-SA's SAM-extension and allows for a more in-depth view of the flow of government finances.

$$VENTGOV = GOV\_TR\_ENT + GOV\_INT\_ENT \qquad (2.5.D)$$

It should also be noted at this stage, that both households and enterprises earn interest on government debt, based on the amount of debt each user owns. To estimate a likely split between the debt owned by household and government we use savings data from Van Seventer et al. (2016) as well as savings data from the South African Reserve Bank (South African Reserve Bank, 2018).

Column 11 in Table 2B represents the outlays incurred by South African enterprises. Income taxes are paid to the government ($VTAXENT$) and transfers are made to the government ($VGOVENT$), households ($VHOUENT_{HOU}$), and the rest of the world ($VROWENT$). Transfers include, but are not limited to: dividend pay-outs, property income, non-life insurance claims, pensions from previous employment, annuities from own investments, claims, non-refundable bursaries, donations and gifts (Van Seventer, et al., 2016)[17]. Savings or retained earnings of enterprises can then be calculated as the residual between income and payments:

[17] Van Seventer et al. (2016) give a detailed description of most of the receipts and payments present in South Africa's social accounting matrix.

$$VSAVENT = VENT - [VHOUENT_{HOU} + VGOVENT + VTAXENT + VROWENT] \quad (2.5.E)$$

It is further assumed in TERM-SA that the transfers received by households, government and the rest of the world are determined by the percentage change in the post-tax income of enterprises. Also important is our assumption that enterprises pay interest on their net-foreign liabilities which form part of $VROWENT$.

2.5.3 Household Income

Different households-types (distributed from the poorest 5% to richest 5%) earn incomes from various sources in SA. Households receive a portion of national gross operating surpluses ($VHOUGOS_{HOU}$), they sell their labour and receive compensation in return (LAB_{HOU}); this income was previously represented by LAB(i,o) in Figure 2A. But, households also receive transfers from enterprises ($VHOUENT_{HOU}$), government ($VHOUGOV_{HOU}$), and from the rest of the world ($VHOUROW_{HOU}$)[18]. It is also worth explaining that the transfers households receive from government include interest payments on the share of government debt owned by households; this point will be elaborated on later in this thesis. The pre-tax income can therefore be expressed as:

$$VINCHOU_{HOU} = VHOUGOS_{HOU} + LAB_{HOU} + VHOUENT_{HOU} + VHOUGOV_{HOU} + VHOUROW_{HOU} \quad (2.5.F)$$

Both government, and rest of the world, transfers to households follow movements in nominal GDP, a default assumption of Corong and Horridge (2012) which can be changed depending on the modeler's, needs. Disposable income, which is key to welfare analysis, is calculated by deducting direct income taxes ($VTAXHOU_{HOU}$), other non-tax related transfers to the government ($VGOVHOU_{HOU}$), as well as interest paid on net foreign liabilities to foreigners ($VROWHOU_{HOU}$), from household income:

[18] Van Seventer et al. (2016) provide an in-depth explanation of what these transfers include in the South African context.

$$VDISPINC_{HOU} = VINCHOU_{HOU} - VTAXHOU_{HOU} - VGOVHOU_{HOU} - VROWHOU_{HOU} \tag{2.5.G}$$

When estimating household income tax, two shift variables are included to allow for household-specific, or nationwide identical changes. Changes of this nature have frequented SA's fiscus. In recent years, income taxes of the richest 5% and 10% of the workforce have increased more rapidly than for other households (Treasury, 2018). Corong and Horridge (2012) also explain that changes in household transfers to government can be implemented by one of two ways. Either payments are proportional to the household's pre-tax income, or the two household-specific tax shift variables can be included in the household transfer equation. By including these variable changes in the household, non-tax transfers follow exogenous changes in the tax structure (Corong & Horridge, 2012). In TERM-SA we adopted this strategy.

2.5.4 Household Spending and Savings

To effectively measure the welfare implications of economic policies on different households in SA, TERM-SA includes equations to measure disposable income, consumption of goods and services ($V3TOT_{HOU}$) and savings ($VSAVHOU_{HOU}$) for the 12 different household types. $V3TOT_{HOU}$ was previously illustrated as the summation over household USE and TAX in the flows database illustrated in Figure 2A. Later, this will correspond to the CGE-core database in Table 3A as the purchase value paid by households.

Household consumption in TERM-SA is driven by disposable income and two exogenous shift variables; one of which is household-specific, and the other an overall nationwide consumption shifter. Households in SA also make transfer payments to the rest of the world which include interest on net foreign liabilities. Normal transfers to the rest of the world is assumed to move with disposable income. Household savings can be calculated as the residual after deducting household expenses from gross income:

$$VSAVHOU_{HOU} = VINCHOU_{HOU} - V3TOT_{HOU} - VENTHOU_{HOU} - VGOVHOU_{HOU} - VTAXHOU_{HOU} - VROWHOU_{HOU} \quad (2.5.H)$$

2.5.5 Government Income

Equation (2.5.I) shows the different sources of government revenue modelled by TERM-SA.

$$VINCGOV = TAX\_csu + VGOVGOS + VGOVENT + VTAXENT + VGOVROW + VGOVHOU_{HOU} + VTAXHOU_{HOU} \quad (2.5.I)$$

The government receives numerous indirect taxes (TAX_csu) from various users modelled by TERM-SA; these form part of the CGE-core, but a brief explanation helps to emphasise TERM-SA's in depth ability to cover various fiscal policy tools. Indirect taxes include valued added taxes (VAT) from industries $TAX(c,s,IND)$, investors $TAX(c,s,INV)$, households $TAX(c,s,HOU)$, exporters $TAX(c,s,EXP)$, and from the government itself $TAX(c,s,GOV)$. Other indirect taxes include production taxes ($PRODTAX$), which include other costs (OTC) payable by each industry, and import tariffs (TAR_c) from many commodities sourced abroad:

$$TAX\_csu = TAR\_c + TAX(c,s,IND) + TAX(c,s,INV) + TAX(c,s,HOU) + TAX(c,s,EXP) + TAX(c,s,GOV) + PRODTAX \quad (2.5.J)$$

Other sources of government revenue include the government's share of gross operating surplus ($VGOVGOS$), direct taxes levied on households ($VTAXHOU_{HOU}$) and enterprises ($VTAXENT$). All of which have been explained previously. Government also receive transfers from enterprises ($VGOVENT$), households ($VGOVHOU_{HOU}$), and the rest of the world ($VGOVROW$)[19]. It is once again assumed that transfers from the rest of the world follow nominal GDP.

[19] Van Seventer et al. (2016) provide a detailed description of the different transfers which government receive.

2.5.6 Government Expenditure and the Deficit

Government spending ($VEXPGOV$) is broadly split into two main categories in TERM-SA: current ($VCURGOV$) and capital ($VGOVINV\_I$) expenditure:

$$VEXPGOV = VCURGOV + VGOVINV\_I \tag{2.5.K}$$

Capital expenditure is investment expenditure made by the South African government in the three main government industries: general public services, health and education. Here it is indicated by the summation of government investment over all industries $VGOVINV\_I$, although there is only investment made in the three government industries. How this investment is calculated in TERM-SA is explained in detail in Section 3.6.5. However, current expenditure can be further disaggregated into:

$$\begin{aligned} VCURGOV = {} & V5TOT_{COM} + VENTGOV + \\ & VROWGOV + VHOUGOV_{HOU} \end{aligned} \tag{2.5.L}$$

$V5TOT_{COM}$ is the standard spending on goods and services by the South African government; this is USE plus TAX of the government in Figure 2A and will later be shown in the CGE-core as the purchase values of government in Table 3A. $VENTGOV$ was explained previously in the enterprises section, Section 2.5.2, following equation (2.5.D) and includes interest payments made to enterprises for the share of government debt they own. Household transfers ($VHOUGOV_{HOU}$) were discussed in the household section following equation (2.5.F). The South African government also makes transfers to the rest of the world ($VROWGOV$), which is commonly associated with payments made to the South African Custom's Union (SANCU). Changes in these transfers are linked to GDP; a default assumption assumed by Corong and Horridge (2012).

The government deficit is then calculated as the residual between income and expenditure and thereby links the government in TERM-SA's SAM-extension to the dynamic extension in equation (2.3.M); for simplicity the time variable has been dropped in the preceding equations.

2.5.7 Private Investment Expenditure

Aggregate private investment expenditure ($VCAPPRIV$) is calculated as a residual between total investment in the economy, which includes inventories ($STOCK_{IND}$), and those investments made by government (illustrated here before summations have been made, $VGOVINV_{IND}$):

$$VCAPPRIV = V2TOT_{IND} - VGOVINV_{IND} + STOCK_{IND} \tag{2.5.M}$$

Here, $V2TOT_{IND}$ corresponds to the Invest-matrix in Figure 2A and will later be shown in the CGE-core as the purchase values of Investors in Table 3A.

2.5.8 Rest of the World

The following section expresses the link between the local economy and the rest of the world (RotW). Total receipts from the RotW ($VEXPROW$) can be expressed as a summation of exports ($V4TOT_{COM}$) and the various transfers received from the RotW by the South African government, enterprises and households:

$$VEXPROW = V4TOT_{COM} + VGOVROW + VENTROW + VHOUROU_{HOU} \tag{2.5.N}$$

Here, also, $V4TOT_{COM}$ corresponds to the spending on goods and services by the export user; and relates to the USE plus TAX of the export user in Figure 2A. Later this will be equated to the CGE-core as the purchase values of exporters in Table 3A.

Payments made from the domestic economy to the RotW include imports ($VIMP$) and transfers made to the RotW by the government, enterprises, and households:

$$VROWINC = VROWHOU_{HOU} + VROWGOV + VIMP + VROWENT \tag{2.5.O}$$

By subtracting these from one another, TERM-SA can calculate the current account balance, or put differently, the foreign savings in SA's economy which is financed by borrowing from the rest of the world. Following this explanation, it is easier to understand that $VSAVROW$ is also the CAD initially introduced in Section 2.3.5.

$$VSAVROW = VROWINC - VEXPROW \quad (2.5.P)$$

2.5.9 Household and Government, Saving Linkages in TERM-SA

Total savings (Row 14 in Table 2B) in the South African economy can be defined as the savings aggregate between households, government, enterprises, and the $RotW$. This aggregation illustrates the link between household savings and the balance of payments (the net-sum of income and spending in the economy).

Household disposable income can also be calculated by using GDP aggregates, as the product of GDP, government spending (the actual tax amount removed from the productive economy), net debt servicing costs, and net transfers to and from the $RotW$ (Dixon & Rimmer, 2002). This theoretical expression emphasises the link between the disposable income of households and the government fiscus, but also with the balance of payments. It also helps to illustrate how household savings will be impacted by changes in the fiscus, or an increase in government debt servicing costs which may result from a downgrade in sovereign credit rating.

Transfers and interest payments from government to households emphasise a further link between the government fiscus and household disposable income. A final important variable to consider, is that of taxes. Direct and indirect taxes are subtracted from a household's income to derive a disposable income, once again emphasising the government's role in a household's disposable income. Government therefore, plays an important role in the real incomes of households. TERM-SA has been specifically designed to measure the fiscal incidence of different policies or shocks to the South African economy.

2.6 Concluding Remarks

This chapter provided a detailed explanation of TERM-SA's theoretical structure. By first explaining the core principles of single-country and regional CGE-models, ORANI (Dixon, et al., 1982) and TERM (Horridge, et al., 2005). Core principles used in TERM-SA were explained by referring to the flow database, production structure and sourcing mechanisms used to set up TERM-SA. Chapter 2 also explained the dynamic extensions that were added to the core CGE-principles, those of capital accumulation, lagged wages, and government debt accumulation. This chapter also elaborated on how TERM-SA allows for multiple-household modelling and SAM-analysis in a dynamic, regional setup. These unique features of TERM-SA illustrate how factor incomes, tax revenues, and interest on outstanding debt accrue to different household types, government, enterprises, and the $RotW$. In doing so, TERM-SA can better illustrate the link between producers and users throughout the economy.

CHAPTER 3 – MODEL DATABASE

3.1 Introduction

Chapter 3 considers the database construction process which inform the theoretical structure outlined in Chapter 2. Throughout the database-creation process, our initial 2011 dataset was updated with 2015 weightings that will allow us in Chapter 5 to start simulations in 2015. When data for 2015 was not available we chose datasets that were closest to this year. The reason we could do this is because TERM-SA measure percentage deviations away from a baseline. We are therefore less concerned about absolute values and more concerned with relative weightings. Also, TERM-SA focuses on dynamic and often long-term modelling, in which case the dataset must reflect long-term weightings, rather than being fixed to one specific year's data.

Constructing TERM-SA's database starts with the unpublished 2011 supply-use tables of South Africa, provided by Statistics South Africa (StatsSA). These tables are converted to the input-output (I-O) format used by TERM-SA. From here, we follow the advice of Horridge (2011) and consolidate national industries into the 30 industries modelled by TERM-SA. The government industry is split into three industries: general, education, and healthcare. This split is crucial to TERM-SA's objective of allowing the modelers the ability to evaluate the fiscal incidence of government policy. After the national database is finalised, we add regionality by following Horridge et al. (2005) and using unpublished regional I-O tables from StatsSA, pre-built by Quantec, a data provider. Regional I-O tables from 2013 are used, because these are the latest available of their kind, and therefore the closest to our simulation starting point, 2015. Once again, we are more concerned with relative weightings than absolute values.

Later in Chapter 3 we explain why we believe it is enough to only have one government user in TERM-SA's, unlike some recent developments of TERM models that allow for a greater disaggregation of the government user. Chapter 3 also provides a detailed description of the SAM-database which is constructed based on national accounts' data from StatsSA and published research by Van Seventer et al. (2016). Finally, we discuss the data calibration process where maximisation conditions are used to infer unknown variables or parameters from those that are known. Throughout the database construction process we also test for data integrity to ensure that adjustments do not reduce the accuracy of our data.

3.2 The National Input-Out Database

Creating the TERM-SA database starts with the unpublished 2011 South African supply-use tables (SUTs) which were sourced from Statistics South Africa (StatsSA). South Africa's SUTs distinguish between 104 industries of the national, single-region, economy. SUTs first had to be converted to the input-output (I-O) format used by ORANI-G; the standard single-country CGE-model. Whilst SUTs are only published every other year (often only every 5 years) in SA, input-output tables (Statistics South Africa, 2016) are published more frequently. At the onset of this dissertation the 2011 SUTs were the most recent, but since then, a 2015 dataset has been published by Statistics South Africa. For the purposes of this dissertation, where our aim is to evaluate and make policy suggestions based on simulations that measure deviations away from a baseline, the relative size of the values is more important than their absolute values. For this reason, we could simply update our initial 2011 dataset with the weightings from the 2015 dataset. Once updated, we could use our initial 2011 dataset as a representation of the 2015 dataset, although absolute values were not adjusted.

After the single-region I-O is created, regional adjustments were applied based on Horridge et al. (2005) to create TERM's regional database, which was illustrated earlier by Figure 2A, in Chapter 2. Horridge (2000) provides a detailed description of the process that was implemented to create this initial core, single-region flows database. The core database is illustrated by Table 3A below and was adjusted from Horridge (2000) by adding values from SA's 2011 SUTs. Many of the items in Table 3A are found in the regional-expanded database presented earlier in Section 2.2.2, Chapter 2.

Column headings in Table 3A identify the following agents in the South African economy: industries, investors, households, an aggregate foreign purchaser of exports, government, and changes that are made to inventories. Table 3A illustrates the absorptive nature of the core single-region database. That is, how industries (Column 1) demand inputs (factors and intermediate commodities) to produce products. But, also how other agents (Columns 2 – 6) demand commodities to produce capital, satisfy household needs, export commodities, or add or subtract commodities from inventory. Each commodity can be sourced both locally (d, dom in the SRC-matrix) or abroad (i, imp in SRC). It is assumed in TERM-SA that only domestically produced commodities are exported; imported commodities can therefore, not be directly exported.

Table 3A: TERM-SA's National I-O Database

← *All intermediate (1) and final (2-6) users (u) in the economy are shown across these columns* →

		1	2	3	4	5	6	
		Producers	Investors	Households	Exporters	Government	Inventories	
	Dimension	← IND →	← IND →	← HOU →	← 1 →	← 1 →	← 1 →	
Basic Flows	(c,s,u) ↕	BAS(s,c,u)	BAS(s,c,u)	BAS(s,c,u)	BAS(s,c,u)	BAS(s,c,u)	BAS(s,c,u)	DOM: 5,383,839 IMP: 897,589
Margins	(c,s,m,u) ↕	MAR(c,s,m,u)	MAR(c,s,m,u)	MAR(c,s,m,u)	MAR(c,s,m,u)	MAR(c,s,m,u)	zero	MARUSE: 525,110
Commodity Tax	(c,s,u) ↕	TAX(c,s,u)	TAX(c,s,u)	TAX(c,s,u)	TAX(c,s,u)	TAX(c,s,u)	zero	Indirect Taxes: 297,697
BAS+MAR+TAX = PUR values	(c,s,u) ↕	Use Table 3,273,918	Investment 550,362	Consumption 1,743,124	Exports 897,589	Government 627,873	Stock (3,428)	7,091,555
Labour Inputs	(o) ↕	LAB(i,o) 1,321,802						
Capital Rentals	1 ↕	CAP(i) 1,272,533						
Land Rentals	1 ↕	LND(i) (part of CAP)						
Production Taxes	1 ↕	PRODTAX 40,696						
Other Costs	1 ↕	OCT (part of COSTS)						
		IND Costs 5,908,949						

c, COM = commodities ; IND = industries ; s, SRC = d, DOM = domestic or I, IMP = imports; m, MAR = commodities used as margins ; o, OCC = occupation types

	MAKE Matrix
Dimension	← IND →
COM ↕	Supply Table incl. SUPPMAR 5,908,949

	IMPORT Duties
Dimension	← 1 →
COM ↕	TAR(c)

Margins (M in MAR)are those shares of domestically produced commodities that are used to transfer commodities and facilitate the trade of commodities between agents in South Africa. What is clear in Table 3A is that commodity taxes are payable on purchases. Because Table 3A only represents the initial database of TERM-SA, before different regions are added, it does not include delivered prices that would be used for regional flows. Only basic flows (indicated by the coefficient BAS) and purchaser's prices (indicated by the coefficient PUR) are captured by Table 3A. It is also worth noting that production taxes include output taxes or subsidies, and that these taxes are not user-specific. In TERM-SA provision is also made for "other costs", to cover various miscellaneous taxes, like municipal taxes or charges (Horridge, 2000).

Each cell in Table 3A contains the name of the corresponding data matrix. For example, in column 3, $MAR(c, s, m, u)$ is a four-dimensional matrix that shows the cost of margins (MAR) on the flow of domestic (dom in SRC) and imported (imp in SRC) commodities (COM) to households (HOU). The $MAKE$-matrix at the bottom of Table 3A corresponds to the $MAKE$-matrix in Figure 2A of Chapter 2 and indicates the aggregate value of commodity output for each industry. Like before, tariffs on imports differ by commodity, but not by user, and the tariff revenue collected in South Africa is captured by the vector $TAR(c)$.

In addition to the data presented by the national I-O table additional data on the current account, balance of payments and capital flows were obtained from the South African Reserve Bank (South African Reserve Bank, 2010 - 2018). The National Treasury provided data on the gross national government debt (National Treasury, 2018). Statistics South Africa also provided national and regional employment data (Statistics South Africa, 2018).

3.3 National Industry Adjustments

Before the regional flow database (illustrated by Figure 2A in Chapter 2) could be constructed, we applied two major adjustments to the national I-O table. First, the original industries were condensed. The government industry was split into three sub-classifications.

During the first step the 104 industries presented in StatsSA’s SUTs were condensed into the 30 industries used in TERM-SA. This step was accomplished by using the seventh edition of StatsSA’s Standard Industrial Classification (Statistics South Africa, 2012). The second step involved removing the healthcare and education portions from the government industry; in doing so, TERM-SA can differentiate between general government services, government healthcare, as well as government education.

To remove the sub-classifications from the initial government sector we multiplied consolidated government expenditure weightings with the government I-O totals in StatsSA’s SUTs; later studies might consider a more appropriate manner. Consolidated government expenditure weightings were obtained from SA’s National Treasury (National Treasury, 2018);

a ten-year average from 2011/12 to 2020/21 was used for each of the sub-classifications. Data showed that healthcare constitutes 17.3% of total consolidated expenditure, education 22.7%, and general or other government services (the residual) 60%[20]. These weightings were then multiplied with the government I-O totals in StatsSA's SUTs. Using this approach, we were able to compare government's share of education and healthcare, to that of the private sector. We found that the government sector's share of total education in SA is roughly 80%, whereas its share of total healthcare is only about 60%.

After we determined which portion of the initial aggregate government industry could be allocated to each sub-classification, we constructed the I-O for government healthcare and education based on the weightings of their private sector counterparts. In doing this, we assumed that government healthcare and education follow similar I-O patterns as their private sector counterparts. Once again, later studies might consider a more accurate approach. After the split and construction of government healthcare and education we had to RAS the original matrix using Horridge (2011). RAS is a data-manipulating technique that allows us to target specific row and column totals by using initial table weightings to adjust individual cells in a two-by-two table. By applying this data-adjusting technique. data integrity is maintained. This is to make sure that key macro and regional-economic identities are consistently upheld. There are four macro-economic identities that had to be adhered to.

First, GDP measured from the income side, GDP_{INC}, (the sum of labour costs, capital rentals, production taxes, and indirect taxes), is equal to GDP from the expenditure side, GDP_{EXP} (investment, household, export, and government spending, as well as changes in inventory and imports). Using Table 3A this implies that:

$GDP_{INC} = GDP_{EXP}$, where:

$$GDP_{INC} = V1LAB + V1CAP + V1PTX + TLSP$$

$$GDP_{EXP} = V2PUR + V3PUR + V4PUR + V5PUR + V6BAS - IMP$$

[20] We include National Treasuries projected figures for 2019/20 and 2020/21 because our aim is to create a long-term projected view of these shares. It is therefore, useful to include some projected figures in our assumption.

Second, industry cost, IND_{Cost} (the summation of intermediate inputs, labour inputs, capital rentals, and production taxes), is equal to industry output, IND_{Output}:

$IND_{Cost} = IND_{Output}$, where:

$$IND_{Cost} = V1PUR + V1LAB + V1CAP + V1PTX$$

$$IND_{Output} = MAKE\_C$$

Third, total commodity demand, TC_D, (the sum of intermediate and final demand) is equal to total commodity supply, TC_S (the sum of industry output, imports, indirect taxes, and net-margins):

$TC_D = TC_S$, where:

$$TC_D = V1PUR + V2PUR + V3PUR + V4PUR + V5PUR + V6PUR$$

$$TC_S = MAKE\_I + IMP + TLSP + (MARUSE - MARSUP)$$

Fourth, total demand of domestically produced commodities, is equal to total supply of domestically produced commodities:

$CD_{LOC} = CS_{LOC}$, where:

$$CD_{LOC} = VBASDOM + MARUSE$$

$$CS_{LOC} = MAKE\_I$$

By applying the split and construction of government education and healthcare, it allows TERM-SA to more accurately distinguish between the larger sub-classifications of the government sector. TERM-SA can also more accurately model the impact of various policies on both private and public education and healthcare sectors; which will be important for our analysis. For the purposes of this study the initial split is enough, although it is possible to further disaggregate other government services.

3.4 Adding Regionality

After the national input-output (I-O) database (Table 3A) was created from StatsSA's SUTs and the industries were adjusted for use by TERM-SA, regionality could be added to the database. Earlier, Figure 2A in Chapter 2 illustrated TERM-SA's regional database, the structure of which is based on Horridge et al. (2005). To accomplish the task of adding regionality each industry and final demander's share of the national activity is needed. Here, the aim is to create a full I-O table for each province (region) in South Africa. To accomplish this task, the following regional data is needed: industry I-O shares, investment shares, household income and spending shares, import and export shares, as well as government expenditure shares (Horridge, et al., 2005).

The main data source we used for the industry split was unpublished regional I-O tables from StatsSA which were compiled and supplied by Quantec, for the calendar year of 2013. Because this is the most recent regional dataset that is available, and it will therefore be able to more accurately capture current regional industry weightings. For our purposes, we are less concerned about absolute values, and more concerned about relative shares. Using the same source, we were able to split the national investment by industry, for each region. Specifically, we used an average of the industry and region-specific gross operating surpluses, as well as data on capital formation.

Regional household demand data was obtained from StatsSA's regional Income and Expenditure Surveys (Statistics South Africa, 2012). Import and export shares for each airport and harbour, which is needed to compile international trade data by region, was provided by Quantec and the Department of Trade and Investment (DTI). Various distance-related data, that was used to create the $TRADE$-matrix, was provided by Prof. JH van Heerden from the University of Pretoria.

Unpublished regional government expenditure data was provided by the National Treasury; this data provides a much more detailed view of regional government spending than was previously available. It allows TERM-SA to more accurately portray regional government finances and will allow us to more accurately model the regional government industry.

Using these regional datasets TERM-SA estimates the following core matrices illustrated on the left side of Figure 2A in Chapter 2: $FACTORS$, USE, and TAX matrices. To create the other important matrices of Figure 2A: $TRADE$, $TRADMAR$, and $SUPPMAR$, further assumptions concerning the gravity formula and regional technology is applied[21].

3.4.1 Gravity and the $TRADE$-matrix

In Figure 2A the $TRADE$-matrix is a 30x30 sub-matrix of each imported or domestically supplied commodity. Rows correspond to the origin region (r) and columns to the destination region (d). In doing so, diagonal cells represent locally consumed production of a certain commodity. However, Horridge et al. (2005) explain that very little inter-regional trade data is available. Horridge et al. (2005) therefore, suggest implementing the gravity formula to construct trade matrices which are consistent with USE and $MAKE$-matrices. The gravity formula assumes that trade volumes follow an inverse power distance relationship, and three points can be raised in defence of this assumption:

1. In the research originally done by Horridge et al. (2005) it is shown that the gravity hypothesis is barely implemented where commodity production or consumption is concentrated in only a few regions. Due to TERM-SA's detailed sectoral classification and limited number of regions, the gravity hypothesis is therefore rarely implemented.

2. Regions outside South Africa's main cities are rural and characterised as regions that export primary factors and import manufactured commodities. Rural areas are well defined in South Africa and one main city is almost always closer to a rural area than another. This implies that flows from a rural area have a higher probability of flowing between a main city that is closer, than flowing between one that is further away and

[21] Both the gravity and regional technology concepts are explained in detail in Horridge et al. (2005).

would require higher transport costs. Horridge et al. (2005) explain that this reality reduces the weight of the gravity hypothesis even further.

3. Disaggregated databases are used to calculate model estimates which also reduce the weight of the gravity hypothesis (Horridge, et al., 2005).

