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Analysing Impacts of Alternative Policy Responses to High Oil Prices using an Energy-focused Macro-Micro Model for South Africa

Ismaël Fofana • Ramos Mabugu • Margaret Chitiga

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Preface

World oil prices have risen to unprecedented levels recently. The world demand-driven oil price shock has affected the way emerging countries pursue macro-economic policy. South Africa, the subject of this report, has been concerned about the impact of the oil price increases on economic growth and on poor people. The government is also concerned about the windfall profits associated with this increase. This report seeks to analyse the impacts of macro-economic responses, with emphasis on fiscal policy, open to an emerging economy such as South Africa. An energy-focused computable general equilibrium model linked to a micro-simulation household model is used for this analysis. Consistent with the modeling work being pioneered at the Financial and Fiscal Commission, the report makes three contributions to South African policy analysis as follows:

- Development of a unique energy focused macro-economic model capable of integrating macro, meso- and micro level effects of alternative policy response to energy policy;
- Development of a unique database that integrates completely and consistently production, consumption and exchange accounts with explicit energy accounts
- Simulations to guide policy analysis.

The study examines the effects on the South African economy and households of either subsidising or allowing fluctuation of domestic petroleum prices in response to a ten United States dollar exogenous oil price increase. The model predicts that output would fall under these scenarios. The government deficit would worsen and unemployment increases among medium and low skilled workers while skilled workers witness a substantial fall in their remuneration, in particular in rural areas. There is a significant increase in the wage and employment gap between urban and rural workers, skilled and medium and low skilled workers, male and female workers, in particular when domestic oil prices are subsidised. Poverty headcount ratio increases, poverty gap and severity also increase and poorest households are more adversely affected. The overall assessment of the net macro-economic policy responses is cautiously pessimistic. These findings suggest that government should allow oil prices to continue to float in order to minimise the short term negative impacts on economic growth, on the budget deficit, and on the distributional impacts amongst industries and households. The success of certain fiscal policy responses to ameliorate poverty effects is a reassuring sign that macro-economic policy management of oil shocks can make positive contributions to development.

The Synthesis Report with its Summary for Policymakers is published here in a single volume together with the Technical Summaries as well as a comprehensive description of the energy model, the GAMS code of the energy model and the procedures followed in building up the Energy Social Accounting Matrix. The purpose of these technical papers is to enable the (technical) reader of this Report to understand what we did and reproduce easily the steps followed.

The full English text of the Report has been published in both print and digital form, with searchable versions available at http://www.ffc.co.za

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About the Authors

Ramos Mabugu holds a Ph.D. in Economics from Gothenburg University, Sweden. He joined the Financial and Fiscal Commission in 2006. Ramos's research work is mainly focused on the development of 'state of the art' macro-economic frameworks used to assess the necessary macro-micro links of public policy in such a way that issues of poverty, equity, growth and macro dynamics are better understood. In collaboration with colleagues, Ramos has pioneered amongst the first applications of CGE microsimulation (static and dynamic) applications to South Africa and Zimbabwe. He has published many articles in leading academic journals and as book chapters. Prior to joining the Financial and Fiscal Commission Ramos taught and supervised at postgraduate level at the University of Zimbabwe (1996-2002) and University of Pretoria in South Africa (2003-2006). While at university, Ramos served as external examiner for a number of Southern and East African universities and has been supervisor and an external opponent to several PhD dissertations. Ramos has also consulted for various international organisations such as the World Bank, ACBF, ILO, IUCN, FAO, CIDA, SIDA, USAID, UNIDO, USAID and WWF. Ramos has been invited to teach economic modeling courses on two occasions at the prestigious Ecological and Environmental Economics Programme at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Italy. In 2006 Ramos received a visiting fellowship from Curtin University in Australia.

