

**SECTORAL IMPACT OF GLOBAL FINANCIAL CRISIS AND HIGH FOOD
PRICES: A COMPUTABLE GENERAL EQUILIBRIUM (CGE) ANALYSIS FOR
SOUTH AFRICAN AGRICULTURE**

by

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A dissertation submitted to the
Faculty of Health and Environmental Sciences
in partial fulfilment of the requirements for the degree

Doctor Technologiae: Agriculture

Department of Agriculture
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December 2017

DECLARATION OF OWN WORK

I, **Oluwatoba Akinsuyi FADEYI**, hereby certify that the work which I now submit on the programme of study leading to the award of **Doctor Technologiae: Agriculture** is my original work, and that it has not been previously submitted at any academic institution for any particular degree.



2017-12-01

Signature

Date

DEDICATED TO

God Almighty that remains impartial where and when mortals arbitrate with pride and prejudice.

My mother, Mrs. Abiola Olusayo Fadeyi, for her unreserved love, support and encouragement.

ACKNOWLEDGMENTS

Foremost, all thanks and praises to Almighty God for His grace and mercy.

Special thanks are due to my dissertation supervisor, Professor Carlu van der Westhuizen, for kindly sharing his knowledge and wisdom to help me develop my potential throughout this doctoral journey. I could not have asked for better guidance, support, and encouragement.

I am grateful to Dr. Moosa M. Sedibe who co-supervised my thesis. Not only did he support me throughout this process with his timely and spot-on advice, but he also helped me to overcome many obstacles I faced along this journey.

I am thankful to the National Research Foundation (NRF) in South Africa for the financial support to make this study possible. I was privileged to have received the funding to pursue my doctoral studies at Central University of Technology, Free State.

I am glad to mention my special friend, Anastasia. Thank you for your love, care and support. I would also like to mention Dr. Zaid Bello, Dr. and Mrs Matthew Achilonu and Lucky Igene for their supports throughout the journey. Finally, I continue to be amazed by the amount of unconditional care and support I have been lucky to receive from my mother and siblings. Thank you so much!

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ABSTRACT

This thesis contains studies that provide theoretical analysis and empirical evidence on the sectoral impact of the global financial crisis and high food prices on the agricultural sectors of South Africa.

The study investigates the effects of the global financial crisis on the production, employment, trade and household consumption by using the ORANI-G Model, a static single country computable general equilibrium framework. The results show that a 10% decrease in export as a result of the fall in global demand leads to a decline in GDP and return on capital, and an increase in unemployment at the macro level, while the agricultural sector suffers a decline in production output and household demand.

The study also explores the effects of the 2007/08, as well as the 2011 global high food prices on the South Africa economy. The global high food prices was simulated by imposing price shocks of a 25% increase in food prices. When the price shocks are incorporated, the result shows that there is an increase in consumer price and agricultural production, among others. However, there is a sharp decline in household demand for basic items. High and rising food prices undermine food security and threaten the livelihood of the poor. Empirical evidence supports the hypothesis that there are clear links between high food prices and lower caloric intake, lower quality diet, and an increase in malnutrition.

CHAPTER ONE

INTRODUCTION

1.1 Background

The global financial crisis and high food prices wiped out any gains toward the achievement of the Millennium Development Goals (MDGs) in most developing countries. This goal, which emphasises the eradication of poverty and hunger, was abdicated, as most developing countries now have to focus more on macroeconomic stabilisation and recovery (Ahmed 2010). The global financial crisis, which led to a global recession, started to manifest itself in international trade. The reduction in trade has several interrelated causes comprising both the price and income effects, as global financial flows readjust; real exchange rates realign; terms of trade changes; and domestic savings rise with attendant drop in demand domestically. The fall in global demand and the slowing down in economic growth translated into a substantial reduction in international trade that has affected the cross-border trade of virtually all countries and across all economic sectors (McKibbing and Stoeckel 2009).

This trend is particularly disturbing from a development perspective. International trade in most developing countries serves as an engine for growth and helps in a substantial way to fight poverty and raise the standard of living. By maintaining and increasing share of trade to generate development finance and industrialisation, trade integration has been one of the main pillars of development strategies for many developing countries. The extent to which developing countries trade performance is affected by the current economic crisis, and it is affected by their dependence on international markets, their exports composition and exchange rate fluctuations needs to be explored (Board 2015).

Furthermore, the global financial crisis hit developing countries notably through worsening terms of trade and reduced demand for exports, a decline in foreign direct investments (FDI), remittances, tourism, and also a reduction in international aid flows. The crisis caused the GDP growth in emerging and frontier markets such as South Africa to slow down more rapidly because of the relative openness of their economies. The World over, the crisis has now turned into an unemployment crisis, raising serious concerns for governments (Abdul 2010).

However, many countries were able to draw on their reserves to cushion the global shock. Despite the positive steps taken in a number of economies, it is clear that African countries do not have adequate domestic resources to fully offset the impacts of the crisis (Gelb 2010). A country such as South Africa with a small open economy, which is dependent on foreign trade and attracting foreign savings to support domestic investment, is vulnerable to the impact of the global financial crisis-induced economic slowdown (Baxter 2009).

In general, the more an economy has relied on exports to drive its economic development, the more problems it is likely to face as a result of a global economic crisis. Commodities exporting countries may encounter further difficulties, as commodities prices have plummeted (Board 2015). In recent years there has been a tremendous increase in the degree of dependence by developing countries on international trade, and thus their exposure to external markets, as measured by the exports-to-GDP ratio.

In the wake of the global financial crisis was also the high food price crisis, and this was attributed to many factors including increasing global demand for food, higher demand for biofuel and increasing fuel prices among others. This crisis could have had diverse impacts on agriculture and the poor. The agricultural sector is unquestionably critical to South Africa's economy, as it plays a significant role in food security, job creation, poverty reduction, export

revenue and rural development (Dube, Scholes, Nelson, Mason-D'Croz and Palazzo 2013). However, this sector is influenced by many factors that are often beyond its control, such as climate variation, external shocks in terms of trade, exchange rate, international pricing levels, foreign direct investments (FDI) and also the willingness of farmers to produce. The sector has experienced a negative trade balance in processed agricultural products due in part to lack of sufficient investment in the sector, which consequently had a negative impact on household consumption levels (Fadeyi, Ogundeji and Willemse 2014).

The most vulnerable sectors during the global economic crisis are labour-intensive and export-oriented industries (Claessens, Dell'Araccia, Igan, and Laeven 2010). Since the agricultural sector is regarded as a critical source of rural employment and poverty alleviation, the central question to ask is: To what extent has the global economic crisis affected the South African agriculture sector in terms of employment, production and trade, and how can the country translate international agricultural trade into poverty reduction, since not all agricultural sub-sectors have equal potential to contribute to spill-overs and economic growth? The economic literature review as documented in the second dissertation chapter did not provide sufficient evidence on the impacts of high food prices and the global financial crisis on the agricultural sector in South Africa.

1.2 Problem statement

Many developing countries have been hit hard by a series of crises during 2007 to 2009, yet analytical evidence of their sectoral impact on development and how they might have affected each country remains scarce. Prior to the global financial crisis, South Africa experienced rapid economic growth both in the agricultural and non-agricultural sectors as a result of the commodity boom. If an economy is open, like South Africa, then domestic activity is likely to

display some comovement with global activity because developments abroad transmit to South Africa, or because South Africa is affected by the same shocks that affect other countries. In part due to worsening terms of trade, low or lack of foreign direct investment, increase in unemployment levels etc. Indeed, with global demand shrinking, the prices of most commodities dropped to significantly lower levels that had never been seen in recent years. The consequences of such losses on the economy, particularly on agriculture was huge. The agricultural sector has a multiplier effect on the South African socio-economic and manufacturing framework, and it plays an important role in the development of the nation. The pass-through channels by which these external shocks and macroeconomic changes impact poverty, hunger and malnutrition will be through unemployment, reduced private capital flows, high import prices and low exports. Additionally, this economic situation is worsened by the recent drought in the country, with dire consequences on food production and trade.

1.3 Research Objectives

The main objective of this study was to decompose the high food prices and global financial crisis as external shocks and to estimate the combined impact thereof on agricultural growth, employment, and poverty in South Africa. The specific objectives of the study were:

1. to appraise the extent to which the global financial crisis affects production and trade in the South African agricultural sector;
2. to examine the impact of high food prices on production in the South African agricultural sector; and
3. to examine the impact of these both crises on local food prices, employment, household consumption, and poverty.

1.4 Methodology

1.4.1 Conceptual framework

To achieve these objectives, a computable general equilibrium (CGE) modeling framework was used. Since the study aimed to determine the impact of food price shocks and the global financial crisis on agriculture as well as households' poverty, the CGE model was used to generate the economy-wide (macro) impacts of the shocks on the agricultural sector and the distributional impact on households' poverty.

Firstly, to develop a CGE model for South Africa, a social accounting matrix (SAM) would be built to represent South Africa's economy, using 2011 as the base year for the model. Data for the SAM were collected, adjusted and balanced so that total receipts are equal to total outlays for each account. The SAM data represents the so-called benchmark general equilibrium. The CGE model is an economy-wide, multi-sectoral model that solves simultaneously and endogenously for both quantities and prices of a series of economic variables. It is a suitable tool to analyse the impact of the crisis and policy responses on South African agriculture sector and financial flows.

The CGE model explicitly models the relationship between supply and demand, which determines the equilibrium prices in domestic markets. To capture the linkages between the domestic and international markets, the model assumes price-sensitive substitution (imperfect substitution) between foreign goods and domestic production, although the linkages between demand and supply through changes in income (endogenous variable) and productivity (exogenous variable) are the most important general equilibrium interactions in an economy-wide model. Production linkages also occur across sectors through the intermediate demand and competition for primary factors employed in production.

Since the CGE model is a representation of the entire economy, the output from the model gives a complete set of market-clearing prices and quantities in the product and factor markets. Thus, almost any economic variable of interest can be compared to the baseline: GDP; employment levels by sector; aggregate consumption; exports; imports; investments and many more (Cappuis & Walmsley 2011). An explicit measure of welfare, the equivalent variation, may sometimes be calculated from the results so that the change in welfare for different simulations can be estimated.

1.4.2 Data and sources

Major data used for constructing the CGE model include the most recent Supply-Use table (SUT), Input-Output table (IO), and Social Accounting Matrix (SAM) – all from Statistics South Africa (Stats SA), while the National Accounts and balance of payments is from the South African Reserve Bank (SARB); government budget and government revenue data from National Treasury; abstract of agricultural statistics from the Department of Agriculture, Fishery and Forestry (DAFF); and the latest household budget survey from Statistics South Africa (Stats SA). Data were also sourced from World Trade Organization's (WTO) and Integrated Data Base (IDB) that contain imports by commodity and partner country.

1.5 Organisation of the study

The study consists of five chapters. The current chapter introduced the topic under investigation with the background, research problem, objectives and methodology.

Chapter 2 contains a comprehensive review of both theoretical and empirical literature on high food prices and the global financial crisis, foreign direct investments, agricultural production and trade, household consumption and also the CGE model.

Chapter 3 documents the ORANI-G theoretical specification. The first sections provide a general overview of the CGE methodology and ORANI-G Model's theoretical structure. This is intended to assist in understanding the main macroeconomic relationships and basic functioning of the model, and thereafter a stylised representation of the ORANI-G Model is discussed.

Chapter 4 contains all the modeling results and a policy analysis relevant to this study. After motivating the policy shocks, the policy simulation was conducted under different modeling scenarios. Furthermore, the impact of the global financial crisis and high food prices on the economy of the South Africa agriculture was captured in this chapter.

Chapter 5 conclude the study with findings, recommendations, and suggestions for further research in this field. While Appendix provides information supplemental to a specific section or topics in Chapter 3.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature related to the topics as discussed in each chapter of this thesis is introduced. Firstly, literature findings related to the global financial crisis are discussed. This is followed by a discussion of literature findings related to high food prices. Hereafter, literature findings on the impacts of the global financial crisis and high food prices on agriculture were highlighted. Lastly, literature reviews on the Computable General Equilibrium (CGE) Model for analysing impacts of a shock on an economy, as well as literature reviews related to the ORANI-G Model, were discussed.

2.2 Global financial and economic crisis

A large amount of literature was found that discuss the global financial crisis, which has resulted in a significant downturn in the global economy. The World economy is currently facing a severe crisis that spilled from the financial sector to the real economy, including international trade in manufactures, commodities, and services. Although there have recently been signs that the worst of the crisis may be over, the global economy still remains fragile, with much uncertainty remaining (WTO 2009a; IMF 2016).

The onset of the present crisis can be traced back to July 2007 with the liquidity crisis, due to the loss of confidence in the mortgage credit markets in the United States (Board 2015). The financial crisis quickly spread to Europe and developing countries; hence the crisis turned into

a global recession by the end of 2008 (Brinkman, De Pee, Subran and Bloem 2010). The sheer size of the US financial market and its central role as investment destination contributed to the spreading of the crisis, therefore any shock to the financial market and economy of the U.S. will have a global effect (Claessens, Dell’Ariccia, Igan and Laeven 2010).

Global financial crises portray a contagious characteristic, as they tend to spread quickly in their effects from the initial epicenters. This crisis, which originated from the subprime mortgage lending problems in the United States, led to major negative effects on global economic performance, trade, private capital flows and employment, among others. This crisis is claimed to be different from earlier ones for several reasons. For example, it originated from a country which has a highly flexible exchange rate, unlike most of the previous crises which originated from some emerging economies with sticky exchange rate regimes (Kazi 2014).

According to Shahrokhi (2011), the financial sector is at the front and centre of the tragedy; the real sector, manufacturing and trade, plays a backstage role. The financial sector’s indefensible recklessness, given free rein by mindless deregulation, was the obvious precipitating factor for the crisis (Stiglitz 2011 a, b; Campello, Graham & Harvey 2010). Deregulation of the financial sector in the developed economies started in the early 1980s and resulted in various complicated and widely used financial innovations that attempted to reduce individual investors’ risks, but in hindsight, it actually increased systemic risks (Lin and Martin 2010). Regrettably, weaknesses in financial regulations in many developed economies interacted with innovations such as securitised lending to create serious financial sector vulnerabilities (Lin and Martin 2010).

The crisis can be seen as being driven by the reversal of the three positive shocks that developing countries experienced during the recent boom, namely: rapid growth of

remittances, capital flows and international trade (Griffith-Jones and Ocampo 2009). By 2009, economies around the World had slowed as credit tightened and international trade declined. The crisis also spread quickly Worldwide due to modern communications and financial markets integration. This created uncertainties, which was part of the cause for a slowing or even freezing of some credit and derivative markets (Herbst and Wu 2009).

What was surprising is that, though the crisis originated from the advanced economies, the contraction in emerging market economies was huge. Two main channels, known as the pass-through channels by which the global financial crisis spilled over to emerging market economies are the financial channel (decline in financing conditions) and the trade channel (decreased demand for exports) (Coulibaly, Sapriza and Zlate 2013). It became clearer that sharply shrinking global trade, foreign direct investments, remittances, and tourism receipts would make a quick recovery elusive in most developing countries (Shahrokhi 2011).

The crisis resulted in net capital flows to the developing countries sinking sharply. According to the World Bank, capital flows to the developing countries sank to USD 727 billion in 2008 from USD 1,160 billion in the previous year, which is a 37 per cent decrease (World Bank 2010). The heavy toll taken by the financial crisis on trade and global economic performance has contributed significantly to the depreciation of currencies experienced by developing countries, including Sub-Saharan Africa countries. This, in turn, has affected agricultural markets significantly (von Braun 2008a). The financial crisis and global recession have contributed not only to lower incomes and reduced import demands but also increased the domestic prices as a consequence of depreciating currencies, job losses and other debilitating effects (Abbott and De Battisti 2009).

For exporters of goods and services, the main channel of transmission of the crisis is through a decline in trade volumes, while exporters of primary goods have been more affected by declining prices. The exchange rates of several large emerging market economies, including South Africa, depreciated by about 40 per cent in nominal effective terms during 2010 to 2015. The increased connections and simultaneous build-up of systemic risks across many countries made the management of shocks more complex, especially looking at the institutional deficiencies of many countries, plus the inability of large cross-border financial institutions to resolve such risks timeously (Claessens *et al.* 2010).

According to Tatiana-Didier (2012), capital flows are also a cause of crisis penetration. Globalisation and securitisation made global financial systems more interconnected, but also opaque, increasing moral hazard. Reinhart (2009) analysed the correlation between abnormally large capital inflows (capital flow “windfall”) and higher risk of the financial crisis in a number of countries. Due to the relatively smaller financial markets of developing countries, swings in investors’ sentiments can play a significant role in the transmission of a crisis. New appealing markets for investors attract large inflows of capital, which may result in the appreciation of currency, surging assets, and commodities prices.

2.3 Global high food prices

The World experienced a dramatic increase in food prices to crisis levels, but these have recently started to stabilize. In nearly three decades, nominal as well as real international prices of all major food commodities reached their peak during the first half of 2008 (Salami, Kamara and Brixiova 2010). While the food market situation may differ from country to country, the future progression of food prices remains unclear, with some predictions suggesting a permanent shift to higher levels, while others reckon that it is merely a temporary market disturbance that will soon revert to the long-term trends in food prices.

The real international prices of food commodities reached levels that have not been witnessed before in 2008. The FAO real food price index surpassed the 150 mark - the result of a sharp increase in 2006-07 - followed by and even steeper increment in the first part of 2008, and also in 2011 (FAO 2013). These sharp increases led to social and political instability in a number of developing countries, and prices are expected to continue above the pre-2004 trend level for the foreseeable future (OECD-FAO 2008).

According to the FAO (2008), the soaring food prices have triggered World-wide concern about threats to global food security, shaking the complacency created by many years of low commodity prices. In June 2008, representatives of 180 countries, including many heads of state, met in Rome to express their conviction “that the international community needs to take urgent and coordinated action to combat the negative impacts of soaring food prices on the World’s most vulnerable countries and population” (FAO 2008).

Agricultural commodity price increases were delayed but climbed spectacularly over the last few years to attain historically high peaks around mid-2008. Looking closely at the sequencing of the commodity boom, the agricultural price rise lagged behind crude oil or fertilizer price increases (Abbott and De Battisti 2009). Exasperating factors occurred at the time when commodity prices were booming, including the crude oil-corn price connection, rising input costs and biofuels demand, bad weather events (droughts and flood) and destructive policy responses to high food prices (Abbott and De Battisti 2009).

The drop in international commodity prices, together with the simultaneous financial crisis and the current global economic recession, could have momentarily diverted attention from the previous episode of the food price boom (Abbott and De Battisti 2009). The Food and Agricultural Organization (FAO) cereal price index tripled between 2000 and its peak in 2008.

The rise in food prices led to a decrease in both quality and quantity of food consumed among vulnerable households who spend a large share of their income on food (Brinkman *et al.* 2010). This extreme food price volatility brought havoc to World food markets and pushed millions into a situation of food insecurity (Clapp and Helleiner 2015). The crisis also led to macroeconomic instability (Salami *et al.* 2010), increasing poverty and hunger levels in many African countries.

The steep increases in agricultural commodity prices followed somewhat later than the general commodity boom. Wheat was the first grain to peak, achieving a 200 per cent price increase between 2002 and March 2008. The most impressive boom, however, was experienced by rice. An increase in the price of rice started in 2004 from very low levels and accelerated in late 2007 to reach 430 per cent of its 2002 value in April 2008. Maize prices peaked somewhat later in June, followed by sorghum and soybeans (Brinkman *et al.* 2010).

The underlying rising global demand, pulled by population and economic growth, notably in developing countries, put pressure on food and feed supply; depleted stocks; resulted in a decline in research and development in agriculture; slowed yield growth, and caused macroeconomic imbalances; financial speculation; climate change (droughts, floods etc.) and export restrictions. These are some of the reasons for the high food prices (Abbott and De Battisti 2009; Headey 2011). Disturbing supply tightness, low investments in agriculture as well as low prices contributed to the decline in agricultural productivity growth, and the resulting low stockpiles made markets more inelastic, exacerbating the effects of quantity shocks (Anderson and Nelgen 2012). Few, if any, observers have emphasised trade shocks as “the great uncertainty” underlying the most recent volatility in food prices (Headey 2011).

However, the global economic recession, coupled with slowing income growth, an appreciating dollar, and the crude oil price decline, have suddenly brought World food prices down. These forces that brought this rapid decline in prices are the same as those identified as principal causes behind the earlier surge in prices. In developing countries, depreciating exchange rates have helped to keep prices relatively high for longer (OECD and FAO, 2009; USDA, 2009; World Bank, 2009; Abbott and De Battisti 2009). A factor such as biofuel production is likely to continue to promote persistent greater demand for grains and oilseeds, and worldwide growth in demand for food commodities will certainly remain high once global economies recover. Thus, factors that lead to the expectation of continued high food prices – energy prices, Worldwide demand, and exchange rates – are critically dependent on the extent and trajectory of the global recession (Abbott and De Battisti 2009).

The price of oil has been driven by long-run demand and supply factors. Short-run overshooting forces are also estimated to have substantially increased the cost of agricultural production and trade, even beyond their impacts on the demand for biofuels. On the supply side, authors such as Timmer (2010); Abbott and De Battisti (2009); and Piesse and Thirtle (2009) have all argued that the long period of low real food prices in the 1980s and 1990s led to under-investment in agricultural production. Consistent with this hypothesis, it was observed that the global food demand outstripped production for a number of years prior to the high food prices (Headey 2011).

More than 80 per cent of the population in most developing countries live on less than US\$10 per capita per day. High food prices are therefore likely to affect the majority of the population in developing countries (Banerjee and Duflo 2008). Populations, who spend a large share of their income on food, buy more food than they sell (net buyers), and have few coping strategies at their disposal, are the most vulnerable groups to high food prices. These groups include the

rural poor, urban poor, rural landless, pastoralists, and many small-scale farmers. The middle income class are also at risk in most developing countries (Brinkman *et al.* 2010).

The high food prices and the global financial crisis reduced the level of food security through a combination of high food prices, high input prices, lack of credit access, international financial aid reduction, and government transfers to agriculture, loss of employment or reduction in wages and income (Kadlečíková, Kapsdorferová, Filo and Malejčíková 2012). Understanding the causes of the high food prices and assessing the impacts on South Africa are keys to analysing the adequacy and efficiency of the observed government responses, as well as suggesting policy options for the future. There remain some uncertainties aggravated by the persistent global economic recession.