It is also worth noting from Horridge et al. (2005) that a traditional gravity formula causes implausible results in regional models like TERM-SA, especially for service commodities. They suggest adjusting the gravity formula as follows, to overcome the problem:

$$V(r,d)/V(**,d) \propto \sqrt{V(r,**)}/D(r,d)^k \qquad r \neq d \tag{3.4.A}$$

Here, $V(r,d)$ is the value of the flow from region r to d, and corresponds to the TRADE-matrix in Figure 2A. $V(r,**)$ is the production in region r and $V(**,d)$ is the demand in region d[22]. $D(r,d)$ in turn, is the distance from region r to d. Also, k, is a commodity-specific parameter used to indicate the ease of trade, where $0.5 \leq k \leq 2$. A lower parameter indicates commodities that are readily tradable. Diagonal cells in the $TRADE$-matrix and sub-matrices are estimated by $V(d,d)/V(d,x)$, to equal locally-supplied demand at destination d, and satisfies:

$$V(d,d)/V(d,**) = MIN\{V(d,**)/V(**,d),1\} * F \tag{3.4.B}$$

F is a commodity-specific parameter like k in equation (3.4.A) that satisfies $0.5 \leq F \leq 1$. Initial estimates from the adjusted gravity formula are then scaled using the data-adjusting RAS procedure to solve equation (3.4.A) (Horridge, et al., 2005).

A final assumption is introduced to allow transport costs as a share of trade flows, to increase with the distance between origin and destination regions:

[22] In this equation a double-asterisk (**) is used to refer to the empty vector within each of the functions $V(r,**)$ and $V(**,d)$.

$$T(r,d)/V(r,d) \propto \sqrt{D(r,d)} \quad (3.4.C)$$

$T(r,d)$ corresponds to $TRADMAR$ in Figure 2A of Chapter 2 and are chosen in such a manner to satisfy the proportionality constraints from the national I-O tables (Horridge, et al., 2005). After calculating $TRADE$ and $TRADMAR$ matrices from the equations above, the supply of margins, $SUPPMAR$ in Figure 2A can be calculated. Section 3.4.2 explains how to ensure that industry technology differs by region.

3.4.2 Regional Technology

By default, when applying regional output splits to a national dataset, regional industry technology does not vary by region. A crude assumption like this is overcome by following the guidelines in Horridge (2011). The most prominent guideline is to ensure that enough industries are distinguished during the data construction process, before regional splits are applied; this also ensures that the $MAKE$-matrix is diagonal to avoid complications. Industries with similar technology preferences across different regions can then be aggregated together. When the regional split is eventually applied, technologies do in fact vary across regions. Another strategy is to aggregate similar industries together, whilst leaving their associated commodities separate (Horridge, 2011). In doing so, TERM-SA allows input technologies to vary by region and commodity-mix. Factor inputs can then also be switched between commodities to facilitate the analysis of changes in certain factor inputs (Horridge, 2011).

As an example, Horridge (2011) uses this process to capture technology and preference variations in different agricultural products. In TERM-SA however, we do not assume technological variation among agricultural commodities. We believe this simplifying assumption is acceptable if one considers the relatively small size of technological intense agricultural products in South Africa. For this reason, TERM-SA only distinguishes one agricultural sector. This simplifying assumption can, however, be eased if the modelers needed to. Horridge (2011) also shows how the process can be applied to the mining industry that produces different commodities. Mining commodities that share technology preferences can be considered as single-product industries. In TERM-SA we distinguish between gold and precious metals, coal mining, and other mining industries.

3.5 The Regional Government User

In Chapter 2 we explained that the structure of the South African government finances makes it unnecessary to extend TERM-SA's modelling capabilities to include lower levels of government accounts, i.e. government users, such as the provincial and municipal accounts. To summarise the reasons, provincial debt is written off annually and accumulates into the national government debt. For this reason, only the national government pays interest; roughly 11% of total government expenditure (National Treasury, 2018). More importantly, national government does the bulk of government spending, either directly or indirectly through transfers made to provinces. The reason for this is because revenue is sourced from a national, and not provincial, level and only then distributed to various provinces. The bulk of revenue which provinces receive is through transfers from the national government. Because it is not necessary to include more government users, there is only one national government user, that spends in each province (region). This user spends on commodities in each province according to Table 3B. Welfare and other spending are captured by the SAM (see Column 12 "Government" in Table 3C). In its current set up, TERM-SA only makes provision for a national, and not provincial SAM, in which case we are unable to easily observe how the national government user distributes welfare and other spending to provinces. However, this does not imply that the transfers are not made. As an example, the national government transfers to household users, which can then be aggregated on a regional level to determine the amount of regional government transfers to households.

We do, however, believe it is prudent to increase the accuracy of the regional commodity splits which are applied to the government user in the previous step. Specifically because TERM-SA is designed to address policy questions about the South African economy, and more so because we attempt to find a better fiscal policy alternative. The more accurate the model is, the more trustworthy its results should be. By accuracy we mean it is important to increase the accuracy of national government spending in each region (province). Like most CGE-models, TERM-SA defines the government as both an industry and a final user. The government user demands different commodities, but especially those produced by the three government industries, to satisfy its needs. Government industries however, demand different commodities as inputs, to ultimately produce various government services; general services, healthcare and education. Like other industries modelled in TERM-SA, the government industries' commodity and regional splits are determined by StatsSA's unpublished regional I-O tables, as well as unpublished government expenditure data. In this section we therefore explain the process involved with increasing the regional accuracy of the commodities used by the government user.

In older regional CGE-models of South Africa, such as the TERM model used in Stofberg and van Heerden (2015), it was simply assumed that regional government splits follow regional GDP. In TERM-SA however, we use unpublished regional government expenditure data provided by the National Treasury to inform us about regional government spending[23]. Published data of this nature only disaggregates government spending on a level of 20 items, which is not enough for the depth of regional economic and fiscal analysis we want to accomplish with TERM-SA. The unpublished dataset provided us with the lowest level of government spending disaggregation, that is, a disaggregation of 1581 commodities in each of SA's nine provinces. A more detailed view of the structure of regional government spending ultimately allows for more accurate analysis.

We chose to use government spending data for the 2012/13 fiscal year, after adjusting the fiscal calendar amounts to the annual calendar amounts used by TERM-SA, to determine government spending in 2012. Although this was the most recent dataset provided by the National Treasury, it was chosen over the 2011/12 year because it represents the most recent year in which major changes (especially in social spending) were made to the structure of government spending. Of the data provided by National Treasury, major changes occurred in 2005/06, 2008/09, 2010/11 and 2012/13. The 2012/13 period is also the period which is closest to the start of our simulation period, namely 2015.

[23] Because of the sensitive nature of this data it is not published. Less disaggregated datasets are however, available on the website of the National Treasury of South Africa: http://www.treasury.gov.za/.

To aggregate National Treasury's 1581 expenditure items for each province into the 30 commodities recognised by TERM-SA, we once again used the seventh edition of StatsSA's Standard Industrial Classification. All but one of the 30 commodities, the trade commodity, could be aggregated with ease. Trade commodities are those commodities that facilitate the flow and trade of other commodities (previously referred to as margins). In many instances trade is not considered as a separate commodity like it is in Supply and Use Tables (SUTs) on which TERM-SA is built. As the final step in the aggregation process, we recreated TERM-SA's trade commodity from the unpublished National Treasury data. To do this we used retail and wholesale profit margins levied on various industries (Statistics South Africa, 2014). From these percentages we were able estimate the likely size of the trade industry in each province. Table 3B below illustrates final regional government spending, after the abovementioned changes were made:

Table 3B: Regional Government Spending

Commodity, Province	Limpopo	North West	Mpulanga	Gauteng	Free State	Nothern Cape	Western Cape	Eastern Cape	KwaZulu-Natal	Total
1 Agric	12%	6%	7%	24%	7%	2%	7%	10%	24%	100%
2 Coal	11%	6%	8%	21%	7%	3%	10%	13%	21%	100%
3 Gold	11%	6%	8%	21%	7%	3%	10%	13%	21%	100%
4 Other_Mining	12%	7%	8%	18%	6%	5%	9%	15%	20%	100%
5 Food_Bev	11%	5%	9%	20%	6%	3%	11%	16%	19%	100%
6 Text_Foot	6%	4%	13%	25%	4%	2%	16%	8%	21%	100%
7 Wood_Paper	13%	10%	14%	10%	9%	3%	9%	14%	18%	100%
8 Petro_Chem	10%	5%	8%	16%	8%	3%	8%	16%	26%	100%
9 Glass_No_Met	8%	9%	5%	44%	5%	1%	7%	9%	11%	100%
10 Metal_Mach	10%	8%	7%	15%	5%	3%	12%	12%	27%	100%
11 Electrical	15%	7%	7%	18%	7%	3%	13%	11%	21%	100%
12 Radio_TV	4%	3%	4%	64%	3%	1%	5%	6%	9%	100%
13 Trans_Equip	24%	4%	9%	10%	11%	3%	4%	8%	27%	100%
14 Other_Manuf	7%	6%	6%	23%	8%	2%	12%	11%	24%	100%
15 Electricity	10%	6%	6%	15%	5%	2%	18%	15%	21%	100%
16 Water	11%	6%	8%	19%	6%	3%	15%	13%	21%	100%
17 Construction	4%	4%	6%	16%	3%	3%	7%	17%	40%	100%
18 Trade	10%	7%	8%	22%	11%	2%	6%	14%	21%	100%
19 Hotels	17%	6%	11%	13%	4%	3%	7%	11%	27%	100%
20 Trans_Serv	11%	8%	8%	18%	7%	4%	10%	15%	20%	100%
21 Comm	11%	8%	9%	16%	7%	3%	10%	16%	20%	100%
22 Financial	9%	5%	6%	13%	29%	2%	8%	12%	16%	100%
23 Real_Estate	15%	6%	6%	16%	5%	9%	8%	12%	24%	100%
24 Business	10%	7%	7%	19%	6%	3%	11%	15%	22%	100%
25 Gov_Gen	10%	6%	7%	27%	7%	3%	9%	14%	17%	100%
26 Gov_Educ	10%	7%	8%	19%	7%	3%	11%	17%	18%	100%
27 Gov_Health	9%	8%	8%	28%	5%	3%	15%	10%	14%	100%
28 Health_Soc	9%	8%	8%	28%	5%	3%	15%	10%	14%	100%
29 Education	10%	7%	8%	19%	7%	3%	11%	17%	18%	100%
30 Other_Serv	9%	8%	7%	20%	7%	4%	9%	16%	21%	100%
Average (weighted)	**6%**	**6%**	**7%**	**35%**	**5%**	**2%**	**14%**	**8%**	**17%**	

An interesting observation can be made from Table 3B. Most government spending is consumed in Gauteng, Kwazulu-Natal and the Western Cape: 35%, 17% and 14% of total government spending, respectively. As a share of total government spending, the least amount of consumption is spent in the Free State (5%), as well as Limpopo and the North West (6%).

3.6 SAM-Database Extension

TERM-SA's SAM-extension uses as square SAM that adheres to double entry accounting. The SAM-database illustrates how incomes (along the rows) are earned and expenditures made (along the columns) by various agents (Corong & Horridge, 2012) within the South African economy. A savings row acts as a residual to allow each row and column total to correspond.

Table 3C below illustrates TERM-SA's SAM-database. SAM illustrates the link between the 2011 core single-region CGE-data (the National I-O Database) of Section 3.2, and TERM-SA's SAM-model extension (Figures, 2.5A and 3.5A). Core single-region CGE-data are those values not shaded in grey (the first 8 rows), whereas shaded values illustrate the SAM-additions that have been added to TERM-SA.

Earlier, Figure 2.5A in Chapter 2 gave a schematic illustration of TERM-SA's entire database. Now, Table 3C presents the value flows of that SAM-extension. Values for the core database were obtained through the process outlined in the Sections 3.2 to 3.5. Weightings for the SAM-extension were obtained from StatsSA's National Accounts data (Statistics South Africa, 2016) and from Van Seventer et al. (2016). Both sources focus on the 2012 South African economy and allow us to adjust our 2011 SUT dataset with newer weightings. Because we are less concerned with absolute values but rather with relative values, an adjustment like this is enough. The following section briefly considers some of the SAM details of Table 3C; the structure of the SAM-extension was explained in detail in Section 2.5.

3.6.1 Capital and Gross Operating Surplus

By using StatsSA's National Accounts and the relative weights calculated in Van Seventer et al. (2016) we were able to allocate the capital incomes generated by South Africa's economy (row 5) towards those users who receive them (column 5). Users who receive these incomes include: households, enterprises, government and the rest of the world (foreigners). Although foreigners also earn GOS the share of foreign ownership is relatively small and varies considerably between years. In 2009 foreign ownership of GOS was 0.09% (Davies & Thurlow, 2013), in 2012 it was 8.1% (Van Seventer, et al., 2016). In 2014 it was 0.00% (Phoofolo, 2018), and in 2016 it was 9.4% (Van Seventer & Davies, 2019). For this reason, and because our aim is to analyse various policies over the long-term, we assumed foreign receipts of GOS would average 5% over the simulation period.

3.6.2 Direct Taxes

Direct Taxes are collected (row 9) from households (personal income taxes) and enterprises (company income taxes) in the South African economy. The government user receives the sum of these two tax streams (column 9). The split between households and government was obtained from Van Seventer et al. (2016).

3.6.3 Households

Households (Row 10 in Table 3C) receive an income from labour and capital, as well as from transfers from enterprises, government (which include interest income) and the rest of the world. Labour income by household is obtained from StatsSA's (Statistics South Africa, 2012) regional Income and Expenditure (IES) data, pre-built and provided by Quantec, for 2012. We also used data from Van Seventer et al. (2016), who provide invaluable SAM-based estimates on gross operating surplus (GOS), transfers from government and the rest of the world ($RotW$), for various household types. Figure 3A below indicates each income category's allocation to each household type.

Column 10 shows the total spending of each household in SA. From the National I-O table data was acquired for each household's spending on local and imported commodities, as well as commodity-related taxes paid by households. Income taxes levied on labour income by each household, are calculated by using the applicable South African Income Tax Rate, as provided by the South African Revenue Services (SARS).

Household transfers made to the government and the $RotW$ (which include interest payments on net-foreign liabilities) are split using data from van Seventer et al. (2016) and where needed savings data from the SARB (South African Reserve Bank, 2018). Household transfers to government include miscellaneous transfers and social contributions (Van Seventer, et al., 2016). Miscellaneous transfers include membership dues, subscriptions, and donations made to non-profit institutions serving households (NPISHs), as well as fines and penalties paid to government. Social contributions consist of actual or imputed contributions to make provision for social benefits. In SA's context these include payments made to the unemployment insurance fund (UIF), and the skills development levy (SDL), as two examples. Household transfers to the rest of the world are like the transfers made to enterprises (Van Seventer, et al., 2016) and include property income payable, as well as non-life insurance premiums. More specifically, these transfers include interest on household bonds, contributions to retirement funds (pension, provident, and annuities), as well as the employer's contribution thereof. Following van Seventer et al. (2016) we allow transfers which households make to enterprises to follow household spending patterns. Based on the structure of National Accounts the residual of a household's income and expenditure can then be considered as the household's savings. Figure 3A below indicates each SAM-expenditure category's allocation to each household type from the poorest to the richest. Each household type represents a different decile, following IES descriptions, the poorest and richest deciles were then further split into ventiles. Household type 1, therefore represents the poorest 5% of households in SA. Household type 5 represents decile four.

Figure 3A: Household Weights

			Household Transfers from			Household Transfers to		Transfers to and from
Household type, by decile	Labour Income	Gross Operating Surpluss	Government	Enterprises	Income Tax Paid to Government	Government	Enterprises	RotW to Households
1	1.0%	0.2%	10.1%	0.1%	0.0%	0.0%	0%	5.0%
2	1.5%	0.3%	13.0%	0.1%	0.0%	0.0%	0%	3.6%
3	2.4%	0.7%	13.2%	0.3%	0.1%	0.1%	0%	4.5%
4	3.1%	1.0%	12.9%	0.6%	0.2%	0.3%	0%	4.7%
5	4.1%	1.4%	12.0%	1.0%	0.7%	1.0%	1%	6.2%
6	5.6%	2.3%	8.8%	2.2%	1.1%	1.5%	2%	6.3%
7	7.8%	3.6%	8.1%	3.6%	2.9%	3.4%	3%	6.3%
8	11.9%	7.1%	6.4%	7.5%	7.6%	8.9%	9%	7.7%
9	21.3%	22.5%	6.3%	17.2%	17.3%	23.6%	24%	6.9%
10	6.3%	6.4%	3.0%	6.6%	6.5%	9.3%	9%	12.4%
11	12.7%	20.3%	2.0%	19.1%	14.7%	22.3%	22%	16.0%
12	22.2%	34.2%	4.3%	41.6%	48.8%	29.5%	30%	20.4%

3.6.4 Enterprises

Enterprises in TERM-SA represent all public and private corporations (which include financial and non-financial corporations) in South Africa. This economic user receives an income from capital (GOS), as well as transfers from households, government (which include interest earned on debt ownership), and the rest of the world ($RotW$, which include interest payments to foreigners based on their ownership of net foreign liabilities). Once again to split GOS between different users we used National Accounts data from StatsSA, as well as user weightings from Van Seventer et al. (2016). Transfers from the government were sourced in a similar manner. Transfers from households were explained above.

Enterprises pay corporate income taxes to government, and make transfers to households, government, and the $RotW$ (which include interest payments on net foreign liabilities owned by enterprises). Data sourcing for these expenditure items follows a similar path as those for income items. The residual between income and spending is the savings made by enterprises. In line with the input-data, Table 3C shows that enterprises are the largest savers in the South African economy.

3.6.5 Investment Expenditure

To maintain consistency between the various databases used by TERM-SA, Table 2B simply referred to investments made by both the government and private sector as: $BAS(c,d,INV) + MAR(c,d,INV)$. In doing so it is easier to link the flows database of Figure 2A with the core CGE-database illustrated in Table 3A. Until the inclusion of the SAM database standard CGE models could not separate the investments made by the government user. Here, only government industries made investments. Using the National I-O database we assume the government user invests in proportion to the investments made by the different government industries: general government services, education and health. For each of these government industries we sum their $BAS(c,d,INV) + MAR(c,d,INV)$, which yields $VGOVINV\_I$ in Table 2B. Aggregate private investment expenditure ($VCAPPRIV$) can then be calculated as a residual between total investment ($V2TOT_{IND}$) in the economy, inventories ($STOCK_{IND}$), and those investments made by government. Referring to Section 2, this was illustrated as:

$$VCAPPRIV = V2TOT_{IND} - VGOVINV\_I + STOCK_{IND} \qquad (2.5.M)$$

Table 3C: TERM-SA's SAM-Database

R'millions		1 Industries	2 Domestic Commodities	3 Imported Commodities	4 Labour	5 Capital	6 Production Taxes	7 Commodity Tax	8 Tariff	9 Direct Tax	10 Households	11 Enterprises	12 Government	13 Government Investment	14 Private Investment	15 Stocks	16 Rest of the World	17 Total
	Dimension	IND	COM	COM	OCC	CAP	1	1	COM	1	HOU	1	1	IND	IND	IND	1	1
1 Industries	IND		R 5,908,949															R 5,908,949
2 Domestic Commodities	COM	R 2,592,248									R 1,389,193		R 627,873	R 15,317	R 390,158	-R 3,428	R 897,589	R 5,908,949
3 Imported Commodities	COM	R 521,281									R 216,623		R 0	R 5,473	R 139,414			R 882,791
4 Labour	OCC	R 1,321,802																R 1,321,802
5 Capital + LND	CAP	R 1,272,533																R 1,272,533
6 Production Taxes	1	R 40,696																R 40,696
7 Commodity Tax	1	R 160,389									R 137,308							R 297,697
8 Tariff	COM			R -														R -
9 Direct Tax	1										R 255,482	R 164,303						R 419,785
10 Households	HOU				R 1,321,802	R 364,911						R 475,756	R 277,148				R 11,000	R 2,450,618
11 Enterprises	1					R 842,460					R 193,191		R 259,093				R -	R 1,294,744
12 Government	1					R 65,163	R 40,696	R 297,697	R -	R 419,785	R 169,420	R 147,150					R 2,000	R 1,141,912
13 Government Investment	1												R 20,790					R 20,790
14 Savings	1										R 86,665	R 416,174	-R 102,645				R 125,950	R 526,143
15 Stocks	IND														-R 3,428			-R 3,428
16 Rest of the World	1			R 882,791							R 2,735	R 91,361	R 59,652					R 1,036,539
17 Total	1	R 5,908,949	R 5,908,949	R 882,791	R 1,321,802	R 1,272,533	R 40,696	R 297,697	R -	R 419,785	R 2,450,618	R 1,294,744	R 1,141,912	R 20,790	R 526,143	-R 3,428	R 1,036,539	

Note: Shaded cells indicate additional data from the SAM-database (i.e. not found in the National CGE-database).

Legend: IND – number of industries (30); COM – number of commodities (30); OCC – number of occupations (11), CAP – types of Capital; HOU – number of households (12).

3.7 Database Calibration

Calibration is a process used in CGE-modelling whereby maximisation conditions are used to infer unknown variables or parameters from those that are known. Certain known variables, including elasticities and preference variables, are selected based on literature from sources such as Dixon and Rimmer (2002), Horridge et al. (2005), and Wittwer et al (2005). Other macro-economic variables are sourced from industry experts or assumed based on the modeler's specific requirements.

Another important assumption used during database calibration is that the number of firms in a specific industry and region, is set equal to one. This simplifying assumption allows the parameter to be used as a relative measure; the assumption holds even when setting the quantity and prices encountered by small firms equal to the summed total in the data.

A final important calibration procedure followed in TERM-SA, is calibrating the first modular period, that is, 2015. In CGE-analyses, where our aim to estimate the percentage deviation from a baseline, we are less concerned with the size of variables and more concerned with the relative sizes of those variables. We are therefore, able to assume that the first modulating period of TERM-SA is 2015 if the relative sizes of key variables do not differ significantly from the starting year of our core database, namely 2011. If the relative sizes do not differ significantly it implies that the structure of the database between the two periods remain consistent, and the totals can simply be calibrated to represent the economy in 2015.

With TERM-SA's regional dynamics focus, a test was conducted on the relative size of provincial economies to ensure that these regions did not differ significantly between the periods 2011 and 2015. To this extent we analysed each regional sector's contribution to that region's output and compared the relative sizes of 2011 and 2014 (the most current regional dataset available in SA). We found no significant difference in each regional sector's contribution between the periods in question. We can therefore infer that the regional structure has not changed significantly between 2011 and 2015. Given the objective of modelling based on regional percentage deviations, the calibration process supports the use of 2015 as our initial period.

3.8 Concluding Remarks

Building on the theoretical structure outlined in Chapter 2, Chapter 3 explained the database construction process that was implemented to create TERM-SA's database. Starting with StatsSA's national 2011 supply-use tables, we adjusted the initial dataset to fit our simulation requirements. Because simulations conducted by TERM-SA's measure percentage deviations away from the baseline, relative weightings in our data are more important than absolute values. For this reason, we adjusted the weightings of our data without similar adjustments to absolute values and still start our simulations in 2015.

An important change that was made to the initial dataset was the disaggregation of the government industry, into three sub-classifications: general, education, and healthcare. This adjustment allowed TERM-SA to more accurately model the fiscal incidence of government policy. By adding greater accuracy to the government user's purchasing habits, we further improved TERM-SA's modelling accuracy.

Chapter 3 also considered the process of creating regional datasets that captured various flows between users in the South African economy. Using data from StatsSA and Van Seventer et al. (2016) we created a social accounting matrix (SAM) database to allow for SAM-modelling in TERM-SA. We also discuss the database calibration procedure and explain the data integrity measures we applied to ensure the accuracy of our data is maintained throughout the adjustment processes. In the following chapter we will discuss the model closures that are applied to TERM-SA, that will allow us to create the proposed simulations.

CHAPTER 4 – MODEL CLOSURES

4.1 Introduction

Computable general equilibrium models (CGE-models), like TERM-SA, consist of large numbers of equations (x) and variables (y). It is common for these models to have more variables than equations. However, to successfully compute a solution using TERM-SA the number of endogenous variables (dependant variables calculated by the model) should equal the number of equations in the model. To adhere to this requirement, ($y - x$) variables must be assumed exogenous, that is, determined outside of the model. Although the decision about which variables to assume exogenous is mainly user-determined, it must be done in such a manner as to best describe the economic environment in which the simulation is run. This process of choosing the correct exogenous variables, that would allow TERM-SA to solve its equations in a suitable manner, is referred to as the model's closure.

Dixon and Rimmer (2002) developed four basic model closures, each with a distinct application in mind. These modes include historical, decomposition, forecast (baseline) and policy modelling. These form an intricate set of solutions that build on one another. The aim of our simulations will be to evaluate the fiscal incidence of a specific government policy; keeping the wage bill of government employees fixed for five years and using the savings to increase investments via a subsidy in the construction industry. For this reason and based on the guidance of Dixon and Rimmer (2002), this chapter will focus on forecast (baseline) and policy closures. After the correct closure is applied to TERM-SA, the model is solved by manipulating the linearized data-matrices using GEMPACK. Although CGE-models contain numerous non-linear equations and relationships, these are simplified by implementing Johansen's (1960) system of linearization[24].

Before we discuss the different model-closures used in our application of TERM-SA, we provide a stylized back-of-the-envelope representation of TERM-SA. This simplified

[24] The linearization process is explained in detail in Appendix B1.

representation allows for an easy-to-understand view of how causality is applied throughout TERM-SA's system of equations and will be important for Chapter 5. After applying the system of equations, we will introduce TERM-SA's forecast closure, that is, the process of creating a believable business-as-usual picture of the likely evolution of South Africa's economy over multiple years. Finally, in this chapter we will discuss how the policy closures was set up in TERM-SA, and how this allowed us to analyse the impact of the suggested policy changes as a percentage deviation away from the baseline.

4.2 A Stylised Representation of Reality

4.2.1 Introduction: S-BOTE

Stylised back-of-the-envelope (S-BOTE) equations, originally adopted from Giesecke and Madden (2011), represent a miniature version of TERM-SA. These equations illustrate the nature and direction of regional economic causation in the short and long run by using key representational equations of the model. To gain an in-depth understanding of the results generated by TERM-SA (which will be presented in Chapter 5) it is important to consider the database and micro theory in conjunction with the S-BOTE equations.

Table 4A shows the S-BOTE equations, $(S1)$ to $(S24)$. To close this S-BOTE representation of TERM-SA, 19 variables must be set exogenous (assumed outside of the model). In doing so, the difference between the number of variables (37) and the number of static equations (18), is filled. In static CGE-models, either a short- or long-run closure is modelled. However, in dynamic long-run modelling, which TERM-SA is designed to do, key variables in the short-run year-on-year simulations transition equations into long-run equations (Giesecke & Madden, 2011). This transitionary process is found in equations $(S21)$ to $(S24)$. Through the transitionary process variables such as ROR_r, Ψ_r, and $F_r^{(LR)}$ satisfy the requirements of exogeneity, without having to impose exogeneity.

Equations $(S1)$ to $(S18)$ describe the macro-economic relationships within a specific year. Equations $(S21)$ to $(S24)$ however, describe the movements of stock variables: capital (K_r), government debt (GD), and net foreign liabilities (NFL_r), between years and are therefore assumed exogenous within years. These movements depict the dynamic nature of TERM-SA. As an example, changes in K_r between years, is driven by the accumulating relationships between investment and savings, within years. Similarly, equation $(S20)$ describes the adjustment process of sticky wages from a short to long-run closure, an adjustment which is often used in policy simulations; in the short-term, real wages are often exogenous and the employment rate endogenous. Equation $(S20)$ then allows these variables to adjust over time to a long-term setting where the employment rate is exogenous and real wages are endogenous.