Ismaël Fofana is a development economist and member of the "Centre Interuniversitaire sur le Risque les Politiques Economiques et l'Emploi" and the Poverty and Economic Policy (PEP) research network at Laval University (Canada). He acted as director of African office of the PEP research network in Dakar (Senegal) from September 2005 to August 2007. His principal areas of interest and expertise is on the impact assessment of macro policies and shocks. He has been conducting research and providing scientific support to researchers in developing countries on building of social accounting matrices and computable general equilibrium models related to fiscal policy, gender and poverty issues. In collaboration with the Africa Centre for Gender and Development of the United Nation Economic Commission for Africa, he has developed a macro-economic framework that integrates both market and non-market activities, as well as male and female work to evaluate impacts of policy reforms on poverty reduction and, on the well-being of men and women in Africa, with a pilot study applied to South Africa.

Margaret Chitiga is Associate Professor in the Economics Department at the University of Pretoria in South Africa. She obtained her PhD in economics at the University of Gothenburg in Sweden. She teaches Micro-economics and has taught Public Sector Economics, Development Economics and Mathematics for Economists and CGE Modeling. Her research interest is in investigating the effects of policies on welfare, industry and the rest of the economy. She uses computable general equilibrium models, social accounting models and input-output models to do such investigations. She has worked on various issues including income distribution effects of alternative transfer initiatives by the government, Impact of the transport sector in South Africa, impacts of recycling CO_2 emission taxes, poverty implications of trade reforms and welfare effects of land reforms, among others. She continues to be curious and intrigued by the general equilibrium effects of policies and shocks on economies and welfare. She has published in local and international refereed journals.

Summary for Policymakers

The recent oil price increase has created widespread concern about its impact on world economic growth and on poor people in many countries. In South Africa, government is also worried about the windfall profits associated with this increase. This report examines the effects of alternative policy responses to the recent oil price changes in South Africa. It is a follow up to the report produced in 2007 that focused on the impact of oil price increases (Fofana *et al*. 2007). The report extends that work in terms of the range of policy scenarios tested and the complexity of the models used.

In Fofana *et al.* (2007), it was shown that the adverse impact of higher oil prices is much more diversified depending on the share of oil cost in national income and the energy efficiency and substitution possibilities of the industries in the economy. It was predicted that oil price increases would have negative effects on the economy and welfare. In this report, we explore the likely impacts of alternative government interventions in the face of such adverse impacts of oil price increases. Government policies can minimise or worsen the loss on income and welfare induced by higher oil prices. In order to understand the magnitude and distributional effects of oil price shocks and consequently to help formulating policies to ameliorate these effects, three levels of analysis are used to track the channels by which the South African economy and individuals are impacted. These 3 channels are:

- The macro-economic level, looking at the impacts of oil price shocks and policy responses on the global economy, that is gross domestic product (GDP), the current account balance, government fiscal balance, inflation, private consumption, investment and unemployment.
- The meso-economic level, related to the distributional impacts of higher oil prices and policy interventions among industries and its translation into factors and commodities prices.
- The micro-economic level, looking at the distributional impacts on households' real income and welfare.

To understand as well as quantify these three levels of impacts for South Africa, this study uses a Computable General Equilibrium (CGE) Model specifically designed for South Africa. This is a major advance when compared to the accounting approach based on household survey dataset and an input output dataset used in Fofana *et al.* (2007). The approach used in this Report is appropriate because there are likely to be significant indirect effects that will have strong effects on allocation of scare resources following the interventions. The principal advantage of using CGE models in such policy analysis is that it permits taking into account interactions throughout the economy in a consistent manner. If something is changed in only one part of the economy, namely the oil sector, due to oil prices and government policy response, then there will be effects on the other parts of the economy, and these are automatically taken into account when one computes effects using a general equilibrium model. Hence this approach has both a sound theoretical structure as well as an exhaustive accounting strategy. The study makes three contributions to South African policy analysis as follows:

- Development of a unique energy-focused macro-economic model capable of integrating macro-, meso- and micro-level effects of alternative policy response to energy policy;
- Development of a unique database that integrates completely and consistently production, consumption and exchange accounts with explicit energy accounts
- Simulations to guide policy analysis.