2.4 Impacts of the global financial crisis and high food prices

While the media's attention is on the global financial crisis (which predominantly affects the wealthy and middle classes), the effects of the global high food prices (which predominantly affects the poorer and working classes) seems to have fallen off the radar. These two are in fact inter-related issues. Both have their causes rooted in the fundamental problems associated with a neoliberal, one-size-fits-all economic agenda imposed on virtually the entire World. Claessens, Ghosh & Mihet (2013) found that, in comparison to developed countries, there was greater concurrence of financial crises and recessions in emerging markets relative to advanced economies, and the decline of output was greater.

One of the most striking features of the financial crisis of 2008 was the collapse in international trade. The decline in World exports was much greater than the decline in World GDP. Between

the first quarter of 2008 and the first quarter of 2009, the real value of GDP fell 4.6 percent, while exports plunged 17 percent. Interestingly, the decline in exports was much larger than what many macro-economic models of trade would have predicted based on changes in supply, demand, and relative prices (Chinn (2009); Campbell, Lobell, Genova, and Field (2008); Levchenko, Lewis, and Tesar (2009); and OECD (2009)).

The impacts of the global financial crisis and high food prices include but not limited to the following: i) falling exports of minerals and other natural resources due to shrinking global demand, leading to loss of export revenues and foreign exchange; ii) Loss of jobs due to retrenchment in the agriculture and extractive resource sectors; iii) Widening fiscal deficit; iv) Declining investment putting at risk socio-economic infrastructural projects (N'zue, 2010). According to Ngowi (2010) the actual extent of impacts of the crisis will depend on a number of issues. The issues include but are not limited to the degree to which a particular country (in this instant South Africa) is integrated into the dynamics of global investment flows, expanded trade, information technology (IT) and vibrant financial security measures. It will also depend on the extent to which a country is marginalized from the dynamic processes above (Ngowi, 2010).

Looking closely at the agriculture sector, both small- and large-scale farmers have been affected by the global financial and economic crisis. However, smallholder farmers are less directly affected, since they are less integrated into the World financial markets, and thus less exposed to the losses in the equity and financial markets than the large-scale farmers. At the same time, the large-scale farmers have a greater capacity to absorb the shocks, because they have more diversified asset holdings (Salami *et al.* 2010). Other causes of changes to the agro-food sector were limited credit availability and consequent liquidity problem; high

foreign exchange rates; increasing price volatility and decrease in consumer income and remittances (Institute for Agriculture and Trade Policy 2009).

The financial crises can be argued to have particularly large effects on output. Reinhart and Rogoff (2014), for instance, found that financial crises are associated with larger output losses and slower recoveries than ordinary conventional economic downturns. One should also consider that a substantial amount of welfare loss came through the increase in food prices even before the global financial crisis. Adding context to the global economic crisis is the fact that the overall South African unemployment rate has been consistently above 25 per cent. Although the contribution of primary agriculture to GDP is limited, adding food manufacturing as well as food retailing enables this contribution to be much more significant. Its contribution to South Africa's total exports is approximately 13 per cent (DAFF 2010).

Reduced investment in agriculture, reduction in demand for agricultural products and increase in public intervention that could lead to a partial reversal of reforms in agriculture are the three factors identified by Kadlečíková *et al.* (2012) to be responsible for the negative impact of the financial crisis on the agricultural sector. The financial crisis led to the drop or fluctuation in the inflow of foreign direct investment. Kadlečíková *et al.* (2012) argue that global financial crisis may lead to a decrease in domestic demand for higher value agricultural products, and a switch to basic products due to a decrease in households' disposable income.

Estimates from the Food and Agriculture Organization of the United Nations (FAO) show that the number of undernourished people increased from 848 million to 963 million between 2003 to 2005, and 2008, largely owing to the food price crisis (FAO 2008). Food price hikes have also exacerbated micronutrient deficiencies, with negative consequences for nutrition and

health, such as impaired cognitive development, lower resistance to disease, and increased risks during childbirth for both mothers and children (von Braun 2008a).

For a small open economy such as South Africa, which is dependent on foreign trade and attracting foreign savings to prop up domestic investment, the country will not be immune to the impact of the global financial crisis-induced economic slowdown. Slower economic growth and recessions in key export markets, combined with lower commodity prices and a slowdown in capital flows to developing countries, will impact on the South African economy (Baxter 2009).

South Africa, the largest economy in Africa, has been engulfed by the global financial crisis. For example, the global economic slowdown has contributed to lower demand and falling prices of South African exports. In the midst of the crisis, the monetary authority employed a restrictive monetary policy that further raised the lending rate, thereby reducing private consumption and investment. The South African economic downturn has spread to other countries in the Southern Africa region (UNCTAD 2009; Kalula 2012; Gurtner 2010).

The impact of the financial crisis on South Africa is manifold. There are direct as well as indirect effects. The impact also varies from one sector of the economy to another. Although at the onset, many thought that the global financial crisis would not have any bearing on South Africa given the negligible connectivity of its markets to the World economy, empirical evidence has now shown that those who made these initial statements were wrong (N'zue 2008). The global financial crisis did indeed have a negative impact on the South African economy. In 2009 the recession began widely in South Africa. Key drivers of development, namely trade, investment, the mining and manufacturing sector were impacted by the global financial crisis, and it is

estimated that it had caused the South African economy to drop by 2 per cent (Assubuji and Luckscheriter 2010).

The crisis did affect South Africa principally through financial flows and trade. On account of the crisis, there was a sharp fall in the demand for goods and services from the developing and emerging countries. Sinking prices and export volumes led to a collapse in export income (UNCTAD 2009). The financial crisis has also amplified the impacts of the high food prices. Indeed, the depreciation of the national Rand against major reserves currencies raised the cost of food imports, and this is harder on the economy. Over the past year, the Rand has depreciated by 30 per cent against the US dollar (The National Treasury of South Africa 2016).

South Africa's growth continued to slow down, recording only 1.5 per cent - the weakest performance since the global financial crisis. The weakness of South Africa's economy has been exposed by the prolonged global economic slump. The projected GDP growth went down 0.9 per cent in 2016. Low commodity prices, heightened financial market volatility, and diminished consumer and business confidence weighed on the economic outlook (The National Treasury of South Africa 2016). When the tempest hit, South Africa was sitting on relatively strong fundamentals and has emerged from a protracted period of economic expansion. The global economic crisis has allowed "not-so-well-hidden" vulnerabilities in South Africa to become apparent.

Unemployment, inequality, poverty, crime, and HIV/AIDS were on the increase in South Africa as the country continue to feel the impact of the financial crisis (Verick 2012). Agriculture, mining, and manufacturing have declined, while the trade and current account deficit (CAD) widened. The negative terms of trade shock to commodity exporters will continue to broaden

their current account deficit, although it will be done at a slower pace. This will exercise constraint on their external accounts. In years ahead, the impact of the crisis on the real economy will remain the key issue. The lower global demand will hurt South Africa's export sector, and the falling Rand is not expected to significantly counter the decline (Zini 2008; The National Treasury of South Africa 2016).

The financial sector in South Africa experienced a collapse of asset prices, dramatic increases in the cost of capital, and a severe contraction in lending. This led to sharp downturns in the retail and manufacturing sectors. Between May 2008 and March 2009, South Africa's JALSH index fell by about 46%. Manufacturing production slowed down, the mining sector shrank further, and retrenchments are on the increase. Growth is expected to slow down, which is a risky proposition for South Africa, and for Africa as a whole (N'zue 2008; Taylor 2009).

It can be argued that, the higher the proportion of exports in the gross domestic product (GDP) of a country, the harder the impact of decreasing demand during a crisis. South Africa - as one of the BRICS members (Brazil, Russia, India, China and South Africa) - is well integrated into the global economy. African countries suffer and will continue to suffer more from the financial crisis and its aftershocks than other countries of the World. This is a serious problem for the continent's economies, as argued by many scholars, due to the fact that African countries are not only ill-prepared to resist the external shock, but they also do not have the resources (financial as well as human) to bail out troubled industries, and, even if they did, such actions cannot be sustained if the crisis was to last longer than expected (N'zue 2008).

Many have argued that the crisis, with its resulting credit crunch - especially for micro, small and medium-sized businesses - could lead to the drying up of credit for smallholder farmers,

and thus limit their means to purchase production inputs such as fertilizers, chemicals, and seeds, resulting in greater food shortages. The smallholder farmers thus suffer from second-round effect of the global economic crisis (Salami *et al.* 2010). The World has been forced to rethink its agriculture development approaches, including the role of subsidies to smallholder farmers. This recent development could revitalise agriculture in general, and smallholder farming in particular, for South Africa.

One of the resultant effects of the financial crisis has been a decline in domestic demand in South Africa. This, in turn, has reduced income and inhibited efforts for job creation, thereby endangering prospects for sustainable growth (N'zue 2008; Balchin 2010). A significant reduction in growth will reverse the modest gains made over the past years, which will worsen the poverty situation. It is critical that actions are taken to mitigate the impacts of the financial crisis on the South African economy.

Access to foreign capital contributes to a country's ability to increase future income streams and productive capacity by undertaking investments of which the prospective returns exceed the cost of finance, and therefore leads to smooth consumption over time. Before the global economic meltdown, South Africa has increasingly become reliant on international capital flows to sustain the internal capital investment drive. Moreover, before the crisis, Foreign Direct Investment (FDI) contributed 36 per cent of the total net inflows to South Africa (Reserve Bank SA 2009).

The country recorded its highest annual attraction of FDI in 2008, and this is just when the World was entering a period of significant economic crisis. There has been a significant decline in the FDI contribution (from 36 per cent to 16 per cent) during this crisis period (Beer 2015).

The author argued that, despite having a high potential to attract FDI, South Africa has fared relatively poorly in attracting FDI.

The perceptions of risk associated with lending or investing in South Africa have increased. Deterioration in the credit-rating outlook towards the end of 2015 was followed by changes in the finance portfolio, catching investors off guard and raising concerns about fiscal probity. Business confidence is now at its lowest point since the 2009 global recession. This was reflected in slowing private investment. Consumer confidence is also at historically low levels, and the demand for durable goods has subdued (The National Treasury of South Africa 2016).

Developments in the Rand foreign exchange market since the financial crisis have also increased the focus on cross-border capital flows and the implications it has for the country's ability to deal with surges and reversals in cross-border capital flows. The developments in the Rand reflected both domestic as well as international developments (Gruss 2014). As credit was restricted globally and trade volumes collapsed around the World, the value of real exports of goods and services from South Africa fell by 19.5 percent in 2009 (Stats SA 2013).

For many economies, including South Africa, the decline in trade triggered the actual recession, as it led to sharp contractions in output and labour retrenchment. South Africa's quarter on quarter annualised growth in gross domestic product contracted by 1.7 per cent in the fourth quarter of 2008, falling to -6.3 and -2.8 per cent in the first and second quarters of 2009 respectively. The economy's real GDP growth rate was -1.5 per cent in 2009, and 2.9 per cent in 2010 (Kganyago 2012).

According to Beer (2015), South Africa's exchange rate regime is very flexible. Since the sharp depreciation that accompanied the financial crisis, the Rand initially strengthened by 45 per cent against the US dollar between October 2008 and April 2011, and with 34 per cent against a trade-weighted basket of currencies. However, from April 2011 the Rand has experienced sharp periods of depreciation with only momentary appreciation, on average depreciating by 44 per cent between April 2011 and May 2015 (35 per cent against a trade-weighted basket of currencies).

During the global boom years of 2002 to 2007, unemployment figures in South Africa began to finally improve, as economic conditions improved. In this respect, the unemployment rate in 2007 stood at 25 per cent but reached a low of 21.9 per cent in the third quarter of 2008, coming from 31.2 per cent in 2003. Owing to South Africa's strong trade and financials links, the country was hit hard by the global financial crisis, which came on top of the longer term structural problems in its economy and labour market (Verick 2012).

Consequently, the country fell into a recession in the fourth quarter of 2008 and contracted by 1.7 per cent in 2009. This severe slump was largely driven by a contraction in the manufacturing sector, along with a fall in output in the mining, financial, real estate and business services, and wholesale and retail trade sectors (Stats SA 2015, Reserve Bank SA 2009). The South African government recognised the severity of the downturn and responded with a fiscal stimulus package that aimed to support demand and create jobs, while the South African Reserve Bank loosened monetary policy (Mboweni 2009).

It is generally assumed that the urban informal sector absorbs workers who are unable to find a job in the formal sector. This sector is increasingly viewed as consisting of both survivalists

and entrepreneurs who chose to operate informally. However, during an economic downturn, particularly one that is driven by an external shock, it is generally expected that employment in a developing country will fall in the formal sector, accompanied by a rise in employment in the informal sector (Fallon and Lucas 2002).

Contrary to this established fact, informal sector employment in South Africa fell during the recession of 2008 to 2009. The share of informal sector employment declined from 17 per cent in the first quarter of 2008, to 15.5 per cent in the third quarter of 2009. From 2008 to 2009, annual employment losses in this sector accounted for 36.1 per cent of the fall in employment (despite its share being below 20 per cent), compared to 37.3 per cent for the formal sector. However, this has since reversed: from 2009 to 2010, 64.2 per cent of the fall in total employment was due to losses in the formal sector. All in all, informal sector employment declined by 14 per cent from the first quarter of 2008 to the third quarter of 2009, while formal sector employment fell by 5.3 per cent from the first quarter in 2008 to the second quarter in 2010. During 2010, employment in the informal sector recovered much more rapidly than in the formal sector (Stat SA 2013).

According to Verick (2012), the impact of the global recession on labour market status in South Africa was multifaceted, and in some respects unexpected. Overall, the number of South Africans employed decreased from 13.7 million in 2008 to 12.9 million in 2010 (a drop of 5.8 per cent), which was driven by employment losses in the manufacturing, wholesale and retail trade and construction sectors. This dramatic fall in employment represents a partial destruction of the gains made during the 2000s, when total employment grew by 3.8 million, from 10.9 million in 2001 to 13.7 million in 2008. Already among the lowest in the World, the employment: population ratio in South Africa subsequently dropped from 44.6 per cent in 2008

to 40.7 per cent in 2010. The fall in employment during the recession translated to a larger increase in discouragement, and hence the broad unemployment rate.

There was the sustained rise in global food prices, which generated strong upward pressure on domestic food prices, and eventually the overall price level. Inflation rose strongly, peaking at 11.1 per cent in September 2008. The rise in inflation and subsequent monetary policy response sharply worsened the financial conditions of South African households and industries and increased their levels of indebtedness in the period prior to 2007. The various positive factors of the 2003 to 2007 period resulted in a sharp rise in indebtedness which could not be sustained, as growth and income in the economy slowed down, and inflation increased. South African households' indebtedness increased from 54.5 per cent of disposable income in 2003, to 82.3 per cent by 2008 (Kganyago 2012).

To lessen the impacts of the global financial crisis, South African government prepared a stimulus package of R690 billion injected into public projects over three years, to encourage and sustain public sector employment programmes. Government also supports the financing of industries and gives incentives in order to bring back to life distressed companies. South African government further gave a tax relief of R13.6 billion in an effort to reduce the impact of the crisis, particularly on the middle and lower income earners (Mboweni 2009).

2.5 Computable General Equilibrium (CGE) model

CGE modeling is an empirical approach of general equilibrium analysis. Since 1960, it has progressively replaced input-output modeling and economy-wide econometric modeling. In the 1990s, CGE modeling became the dominant economy-wide framework for policy analysis,

with much literature developed concerning various aspects and applications of CGE modeling (Dixon 2006; Dixon and Jorgenson 2013). CGE modeling was described by Dixon, Parmenter, Powell, and Wilcoxon (1992) as an integration of a general equilibrium theoretical structure, data about the economy of interest, and solution methods to solve the models numerically.

Dervis, Melo and Robinson (1982) identified CGE models as those that “postulate neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a Walrasian general equilibrium model that endogenously determines quantities and prices”. Shoven and Whalley (1992), on the other hand, defined CGE modeling as a conversion of the Walrasian general equilibrium structure into realistic models of actual economies by specifying production and demand parameters and incorporating data reflective of real economies.

The CGE model is one of the most rigorous, cutting-edge quantitative methods to evaluate the impact of economic and policy shocks, mostly policy reforms, in the economy as a whole. Because of its nature, this tool is significantly useful for policy design. Over the past two and a half decades, CGE models have become a standard tool of empirical economic analysis. The recent improvements in model specification, data availability and computer technology have improved the payoffs and reduced the costs of analysis based on CGE models, paving the way for their widespread use by policy analysts throughout the World (Lofgren, Harris, Robinson, Thomas and El-Said 2001).

CGE models are aggregate representations of the economy and are based on the flow equilibrium in product and factor markets in real as well as in nominal terms. According to Menezes, Fortuna, Silva and Veira (2006), general equilibrium models explicitly model all key

aspects of a given economy, in contrast with partial equilibrium models, which only focus on given important aspects of the economy. A CGE model has fundamental macroeconomic general equilibrium association among different income groups, form of demand, the balance of payments and a multisector production structure. The model combine sets of behavioural equations describing the optimising economic behaviour of the agents identified in the model and the technological, endowment and institutional constraints that these agents encountered (Menezes *et al.* 2006).

Literature is replete with the impact of crises that had been studied using various quantitative techniques. The CGE models and other macroeconomic methods have been used extensively to study the impact of price shocks, supply constraints and economic crises (Robilliard, Bourguignon and Robinson 2001; Bourguignon, Robilliard and Robinson 2003; Weeks 2009). As an example, on structural foundation of the 1994 Turkish financial crisis, Yeldan (1998) used the CGE Model to analyse the crisis.

To access the impacts of the Indonesia's financial crisis in 1997, Robilliard *et al.* (2001) and Bourguignon *et al.* (2003) also applied the GGE Model. For assessing global CGE Model validity using agricultural price volatility, Valenzuela *et.al* (2007) used the CGE model for this purpose too. Robilliard *et al.* (2001) in using a CGE model simulate the impact of Indonesia's financial crisis of 1997 through real devaluation, foreign and domestic credit crunch. Their results indicate a decline in the wages for skilled and unskilled labour of around 24 and 21 percent respectively. Poverty and Inequality increase by 93 and 5.5 percent respectively. Block *et al.* (2004) using CGE model in discussing the impact of Indonesia's financial crisis of 1997 on child nutrition explain that despite a rise in food prices which significantly altered the nutrition profile, the child weight-for-age remained constant throughout the crisis.

Lokshin and Ravallion (2002) studied the welfare impacts of the 1998 financial crisis in Russia and the response of the public safety net using the CGE model. They found that there was a general deterioration in the welfare levels during the crisis period with expenditures contracting more than incomes as the households expected worse times ahead. Friedman and Levinsohn (2001) using the CGE model show that during the Indonesian financial crisis the distributional consequences remain the same whether we allow the households to substitute towards relatively cheaper goods or not. While every household was adversely impacted by the crisis, the urban poor faced the worst consequences.

Based on a robust and widely accepted modeling, CGE models are able to provide a detailed description of the impact of shocks on the economy. A number of robust and well-identified mechanisms are quantified in a single, rigorous and consistent framework. Such analysis makes it possible to put forward the main mechanisms, to give their sign and their order of magnitude (Decreux, Guérin, and Jean 2002). We can also argue that CGE models possess a rigorous structure derived from sound microeconomic optimisation theory. This feature leads to results with a clear structural or theoretical interpretation (Rege 2003).

CGE models have been used in areas as diverse as fiscal, development planning, and social policy. The models have also contributed to policy debates on structural adjustment, international trade, public finance, agriculture, energy and environmental issues. This widespread use is not only due to rapid development in computing technology, but also to the fact that general equilibrium models offer the possibility to study differential impacts across sectors of production and across socioeconomic groups, and the opportunity to account for interaction among different sectors and economic agents (Devarajan and Sherman 2002; Essama-Nssah 2006).

CGE models are the best choice if the economic or policy shock to be evaluated is expected to have significant impacts throughout the economy. Moreover, CGE models are the best option if the research question involves analysing the static/dynamic, direct/indirect and short/long term effects caused by a shock. Thus, because of its nature, CGE analysis performs well when evaluating, among others trade policy, climate change shocks, and shocks in international prices (Menezes 2006). One of the main reasons for the growth in the application of the CGE models has been the success in software development and prototyping. Today CGE models do not impose huge computational/software related costs. They have been programmed using packages such as General Algebraic Modelling Software also called GAMS (Lofgren et al. 2002, Keyzer 1997 and Hosoe et al. 2004), General Equilibrium Modelling Package also called GEMPACK (Harrison et al. 1994, Codsì et al. 1988) and E-Views (Essama-Nssah 2004)

The strengths of the CGE Model explained above have also revealed some of its weaknesses. Although CGE models have raised the level of sophistication of the policy debate, they are also subject to criticism on many counts. The criticism of the model is mainly directed towards their functional and numerical structures (Iqbal and Siddiqui 2001). The quality of the CGE Model is heavily dependent on the quality of the data of chosen benchmark period (Greenaway, Leybourne, Reed, & Whalley 1993).

CGE models require data in order to produce quantitative results. The initial database of a CGE Model is vital, because, firstly, it contains information regarding the structure of the economy to be modeled in the base year; secondly, it is a critical aid in the interpretation of results, and thirdly, in a Johansen-style CGE Model, it is the initial solution to the CGE Model. The structure of a typical CGE Model database is built upon a country's input-output data for a given year. The theory of the model is then essentially a set of equations that describe how

the cells of the input-output database move through time and move in response to given policy shocks (Roos, Adams, and Van Heerden 2014).

Some parameters are taken from empirical studies, some are chosen arbitrarily, and some are calibrated, in the sense that they are picked in a way that forces the model to replicate the data of a chosen benchmark year. This calibration in the CGE Model is common to any calibration exercise, and it generates a lot of criticism. The formal way of testing for validity of the parameters calibrated is not certain since by construction they guarantee that the CGE model replicates the benchmark data. Calibrating a CGE Model to a given benchmark year may be problematic, as the benchmark year may not accurately represent the natural state of the economy, or it may not provide sufficient data (Menezes *et al.* 2006).

In recent years, economy-wide policy analysis in South Africa has seen a considerable increase in the use of computable general equilibrium models. Numerous of these models have contributed to the local policy-making process. Gelb, Gidson, Taylor, and Seventer (1993) developed a dynamic one-sector computable general equilibrium (CGE) Model for the South African economy, based on an aggregate Social Accounting Matrix (SAM) for the year 1990. The CGE Model was used to evaluate the impact of a negative external shock to the South African economy, as well as a programme of government incentives.