Table 4A: S-BOTE Equations

Equations	Eq.
$GRE_r = C_r + I_r + G_r$	$(S1)$
$Y_r = GRE_r + \left(X_r^{(R)} - M_r^{(R)}\right) + (X_r^{(*)} - M_r^{(*)})$	$(S2)$
$C_r = APC_r * HINC_r$	$(S3.1)$
$HINC_r = [Y_r * f(TofT) - NFT_r]$	$(S3.3)$
$G_r/C_r = \tau_r$	$(S4)$
$X_r^{(*)} = b(P_r/V_r)$	$(S5.1)$
$M_r^{(*)} = f(Y_r, TofT, TWS)$	$(S6.3)$
$TofT = PX/PM$	$(S7.1)$
$PY = f(CPI, TofT)$	$(S8)$
$ROR_r = R_r/P_r$	$(S9.1)$
$I_r = u(ROR_r/\vartheta_r)$	$(S10)$
$I_r/K_r = \Psi_r$	$(S11)$
$P_r = A_r * u(\{W_r * A_r^L\}, R_r)$	$(S12)$
$Y_r = [1/A_r]f(\{L_r/A_r^L\}, K_r)$	$(S13)$
$K_r/\{L_r/A_r^L\} = g(\{W_r * A_r^L\}/R_r)$	$(S14)$
$L_r = f(ATRW_r, \Delta L\_Pref_r)$	$(S15)$

$ATRW_r = BTRW_r * (1 - TL)$	$(S16.1)$
$BTRW_r = W_r/CPI$	$(S17.1)$
$W_r/W = F_r^{(LR)}$	$(S18)$

Dynamic Equations	**Eq.**
$K_{t+1} - K_t(1 - Dep_t) = I_r$	$(S21.1)$
$\Delta GD = GDef$	$(S22)$
$\Delta NFL_r = GRE_r - Y_r - NFT$	$(S23)$

The lagged wage adjustment process	**Eq.**
$\left\{\frac{W^p(t)}{W^f(t)} - 1\right\} = \left\{\frac{W^p(t-1)}{W^f(t-1)} - 1\right\} + \alpha\left\{\frac{E^p(t)}{E^f(t)} - 1\right\}$	$(S24)$

4.2.2 S-BOTE Equations

Giesecke and Madden (2011) explain each equation of S-BOTE in detail and elaborate on both static and dynamic modelling with S-BOTE representation. This section highlights key points of their explanation, but also draws from BOTE-M in Bohlmann (2011). It should be noted at this stage, that although this section will mostly focus on regional expressions, variables and equations can also be used to express national variables. In this instance national variables and equations are often simply the summation of regional variables and equations.

Equation $(S1)$ illustrates gross regional expenditure GRE_r, at constant prices:

$$GRE_r = C_r + I_r + G_r \qquad (S1)$$

Where C_r, I_r, G_r are the real regional household consumption, investment, and government expenditure, respectively. Regional gross domestic product Y_r, can then be expressed as:

$$Y_r = GRE_r + \left(X_r^{(R)} - M_r^{(R)}\right) + (X_r^{(*)} - M_r^{(*)}) \qquad (S2)$$

Where $X_r^{(*)}$ and $M_r^{(*)}$ indicate each region's exports to, and imports from the rest of the world. $X_r^{(R)}$ and $M_r^{(R)}$ however, indicate exports and imports between regions.

Real regional household consumption C_r, is expressed by equation $(S3.1)$ as the average propensity of a household (APC_r) to consume their disposable income $(HINC_r)$. For the sake of simplicity, we have removed the household-type subscript from the household equations even though TERM-SA models consumption and income patterns for 12 different household types.

$$C_r = APC_r * HINC_r \qquad (S3.1)$$

From here, regional household income can be expressed as:

$$HINC_r = [\{(PY_r/CPI) * Y_r\} - NFT_r] \qquad (S3.2)$$

NFT_r are the net-foreign transfers between households and the rest of the world, as defined in the SAM-extension of TERM-SA. The first expression on the right of equation ($S3.2$) expresses real GDP. PY_r is the regional GDP-deflator and contains information about prices of domestically produced exports but does not contain information about import prices. On the other hand, the consumer price index, CPI, contains information about import prices, but not about export prices. The term (PY_r/CPI) can therefore, also be interpreted as a function of the terms of trade[25]. Regional household disposable income can, therefore, be rewritten as:

$$HINC_r = [\{Y_r * f(TofT_r)\} - NFT_r] \qquad (S3.3)$$

At this point it is important to explain that TERM-SA incorporates both national and regional prices, as well as foreign currency expressions of these prices. Also, national and regional price variables and equations follow a similar format. As an example, the regional GDP deflator PY_r

[25] The terms of trade can be defined as the relationship between foreign-currency export prices and foreign-currency import prices. This relationship is expressed by equation ($S7.1$) and elaborated on in equation ($S7.2$).

could also be expressed as PY. Because of this, we will refer to either one of the two expression in this simplified expression of TERM-SA.

Finally, after some manipulation and adding taxes, the disposable household income in each region, ($S3.3$), can be rewritten as:

$$HINC_r = [\{Y_r * f(TofT_r)\} * (1 - TQ) - (BTRW_r * LD_r) * TL - NFT_r] \quad (S3.4)$$

Here, TQ and TL are tax rates on production and labour, respectively. $BTRW_r$ is the regional before-tax real wages and will be explained in more detail later when we discuss equations ($S15$) to ($S17.2$). Labour demand LD_r, is obtained from: $LD_r = L_r - U_r$; the difference between labour supply and unemployment.

Equation $(S4)$ relates τ_r, the ratio of government consumption expenditure to household consumption. This simplified version of government expenditure allows the modelers to fix the ratio and thereby force government expenditure to move with household consumption. TERM-SA can, however, be set up in such a manner as to allow the government to spend independently from household consumption:

$$G_r/C_r = \tau_r \qquad (S4)$$

By summing each region's government expenditure G_r, the modelers obtain the aggregate expenditure expressed by equation $(2.5K)$ in the SAM-extension section of Chapter 2. Government spending in turn, impacts the government's deficit $GDef$, in equation $(2.3M)$, and ultimately government debt GD, which was originally introduced in the dynamic equation $(2.3L)$ and will later be expressed in equation $(S22)$. For simplicity the time variables were removed from these variables.

Exports facilitated to the $RotW$ from each region $X_r^{(*)}$, are expressed in terms of the price of regional output and a vertical scalar variable that represents the region's willingness to pay for their specific export demands (Giesecke & Madden, 2011).

$$X_r^{(*)} = b(P_r/V_r) \qquad (S5.1)$$

TERM-SA follows a similar approach to many regional CGE-models and uses an Armington (CES) assumption to model the various supply substitution possibilities between different commodities in each region. Users can either source commodities from the region they reside in, from other regions, or import them from the rest of the world. The functional form of these decisions can be expressed as:

$$X_r^{(R)} = s(P_r/PY, \nexists_r) \qquad (S5.2)$$

$$M_r^{(*)} = h(P_r/P_m, Y_r) \qquad (S6.1)$$

$$M_r^{(R)} = d(P_r/PY, Y_r) \qquad (S6.2)$$

Equations $(S6.1)$ and $(S6.2)$ represent each region's imports from both international and local sources. These equations associate the level of imports to the relative (regional) price and regional activity Y_r. In a similar manner equation $(S5.2)$ associates regional exports to relative prices and allows for cost-neutral autonomous changes in preferences, to or away from a specific region's commodities. This is done through an inter-regional twist term $\nexists_r$ (Giesecke & Madden, 2011)[26]. In both equations ($S5.2$) and ($S6.2$) relative prices are expressed as a specific region's prices relative to other regions. However, in equations ($S5.1$) and ($S6.1$) relative prices are expressed as a specific region's price relative to foreign currency import prices (P_m). Also, in these instances the regional price can be viewed in terms of their foreign currency value, P_X, which will later help us to derive equation ($S7.1$). For simplicity we remove the regional dimension in this expression. Applying Bohlman's (2011) BOTE-M equations, $(S6.1)$ and $(S6.2)$ can be expressed as a function of the regional activity Y_r, $TofT$, and some import-domestic preference variable; this will become clearer once we define equation ($S8$).

$$M_r^{(*)} = f(Y_r, TofT, TWS) \qquad (S6.3)$$

$$M_r^{(R)} = f(Y_r, TofT_r, \nexists_r) \qquad (S6.4)$$

[26] Estimating inter-regional sourcing twist terms such as $\nexists_r$ are further discussed in Horridge (2003).

It is important to note that there are two different $TofT$ variables, one for regional substitution (between regions, $TofT_r$), and another for international substitution (between regions and the $RotW$, $TofT$). However, for simplicity our reference to terms of trade will refer to relative prices when international substitution is considered. Equations that consider regional imports and exports between different regions were included to explain how the process works in TERM-SA. The regional decision about which commodities to import from international sources is defined by equation ($S7.1$). Although export prices differ on a regional basis in TERM-SA we have removed the regional dimension in this simplified S-BOTE representation.

$$TofT = P_X / P_M \qquad (S7.1)$$

The foreign-currency price of commodities can in turn be related to the volume of exports and some export-demand shifter: $P_X = f(X, F_x)$. Consistent with the nature of South Africa's small, open economy, foreign demand for local commodities X, are inversely related to foreign-currency prices through constant elasticity demand functions. This implies that the demand curve for exports is downward sloping. Being a small open economy also implies that South Africa is a price taker in the global import market; import prices P_M, are therefore, exogenously determined outside of the model. Consequently, the terms of trade can then also be expressed as:

$$TofT = f(X, F_x) \qquad (S7.2)$$

Bohlmann (2011) explains how equation ($S8$) is deducted from the economy-wide output price equation: $PY = [S_A P_A + S_X(P_X - P_M)]$[27]. Here, S_A reflects the share of absorption and S_X the share of exports in the economy. Whereas, PY, P_A, P_X, and P_M each respectively reflects the percentage-change in the price of output, absorption, exports, and imports. Although TERM-SA allows for price differences between users, S-BOTE assumes that trade is balanced and that user prices, or the price of absorption, is reflected by CPI. From here, we

[27] It should be noted that this equation can be adopted to reflect regional output prices, PY_r. Here our focus is on the aggregate, rather than regional output, and on aggregate prices and their relevance to previous equations.

can express the price of aggregate output; the GDP deflator PY, to CPI and the terms of trade:

$$PY = f(CPI, TofT) \quad (S8)$$

Regional industry investment I_r, is related to the regional rates of return on capital ROR_r, for each industry via the following equations from Giesecke and Madden (2011):

$$ROR_r = R_r / P_r \quad (S9.1)$$

$$I_r = f(ROR_r / \vartheta_r) \quad (S10)$$

Here, the regional real rental price per unit of capital is defined by R_r, and is used with the regional price level P_r (which we will later define as the price of investment), to determine regional rates of return ROR_r. Regional rates of return, are in turn, used in conjunction with a shift variable ϑ_r. This allows regional investment to change autonomously in the short-term. From here, the regional gross capital growth rate (Ψ_r) can be calculated:

$$I_r / K_r = \Psi_r \quad (S11)$$

By applying a cost-minimising regional output function to $(S13)$, a unit cost function can be determined, namely equation $(S12)$. This cost structure is a function of regional primary factory prices, and the efficiency of regional primary factor usage A_r, as well as regional labour efficiency A_r^L. This unit cost function is therefore also the regional price level P_r. As explained earlier, this equation can also be adopted on an aggregate scale to express the national price level, P, in which case PY, will once again represent the national GDP-deflator in equation $(S8)$.

$$P_r = A_r * u(\{W_r * A_r^L\}, R_r) \quad (S12)$$

Common in long-run CGE modelling is the assumption that regional capital allocation among industries occur in such a way as to equalise risk-adjusted rates of return (Giesecke & Madden, 2006). This is achieved by calculating long-run rates of return exogenously, which allows the cost of capital creation to change capital rental prices. Assuming an exogenous R_r, a fixed A_r, and using real wages (W_r) determined by equation $(S6)$, the long-run regional prices tend to move together (Giesecke & Madden, 2006).

Equation $(S13)$ illustrates GDP from the income side and shows how regional output Y_r, corresponds to primary factor inputs and technology through a constant return to scale production function:

$$Y_r = [1/A_r]f(\{L_r/A_r^L\}, K_r) \qquad (S13)$$

Here, A_r indicates the efficiency at which primary factor inputs are transformed into output, on a regional level. A_r^L focuses on the technical efficiency of regional labour inputs. L_r and K_r describe regional employment and capital stock, respectively.

Given the assumption of constant returns to scale and regional producer's cost-minimising behaviour in TERM-SA, the regional capital-labour ratio can be related to the regional wage-rent ratio in the following manner (Giesecke & Madden, 2011):

$$K_r/\{L_r/A_r^L\} = g(\{W_r * A_r^L\}/R_r) \qquad (S14)$$

It is worth noting from equation $(S14)$ that the marginal product of capital (MPK) is negatively related to the K/L ratio, but that the marginal product of labour (MPL) is positively related to the ratio.

Removing the regional dimension for simplicity, the rate of return on capital (ROR) can then be defined by $[R/PI]$, where R is the factor payment made to capital and PI is the price index of investments (Bohlmann, 2011). Capital factor payments (R) are in turn, determined by the value of the marginal product of capital: $[MPK * PY]$, where MPK is a function of the K/L ratio and technical change. Also, $[PY/PI]$ is a function of the terms of trade. From these assumptions we can adjust equation $(S9.1)$ in the following manner:

$$ROR = f\{(K/L), TofT, A\} \qquad (S9.2)$$

Following Giesecke and Madden (2006) per-capita migration income is similar across regions. Migration income includes elements of real income that depend on an individual's location; these include real wages and transfers from government, amongst others. However, migration income excludes capital and land rentals as their region of origin remains unchanged as an individual relocates. By adjusting Bohlmann's (2011) single-region BOTE-M to fit TERM-SA's regional modelling capabilities, equations $(S15)$ to $(S16)$ illustrate various labour-related functions of TERM-SA.

Regional employment L_r in equation $(S15)$, is expressed as a function of the regional after-tax real wages, and the regional change in labour supply preferences:

$$L_r = f(ATRW_r, \Delta L\_Pref_r) \qquad (S15)$$

where,

$$ATRW_r = BTRW_r * (1 - TL) \qquad (S16.1)$$

We are also able to express the change in after-tax real wages through the following equation:

$$\Delta ATRW_r = f(D_r, L_r). \qquad (S16.2)$$

In doing so, this equation, and that of $(S15)$, capture the real wage adjustments and labour supply mechanisms used in TERM-SA's policy simulations. If in a certain policy, labour demand is relatively higher than supply, $\Delta ATRW_r$ will increase relative to its baseline, over time. In doing so the regional labour market does not clear in the short-term. Parameters in the wage adjustment equation $(S24)$ govern the response of lagged wages to the gap between labour demand and supply, to ultimately reduce the gap in the long-term. Labour demand is captured by the following before-tax real wage equations, $(S17.1)$ and $(S17.2)$. Labour supply was previously expressed by equation $(S15)$.

Before-tax real wages $BTRW_r$, can be expressed in the following manner:

$$BTRW_r = W_r / CPI \qquad (S17.1)$$

Here, W_r is the regional wages received by employees, and CPI is the consumer price index, which is assumed fixed over regions. Regional wages in turn, are determined by the value of the marginal product of labour (MPL) and the GDP deflator: $W_r = MPL_r * PY$. Following the same reasoning as with equation ($S9.2$), $BTRW_r$ can alternatively be expressed as a function of the K/L ratio, $TofT$, and technical change:

$$BTRW_r = f(K_r/L_r, TofT, A) \qquad (S17.2)$$

The ratio of regional wage rates and the national wage rate aids the process of calculating exogenous wage relatives across regions by means of:

$$W_r/W = F_r^{(LR)} \qquad (S18)$$

To derive the rate of return (ROR) in equation ($S9.2$) and the before tax real wage ($BTRW_r$) in equation ($S17.2$) we initially made two assumptions: that production follows CES production function, and that the cost of employing capital and labour equal values that correspond to their MPK and MPL, respectively. In other words, we maximised the economy-wide profits, subject to a CES production function; explained in more detail in Appendix B3. In doing this, we can derive equations ($S19$) and ($S20$). These equations can later aid in our interpretation of capital and labour changes, as well as subsequent changes in the K/L ratio.

$\frac{\partial Y_r}{\partial K_r} = MPK \approx \frac{1}{A} * \frac{R}{PY}$ or put differently, $MPK \approx \frac{1}{A} * \frac{R}{PI} * \frac{PI}{PY}$ so that

$$MPK \approx \frac{1}{A} * ROR * \frac{PI}{PY} \qquad (S19)$$

$\frac{\partial Y_r}{\partial L_r} = MPL \approx \frac{1}{A} * \frac{W_r}{PY}$ or put differently $MPL \approx \frac{1}{A} * \frac{W_r}{CPI} * \frac{CPI}{PY}$ so that

$$MPL \approx \frac{1}{A} * BTRW_r * \frac{CPI}{PY} \qquad (S20)$$

As previously stated, W_r and R are factor payments made to labour and capital, respectively. Also, PI is the price index for new investment goods. CPI, is the consumer price index, and PY the GDP deflator. In equation ($S19$), (R/PY) can be split into two. First, (R/PI), or the rate of return on capital (ROR) of equation ($S9.1$), so that $PI = P_r$. Second, (PI/PY) is a decreasing function of the $TofT$, because PI includes imports but not exports, whereas PY includes exports, but not imports. This $TofT$-effect is especially important in countries like South Africa where imports and exports are a relatively large share of GDP. In equation ($S20$) the term that represents real producer wages, or put differently, the cost of employing a unit of labour (W_r/PY), can also be split in two. First, (W_r/CPI), the real before-tax consumer wage of equation ($S17.1$). Second, like previously, (CPI/PY), is a decreasing function of the $TofT$.

By recognising that the MPK is negatively related to the K/L ratio, equation ($S19$) can be used to show that the K/L ratio in equation ($S9.2$) is negatively related to the ROR, and positively related to the $TofT$ and A. As the relative amount of capital increases the MPK decreases, consequently the rate of return on capital also declines. However, this relative increase in capital should lead to a better $TofT$ and a more productive economy. In a similar manner, recognising that the MPL is positively related to the K/L ratio, equation ($S20$) shows that the K/L ratio in equation ($S17.2$) is positively related to the real wage ($BTRW_r$).

The dynamic process used in TERM-SA whereby certain regional stock variables are changed into flow variables can be expressed by the following equations of capital, government debt and net foreign liabilities:

$$K_{t+1} - K_t(1 - Dep_t) = I_r \qquad (S21.1)$$

Which can be simplified into:

$$\Delta K_r = I_r \qquad (S21.2)$$

$$\Delta GD = GDef \qquad (S22)$$

$$\Delta NFL_r = GRE_r - Y_r - NFT \qquad (S23)$$

In equation ($S21$) regional capital stock is associated with regional investment. Equation ($S22$) defines changes in national government debt, and equation ($S23$) associates regional net foreign liabilities to the difference between regional consumption and production after adjusting for net foreign transfers (NFT).

Finally, equation ($S24$), which has been explained in detail in the Section 2.3.3 of Chapter 2, directs wages in the policy and forecast simulations, $W^p(t)$ and $W^f(t)$, respectively. Equation ($S24$) also shows how employment rates that are above (below) the baseline, cause the deviation in real wages to increase (decrease). Again, equation ($S24$) can be adopted for regional wages as well.

$$\left\{\frac{W^p(t)}{W^f(t)} - 1\right\} = \left\{\frac{W^p(t-1)}{W^f(t-1)} - 1\right\} + \alpha\left\{\frac{E^p(t)}{E^f(t)} - 1\right\} \qquad (S24)$$

4.3 The Forecast Closure

4.3.1 Introduction

TERM-SA's forecast closure is used to produce a believable business-as-usual picture of the likely evolution of the South African economy over multiple years. Often referred to as the baseline closure, the business-as-usual environment creates a starting point for relevant policy shocks to be imposed. A policy shock enacts changes to exogenous variables, thereby creating a percentage change deviation away from the baseline. By analysing these deviations, modelers can evaluate the impact of various policies on the South African economy. In Chapter 5 we will discuss and consider such a policy change in detail.

To create a suitable forecast closure, we follow the guidelines set out in Dixon and Rimmer (2002) and start by using the Automatic Closure function of TAB-mate Tools. Automatic Closure is a product of the GEMPACK (Harrison & Pearson, 1996) software and relies on the correct naming of model equations to enable the software to match equations and variables to one another. After the initial matching was carried out, we made appropriate adjustments to match unmatched variable and equation pairs, to ensure that the model is solvable. Setting up the baseline closure is done in such a manner that it considers the addition of reliable macro-economic forecast data, everything we think we know about the future, and often has little regard for causation. Some other steps in the setup process include creating a short run environment and activating dynamics. Adding reliable macro-economic data and creating a short-run environment is done making use of various swap statements between exogenous and endogenous variable pairs, which swaps the status (exogenous or endogenous) between the two variables.

It is also important to mention that baseline forecast simulations in dynamic CGE-models, like TERM-SA, are performed as a sequence of annual solutions, and are therefore, short-run in nature. Dixon and Rimmer (2002) note that in these annual solutions, the start-of-year $(t+1)$ stock variables are determined by end of year (t) stock variables in the baseline. Stock variables in TERM-SA include capital and government debt. Although start-of-year stock variables are considered exogenous within a year (t) they are endogenous between years. In the following example TERM-SA's capital accumulation mechanism is expressed by equations $(S25)$ and $(S26)$, adjusted from $(S21)$ and $(S10)$, respectively:

$$K_{t+1} = K_t * [1 - DEP_t] + I_t \qquad (S25)$$

$$I_t = f(EROR_t) \qquad (S26)$$

Equation $(S25)$ shows that the end-of-year capital stock (K_{t+1}) is a function of the depreciation-adjusted start-of-year capital stock (K_t), and investments made during year t. Equation $(S26)$ defines investment decisions as a function of the current expected rate of return, explained in Section 2.3. Investments in this period only affect capital growth in the following period. By introducing this assumption, TERM-SA can keep start-of-year capital stock exogenous and end-of-year capital stock endogenous in the year-on-year short-term closure. A similar process can be implemented for government debt accumulation in TERM-SA. To create a suitable short-run environment to facilitate this year-on-year process in TERM-SA, we use swap statements. These swaps allow regional household consumption to follow wage income and fix the nominal balance of trade (measured as a percentage of GDP); which will later be endogenized again.

In addition to creating a short-run environment we activate the dynamic mechanisms described above by introducing three more swaps. The first two endogenizes capital and fixes the investment/capital ratio, previously illustrated in equation ($S11$), to activate the dynamic investment rule that starts the capital accumulation mechanism described previously. In doing so, capital can be made endogenous even though it appears not to be coherent with short-run theory. The third swap activates SA's national labour adjustment mechanism. Normally short-run modelling real wages are made sticky and aggregate labour made flexible. However, we are creating a baseline of the likely progression of SA's economy and have reliable forecast data for labour. We therefore, exogenise labour and shock the employment trend growth rate with the labour force growth rate. In this instance, both the real wage and employment are endogenous. In doing so we have assumed an upward sloping labour supply curve, which will continuously move to the right (up) when actual employment exceeds trend employment.

After these initial steps are introduced, we use more swaps to incorporate the macro-economic forecast data for the following aggregate economic variables: real gross domestic product (Y), employment (L), household consumption (C), investment (I), government expenditure (G), and exports (X). To make these variables exogenous, many naturally exogenous variables must be made endogenous. These include: primary factor technical change, nominal balance of trade, and the average propensity to consume, to name but a few. At this stage it is important to mention that the exchange rate was used as numeraire and that GDP was not over-determined. Also, because both technical change and export-demand have been set endogenous, we have essentially exogenised the quantity of exports (X) and the terms of trade ($TofT$) at their equilibrium rates. The latter assumption was achieved by exogenising F_x, an export shift variable introduced in equation ($S7.2$) that shifts the export demand function. Bohlmann (2011) explains in detail the importance of endogenising the correct variables to allow for exogenous exports.

After introducing the necessary swaps and considering the available macro-economic forecast data, a suitable business-as-usual representation of the South African economy was created. Details about the actual forecast values and baseline forecast results will be further explained in Chapter 5.

4.4 The Policy Closure

Policy closures are used to analyse the impact of exogenous shocks to the baseline economic environment and illustrate the impact as a percentage deviation away from the baseline. Like baseline closures, policy simulations are performed as a sequence of annual solutions. For this reason, the policy closure also resembles many short-run features and is set up accordingly. Policy closures are more conventional because naturally endogenous variables, like components of GPD and employment, are kept endogenous, unlike in the forecast closure. Concurrently, naturally exogenous variables are kept exogenous and assume the values generated in the preceding forecast simulations. These variables include: the positions of foreign demand curves, and the average propensity to consume, to name but a few. Furthermore, policy changes are introduced by using swap statements with variables that are not usually affected by policy decisions.

This conventional route is preferred by modelers because it allows them the opportunity to evaluate the impact of policy changes on key macro-economic variables. TERM-SA not only produces results for aggregate macro-economic variables, but also provides disaggregated results on an industry, regional, and household level. In doing so modelers can discern possible winners and losers for any imposed policy changes.

Like the forecast closure, a short-run environment is created in the policy closure by exogenising start-of-year capital. The wage adjustment mechanism was already active; which keeps wages sticky in the short run. This allows us to endogenise employment (L_r) and the rates of return (ROR) through equations $(S9.2)$ and $(S17.2)$. Following equations $(S9.2)$, $(S13)$, $(S17.2)$, $(S19)$ and $(S20)$, technical change and the real wage rate, determine the ROR via the factor-price frontier (the relationship between the MPK and the MPL). However, technical change (A) is assumed fixed; a common assumption in policy closures. Consequently, one can consider capital stock (K), real wages, and technical change as exogenous in the policy closure.

Dynamic functions of TERM-SA are also active in the policy closure. However, unlike the forecast closure, macro-economic variables that were assumed exogenous in the forecast simulation are now kept endogenous. Real gross domestic product (Y) is endogenised via $(S1)$. Household consumption (C) and investment (I) are endogenised via $(S3.1)$ and $(S10)$, respectively. With the balance of trade $(X - M)$ endogenous, we exogenise the export demand shifter (F_x) in equation $(S7.2)$ and a (twist) variable that captures the import/domestic preferences in our economy. Exports (X) are determined by $(S1)$ and the $TofT$ can be endogenised via equation $(S7.2)$. In our policy closure we do not use equation $(S4)$ to force government consumption to follow household consumption, even though this is a common assumption in CGE-modelling[28]. We have also assumed that the government deficit remains unchanged between the baseline and forecast closures. This assumption is introduced because the objective of our analysis is to find a better alternative for the government's planned expenditure and not to change expenditure levels; this can be considered in future research.