The contribution to modelling made by this Report is in the form of a South Africa specific energy CGE model. But what are CGE models in any case? A CGE model is a system of equations, which simulates the working of a market economy. The prices and quantities of all goods and factors are determined simultaneously in every market (hence G for "general") by the need to equate supply with demand (hence E for "equilibrium"). The system of equations is simultaneously solved using a numerical database ranged in a matrix format called a Social Accounting Matrix (SAM), and a computer with appropriate software (hence C for "computable"). CGE models are based on the theory of general equilibrium that was pioneered by Leon Walras in 1877 and formalized by Arrow and Debreu in 1954. The model collapses a whole economy into five major parts of producers, factors of production (workers, capital, and land), households, government, and the rest of the world. It then builds equations meant to capture the behaviour and interaction between the five components. The model developed in this Report specifies at least three structural features designed to reflect the characteristics of the South African economy that distinguishes it from other standard models in this class of models. These are:

- Better specification of South African labour market compared to labour market specifications in standard models. The labour market in the model is segmented, distinguished by area as well as skill category. Each segment corresponding to a skill-level performs differently in terms of earnings, job opportunity, unemployment and wage flexibility.
- Explicit treatment of the trade and transportation margins for commodities that enter the market sphere. A constant trade and transportation margins coefficient is added to each transaction and included in the purchasing price of commodities.
- Distinction of the energy supply and demand specificities and the price setting rules in the domestic oil market. Energy activities are disaggregated into coal, synthetic petroleum, oil petroleum, and electricity while energy related products account for coal, crude oil, refined petroleum (including synthetic and oil petroleum), and electricity (including gas, and renewable energy).

The data required to run the CGE model contributed by this study consists of benchmark data, reaction data and "shares" data. The benchmark data is presented in the form of a SAM which is a set of accounts written in a condensed matrix form with an important property that the sum of the row elements is equal to the sum of the corresponding column elements. The SAM is therefore consistent in the sense that it describes a general equilibrium of the economy in question from which counterfactual analysis can be carried out. An appropriate and coherent presentation of the SAM's factor payments and labour market required the use of additional information from the household surveys. The ones used were the Income and Expenditure Survey and the Labour Force Survey to construct the standard SAM that is similar to what many other researchers in South Africa are using. The standard SAM presents one aggregate account of "petroleum products" and fails to distinguish them either by origin (that is, synthetic fuel or refined oil) or by type (that is, petrol, LPG, diesel, paraffin, etc). Furthermore, crude oil activity (production and import) is neither highlighted in the Supply Use Tables nor in the standard SAM. It is rather included in the "Other mining and quarrying" category of industry or product. The structure of the standard SAM is not appropriate for energy policy analysis. It is not suitable for the analysis of supply and demand behaviour, as well as interactions between different energy sources. To address these issues, an energy SAM for South Africa was constructed specifically for this study. Three procedural steps are followed in building the energy-focused SAM as follows:

- First, the supply of "crude oil" is extracted from "other mining and quarrying". As there is no domestic production of "crude oil", the total supply is satisfied by imports.

- Second, the petroleum industry is decomposed into synthetic petroleum industry and oil petroleum industry. South Africa has large endowments of coal which have been converted into close substitutes of refined oil products by the well-developed synthetic fuel industry.

- Third, most SAMs present households' consumption by product-category. As a result, the Energy SAM rearranged the households' consumption by purpose for all the additional accounts.

The calibrated CGE model mimicked well the working of the South African economy because it incorporated various institutional and structural characteristics such as rigidities and constraints in different markets that simple theoretical analysis fails to capture. The model was then used to develop several "what if" scenarios. Specifically, the study experiments with an increase of international (import and export) oil and oil products prices under alternative government policy responses. Two scenarios are tested in this study. They are determined by the government response to the oil shock as follows:

The first scenario assumes that a US $10 increase of the prices of imported crude oil (accompanied with a smaller increase of the prices of imported and exported oil products) by South Africa is fully transmitted to end-users (consumers and producers) through an increase of the purchasing prices of petroleum products. Therefore, the current intervention of the government in the oil market is maintained. The simulation is referred to as the *"Floating Price Scenario"*.