2.6 ORANI-G Model

ORANI is an applied general equilibrium (AGE) Model of the Australian economy. It was first developed in the late 1970s as part of the government-sponsored IMPACT project. ORANI-G and other Centre of Policy Studies (CoPS) style CGE models can be readily identified as

belonging to the Johansen class of multi-sectoral CGE models (Dixon, Koopman and Rimmer 2013; Dixon, Parmenter, Sutton and Vincent 1982). Initial versions of ORANI were static, with applications confined to comparative-static analysis. ORANI-G, which is a generic version of ORANI, resembles the original ORANI specification and is designed both as an introduction to the ORANI methodology and as a launching pad for developing new models. Indeed, it has already served as the basis for models for South Africa, Indonesia, South Korea, Thailand, the Philippines, Pakistan, Denmark and China (Horridge 2003).

ORANI-G has received considerable recognition from modelers around the World since the database and model structure are comparatively simply tailored to a set of published input-output accounts. Therefore, national economy models employing the ORANI-G template have been developed for over 30 countries around the World (Philippidis and Sanjuan Lopez 2009). Independence, full documentation, and involvement of the policy clientele were the conditions under which ORANI was developed. A number of innovations such as flexible closures; multi-product industries and multi-industry products; the CRESH and CRETH substitution possibilities; specifications of technical change and indirect taxes associated with every input-output flow; explicit modeling of transport, wholesale and retail margins; and a regional dimension were introduced by ORANI (Dixon and Rimmer 2010).

ORANI model has been used for many purposes. It was primarily built to analyse the impacts of high tariffs, identifying the losers from protection and quantifying their losses. The Model showed how high tariffs caused high costs in Australia and confirmed that cutting tariffs from the high levels in the 1970s would produce overall benefits for Australia. ORANI simulations showed that cutting tariffs would increase average wage rates - and hence, living standard - while not harming aggregate employment. It would also stimulate export activity (Dixon,

Parmenter, Ryland and Sutton 1977). The model theory described how the theory of joint maximisation forms a basis for ORANI's computational technique (Dixon 1978).

The ORANI-G Model has been used for numerous analyses and simulations such as the effects of mineral discoveries, major infrastructure projects, new technologies, mining booms and busts, and the impacts of various government policy changes in policy instruments such as import tariffs, other tax rates, public spending, interest rates, microeconomic and labour market reform, as well as other environmental and legal regulations on the Australian economy (Lkhanaajav 2016).

Like all models, CGE models are limited by the data they use. This applies both to the quality of the data and the availability of the data. Largely, a CGE Model needs values or quantities and prices of all goods, services, factors of production, and any other variables for the initial (unchanged) state of the economy; as well as elasticities describing how they respond to a change. These are used to calculate the remaining parameters, check the model design, and for comparing with the post-change results. Elasticities are usually parameters in a CGE Model; the results of the Model are the changes in prices and quantities and their effects on macro variables such as GDP. Data limitations are the main constraint on the number of sectors and the level of detail a CGE Model can attain (King 2012).

2.7 Concluding Remark

In this chapter, we discussed relevant literature that were reviewed the on various aspects of the study. The chapter opened by reviewing literature on global financial crisis. There we explained the source and causes of the global financial crisis. The crisis which emanated from

the subprime mortgage lending problems in the United States led to major negative effects on global economic performance, trade, private capital flows and employment, among others. Two main channels were identified as the transmission channel; the financial channel and trade channel. This chapter also review literature on global high food prices. The real international prices of food commodities reached levels that have not been witnessed before in 2008. The FAO real food price index surpassed the 150 mark - the result of a sharp increase in 2006-07. According to the FAO (2008), the soaring food prices have triggered World-wide concern about threats to global food security. The rise in food prices led to a decrease in both quality and quantity of food consumed among vulnerable households who spend a large share of their income on food.

This chapter also discussed the review of relevant literature on the model that was used for the study. The CGE model is one of the most rigorous, cutting-edge quantitative methods to evaluate the impact of economic and policy shocks, mostly policy reforms, in the economy as a whole. Various studies had employed CGE models and other macroeconomic methods to study the impact of price shocks, supply constraints and economic crises. One of the main reasons for the growth in the application of the CGE models has been the success in software development and prototyping. The Study use ORAN-G, a static CGE model has received considerable recognition from modelers around the World since the database and model structure are comparatively simply tailored to a set of published input-output accounts.

CHAPTER THREE

MODEL THEORY, DATABASE AND CLOSURES

3.1 Introduction

In this chapter we intend to introduce the ORANI-G Model - an applied general equilibrium (AGE) framework - which is a single region Model that includes imports and exports, to give readers an intuitive understanding of the overall structure of ORANI-G, and to also describe the theoretical structure of the model. This is then followed by a detailed description of the database construction, sets mapping process, model closures, and lastly, simulation design.

3.2 Computable General Equilibrium (CGE) Model

A CGE Model which is carefully designed will have a transparent and theoretically consistent structure and will offer a tool for policy appraisal. Undeniably, with the availability of appropriate and sophisticated software, CGE has become a productive research area over two decades (Karaca and Philippidis 2006). A simple model identifies a single representative consumer, who is assumed to own an initial endowment of a number of commodities and factors, and a set of preferences. By maximising the utility subject to a budget constraint, market demand functions for each commodity can be derived. Market demands must satisfy Walras's Law, namely that at any set of prices, the total expenditure of consumers equals consumer income.

On the production side, technology is typically described by constant returns to scale production functions, and producers maximise profits (or minimise costs). A general

equilibrium can, therefore, be characterised by a set of prices and levels of production in each industry, which equals market demand across all commodities. This simple model can be extended to include many other elements, like a government sector or an external sector. However, regardless of the level of additional complexity of the market clearing condition, this is what characterises a general equilibrium (Greenaway, Leybourne, Reed and Whalley 1993).

Generally, CGE models link economic theory to observed accounting data from countries and regions in order to measure the changes that occur in the data after certain policy variables within the model have been shocked. CGE models thus allow for experimental settings with hypothetical policy scenarios; these settings abstract from reality through assumptions which are common in economic theory. The ways in which these theoretical assumptions are implemented into a model determine those aspects of reality that a specific model can highlight for closer analysis. However, no model captures all of reality. Instead, scientific models must be suited for the questions they are employed to answer (Heisenberg 2005).

The strength of the CGE Model lies in its ability to capture the various inter-linkages in the real economy in great detail. This ability makes the CGE Model superior over a partial equilibrium model, which only focuses on one sector of the economy. Since data for only one reference year is required for the initial solution to the model, more details are incorporated in the analysis compared to many other econometric methods that require large time-series datasets in order to produce robust simulation results. The large amount of detail to be specified for the agricultural sector in this study, capturing its cost and sales structures along with a number of behavioural parameters, combined with the policy questions within the sector to be addressed for the study, makes CGE modeling the method of choice.

CGE models have also been established as a superior methodology over the Input-Output or Social Accounting Matrix (SAM) multiplier models, despite being based on the same underlying set of national accounts. The ability of CGE models to accurately reflect resource constraints and the impact of relative price changes in the economic decision-making process, and ultimately the structure of the economy, is of significant importance in conducting accurate and credible policy analysis, as illustrated in Figure 3.1. A CGE Model, therefore - apart from the theoretical structure provided by a general equilibrium model - also requires data about the economy. Once the general equilibrium model and data have been integrated, an actual solution method is needed in order to solve the equilibrium prices and decision variables in the equilibrium system (Menezes 2006). ORANI-G a static CGE model was used for this study. The next section explains the model in detail.

3.3 ORANI-G Model

ORANI-G Model is a generic form of the ORANI Model that was originally designed in the late seventies as a government-sponsored policy evaluation tool for the Australian economy. ORANI-G is a comparative static representation, in that it compares two points in time, and it belongs to the Walras-Johansen class of economy-wide models that provide industry-level disaggregation in a quantitative description of the entire economy. The model postulates neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a general equilibrium model that endogenously determines quantities and prices (Dixon *et al.* 1982). ORANI-G is written almost exclusively in percentage change form and is implemented using the GEMPACK software (Harrison and Pearson 1996; Horridge, Meeraus, Pearson & Rutherford 2013).

ORANI-G has various dimensions and parts. These include production, household, investment, and government parts. These parts interact with the rest of the World through imports and exports. Initial versions of ORANI-G were static, with applications confined to comparative-static analysis. However, later versions have contained dynamic elements, arising from stock/flow accumulation relations between capital stocks and investment, and between foreign debt and trade deficits. Other extensions to the basic model have included systems of government accounts and regional breakdowns of model results (Horridge 2003).

There are four basic tasks that distinguish a CGE-based analysis. The first is theoretical derivation and description of the model, which incorporates the formal theory and linearisation of equations. Linearisation of the system of equations simplifies both the implementation and interpretation of complex functional forms such as the constant elasticity of substitution (CES) in the model. Calibration, on the other hand, incorporates the construction of a balanced database and evaluation of coefficients. The third task is solving the model using a suitable closure. The model closure is important since it determines the economic environment under which we run the simulations. The system of linear equations that make up the model is then solved via a series of matrix manipulations. The final task involves proper interpretation of simulation results, drawing only on values given in the database, the underlying theory or model closure (Roos et. al 2014).

3.3.1 Theoretical structure of the ORANI-G Model

3.3.1.1 Production

Industries are assumed to perfectly maximise profit competitively. This means that input demand is consistent with cost-minimising behaviour, as well as revenue-maximising output-

choices in cases where more than one good is produced by a single industry. Each industry uses intermediate inputs, which might be domestically produced or imported, and primary factors. The primary factors are land, capital, and several types of labour, brought from one representative household. Each industry can also produce more than one commodity, which are then intended for local and export markets. They minimise costs by choosing the input mix, subject to a three-tier constant-returns-to-scale input technology (see Figure 3.1).

At the top level, it is assumed that intermediate commodity composites, primary-factor composites, and other costs are combined using a Leontief function. In the second level of the nest, Hicksian demands for domestic and imported intermediate inputs are subject to a CES (constant elasticity of substitution) production function.

The demands for land, labour, and capital are also derived by minimising the cost of primary factor composites formed according to CES technology. The bottom level of the input technology is only applicable to labour. As in the case of the second level, composite labour is a CES aggregate of skilled and unskilled labour. The demands for labour in the two skill categories are derived by minimising labour costs subject to technology. For the output, each industry can produce both domestic and export goods. The choice on the composition of output is made subject to a CET (constant elasticity of transformation) production frontier. This multi-production decision is illustrated in the production tree in Figure 3.1.

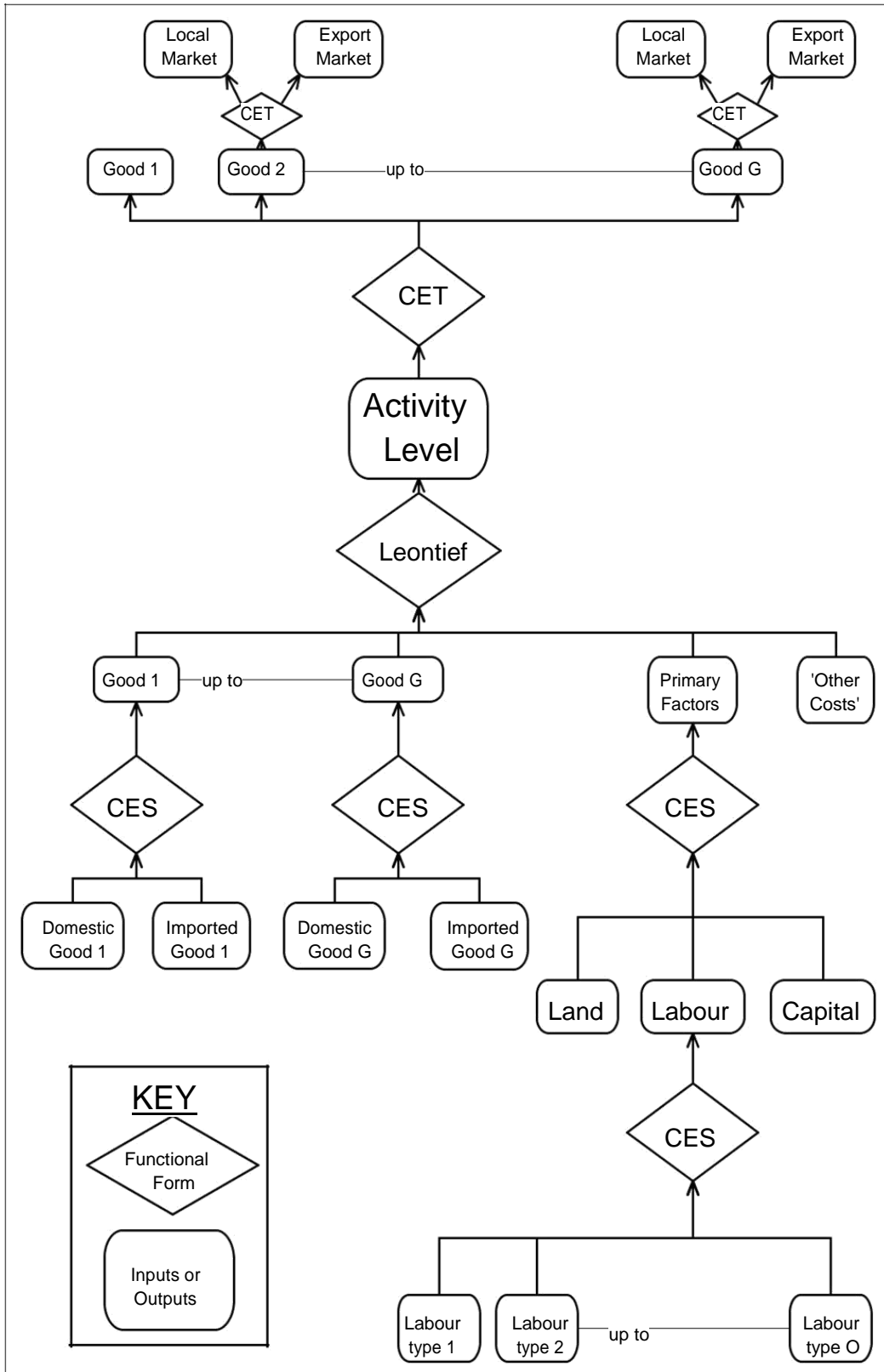


Figure 3.1: The production structure of ORANI-G Model

Source: Adapted from Horridge, 2003

3.3.1.2 Household demand

Household demand stems from four main sources: household consumption, investment/capital creation, government consumption, and exports. This is also the classification of final demand adopted in input-output tables - the main source of the model database. Private final demands are characterised by a single representative household, which maximises the Linear Expenditure System (LES) utility function subject to a budget constraint, as illustrated in Figure 3.2. The household maximises utility by allocating its budget across composite commodities consisting of domestic and imported goods. Household demand responds to changes in the relative prices of domestic and foreign commodities by substituting between domestic and imported goods (Armington 1969). As explained above, the LES function is preferable to CES, since it permits non-unitary income and price elasticities of demand. This is of particular relevance when characterising food demand, which has been empirically proved to be income inelastic (Philippidis and López 2009, Roos et al. 2014).

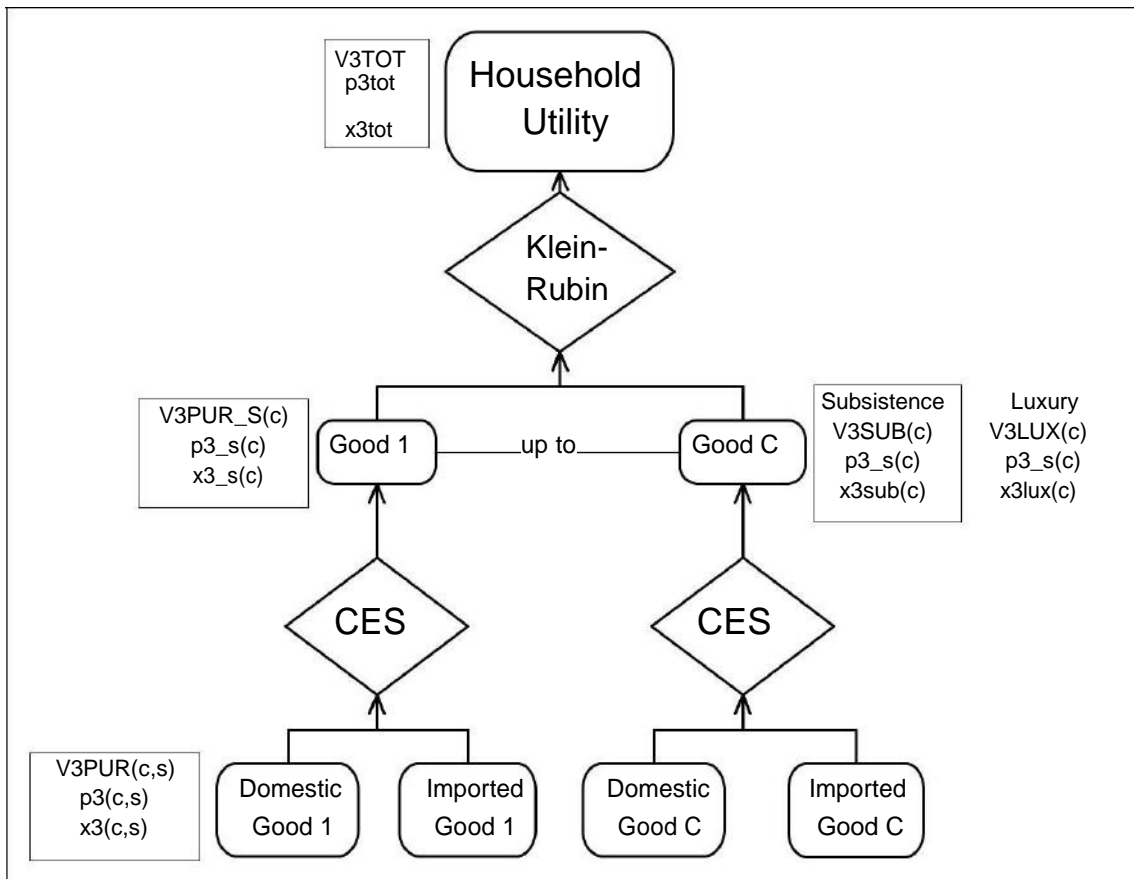


Figure 3.2: Private Demands in ORANI-G models

Source: Adapted from Horridge, 2003

3.3.1.3 Investment demands

Figure 3.3 illustrates the nesting structure for capital creation. A new unit of fixed capital used in industry j is structured according to a two-tiered technology. At the top level, industry minimises cost by choosing the composite goods subject to a Leontief production function, implying that all composite goods are used in fixed proportions. At the next level, substitution between domestic and imported goods is possible. It is assumed that primary factors are not employed in capital goods creation (Philippidis & Sanjuán 2009; Roos et al. 2014). In the absence of a detailed dynamic investment mechanism, ORANI-G offers the modeler a choice of three potential investment allocation mechanisms. Firstly, the accumulation of capital goods

in industry i to capital stock in industry i is a direct function of changes in the rate of return in industry i (this is the ratio between the unit rent to capital and the unit price (average cost) of a unit of capital good construction) relative to the economy-wide rate of return. Secondly, the production of capital goods in industry i is directly proportional to the economy-wide increase in capital goods production. This rule is more appropriate in those industries where investment is determined by government policy. Thirdly, the new capital goods production in industry i perfectly shadows the change in capital stock usage in industry i . It should be noted that in none of these rules is the change in new capital goods fed into the endowment stock of capital. If the user requires an increase in the capital stock, a long-run closure must be employed where capital stock is exogenous and shocked.

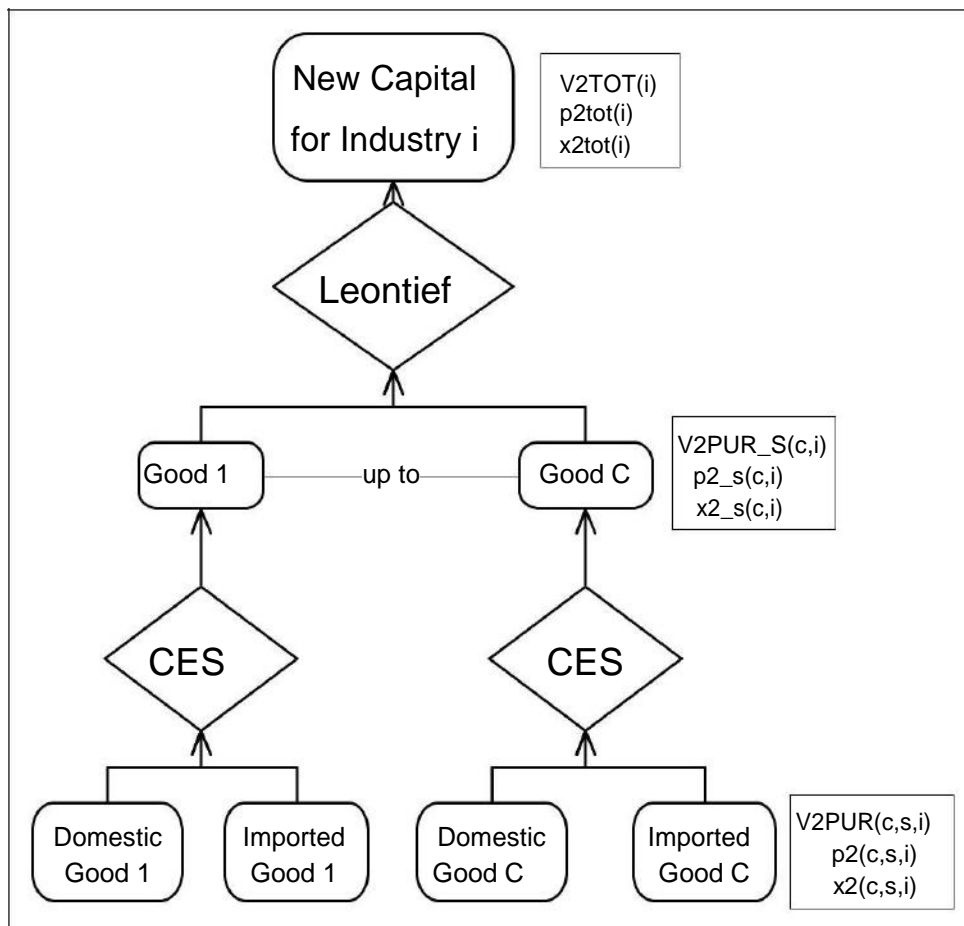


Figure 3.3: Investment demand structure in ORANI-G Model

Source: Adapted from Horridge, 2003

3.3.1.4 Public and export demands

Export demand is specified by a downward-sloping schedule. Export volume for each commodity is a decreasing function of its price in foreign currency. The sensitivity of export volume to the change in its price is determined by an export demand elasticity parameter. In the case of public demands, through a closure substitution, we may either specify an exogenous increase in public spending or assume that public expenditure moves in tandem with changes in private household expenditure (Roos et al. 2014).