In the policy closure we also introduce the necessary swaps that would later allow us to shock the relevant policy variables. Although the specific shocks will be discussed in more detail in Chapter 5, we offer a simple explanation about the swaps that will be used to allow our policy simulation. The aim of this study is to provide a fiscal policy alternative to the government's current mix, that can lead to greater economic and social development. Our proposed alternative is to keep the real government wage bill fixed for five years. The savings from this decision can then be used to boost aggregate investment via a subsidy in the construction industry. To do this we introduce a first set of swaps that exogenise the real wages ($BTRW$ in equations $S16$, S17.1, and $S17.2$) of the three government industries in South Africa: general government, health and education[29]. By applying these initial swaps real wages are determined by standard wage-related equations such as $(S17.2)$. The second set of swaps endogenises labour productivity and exogenises employment in the government industries. Together, these two set of swaps fix the real wage bill of the total government industry in South Africa.

[28] If this assumption is applied, the results do not differ in direction or relative magnitude.

[29] Real wages in TERM-SA are defined on an industry, occupation and destination level which allow us to isolate the shock to government wages only.

In the final set of swaps, we boost investment by the amount of savings that was generated from the decision to keep the government wage bill fixed for five years. This investment boon is facilitated by subsidising the South Africa's construction industry, which endogenously adjusts to accommodate the deviation (saving) in government expenditure, via the reduced wage bill. In this instance, the construction industry is used as a proxy for total investment. We believe this is prudent, because according to the Supply-Use Tables (Statistics South Africa, 2016) the construction industry represents 48% of total investments in South Africa. Also, 78% of the construction industry is used as inputs in creating investment products in the South African economy.

4.5 Concluding Remarks

In this chapter we provided an introduction of the model closure procedure and choosing the correct number of exogenous variables to solve TERM-SA's system of linear equations. We then provided a stylised back-of-the-envelope (S-BOTE) representation of TERM-SA, S-BOTE. This simplified representation allows for an easy-to-understand view of how causality is applied throughout TERM-SA's system of equations and will be important in the Chapter 5. S-BOTE also allows for an understanding of how the baseline and policy closures are created. After S-BOTE was discussed, we introduced TERM-SA's forecast and policy closures. We explained how our choice of exogenous variables is based on the guidelines set out in Dixon and Rimmer (2002) and the availability of reliable forecast data. The forecast closure created a believable business-as-usual picture of the likely evolution of the South African economy. This policy closure was set up in such a manner that it would allow us to analyse the impact of the suggested policy changes as percentage deviations away from the baseline. In the following chapter we discuss the results of our baseline and policy simulations.

CHAPTER 5 – SIMULATIONS AND RESULTS

5.1 Introduction

The main purpose of TERM-SA is to estimate the impact of economic policies on a variety of macro and micro-economic variables in the South African context. In this chapter we will simulate an alternative fiscal policy mix different than the one government has been following and evaluate the impact of policy suggestions on the South African economy. Specifically, we will reduce the redistributive nature of government's policy mix, by keeping the real government wage bill fixed for five years. Savings generated from this decision are used to exogenously increase spending on wealth creative policies during the same period. By doing this we will boost aggregate investment by providing a subsidy to the construction industry.

In 2018 South Africa's Minister of Finance, Tito Mboweni, announced during his Medium-Term Budget Policy Statement (MTBPS) that South Africa is at a crossroads and that tough decisions must be made (National Treasury, 2018). In 2019, during his annual Budget Speech, he elaborated on this by explaining that the salaries of members of parliament, and those of the directors of large state-owned enterprises (SOEs), will not be increased (National Treasury, 2019). Minister Mboweni also explained that the structure of key SOEs will be changed and to a certain extent, privatised (National Treasury, 2019). Radical policy statements like these point towards a government that is willing to consider other fiscal policy strategies to create a more prosperous South Africa for all. In this chapter we will add to this debate through our analysis of an alternative fiscal policy mix.

In this chapter, we will first consider a plausible 20-year business-as-usual forecast (which we also refer to as the baseline forecast) of the South African economy, from 2015 up to 2035. The baseline forecast incorporates available macro-economic forecast data from experts and illustrates how the South African economy is likely to evolve in the absence of any policy shocks. Considering its impact on the policy simulation, Dixon and Rimmer (2002) explain the importance of setting up the baseline in the correct manner. Results generated by the baseline forecast simulation will briefly be considered before we introduce a fiscal policy alternative to the government's current strategy. This alternative is simulated as a policy shock or deviation from the baseline and allows us to estimate the economic impact of the change in policy. We will consider in detail the impact of a change in government policy on national and provincial macro-economic variables, industries and different household types. We will also make use of the SAM-extension of TERM-SA to discern a more accurate impact of a change in fiscal policy on the flow of income between various economic agents in the South African economy. TERM-SA is used to simulate both the baseline and policy alternative and is solved using the GEMPACK software package developed by Harrison and Pearson (1996)[30].

5.2 Baseline Forecasts

The baseline forecast simulation aims to produce a believable business-as-usual picture of the South African economy from 2015 until 2035 and therefore excludes the impact of policy shocks. To estimate the effect of the alternative fiscal policy mix (the policy shocks) we run the policy simulation. Comparing the results of the baseline and policy simulations, as a percentage deviation from one another, we can ultimately determine the impact of the suggested policy changes. We first need to know how the government wage bill and aggregate investments in the economy would have evolved in a business-as-usual environment, before alternatives can be measured against them.

Following from our discussion in Chapter 4, the forecast closure was created by exogenising macro-economic variables for which we have reliable forecast estimates. In doing so, we created a simulation environment that could apply these projections and ultimately create the business-as-usual (baseline) picture of the South African economy. It is important to remember that in order to exogenise these naturally endogenous variables, it was necessary to exogenise some naturally endogenous variables. These included: the average propensity

[30] When solving the model, we used a Euler 12-step solution method to eliminate possible linearization errors which can occur in simpler methods like the Johansen one-step method. A description of the Euler method is provided in Appendix B2.

to consume and some preference and shift variables, to name but a few. After applying the necessary swaps and projections, the baseline forecast simulation was run from 2015 to 2035. The 20-year time horizon is not too long to be considered irrelevant to today's policymakers, but long enough to allow the economy to adjust to a new steady-state after the policy shocks were imposed.

5.2.1 Baseline: National Macro-Economic Results

Table 5A shows the macro-economic results that were estimated by TERM-SA in the baseline forecast simulation. As far as possible these variables correspond to those described in the S-BOTE equations of Chapter 4 and aid the reader in understanding the underlying model closures and the results generated by TERM-SA. Variables that are indicated in red are those that were exogenously set by either making use of actual data or reliable forecast estimates from experts. Each year's results are reported as the cumulative percentage from to 2015.

Table 5A shows that we have chosen to exogenise all components of GDP from the expenditure side and set real GDP on a trajectory to reach a cumulative growth of 59.64% in 2035. This translates into an average annual growth rate of roughly 2.37%, compounded annually from 2016 to 2035. Investment expenditure (I) is expected to grow only slightly faster than government expenditure (G). Considering the imposed forecasts, very little change in the budget deficit to GDP and debt to GDP ratios are expected.

In the baseline forecast simulation we exogenise the trend employment rate but choose to endogenise employment demand (D), labour supply (L), and real wages (RW). Trend employment is increased annually by the expected growth in the labour force, 1.25%. We also exogenously increase labour productivity by 1.1% annually. As a result, employment demand only increases above labour supply in 2031, i.e. unemployment increases until 2030 and only in 2031 does unemployment start to decrease. This captures the nature of South Africa's structurally high and increasing levels of unemployment which has been increasing from 16.9% in 1995 to 29.1% in 2019.

Table 5A: Selected Macro Variables, Baseline Forecast Simulation

Macro-Economic Variable	2016-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Real GDP (GDP)	12.25%	14.87%	17.57%	20.34%	23.19%	26.11%	29.11%	32.19%	35.35%	38.58%	41.89%	45.28%	48.75%	52.30%	55.93%	59.64%
Private Consumption (C)	11.11%	13.52%	16.01%	18.59%	21.26%	24.02%	26.87%	29.81%	32.84%	35.96%	39.16%	42.45%	45.82%	49.28%	52.82%	56.45%
Investment (I)	15.11%	18.25%	21.43%	24.66%	27.93%	31.23%	34.58%	37.95%	41.37%	44.83%	48.33%	51.89%	55.49%	59.16%	62.90%	66.71%
Government Expenditure (G)	13.14%	15.97%	18.87%	21.84%	24.89%	28.01%	31.21%	34.49%	37.85%	41.30%	44.83%	48.45%	52.16%	55.97%	59.87%	63.86%
Exports (X)	12.44%	15.09%	17.80%	20.59%	23.44%	26.36%	29.35%	32.41%	35.54%	38.73%	41.99%	45.32%	48.72%	52.19%	55.74%	59.36%
Foreign Demand Shifter (Fx)	3.15%	3.77%	4.40%	5.02%	5.65%	6.28%	6.92%	7.56%	8.20%	8.84%	9.48%	10.13%	10.78%	11.43%	12.09%	12.74%
Imports (M)	12.61%	15.30%	18.06%	20.89%	23.79%	26.76%	29.80%	32.91%	36.09%	39.34%	42.67%	46.07%	49.54%	53.09%	56.72%	60.43%
Capital Stock (K)	11.03%	13.54%	16.15%	18.85%	21.64%	24.52%	27.48%	30.53%	33.67%	36.89%	40.19%	43.57%	47.03%	50.57%	54.20%	57.90%
Technical Change, Regional Average (A)	0.04%	0.06%	0.08%	0.10%	0.12%	0.14%	0.16%	0.18%	0.20%	0.23%	0.25%	0.27%	0.30%	0.32%	0.34%	0.37%
Labour Productivity, Industry Average (AL)	-6.08%	-7.11%	-8.13%	-9.15%	-10.14%	-11.13%	-12.11%	-13.08%	-14.03%	-14.98%	-15.91%	-16.84%	-17.75%	-18.66%	-19.55%	-20.44%
Price of Labour, Compensation (CoE)	2.91%	3.86%	4.88%	5.96%	7.08%	8.24%	9.44%	10.67%	11.93%	13.22%	14.53%	15.86%	17.21%	18.58%	19.96%	21.35%
Employment (D)	7.49%	8.93%	10.37%	11.83%	13.30%	14.78%	16.29%	17.81%	19.34%	20.90%	22.47%	24.06%	25.67%	27.30%	28.94%	30.61%
Real Wage (RW)	2.73%	3.65%	4.65%	5.69%	6.79%	7.92%	9.09%	10.30%	11.53%	12.79%	14.07%	15.37%	16.68%	18.02%	19.37%	20.73%
Price of Capital (R)	2.96%	3.16%	3.31%	3.41%	3.48%	3.51%	3.53%	3.52%	3.51%	3.49%	3.46%	3.43%	3.40%	3.37%	3.34%	3.32%
Price of Investment (PI)	0.56%	0.56%	0.55%	0.54%	0.53%	0.51%	0.50%	0.48%	0.47%	0.47%	0.46%	0.46%	0.46%	0.47%	0.48%	0.49%
Consumer Price Index (CPI)	0.18%	0.20%	0.23%	0.25%	0.27%	0.29%	0.31%	0.34%	0.36%	0.38%	0.40%	0.43%	0.45%	0.47%	0.50%	0.52%
GDP Price Index (PY)	0.04%	0.05%	0.06%	0.07%	0.09%	0.11%	0.13%	0.15%	0.17%	0.19%	0.22%	0.25%	0.28%	0.31%	0.34%	0.37%
GNE Price Index (PGNE)	-0.01%	-0.01%	0.00%	0.01%	0.02%	0.03%	0.05%	0.07%	0.09%	0.11%	0.13%	0.16%	0.18%	0.21%	0.24%	0.27%
Terms of Trade (TofT)	0.16%	0.18%	0.20%	0.22%	0.23%	0.24%	0.25%	0.26%	0.27%	0.28%	0.29%	0.30%	0.31%	0.32%	0.33%	0.34%
Exchange Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Number of Households (Hs)	6.41%	7.74%	9.09%	10.45%	11.83%	13.23%	14.64%	16.08%	17.53%	19.00%	20.48%	21.99%	23.51%	25.06%	26.62%	28.20%

Note: Values are indicated in cumulative percentage change, measured from the start of the forecast simulation in 2016.

Measured from the income side of the GDP, most of the annual growth is facilitated by labour (D) and labour productivity (AL), contributing 0.59% and 0.50% of the annual average growth rate of 2.37%. Capital growth (K) is linked to investment (I) via the capital accumulation mechanism and contributes a substantial amount to annual GDP growth, roughly 1.0%. For this reason, only a small amount of economy-wide technical change is needed to balance the GDP from the supply side.

Facilitated by a faster growing economy in the baseline forecast simulation, export demand (X) is exogenously set to increase annually by roughly 2.36%, i.e. 59.36% cumulatively over 20 years. By endogenizing both the Terms of Trade ($TofT$) and the export demand shift variable (F_x), that is a shift variable to change the global demand for South Africa's exports, the model can adjust to accommodate higher levels of exports. Consistent with historical evidence, changes in the $TofT$ are relatively stable over the simulation period and only increase cumulatively by 0.34%. As explained in Section 4.2, specifically equation ($S7.1$), the $TofT$ are driven by changes in local prices as import prices were effectively exogenised, i.e. South Africa is a price taker in global markets. Consequently, F_x increases cumulatively by 12.75% over the simulation period to facilitate higher levels of export growth. We do not impose an annual level of inflation on the model because our aim is to estimate price deviations between the baseline and policy simulation, not specific levels of prices within specific years. These deviations are evident with or without an inflation assumption[31]. The shift in world prices can therefore either be viewed as an increase in the price of foreign commodities, or as a depreciation of the exchange rate.

In the baseline simulation we forecast a relatively stronger (66.71%) growth in investment expenditure (I) compared to other GDP expenditure items. As a result, capital (K) also accumulates relatively faster, 57.90% over the simulation horizon; according to equations ($S10$) and ($S11$) in Chapter 4. Employment (L) is expected to grow endogenously by 30.61% and real wages (RW) by 20.73% to facilitate the growing economy; according to equations

[31] If we introduce inflation in the baseline and policy simulations, real results do not change in direction or magnitude.

($S15$) to ($S18$)[32]. Real wage appreciation occurs as the MPL increases due to exogenously set productivity increases that accumulate to 19.85% in 2035. TERM-SA's dynamic investment mechanism allows the rate of return on capital (RoR) to start decreasing in the long-term after an initial increase; following Section 4.3.1. This occurs whilst RW continues to increase throughout the simulation period; cumulative increases in RW overtake RoR in 2019. The result is that the effective capital-labour ratio increases from 0.92 in 2015 to its high of 0.94 in 2022, before falling back to 0.93 in 2035. This slight preference for capital supports the expected trajectory of the capital-labour ratio in South Africa.

5.2.2 Regional Macro-Economic Results

Table 5B illustrates some of the key regional macro-economic results of our baseline forecast simulation. Considering the nature of the shocks, and the resulting stable impact on national macro-economic variables, it is not surprising that regional variables follow a similar path. It is important to note that the results illustrated in Table 5B are shown as a cumulative percentage change over the 20-year simulation period, from the first simulation period in 2016 to the final period in 2035. The stable nature of these results imply that regional contributions would not change dramatically over time. What is evident from Table 5B is that some preference is given to the region Gauteng, which according to the database provides the bulk of South Africa's economic activity. After Limpopo and Western Cape, Gauteng offers the third greatest cumulative real rentals on capital. However, Gauteng offers relatively lower levels of real wages. More regional depth will be provided in the results section of this chapter.

5.2.3 SAM, Household & Other Results

Consistent with standard ORANI-type CGE-models, TERM-SA produced the preceding national and regional baseline forecast results. However, TERM-SA also has capabilities that enable SAM, and multiple household modelling. SAM-based behavioural equations allow modelers

[32] It should be noted that employment is measured in terms of the wage bill (cost) of employment, and not in the actual jobs that have been created. In Section 5.4.1 we will also refer to the number of jobs that have been created.

Table 5B: Cumulative Growth in Regional Macro Variables, Baseline Forecast Simulation, 2035

Regional Macros	Limpopo	North West	Mpumalanga	Gauteng	Free State	Northern Cape	Western Cape	Eastern Cape	Kwazulu-Natal
Real GDP (GDP)	59.52%	59.52%	59.11%	59.96%	59.60%	59.52%	59.41%	59.67%	59.50%
Household Consumption (C)	56.31%	56.48%	56.45%	56.46%	56.46%	56.59%	56.61%	56.34%	56.35%
Investment (I)	66.63%	66.95%	65.51%	67.42%	66.68%	66.04%	66.47%	66.42%	66.22%
Capital Stock (K)	57.70%	57.84%	57.44%	58.16%	57.85%	57.60%	57.73%	57.81%	57.90%
Real Rental Price of Capital (RoR)	3.01%	2.81%	2.82%	2.89%	2.89%	2.69%	2.90%	2.70%	2.72%
Government Expenditure (G)	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%
Exports (X)	56.32%	56.29%	57.91%	58.63%	55.86%	55.52%	59.60%	59.80%	59.91%
Imports (M)	60.19%	60.46%	60.38%	60.71%	60.63%	60.34%	60.23%	60.18%	60.10%
Employment (D)	30.70%	30.44%	30.04%	30.88%	30.33%	30.57%	30.55%	30.63%	30.45%
Real Wage (RW)	20.77%	20.81%	20.78%	20.66%	20.75%	20.82%	20.77%	20.69%	20.73%
Price of Labour, Compensation (CoE)	21.35%	21.35%	21.35%	21.35%	21.35%	21.35%	21.35%	21.35%	21.35%
Consumer Price Index (CPI)	0.48%	0.45%	0.47%	0.58%	0.50%	0.44%	0.48%	0.55%	0.51%
GDP Price Index (PY)	0.41%	0.37%	0.29%	0.40%	0.30%	0.27%	0.50%	0.28%	0.32%
Technical Change, Regional Average (A)	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%
Labour Productivity, Industry Average (AL)	-20.58%	-20.78%	-19.84%	-20.44%	-20.17%	-20.71%	-20.45%	-20.50%	-20.47%

Note: Values are indicated in cumulative percentage change.

to illustrate how factor incomes, tax revenues, and interest on outstanding debt, accrue to households, government and enterprises. TERM-SA is better able to illustrate the link between producers and the rest of the economy. Multiple household modelling allows TERM-SA to show how different household types (distributed according to income levels) behave in different economic environments. Chapter 2 explained the various equations that were added to the standard TERM framework to allow for SAM and multiple household analysis.

Chapter 3 focused on the databases that is needed to allow these analyses and specifically elaborates on the structure of the various households that are modelled by TERM-SA. Table 5C illustrates key variables from these contributions after executing the baseline forecast simulation.

Nominal variables all grow at a stable rate, and adjusted for inflation, do not differ significantly from one another and there are no outliers. The model's exogenously-set preference for Investments supports a slightly faster growth in gross operating surplus (GOS); capital and land rentals. GOS is allocated towards households, government, and enterprises. Government spending is projected to grow slightly faster than income, increasing the deficit GDP from 3.10% in 2016 to 3.77% in 2035. It should be noted that the government debt, as a percentage of GDP, grew from 55% in 2016 to 84% in 2035. The reason for this rather substantial growth, is not because of the growth in the deficit, which is rather muted over the simulation period, but because we assumed inflation is zero in our simulation. This was done because we are more concerned with price deviations than absolute changes in prices. If we adjust for an annual inflation of 4.5% throughout the simulation period, government debt decreases from 55% in 2016 to 61% in 2035. The reason for this is because the forecasted growth of nominal GDP is greater than the forecasted growth of the government deficit, in other words the amount added to debt annually, is expressed as a percentage of total debt. From 2016 to 2029 nominal GDP grows faster than the deficit/debt ratio. During this time, the total debt decreases. After 2029 however, when nominal GDP no longer grows faster than the deficit/debt ratio, debt starts to increase again. Like our interest in prices is more concerned with price deviations, so too, is our interest in the government debt levels more concerned about debt deviations between the baseline and policy simulations.

Table 5C: SAM- and Household Variables, Baseline Forecast Simulation

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Gross Operating Surplus (GOS)	14%	17%	20%	23%	26%	29%	32%	35%	38%	41%	45%	48%	52%	55%	59%	63%
Enterprise Income (VENT)	14%	17%	20%	23%	26%	29%	32%	35%	39%	42%	45%	49%	53%	56%	60%	64%
Enterprise Savings (VSAVENT)	12%	15%	17%	20%	22%	25%	28%	30%	33%	36%	39%	42%	45%	48%	51%	55%
Government Income (GOVINC)	13%	15%	18%	21%	24%	27%	30%	33%	36%	40%	43%	46%	50%	54%	57%	61%
Government Spending (GOVSPEND)	13%	16%	19%	22%	25%	28%	31%	34%	38%	41%	45%	49%	53%	57%	61%	65%
Gov. Deficit (% of GDP)	-3.01%	-3.04%	-3.09%	-3.13%	-3.18%	-3.23%	-3.28%	-3.33%	-3.39%	-3.44%	-3.50%	-3.55%	-3.61%	-3.66%	-3.72%	-3.77%
RotW Savings (CAD, % of GDP)	3.69%	3.76%	3.82%	3.89%	3.95%	4.01%	4.08%	4.14%	4.21%	4.27%	4.33%	4.40%	4.46%	4.53%	4.59%	4.65%

Household Disposable Income (HHDINC)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	12%	14%	17%	20%	23%	25%	28%	31%	35%	38%	41%	45%	48%	52%	55%	59%
2	12%	14%	17%	20%	23%	25%	28%	32%	35%	38%	41%	45%	48%	52%	56%	59%
3	12%	14%	17%	20%	22%	25%	28%	31%	35%	38%	41%	45%	48%	52%	55%	59%
4	12%	14%	17%	20%	22%	25%	28%	31%	35%	38%	41%	45%	48%	52%	55%	59%
5	12%	14%	17%	19%	22%	25%	28%	31%	35%	38%	41%	45%	48%	52%	55%	59%
6	11%	14%	17%	19%	22%	25%	28%	31%	35%	38%	41%	45%	48%	52%	55%	59%
7	11%	14%	17%	20%	22%	25%	28%	31%	35%	38%	41%	45%	48%	52%	56%	59%
8	12%	14%	17%	20%	23%	25%	28%	32%	35%	38%	41%	45%	48%	52%	56%	60%
9	12%	14%	17%	20%	23%	26%	29%	32%	35%	39%	42%	45%	49%	53%	56%	60%
10	12%	14%	17%	20%	23%	26%	29%	32%	35%	38%	42%	45%	49%	52%	56%	60%
11	12%	15%	18%	20%	23%	26%	29%	32%	36%	39%	42%	46%	49%	53%	57%	61%
12	12%	15%	18%	21%	23%	26%	30%	33%	36%	39%	43%	46%	50%	53%	57%	61%

Household Savings (change variable)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	0.11%	0.13%	0.16%	0.18%	0.20%	0.23%	0.25%	0.27%	0.30%	0.32%	0.35%	0.37%	0.39%	0.42%	0.44%	0.46%
2	0.11%	0.13%	0.16%	0.18%	0.20%	0.23%	0.25%	0.27%	0.30%	0.32%	0.35%	0.37%	0.39%	0.42%	0.44%	0.47%
3	0.11%	0.13%	0.16%	0.18%	0.20%	0.23%	0.25%	0.27%	0.30%	0.32%	0.34%	0.37%	0.39%	0.42%	0.44%	0.46%
4	0.11%	0.13%	0.15%	0.18%	0.20%	0.22%	0.25%	0.27%	0.30%	0.32%	0.34%	0.37%	0.39%	0.42%	0.44%	0.46%
5	0.10%	0.13%	0.15%	0.17%	0.20%	0.22%	0.24%	0.27%	0.29%	0.31%	0.34%	0.36%	0.39%	0.41%	0.44%	0.46%
6	0.10%	0.12%	0.14%	0.17%	0.19%	0.21%	0.24%	0.26%	0.29%	0.31%	0.33%	0.36%	0.38%	0.41%	0.43%	0.46%
7	0.09%	0.11%	0.13%	0.16%	0.18%	0.20%	0.23%	0.25%	0.28%	0.30%	0.33%	0.35%	0.38%	0.40%	0.43%	0.45%
8	0.07%	0.09%	0.11%	0.14%	0.16%	0.18%	0.21%	0.23%	0.26%	0.28%	0.31%	0.33%	0.36%	0.38%	0.41%	0.43%
9	0.04%	0.06%	0.09%	0.11%	0.13%	0.16%	0.18%	0.21%	0.23%	0.26%	0.28%	0.31%	0.34%	0.36%	0.39%	0.41%
10	0.06%	0.08%	0.10%	0.13%	0.15%	0.17%	0.20%	0.22%	0.25%	0.27%	0.30%	0.32%	0.35%	0.37%	0.40%	0.42%
11	0.05%	0.07%	0.09%	0.12%	0.14%	0.16%	0.19%	0.21%	0.24%	0.27%	0.29%	0.32%	0.34%	0.37%	0.40%	0.42%
12	0.06%	0.08%	0.11%	0.13%	0.15%	0.18%	0.20%	0.23%	0.25%	0.28%	0.30%	0.33%	0.36%	0.38%	0.41%	0.43%

Note: All values, except those expressed as a percentage of GDP, are indicated in cumulative percentage change.

The exogenous forecasts imposed on the model produced stable growth across all industries of the economy. It is important to note that the variables discussed above are not the only variables which the model produces. Rather, these are key variables used to explain the business-as-usual forecast of the South African economy. Using the baseline forecast simulation, TERM-SA is now able to generate a realistic estimate of any deviation away from the baseline. Deviations are introduced via policy shocks, which will be discussed in Section 5.3.

5.3 Policy Shocks and Simulations

Using TERM-SA we can conduct policy simulations to produce detailed results of proposed policy scenarios (shocks) on the South African economy, over a certain period. The results of the policy simulation are contrasted against the results of the baseline described in Section 5.2. In doing so we can compare the policy results as deviations away from the baseline.

In our policy simulation we fix the government real wage bill for 5 years by exogenising both the real wages and employment of government employees in all three the government industries. The perpetuated savings from this decision, are used annually to subsidise the construction industry which cause investments to increase. We've estimated that the savings generated by government can, on average, perpetually increase investments by 3.15%, annually.