The alternative scenario supposes that the government is willing to intervene and control for the increase of the purchasing prices of petroleum products in order to protect consumers and producers. Thus, it decides to fully compensate the increase through the price subsidy mechanism. The price subsidy mechanism - applicable to all petroleum products regardless of their final use - is fully compensated by the Government in the sub-scenario 1, while a 50 percent tax on the synthetic fuel windfall profits contribute to finance government revenue loss in the *sub-scenario 2*. These scenarios are referred to as the *"Setting Price Scenario"*.

Starting with the macro-economic effects, the model predicts that GDP would fall by between 2.2 and 2.5 percent under the three scenarios. A key driver of these results is the exchange rate effect. The exchange rate depreciates more in the fixed price relative to the floatation price scenarios leading to a fall in the average domestic prices by 3.4 percent and 2.6 percent, respectively. The impact on the government deficit varies widely among the scenarios, ranging from a worsening of 12 to 22 percent in the floating prices and the fixed prices scenarios, respectively. Unemployment increases among medium and low skilled workers.

The meso-economic effects show important distributional impacts amongst industries. Synthetic petroleum, coal, and electricity which are alternative sources of energy to oil petroleum, benefit under the floating price scenario. Electricity does not benefit from high oil prices under the fixed price scenario, as refined petroleum products become less expensive and less substituted with the alternative source of energy compared to the floating price scenario. None of the energy industries expands its output when a 50 percent tax is levied on the profit of the synthetic petroleum industry. Except the mining sector that benefits from the exchange rate depreciation (appreciation of the real exchange rate), all other industries experience a fall of their production but with different magnitudes. Agriculture, food and light manufacturing and private services are the big losers of the high oil price shock being directly affected by a fall in the final demand.

There is a significant increase in the wage gap between urban and rural high skilled workers which is worsened under the fixed price scenario. Employment increases among medium and low skilled workers, mostly in urban areas rather than rural areas. This is accentuated when government subsidizes the oil price increase. In both areas, women are adversely affected relative to men by high oil prices. They are more intensively used in contracting industries (agriculture, food and light manufacturing and private services) and less in expanding industries (energy related activities and mining). There is no significant difference in male and female wages and employment opportunities among the three scenarios.

Poverty headcount ratio increases by 1 percent when the imported crude oil and oil products prices rise by 50 and 25 percent with respect to their values in year 2000, respectively. The poorest households are most adversely affected by the increase of oil prices. Although employment and wages drop more in rural areas, households in those areas observe a lower increase in the poverty indexes because of their relatively low dependency on factor incomes compared to their counterparts in urban areas. African and Coloured household categories record the highest increase in their poverty indexes as they rely heavily on low and medium skilled labour incomes. Inequality increases in urban areas while it falls in rural areas. Poverty and inequality increase slightly more in the fixed price scenarios relative to the floating price scenario.

Although previous studies provided interesting insights of the macro and distributive impacts of the recent oil price increases in South Africa, our analysis contributes to the debate in investigating the likely effects of policy interventions in response to the shock and aims at providing meaningful guidance to government policy. Furthermore, unlike in the previous analyses, our study provides special treatment to the energy sector and separate synthetic petroleum industry which is coal intensive from oil petroleum industry, intensive in crude oil. This allows us to account for the energy sector specificities and the inter-fuel substitutability and complementarity that standard specification fails to capture.

Essama-Nssah *et al*. (2007) perform a 125% increase of the crude oil prices which corresponds to a nearly US $40 increase as compared to its average price of US $30 in 2003 (Annexe 1). This increase of crude oil price combined with a smaller increase of oil related products lead to a 2 percent fall of GDP. Our analysis gives rise to the same magnitude of adverse impact on GDP under a four times smaller increase of the crude oil prices and also combined with a smaller increase of the refined petroleum products. We conclude that the two results are heavily driven by the choice of the macro-closure rules, in particular the "saving-investment" equilibrium. In Essama-Nssah *et al*. (2007), investment is saving driven so that consumption today is partially possible at the expense of future consumption through a fall in the investment capacities. This can be referred to an inter-temporal free lunch. When one eliminates this transfer of income, the fall in (today) consumption and macro-economic performances of South Africa are more important.