3.3.1.5 Demand for indirect margin services

Indirect margin services of domestic origin (i.e., wholesale, retail, transport, etc.) are used to facilitate the flow of domestic and imported commodities to agents. These demands are assumed to be in direct proportion to the commodity flows with which each specific margin is associated. However, the model has nothing to say about international margin services that facilitate the flow of imported commodities from their countries of origin to the point of entry within the domestic economy (Roos et al. 2014).

3.3.1.6 The price system

ORANI-G distinguishes two types of prices, namely basic values and purchaser's prices. For domestically produced goods, basic value is defined as the producer price, excluding commodity taxes and margins used to deliver goods to end users. For imported goods, basic value is the price received by importers, including the tariff, but excluding commodity taxes and margins used to deliver goods to end users - that is, the landing duty-paid price. Purchasers' prices for both imported and domestically produced commodities are the basic

prices plus sales taxes and margin costs. In the case of exports, the purchasers' prices include the margins and subsidy costs (Horridge 2003; Roos et al. 2014).

In deriving equations representing the model's pricing system, the following simplifying assumptions are adopted: pure profit does not prevail in any economic activity; production; capital creation; distribution; exporting or importing. Basic prices are uniform for all users and producing industries. This assumption implies that, if a difference in purchasing prices exists across users, this is entirely due to the differences in sales tax and margin costs. In other words, while the basic price is the same for all users, the purchaser's price paid by each user may be different. Since we assume constant returns to scale, industry's per unit cost and per unit revenue are independent on output level and are being influenced only by the level of technology and the prices of commodities. With the above assumptions, the basic prices per unit of an industry's output equals the total payment for the inputs needed to produce one unit of output (Roos et al. 2014).

3.3.1.7 Government revenue

Government fiscal revenue are derived from different types of taxes. Governments also receive part of the remuneration of capital and transfers from other agents. The rest of the World receives payments for the value of imports, part of capital income and transfers from domestic agents. Foreign spending in the domestic economy consists of the value of exports and transfers to domestic agents. The difference between foreign receipts and spending is the amount of rest-of-the-World savings, which are equal in absolute value to the current account balance, with opposite signs (Philippidis & Sanjuán 2009; Roos et al. 2014)

3.3.1.8 Market clearing equations

For domestically produced commodities, the total supply is driven by the sum of demands for (i) intermediate inputs to current production; (ii) capital creation; (iii) households' consumption; (iv) exports; (v) government purchases; and (vi) margin services. The benefits resulting from the theoretical structure of the model develop from the applicability of Walras' Law. The law states that if: (i) all households are on their budget constraint; (ii) all firms exhaust their revenues on factor payments, taxes, and transfers of excess profits to households; and (iii) all markets are in equilibrium (i.e. supply = demand), then one of the equilibrium relationships in the model will be redundant and may be dropped. This provides an extremely powerful check on the consistency of the model, since the redundant equilibrium condition may be checked. This assists in verifying that there are no errors in database management, model coding, or possibly in the theoretical structure. Given the complexity of implementing a large-scale empirical model, this is a very powerful tool (Philippidis & Sanjuán 2009; Roos et al. 2014).

Over the last two decades, with significant developments in computational power, the ORANI-G Model has evolved in terms of its complexity. This means that imperfect competition and dynamic investment behaviour can be modeled using ORANI-G while retaining a high degree of flexibility. The standard data used in ORANI-G resemble quite closely input-output (IO) and national accounts data (Horridge 2003).

3.3.2 A comparative-static interpretation of ORANI-G Model results

ORANI-G is designed for comparative-static simulations. The time dimension is split into long and short run, implied by the variables' allocation between the endogenous and exogenous categories. Once the Model is closed, the economy is shocked according to the selected policy

and solved for the counterfactual equilibrium. Results of a simulation for a counterfactual equilibrium are expressed as percentage change deviations from the benchmark economy, with no track of the evolution path of the variables. Hence, the Model is informative on the effect of a shock on the Model's variables, by comparing the economy with policy, and with no policy, at a certain time (T), which can be short or long (Horridge 2003).

The equations and variables all refer implicitly to the economy at some future time period. This interpretation is illustrated by Figure 3.4. A is the level of GDP in the base period (period 0), and B is the level which it would attain in T years' time if some policy – for instance, a tariff change was not implemented. With the tariff change, GDP would reach C, all other things being equal. In a comparative-static simulation, ORANI-G might generate the percentage change in GDP $100(C-B)/B$, showing how GDP *in period T* would be affected by the tariff change alone.

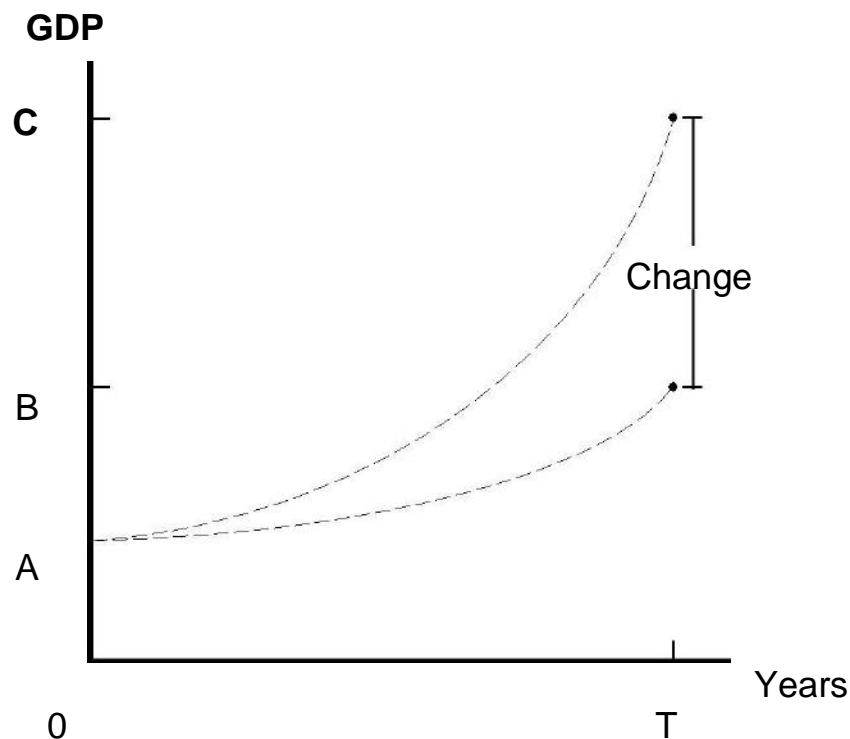


Figure 3.4: Comparative-static interpretation of results

Source: Adapted from Horridge, 2003

ORANI-G can be used to run simulations to analyse the short-run effects of policy changes. For these simulations, capital stocks have usually been held at their pre-shock levels. Econometric evidence suggests that a short-run equilibrium will be reached in about two years, i.e., $T=2$ (Cooper, McLaren and Powell 1985). ORANI-G can also be adopted for long-run assumption that capital stocks will have adjusted to restore (exogenous) rates of return - this might take 10 or 20 years, i.e. $T=10$ or 20 . In either case, only the choice of closure and the interpretation of results bear on the timing of changes: the model itself is a-temporal. Consequently, it says nothing about the adjustment paths, shown as dotted lines in Figure 3.4.

3.3.3 The Percentage-change approach to ORANI-G Model solution

The ORANI-G theoretical Model is represented through a system of non-linear equations. Following Johansen (1960), the Model is solved by representing it as a series of linear equations relating percentage changes in model variables. This system is then easily solved by numerical integration technique, such as Euler procedure. Appendix A gives the equations on how the linearised form can be used to generate exact solutions of the underlying non-linear equations, as well as to compute linear approximations to those solutions.

3.4 Model database

The building blocks for creating a database for a CGE Model are official statistics from the input-output (IO) table, or a Supply-Use table (SUT), or a Social Accounting Matrix (SAM). The primary source of data for our CGE Model is the 2010 Supply-Use tables (SUT), published by Statistics South Africa. The 2010 Supply-Use tables were estimated according to the recommendations of the 2008 System of National Accounts (Stat SA 2016a). In addition to the SUT, the 2011 SAM published by Statistics South Africa was also used. The SAM

integrates the SUT and institutional-sector accounts into a single matrix format. The 2011 SAM also focuses on households and their income and expenditure patterns (Stat SA 2016b). Other sources of data are the *Quarterly Bulletin* which contains the National Account as published by the Reserve Bank (SAQB). The benefits of using a SAM can be summarised in terms of increased relevance, reliability, and efficiency. The SAM increases the relevance of economic and social indicators, as they are derived from a meso-level information system.

Before creating the CGE database, it is important to review and understand the valuation, structure and unique features of the published data, as these dictate what data manipulating procedures will be required. The 2008 System of National Accounting recommends three ways to value the production of goods and services: in basic prices, in producers' prices, and in purchasers' prices. The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output, minus any tax payable, and plus any subsidy receivable on that unit as a consequence of its production or sale. Basic prices exclude any transport charges involved separately by the producer.

The producers' price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output, minus Value Added Tax (VAT), or similar deductible tax, invoiced to the producer. It excludes any transport charges invoiced separately by the producer. Lastly, the purchasers' price is the amount paid by the producer, excluding any deductible VAT or related deductible tax, in order to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchasers' price includes any transport charges paid separately by the purchaser to take delivery at the required time and place (United Nations 2009). The basic structure of the South African SUT where the supply table is valued at basic price and the use table valued at purchasers' price is described below (Stats SA Supply-Use Table 2010).

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
size	1	1	1		1	1	IND 1...i
C ↓	Total supply at purchasers' price	Taxes less subsidies on products	Trade and transport margins	Total supply at basic prices	c.i.f./f.o.b. adjustment on imports	Imports	MAKE

C = 104 commodities

Figure 3.5: The format of supply table

Source: Adapted from Roos (2013).

Figure 3.5 shows a simple illustration of the South African supply table. The first column lists the 104 commodities as they appear in the supply table. Column 2 lists the total supply of all commodities at purchasers' prices. In principle, the values in this column should be equal to the commodity-specific use, valued at purchasers' prices. Column 3 lists the commodity-specific taxes, which include taxes and duties on imports and value added type of taxes, less subsidies on products. Column 4 lists the commodity-specific trade and transport margins. Column 5 shows the value of the domestic supply of commodities valued at basic price, that is, the MAKE matrix summed over industries.

Total supply valued at basic price is calculated by adding the domestically produced commodities (Column 5) to the imported commodities after taking into account the c.i.f./f.o.b adjustment (Column 6 and 7). Column 6 lists the commodity-specific c.i.f./f.o.b adjustments on imports. Column 7 lists the value of commodity-specific imports, and Column 8 the multi-production matrix (MAKE) shows the domestic production of 104 commodities by 174 domestic industries valued at basic prices. Total supply valued at basic price is transformed

into producers' price by adding the taxes on commodities (Columns 3). Finally, total supply at purchasers' price is calculated by adding the trade and transport margins (Column 4). In principle, the total supply of commodities at purchases' prices (Column 2) is equal to the total use at purchases' prices.

Users		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Size	Producers	Investors	Household	Exports	Government	Inventories	Total use at purchaser price
			↔ 1 ↔	1	1	1	1	1	1
(1)	Flows	C ↓	V1PUR_S	V2PUR_SI	V3PUR_S	V4PUR	V5PUR_S	V6PUR_S	Sum over column
(2)	Compensation of employees	1	V1LAB_O						
(3)	Operating surplus	1	OPSUR						
(4)	Depreciation	1	DEPR						
(5)	Net taxes on production	1	V1PTX						

C = 104 commodities

I = 174 industries

Figure 3.6: The layout of use table

Source: Adapted from Roos (2013).

The use table, valued at purchasers' prices, is illustrated in Figure 3.6. This table contains information on the sales of commodities to final users, as well as information on factor payments. Commodities may be used as intermediate inputs by producers or final demanders such as investors, households, exporters, and government. For instance, in the South Africa

use table, the intermediate use matrix, $V1PUR_S$, is a 104×174 matrix that records the flow of each commodity c used by industry i in current production. The final demand vectors consist of investors ($V2PUR_SI$), a representative private household ($V3PUR_S$), exporters ($V4PUR$), government ($V5PUR_S$) and changes in inventories ($V6PUR_S$). Column 8 is the value of total use at purchasers' price, and the sum of all users of commodity c . In theory, the commodity-specific values in column 8 are equal to the commodity-specific total supply at purchasers' price (Figure 3.5, column 2).

3.4.1 The structure of the CGE database

The database for our comparative-static CGE model for South Africa consists of a set of matrices capturing the unique economic structure and a set of parameters describing the South African economy, as illustrated in appendix A. This consists of an absorption matrix, joint-production matrix, and vector of import duties. It reveals the basic structure of the model's database, which is disaggregated along many factors of production and final users, with multiple dimensions possible within each. The elements in the database are listed in Table 3.1. We use the GEMPACK naming system to label the main data cells within the absorption matrix (Kohlhaas & Pearson 2002).

Moreover, the database consists of a set of matrices capturing the unique economic structure and a set of parameters describing the South African economy. These sets include elements related to commodities, industries, sources and margins that are included in the model. The row 1 column 3 matrix called $V3BAS$ has the dimensions of commodity c from source s . This implies that $V3BAS$ contains values for all 104 commodities from 2 sources. The first three numbered rows form the absorption matrix, rows 4 to 7, are the production matrix, and the two satellite matrices are the multi-production matrix and the tariff matrix.

The matrices in the first row, that is, V1BAS to V6BAS, represent the direct flow of commodities from all sources to users valued at basic prices. The first matrix, V1BAS, shows the direct flow

Table 3.1: Contents of the ORANI Input–Output data files

TABLO name	Name	Dimension
1. Sets		
COM	Set COM commodities	40 commodities
IND	Set IND industries	34 industries
SRC	Set SRC sources	2 sources
MAR	Set MAR margin commodities	2 margins
OCC	Set OCC occupations	11 occupations
2. Coefficients in the core database		
V1BAS	Intermediate basic	COM*SRC*IND
V2BAS	Investment basic	COM*SRC*IND
V3BAS	Household basic	COM*SRC
V4BAS	Export basic	COM
V5BAS	Government basic	COM*SRC
V6BAS	Inventory basic	COM*SRC
V1MAR	Intermediate margins	COM*SRC*IND*MAR
V2MAR	Investment margins	COM*SRC*IND*MAR
V3MAR	Household margins	COM*SRC*MAR
V4MAR	Export margins	COM*MAR
V5MAR	Government margins	COM*SRC*MAR
V1TAX	Intermediate tax	COM*SRC*IND
V2TAX	Investment tax	COM*SRC*IND
V3TAX	Household tax	COM*SRC
V4TAX	Export tax	COM
V5TAX	Government tax	COM*SRC
V1CAP	Capital rentals	IND
V1LAB	Labor	IND*OCC
V1LND	Land rentals	IND
V1PTX	Production tax	IND
V1OCT	Other cost	IND
MAKE	Multi-product matrix	COM*IND
VOTAR	Tariff revenue	COM
3. Parameters and elasticities		
SIGMA0	Elasticity of transformation	IND
SIGMA1	Armington elasticity – intermediate inputs	COM
SIGMA2	Armington elasticity – capita inputs	COM
SIGMA3	Armington elasticity – household consumption	COM
SIGMA1PRIM	Elasticity of substitution for primary factors	IND
SIGMA1LAB	Elasticity of substitution between labor types	IND
FRISCH	Frisch parameter	1
DELTA	Household marginal budget share	COM
EXP_ELAST	Export elasticity	COM

Source: Adapted from Roos (2013)

of commodity c , from source s , used by industry i as an input into current production. V2BAS shows the direct flow of commodity c , from source s , used by industry i as an input to capital formation. V3BAS shows the flow of commodity c from source s that is consumed by a representative household. V4BAS is a column vector and shows the flow of commodity c to exports. V5BAS and V6BAS show the flow of commodity c from source s to the government, and changes in inventories, respectively. It should be noted that all the values, with the exception of V6BAS, are positive. V6BAS records the changes in inventories, and can, therefore, be positive or negative.

The second row in Figure 3.6, V1MAR to V5MAR, represents the value of commodities used as margins to ease the basic flows recorded in row 1. In ORANI-G style models, we assume that all margins are produced domestically. V1MAR is a four-dimensional matrix that shows the cost of margin service m used to facilitate the flow of commodity c , from source s to industry i for use in the production process. V2MAR can be interpreted in a similar way. V3MAR and V5MAR are three-dimensional and show the cost of margin service m that facilitates the flow of commodity c from source s to the representative household and the government respectively. V4MAR is a two-dimensional matrix and shows the cost of margin service m that facilitates commodities flow to exporters. There are flows that do not require any margins, and therefore the values in these matrices are zero. This is mainly for service commodities and inventories.

The third row in Figure 3.6, V1TAX to V5TAX, represents the tax matrices. These matrices show the taxes paid in the delivery of domestic and imported commodities to the different users. The positive value will be allocated to taxes, while subsidies will have a negative value. For example, a positive element in V1TAX and V2TAX can be interpreted as the tax associated with the delivery

of commodity c from source s used by industry i as an input into current production and capital formation respectively. A negative value means a subsidy paid on commodity c , from source s , used by industry i . We interpret V3TAX and V5TAX as the taxes connected with the delivery of commodity c from source s used by households and government respectively. The delivery of commodities to exporters will be V4TAX in the matrix. There are no taxes paid on inventories, and therefore there is no V6TAX matrix. However, there is the likelihood of commodity-specific tax rates being different between users and sources.

Rows 4 to 6 comprise matrices that provide a breakdown of the cost of primary factors used by industry in current production. These matrices include the inputs of three factors of production: labour (V1LAB), capital (V1CAP) and agricultural land (V1LND). The inclusion of these factors allows the model to determine the percentage change in the industry-specific demand for factors due to a change in relative price. V1LAB shows the purchase of labour of class o by industry i that is used as an input into the production process. V1CAP comprises the rental value of each industry's capital, and V1LND shows the rental value of agricultural land used by each industry. Industry also pays production taxes such as business licenses, payroll taxes, and stamp duties. These taxes are contained in V1PTX in row 7. The database shows that labour, capital, land, and production costs are only used in current production, and therefore these matrices are absent from entries in the capital formation, household consumption, exports, government and change in inventories columns.

The satellite matrices explain the multi-production matrix (MAKE) and tariff matrix. Each element in the MAKE matrix refers to the basic value of commodity c produced by industry i . In principle, there are two different types of MAKE matrices. The first is where the entries in the matrix are

diagonal, that is, an industry only produces one unique commodity, and a commodity is only produced by one industry. All non-diagonal values are zero. The second type of matrix is a joint-production matrix where an industry can produce more than one commodity, and a commodity can be produced by more than one industry. Therefore, a number of the off-diagonal values are non-zero. The ORANI-G Model includes the second type of MAKE matrix. The implication of a joint-production matrix is that a producer will choose to produce a combination of output commodities that will maximise their revenue.

The final matrix, tariffs (VOTAR), contains tariff revenue by imported commodity. This matrix is separate from the absorption matrix, as the values of tariff revenues are already included in the basic price of imports, that is, they are included in the basic flows in row 1. This allows for calculating ad valorem rates as the ratio between tax revenues and the relevant basic flow of commodities on which the taxes are levied.

Four basic requirements must be satisfied by the CGE database. The first requirement is that the values in most matrices should be positive. Only matrices relating to taxes and change in inventories may include negative values. The second requirement is market clearing, which means the value of output of domestically produced commodities must equal the total value of the demand for these commodities. Therefore, for all non-margin commodities, the sum of all inputs used in an industry should equal the sum of all basic values of the direct use of the corresponding commodities. For margin commodities, the sum of all inputs into the production of margin m should equal the sum of all direct usage of m plus the sum of all usage of m as a margin. The third requirement is that of zero-pure profit, which implies that for each industry the value of output must equal the total production cost. The final requirement of the database is that GDP

from the income side is equal to GDP from the expenditure side. We satisfy all these requirements in constructing our model database.

3.4.2 Creating the CGE database

In constructing the CGE database we write a sequence of data programmes coded in GEMPACK (Harrison and Pearson 1996). Each step in the data management process addresses a specific data query. This is an automated process with many advantages. Recording each step promotes transparency, and this enables the data programme to become permanently documented on the data manipulation process. Each data programme also serves as a record of the process used to manipulate the data. Another advantage is that adjustments and corrections to formulas can be easily made. Lastly, the automation enables fast replications of the process whenever it is needed. This is useful when new data are available. The following steps were taken to convert published data into the CGE database.

Step 1: Adjustments to published data

Time was devoted in reviewing all available published data. This enabled us to identify the accounting identities within the data and the presence of implausible values. We checked that the GDP calculated from the income side is equal to the GDP from the expenditure side; that the share of the components of the GDP identities are plausible; that commodity-specific aggregate supply equals aggregate demand; that zero pure profits conditioned by industry are satisfied; and lastly, that industry-specific factor shares are plausible. After reviewing the data, lots of discrepancies were noted. We then proceeded with the adjustments of the data. The supply table

required adjustment, the c.i.f/f.o.b adjustment. Imported goods c.i.f. include values for (i) imported goods f.o.b, (ii) transport services rendered by both resident and non-resident transporters, and (iii) insurance services rendered by both resident and non-resident insurers. If the services stated in (ii) and (iii) are rendered by non-residents, their value is already included in the total value of imports of market services. If these services are rendered by residents, it is part of domestic output, and should not be treated as imports. If no adjustment is made, there is double counting to the value of the transport and insurance services. The adjustment column consists of a deduction from the services items for transport and insurance equal to the c.i.f/f.o.b adjustment for the commodities (United Nations 2009). Commodity-specific imports after the adjustment is calculated as:

$$Imp_adj_{(c)} = Imp_{(c)} + adj_{(c)} \text{ for } \in COM \quad \text{EQ.1}$$

Where $Imp_{(c)}$ and $Adj_{(c)}$ are the commodity-specific imports c.i.f and adjustments respectively. These two column vectors appear in the supply table.

Step 2: Reviewing Industry-specific factor payments and production taxes

ORANI-G style models distinguish between three types of factors of production, namely agricultural land, labour, and capital. The use table includes information on compensation of employees, gross operating surplus, and indirect taxes, but there are no values for land rentals. Hence, there was the need to allocate some part of the gross operating surplus to land-using industries. External land rental data were adopted from DAFF and Statistics SA. We adopted the factor shares from the GTAP database to redistribute labour payments, rental and land payments over the land-using industries. For non-land using industries, none of the gross operating surplus was allocated to land. Production taxes mainly comprise taxes on the ownership or the use of

land and other assets used in the production process. We assumed that the production tax paid was proportional to industry-specific output.