Table 5D: Selected Macro Variables, Policy Simulation

Macro-Economic Variable	2016-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Real GDP (GDP)	13.08%	16.14%	19.33%	22.63%	26.05%	29.57%	33.19%	36.90%	40.69%	44.56%	48.49%	52.49%	56.56%	60.67%	64.84%	69.05%
Private Consumption (C)	9.95%	12.48%	15.25%	18.21%	21.32%	24.59%	28.00%	31.54%	35.22%	39.02%	42.93%	46.95%	51.06%	55.26%	59.55%	63.90%
Investment (I)	22.82%	27.66%	32.33%	36.97%	41.60%	46.20%	50.76%	55.27%	59.71%	64.08%	68.38%	72.59%	76.73%	80.79%	84.78%	88.71%
Government Expenditure (G)	13.14%	15.97%	18.87%	21.84%	24.89%	28.01%	31.21%	34.49%	37.85%	41.30%	44.83%	48.45%	52.16%	55.97%	59.87%	63.86%
Exports (X)	13.95%	17.20%	20.54%	23.98%	27.51%	31.12%	34.80%	38.54%	42.35%	46.20%	50.10%	54.03%	58.00%	62.00%	66.03%	70.08%
Foreign Demand Shifter (Fx)	3.15%	3.77%	4.40%	5.02%	5.65%	6.28%	6.92%	7.56%	8.20%	8.84%	9.48%	10.13%	10.78%	11.43%	12.09%	12.74%
Imports (M)	13.81%	16.95%	20.19%	23.51%	26.92%	30.41%	33.97%	37.59%	41.28%	45.03%	48.83%	52.69%	56.59%	60.53%	64.52%	68.55%
Capital Stock (K)	11.89%	14.92%	18.13%	21.52%	25.05%	28.74%	32.56%	36.51%	40.58%	44.75%	49.03%	53.39%	57.83%	62.33%	66.90%	71.52%
Technical Change, Regional Average (A)	0.04%	0.06%	0.08%	0.10%	0.12%	0.14%	0.16%	0.18%	0.20%	0.23%	0.25%	0.27%	0.30%	0.32%	0.34%	0.37%
Labour Productivity, Industry Average (AL)	-6.08%	-6.42%	-7.45%	-8.47%	-9.48%	-10.47%	-11.46%	-12.43%	-13.40%	-14.35%	-15.29%	-16.22%	-17.14%	-18.06%	-18.96%	-19.85%
Price of Labour, Compensation (CoE)	1.63%	2.40%	3.33%	4.38%	5.54%	6.81%	8.18%	9.64%	11.19%	12.82%	14.52%	16.28%	18.10%	19.97%	21.88%	23.82%
Employment (D)	6.20%	7.96%	9.73%	11.53%	13.33%	15.13%	16.93%	18.72%	20.50%	22.26%	24.01%	25.74%	27.46%	29.16%	30.84%	32.50%
Real Wage (RW)	2.39%	3.30%	4.34%	5.51%	6.80%	8.20%	9.70%	11.29%	12.97%	14.71%	16.53%	18.40%	20.31%	22.26%	24.24%	26.24%
Price of Capital (R)	2.52%	2.38%	2.17%	1.89%	1.55%	1.14%	0.68%	0.17%	-0.36%	-0.91%	-1.47%	-2.03%	-2.57%	-3.10%	-3.61%	-4.08%
Price of Investment (PI)	-3.37%	-4.15%	-4.77%	-5.32%	-5.83%	-6.31%	-6.76%	-7.18%	-7.56%	-7.91%	-8.22%	-8.49%	-8.71%	-8.89%	-9.03%	-9.12%
Consumer Price Index (CPI)	-0.74%	-0.86%	-0.97%	-1.08%	-1.18%	-1.29%	-1.39%	-1.49%	-1.58%	-1.66%	-1.73%	-1.79%	-1.84%	-1.88%	-1.90%	-1.92%
GDP Price Index (PY)	-2.79%	-3.08%	-3.31%	-3.53%	-3.73%	-3.92%	-4.09%	-4.25%	-4.39%	-4.50%	-4.59%	-4.66%	-4.71%	-4.74%	-4.74%	-4.73%
GNE Price Index (PGNE)	-2.75%	-3.01%	-3.22%	-3.40%	-3.57%	-3.73%	-3.87%	-4.00%	-4.11%	-4.21%	-4.28%	-4.33%	-4.37%	-4.38%	-4.38%	-4.36%
Terms of Trade (TofT)	-0.17%	-0.27%	-0.37%	-0.48%	-0.58%	-0.68%	-0.78%	-0.87%	-0.95%	-1.03%	-1.10%	-1.16%	-1.20%	-1.24%	-1.27%	-1.29%
Exchange Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Number of Households (Hs)	6.41%	7.74%	9.09%	10.45%	11.83%	13.23%	14.64%	16.08%	17.53%	19.00%	20.48%	21.99%	23.51%	25.06%	26.62%	28.20%

Note: Values are indicated in cumulative percentage change, measured from the start of the policy simulation in 2016.

Table 5E: Cumulative Growth in Regional Macro Variables, Policy Simulation, 2035

Regional Macros	Limpopo	North West	Mpumalanga	Gauteng	Free State	Northern Cape	Western Cape	Eastern Cape	Kwazulu-Natal
Real GDP (GDP)	69.44%	70.85%	66.03%	69.76%	66.64%	70.70%	69.06%	68.61%	69.33%
Household Consumption (C)	63.56%	63.87%	63.97%	64.07%	63.77%	63.98%	63.84%	63.79%	63.78%
Investment (I)	88.77%	90.28%	85.45%	89.99%	86.53%	89.34%	88.58%	87.84%	88.67%
Capital Stock (K)	71.19%	72.53%	70.02%	72.16%	70.30%	71.98%	71.22%	70.86%	71.74%
Real Rental Price of Capital (RoR)	6.30%	5.89%	5.77%	5.90%	5.95%	5.87%	6.20%	5.88%	5.99%
Government Expenditure (G)	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%	63.86%
Exports (X)	75.62%	75.66%	76.51%	68.67%	75.92%	75.81%	69.93%	71.04%	70.54%
Imports (M)	68.24%	69.87%	66.95%	69.26%	66.99%	69.88%	68.41%	67.67%	68.33%
Employment (D)	31.67%	32.97%	31.56%	33.03%	31.72%	31.94%	32.91%	31.02%	32.69%
Real Wage (RW)	25.83%	26.29%	26.63%	26.27%	26.37%	26.00%	26.22%	25.86%	26.31%
Price of Labour, Compensation (CoE)	23.52%	23.83%	24.09%	23.79%	24.02%	23.54%	23.92%	23.48%	23.89%
Consumer Price Index (CPI)	-1.84%	-1.95%	-2.01%	-1.97%	-1.86%	-1.95%	-1.82%	-1.89%	-1.91%
GDP Price Index (PY)	-5.40%	-5.09%	-3.67%	-4.78%	-3.55%	-5.81%	-4.74%	-5.28%	-4.90%
Technical Change, Regional Average (A)	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%	0.37%
Labour Productivity, Industry Average (AL)	-19.84%	-19.82%	-19.89%	-19.84%	-19.88%	-19.83%	-19.85%	-19.84%	-19.84%

Note: Values are indicated in cumulative percentage change.

Table 5F: SAM- and Household Variables, Policy Simulation

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Gross Operating Surplus (GOS)	15%	18%	21%	24%	27%	30%	33%	37%	40%	44%	47%	51%	54%	58%	61%	65%
Enterprise Income (VENT)	14%	17%	20%	23%	26%	29%	33%	36%	40%	43%	47%	50%	54%	58%	62%	66%
Enterprise Savings (VSAVENT)	12%	15%	17%	20%	23%	26%	29%	32%	35%	38%	41%	44%	47%	50%	53%	56%
Government Income (GOVINC)	9%	11%	14%	16%	19%	22%	25%	28%	31%	34%	38%	41%	45%	48%	52%	56%
Government Spending (GOVSPEND)	7%	10%	13%	16%	19%	22%	25%	28%	32%	36%	39%	43%	47%	51%	55%	60%
Gov. Deficit (% of GDP)	-2.57%	-2.50%	-2.61%	-2.68%	-2.74%	-2.81%	-2.87%	-2.95%	-3.02%	-3.10%	-3.19%	-3.27%	-3.36%	-3.45%	-3.54%	-3.63%
RotW Savings (CAD, % of GDP)	3.69%	3.76%	3.86%	3.93%	3.99%	4.05%	4.11%	4.17%	4.22%	4.28%	4.34%	4.40%	4.46%	4.52%	4.58%	4.64%

Household Disposable Income (HHDINC)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	9%	12%	15%	18%	21%	24%	27%	31%	34%	38%	41%	45%	49%	53%	57%	61%
2	9%	12%	15%	18%	21%	24%	27%	31%	34%	38%	42%	46%	50%	54%	58%	62%
3	10%	12%	15%	18%	21%	24%	28%	31%	35%	38%	42%	46%	50%	54%	58%	62%
4	9%	12%	15%	18%	21%	24%	28%	31%	35%	39%	42%	46%	50%	54%	58%	63%
5	9%	12%	15%	18%	21%	24%	28%	31%	35%	39%	42%	46%	50%	54%	59%	63%
6	9%	12%	15%	18%	21%	24%	28%	31%	35%	39%	43%	47%	51%	55%	59%	63%
7	9%	12%	15%	18%	21%	24%	28%	31%	35%	39%	43%	47%	51%	55%	59%	63%
8	9%	12%	15%	18%	21%	25%	28%	32%	35%	39%	43%	47%	51%	55%	59%	64%
9	10%	13%	16%	19%	22%	25%	29%	32%	36%	40%	43%	47%	51%	56%	60%	64%
10	10%	13%	16%	19%	22%	25%	28%	32%	36%	39%	43%	47%	51%	55%	59%	63%
11	11%	14%	16%	19%	23%	26%	29%	33%	36%	40%	44%	48%	52%	56%	60%	64%
12	11%	14%	17%	20%	23%	26%	30%	33%	37%	41%	44%	48%	52%	56%	60%	64%

Household Savings (change variable)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	0.09%	0.11%	0.14%	0.16%	0.19%	0.21%	0.24%	0.27%	0.29%	0.32%	0.35%	0.37%	0.40%	0.43%	0.45%	0.48%
2	0.09%	0.11%	0.14%	0.16%	0.19%	0.22%	0.24%	0.27%	0.30%	0.32%	0.35%	0.38%	0.40%	0.43%	0.46%	0.48%
3	0.09%	0.11%	0.14%	0.16%	0.19%	0.22%	0.24%	0.27%	0.30%	0.32%	0.35%	0.38%	0.41%	0.43%	0.46%	0.49%
4	0.09%	0.11%	0.14%	0.16%	0.19%	0.21%	0.24%	0.27%	0.30%	0.32%	0.35%	0.38%	0.41%	0.43%	0.46%	0.49%
5	0.08%	0.10%	0.13%	0.15%	0.18%	0.21%	0.23%	0.26%	0.29%	0.32%	0.35%	0.37%	0.40%	0.43%	0.46%	0.48%
6	0.07%	0.09%	0.12%	0.14%	0.17%	0.20%	0.23%	0.25%	0.28%	0.31%	0.34%	0.37%	0.40%	0.43%	0.46%	0.48%
7	0.05%	0.07%	0.10%	0.12%	0.15%	0.18%	0.21%	0.24%	0.27%	0.30%	0.33%	0.36%	0.39%	0.42%	0.45%	0.48%
8	0.01%	0.03%	0.06%	0.08%	0.11%	0.14%	0.17%	0.20%	0.24%	0.27%	0.30%	0.33%	0.37%	0.40%	0.43%	0.47%
9	-0.05%	-0.02%	0.00%	0.03%	0.06%	0.09%	0.12%	0.15%	0.19%	0.22%	0.26%	0.30%	0.33%	0.37%	0.41%	0.44%
10	-0.01%	0.01%	0.04%	0.06%	0.09%	0.12%	0.15%	0.18%	0.21%	0.25%	0.28%	0.32%	0.35%	0.38%	0.42%	0.45%
11	-0.03%	-0.01%	0.01%	0.04%	0.07%	0.10%	0.13%	0.17%	0.20%	0.23%	0.27%	0.31%	0.34%	0.38%	0.41%	0.45%
12	0.00%	0.02%	0.04%	0.07%	0.10%	0.13%	0.16%	0.19%	0.22%	0.26%	0.29%	0.33%	0.36%	0.39%	0.43%	0.46%

Note: All values, except those expressed as a percentage of GDP, are indicated in cumulative percentage change.

Instead of using a conventional manner whereby savings are used to increase government infrastructure spending, the proposed unconventional subsidy on taxes in the construction industry is used. Our aim is not to increase government-related infrastructure projects, but rather to increase aggregate investments in South Africa, which include non-infrastructure projects as well. Like Calderón et al. (2015), this is done to reduce the inefficiencies and corruption related to government infrastructure projects. A subsidy in the construction industry is used because according to the Supply-Use Tables (Statistics South Africa, 2016) this industry represents 48% of the total investments in South Africa. The second largest industry, metal and machinery only represents 21% of the total investments. Also, 78% of the construction industry is used as inputs in the creation of investment products in South Africa.

In Section 5.4, we consider the results that TERM-SA generated during this simulation. These results should be interpreted as a percentage deviation away from the baseline.

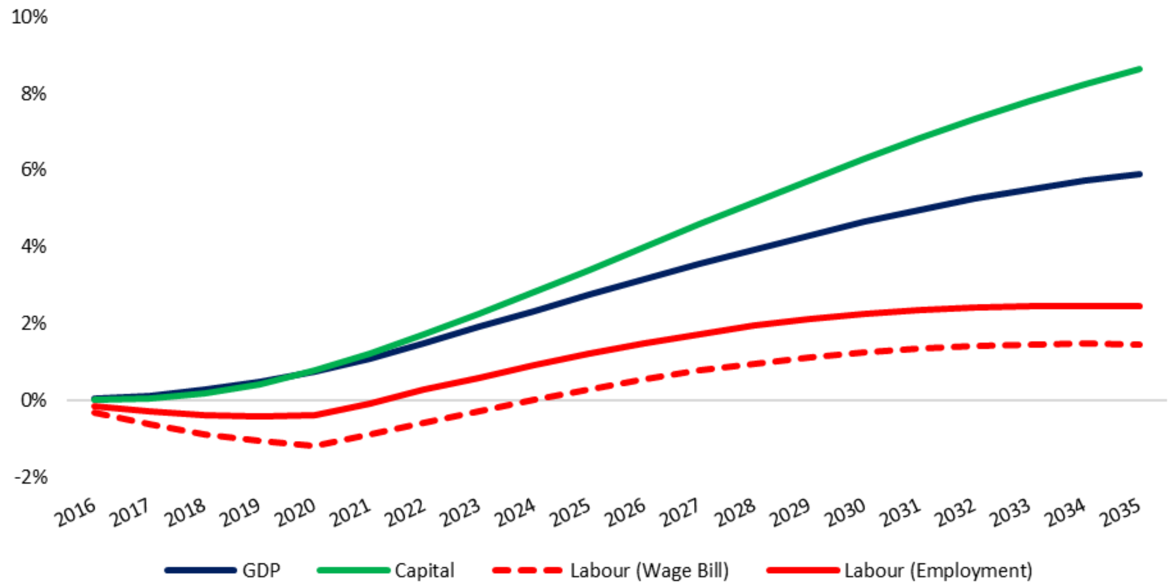
5.4 Results

5.4.1 National Macro-Economic Results

Figure 5C and 5D show the macro-economic impact of the policy shock on both the supply (income) and demand (expenditure) side of the economy during our simulation. Each graph illustrates these impacts as a percentage deviation away from the baseline.

Figure 5C illustrates the main variables of the supply (income) side of the economy. Investment increases via the construction subsidy, which is paid for by the savings generated from keeping the real government wage bill fixed for 5 years. It is worth noting that the estimated savings, and consequent tax relieve in the construction industry is roughly R6.3 billion over this 5-year policy shock period; which is only a fraction (0.14%) of government's aggregate income over this period.

Figure 5C: Supply Side GDP (Percentage Deviation from The Baseline)



Higher investment in each period, mean capital can also be expected to be higher in each subsequent period; as explained in Section 2.3.1. In fact, compared to the baseline, capital is cumulatively 8.63% higher at the end of the policy simulation (2016 – 2035). Investments are cumulatively 13.20% higher in 2035; illustrated by Figure 5D. Although we assume long-run rates of return remain unchanged, labour productivity among government-related industries increased during the policy simulation. As a result, the K/L ratio increased slightly.

In 2035 the total labour input, wage bill weighted, was 1.45% higher in the policy simulation than in the baseline. A wage bill weighted measure of labour can more accurately reflect the productivity differences between various skills or occupations in the South African economy. However, this measure does not accurately portray the number of jobs created in the economy, which is an important variable for South African policymakers. For this reason, an alternative measure (displayed in Figure 5C) considers labour, weighted by jobs; the total employment in the economy. This measure shows that labour increased by 2.44%, slightly more than the wage bill weighted measure. The reason for this is because the increase in employment is mostly in investment-related industries such as construction, electrical, and glass and non-metals; a more in-depth explanation for the growth in these industries will be provided in Section 5.4.3. These industries employ relatively more semi-skilled employees who earn less than skilled workers who are concentrated in South Africa's service industries.

As a result, relatively more employees are employed with the same amount of wage bill increases. In fact, during the policy simulation 160,000 more unskilled jobs are created, 190,000 semi-skilled jobs are created, and 106,000 more skilled jobs are created.

During the first 5 years of the policy simulation, we kept the real wage bill of government employees fixed by endogenising their productivity. Instead of merely exogenising the wage bill, both the real wage rate and employment were exogenised. The reason we do this, is to avoid unfavourable or unrealistic changes in either one of the remaining variables, which occur if only one is exogenised. However, keeping both the real wages and employment fixed in the policy simulation, implies a reduction in both, compared to the baseline. To facilitate this reduction, whilst maintaining the government user's expenditure levels, the productivity of government employees in each government-related industry (general, health, and education) is roughly 1.5% higher during each year of the initial 5-year simulation.

To determine if this increase in productivity is acceptable, we turn to research that considers the impact of employment protection on labour productivity. Reducing the real wage bill and employment, relative to the baseline, can be considered a decrease in employment protection. Because employment protection impacts labour productivity through multiple mechanisms, research findings are ambiguous, in both direction and magnitude.

Initially Hopenhayn and Rogerson (1993) used firm-level United States dynamics to show that greater employment protection increases firing costs and thereby the ability of firms to adjust their employment levels. Through this misallocation of resources, they concluded that restricting a firm's ability to adjust employment levels had a negative impact on labour productivity. Their policy results indicated a 2% reduction in productivity where employment protection is equal to one year's worth of wages. Koeniger (2005) however, showed that higher firing costs in Organisation for Economic Co-operation and Development (OECD) countries could lead to firms increasing their Research and Development and investments in human capital. Although greater levels of human capital could support higher levels of labour productivity, their research does not reach this conclusion.

Using an alternative approach Belot, Boone and Van Ours (2007) illustrate how employees in OECD countries are more likely to acquire firm-specific skills due to job security regulations. Like in Koeniger (2005) one can reasonably conclude that greater firm-specific skills should increase productivity, but these increases are not quantified. Bassanini, Nunziata and Venn (2009) did quantify these changes and show that layoff restrictions, i.e. employment protection in OECD countries, has a negative impact on productivity. They found that a one-point change in employment reform could increase productivity by 0.17% to 0.56% between firms whose layoff rates differ by 1%. Cross-country analyses like these however face the problem of comparability of legislation across countries (OECD, 2004). To overcome this issue of comparability, Autor, Kerr and Kugler (2007) and Okudaira, Takizawa and Tsuru (2013) use variations within a specific country to determine the impact of employment protection on labour productivity.

Autor et al. (2007) use data on wrongful discharges in the United States to show that, as this measure of employment protection increases, total factor productivity (TFP) decreases, but labour productivity increases. Their research showed that a rise in adjustment cost caused firms to increase investments and non-production employment, causing labour productivity to rise between 1% and 4%. However, using variations in court decisions in Japan, Okudaira et al. (2013) find that more employment protection decreases both TFP and labour productivity, by -0.2% and -0.4% respectively. It is important to note that these studies focused on an increase in employment protection, and that the impact of a reduction in protection may not have the opposite effect.

Research done by Cappellari, Dell'Aringa and Leonardi (2012) and Bjuggren (2018) showed that a reduction in employment protection in Italy and Sweden, respectively, increases labour productivity. Cappellari et al. (2012) showed that by making use of apprenticeship employment reforms, in other words reducing employment protection, labour productivity increased by 0.9% to 1.6% in Italy. Bjuggren (2018) used Swedish register data to illustrate that a reduction in employment protection, via an exemption of seniority rules for smaller firms, increased labour productivity by 2% to 3%. However, like the comparability issues between OECD countries, one cannot simply infer results between countries. For this we turn to the seminal work done by Boedo and Mukoyama (2012).

Based on Hopenhayn and Rogerson (1993) they use the World Bank's "Doing Business" dataset to quantitatively analyse employment protection, in other words costs associated with entry and firing of employees, via a general equilibrium industry-dynamics model. By creating a benchmark against which other countries can be compared, they show that higher levels of employment protection reduce productivity, in this instance they specifically refer to TFP. Moving from the benchmark level, the US, where entry and firing costs are low, to that of average low-income countries (countries like South Africa with a gross national income below 2% of the United States level) the TFP is reduced by 34%. Using their model to measure the impact of firing costs originally done by Hopenhayn and Rogerson (1993), they show that productivity can fall by as much as 4%[33].

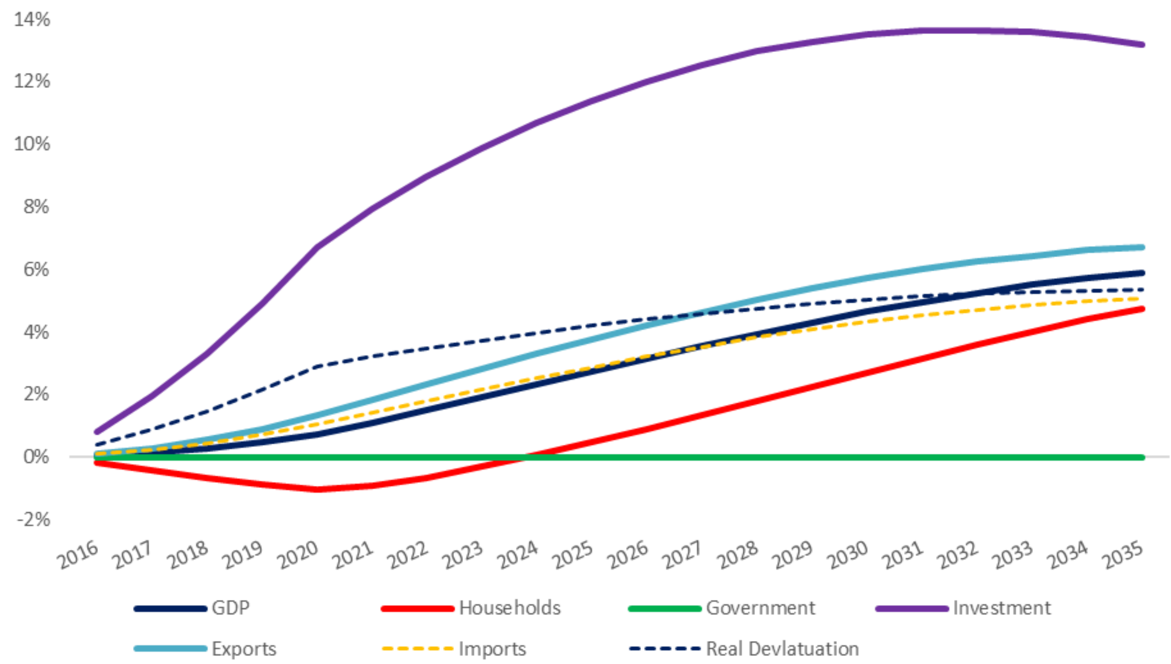
The direction and magnitude of seminal research on the topic of employment protection seem to support our findings of an average productivity increase of 1.5% in South Africa. It might still be better to have future research specific to South Africa, substantiate our assumptions. However, we are not aware of any such research.. For this reason, it might be easier to assume these levels of productivity increases are the level that would be needed to allow the implementation of a policy that would keep the real wage bill of government fixed whilst delivering the same level of services. Nevertheless, in our simulation the increase in productivity helps to offset the reduction in employment (labour), to facilitate higher levels of GDP (measured from the income side) brought about by the higher levels of investment.

Figure 5D illustrates the demand side of the economy and shows that, barring two exceptions, the long-run impact of the policy on aggregate expenditure variables is positive, and of similar magnitude than the overall change in GDP. Government expenditure was exogenously set to remain unchanged between the baseline and policy simulations. This assumption can be relaxed, but our aim is to find a better use for the government's current spending levels, and not change the size of government spending. Also, compared to the baseline through the tax subsidy in the construction industry, investments increase cumulatively by 13.20%.

[33] Although in their rerun of the research done by Hopenhayn and Rogerson (1993) they do not adjust for model calibration differences. In their model, one period is considered 1 year, whereas in Hopenhayn and Rogerson (1993) one period is 5 years.

Measured against the baseline, cumulative export demand growth in 2035 (6.73%) is slightly greater than overall GDP growth (5.90%), mostly because of the relatively higher export growth during the initial 5-year policy shock. Compared to exports, GDP growth was relatively slower because of lower household consumption, unchanged government expenditure (no deviation from the baseline), and relatively higher imports. Export demand however saw persistent increases throughout the policy simulation and was therefore cumulatively higher at the end of the simulation period.

Figure 5D – Demand Side GDP (Percentage Deviation from The Baseline)



Initially the policy shock that kept real wages of government employees fixed for 5 years offered marginal support to exporters by reducing the input cost of labour whilst increasing productivity of certain occupations; those prevalent in the government industries. Referring to S-BOTE, equation ($S13$) illustrates how lower marginal costs and better productivity aids economic performance. In addition to this, the positive impact of the policy on the overall size of the economy lent further support to exporters. A larger economy, facilitated by perpetual investment increases throughout the simulation period, supports greater export volumes; illustrated by equations ($S1$) and ($S2$). However, as shown in equation ($S5.1$) without a shock to the foreign demand curves (which is assumed exogenous in the policy simulation) for South African exports, an increase in export volumes is accompanied by a fall in the foreign-currency prices of domestically produced commodities. It is important to remember that we assume local demand in South Africa has no effect on import prices, which are therefore exogenous in our simulation. The result is a deteriorating terms of trade, the price of exports relative to the price of imports in equation ($S7.1$), by -1.62%, which supports higher export demand by making South African products more globally competitive.

Following equation ($S6.3$) imports can be related to the level of GDP, the terms of trade, and import/domestic Armington elasticities. It is reasonable to assume that imports would grow in line with aggregate economic growth. In fact, cumulative import growth in 2035 is 5.06%, and compares well with aggregate economic growth of 5.90%. Imports could not grow as fast as exports or even GDP because of the deteriorating terms of trade that favours locally produced commodities over imports. Disaggregating economic growth into each final user provides another interesting revelation about imports. Although imports grew in line with household demand growth (4.76%), imports did not slump during the initial 5-year policy period like household growth did. In fact, import demand grew consistently throughout the simulation period. The reason imports did not slump is because resources were allocated away from the three government industries who import relatively little of total imports (4.21%), towards investors who import a larger share of total imports (16.4%). The increase in investment during this period (cumulative 13.20%), and the resulting increase in demand for imports helped to offset the fall in demand for imports by households. It is also important to note that in our closure we assumed that the trade balance (exports less imports) would remain unchanged between the baseline and policy simulations.

Figure 5D shows an initial decrease in aggregate household spending (C) that reaches -1.05% in 2020, before starting to recover. At the end of the simulation household spending is 4.76% higher than the baseline case. To explain the initial slump, it is worthwhile referring to the S-BOTE equations ($S3.1$) to ($S3.4$) in Chapter 4. These equations illustrate how household spending is a function of disposable income. As illustrated in Figure 5C, labour income, measured against the baseline, is reduced during the initial 5-year policy shock. In the following section we use TERM-SA's SAM-capabilities to explain in more detail why disposable income decreased. However, at this point it is worthwhile noting that less labour income and higher levels of net foreign liabilities, amongst others, reduce disposable income which reduce aggregate consumption. After the initial policy period, a larger economy implies a greater demand for labour income, illustrated in Figure 5C, and supported by equation ($S13$), and consequently more consumption, as illustrated in Figure 5D.