Our results show that the indirect effects of oil and oil price shock are very important in determining the distributional impacts among industries. The most oil-intensive industries ("*Transport services*" and "*Primary plastics*") which are more likely to be directly hurt by the oil price shock (Fofana, *et al*., 2007) do not appear among the most affected industries when account is taken for both direct and indirect effects. The previous studies (McDonald and van Schoor, 2005; and Essama-Nssah, *et al*. 2007) stressed the importance of the exchange rate in the distributional impacts among industries of the oil price shock, the less traded (tertiary) sectors being more negatively affected. Our study demonstrates that beside the exchange rate effects, the macro-closure rules, in particular the saving-investment and the government fiscal policy are also crucial in the sense that the compensatory lump-sum tax on households' income and wealth integrated into the model to maintain the government expenditures and the economy-wide volume of investment unchanged is not industry-neutral. The fall in the tax-induced expenditure capacity of households affects more industries that produce final consumption goods and services (agriculture, light manufacturing including food processed products and privates services) relative to investment goods oriented industries (heavy manufacturing). An alternative saving investment closure rule would have modified the distributional impact among industries. Therefore, individuals' perception of the shock, i.e. whether it is temporary or permanent, would affect seriously their expenditure decision (final consumption vs. investment) in order to cope with the increase of oil prices. Consequently, this would ultimately affect the distributional impacts of the shock among industries. However, given the short run perspective of the study and also the implicit assumption that individuals and corporations consider the oil price shock as a temporary event, agents do not modify their investment plan.

Cognisant of the fact that only three alternative policy responses have been tested, that the analysis is only for the short run and that other interventions which may dampen the impact of oil price shocks on the economy have been held fixed, the results of this study suggest the following recommendations:

- Government should allow oil prices to continue to float in order to minimise the short term negative impacts on economic growth, on the budget deficit, and on the distributional impacts amongst industries and households.
- Government can minimise or eliminate the negative impact of high oil prices by designing and implementing efficient export-oriented trade policies that would contribute to reduce the exchange rate depreciation induced by high oil import cost.

- An efficient reallocation of government spending through appropriate fiscal policy toward domestic-oriented products and activities (agriculture, light manufacturing including food processed products and privates services) would also contribute to minimise the adverse impacts of high oil prices. In the same vain, temporarily subsidising vulnerable sectors in order to reduce the overall output loss and the distributional impacts among industries would save medium and low skilled jobs from mass retrenchments.

- To cushion households in general and poor household in particular, from negative effects of oil price increases in the short term, Government should target and support industries that mostly contribute to generate income for the poor and should spend on locally-produced commodities whose increase of prices affects mostly the cost of living of the poor.

- The amount of money needed to bring poor people to the poverty line has increased as seen in the poverty gap index. This calls for Government to put greater effort by providing short and medium term support services in the form of increases in social grants to vulnerable groups (especially women).

- Government should explicitly tax import substituting industries on their windfall profits to recoup revenue from oil price increases above the normal in order to minimise its revenue loss and support its spending programs on non-oil products and industries.

- Policy interventions to minimise the loss of output and welfare and protect vulnerable groups of society create further distortions on the economy with little pressure for energy efficiency and oil substitution that might be damaging for the environment. In contrast, pressures of higher oil prices lead to substitution towards other sources of energy that may be the least environmentally friendly and contribute to greenhouse gases emission and global warming. The short term fiscal policy responses should integrate the economic performance, the impacts on poor, and the environmental concerns and government faces the difficult task of managing these trade-offs.