Step 3: Adjusting the MAKE matrix

Each element in the MAKE matrix refers to the basic value of commodity c produced by domestic industry i . The initial MAKE matrix available in the South African supply table shows a high level of multi-production in the economy, implying that an industry can produce more than one commodity, and a commodity can be produced by more than one industry. We adjusted the MAKE matrix using the following steps: (1) removal of all flows that constituted less than one per cent of the commodity and/or industry flows. After the adjustment, most cells from the MAKE matrix kept their original values, while the negligible flows were turned to zero. The values of the insignificant flows were then added to the diagonal elements. (2) The next step was to remove all implausible elements in the MAKE matrix. The implausible elements were set to zero, and the values of the elements were either added to the diagonal element or to a suggested element. This adjustment preserved commodity-specific output totals but altered the industry-specific output totals. We accepted the adjusted MAKE matrix as our target matrix and scaled the remaining matrices, using RAS, so as to retain commodity and industry balances across the SUT (Horridge 2011).

Step 4: Removing any negative flows

The CGE database do allow for a matrix to include negative values for all non-service commodities. We did not allow values for service commodities, as services usually cannot be stored, and hence cannot be put into inventories. In the process of the adjustments to the

intermediate use and change in inventories matrices, we observed that commodity-specific aggregate demand did not equal aggregate supply, and industry cost did not equal industry output as a result of the adjustment. We then used RAS procedure as illustrated in Horridge (2011) to ensure that the balancing conditions hold. With the RAS procedure we took an original matrix, say $A(r,c)$, where r refers to the number of rows of size $1-r$, and c is the number of columns of size $1-c$, and we then identified target vectors of row totals $RT(r)$ and column totals of $CT(c)$. The RAS attempts to find a new matrix $B(r,c)$ so that:

$$\sum_c B_{(r,c)} = RT_{(r)} \quad \text{for all } r \text{ row totals} \quad \text{EQ.2}$$

$$\sum_r B_{(r,c)} = CT_{(c)} \quad \text{for all } c \text{ column totals} \quad \text{EQ.3}$$

The new $B(i,j)$ matrix is related to the original $A(r,c)$ through (EQ.4).

$$B_{(r,c)} = rm_{(r)} \times cm_{(c)} \times A_{(r,c)} \quad \text{for } r = 1 \dots r \text{ \& } c = 1 \dots, c \quad \text{EQ.4}$$

where $rm_{(r)}$ is a vector of row multipliers, and $cm_{(c)}$ is a vector of column multipliers.

Step 5: Splitting flows into domestic and imported sources

Steps one to four described data adjustments imposed on published data to address any inconsistencies, errors and negative values. Step five described how we transformed the published data into the matrices that constitute a CGE database. Our first aim was to create the domestic and imported flows of commodity c to user u . This was a difficult task since the SUT only presents commodity-specific import values and not commodity- and user-specific import values. In appendix A, row one shows that all final users, except exporters, use both domestically produced and imported commodities. For illustration, V3BAS is defined by commodity c and source s and shows the flow of commodity c from domestic and imported sources consumed by

households. The basic prices of imported goods are the prices received by importers, minus transport and other margin costs involved in transferring imports to final users, i.e. the basic price of imported goods is the c.i.f. price of imported goods plus the tariffs (Dixon *et al.* 1982). Import duties were included in the taxes and subsidies column (see Figure 3.5, column 3).

In the absence of the availability of an external import duty data, the tariffs matrix in the CGE database could be set to zero, and the commodity-specific import numbers in the SUT could then be used without any further adjustments. The commodity-specific flows, as they appeared in the use table, were valued at purchasers' prices and include imports (Appendix A, row 1). As no information was available on user-specific imports, we calculated the commodity-specific import share as:

$$IMP_{SHR(c)} = \frac{VOIMP(c)}{\sum_{u \in USERS} VPUR(c,u)} \quad for \ c \in COM, u \in USER \quad EQ.5$$

where VOIMP(c) is the commodity-specific imports valued at basic price, and VPUR(c,u) is the value of commodity c used by user u at purchaser's price. The element u refers to the following users: (1) industries, (2) investors, (3) household, (5) government and (6) stocks. Exporters are omitted deliberately from the u element because no imported good was directly re-exported. We assumed that the commodity-specific import share was the same for all users. The value of imports by commodity and user can thus be calculated as:

$$VPUR_{(c,imp,u)} = IMP_{SHR(c)} \times VPUR_{S(c,u)} \quad for \ c \in COM, u \in USER \quad EQ.6$$

where IMP_SHR is the commodity-specific share calculated in (E.5), and VPUR_S(c,u) is the total value of commodity c by user u valued at purchasers' price. To decide the domestic source, the commodity- and user-specific imports were then deducted from the total use valued at purchasers'

price. The final result was matrices showing the use of commodities valued at purchasers' prices by domestic and imported sources.

Step 6: The creation of margin matrices

Trade and transport margins are the difference between the purchasers' price and the producers' price of a product. Therefore, there is a possibility that a product can be sold at different purchasers' prices due to differences in commodity-specific margins and net taxes. Treatment of margins was included for many reasons. Firstly, the margin sectors' (trade, transport, distribution) contribution to South Africa's GDP is 18.9% (DAFF 2010). Consequently, to determine the total demand for road transport, the model determines the demand for transport used in facilitating the flow of commodity c , from source s to the final user u . Secondly, it allows for the detailed modeling of variations in purchasers' price of commodity c , from source s across user u . Thirdly, we can simulate the effects of technical change involving particular use of margins. The margin matrices were created by calculating the commodity-specific margin share in the total use of each commodity. The margin share is calculated as:

$$MAR_SHR_{(c)} = \frac{MARGIN_{(c)}}{\sum_{u \in USER} \sum_{s \in SRC} VPUR_{(c,s,u)}} \text{ for } c \text{ COM}, s \in SRC, u \in USER \quad \text{EQ.7}$$

where $MARGIN(c)$ is the commodity-specific margins; and $VPUR(c,s,u)$ is the value at purchasers' price of commodity c from source s used by user u . The element u refers to the following users: industries, investors, households, exporters, and government. No margin is associated with stocks. We multiplied the shares with user-specific flows valued at purchasers' price to create the commodity- and user-specific aggregate margins.

$$VMAR_M(c,s,u) = MAR_SHR(c) \times VPUR(c,s,u) \text{ for } c \in COM, s \in SRC, u \in USER$$

EQ.8

VMAR_M(c,s,u) is the total value of margins facilitating the flow of commodity c from source s to user u . After this, we defined these margin matrices in terms of transport and trade margins. This split was based on the share of each margin in the total value of margins, that is:

$$MARCOM_SHR(m) = \frac{MARCOM(m)}{TOT_MAR} \text{ for } m \in MAR$$

EQ.9

where MARCOM_SHR is the share of margin commodity m , MARCOM is the value of margin commodity m , and TOT_MAR is the total value of margins. Margin-specific flows are then calculated as:

$$VMAR(c,s,u,m) = MARCOM_SHR(m) \times VMAR_M(c,s,u) \text{ for } c \in COM, s \in SRC, u \in$$

$$USER, m \in MAR$$

EQ.10

Several assumptions were made to create the user-specific margins. Firstly, the commodity-specific margin share calculated in (EQ.7) was the same for all users. Secondly, we assumed that all users use the same proportion of trade and transport margins as calculated in (EQ.9).

Step 7: Creating indirect tax matrices for all users

Taxes on products are payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers. Our task is to allocate these taxes across

users. ORANI-G styled models exclude taxes on inventories. We calculated tax matrices using (EQ.11) and (EQ.12).

$$VTAX_{(c,s,u)} = INDTAX_{(c,s)} * TAXFAC_{(u)} * VPUR_{(c,s,u)} / WTOT_{(c,s)} \quad \text{EQ.11}$$

$$WTOT_{(c,s)} = \sum_{u \in USER} TAXFAC_{(u)} * VPUR_{(c,s,u)} \quad \text{EQ.12}$$

where VTAX is the value of indirect tax by commodity c , source s and user u ; INDTAX is the value of commodity and source-specific taxes in the supply table. TAXFAC by user is a tax factor assigned to each user, reflecting the proportion of tax paid by that user. VPUR is the value of commodities from source s used by user u at purchasers' price, and WTOT is the factor-weighted value of commodities c from source s . For a highly disaggregated SUT table, some commodities are mainly sold to a single user. In this case, we might assume that users of this commodity pay the same tax rate.

Step 8: Creating matrices for the basic flows

The purpose of this step was to create the domestic flow valued at basic prices of commodity c from source s to user u (see Figure 3.6, row 1). As explained earlier, the flows at purchasers' prices include domestic and imported flows valued at basic value, plus margin costs, plus taxes. The imported flows valued at basic prices were calculated in Step 5, margin flows in Step 6 and tax matrices in Step 7. To calculate the domestic basic flows, we deduct the imports, margin and tax matrices from the total purchase values summed over source. The final result was a matrix with positive values reflecting the flow of commodity c , from all domestic sources to final users u , valued at basic prices.

Step 9: Creating an industry dimension for the investments column

In the use table (see Figure 3.6), column 3 is the matrix pertaining to investors, and this is a column vector implying that there was only one representative investor. But, we know that investors buy commodities to construct capital in each industry. We, therefore, had to split the investment vector into an investment matrix with c commodities and I industries. In order to achieve this, we calculated the industry-specific shares in gross capital rentals (V1CAP) and multiplied it with the total investment value. We were then left with the investment matrix. In the absence of additional data, we assumed that the industry-specific shares were uniform over all commodities. An alternative method would be to use the RAS procedure in order to adjust the matrix (Horridge 2011).

Step 10: Balancing of the database

The final step is to check that the data added up and that the balancing conditions still hold. We made sure that the commodity-specific flows valued at purchaser's price added up to the commodity flows at basic price, plus the taxes, plus margin flows. The first balancing condition states that industry costs should equal the industry output. Looking at Figure 3.6, the column totals for each industry in the producer's column should equal the domestic output of each industry. The domestic output per industry is the MAKE matrix summed over commodities. The second condition states that the domestic commodity output valued at basic price should equal the total domestic sales valued at basic price. After the data adjustment procedure was completed, slight discrepancy in the balancing condition was observed. The RAS procedure was used to balance the final CGE database (Horridge 2011). Finally, the database with 174 industries

and 104 commodities were mapped to 40 commodities and industries. The advantage of a smaller database is that it saves computational time when simulations are conducted.

Step 11: Parameterisation

In order to calibrate the model, elasticities and behavioural parameters are required to replicate how economic agents respond to changes in quantities and prices. Elasticities govern the magnitude by which these economic agents adjust their behaviour due to changes in, for example, relative price. The equilibrium conditions of the model are then used to determine the behavioural equation parameters consistent with the benchmark data set. This is how we calibrate the model, in the sense that the benchmark data can be reproduced as an equilibrium.

Choosing a numeraire, all benchmark equilibrium prices are equal to 1 Rand, and the observed values are the benchmark quantities. The equilibrium conditions of the model were then used to determine the behavioural equation parameters consistent with the benchmark data set. The primary factor nest requires an estimate of the substitution parameters between the primary factors, labour, and capital. Although this has not been calculated for South Africa, we depend on values used in literature which assign 0.15. And based on studies like De Wet & van Heerden (2003) and Punt (2013), the elasticity of primary factor costs used for South Africa is 0.15 using CES function. However given the country economic structures and realities, it is a realistic value for South Africa. For the nest of demand for labour, estimates of the substitution parameter value was set at 1.5. The short-run elasticity of real investment with respect to rates of return to capital was calculated endogenously. The CRETH product-product transformation parameters are set to 0.15 for multi-product industries. For single-product industries, the estimates are not required.

As shown in Table 3.1, SIGMA1PRIM denotes the constant elasticity of substitution (CES) between the three primary factors, labour, land, and capital, while SIGMA1LAB denotes the CES elasticity between skills types in industry. SIGMA0 represents the constant elasticity of transformation (CET) and governs the behaviour of multi-product industries that choose their output to maximise revenue. SIGMA1, SIGMA2, and SIGMA3 are the Armington elasticities and reflect the degree of substitution between domestic and imported commodities for use in current production, capital formation and household consumption.

The FRISCH parameter shows the relationship between households' total expenditure and their luxury expenditure in the linear expenditure system (LES). We set the value for FRISH at 1. *DELTA* denotes the household marginal budget shares. These are used to calculate the expenditure elasticities in the household demand equations. *EXP_ELAST* is a vector of foreign-demand elasticities for South African commodities.

3.5 The mapping processes

For calibration purposes, the model database distinguishes 40 industries and commodities, and 11 occupation groups. However, in order to simplify the presentation of results in this study, we first aggregated the database to 34 sectors and a single representative household. From there, we disaggregated the agriculture sector and relevant industries within the food manufacturing sector to produce a database that distinguishes 34 industries and commodities. The disaggregation and mapping framework used in this study is presented in Figure 3.7. The core database contains three sets of information, namely:

- **coefficients** representing the basic flow of commodities between users, commodity taxes paid by users and margin flows that facilitate the flow of commodities;
- **behavioural parameters** which are elasticities that influence the degree to which economic agents change their behaviour when relative price changes; and
- **government accounts** which include South African financial accounts with the rest of the World and relevant interest rate parameters.

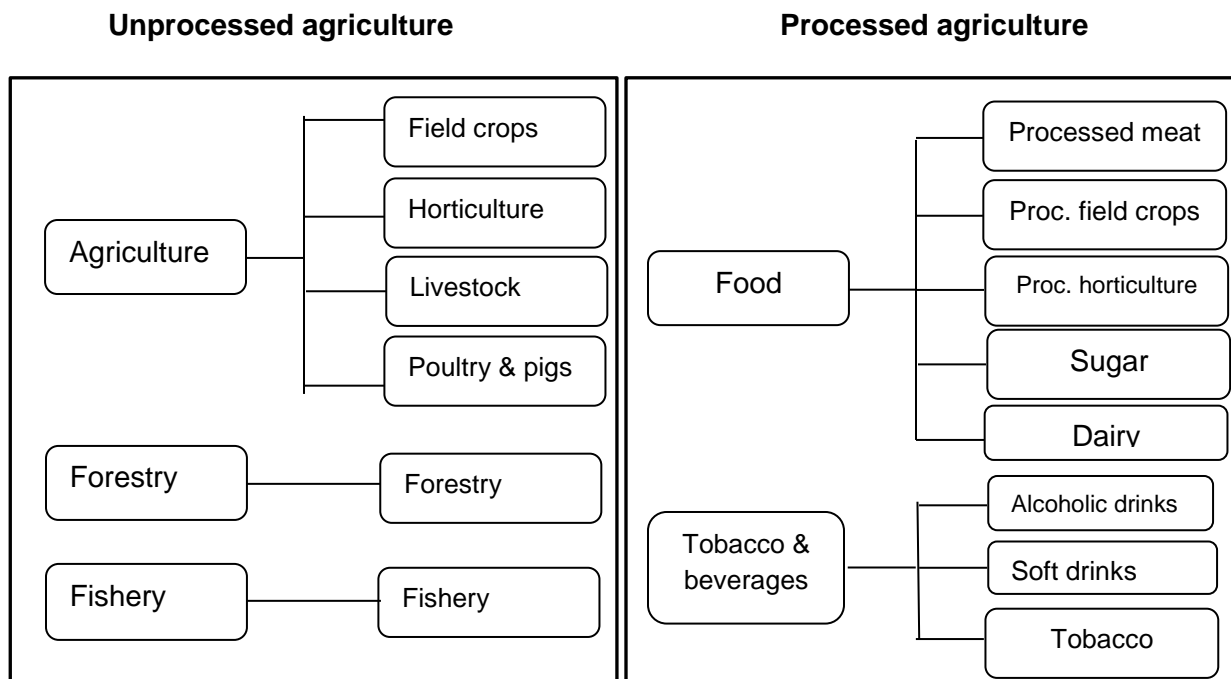


Figure 3.7: Mapping process to disaggregate agriculture and food industries

Source: Author's diagram

3.6 Model closures

The assumptions concerning the choice of endogenous and exogenous variables are known as the 'model closure', and this should reflect the true economic environment in which the shocks were applied as closely as possible (De Wet 2003). Using the comparative static CGE framework, we face a fundamental problem in closing the model. This is because any SAM will have an activity related to investment, yet there is no inter-temporal mechanism for determining the level of this activity in a static model. However, four popular solutions to this problem were identified. The first three are non-neoclassical closures in which investment is simply fixed and another source of adjustment is permitted. In the fourth closure, investment adjusts endogenously to accommodate for any change in savings. This neoclassical closure is the most common one in comparative static CGE models.

In addition to adopting a closure rule with respect to investment, it is necessary to come to grips with potential changes in the current account. The difference between national savings and investment must equal exports, plus international transfers, minus imports. The question is how much of the investment will be financed by domestic savings, and how much by foreign savings. This question is difficult to address in the context of a single region, comparative static model. Therefore, it is common to fix the trade balance exogenously, in which case any change in investment must be financed from national savings. In deciding to exogenise the trade balance, we acknowledge that it is largely a macroeconomic phenomenon.

The changes in global capital markets dictate what will happen on the current account. This approach facilitates analysis by forcing all adjustment onto the current account. Finally, there is

the question of labour market closure. The most common alternatives involve either assuming flexible wages and full employment on the one hand, or fixed real wages and unemployment on the other. Labour market closure plays a significant role in determining the incidence of technological change in agriculture on the rural population, particularly the landless poor (Roos 2013).

To close the model, we chose the variables that are to be exogenous and those to be endogenous (Table 3.2). The number of endogenous variables must equal the number of equations. For a complex CGE model, it may be remarkably difficult to find a workable closure which satisfies these accounting constraints. The model closure settings can be considerably different between the two (i.e. short and long runs). We chose a short-run closure due to the fact that the impact of food price volatility decays over a long term; hence its impact is only significant in the short period. Since the study is aimed at assessing the impact of food price hikes and global financial crisis on the agriculture sector, the study opted for a short-run simulation. In the short run, real wages are exogenous, as economics theory postulates that wages are sticky in the short run. Employment is allowed to vary among industries in the model. The rate of return on capital as well as trade balance is also allowed to be flexible and reacts to the policy shock imposed in the model. Table 3.2 provides the list of the short-run equations in the model.

A choice of closure reflects two different types of consideration. First, the closure is associated with our idea of the simulation timescale - that is the period of time which would be needed for economic variables to adjust to a new equilibrium. The timescale assumption affects the way we model factor markets. Normally, we hold capital stocks fixed in a short-run simulation. The idea is that capital stocks take some time to install - too long for them to be affected, in the short run,

by the shocks. Short-run closures often also allow for rigidities in the labour market: in this case by holding real wages fixed. The length of the 'short' run is not explicit but is usually thought to be between one and three years (Roos 2013).

Table 3.2 The ORANI-G short-run closure

<i>Exogenous variables constraining real GDP from the supply side</i>	
x1cap x1lnd	industry-specific endowments of capital and land
capslack	allows industry-specific rates of return
a1cap a1lab_o a1lnd a1prim a1tot	all technological change
a2tot	
realwage	average real wage
<i>Exogenous settings of real GDP from the expenditure side</i>	
x3tot	aggregate real private consumption expenditure
x2tot_i	aggregate real investment expenditure
x5tot	aggregate real government expenditure
f5	distribution of government demands
delx6	real demands for inventories by commodity
<i>Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes</i>	
pf0cif	foreign prices of imports
f4p f4q	individual exports
f4p_ntrad f4q_ntrad	collective exports
<i>All tax rates are exogenous</i>	
delPTXRATE f0tax_s f1tax_csi	
f2tax_csi f3tax_cs	
f5tax_cs t0imp f4tax_trad f4tax_ntrad	
f1oct	
<i>Distribution of investment between industries</i>	
q	number of households
a3_s	household tastes
<i>Numeraire assumption</i>	
phi	nominal exchange rate

Source: Adapted from Roos (2013)

Secondly, the choice of closure is affected by the needs of a particular simulation and by our view of the most appropriate assumption for those variables that the model does not explain. For example, ORANI-G provides little theory to explain the size and composition of absorption. In Table 3.2 the major expenditure-side aggregates are simply held fixed. Therefore, if some shock reduced GDP, the balance of trade (which is endogenous) might move towards deficit, reflecting national dis-saving. We might wish to prevent this by fixing the balance of trade, $delB$, instead of, say, $x3tot$. This would allow us to use the endogenous $x3tot$ as a simple index of welfare.

3.7 Validation of the model

Model's validation is an important element when a new model is built. The purpose is to ensure a reliable and successful application of the model to policy analysis. CGE modeling has several levels of validation. Since we are dealing with a comparative static model, we consider checks intended to make the model computationally sound; built on up-to-date and accurate data; capable of adequately capturing behavioural and institutional characteristics of the relevant part of the South African economy.

The first step was to show that the model has been correctly computed. Here we look for coding and data-handling errors by means of homogeneity tests. We first run two simulations for which the correct results are known *a priori*, as they exploit some of the model's theoretical features. Then, we test our model by comparing the generated results with the expected outcomes. Since the model is established under neoclassical theory, economic agents' decisions are only affected by relative prices, with nominal prices playing no role. Thereafter, we run a nominal homogeneity test by shocking the numeraire by a certain percentage (5, 10 and 20 per cent). In response, all

endogenous nominal variables change by the same percentage, while the real variables are unchanged. This proves that the ORANI-G Model was correctly specified.

The second step taken was to check the initial data by making sure that national accounts identities are satisfied. This is relevant because the validity of percentage change equations depends on the validity of the data from which the equation coefficients are calculated. We set this up around the fact that the SUT used for the construction of the model's database satisfies a balance condition, according to which the sum of the basic values of activity outputs equals the sum of the basic values of demands for these outputs. It can be argued that a model is computationally sound if its database is balanced as well. We ensure that the model satisfies the balancing conditions by making sure that output of domestically produced commodities equals the total of the demands for them, and the value of output by each industry equals the total of production costs.

We checked the validity of CGE calculations by ensuring that no inconsistency exists between GDP computed on both the income side and expenditure side, in nominal and real terms. Following the theoretical model's assumptions of zero pure profits and market clearing, the GDP identity will continue to hold throughout all simulations, if the model has been properly implemented. We ensured that the database is balanced and no errors in equations exist, as changes in GDP resulting from the aforementioned simulations are the same from both sides. Lastly, we ensured that no inconsistency exists between GDP computed on both the income side and expenditure side. Results analysis is a vital part of quality control for an economic model, as it reveals the model's properties, imperfections, and weaknesses.