5.4.2 Aggregate Prices, the GDP-deflator

Real GDP grew cumulatively by 0.74% during the policy period and the GDP-deflator decreased cumulatively by -2.82% in 2020, causing a reduction in nominal GDP of -2.10%. In 2035, measured against the baseline, real GDP is 5.90% higher and the GDP-deflator is -5.08% lower; nominal GDP is therefore only 0.53% higher than the baseline. Aggregate prices remained under pressure throughout the simulation period, 2016 to 2035. To explain the fall seen in the GDP deflator it is worthwhile to mention that the deflator can be expressed as the weighted sum of user (agent) prices in the South African economy. Also, it is important to consider the nature of our policy shock that exogenously increases investment, perpetually over the simulation period. More productive capacity cause prices to decrease relative to the baseline, or put differently, prices will be rising at a slower rate.

Following equations ($S9.1$) and ($S10$) in Chapter 4 the price of investment is set to fall faster than the price of capital, as the rate of return on capital increases over time. As expected, our results showed that, measured against the baseline, the price of capital fell cumulatively by -7.16% and the price of investments fell cumulatively by -9.56%. Consequently, compared to the baseline, the rate of return on capital gradually increased from -0.28% in 2016 to 0.75% in 2035. It is important to note that the price of labour increases as the demand for labour increases, to facilitate greater levels of productive capacity. However, the fall in capital prices (-7.16%) more than offset the increase in labour prices (2.03%). As a result, the cost of production decreased, which in turn reduced the prices users (industries, government, investors, households and exporters) pay for commodities.

Initially household prices fell cumulatively by -0.91% in 2020 as a result of the decline in demand, caused by the fall in income. After the policy period household spending stabilised and started to increase as labour income grew in line with a faster growing economy. At this point the prices households pay for various commodities were reduced relative to the baseline. Or put differently, prices increased at a slower rate, because a lower cost of production kept commodity prices low. At the end, household prices were reduced by -2.43%, measured against the baseline.

Section 5.3.2 explained why export prices fell (cumulatively by -1.62% in 2035) and why import prices are left unchanged. Because spending of the government user was set exogenous, demand was not the driver of lower government prices. The price index paid by the government user is obtained through a weighted average of the purchases made by this user. The bulk of commodity purchases made by this user are general government services, government education, and government healthcare services; these represent 67.2%, 20.1% and 12.7% of the user’s total purchases, respectively. Keeping the real wage bill of government employees in these industries fixed for 5 years will therefore reduce the (basic) price of (labour) inputs. The users who purchase the largest share of various government services (the government user) will therefore experience the largest decrease in prices. In fact, the cumulative (nominal) price decrease experienced by the government user in 2020 was -6.69%. After the initial policy period and measured against the baseline the wage bill starts to recover back to pre-policy levels. This in turn, causes the government price index to increase, but not fast enough to offset the reduction caused by the policy. In the end, compared to the baseline, the government’s price index is cumulatively -5.69% lower in 2035.

Investment prices also fall by a relatively large amount compared to other price changes (-9.56% in 2035), because of lower taxes and a lower cost of production, driven by lower input costs. Subsidising the construction industry to facilitate higher levels of investment, reduces the final price investors must pay. Additionally, the basic price of investors is reduced by lower costs of labour and capital in those industries which provide input to investors. Also, relatively higher levels of investments lead to a higher capital-labour (K/L) ratio, which in turn, reduces the marginal product of capital (MPK) and thereby the rental price of capital. In the end the price of investments is cumulatively reduced by -3.91% during the 5-year policy period. Through a weighted sum of those user prices described above, the GDP-deflator decreased cumulatively by -2.82% in 2020, and -5.08% in 2035.

5.4.3 Industries

Industry growth is driven by macro-economic growth and changes that were brought about by policy shocks. The previous section highlighted major drivers of aggregate economic growth and explained how certain policy shocks drove those changes. Government expenditure was exogenously set to remain unchanged between the baseline and policy simulations. Aggregate investment was also exogenously increased based on the perpetual savings generated from keeping government's real wage bill fixed for 5-years. Greater investment implied a larger economy which supported greater levels of exports, as well as household and import demand. The deteriorating terms of trade also supported higher export demand by making South African products more globally competitive.

During the simulation period, 2016-2035, more investment favoured the Construction, Electrical, as well as Glass and Non-Metals industries. Measured against the baseline, these industries experienced a 14.28%, 12.12%, and 12.2% increase, respectively. It is important to recall that the flow from savings generated by keeping government's wage bill fixed, to higher levels of investment, was facilitated through a subsidy in the construction industry. The construction industry was chosen because 48% of the inputs required to produce investments in South Africa are construction materials. But more importantly 78% of all construction commodities are supplied to investors. The closest comparison is the 33% of all Electrical commodities that are supplied to investors. Because the bulk of these two industries are used by investors, they experience the greatest output increases, relative to the baseline. The glass and non-metals industry experience a similar increase in output, but for somewhat different reasons. Instead of supplying the bulk of its output to investors, the glass and non-metals industry supply the bulk (51%) of their output to the construction industry. A faster growing construction industry therefore implies a faster growing glass and non-metals industry. Additionally, the glass and non-metals industry supply 4.4% to the fast-growing export sector and 9.9% is used by the industry itself; growth in the sector therefore supports further growth.

Industries who experienced the smallest output increases were those industries who supply their output to the government user. These industries are most notably general government services, government education, and government healthcare who contribute 82.9%, 82.0%, and 82.3% of their output to the government user, respectively. Because we kept the government user's spending and deficit unchanged between the baseline and policy simulation, government industries that supply services to this user will therefore have limited output potential beyond baseline levels. The reason we do this, is because our aim is to determine if our policy mix is a better policy alternative, and not to reduce the overall size of the government. As a result, the general government industry, health, and education industries only, experienced a 0.40%, 0.87%, and 1.54% increase, respectively. The reason the government's education industry experienced a greater increase is because this industry provides the least amount of its output to the other slower growing government industries. General government services provide 11.7% of its output to itself, government healthcare provides 8.4% to the general government industry, and government education only provides 1.5% to the general government industry. In this instance, slower growth fuels further slower growth.

Following the government industries, the Food and Beverages, as well as Textile and Footwear industries, experienced the smallest output increases, 4.53% and 4.23%, respectively. The reason for these muted increases is because these two sectors supply the largest share of their output to households, 71.3% and 63.5%, respectively. Compared to any other industry these industries provide the largest share of their output to households. Because household spending saw the smallest increase (4.76%) among macro-economic expenditure variables, those industries with the largest exposure to households will only see muted output increases.

The reason the real estate industry was able to grow at 7.65% despite providing 60.4% to the household user, is because 6.9% of its output is supplied to investors. Also, the real estate industry supplies 10.3% of its output to the trade industry, which facilitates trade between industries and other users. As the economy grows 5.90% faster in the policy simulation, the trade industry also grows faster, which ultimately benefits the real estate industry. But most importantly is the nature of household demand. The bulk of real estate services (70.3%) is purchased by the wealthiest 5% of households who experienced the greatest increase in disposable income and increases in spending. Furthermore, 34% of all their income is spent on real estate commodities, 7.3% is spent on food and beverages and only 1.0% is spent on textiles and footwear. Poorer households, spend a much larger portion of their slower growing income, compared to richer households, on food and beverages and textiles and footwear. That is, the poorest 5% of households spend 38.5% on food and beverages, 2.3% on textiles and footwear, and only 0.9% on real estate.

Another industry that does relatively well is the hotel and accommodation industry that experienced cumulative growth of 9.05% after the introduction of the policy shock. Hotels and accommodation are used most notably by households (40.1%) and foreigners (34.5%). However, the bulk of household demand for hotels and accommodation (61.3%) is imported, meaning that households only demand 35.6% of South Africa's hotel and accommodation industry. For this reason, the relatively lower demand growth from households is offset by higher foreign demand for services rendered by the hotel and accommodation industry. A fall in South Africa's terms of trade (-1.62%) implies that South Africa's products become relatively more competitive, fuelling foreign demand.

5.4.4 Households: Income, Spending and Savings

In the S-BOTE section of Chapter 4, equations $(S3.1)$ to $(S3.4)$ express aggregate household spending (C) as a function of the average propensity of households to consume their disposable income. Changes in aggregate household income therefore explain changes in aggregate household consumption. To determine what drives changes in household income an alternative definition of household disposable income is useful. That is, disposable income is the sum of all sources of household income in an economy, minus payments made to the rest of the world and taxes paid to the government. Building on this, TERM-SA's SAM-capabilities allow us to model an elaborate definition of household income and spending. Equation $(2.5.F)$ of Chapter 2 expresses aggregate household income as the sum of: labour income (measured as the wage bill), a household's share of gross operating surplus, as well as transfers from enterprises, the government and the rest of the world.

Based on South Africa's supply-use tables (Van Seventer, et al., 2016) income from labour (the wage bill) constitutes 53.9% of total household income. Transfers from enterprises contribute 19.4% to total household income, and a household's share of gross operating surplus (GOS)

contributes 14.9% to the total income. Transfers from government contribute 11.3% (which include interest income on debt owned by households), and transfers from the Rest of the World ($RotW$) contribute 0.4%. Disposable income can then be obtained by subtracting taxes, household transfers to government, and interest payments to foreigners, from total income; this is illustrated in equation $(2.5.G)$. Total household taxes (income and consumption taxes) represent 16% of aggregate income, whereas transfers to the government represent 7% of total income. Interest payments to foreigners are only 0.11% of total income. In addition to TERM-SA's SAM-capabilities the model's inclusion of multiple-households allows us to evaluate how twelve different households-types in South Africa earn income and consume various goods and services over time. Each household type represents a different decile of income distribution. The poorest and richest deciles (10%) were split into ventiles (5%) to derive 12 household types. The first decile was split into the 1st and 2nd ventiles of income distribution (0% – 5%, and 6% – 10%), whereas the 10th decile was split into the 19th and 20th ventile distribution group (90% – 95%, and 96% – 100%).

To estimate the savings of each household type, household spending, as well as transfers to enterprises and the $RotW$, are subtracted from each household type. Transfers to enterprises represent 8.0% of total household income and transfers to the $RotW$ only 0.1%.

5.4.5 Aggregate Household Income

Keeping the real wage bill of government employees fixed during the 5-year policy period, reduces the cumulative nation-wide real wage bill by -1.53%, relative to the baseline. However, measured against the baseline the wage bill is cumulatively 4.46% higher in 2035. Transfers which households receive from enterprises are cumulatively increased by 0.52% during the initial policy period and 3.38% higher at the end of the simulation; we assume enterprise transfers grow in-line with post-tax enterprise income. Initially household income from gross operating surplus (GOS) increased cumulatively by 1.30% but ends 3.83% higher than the baseline in 2035; driven by growth in aggregate payments to capital and land. Transfers from the rest of the world ($RotW$) and government are assumed to grow in-line with nominal GDP, and both decreased cumulatively by -1.18% by 2020; Section 5.4.2 explains why nominal GDP decreased. By the end of the simulation period, transfers from government and the $RotW$ are 2.96% higher than the baseline.

Measured against the baseline, the interest rate earned on government debt, decreased cumulatively by -13.87% over the initial 5-year policy period. The reason for this relatively large fall is because of our model assumptions. TERM-SA follows the example of other regional dynamic models like USAGE-TERM, and VERM and link interest rates to inflation and changes in government debt, both of which decrease during the policy period. As both debt and inflation decrease, interest rates also decrease. The decrease in inflation was explained in Section 5.4.2. Following the discussion on debt in Section 5.2.3, debt decreases during the policy period because nominal GDP grows faster than the deficit/debt ratio. After the policy period interest rates continue to increase, but at a slower rate as the rate of inflation and growth in debt also increase at slower rates.

By summing the different sources of household income, real aggregate household income decreased by -1.53% during the initial 5-year policy period but increased to 4.46% above the baseline in 2035. On closer inspection richer households experienced a smaller decline in their real incomes during the policy shock and later enjoy greater increases as the simulation ends. Measured against the baseline the poorest households (the 1st ventile among household-types) experienced a -1.29% real decrease in their income, whereas the richest households (20th venitle) only experienced a -0.31% decrease, during the policy period. By the end of the simulation the poorest ventile experience a 3.79% increase in real income, and the richest households a 4.69% increase.

Compared to poorer households, wealthier households derive a larger share of their income from GOS and transfers from enterprises, which were the only two sources of household income that saw growth during the policy-period; 1.30% and 0.52% respectively. At the end of the simulation, GOS and transfers from enterprises, experience the second and third largest increases among household income sources, 3.83% and 3.38% respectively; at this stage growth in labour income (wages) was higher at 4.57%. The richest households receive 20% of their income from GOS and 31% from enterprise-transfers, compared to 2% and 1% for the poorest households. Poorer households derive the bulk of their income from the government, via transfers, which, measured against the baseline, saw the largest contraction (-1.18%) during the policy period. In fact, poor households receive 65% of their income via government transfers, compared to the richest households who only receive 2% of their total income in the form of government transfers. Only after the initial 5-year policy shock, transfers from government start to increase and measured against the baseline, cumulatively increases by 2.96% in 2035.

In addition to these household-specific differences that occur within various income sources, labour income between different household types also differ. During the 5-year policy period the poorest 5% of households (1st ventile) experienced a cumulative labour-income decrease of -1.36%, measured against the baseline. This compares well to the richest 5% (20th ventile) of households who experienced a -1.43% reduction. However, some larger variations were seen among the 2nd decile and 9th decile households, the best and worst performing households, respectively. Labour-income in these households were reduced by -0.91% and -1.71%, respectively. To understand these differences, it is important to consider the impact of the 5-year wage-bill policy shock on the wage bills and output of various industries.

Section 5.4.2 explained how the 5-year wage-bill policy shock led to relatively slower growth in the various government industries: general government services (GS), government education (GE), and government healthcare (GH), during this period. Relatively slower growth, in addition to the outright reduction in wages and employment, led to a wage bill reduction of -9.55% in GS, and -9.24% in both GE and GH industries. In contrast, higher output growth in the construction, electrical, and glass and non-metals' industries, led to a wage bill increase of 9.93%, 6.48%, and 5.41%, respectively. In TERM-SA we differentiate household labour income by household-type, province, and occupation. To determine the impact of labour income on different household-types, it is therefore important to consider the impact of the beforementioned on different occupations. The three government industries collectively employ 47% of all "service workers and shop and market sales workers" (srv), and "domestic workers" (dwk). These industries also employ 45% of all "unclassified" (usf) workers and 38% of all "professionals" (prf). This explains the relatively large real wage bill reductions in these occupations; -3.73% (srv), -3.61% (dwk), -3.42% (usf), -2.71% (prf).

In contrast, government industries demand the least amount of "craft and related trades workers" (crf), "operators and assemblers" (opr), "elementary workers" (elt), and to a lesser extent "senior officials and managers" (leg). As a percentage of total industry employment, the three government industries collectively employ 9% (crf), 10% (opr), 18% (elt), and 21% (leg) of the workers in these occupations. The construction industry however employs 11% of all crf workers and 9% of all elt workers. Although their contribution to aggregate employment is small (0.9%, wage bill weighted), the glass and non-metals and electrical industries employ relatively more crf and opr workers. As a share of their total employment both the glass and non-metals and electrical industries employ 13% crf and 9% opr workers. In the end, the relatively small demand government industries have for these occupations, in addition to the relatively large demand the faster growing industries have for them, explains the growth in their wage bills; crf (1.42%), opr (0.54%), and elt (0.28%). As a share of total employment leg workers have a relatively small exposure to government industries (21%), but they also have a relatively small exposure to fast growing industries (4%). However, it should be noted that leg workers represent a relatively large share of the total employment in each of the fast-growing industries; 29% in the electrical, glass and non-metals, and 26% in the construction industry. As a result, the real wage bill of leg workers was only reduced by -0.62%.

Among the poorest 5% (first ventile) of households, 52% are employed in those occupations that experienced the greatest increase in labour income growth during the 5-year wage bill policy shock. Their exposure to this group of fast-growing industries is the second greatest level of exposure among all household-types; 15% are employed as crf, 18% as opr, 20% as elt workers. However, poor households also have a large (44%) exposure to those occupations that experienced the largest decrease in labour income; 26% are employed as dwk, 11% as usf and 7% as srv. The net effect was a -1.36% reduction in labour income among the poorest households in South Africa. In contrast, the 2nd decile households experienced the smallest decrease in labour income, -0.91%, most notably because this group has the largest exposure (56%) to occupations who experienced fast-growing income growth. However, unlike the first ventile group, this group only has a 38% exposure to those occupations that experienced the greatest decrease in labour income. The 9th decile household group experienced the greatest decline in labour income, -1.71%. Not only do they have a 43% exposure to occupations that experience the greatest decrease in labour income, but they also only have a 7% exposure to occupations that experienced the greatest increase in labour income. The richest ventile (5%) of households experienced a similar decrease in labour income as that of the poorest ventile, namely -1.43%. But this is largely because 54% are employed as leg workers and 23% are employed as prf workers, both of which experienced a decrease in their wage bills; -0.68%, and -2.71%, respectively.

At the end of the simulation, the same occupations who experienced the highest cumulative growth and greatest cumulative contraction in their real wage bill in 2020, where once again the fastest and slowest growing occupations in 2035. The fastest growing occupations were: crf (9.72%), opr (9.06%), elt (8.20%), and to a lesser extent leg (7.29%). Once again, these occupations are more prevalent in the fast-growing industries, such as construction, electrical, as well as glass and non-metals. Additionally, except for leg workers, these occupations have a relatively smaller exposure to the three government industries. The slowest growing occupations in 2035 were once again: srv (3.01%), dwk (3.24%), usf (3.51%), and prf (4.53%). Their relatively large exposure to the slow-growing government industries kept these occupations from performing like their fast-growing counterparts. Like before, the poorest ventile households still experienced a similar real increase in labour income (6.03%), compared to that of the richest ventile households (6.13%). However, the 9th decile households are no longer the worst performing households, but the 7th decile households are. Relative to the baseline the 9th decile households experienced an increase of 5.67% compared to the 5.75% increase experienced by households in the 7th decile. The reason this occurred is because the 7th decile households had a greater exposure (26%) to the three worst performing occupations, compared to the 18% exposure of the 9th decile households. What remained unchanged is that the 2nd decile households still experienced the best performing wage bill changes. Initially this household-type experienced the smallest cumulative decline, -0.91% in 2020, and at the end of the simulation they experienced the greatest increase in their wage bill, namely 6.65%.

To summarise, during the 5-year policy shock real wages and employment in the government industries were kept unchanged. Measured against the baseline, this implied a reduction in both variables. Savings generated from keeping the government's real wage bill unchanged is used to increase investments, perpetually throughout the simulation period. Driven by wage-bill specific changes, as well as industry changes that occur as a result of the policy shock, the nationwide real labour income was cumulatively reduced by -1.53% in 2020. At the end of the simulation, perpetually higher levels of investments, facilitated by a subsidy in the construction industry, led to labour income that is 4.46% higher compared to the baseline. Household transfers from enterprises were cumulatively increased by 0.52% in 2020 but reach 3.38% in 2035. Household income from gross operating surplus (GOS) increased cumulatively by 1.30% in 2020 but reached 3.83% in 2035. Finally, compared to the baseline, transfers from the rest of the world ($RotW$) and government, decreased cumulatively by -1.18% in 2020 but reach 2.96% in 2035. Summing all these sources of household income implies a cumulative decrease in aggregate household income of -0.71% during the initial 5-year policy period.

However, by the end of the simulation aggregate household income is 4.71% higher, compared to the baseline. In 2020, measured against the baseline, households in the poorest ventile experienced a cumulative -1.29% real decrease in their income, whereas the richest ventile experienced a -0.31% decrease. However, in 2035 the poorest ventile experienced a 3.79% increase and the richest ventile a 4.69% increase. Wealthier households derived a larger share of their income from GOS and transfers from enterprises, whereas poorer households derived the bulk (65%) of their income from government transfers. Labour income between different households also differ. The poorest and richest ventile households experienced similar reductions in labour income, both at the end of the initial policy period and at the end of the simulation period. The 2nd decile households experienced the smallest decline in 2020 and the greatest increase in labour income in 2035. Also, in 2020 the 9th decile households experienced the largest decrease in labour income, whereas the 7th decile household experienced the smallest increase in labour income, in 2035.

5.4.6 Disposable Income, Spending and Savings

Disposable household income in TERM-SA is obtained by subtracting taxes, household transfers to government, as well as interest payments on net foreign liabilities, from aggregate household income. In Chapter 2 this is illustrated by equation $(2.5.G)$. In Section

5.4.5 we explained that the poorest ventile households experienced a real income increase of 3.79% in 2035; 1.36% in nominal terms. The richest ventile households experienced a 4.69% increase in their aggregate income; 2.26% in nominal terms. Halfway through the distribution spectrum of household income, the 5th decile households saw a 4.94% increase in real income; 2.51% in nominal terms. From here we turn to household taxes, transfers to the government, and interest payments on net foreign debt, in order to calculate household disposable income and savings.

It is worth noting that standard household taxes, income and consumption taxes, and transfers to government, represent 16% and 7% of aggregate income, respectively. Interest payments on net foreign debt however only represent 0.11% of total household income. In TERM-SA we assume that changes in nominal taxes and household transfers to government follow nominal changes in household income, adjusted for possible changes in household taxes. Interest payments on foreign debt are calculated like interest payments made by government to households and enterprises, which has been explained in detail in Section 5.4.5, and follow changes in inflation and debt. After considering that these expense items in total only account for roughly 23.11% of total income and grow at a similar or slower rate than income, their weighted growth is less than that of income. For this reason we see that disposable income increases relatively faster than income, measured against the baseline.

SAM-data shows that the poorest (1st venitle) households only pay 0.001% of aggregate transfers to government. The 5th decile, richest and second richest households pay 2%, 22%, and 33%, respectively (Van Seventer, et al., 2016). Additionally, the poorest ventile households only pay 0.02% of all household taxes, the 5th decile households pay 1%, but the 19th and 20th ventile households pay 15% and 49%, respectively. We assume that households own foreign debt in the same proportion as they own government debt, which we allocate to households according to IES savings data (Statistics South Africa, 2012). In doing so the poorest households only pay 5% of the interest owed on net foreign debt whereas the richest two ventiles pay 16% and 20%, respectively. Measured against the baseline the poorest households experienced a nominal increase of 1.36% in the transfers they make to the government. The 5th decile households experienced a 2.51% increase, whereas the 19th and 20th ventile households experienced a 2.15% and 2.26% increase, respectively. Following our assumption, taxes grow at similar rate than household transfers to government, i.e. the rate at which income grows adjusted for possible tax shocks. For simplicity we've assumed that the same interest rate is paid by all households, in which case the growth in interest rates will also be similar as they are impacted by similar levels of inflation and changes in debt. Household disposable income is calculated by subtracting these values from aggregate household income, and because their relative growth is less, disposable income therefore increases. Measured against the baseline, the poorest (1st ventile) households experience a 1.41% increase in their disposable income. The 5th decile households experience a 2.54% increase and the 19th and 20th ventile households experience a 2.17% and 2.28% increase, respectively. In real terms these increases are: 3.84% (1st ventile), 4.97% (5th decile), 4.60% (19th ventile), and 4.71% (20th ventile), respectively. We assume households experienced similar levels of price changes, namely -2.43%[34].

Following the S-BOTE section of Chapter 4, equations $(S3.1)$ to $(S3.4)$ express aggregate household spending (C) as a function of the average propensity of households to consume their disposable incomes. Based on the household-specific increases in real disposable income, the poorest ventile households experienced a 3.84% increase in spending. Measured against the baseline the richest 19th and 20th ventile households experienced spending increases of 4.60% and 4.71%, respectively, and 5th decile households experienced increases of 4.97%.

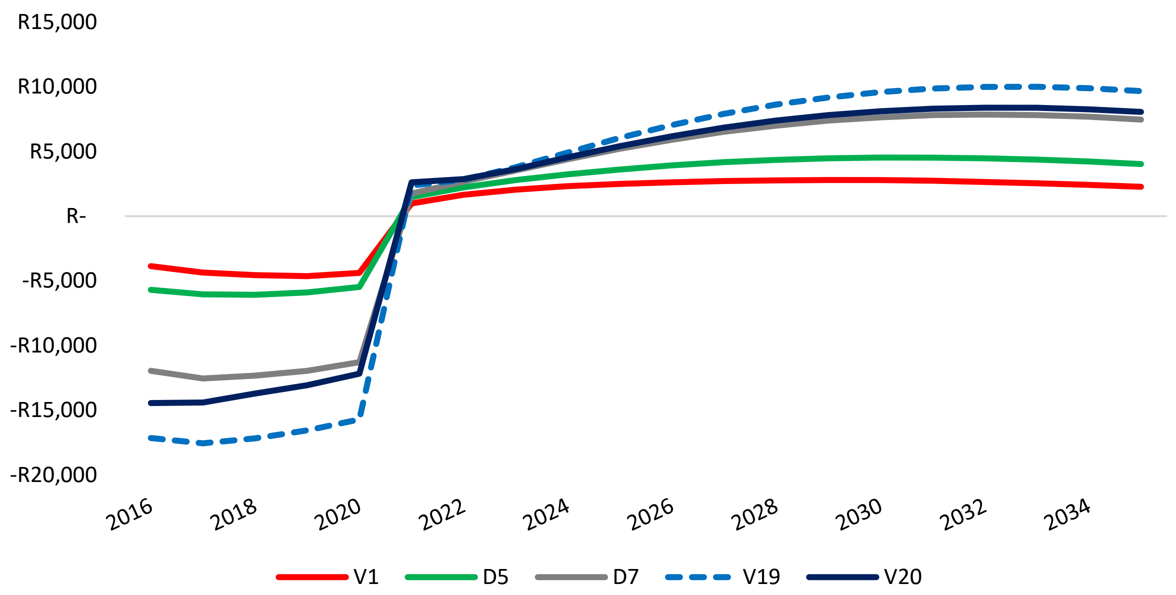
Finally, to estimate household savings we follow Section 2.5.4, specifically equation $(2.5.H)$. That is, household savings is the residual after subtracting spending, as well as household transfers to enterprises and the rest of the world, from disposable income[35]. It is possible that a specific household spends more than its income, in which case a dissaving occurs. To model this dissaving in TERM-SA, considering our interest in deviations away from the baseline, savings are not reported in percentage change terms. Instead we measure the absolute difference $(SAV_t - SAV_{t-1})$ in savings between different years. Figure 5E in turn, illustrates

[34] For consistency with previous interpretations the 2nd and 7th decile households experienced real labour increases of 4.51% and 4.94% in 2035; measured against the baseline.

[35] In TERM-SA we assume household transfers to enterprises grow at the same rate as household gross operating surpluses. Also, we assume household transfers to the rest of the world grow at the same rate as disposable income.

the annual absolute difference in savings between the base and policy simulations. These results have shown that savings among the poorest ventile households are 1.93% higher in 2035 compared to the baseline. The 5th decile household saw an increase in savings of 4.59% and the richest 19th and 20th venitle households experienced increases of 3.46% and 5.58%, respectively.