- The short run fiscal policies are designed to support the economy and to protect various household groups in order to gradually adjust to the oil shock. Once the adjustment process is in place, government should gradually substitute the short run for medium and long run fiscal policies that will focus on reducing the vulnerability of the economy to the oil shock. In the longer term the choice of fuels and energy practices should be essentially driven by market incentives. Complementary policies encouraging energy efficiency and a switch from fossil-fuel energy toward renewable and environmentally friendly energy should be implemented in a form of a financial incentive.

Analysing Impacts of Alternative Policy Responses to High Oil Prices Using an Energy-focused Macro-Micro Model for South Africa

Abstract

The study examines the effects on the South African economy and households of either subsidising or allowing fluctuation of domestic petroleum prices in response to a United States ten-dollar exogenous oil price increase. An energy-focused computable general equilibrium model linked to a micro-simulation household model is used for this analysis. The model predicts that GDP would fall by 2 percent under these scenarios. The government deficit would worsen by 12 and 22 percent under the floating and setting prices scenarios, respectively. Unemployment increases among medium and low skilled workers while skilled workers witness a substantial fall in their remuneration, in particular in rural areas. Synthetic petroleum, coal and to some extent electricity and mining are the clear winners. All other industries experience a fall of their production but with different magnitudes. These results are primarily attributed to the depreciation of the exchange rate, and are accentuated in the scenario when Government fully subsidizes the increase of oil prices.

There is a significant increase in the wage and employment gap between urban and rural workers, skilled and medium and low skilled workers, male and female workers, in particular when domestic oil prices are subsidised. Poverty headcount ratio increases by 1 percent; poverty gap and severity also increase and poorest households are more adversely affected. Poverty increases less among rural households more dependent on transfer incomes kept unchanged in real terms in the model, and more among African and Coloured household groups relying more on low and medium skilled income. Inequality rises in urban areas while it falls in rural areas. Cognisant of the limited number of alternative policy responses, experiments and the short run perspective of the analysis, Government should allow oil prices to continue to float in order to minimise the short term negative impacts on economic growth, on the budget deficit, and on the distributional impacts amongst industries and households.

Key words: Oil; Energy; Social Accounting Matrix; Computable General Equilibrium; Income distribution; Welfare

1. Introduction

The recent oil price increase has created widespread concern about its impact on world economic growth and on poor people in many countries. During the last years, the oil market has witnessed substantial price volatility as well as historically high prices for crude oil and the major light products. On July 2008, oil prices struck an all time record high above $144 a barrel, seven times higher than when it was at $19.70 a barrel in December 2001. When adjusted by inflation to compare the oil prices in real terms, oil is now more expensive than at any time (Annexure 1).

Analysts have pointed out that higher oil prices are inevitable and it is unlikely that prices will be reduced in the long term without major discoveries of sufficient sources of oil or alternative energy sources. Moreover, they are unanimous that government management of the higher oil prices will have significant repercussions on the economy of countries in terms of income distribution and poverty reduction. Because oil is such a basic component of production, flotation of oil prices will directly affect the whole economy, income distribution and poverty reduction. Higher oil prices will lower oil consumption in favour of other sources of energy such as coal, which are known to be more damaging for the environment.

On the other hand, if government subsidises oil prices, this distorts the real market signal. The market no longer reflects real costs and one consequence of this is that people no longer have an incentive to save on oil use. Subsidising oil products sends the wrong message to consumers who are in fact encouraged to consume more of these products, particularly in the production sector, and consequently, contribute more to the emission of greenhouse gases (GHGs). In the long term, subsidising oil prices, even if it might be beneficial to competitiveness and the whole economy, raises the risk of increasing the trade deficit with increased oil imports. It may cause higher prices for domestic goods thereby lowering consumption. Consequently, higher inflation will ultimately pressure the government to increase interest rates, thereby reducing short-term investments and restricting predicted growth in the domestic economy.