3.8 Simulation design

Modifying the closure of the model allows for simulation under different assumptions, time frames, and the ability to apply different shocks to the economy. For all economic modeling, it is imperative when interpreting the results to be aware of the assumptions and restrictions under which the model is run, and how this may influence the various outcomes. We simulated a benchmark scenario that seeks to replicate the main economic facts during the recent global economic crisis.

Four big scenarios comprise this scenario: three crisis scenarios and one public policy scenario. The crisis scenarios seek to replicate the main transmission channels of the global crisis to the South African economy: (1) collapse in global trade, (2) increase in international food prices, and (3) drop in foreign capital flows. The policy response scenario is composed of two different policies implemented by the South African government during the crisis: a fiscal stimulus package that is aimed at boosting domestic demand and creating jobs, while the South African Reserve Bank loosened the monetary policy.

The crisis scenario replicates the main shocks suffered by the South African economy during the global crisis: a trade shock and a fall in capital inflows. As presented previously, the global crisis affected South African economy through two main channels: a fall in export and a fall in international prices of commodities. Together with the negative price or demand shock on export sectors during the crisis, South Africa also received a positive external shock, as international prices of its main import commodities fell as a consequence of the crisis. Regarding the external

financing channel, we simulated the negative financial restriction from the rest of the World via a negative shock in the rest of the World's savings. We took the reduction of Foreign Direct Investment (FDI) (the most important and structural part of capital inflows) to estimate the magnitude of the shock. The FDI declined by 48% between June 2008 and June 2009 (Balance of Payments Statistics, Reserve Bank of South Africa). We simulated this shock via an equivalent reduction of the current account balance.

According to WTO, the global exports declined in 2009 for the first time since 1982. The WTO estimated exports to decline by 10 percent. The simulation scenario was based on this estimates. As noted, the government increased consumption and investment during the period of the crisis, allowing for a higher fiscal deficit. This is aligned with the main objective of this study, namely to decompose the high food prices, the global financial crisis as well as other external shocks, and to estimate the combined impact on agricultural growth, employment and poverty in South Africa.

3.9 Solution Algorithm

A model of this type can be solved in linearised form, using the GEMPACK suite of software (Horridge et al. 2013). Our implementation of the model using this software relies heavily on a code drawn from the ORANI-G Model (Horridge 2003). Linearisation means that most results are presented in the form of percentage changes of variables from their benchmark values. The exceptions are variables with values that may pass through zero – for example, the current account of the balance of payments and the government's budget deficit. These enter the model as levels changes rather than percentage changes.

Models of this type are sometimes criticised as being subject to linearisation errors, so that larger magnitude shocks are associated with larger (and rapidly increasing) errors in predicted outcomes. Single-step solutions of this class of model are vulnerable to this criticism. However, the GEMPACK software we use allows for the use of multiple-step algorithms that render such errors trivially small.

3.10 Concluding remark

In this chapter we discussed the methodology used for the study in detail. The chapter provides interesting insights on the theoretical framework underpinning the computable general equilibrium (CGE). A simple model identifies a single representative consumer, who is assumed to own an initial endowment of a number of commodities and factors, and a set of preferences. Generally, CGE models link economic theory to observed accounting data from countries and regions in order to measure the changes that occur in the data after certain policy variables within the model have been shocked. CGE models thus allow for experimental settings with hypothetical policy scenarios; these settings abstract from reality through assumptions which are common in economic theory. The chapter also discussed in detail the theoretical structure of ORANI-G model. The various data used and how the database was constructed were discussed. Modifying the closure of the model allows for simulation under different assumptions, time frames, and the ability to apply different shocks to the economy. We simulated a benchmark scenario that seeks to replicate the main economic facts during the recent global economic crisis

CHAPTER FOUR

IMPACT OF THE GLOBAL FINANCIAL CRISIS AND HIGH FOOD PRICES ON SOUTH AFRICAN AGRICULTURE

4.1 Introduction

In this chapter, we focus on discussing the results from analysing the impacts of the recent global financial crisis and high food prices on the South African agricultural sector. After producing a credible baseline for the South African economy in 2011, the simulations conducted in this study replicates the main shocks suffered by the South African economy during the global crisis: a trade shock and a fall in capital inflows. As explained in previous chapters, the global crisis affected South African exports through two main channels: a fall in external demand and a fall in international prices of commodities. The trade channel is particularly significant for open and export-oriented industries. During the economic growth period, budget surpluses may reflect large export earnings, thanks to the high prices of raw materials and booming external demand. During economic downturns, however, external shocks may suddenly worsen economic indicators (Reisen 2009).

4.2 Simulations

It is important to emphasise that the selected short-run model closure implies that capital, government and household consumption are all exogenous. This means they are kept constant to the baseline. The economic theory informing/underlying these rules postulate that wages are

sticky in the short run and employment is fluid, implying industries can absorb or reduce employment to adjust to changing prices. Industries do not necessarily change capital in the short run.

4.3 Simulation results – scenario 1

4.3.1 Macroeconomic results

In this section, we focus on how a decline in overall exports impacts on some selected macroeconomic indicators. Readers unfamiliar with CGE modelling and the percentage deviation approach should again note that this result is relative to the unperturbed baseline scenario. In our first scenario, a 10 per cent fall in overall exports lead to a -0.35 per cent decline in real GDP, and a -8.3 per cent decline in rate of return on capital (Figure 4.1). The GDP is one of the main indicators by which we can measure the performance of a country's economy. With the GDP slowing down at -0.35 per cent, this is likely to lead to fears of a bad economic outlook that may translates to downsizing, a rise in unemployment, a decline in business revenues, and low consumer spending. The decline in export directly affects export-oriented industries such as agriculture, manufacturing, and mining, while indirectly having a negative impact on secondary industries such as the textile and retail industries.

As a consequence of weakened export competitiveness, the terms of trade also decline, causing different sectors to react by labour retrenchment; hence our simulation result shows employment fall by -1.13 per cent as illustrated in Figure 4.1. The labour market outcomes in South Africa were severe. During the economic growth period, that is, before 2007, about 1.6 million net jobs were created, while during the global financial crisis, that is, from 2008 to 2010, roughly more than 1

million net jobs were lost in all sectors of the economy (Figure 4.2). As the GDP contracted, unemployment increased. As illustrated in Figure 4.2, about 14 million people were employed in South Africa before the full negative impact of the global financial crisis in 2008. Though the economy is slowly recovering from the global downturn in 2011, growth has been sluggish. About 646, 000 jobs have since been added, but this is still less than the number of South African citizens employed before the start of the global financial crisis. The fall of production in export sectors leads to a decrease in government direct and indirect tax revenues. Therefore, as we assume constant public consumption expenditures, government income and savings fall, leading to a fall in total investment in the economy, as we adopt a savings-driven closure in the model.

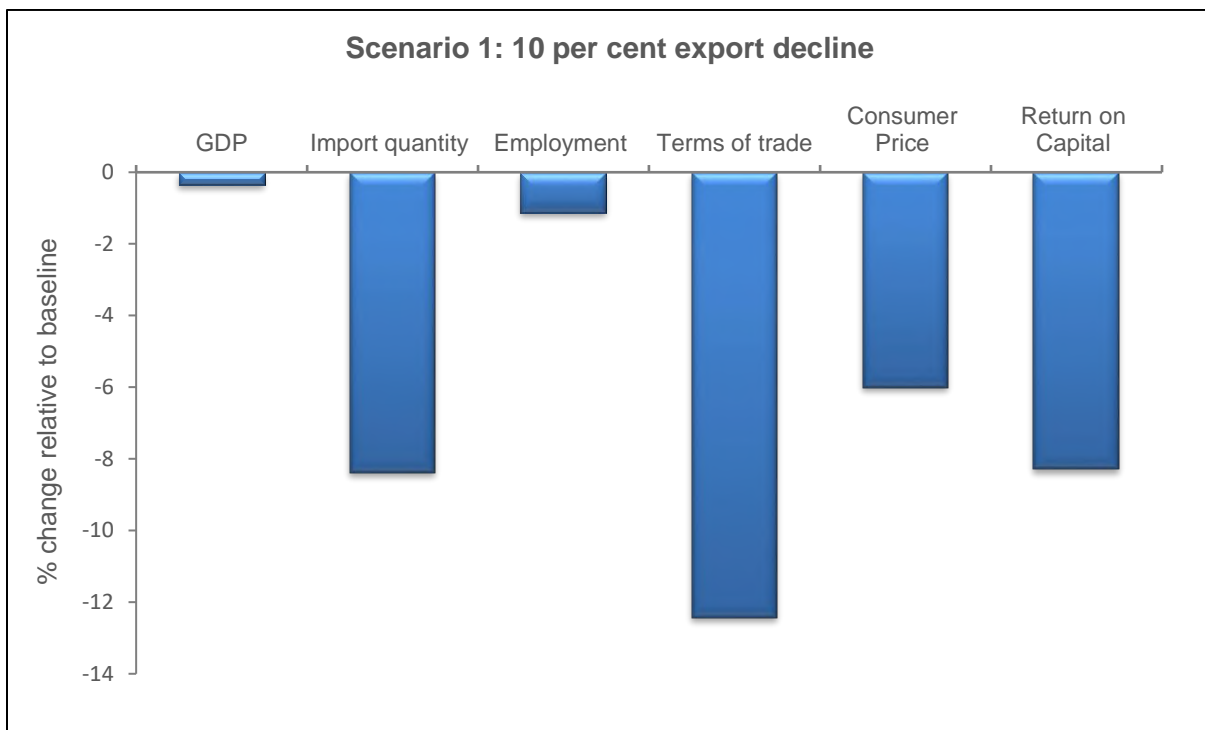


Figure 4.1: Impact of global crisis on selected macroeconomic variables (% variation)

Source: Author's Depiction

The terms of trade were the most affected under this scenario. The terms of trade declined by -12.4 per cent. This implies that worsening South African terms of trade harm the country in the sense that the country can only buy fewer imports for any given level of exports. The terms of trade are typically significant and robustly determinant of economic growth. While the positive relationship between terms of trade and growth has been clearly identified, growth is slower in economies where there is a declining terms of trade. The terms of trade may be influenced by the exchange rate, since a rise in the value of a country's currency lowers the domestic prices of its imports but may not directly affect the prices of the commodities it exports. Both growth and investment are higher when the terms of trade are more favourable. Therefore, since the terms of trade worsen under this scenario, the incentive to invest in the export sector is not guaranteed.

Figure 4.1 shows imports and consumer price decline by -8.39 and -6.02 per cent respectively. In case of food products, it is easier to justify the decline given the decrease in exported value and subsequent greater supply of food available domestically. Although government and household consumption is kept constant to the baseline, that is exogenous, the household price increases significantly as economic growth is lowered. A 10 per cent fall in exports leads to a decline in the overall consumption level. The reduced foreign demand leads to underutilisation of capital, which is also kept constant to the baseline, and subsequently causing the capital rental to decrease. The rate of return on capital declines by -8.29 per cent.

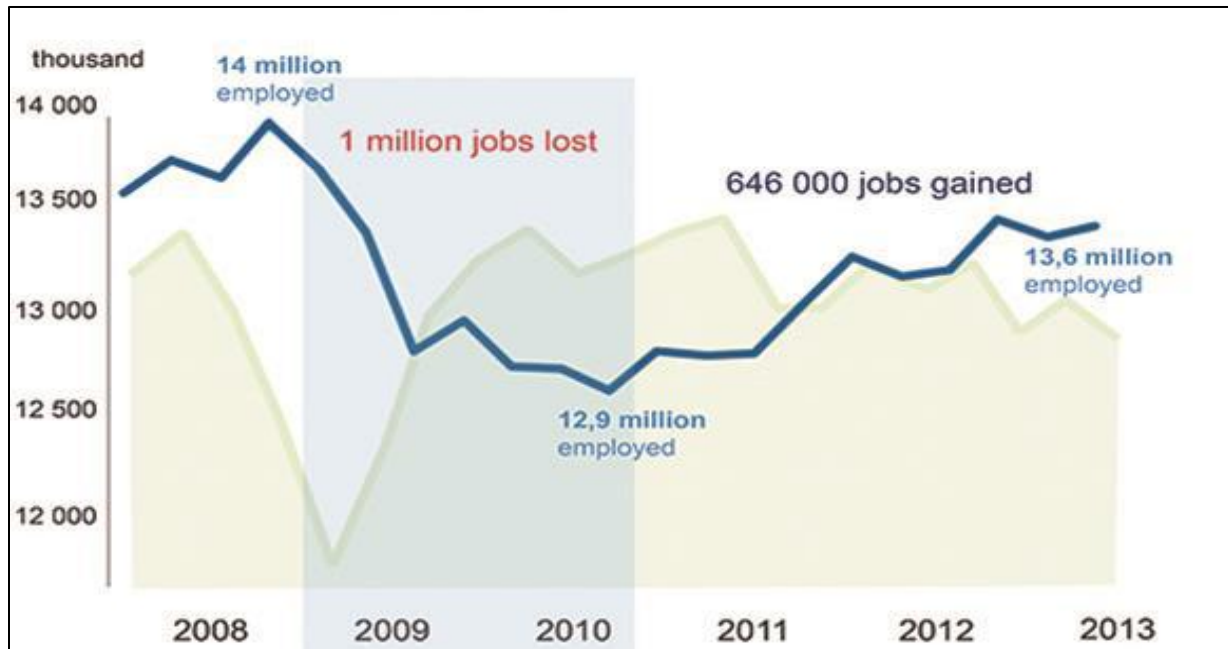


Figure 4.2: Impact of crisis on GDP and employment

Source: Statistics South Africa

4.3.2 Sectoral results under scenario 1

Table 4.1 reports the sectoral effects of the policy shocks, and as stated earlier, all results are shown as percentage changes with respect to the base year. The decrease in export demand does not affect all sectors of the economy in the same way. The sectoral results inform us about how various sectors of the economy were affected after the shock was simulated. Our sectoral focus is the agricultural sector. The model distinguishes six primary agricultural industries; eight food industries and 20 other industries covering mining; manufacturing; energy; government; transport; retail and other sectors.

The main objective of the study is to examine the impact of the global financial on agricultural production and trade. First thing we noted was that measured in terms of production expansion, the agricultural sector experience higher loss in output expansion because it is an export-oriented industries. As was mentioned under the macroeconomic result section, South African exports are dominated by the mining, agriculture and manufacturing industries. The analysis revealed a marginal decrease in output and factor demand in primary agricultural export, as well as in the food and light manufacturing industries.

The global financial crisis significantly affects the fruit and vegetable, fisheries, processed food and alcoholic drinks industries. Production output for fruit and vegetables declined by -2.18 per cent, fisheries declined by -1.38 per cent, processed food declined by -0.94 per cent, while alcohol declined by -1.72 per cent (Figure 4.3). The manufacturing sector is dominated by a few large sub-sectors, specifically chemicals, metals, and machinery, as well as food processing. Production output for this sector declined by -4.2 per cent. Many South African manufacturing sub-sectors are domestic market oriented, while others are highly reliant on export markets, and hence the manufacturing sector was adversely impacted upon by the global economic downturn, mainly due to weakened demand in traditional markets such as Europe, as well as tough domestic trading conditions. The output in the mining sector fell by -3.73 per cent. In terms of production output, the crisis has a clear negative impact on the primary agricultural export sector (Figure 4.3).

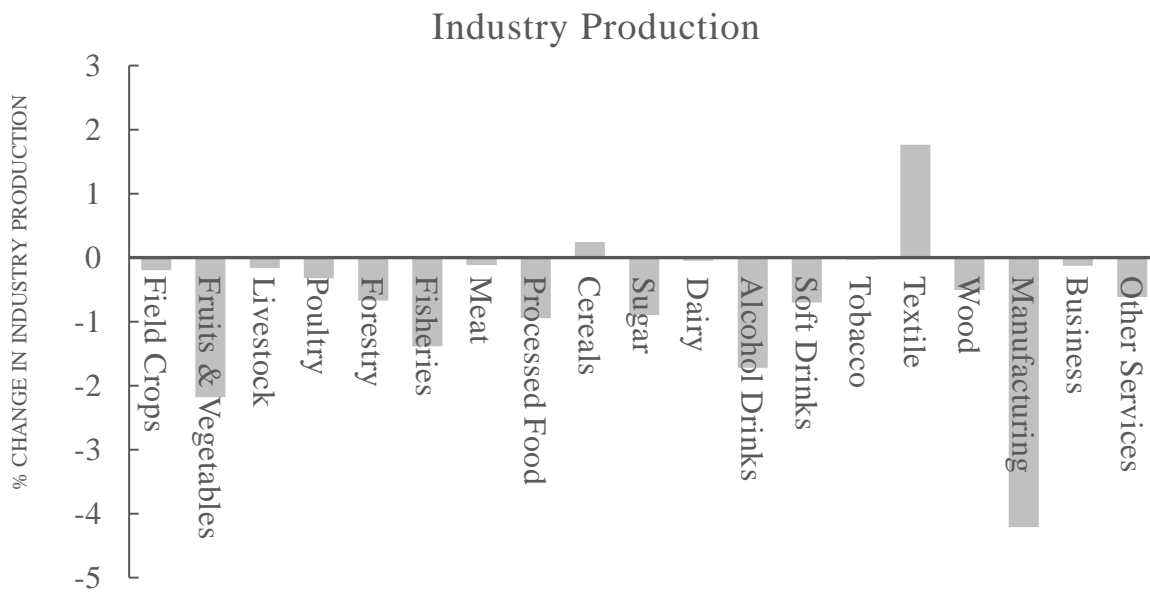


Figure 4.3: Percentage change in agricultural production

Source: Author's Depiction

The decline in agricultural production negatively impacts on agricultural trade during the financial crisis. Countries usually produce first for their domestic markets and then export what is left. Thus, in period of shortage they will export less than normal, and in period of surplus they will export more than normal. Since food and agricultural products have a low price elasticity of demand¹, prices will be highly volatile. This means that a small drop in the volume being traded can result in a rapid increase in the price, and that a small rise in volumes traded can result in a rapid drop in the price.

¹ A low price elasticity of demand means that, while there is an inverse relationship between price and demand (the cheaper a product is, the more likely people will be to buy it), the movement in demand does not move as rapidly as the opposite movement in price. This is the case for food and agricultural products because people have to eat regardless of the cost of food. Likewise, once people have enough food to eat, they are not likely to buy much more even if the price is very low.

The sectoral analysis also revealed decline in the prices of food items (Figure 4.4). The domestic price of field crops (legumes, oil seed, sugar cane, and fodder crops), fruits and vegetables, cereals, sugar, and forestry declined by -6.88 per cent, -9.51 per cent, -5.51 per cent, -7.69 per cent, and -11.13 per cent respectively, while the domestic price of processed meat, poultry, fisheries, and livestock also fell by -6.53 per cent, -6.39 per cent, -13.05 per cent and -6.20 per cent respectively (see Figure 4.4). The largest decrease is seen for forestry and alcoholic drinks, which declined by -11.13 per cent and -10.64 per cent respectively. There is a fall in the domestic price of processed food and tobacco. The fall in domestic price is attributable to the decrease in agricultural exports. The prices of coal and electricity, which remain of crucial importance to the sectoral sector, decreased by -16.41 per cent and -8.54 per cent respectively. The prices of manufactured items decreased by almost -7.25 percent. On the service side, there was a decline in the consumer prices in public services.

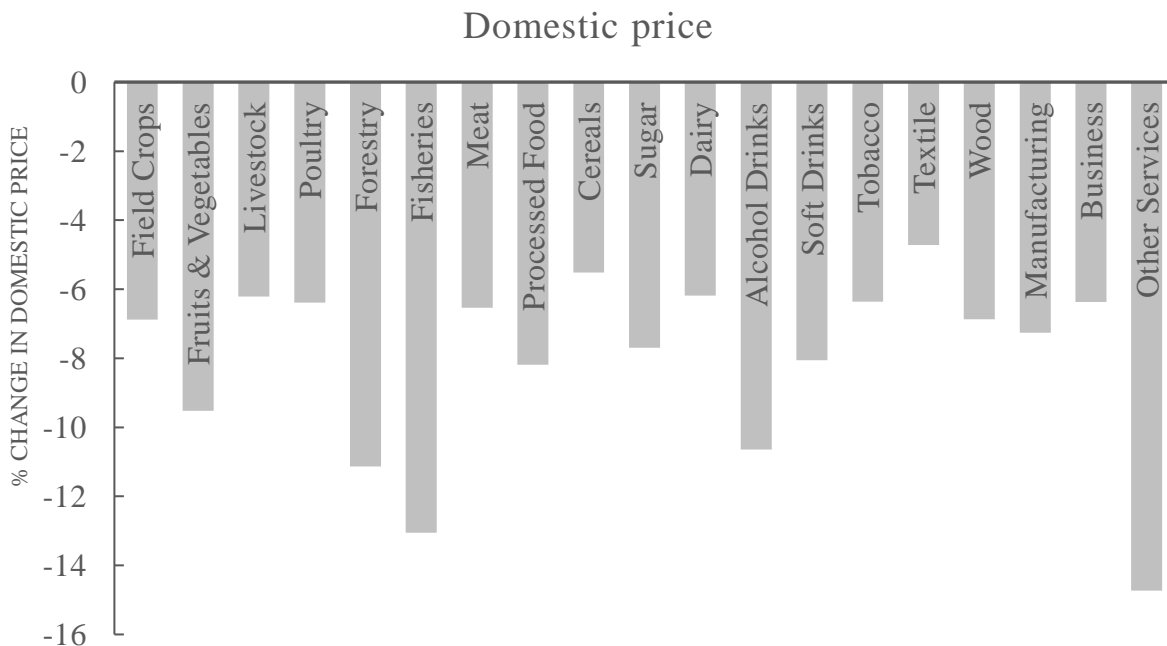


Figure 4.4: Percentage change in domestic price

Source: Author's Depiction

The sector-wise analysis shows there was a fall in household demand. The demand for field crops, fruit and vegetables, poultry, fisheries, meat, cereal and dairy products fell by -3.61 per cent, -5.43 per cent, -4.32 per cent, -6 per cent, -4.12 per cent, -3.57 per cent and -4.30 per cent respectively (see Figure 4.5). We also observed that household demand for manufacturing and service sectors declined. This is not unexpected, as one of the effects of overall export decline is job loss in various sectors. One of the possible reasons adduced to fall in household demand can be the rise in unemployment. A worsening economic situation will impact negatively on household demand and consumption. The decline in household consumption expenditure reflects the rigorous pressure on the financial health of South African households. This was due to market dwindling in the fundamental drivers of household income. The rush in inflation during 2014, rising interest rates, elevated levels of household indebtedness and negative wealth effects arising from the decline in asset prices, particularly residential property and equity prices, have had a negative impact on the household real disposable income.