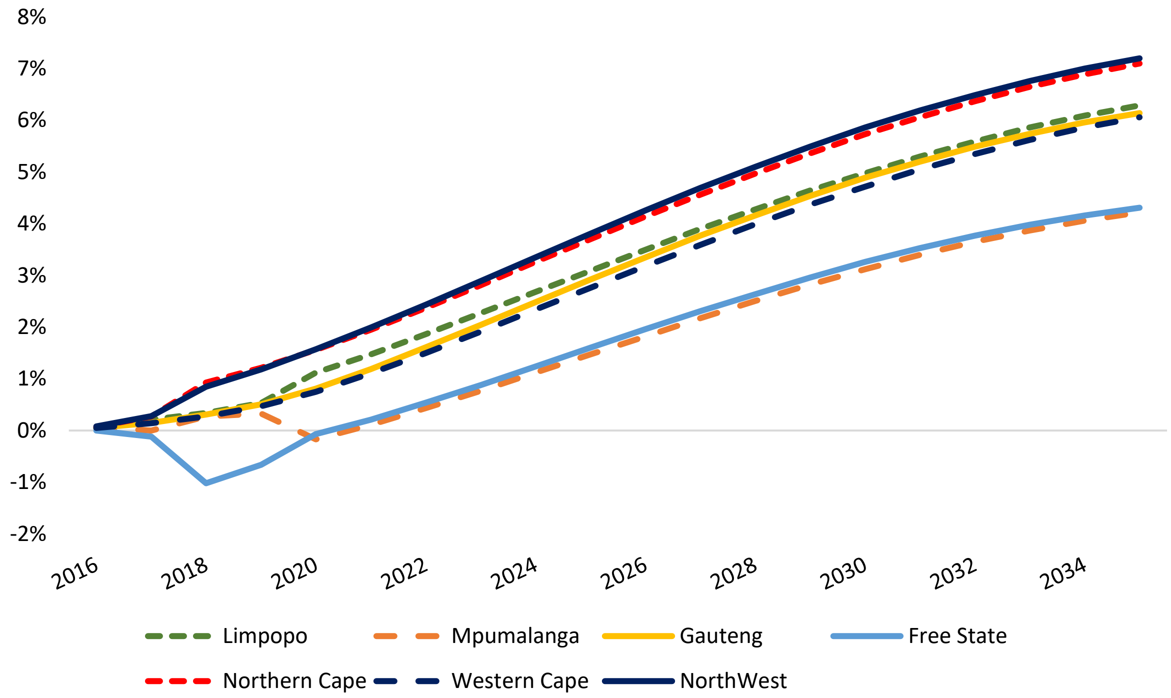
Figure 5E: Household Savings (Annual Differences Between Years)



5.4.7 Regional Economic Impact

We explained in Section 5.1, and illustrated in Table 5B, that the structure and characteristics of each region influences the results generated by TERM-SA. One of these characteristics is that Gauteng (GP) provides the bulk of South Africa's economic activity, followed by Western Cape (WC) and Kwazulu-Natal (KZN). Figure 5F however shows that, measured against the baseline, North West (NW) experienced the greatest increase in economic activity over our simulation period. Cumulatively real GDP is 7.20% higher in NW at the end of the simulation, 2035. The Northern Cape (NC) saw the second greatest cumulative increase in output, 7.10%. Growth in WC and GP was 6.06% and 6.14% higher, respectively. The worst performing regions were Mpumulanga (MP) and the Free State (FS) where real growth was only 4.22% and 4.31% higher in the policy simulation. To understand these regional output differences, it's worthwhile to refer to Section 5.4.2 that explains the difference in output prices which explain output differences.

Figure 5F: Regional Economic Growth (Cumulative Percentage)



Relatively lower prices in NW and NC caused output to increase relatively more in these provinces compared to others. Among final users the cumulative average regional price at households, investors, government, and exporters decreased by: -2.39%, -9.53%, -5.77% and -1.6%, respectively. Although household prices in NW was slightly higher than the regional average (-2.38%), investor prices were slightly lower (-9.59%). However, government (-7.40%) and export (-2.88%) prices were considerably lower. Although price deviations between the regional average in LP, GP and WC are not as severe as in NW and NC, a similar trend is evident. In aggregate prices decreased by -5.48% in NW. Which is relatively greater than decreases in FS (-3.79%) and MP (-3.90%).

Following relatively lower prices in specific regions, output growth was also relatively higher in these regions. This can also be seen in various industries in specific regions. As an example, construction grew 16.20% in NC, the highest among all provinces, but only 13.47% in FS and 12.74% in MP, the slowest growing among provinces. A similar trend is seen in the electrical, glass and non-metals, real estate and hotel and accommodation industries. Although the NW saw the second greatest increase among these faster growing industries, they experienced the greatest increase in output among slower growing regions, which caused final output growth to be slightly higher in the NW (7.20%), compared to the NC (7.10%).

5.4.7 Other Macros

We have explained in detail the household section of TERM-SA's SAM capabilities. Because we have assumed that government expenditure and the deficit remain unchanged between the baseline and policy simulations, we do not provide an in-depth analysis of the government user. This would be better suited for other policy simulations in future research. Concerning enterprise savings, the suggested wage-bill policy shock increases these savings cumulatively in real terms by 2.96% in 2035. Driven by greater income growth from gross operating surplus (GOS) and lower production costs, enterprises were able to save relatively more in the policy simulation.

Section 5.4.1 explained why, measured against the baseline, export volumes increased cumulatively by 6.73% in 2035, but also why the terms of trade declined by -1.62%. Import growth, measured against the baseline was 5.07% higher. However, the total income earned by foreigners (the rest of the world, row 16 in Table 2B and 3C), increased by 4.26%. Put differently, this can also be viewed as all payments made by South Africans to the rest of the world. Total receipts from the rest of the world (column 16 in Table 2B and 3C), only increased by 4.87%. For this reason, the current account deficit (CAD, also referred to as $VSAVROW$ in equation 2.5.P) declined somewhat from -3.4% in 2016 to -4.6% in 2035, expressed as a percentage of GDP. As the CAD declines net foreign liabilities increase from 22% in 2016 to 75% in 2035, expressed as a percentage of GDP. However, as Section 5.2.3 explained concerning government debt, these increases are a result of the model's setup and the assumption that inflation is zero. If we assume inflation is 4.5%, net foreign liabilities would only be 47% in 2035.

5.6 Concluding Remarks

In this chapter we used TERM-SA to estimate the fiscal incidence of an alternative fiscal policy mix on the South African economy. Specifically, we fixed the government's real wage bill for a period of 5-years. Savings generated from this decision were used to perpetually increase investments through a subsidy in the construction industry. We chose this flow because our aim was not to merely increase government infrastructure, but to boost aggregate investments in the economy. Also, by allowing investments to flow through the construction industry and not only through the government, we followed the advice of Calderón et al. (2015). Like their infrastructure proxy, our aim was to reduce the inefficiencies and corruption related to government infrastructure projects by using a subsidy in the construction industry. This policy shock was measured as a percentage deviation away from the baseline. Simulations in TERM-SA were solved using the GEMPACK software developed by Harrison and Pearson (1996).

To create the baseline forecast we followed the steps outlined in Chapter 4 and exogenise macro-economic variables for which we had reliable forecast data. We did this by endogenizing naturally exogenous variables such as the average propensity to consume, and some preference shift variables, to name a few. The baseline is set up in such a manner that it will replicate a long-term business-as-usual view of the South African economy. We exogenously set the aggregate GDP to grow at roughly 2.37% annually. Investment expenditure was set to grow slightly faster than government expenditure. The labour force and productivity were set to grow annually at 1.25% and 1.10%, respectively. Regional output performance favours the Gauteng province over the Western-Cape, which is favoured over Kwazulu-Natal. We also provided the baseline forecast data for the multiple household and SAM-extensions of TERM-SA.

In the policy simulation we considered the fiscal incidence of keeping government’s real wage bill fixed for five years and using the savings to increase investments through a construction subsidy. The results showed that, measured against the baseline, investments increased by 13.20%. Greater levels of investments lead to an economy that was 5.90% larger and employs more individuals. In fact, 160,000 more unskilled jobs, 190,000 semi-skilled jobs, and 106,000 more skilled jobs are created. To facilitate our policy scenario of keeping both components of the real wage bill, employment and wages, fixed for 5-years, productivity in the government industries was endogenized. We found that productivity among government employees increased on average by 1.5%, annually. These productivity increases were supported by seminal research done by Hopenhayn and Rogerson (1993), Boedo and Mukoyama (2012), Cappellari et al. (2012), and Bjuggren (2018). We also found that aggregate exports at the end of the simulation period were slightly higher than GDP which was most notably caused by the nature of the persistent increases in exports. Export growth was driven by a faster growing economy that lead to a fall in the foreign-currency prices of domestically produced commodities. Nominal exports growth was 6.73% higher in the policy simulation and slightly less than import growth, which was 5.06%. For this reason, the current account deficit decreased somewhat from -3.4% in 2016 to -4.6% in 2035.

Real GDP grew cumulatively by 5.90%, however nominally the increase was only 0.53%. The GDP deflator, a weighted sum of different user prices, decreased cumulatively by -5.08% in 2035. Keeping the government wage bills fixed reduced the input costs of government industries. This initial fall in the prices could not be offset by the gradual increase in input costs as the government industries started to increase their wage bill after the policy period. Investor prices were most notably reduced by the tax subsidy in the construction industry. Also, relatively higher levels of investments lead to a higher K/L ratio, which in turn, reduced the MPK and thereby the rental price of capital. The fall in capital prices offset the increase in labour prices, which reduced the basic cost of producing commodities.

In our results section we also explained that industry growth is driven by macro-economic growth and changes that were brought about by policy shocks. Higher levels of investment favoured the construction, electrical, as well as glass and non-metals industries which, measured against the baseline, grew cumulatively by 14.28%, 12.12%, and 12.20%, respectively. Industries which experienced the smallest output increases, were the three government industries which supplied the bulk of their output to the government user. Because we kept the government user's spending and deficit unchanged between the baseline and policy simulation, government industries that supply services to this user will have limited potential to increase output beyond baseline levels. The food and beverages, as well as textile and footwear industries also experienced smaller output increases: 4.53% and 4.23%, respectively.

Driven by wage-bill specific changes, as well as industry changes that occur as a result of the policy shock, the nationwide real labour income was cumulatively increased by 4.46% in 2035.

Household transfers from enterprises and income from GOS are respectively 3.38%, and 3.83% higher in 2035. Transfers from the $RotW$ and government are 2.96% higher. Measured against the baseline, the poorest and richest ventile households experience a real income increase of 3.79% and 4.69%, respectively. Wealthier households derive a larger share of their income from GOS and transfers from enterprises, whereas poorer households derive the bulk (65%) of their income from government transfers. Labour income between different households also differ. Because expense items that are subtracted from total household income only account for 23.11% of total income and grow at a similar or slower rate than income, their weighted growth is less than that of income. For this reason, disposable income increases relatively faster than total income, measured against the baseline. SAM-data however, showed that richer households pay the bulk of taxes and are therefore, more exposed to the reduction in the tax shock. At the end of the simulation, the poorest household, 2nd decile, 5th decile, and richest households, experienced disposable income increases of 3.84%, 4.51%, 4.97%, and 4.71%, respectively. We also showed that households consume in relation to their ability to generate disposable income. As a result, the poorest household, 2nd decile, 5th decile, and richest households, experienced consumption increases of 3.84%, 4.51%, 4.97%, and 4.71%, respectively.

Measured against the baseline, we also showed that output growth in the North West (NW) increased by the greatest amount among provinces in South Africa. Cumulatively real GDP is 7.20% higher in NW at the end of the simulation, 2035. The Northern Cape saw the second greatest cumulative increase in output, 7.10%. Growth in Western Cape and Gauteng was 6.06% and 6.14% higher, respectively. The worst performing regions were Mpumulanga and the Free State where real growth was only 4.22% and 4.31% higher in the policy simulation. To understand these regional output differences, we showed that output prices were relatively lower in the faster growing regions which fuelled greater levels of production.

CHAPTER 6 – CONCLUSION

6.1 Overview of Study

This study evaluated the economic consequence of an alternative fiscal policy mix in South Africa. Our aim was to provide a wealth creative alternative to the government's current redistributive policies that could lead to better levels of economic performance and social development. To do this we specifically simulated the fiscal incidence of keeping governments real wage bill fixed for five-years. Additionally, we used the savings generated from this decision to subsidise the construction industry and thereby boost aggregate investments in the economy.

To conduct our analysis, we used TERM-SA, a dynamic regional computable general equilibrium (CGE) model that describes the South African economy. To facilitate the analysis a few important extensions were added to the standard dynamic TERM-model of Wittwer et al. (2005). To determine the fiscal incidence of government policies on different household types we incorporated multiple household mechanisms like INDOTERM (Horridge & Wittwer, 2006) and USAGE-TERM (Wittwer, 2017). Like PHILGEM we also used Social Accounting Matrix (SAM) mechanisms to allow TERM-SA to better illustrate the link between producers and users throughout the rest of the economy. Specifically, we could illustrate how factor incomes, gross operating surplus, tax revenues, and interest on outstanding debt, to name but a few, accrue to households, the government and enterprises. Chapter 2 provided an in-depth view of TERM-SA's theoretical structure. Key features of the model's database were described in Chapter 3. The most notable features included dividing the single government user and increasing the accuracy of regional government flows. These were aimed at improving the detail and accuracy of our analysis. Chapter 4 discussed the main model closures applied in TERM-SA and provided a stylized back-of-the-envelope (S-BOTE) representation of the model. In Chapter 5 we discussed all the simulations and their results.

Test simulations showed that TERM-SA functions properly and generated results that were consistent with theory. Extensive model validation exercises were also conducted by following the advice of Dixon and Rimmer (2012). Specifically, both nominal and real homogeneity tests were conducted on TERM-SA. Key macro-economic identities were used to check that the model remains balanced in the short and long-term. Finally, S-BOTE equations were used to establish some intuition about the results that would be generated by TERM-SA. After test simulations and final simulations were run, we found that our intuition was consistent with actual results. Based on the outcomes of our test simulations and model validation procedures we are confident in the validity of the results generated by TERM-SA.

6.2 Main Findings

Measured against the baseline, we found that investments increased by 13.20% at the end of the simulation period, 2035. Greater levels of investments lead to an economy that is 5.90% larger and employs many more individuals. In fact, 160,000 more unskilled jobs, 190,000 semi-skilled jobs, and 106,000 more skilled workers are employed. In this, our policy alternative succeeded in its goal of providing improved levels of economic performance and social development. Household-specific data further substantiated the social development benefits of the suggested fiscal policy mix.

Wealthier households derived a larger share of their income from GOS and transfers from enterprises, whereas poorer households derived the bulk of their income from government transfers. Although one might argue that the policy leads to greater levels of inequality the results should rather be seen considering the alternative. If the suggested policy was not introduced all South Africans would be poorer and fewer jobs would be available.

Nevertheless, investment-induced growth in capital, GOS and transfers from enterprises were cumulatively 3.83% and 3.38% higher in 2035. Growth in the transfers from government was however muted at 2.96%. We also showed that labour income between different households differ, depending on their exposure to fast or slower growing industries. Higher levels of investments that were achieved through a tax subsidy in the construction industry, favoured the construction, electrical, as well as glass and non-metals industries. Measured against the baseline these industries grew cumulatively by 14.28%, 12.12%, and 12.20%, respectively. Model assumptions kept government spending and deficits between the baseline and policy simulations unchanged, as a result government industry experienced the smallest output increases. The food and beverages, as well as textile and footwear industries, also experienced relatively smaller output increases: 4.53% and 4.23%, respectively. At the end of the simulation, the poorest households, 2nd decile, 5th decile, and richest households experienced disposable income increases of 3.94%, 4.51%, 4.97%, and 4.71%, respectively. Households, who consume in relation to their ability to generate disposable income were therefore able to consume more in the new policy-mix environment. Following the assumption we imposed, households experienced consumption increases of a similar magnitude than the increases in disposable income.

Regions that did well were those who were exposed to relatively lower output prices. Measured against the baseline, the North West and Northern Cape increased by the greatest amount among provinces in South Africa, 7.20% and 7.10% respectively. The worst performing regions were Mpumulanga and the Free State where real growth was only 4.22% and 4.31% higher in the policy simulation.

After finishing all our analyses, we can summarise our finding into two main contributions from this thesis. Our first contribution is that the specific policy simulations provide a detailed analysis of an alternative fiscal policy mix that can lead to greater levels of economic and social development. This fresh, evidence-based perspective provides policymakers and researchers key insights about the fiscal incidence of government policies in the South African economy. The second contribution is that TERM-SA provides a flexible tool for evaluating many other topics in South Africa.

6.3 Future Research

TERM-SA's flexible analytical framework can be applied to multiple future studies on the South Africa economy. In this thesis we showed that the bulk of government's expenditure is unproductive and that subsidising this expenditure for more productive investment expenditure might lead to some short-term contractions. But, in the long-term this substitution will lead to greater economic and social development. In our analysis we only kept the government wage bill fixed for 5-years. Future studies might consider keeping a larger portion of unproductive expenditure, like government transfers to households, fixed for a certain period. In doing so a larger portion could be allocated towards productive, wealth enhancing policies. More controversial studies might follow the suggestion made by Finance Minister Tito Mboweni and reduce the real wage bill (National Treasury, 2018). Another study might consider an alternative fiscal policy mix that increases the output efficiencies of education and healthcare in South Africa. These wealth creative policies might contribute to total factor productivity and thereby reduce the debt-burden whilst increasing economic and social development.

In this thesis we facilitated the exogenous increase of investments through a tax subsidy in the construction industry because this industry supplies 48% of the inputs used by investors. Future research might consider subsidising more of the industries that supply to investors.

In our analysis we assumed that the government deficit and spending remained unchanged between the baseline and forecast closures. This assumption was introduced because our objective was to find a better alternative for government's planned expenditure and not to change future expenditure levels. Upcoming research might allow these variables to change over time and permit alternative uses of government finances. By keeping the government's real wage bill fixed for five years labour productivity was endogenized, and therefore, measured against the baseline, increased annually by roughly 1.5%. It might be fruitful to use TERM-SA's historical and decomposition closures to determine if this is a probable assumption.

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APPENDIX A

A1. Commodities and Corresponding Industries

Nr	Commodity (COM), Industry (IND)	Description
1	Agric	Growing of crops, horticulture, farming of animals, dairy farming, mixed farming, agricultural services, hunting, production of organic fertilizer.
2	Coal	Mining of coal and lignite.
3	Gold	Mining of gold and uranium ore.
4	Other_Mining	Mining of iron ore, other mining and quarrying, as well as incidental services.
5	Food_Bev	Manufacturing of food products, beverages, and tobacco products.
6	Text_Foot	Manufacturing of textiles, clothing and leather goods.
7	Wood_Paper	Sawmilling and planing of wood. Manufacturing of products of wood, cork, straw and plaiting materials. Manufacturing of paper and paper products.
8	Petro_Chem	Manufacturing of coke oven products. Petroleum refineries and synthesisers. Processing of nuclear fuel. Manufacturing of basic chemicals, other chemical products, man-made fibres, rubber products, and plastic products.
9	Glass_No_Met	Manufacturing of glass, glass products and other non-metallic mineral products.
10	Metal_Mach	Manufacturing of basic precious and non-ferrous metals. Casting of metals. Manufacturing of structural metal products, other fabricated metal products, as well as general and special purpose machinery, household appliances, and office machinery.
11	Electrical	Manufacturing of electrical machinery and apparatus.
12	Radio_TV	Manufacturing of radio, television and communication equipment. Manufacturing of medical, precision and optical instruments. Manufacturing of watches and clocks.
13	Trans_Equip	Manufacturing of motor vehicles, bodies for motor vehicles, trailers, motor parts, ships and boats, aircraft, and transport equipment.
14	Other_Manuf	Manufacturing of furniture. Manufacturing of other manufacturing and recycling activities not included above.
15	Electricity	Production and distribution of electricity.
16	Water	Collection, purification and distribution of water.
17	Construction	Construction, including site preparation, building, building installation, building completion, as well as renting of construction or demolition equipment with operators.
18	Trade	Wholesale and retail trade activities.

19	Hotels	Hotels and accommodation. Food and beverage service activities. Travel agencies and tour operators.
20	Trans_Serv	Land, pipe, water and air transport. Warehousing and transport support activities. Postal and courier activities.
21	Comm	Publishing activities. Motion picture. Video and TV production. Sound and recording. Music publishing activities. Programming and broadcasting activities. Telecommunications, computer programming (consultancy) and related activities. Information service activities.
22	Financial	Financial services and auxiliary activities.
23	Real_Estate	Real estate activities.
24	Business	Legal and accounting, management consultants, architectural and engineering, scientific, and research and development activities. Advertising, design, photographic, and veterinary services. Renting and leasing of equipment. Employment agencies. Security and investigation activities. Office administration and support. Other business activities.
25	Gov_Gen	General public administration activities, including policing, defence and social security.
26	Gov_Educ	Government education activities.
27	Gov_Health	Government health activities.
28	Health_Soc	Human health activities, residential care activities, social work activities (not conducted by Government).
29	Education	Education activities (not conducted by Government).
30	Other_Serv	Arts and entertainment. Libraries, archives, museums and other cultural activities. Gambling, sports activities and clubs. Activities of membership organizations. Repair of computers, personal and household goods, domestic personnel.

A2. Occupations

Nr	Occupation (OCC)	Description
1	leg	Legislators, senior officials and managers
2	prf	Professionals
3	tch	Technical and associate professionals
4	clk	Clerks
5	srv	Service workers, shop and market sales workers
6	sag	Skilled agricultural and fishery workers
7	crf	Craft and related trades workers
8	opr	Plant and machine operators and assemblers
9	elt	Elementary workers
10	dwk	Domestic workers
11	usf	Unclassified

A3. Regions

Nr	Regions	Description
1	LP	Limpopo
2	NW	North West
3	MP	Mpumalanga
4	GP	Gauteng
5	FS	Free State
6	NC	Northern Cape
7	WC	Western Cape
8	EC	Eastern Cape
9	KZN	KwaZulu-Natal

APPENDIX B

B1. The Percentage-Change Approach

This appendix follows that of Bohlmann (2011) and describes the percentage-change approach used by CGE models after equations have been linearized and solved using GEMPACK software.

CGE models like TERM-SA have many equations (x) and even more variables (y). To complicate the process of solving the model further, many of the equations are non-linear in their levels form. GEMPACK therefore, follows Johansen's (1960) percentage-change linearization approach to reduce the computational burden of solving this large and often non-linear system of equations. Johansen (1960) linearized equations by changing variables from their levels form into changes or percentage changes and then solved the system of linear equations through matrix manipulation. Following this approach, we obtain an approximation on the (x) endogenous variables of changes for the $(y - x)$ exogenous variables.

In a system of equations where Y is output and X_1 and X_2 are inputs, so that:

$$Y = f(X_1, X_2) \quad \text{B1.1}$$

Johansen's linear percentage-change approach can be applied to yield:

$$y - \varepsilon_1 x_1 - \varepsilon_2 x_2 = 0 \quad \text{B1.2}$$

Here, y and x_i are the percentage changes for Y and X_i, and ε_i is the elasticity of output as it relates to the inputs of factor i. In matrix notation, this can be expressed as:

$$A\omega = 0 \quad \text{B1.3}$$

So that A is a $(n * m)$ matrix of coefficients and ω is a vector of variables that have been expressed in terms of changes or percentage changes. Because there are many more variables than equations the model can only be solved, or closed, if an n-number of variables are enodogenised and an $(m - n)$ number of variables are exogenised. By expressing the change or percentage change expressions of our endogenous variables as linear functions of the change or percentage changes of our exogenous variables, equation B1.3 can be expressed as:

$$A_1 y + A_2 x = 0 \quad \text{B1.4}$$

Here, A_1 and A_2 are matrices formed by selecting appropriate columns of A, and y and x are vectors of percentage changes of endogenous and exogenous variables, respectively. To calculate the effect that a change in any one of the exogenous variables has on the endogenous variables we solve equations B1.5 via matrix inversion:

$$y = -A_1^{-1} * A_2 x \quad \text{B1.5}$$

Johansen's linearized system of equations, expressed by equation B1.4, offer two distinct benefits over their underlying and often non-linear form (Bohlmann, 2011). First, it is easier to solve and interpret linearized equations. Second, it is easier to interpret elasticity values under the percentage change form. This becomes clear in the next section that considers the percentage-change form of the CES function. However, in an environment where A is assumed constant, large linearization errors may occur in the approximated solutions generated by equation B1.5 if the changes in the vector of exogenous variables are not small. For this reason, the GEMPACK software used to solve CGE models like TERM-SA employ multi-step solutions like the Euler method to sufficiently eliminate the linearization errors. These issues will be explained in more detail in the following section.