This study examines the effects of alternative policy responses to the recent oil price increases in South Africa. It is a follow up to the report produced previously that focused on the macro and micro impact of oil price increases (Fofana, Mabugu and Chitiga, 2007). The report extends that work in terms of the range of policy scenarios tested and the complexity of the models used. In Fofana *et al*. (2007), it was shown that the adverse impact of higher oil prices is much more diversified depending on the share of oil cost in national income and the energy efficiency and substitution possibilities of the industries in the economy. It was predicted that oil price increases would have negative effects on the economy and welfare.

In this report, we explore the likely impacts of alternative government interventions in the face of such adverse impacts of oil price increases. Government policies can minimise or worsen the loss on income and welfare induced by higher oil prices. In order to understand the magnitude and distributional effects of oil price shocks and consequently to help formulating policies to ameliorate these effects, three levels of analysis are used to track the channels by which the South African economy and individuals are impacted. The macro-economic level looks at the impacts of oil price shocks and policy responses on the global economy, i.e. gross domestic product (GDP), current account balance, government fiscal balance, inflation, private consumption, investment and unemployment. The meso-economic level is related to the distributional impacts of higher oil prices and policy interventions among industries and its translation into factors and commodities prices. The microeconomic level analyses the distributional impacts of oil price shock on households' real income and welfare.

To understand as well as quantify these three levels of impacts for South Africa, this study uses a Computable General Equilibrium (CGE) Model specifically designed for South Africa. This is a major advance when compared to the accounting approach based on household survey dataset and an input-output dataset used in Fofana *et al*. (2007). McDonald and van Schoor (2005) and Essama-Nssah *et al*. (2007) use a CGE macro-micro framework to understand the structural and distributional consequences of oil price increases for South Africa. These previous works have been predominantly focused on the impact of crude oil and oil products price increases. In this study, we extend these works to assess the impacts of the recent oil price shock under alternative government policy responses. Specifically, we experiment with three scenarios. The first scenario assumes that the increase of the prices of crude oil and petroleum products imported by South Africa is fully transmitted to end-users (consumers and producers) through an increase of the purchasing prices of petroleum products.

The second and third scenarios suppose that the government fully compensates consumers for the increase through the price subsidy mechanism.

The CGE approach used in this Report is appropriate because there are likely to be significant indirect effects that will have strong impacts on allocation of scare resources following the interventions. The principal advantage of using CGE models in such policy analysis is that it permits taking into account interactions throughout the economy in a consistent manner. If something is changed in only one part of the economy, namely the oil sector, due to change in prices and government policy response, then there will be effects on the other parts of the economy, and these are automatically taken into account when one computes effects using a general equilibrium model. Hence this approach has both a sound theoretical structure as well as an exhaustive accounting strategy.

The study makes three contributions to South African policy analysis. First, it contributes to the development of a unique energy focused macro-economic model capable of integrating macro-, meso- and micro- level effects of alternative policy response to energy policy. Second, it contributes to the development of a unique database that is organized in a Social Accounting Matrix (SAM) and integrates completely and consistently production, consumption and exchange accounts with explicit energy accounts. Third, it provides unique simulations that guide policy analysis.

The Report is arranged into six sections. Section 2 reviews the previous analysis of oil price shocks that have used the CGE framework. In section 3, we discuss the model used and the construction of the dataset. Section 4 provides details on the structure of the South African economy and relevant energy indicators. Section 5 presents and discusses the results of the policy simulations. We conclude in section 6 by providing comprehensive guidance to policy response to high oil prices in South Africa.