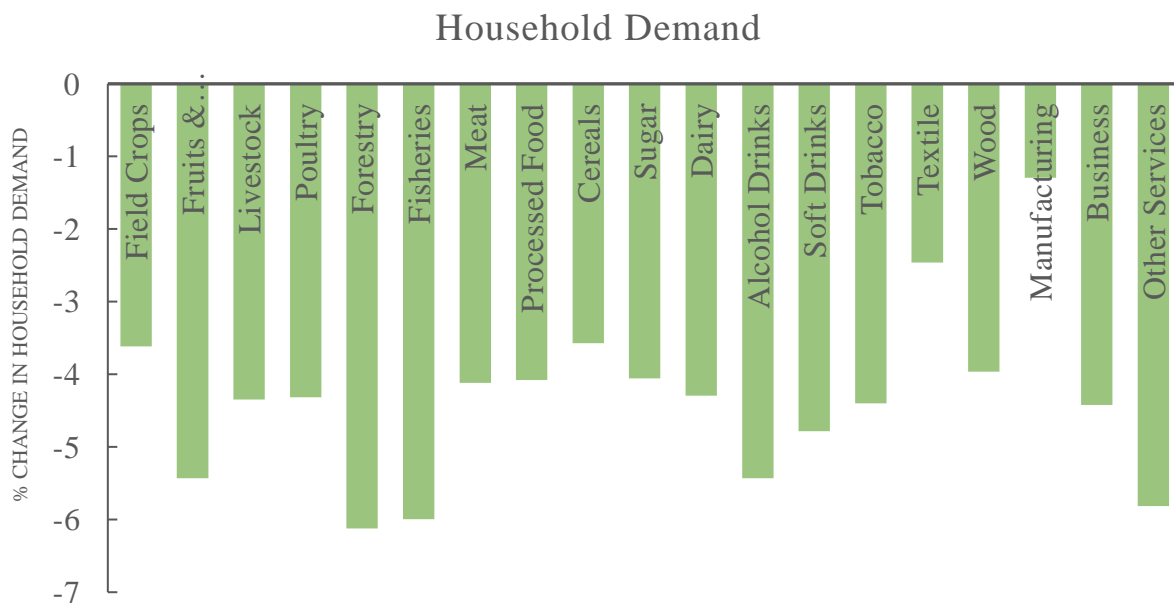


Figure 4.5: Percentage change in household demand

Source: Author's Depiction

For the labor market, unskilled workers are negatively affected, especially those employed in agricultural sectors. The sector is one of the biggest employers in the South African economy. It is also imperative to stress that the sector is labour intensive compared to other sectors, thus, it employs about 4.6 per cent of the total labour force. The mining and manufacturing sectors, in comparison, represent 8.5 per cent and 12.5 per cent of the economy, whilst employing only 2.3 per cent and 11.8 per cent of the labour force respectively (Figure 4.6).

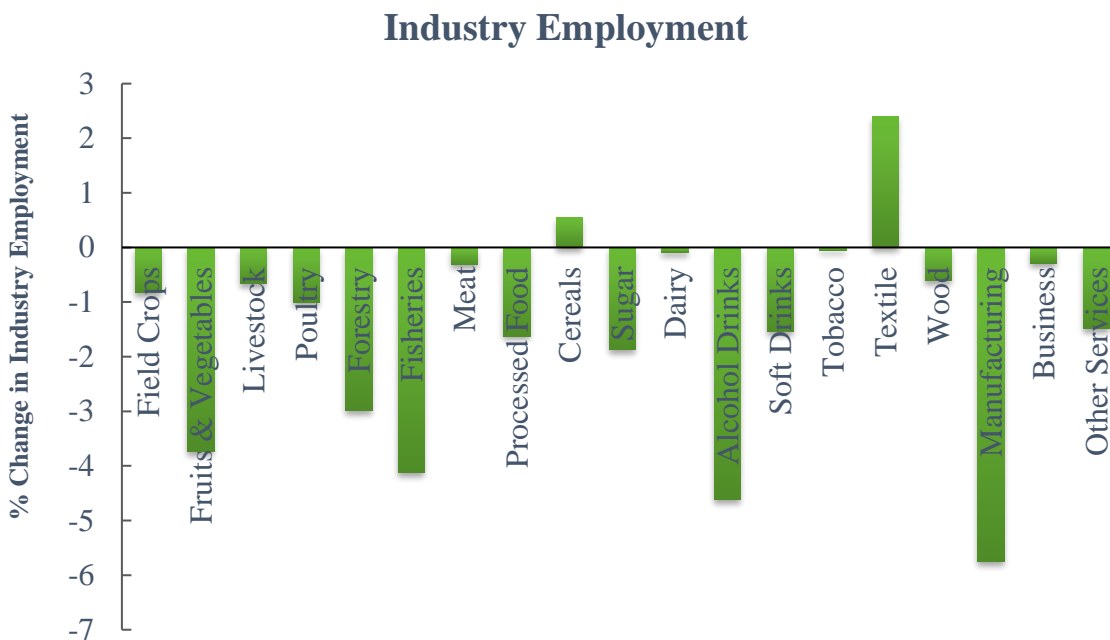


Figure 4.6: Percentage change in employment in agriculture sector.

Source: Author's Depiction

At the broad sector level, substantial job losses were reported in sectors such as agriculture, forestry and fishing, manufacturing and in the construction sector from the sector analysis, and this led to an increase in unemployment. Figure 4.6 illustrates that in the agriculture sector, the hardest hit in terms of job loss are fisheries, which fell by -4.12 per cent of their labour force, while

fruit and vegetables, forestry and poultry lost -3.73 per cent, -2.98 per cent and -1.01 per cent respectively. The coal and mining sectors decline by -9.73 per cent and -9.66 per cent of labour force respectively, while manufacturing fell by -5.75 per cent. It is clear from the analysis that the South African economy is not creating jobs. People are losing jobs in large numbers, which shows that the economy is not growing, as job losses have been recorded in all industries, except in textile (2.40 per cent), petroleum (0.23 per cent), plastic and rubber (0.99 per cent) and retail services (0.39 per cent). South Africa has been plagued by structural unemployment for many years, and therefore job losses recorded in crisis periods are proving extremely difficult to recoup.

Due to the decline in agricultural and services sector prices, consumption levels increase for households having a larger budget share of necessity items. Households that face the highest decline in consumption are the rural poor that spend a larger percentage of their income on food. The declining exports are observed to have contributed to rising poverty and inequality levels in the country. It can be argued that the impact on poverty is likely to be caused by a combination of factors such as declining income levels; already stressed coping strategies among vulnerable households owing to the food and fuel prices crisis; and inadequate safety nets. The most immediate and direct effects are estimated to be on household incomes and consumption, as well as labour and non-labour income.

Table 4.1. Sectoral results for scenario 1 (% variation)

Sector	Output	Domestic price	Employment	Household demand	Factor cost
1. Field crops	-0.20	-6.88	-0.83	-3.61	-0.20
2. Fruit & vegetables	-2.18	-9.52	-3.74	-5.43	-2.18
3. Livestock	-0.16	-6.21	-0.66	-4.35	-0.16
4. Poultry	-0.32	-6.39	-1.01	-4.32	-0.32
5. Forestry	-0.67	-11.13	-2.98	-6.12	-0.67
6. Fisheries	-1.39	-13.06	-4.13	-6.00	-1.39
7. Processed meat	-0.12	-6.53	-0.32	-4.12	-0.12
8. Processed food	-0.94	-8.19	-1.62	-4.08	-0.94
9. Cereals	0.24	-5.52	0.55	-3.57	0.24
10. Sugar	-0.90	-7.69	-1.87	-4.06	-0.90
11. Dairy	-0.05	-6.18	-0.09	-4.30	-0.05
12. Alcoholic drinks	-1.72	-10.64	-4.62	-5.43	-1.72
13. Soft drinks	-0.70	-8.06	-1.53	-4.78	-0.70
14. Tobacco	-0.03	-6.36	-0.05	-4.40	-0.03
15. Textile	1.76	-4.72	2.40	-2.46	1.76
16. Wood	-0.50	-6.87	-0.61	-3.96	-0.50
17. Manufacturing	-4.21	-7.26	-5.75	-1.29	-4.21
18. Coal	-4.46	-16.42	-9.73	-7.10	-4.46
19. Crude gas	1.08	-4.11	2.72	-1.07	1.08
20. Mining	-3.73	-24.16	-9.66	-0.25	-3.73
21. Petroleum	0.04	-7.42	0.23	-2.96	0.04
22. Plastic rubber	0.91	-5.96	0.99	-2.98	0.91
23. Metal steel	-0.37	-6.90	-0.68	-3.95	-0.37
24. Chemicals	-0.30	-8.65	-0.44	-2.55	-0.30
25. Electricity	-0.09	-8.55	-0.25	-5.23	-0.09
26. Water	-0.05	-7.05	-0.23	-4.83	-0.05
27. Construction	-0.06	-5.65	-0.14	-4.31	-0.06
28. Retail	0.19	-5.03	0.39	-2.15	0.19
29. Hospital	-0.68	-8.38	-1.70	-3.25	-0.68
30. Transport	-0.05	-6.18	-0.15	-2.96	-0.05
31. Business	-0.13	-6.37	-0.30	-4.42	-0.13
32. Telecom	-0.34	-7.18	-1.01	-4.41	-0.34
33. Government	-0.04	-5.89	-0.05	-4.40	-0.04
34. Other services	-0.62	-14.73	-1.48	-5.81	-0.62

Note: Scenario 1 is a 10% decrease in export.

Source: Author's Simulation results

4.4 Simulation results – scenario 2

4.4.1 Macroeconomic results

In this section, we focus on the impacts of high food prices on the South African economy, although many thoughtful analyses have addressed the causes and impacts of high and volatile international food prices and proposed solutions to the crisis. However, food price problems have far-reaching implications, and its impacts are wide and interrelated. The price formation mechanism is highly complex and dynamic in nature. Policy actions to combat these problems are politically and economically sensitive. Hence, the situation calls for continuous and comprehensive assessment of the problem to provide timely and evidence-based knowledge for policy makers.

Under scenario 2, the impact of high food prices on production in the agricultural sector was examined. The analysis revealed a decline in GDP (-0.03 per cent), terms of trade (-0.12 per cent), export quantity (-0.25 per cent) and import quantity (-0.17 per cent). The worse impact was on the rate of return on capital, which declined by -8.29 per cent (see Figure 4.7). However, the consumer price increased as expected, by 0.35 per cent in response to the increase in import price. Evidence shows that the effects are minimal in the economy, indicating a low share of the agricultural sector to the entire economy. From the database, agriculture contributes approximately 2.5 per cent to GDP and less than 9 per cent to employment. As a result of limiting the shock to food industries, the aggregate employment reacts slightly by only losing 0.06 per cent in employment relative to the baseline.

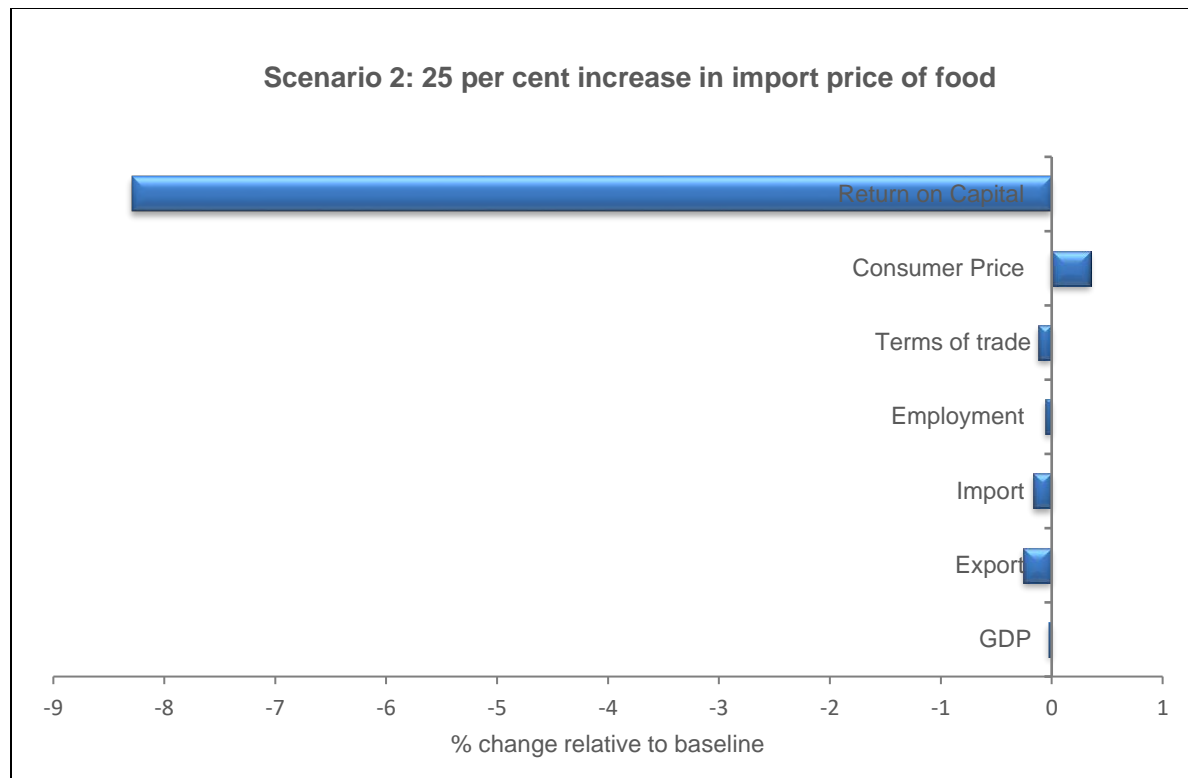


Figure 4.7: Percentage change in selected macroeconomic variables

Source: Author's Depiction

4.4.2 Sectoral results under scenario 2

The sector-wise analysis of the high food prices on production in the agricultural sector was examined under this scenario. The production output for field crops increased by 0.83 per cent, poultry by 0.35 per cent, and livestock output increased by 0.17 per cent. However, the output of some food groups declined. This includes processed meat, cereal, sugar and tobacco, which fell by -0.26 per cent, -0.29 per cent, -0.65 per cent, and -0.27 per cent respectively (Figure 4.5). This scenario tends to benefit those industries that rely less on imported intermediate inputs. However, production output for cereals, processed meat, and tobacco, which import a large amount of

intermediate inputs, tend to suffer under scenario 2 policy shocks. Field crops, which are easily substitutable with imported products, (e.g. South Africa imports 50 per cent of its wheat) benefitted the most under inflated imported food prices.

The value of agriculture imports in 2016, for example, stood at R102 660.3 million which is 9.4 per cent of the total import for South Africa (DAFF 2016). However, food imports in South Africa were reported to be 6.14 per cent of total import. The food imports mainly included wheat and meslin (R6 157 million), rice (R5 126 million), poultry (R4 306 million), un-denatured ethyl alcohol (R3 667 million) and palm oil (R3 632 million), which accounted for the highest imports in terms of value. While the general equilibrium impact of this simulation led to a fall in food consumption, the exchange rate effect led to a decrease in imports of some food items. Depreciation in the value of the Rand against relevant foreign currencies makes import products such as maize, wheat, and oilseeds more expensive in Rand terms, thereby providing some protection for South African farmers, and an incentive to increase production in the medium to longer term.

Employment in the field crops industry increased by 3.81 per cent, in poultry by 1.14 per cent, and in fisheries by 0.33 per cent. However, employment declined in the processed meat (-0.70 per cent), processed food (-0.22 per cent), cereal (-0.65 per cent), sugar (-1.37 per cent) and tobacco (-0.47 per cent) industries. Agricultural and informal sector workers did not experience the price shock early on. Nevertheless, they were affected more indirectly through reduced demand, increased competition from laid-off factory workers, and reduced remittances. Many informal sector workers struggled even before these crises. They were affected the most and for the longest period, and hence recovery is difficult. The results reveal factor cost increase slightly under this scenario 2 for field crops (0.83 percent), poultry (0.35 per cent), and livestock (0.17 per

cent). For others such as processed meat (-0.26 per cent), sugar (-0.66 per cent) and tobacco (-0.27 per cent), factor costs declined.

Sector-wise analysis of an increase in the import price of food also reveals sharp increases in the prices faced by the domestic consumers. In the agricultural sector, the largest increase is seen for the field crops (6.79 per cent), followed by poultry (2.28 per cent), livestock (1.61 per cent), sugar (1.50 per cent) and tobacco (1.17 per cent). An increase in prices of intermediate inputs for the industrial sector is also expected as prices of chemicals, petroleum refining and electricity increase marginally by 0.09, 0.10 and 0.14 per cent respectively. The prices for public and business services also increased by 0.27 and 0.20 per cent respectively (see Table 4.2).

There is a sharp decline in household demand by domestic consumers (see Figure 4.8). Household demand for field crops declined by -10.48 per cent, fruit and vegetables by -13.84 per cent, livestock by -13.55 per cent, poultry by -13.15 per cent, fisheries by -13.66 per cent, and forestry by -14.15 per cent. An increase in food price may cause: 1) a direct impact where real income declines due to job loss, and expenditure on non-essential categories such as health and education will suffer, and 2) an indirect effect where hunger and malnutrition (among other indicators) worsen, as there is a reduction in the calorie intake. Our results show that the impact of an increase in the import price of food has a regressive impact on household consumption. High and rising food prices undermined food security and threatened the livelihoods of the most vulnerable, by eroding their already limited purchasing power.

A rise in food prices affects poor people in several ways. The most important effects are a decrease in real income and increased income unpredictability. An increase in food prices tends to give rise to substantial consumer welfare loss. The rural poor tend to have a high food expenditure share and a low supply response, so there is a decline in their real income. These people are highly vulnerable to food price spikes. Consumers' responsiveness to changes in prices and real income determines the size of the total impact of rising food prices. Food consumption loss is large for highly responsive people. The higher the elasticity of demand for food, the higher the impact on consumption is. Poor people respond to price changes more strongly than the rest of the population by changing caloric intake.

High food prices can also lead to a draw-down on asset. The poor often borrow money for consumption or use up their small working capital, and by doing so they become indebted in ways that are very difficult to recover quickly. The overall impact of assets draw-down reflects in the long-term income-generation capacity of the poor. Therefore, high food prices increase and prolong poverty, making income distribution more unequal. The study by Zezza, Davis, Azzarri, Covarrubias, Tasciotti, and Anriquez (2008) also found that the poorest households in both urban and rural areas are the worst affected by high food prices. Rising food prices affect different income groups differently. If high food prices are not compensated through increased income, the real income of non-food resource owners' declines, and the income of net food producers increases.

The impact of high food prices lasts longer than the temporary increase in poverty and hunger. One long-term effect is the impact on child nutrition and health. Empirical evidence suggests that under-nutrition in early childhood harm physical and mental development, which has negative

consequences for lifetime earnings. High food prices raise malnutrition through both income and substitution effects for consumption (Zezza et al. 2008).

Whenever there is an increase in the price of food, people often shift from more nutritious food to less nutritious food. This leads to reduced consumption of dietary energy and also worsens the distribution of food calories within the household. Income effects, on the other hand, reduce the capacities of households to spend on health, which further increases the risks for malnutrition. Food insecurity was by far the most severe and widely felt impact by the poor and the vulnerable in South Africa. This was more pronounced, as these crises were compounded by local shocks like the prolonged drought in South Africa in 2015/16. Low income households, which spend a large proportion of their income on those tradable staple foods of which the prices increase substantially, are likely to be the ones whose overall welfare will be the worst affected. Households that derive a large proportion of their income from the production and sale of those goods were positively affected. Furthermore, wealthier consumers will respond to higher prices differently by spending more on buying what they would have purchased.

The fact that the poor are hit the hardest by rising food prices in both urban and rural areas is clearly a cause for concern. The loss of real income in poor households not only harms their current ability to cover basic needs but has the potential to do so for some time to come, thus weakening their prospects of escaping poverty. Poor households may be forced to cope with the added stress of high food prices by depleting their asset base, reducing the number or variety of meals they consume or reducing spending on essential non-food expenditures, such as health and education, thereby increasing their vulnerability.

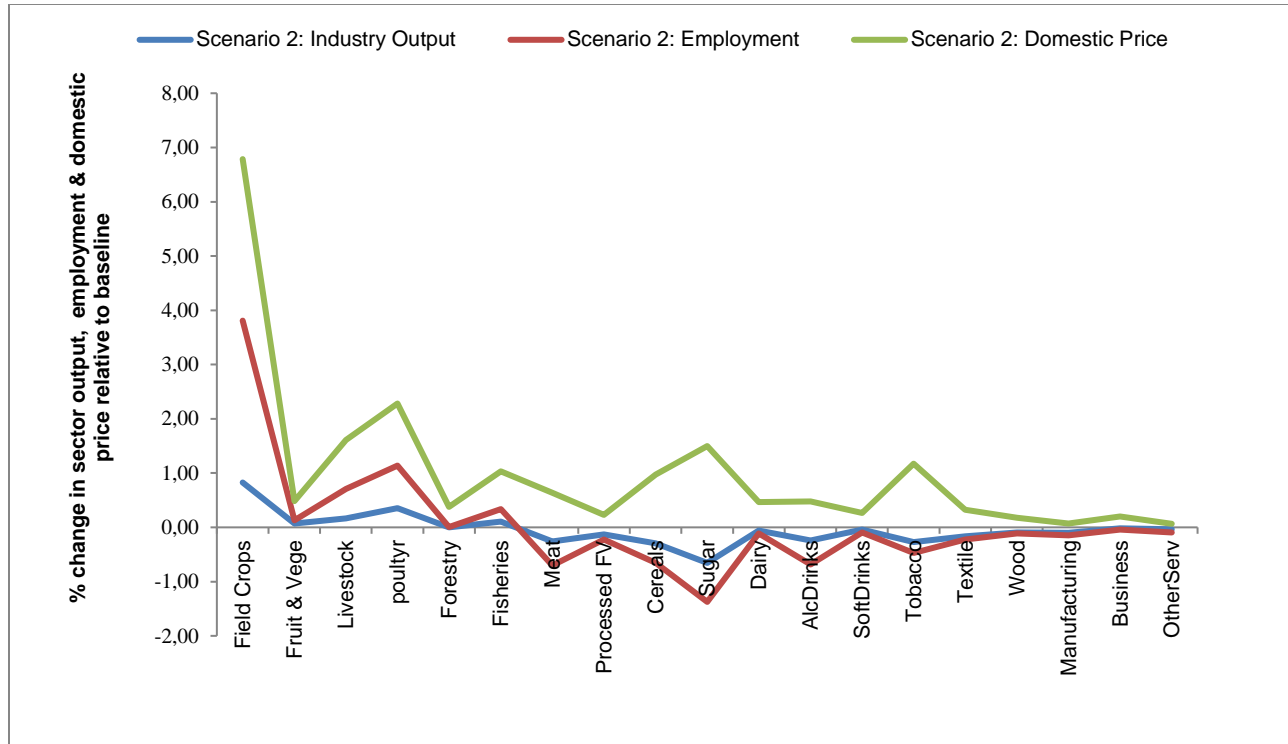


Figure 4.8: Percentage change in sector output, employment, and domestic price

Source: Author's Depiction

In addition to the short-run impacts that high food prices have on poor consumers in South Africa, as discussed earlier, from the long-run economic point of view, there are undesirable consequences. Consumers and investors' confidence are being eroded by unexpected commodity fluctuations. The negative impact of high food prices on households was also confirmed by many authors, such as Von Braun (2008b), Ruel, Garrett, Hawkes, and Cohen (2010), and Ivanic and Martin (2014). However, they argue over the different impacts of high food prices in the short term and long term on farming households. These authors found that long-term effects are favourable for farming households, as supply elasticity is greater than demand elasticity, so poverty reversals can be important for crop (maize, rice, and wheat) producers.