B2. The Linearization Error

Using Bohlmann (2011) this section shows how the linearization error introduced by Johansen's percentage-change approach can be sufficiently eliminated by using multi-step techniques like the Euler method. To do this, we start with equation B2.1:

$$X = Y * Z \qquad \text{B2.1}$$

From which we can write:

$$(X + \Delta X) = (Y + \Delta Y) * (Z + \Delta Z) \qquad \text{B2.2}$$

$$(X + \Delta X) = (Y * Z) + (Y * \Delta Z) + (\Delta Y * Z) + (\Delta Y * \Delta Z) \qquad \text{B2.3}$$

Because B2.1 can be rewritten as $X = Y * Z$, we can subtract X on both sides of the equation and express the total change in X via:

$$\Delta X = (Y * \Delta Z) + (\Delta Y * Z) + (\Delta Y \Delta Z)$$

By dividing with X and multiplying with 100 we can find the percentage change in X:

$$\frac{\Delta X}{X} * 100 = \frac{Y * \Delta Z}{Y * Z} * 100 + \frac{\Delta Y * Z}{Y * Z} * 100 + \frac{\Delta Y * \Delta Z}{X} * 100 \qquad \text{B2.4}$$

Using lower-case symbols to represent percentage-change equation B2.3 can be rewritten as:

$$x = \frac{Y*\Delta Z}{Y*Z} * 100 + \frac{\Delta Y*Z}{Y*Z} * 100 + \frac{\Delta Y*\Delta Z}{X} * 100 \qquad \text{B2.5}$$

Here, the upper-case variable X is expressed by the lower-case expression of x, to satisfy, $x = \frac{dX}{X} * 100$, which can also be expressed as $dX = \frac{X*x}{100}$. Following this notation, equation B2.6 shows that x, the percentage change of X, is equal to the percentage change in Y, plus the percentage change in Z, plus a second-order term:

$$x = y + z + \frac{\Delta Y*\Delta Z}{X} * 100 \qquad \text{B2.6}$$

GEMPACK uses a total differential approach to find the approximate percentage change effect, that changes in independent variables have on dependant variables (Bohlmann, 2011). Applying this derivative-based, or linearized approach to the same equation as before, B2.1, we can compare the approximate results with the true results generated by equation B2.6. From B2.1 we can express the total differential of X for a given change in Y and Z as:

$$dX = \frac{\partial X}{\partial Y} dY + \frac{\partial X}{\partial Z} dZ \qquad \text{B2.7}$$

$$dX = 1(Y^{1-1} * Z)dY + 1(Y * Z^{1-1})dZ \qquad \text{B2.8}$$

$$dX = (Z * dY) + (Y * dZ) \qquad \text{B2.9}$$

Here, we apply the percentage change convention introduced earlier to derive:

$$\frac{x*X}{100} = \left(\frac{y*Y}{100}\right) Z + \left(\frac{z*Z}{100}\right) Y \qquad \text{B2.10}$$

$$x * X = y * YZ + z * ZY \qquad \text{B2.11}$$

Recalling that $X = Y * Z$, we divide both sides of the equation with X to reach the approximate percentage change in X:

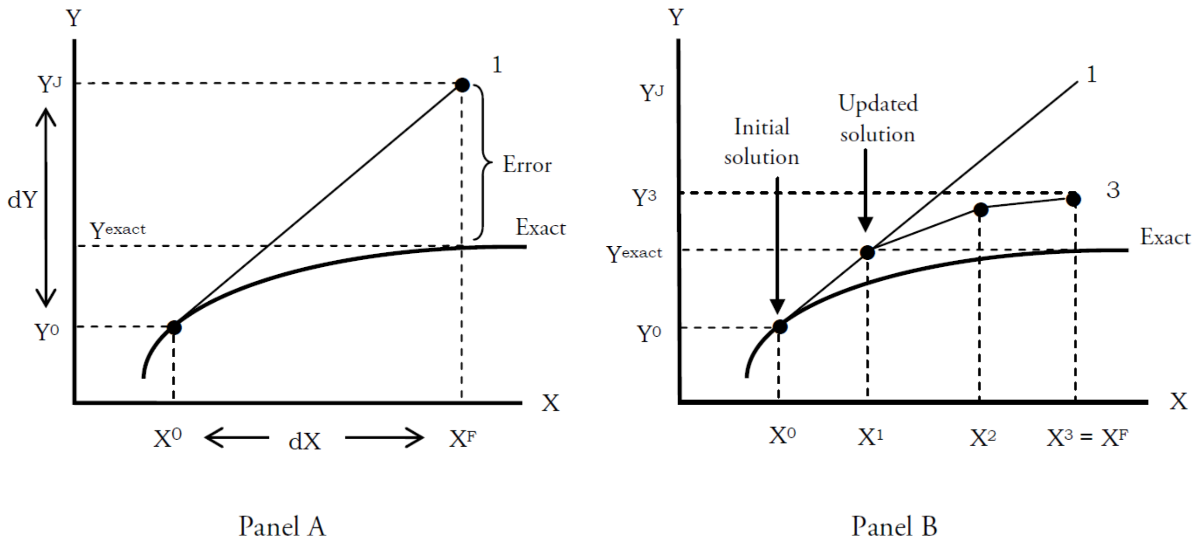
$$x = y + z \qquad \text{B2.12}$$

Comparing the approximate percentage change in X, generated by B2.12, with the true percentage change generated by B2.6, we can observe that the linearization error is equivalent to the second-order term $\frac{\Delta Y * \Delta Z}{X} * 100$. Larger (smaller) changes in independent variables, here represented by Y or Z, therefore lead to larger (smaller) linearization errors. Put differently, the approximated results generated by B2.12 will be a more accurate representation of the true results generated by B2.6, if changes in independent variables are small, that is, tend towards zero. Bohlmann (2011) explains that this forms the basis of the multi-step approach used by GEMPACK to eliminate the linearization error.

In a multi-step approach changes in Y and Z are broken into smaller increments in each step. That is, for each incremental change in Y or Z the linear approximation is used to calculate the incremental change in X. The new values of Y and Z are then used to recalculate the coefficient matrices equivalent to A_1 and A_2 in B1.5. In doing so, the sales and cost shares imbedded in the A matrix are updated. By repeating this process in each step over enough steps, CGE models obtain accurate solutions that approximate to true values (Bohlmann, 2011). This numerical integration method is known as the Euler method, which uses differential equations to move from one step (incremental solution) to the next. Figure B1 from Bohlmann (2011), which was originally adopted from Horridge (2000), show the benefits of the Euler multi-step solution method.

The 3-step Euler solution is illustrated by Panel B in Figure B1, whereas a 1-step Johansen solution is illustrated by Panel A. Applying the Euler 3-step solution and its corresponding increments are indicated in Panel B. This solution path, moving from the initial solution to the first updated solution and eventually reaching the point marked "3", represent the updating of the coefficient matrices that are equivalent to A_1 and A_2 in B1.5 (Bohlmann, 2011). Contrasting the two panels in Figure B1 one can observe the benefit of the Euler method by observing the decrease in the error. In Panel A the error made by a 1-step Johansen solution is the distance between the point marked "1" and the "Exact" curve in Panel 1. In Panel B however, the error is reduced to the distance between the point marked with "3", to the same "Exact" curve.

Figure B1: A 1-Step Johansen & 3-Step Euler Solution (Horridge, 2000)



B3. The CES Function

In this section we focus on the optimisation problem faced by producers and derive the percentage change equation of the Constant Elasticity of Substitution (CES) function. The CES function is homogenous of degree 1 and homothetic, that is, budget shares only depend on the ratio of prices of goods, not income (Bohlmann, 2011). Unlike the standard Cobb-Douglass function the CES function relaxes the assumption of unitary substitution, $\sigma = 1$, but rather defines the elasticity of substitution as $\sigma = \frac{1}{1+\rho}$. Here, ρ is a parameter that determines the value of the CES.

In the CES optimisation problem producers choose inputs X_i, where $i = 1 \dots n$, to minimise the cost of producing a certain level of output, Q, subject to the CES production function. Here, costs are defined as:

$$\sum_i P_i * X_i \qquad \text{B3.1}$$

And the output, CES production function can be defined as:

$$Q = \beta(\sum_i \delta_i X_i^{-\rho})^{-1/\rho} \quad \text{B3.2}$$

Here, β is a parameter to measure the efficiency of technology, and δ_i is a parameter to illustrate the relative factor shares of each product i.

Using B3.1 and B3.2 we can set up the Lagrange function as follows:

$$L = \sum_i(P_i * X_i) + \lambda\left[Q - \beta\left(\sum_i \delta_i X_i^{-\rho}\right)^{-\frac{1}{\rho}}\right] \quad \text{B3.3}$$

From here we take the partial derivatives of L with respect to X_i (where $j = 1 \ldots n$), X_k and λ to derive the first order conditions:

$$\frac{\partial L}{\partial X_i} = P_i - \lambda\beta * \left(-\frac{1}{\rho}\right)\left(\sum_j \delta_j X_j{}^{-\rho}\right)^{-\left(\frac{1}{\rho}\right)-1} * \left(-\rho\delta_i X_i^{-\rho-1}\right) = 0 \quad \text{B3.4}$$

$$\frac{\partial L}{\partial X_k} = P_k - \lambda\beta * \left(-\frac{1}{\rho}\right)\left(\sum_i \delta_i X_i{}^{-\rho}\right)^{-\left(\frac{1}{\rho}\right)-1} * \left(-\rho\delta_k X_k^{-\rho-1}\right) = 0 \quad \text{B3.5}$$

$$\frac{\partial L}{\partial \lambda} = Q - \beta\left(\sum_i \delta_i X_i{}^{-\rho}\right)^{-\left(\frac{1}{\rho}\right)} = 0 \quad \text{B3.6}$$

Now we divide B3.5 with B3.4 to eliminate λ and then simplify to:

$$\left(\frac{P_k}{P_i}\right)^{\frac{1}{1+\rho}} = \left(\frac{\delta_k}{\delta_i}\right)^{\frac{1}{1+\rho}}\left(\frac{X_i}{X_k}\right) \quad \text{B3.7}$$

By rewriting $\left(\frac{\delta_k}{\delta_i}\right)^{\frac{1}{1+\rho}}$ as $\left(\frac{\delta_k{}^{\frac{1}{1+\rho}}}{\delta_i{}^{\frac{1}{1+\rho}}}\right)$ in B3.7 we derive:

$$X_i = \left(\frac{\delta_i * P_k}{\delta_k * P_i}\right)^{\frac{1}{1+\rho}} * X_k \quad \text{B3.8}$$

$$X_i^{-\rho} = \left(\frac{\delta_i * P_k}{\delta_k * P_i}\right)^{-\frac{\rho}{(1+\rho)}} * X_k^{-\rho} \quad \text{B3.9}$$

Next, we can substitute B3.9 into B3.6 and solve for X_k:

$$Q = \beta \left[\sum_i \delta_i \left\{ \left(\frac{\delta_i * P_k}{\delta_k * P_i} \right)^{-\frac{\rho}{(1+\rho)}} * X_k^{-\rho} \right\} \right]^{-1/\rho} \qquad \text{B3.10}$$

By using, $X_k^1 = X_k^{-\rho*\left(-\frac{1}{\rho}\right)}$, we can simplify B3.10 to:

$$Q = X_k * \beta \left[\sum_i \delta_i \left\{ \left(\frac{\delta_k * P_i}{\delta_i * P_k} \right)^{\frac{\rho}{1+\rho}} \right\} \right]^{-1/\rho} \qquad \text{B3.11}$$

Rewriting B3.11 in terms of X_k we can derive the producer's input demand equation:

$$X_k = Q * \beta^{-1} \left[\sum_i \delta_i \left\{ \left(\frac{\delta_k * P_i}{\delta_i * P_k} \right)^{\frac{\rho}{1+\rho}} \right\} \right]^{1/\rho} \qquad \text{B3.12}$$

Which in turn can be simplified to:

$$X_k = Q * \beta^{-1} * \left(\frac{\delta_k}{P_k} \right)^{\frac{1}{1+\rho}} \left[\sum_i \delta_i \left\{ \left(\frac{P_i}{\delta_i} \right)^{\frac{\rho}{1+\rho}} \right\} \right]^{1/\rho} \qquad \text{B3.13}$$

$$X_k = Q * \beta^{-1} * \left(\frac{\delta_k}{P_k} \right)^{\frac{1}{1+\rho}} \left[\sum_i {\delta_i}^{1-\frac{\rho}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}} \right]^{1/\rho} \qquad \text{B3.14}$$

Because $1 - \frac{\rho}{(1+\rho)}$ can be written as $\frac{1}{(1+\rho)}$, B3.14 can be expressed as:

$$X_k = Q * \beta^{-1} * {\delta_k}^{\frac{1}{1+\rho}} * {P_k}^{-\frac{1}{1+\rho}} \left[\sum_i {\delta_i}^{\frac{1}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}} \right]^{1/\rho} \qquad \text{B3.14}$$

Which can be simplified to:

$$X_k = Q * \beta^{-1} * {\delta_k}^{\frac{1}{1+\rho}} \left[\frac{P_k}{P_{ave}} \right]^{-\frac{1}{1+\rho}} \qquad \text{B3.15}$$

Where, $P_{ave} = \left[\sum_i {\delta_i}^{\frac{1}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}} \right]^{\frac{1+\rho}{\rho}}$, or $\frac{1}{P_{ave}} = \left[\sum_i {\delta_i}^{\frac{1}{1+\rho}} * P_i^{-\frac{\rho}{1+\rho}} \right]^{-\frac{1+\rho}{\rho}}$.

Because, $\left[\left(\sum_i \delta_i^{\frac{1}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}}\right)^{-\frac{1+\rho}{\rho}}\right]^{-\frac{1}{1+\rho}}$, must equal $\left[\sum_i \delta_i^{\frac{1}{1+\rho}} * P_i^{-\frac{\rho}{1+\rho}}\right]^{\frac{1}{\rho}}$. In these equations, P_{ave} is obtained by finding an exponent which would equal $\frac{1}{\rho}$ when multiplied with $-\frac{1}{(1+\rho)}$ in equation B3.14 (Bohlmann, 2011).

Now, by calculating the total differential of the CES demand optimisation function, given by equation B3.15, we can convert the function into its percentage change form. Once again, we use the convention that lower-case variables reflect percentage change so that $x = \frac{dX}{X} * 100$, or alternatively $dX = X * x * 0.01$. First, we find that:

$$X_k * x_k * 0.01 = \left(\beta^{-1} * \delta_k^{\frac{1}{1+\rho}} \left[\frac{P_k}{P_{ave}}\right]^{-\frac{1}{1+\rho}}\right) Q * q * 0.01 +$$
$$\left(Q * \beta^{-1} * \delta_k^{\frac{1}{1+\rho}} \left(-\frac{1}{1+\rho}\right) \left[\frac{P_k}{P_{ave}}\right]^{-\frac{1}{1+\rho}-1}\right) d\frac{P_k}{P_{ave}} \qquad \text{B3.16}$$

Then we apply the quotient rule to rewrite, $d\frac{P_k}{P_{ave}}$ as, $\frac{P_{ave}*P_k'-P_{k*}P_k'}{P_{ave}^2}$, which can be simplified into: $\left[\left(\frac{P_k*0.01}{P_{ave}}\right)(p_k - p_{ave})\right]$. Also, recalling equation B3.15, B3.16 can be simplified into:

$$X_k * x_k * 0.01 = X_k * q * 0.01 + \left(X_k \left[\frac{P_k}{P_{ave}}\right]\right)\left(\frac{P_k*0.01}{P_{ave}}\right)(p_k - p_{ave}) \qquad \text{B3.17}$$

Finally, we can write the CES demand equation in percentage change form as:

$$x_k = q - \sigma(p_k - p_{ave}) \qquad \text{B3.18}$$

Where $p_{ave} = \sum_i S_i p_i$, $\sigma = \frac{1}{1+\rho}$. Also, $S_i = \frac{\delta_i^{\frac{\rho}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}}}{\sum_i \delta_i^{\frac{\rho}{1+\rho}} * P_i^{\frac{\rho}{1+\rho}}}$ which can be interpreted as the share of total production cost carried by input X_i.

B4. The Klein-Rubin Function

Households modelled in TERM-SA maximise their utility subject to a Klein-Rubin utility function. Although Dixon et al. (1982) provide a complete explanation of the Klein-Rubin household demand or consumption function, its calculation and percentage change derivation, we follow Bohlmann (2011) and provide a brief introduction.

Unlike the previous functions addressed in Appendix B, the Klein-Rubin function is non-homothetic, which imply that consumer preferences (budget shares) change as income levels increase (Bohlmann, 2011). Put differently, the marginal rate of substitution changes as income increases. This is true even if price ratios are fixed.

Total household demand (X_i) consists of a combination of subsistence (X_i^{sub}) and luxury goods (X_i^{lux}), which can then be expressed as:

$$X_i = X_i^{sub} + X_i^{lux} \qquad \text{B4.1}$$

Where $i = 1 \dots n$. From here, the Klein-Rubin household optimisation problem can be solved by choosing the amounts of subsistence and luxury goods that will maximise utility:

$$U = U(X_1 \dots X_n) = \sum_i S_i^{lux} * \ln{(X_i^{lux})} \qquad \text{B4.2}$$

Subject to the household budget constraint:

$$M = \sum_i X_i * P_i \qquad \text{B4.3}$$

Using equations B4.1 and B4.3, and assuming the household's entire budget is spent (M), we can express spending on luxury goods (M^{lux}) as (Bohlmann, 2011):

$$M^{lux} = M - \sum_i X_i^{sub} * P_i \qquad \text{B4.4}$$

Using B4.4 and understanding from the preceding that luxury spending on good i is a is fixed proportion of total supernumerary income, we find:

$$X_i^{lux} * P_i = S_i^{lux} * M^{lux} \quad \text{B4.5}$$

Which, can be rearranged into:

$$X_i^{lux} = \left[\frac{S_i^{lux}}{P_i}\right] * M^{lux} \quad \text{B4.6}$$

Now, we can substitute B4.4 into B4.6 to derive:

$$X_i^{lux} = \left[\frac{S_i^{lux}}{P_i}\right] * \left(M - \sum_i X_i^{sub} * P_i\right) \quad \text{B4.7}$$

Which, in turn, can be substituted into B4.1 to derive the general levels from of the Klein-Rubin household demand equation:

$$X_i = X_i^{sub} + \left[\left(\frac{S_i^{lux}}{P_i}\right) * \left(M - \sum_i X_i^{sub} * P_i\right)\right] \quad \text{B4.8}$$

Here, spending on each good i is a linear function of income. For an in-depth derivation of the levels, and percentage change form of the Klein-Rubin function please refer to Dixon et al. (1982).

APPENDIX C

Table C1: Selected Macro Variables, Deviation from the baseline

Macro-Economic Variable	2016-2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Real GDP (GDP)	0.74%	1.10%	1.50%	1.91%	2.33%	2.75%	3.16%	3.56%	3.94%	4.31%	4.65%	4.96%	5.25%	5.50%	5.72%	5.90%
Private Consumption (C)	-1.05%	-0.92%	-0.66%	-0.32%	0.05%	0.46%	0.89%	1.34%	1.79%	2.25%	2.71%	3.16%	3.59%	4.01%	4.40%	4.76%
Investment (I)	6.70%	7.96%	8.98%	9.88%	10.69%	11.40%	12.02%	12.55%	12.97%	13.29%	13.51%	13.63%	13.66%	13.59%	13.43%	13.20%
Government Expenditure (G)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Exports (X)	1.34%	1.83%	2.32%	2.81%	3.29%	3.76%	4.21%	4.63%	5.03%	5.39%	5.71%	6.00%	6.24%	6.44%	6.61%	6.73%
Foreign Demand Shifter (Fx)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Imports (M)	1.06%	1.43%	1.80%	2.17%	2.53%	2.88%	3.21%	3.52%	3.82%	4.08%	4.32%	4.53%	4.71%	4.86%	4.98%	5.07%
Capital Stock (K)	0.77%	1.21%	1.71%	2.25%	2.81%	3.39%	3.98%	4.58%	5.17%	5.74%	6.30%	6.84%	7.34%	7.81%	8.24%	8.63%
Technical Change, Regional Average (A)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Price of Labour, Compensation (CoE)	-1.24%	-1.41%	-1.48%	-1.49%	-1.43%	-1.32%	-1.15%	-0.93%	-0.66%	-0.35%	-0.01%	0.36%	0.76%	1.17%	1.60%	2.03%
Employment (D)	-1.20%	-0.89%	-0.58%	-0.27%	0.03%	0.30%	0.55%	0.77%	0.96%	1.13%	1.26%	1.36%	1.42%	1.46%	1.47%	1.45%
Real Wage (RW)	-0.33%	-0.34%	-0.29%	-0.17%	0.02%	0.26%	0.56%	0.90%	1.29%	1.71%	2.16%	2.63%	3.11%	3.59%	4.08%	4.57%
Price of Capital (R)	-0.43%	-0.76%	-1.11%	-1.47%	-1.87%	-2.29%	-2.75%	-3.24%	-3.74%	-4.25%	-4.76%	-5.28%	-5.78%	-6.26%	-6.72%	-7.16%
Price of Investment (PI)	-3.91%	-4.69%	-5.30%	-5.83%	-6.32%	-6.78%	-7.22%	-7.62%	-8.00%	-8.34%	-8.64%	-8.90%	-9.13%	-9.31%	-9.46%	-9.56%
Consumer Price Index (CPI)	-0.91%	-1.06%	-1.19%	-1.32%	-1.45%	-1.58%	-1.70%	-1.82%	-1.93%	-2.03%	-2.12%	-2.20%	-2.28%	-2.34%	-2.39%	-2.43%
GDP Price Index (PY)	-2.82%	-3.12%	-3.37%	-3.60%	-3.82%	-4.02%	-4.21%	-4.39%	-4.55%	-4.69%	-4.80%	-4.90%	-4.98%	-5.03%	-5.06%	-5.08%
GNE Price Index (PGNE)	-2.74%	-3.00%	-3.21%	-3.41%	-3.59%	-3.76%	-3.92%	-4.07%	-4.20%	-4.31%	-4.40%	-4.48%	-4.54%	-4.58%	-4.60%	-4.61%
Terms of Trade (TofT)	-0.33%	-0.45%	-0.57%	-0.69%	-0.81%	-0.92%	-1.03%	-1.13%	-1.22%	-1.31%	-1.38%	-1.45%	-1.51%	-1.55%	-1.59%	-1.62%
Exchange Rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Number of Households (Hs)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Note: Values are indicated in cumulative percentage change, measured from the start of the simulation in 2016.

Table C2: Cumulative Growth in Regional Macro Variables, Deviation from the baseline, 2035

Regional Macros	Limpopo	North West	Mpumalanga	Gauteng	Free State	Northern Cape	Western Cape	Eastern Cape	Kwazulu-Natal
Real GDP (GDP)	6.29%	7.20%	4.22%	6.14%	4.31%	7.10%	6.06%	5.62%	6.18%
Household Consumption (C)	4.62%	4.72%	4.81%	4.87%	4.67%	4.72%	4.63%	4.76%	4.74%
Investment (I)	13.33%	14.04%	11.96%	13.49%	11.83%	14.10%	13.28%	12.89%	13.52%
Capital Stock (K)	8.58%	9.35%	7.93%	8.85%	7.84%	9.17%	8.55%	8.29%	8.78%
Real Rental Price of Capital (RoR)	3.29%	3.08%	2.95%	3.00%	3.05%	3.18%	3.30%	3.18%	3.26%
Government Expenditure (G)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Exports (X)	12.33%	12.37%	11.80%	6.33%	12.90%	13.02%	6.47%	7.03%	6.64%
Imports (M)	5.08%	5.94%	4.00%	5.33%	3.88%	6.03%	5.11%	4.69%	5.15%
Employment (D)	0.78%	1.99%	1.09%	1.65%	1.01%	1.10%	1.82%	0.31%	1.72%
Real Wage (RW)	4.19%	4.53%	4.84%	4.65%	4.64%	4.29%	4.51%	4.28%	4.61%
Price of Labour, Compensation (CoE)	1.79%	2.04%	2.25%	2.01%	2.19%	1.81%	2.12%	1.75%	2.09%
Consumer Price Index (CPI)	-2.30%	-2.38%	-2.47%	-2.53%	-2.34%	-2.38%	-2.29%	-2.42%	-2.41%
GDP Price Index (PY)	-5.81%	-5.48%	-3.90%	-5.16%	-3.79%	-6.09%	-5.22%	-5.55%	-5.21%
Technical Change, Regional Average (A)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Note: Values are indicated in cumulative percentage change away from the baseline.

Table C3: SAM- and Household Variables, Deviation from the baseline

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Gross Operating Surplus (GOS)	0%	1%	1%	1%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	1%
Enterprise Income (VENT)	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Enterprise Savings (VSAVENT)	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Government Income (GOVINC)	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%	-3%	-3%	-3%
Government Spending (GOVSPEND)	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%
Gov. Deficit (% of GDP)	0.44%	0.54%	0.47%	0.45%	0.44%	0.43%	0.41%	0.39%	0.36%	0.34%	0.31%	0.28%	0.25%	0.21%	0.18%	0.15%
RotW Savings (CAD, % of GDP)	0.00%	0.00%	0.04%	0.04%	0.04%	0.04%	0.03%	0.02%	0.02%	0.01%	0.01%	0.00%	0.00%	-0.01%	-0.01%	-0.01%

Household Disposable Income (HHDINC)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	-2.1%	-2.1%	-1.9%	-1.7%	-1.5%	-1.2%	-1.0%	-0.7%	-0.4%	-0.1%	0.1%	0.4%	0.7%	0.9%	1.2%	1.4%
2	-2.0%	-1.9%	-1.8%	-1.6%	-1.3%	-1.1%	-0.8%	-0.5%	-0.2%	0.1%	0.4%	0.6%	0.9%	1.2%	1.4%	1.7%
3	-1.9%	-1.8%	-1.6%	-1.4%	-1.1%	-0.8%	-0.5%	-0.2%	0.1%	0.4%	0.7%	1.0%	1.3%	1.6%	1.8%	2.1%
4	-1.9%	-1.8%	-1.6%	-1.3%	-1.1%	-0.8%	-0.5%	-0.2%	0.2%	0.5%	0.8%	1.1%	1.4%	1.7%	2.0%	2.3%
5	-1.9%	-1.7%	-1.6%	-1.3%	-1.0%	-0.7%	-0.4%	-0.1%	0.2%	0.6%	0.9%	1.2%	1.5%	1.8%	2.1%	2.4%
6	-1.9%	-1.8%	-1.6%	-1.3%	-1.0%	-0.7%	-0.4%	-0.1%	0.3%	0.6%	1.0%	1.3%	1.6%	2.0%	2.3%	2.5%
7	-2.0%	-1.8%	-1.6%	-1.4%	-1.1%	-0.8%	-0.5%	-0.1%	0.2%	0.6%	0.9%	1.2%	1.6%	1.9%	2.2%	2.5%
8	-1.9%	-1.7%	-1.5%	-1.3%	-1.0%	-0.7%	-0.4%	0.0%	0.3%	0.6%	1.0%	1.3%	1.6%	1.9%	2.2%	2.5%
9	-1.7%	-1.5%	-1.3%	-1.1%	-0.8%	-0.5%	-0.2%	0.1%	0.4%	0.7%	1.1%	1.4%	1.7%	1.9%	2.2%	2.4%
10	-1.7%	-1.5%	-1.3%	-1.1%	-0.8%	-0.6%	-0.3%	0.0%	0.3%	0.6%	0.9%	1.2%	1.5%	1.8%	2.0%	2.2%
11	-1.4%	-1.2%	-1.0%	-0.8%	-0.5%	-0.3%	0.0%	0.3%	0.6%	0.8%	1.1%	1.3%	1.6%	1.8%	2.0%	2.2%
12	-1.2%	-1.0%	-0.8%	-0.6%	-0.3%	-0.1%	0.2%	0.5%	0.7%	1.0%	1.2%	1.5%	1.7%	1.9%	2.1%	2.3%

Household Savings (change variable)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1	-0.02%	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%
2	-0.02%	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%
3	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%
4	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%	0.02%
5	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%	0.03%
6	-0.03%	-0.03%	-0.03%	-0.02%	-0.02%	-0.02%	-0.01%	-0.01%	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%	0.03%
7	-0.04%	-0.04%	-0.04%	-0.03%	-0.03%	-0.03%	-0.02%	-0.02%	-0.01%	-0.01%	0.00%	0.01%	0.01%	0.02%	0.02%	0.03%
8	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	-0.04%	-0.04%	-0.03%	-0.02%	-0.02%	-0.01%	0.00%	0.01%	0.02%	0.02%	0.03%
9	-0.09%	-0.09%	-0.08%	-0.08%	-0.08%	-0.07%	-0.06%	-0.05%	-0.04%	-0.03%	-0.02%	-0.01%	0.00%	0.01%	0.02%	0.03%
10	-0.07%	-0.07%	-0.07%	-0.06%	-0.06%	-0.05%	-0.05%	-0.04%	-0.03%	-0.02%	-0.02%	-0.01%	0.00%	0.01%	0.02%	0.03%
11	-0.08%	-0.08%	-0.08%	-0.08%	-0.07%	-0.06%	-0.06%	-0.05%	-0.04%	-0.03%	-0.02%	-0.01%	0.00%	0.01%	0.02%	0.03%
12	-0.07%	-0.07%	-0.06%	-0.06%	-0.05%	-0.05%	-0.04%	-0.04%	-0.03%	-0.02%	-0.01%	0.00%	0.00%	0.01%	0.02%	0.03%

Note: All values, except those expressed as a percentage of GDP, are indicated in cumulative percentage change. For consistency between these tables and those of their likeness in Section 5.2 and 5.3, where applicable, these values are quoted in nominal and not real terms.