Overall policy interventions at national and local levels should concentrate on reducing price spikes and protecting poor people from the short- and long-term effects of food crises.

4.1 Concluding remarks

The financial crisis brought about a reduction in global output and demand, and these had far-reaching, severe consequences for South Africa. The openness of the South African economy and the highly concentrated nature of the export basket make the country extremely vulnerable to global economic developments. Since the financial crisis shrinks the volume of trade, we see a negative impact on South Africa through a decline in GDP, worsening terms of trade and an increase in unemployment. At the sectoral level, the impacts are more pronounced in the primary export sectors like agriculture and processed food.

On the spike in global food prices, the analysis provides a number of interesting insights. In particular, it reveals a decrease in household demand for food, a decrease in income and increased income unpredictability. High food prices lead to substantial household welfare loss, and this could have long-term negative effects. There are clear links between higher food prices, lower caloric intake, lower quality diet, and an increase in child malnutrition. Children are principally vulnerable to hunger and malnutrition. This can affect their ability to learn, and it may hinder them from attending school altogether.

The domestic economy faces a period in which agricultural commodity markets are volatile due to their strong links with natural shocks, heightened financial market volatility, and diminished

consumer confidence. The recent loss of confidence in South African markets will contribute to a large extent to the decline in international capital flow to the country. Improvements in confidence are likely to drive up investment and domestic consumption. The high level of unemployment calls for bold structural reforms to boost the economy and job creation in the agricultural sector.

While the financial and food crises developed from different underlying causes, they are becoming intertwined in complex ways through their implications for financial and economic stability, food security, and political stability. The high food prices has added to general inflation and macroeconomic imbalances to which South African governments must respond with financial and monetary policies. At the same time, the financial crisis and the accompanying economic slowdown have pushed food prices to lower levels by decreasing household demand for agricultural commodities. Moreover, as capital becomes difficult and more expensive to get, in addition to stagnation in consumer spending, the expansion of agricultural production to address the high food prices has been cut short. The fact remains that agricultural growth is crucial for resolving food price crises and enhancing food security.

Table 4.2: Sectoral effects of scenario 2 (% variation)

Sector	Output	Domestic price	Employment	Household demand	Factor cost
1. Field crops	0.83	6.79	3.81	-10.48	0.83
2. Fruit & vegetables	0.07	0.48	0.13	-13.84	0.07
3. Livestock	0.17	1.61	0.71	-13.55	0.17
4. Poultry	0.35	2.28	1.14	-13.15	0.35
5. Forestry	0.00	0.38	0.01	-14.15	0.00
6. Fisheries	0.10	1.03	0.33	-13.66	0.10
7. Processed Meat	-0.26	0.64	-0.70	0.31	-0.26
8. Processed Food	-0.13	0.23	-0.22	0.18	-0.13
9. Cereals	-0.29	0.97	-0.65	0.33	-0.29
10. Sugar	-0.66	1.50	-1.37	0.44	-0.66
11. Dairy	-0.06	0.47	-0.11	0.27	-0.06
12. Alcoholic drinks	-0.24	0.48	-0.69	0.27	-0.24
13. Soft drinks	-0.04	0.26	-0.10	0.21	-0.04
14. Tobacco	-0.27	1.17	-0.47	0.50	-0.27
15. Textile	-0.17	0.32	-0.22	0.14	-0.17
16. Wood	-0.09	0.18	-0.11	0.17	-0.09
17. Manufacturing	-0.10	0.07	-0.15	0.12	-0.10
18. Coal	-0.05	0.04	-0.13	0.14	-0.05
19. Crude gas	-0.07	0.05	-0.18	0.11	-0.07
20. Mining	-0.04	0.01	-0.11	0.12	-0.04
21. Petroleum	-0.02	0.10	-0.08	0.14	-0.02
22. Plastic rubber	-0.13	0.21	-0.14	0.15	-0.13
23. Metal steel	-0.05	0.12	-0.09	0.16	-0.05
24. Chemicals	-0.06	0.09	-0.09	0.13	-0.06
25. Electricity	-0.02	0.14	-0.05	0.18	-0.02
26. Water	0.00	0.29	0.00	0.24	0.00
27. Construction	0.00	0.17	0.00	0.19	0.00
28. Retail	-0.06	0.05	-0.13	0.13	-0.06
29. Hospital	-0.06	0.10	-0.15	0.14	-0.06
30. Transport	-0.03	0.07	-0.10	0.13	-0.03
31. Telecom	-0.03	0.10	-0.08	0.16	-0.03
32. Business	-0.02	0.20	-0.04	0.20	-0.02
33. Government	0.00	0.27	0.01	0.23	0.00
34. Other services	-0.04	0.07	-0.09	0.14	-0.04

Note: Scenario 2 is a 25% increase in the import price of food.

Source: Author's simulation results

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Overview of study

The findings from the analysis generally address the main objectives of this study, which sought to investigate: (1) the impact of the global financial crisis; (2) the impact of high food prices on the South African agricultural sector; and (3) the impacts of the crises on local food prices, employment, household consumption and nutrition. This concluding chapter seeks to provide a summary of the principal findings and implications of the study.

To conduct our analysis, we used the ORANI-G Model for South Africa. ORANI-G is a comparative static computable general equilibrium (CGE) model that compares two points in time. ORANI-G belongs to the Walras-Johansen class of economy-wide CGE models that provide industry-level disaggregation in a quantitative description of the entire economy. An overview of the theoretical structure of the ORANI-G Model, including a full description of the model theory, as well as key features of the model's database, mapping procedures, different closure settings, modeling simulations and model validation, were all described in Chapter 3.

Having chosen the ideal methodology to conduct our analysis, the model's validity and reliability benchmarks were put into consideration. Various test simulations conducted show that the

ORANI-G Model was found to be functioning properly and generating results in a manner consistent with economic theory. The Model's validation is an important issue when a new model is built. The purpose is to ensure a reliable and successful application of the Model to policy analysis. We looked for coding and data-handling errors through homogeneity tests. We followed this by making sure the national account identities were satisfied. This is important because the validity of percentage change equations depends on the validity of the data from which the equation coefficients are calculated. Lastly, we ensured that no inconsistency exists between GDP computed on both the income and expenditure side.

5.2 Study findings

The results discussed in Chapter 4 provide information that addresses all the research objectives. In this first part of the analysis, the main objective has been to examine extent to which the global financial crisis affects production and trade in the South African agricultural sector. The analysis provides a number of interesting discernment. From the simulation point of view, a fall in exports in South Africa led to a decrease in GDP, real investment, employment, terms of trade and household prices. The overall poverty and inequality deteriorated under this scenario. At the sectoral level, the effects of the global financial crisis were particularly harsh on the domestic price for agricultural products and general household consumption levels, which declined by a greater magnitude.

There is a huge decline in foreign direct investment in most of the emerging markets as a result of the financial crisis. The heightened risk perception and declining investors' confidence in South Africa could make it difficult to attract foreign direct investment. There is a general consensus that

immense investments in agriculture are necessary in order to increase food supply and thus meet the projected increases in local food demand, and this will remain essential in the medium to longer-term for South Africa. But the global financial crisis led to capital flight from emerging markets because of high risk levels and uncertainty.

Under *Scenario 2* the second objective of the study which is to examine the impact of high food prices on production in the South African agricultural sector was achieved. The analysis revealed a fall in GDP, import quantity, and rate of return on capital. The sector-wise analysis of the increase in import price of food revealed an increase in the production output for primary agricultural sectors. Employment improves in some agricultural subsectors such as field crops and poultry. However, other sectors suffer employment loss and these include the processed food, processed meat, and sugar sectors. Sharp decline in household demand by the domestic consumers was revealed. The results established that a high import price of food has a regressive impact on household demand and consumption.

High food prices serve as encouragement for net food producers to produce more food. Each time food prices are on the rise relative to input prices, farm income grows, encouraging agricultural investment. Conversely, rising food price trends can impose tremendous challenges on poor people who spend much of their income on food. The impact of high food prices lasts longer than the temporary upsurge in poverty and hunger. One long-term effect is the devastating impact it has on child nutrition and health, which suffers considerably when there is food price inflation.

As a result of the changing global economic environment, the livelihoods of many poor people directly or indirectly depend on global markets to which their local markets are connected. The change in international food prices reaches poor people in many countries through the global price transmission channels. Thus, the impact of international food prices on local economies depends on the extent to which food prices are transmitted across borders.

In addressing objective three, the combination of high unemployment and lower income due to the global financial crisis and high food prices has negatively impacted the agricultural sector and, by extension, the welfare of the poor in South Africa. All in all, the results suggest that the global financial crisis and high food prices had a negative impact on household demand and consumption as well as the welfare of the people of South Africa. The food and financial crises should create the opportunity for the country to support or build more robust and effective social safety nets for the vulnerable population.

A realistic view of the impacts of the global financial crises and high food prices on the lives of people living in poverty recognises the responses to these shocks and involves behaviours that are broadly similar to those of everyday poverty, if perhaps more heightened and less effective. How individual households behave in an economic crisis like this is in many ways parallel to their responses to more common shocks such as illness of a household head or livestock losses. These responses include a reduction in consumption, stretching resources, and trying to beg, borrow, sell, steal and/or earn more.

5.3 Recommendations

The lessons we draw from the global financial crisis for South Africa is that mechanisms should be developed to withstand global economic slowdown; identify new avenues for vulnerable groups; and put the economy on a high growth trajectory which, once sustained, will ensure efforts towards the sustainable development goals. Economic stability should be most critical agenda of the government and policy makers during economic crisis. Government should be proactive in stimulating investment in agriculture through formulating policies that will attract more financial flow and encourage good return on investments in the agriculture sector. High economic growth is bound to increase food prices, not so much due to the increased demand for food, but via demand for energy. Hence, agricultural growth should be encouraged while mitigating market volatilities that results in food price spikes. Food insecurity should be tackled head-on through an increase in food availability, economic and physical access to food, and efficient utilisation of food.

In order to avoid the serious long-term consequences of the increase in the price of basic items, the manner, and extent to which the poor are protected matters a great deal, hence we suggest some policy responses to these crises. The first set of recommendation will be on policy interventions where economy-wide policies are deliberately designed to stabilise domestic food prices. These can include tax cuts, use of food stocks, government subsidies and export restrictions if necessary. This is highlighted in Zaman, Delgado, Mitchell, and Revenga (2008). We also recommend government intervention should focus on human development programmes and social protection in order to extenuate the adverse impact on the poor. These two sets of policies focus mainly on addressing the immediate impact of the food price spike. The third set of

policies and programmes is designed to boost domestic food production over the medium and long term.

Overall policy interventions at national and local levels should concentrate on reducing or stabilizing food price and also protecting the poor from short- and long-term impacts of the crises. Policy formulation and implementation must be supported with timely information and research-based evidence. This study concludes that the impact of economic and food crises cannot be separated.

5.4 Contribution to knowledge

This study contributes to the existing body of knowledge in various ways. Firstly, it offers insight into the effects that the global financial crises had on South African agriculture. Secondly, the combined analysis of the global financial crisis and high food prices on the agriculture sector in South Africa is novel. This is the first study on the combined effects of these crises.

5.5 Limitations and recommendations for future research

This thesis still has several limitations, and hence considerable matters remain for future studies. The framework used opens up a number of possibilities for future research regarding the impact of external shocks on the South African agricultural sector. The present study offers useful information on the static short-run simulations, but there is a need to see the long-run implications

of the crises on the South African agricultural sector through a dynamic general equilibrium framework.

Also, we believe that various aspects to our current modeling effort can be improved upon. The distinction between the short- and long-run impacts of the price increase is important and needs to be explored. Since both men and women were affected by job losses, higher cost of living, and worsening employment conditions, the gender dimension to the crises can also be added in order to reveal how it impacts on males and females in society, and on their coping mechanisms. Given the high frequency with which economic crises are occurring in recent years, there is an urgent need to study the possibility of permanent social safety nets for the vulnerable population.

Nonetheless, it is envisaged that future research could provide further insights by addressing some of the challenges encountered in this study, as well as other issues that are generally relevant, but that were outside of the scope of the current research.

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Appendix A: Stylised Representation of a CGE Model Database

Coefficients	Dimension	← All intermediate (1) and final (2-6) users or buyers in the economy are shown across these columns →																		
		Absorption Matrix																		
		1	2	3	4	5	6	TOTALS												
		Producers	Investors	Households	Export	Government	Inventories													
← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →															
Basic flows	COMxSRC ↓	V1BAS ("dom") V1BAS ("imp")	V2BAS ("dom") V2BAS ("imp")	V3BAS ("dom") V3BAS ("imp")	V4BAS ("dom") V4BAS ("imp")	V5BAS ("dom") V5BAS ("imp")	V6BAS ("dom") V6BAS ("imp")	DOMESTIC & IMPORT												
Margins	COMxSRCxMAR ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	zero	MARUSE												
Indirect taxes	COMxSRC ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	zero	TLSP												
BAS+MAR+TAX equal to PUR values	COM ↓	V1PUR	V2PUR	V3PUR	V4PUR	V5PUR	V6PUR	FINAL DEMAND												
Labour inputs	OCC ↓	V1LAB	<p>COM = Number of commodities; IND = Number of industries; SRC = Domestic and imports MAR = Number of commodities used as margins; OCC = Number of occupation types SUT = Supply use table</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td style="text-align: center;">PROD MATRIX</td> <td></td> <td style="text-align: center;">IMPORT DUTIES</td> </tr> <tr> <td style="text-align: center;">Dimension</td> <td style="text-align: center;">← IND →</td> <td style="text-align: center;">Dimension</td> <td style="text-align: center;">← IND →</td> </tr> <tr> <td style="text-align: center;">COM ↓</td> <td style="text-align: center;">MAKE</td> <td style="text-align: center;">COM ↓</td> <td style="text-align: center;">VOTAR</td> </tr> </table>							PROD MATRIX		IMPORT DUTIES	Dimension	← IND →	Dimension	← IND →	COM ↓	MAKE	COM ↓	VOTAR
	PROD MATRIX								IMPORT DUTIES											
Dimension	← IND →	Dimension							← IND →											
COM ↓	MAKE	COM ↓							VOTAR											
Capital rentals	1 ↓	V1CAP																		
Land rentals	1 ↓	V1LND																		
Production tax	1 ↓	V1PTX																		
Other costs	1 ↓	V1OCT																		

Source: Adapted from UPGE

Appendix B: Percentage-Change Equations of a CES Nest

Problem: Choose inputs X_i ($i = 1$ to N), to minimise the cost $\sum_i P_i X_i$ of producing given output Z , subject to the CES production function:

$$Z = \left(\sum_i \delta_i X_i^{-\rho} \right)^{-1/\rho}. \quad (A1)$$

The associated first order conditions are:

$$P_k = \Lambda \frac{\partial Z}{\partial X_k} = \Lambda \delta_k X_k^{-(1+\rho)} \left(\sum_i \delta_i X_i^{-\rho} \right)^{-(1+\rho)/\rho}. \quad (A2)$$

Hence $\frac{P_k}{P_i} = \frac{\delta_k (X_i)^{1+\rho}}{\delta_i (X_k)^{1+\rho}}, \quad (A3)$

or $X_i^{-\rho} = \left(\frac{\delta_i P_k}{\delta_k P_i} \right)^{-\rho/(\rho+1)} X_k^{-\rho}. \quad (A4)$

Substituting the above expression back into the production function we obtain:

$$Z = X_k \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k} \right]^{\rho/(\rho+1)} \right)^{-1/\rho}. \quad (A5)$$

This gives the input demand functions:

$$X_k = Z \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k} \right]^{\rho/(\rho+1)} \right)^{1/\rho}, \quad (A6)$$

or $X_k = Z \delta_k^{1/(\rho+1)} \left[\frac{P_k}{P_{ave}} \right]^{-1/(\rho+1)}, \quad (A7)$

where $P_{ave} = \left(\sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} \right)^{(\rho+1)/\rho}. \quad (A8)$

Transforming to percentage changes (see Appendix E) we get:

$$x_k = z - \sigma (p_k - p_{ave}), \quad (A9)$$

and $p_{ave} = \sum_i S_i p_i, \quad (A10)$

where $\sigma = \frac{1}{\rho+1}$ and $S_i = \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} / \sum_k \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)}. \quad (A11)$

Multiplying both sides of (A7) by P_k we get:

$$P_k X_k = Z \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} P_{ave}^{1/(\rho+1)}. \quad (A12)$$

Hence $\frac{P_k X_k}{\sum_i P_i X_i} = \delta_k^{1/(\rho+1)} P_k^{\rho/(\rho+1)} / \sum_i \delta_i^{1/(\rho+1)} P_i^{\rho/(\rho+1)} = S_k, \quad (A13)$

i.e., the S_i of (A11) turn out to be cost shares.

Technical Change Terms

With technical change terms, we must choose inputs X_i so as to:

minimise $\sum_i P_i X_i$ subject to: $Z = \left(\sum_i \delta_i \left[\frac{X_i}{A_i} \right]^{-\rho} \right)^{-1/\rho}. \quad (A14)$

$$\text{Setting } \tilde{X}_i = \frac{X_i}{A_i} \text{ and } \tilde{P}_i = P_i A_i \text{ we get:} \quad (\text{A15})$$

$$\text{minimise } \sum_i \tilde{P}_i \tilde{X}_i \text{ subject to: } Z = \left(\sum_i \delta_i \tilde{X}_i^{-\rho} \right)^{-1/\rho}, \quad (\text{A16})$$

which has the same form as problem (A1). Hence the percentage-change form of the demand equations is:

$$\tilde{x}_k = z - \sigma(\tilde{p}_k - \tilde{p}_{ave}), \quad (\text{A17})$$

$$\text{and } \tilde{p}_{ave} = \sum_i S_i \tilde{p}_i. \quad (\text{A18})$$

But from (A15), $\tilde{x}_k = x_k - a_k$, and $\tilde{p}_i = p_i + a_i$, giving:

$$x_k - a_k = z - \sigma(p_k + a_k - \tilde{p}_{ave}). \quad (\text{A19})$$

$$\text{and } \tilde{p}_{ave} = \sum_i S_i (p_i + a_i). \quad (\text{A20})$$

When technical change terms are included, we call \tilde{x}_k , \tilde{p}_k and \tilde{p}_{ave} *effective* indices of input quantities and prices.

The following two sub-topics are more advanced, and could be omitted at the first reading.

Two Input CES: Reverse Shares

Where a CES nest has only two inputs we can write (A19) and (A20) in a way which speeds up computation. Suppose we have domestic and imported inputs, with suffixes d and m. (A19) becomes:

$$x_d - a_d = z - \sigma(p_d + a_d - S_d(p_d + a_d) - S_m(p_m + a_m)),$$

$$\text{and } x_m - a_m = z - \sigma(p_m + a_m - S_d(p_d + a_d) - S_m(p_m + a_m)). \quad (\text{A21})$$

Simplifying, we get:

$$x_d - a_d = z - \sigma S_m((p_d + a_d) - (p_m + a_m)),$$

$$\text{and } x_m - a_m = z + \sigma S_d((p_d + a_d) - (p_m + a_m)). \quad (\text{A22})$$

In order for TABLO to substitute out x, we must express (A22) as a single vector equation:

$$x_k - a_k = z - \sigma R_k((p_d + a_d) - (p_m + a_m)), \quad k = d, m \quad (\text{A23})$$

The R_k are *reverse shares*, defined by:

$$R_d = S_m \quad \text{and} \quad R_m = R_d \circ 1 = S_m - 1 = -S_d \quad \text{note that } R_d - R_m = 1 \quad (\text{A24})$$

(A20) becomes:

$$\tilde{p}_{ave} = \sum_i S_i (p_i + a_i) = R_d(p_m + a_m) - R_m(p_d + a_d). \quad (\text{A25})$$

Twist for Two Input CES

A twist is a combination of small technical changes which, taken together, are locally cost neutral. For example, we might ask, what values for a_d and a_m would, in the absence of price changes, cause the ratio $(x_d - x_m)$ to increase by t% without affecting \tilde{p}_{ave} ? That is, find a_d and a_m such that:

$$S_d a_d + S_m a_m = 0, \quad \text{using (A20), and} \quad (\text{A26})$$

$$x_d - x_m = (1-\sigma)(a_d - a_m) = t, \quad \text{using (A21);} \quad (\text{A27})$$

giving

$$a_d = S_m t / (1-\sigma) \quad \text{and} \quad a_m = -S_d t / (1-\sigma). \quad (\text{A28})$$

Adopting *reverse share* notation:

$$a_k = R_k t / (1 - \sigma) \quad k = d, m \quad (A29)$$

Substituting (A29) back into (A23) we get:

$$x_k = z + R_k t / (1 - \sigma) - \sigma R_k (p_d - p_m + R_d t / (1 - \sigma) - R_m t / (1 - \sigma)) \quad k = d, m$$

so $x_k = z + R_k t - \sigma R_k (p_d - p_m) \quad k = d, m$

allowing us to rewrite (A19) and (A20) as:

$$x_k = z + R_k (t - \sigma (p_d - p_m)) \quad k = d, m \quad (A30)$$

and $\tilde{p}_{ave} = R_d p_m - R_m p_d. \quad (A31)$