2. Impacts of Oil Price Shocks in South Africa: A Review

Economists have used a variety of methods to analyse the extent and magnitude of the oil price-induced shocks, the adjustment policies and the effects of such policies on economic growth and income distribution in developing countries. Mitra (1994) explores different adjustment scenarios in oil-importing developing countries to cope with the 1973/74 and 1978/79 oil-price shocks[1]. The analysis uses three types of approaches in examining the behaviour of a number of oil-importing developing countries. A descriptive approach classifies 33 countries according to the extent of the shocks, the policies pursued and the success of the subsequent adjustment. Partial equilibrium models for Kenya and CGE models for Turkey, Thailand, Kenya and India enable counterfactual and alternative policy responses experiments. The oil price increase benefited the nine oil-export developing countries while the twenty-four oil-importers responded to the price shocks in various ways: domestic resource mobilisation, reduction in domestic investment, borrowing from the international markets, and exports promotion. The group of countries that adopted the latter policy response to the adverse shocks - Chile, Korea, Taiwan and the Philippines – experienced the highest growth rates. Mitra (1994) concluded that the countries studied would have been better off without the oil price increase. Nevertheless, countries should adjust to the external shock rather than borrow from the international markets. The oil price increase should be passed onto the end-users rather than providing subsidies. Government should protect public expenditure on poverty alleviation and finally, investment should be efficiently allocated through the market mechanism.

A recent study by Fofana *et al*. (2007) use three levels of analysis to track the channels by which South Africa and its population are directly impacted by a sustained US $20 a barrel increase of oil price. The study uses an input-output model combined with a household survey for South Africa to track the direct impacts of high oil prices. Assuming a zero price-elasticity of oil and oil products demand, the study suggested that the doubling of oil and oil products prices reduces GDP by 0.2% in South Africa. The modifications in petroleum-products prices are translated into an increase in the oil input bill, in particular, among the high intensive oil input industries. The incidence is significant on the cost of "Transport services" and "Primary plastics", which industries play a key role in the distributional impacts of high oil prices among industries and households. The study shows that the impact of doubling the paraffin price on the cost of living is most burdensome for the poorest expenditure quintiles. Poor households in rural areas and among the "Black" population witness an increase

1. The oil price shocks were accompanied by a subsequent rise in interest rates and this is also accounted for in Mitra (1994).

of their cost of living which is much higher than their corresponding highest expenditure quintile groups. An increase of transport fuel (gasoline and diesel), on the other hand, hits the richer households much harder than poorer households. The distributional impacts of rising transport cost as a consequence of high oil and oil-products prices shows that median quintile expenditure groups observe the highest negative impact both in urban and rural areas.

Studies by McDonald and van Schoor (2005) and Essama-Nssah *et al*. (2007) explored the effects on the South African economy of a rapid rise in the relative price of oil on international markets using a CGE approach. The study by McDonald and van Schoor (2005) uses a representative household CGE model calibrated to the 2000 SAM for South Africa. They successively increase the imported crude oil prices from 5% to 30%, under two alternative government closures. In the first closure scenario, the volume of government expenditure is held constant and its deficit adjusts to the shock. The change in the public deficit is compensated by private saving/investment in such a way that the savings-investment balance is kept constant. Government adjusts its expenditure levels in the second closure scenario; government consumption is a fixed share of the total final demand while the deficit is still kept endogenous. The discussions are focused on the 20% oil price increase scenario.

The analysis by Essama-Nssah *et al*. (2007) integrates a micro-simulation model linked to the CGE model in a recursive fashion. The macro and structural implications are accounted for by a disaggregated CGE model calibrated to a 2003 SAM for South Africa, while agent heterogeneity and impact on income distribution are accounted for by the micro simulation component which combines data from the Labour force Survey (LFS) and the Income and Expenditure Survey (IES) both for 2000. Essama-Nssah *et al*. (2007) carry out two simulations, an oil world price shock as well as an oil and general world price shock. In the first experiment, the world prices of imported crude and refined oil increase by 125%. In the second experiment the world price of imported crude and refined oil increases by 125% as well as the world price of imported basic chemicals by 30% and the world price of all other imported goods by 6%. The closure rules adopted in the study are those found in Kearney (2004) and Go *et al*. (2005) as the authors referred to these studies on the technical aspects. Go *et al*. (2005) adopted a savings driven investment closure with neutrality in the government revenue.

Essama-Nssah *et al*. (2007) found that a 125% increase of the prices of crude oil and petroleum products compared to its average level in 2003 depreciates the exchange rate causing an increase in export earnings to enable crude oil importation and reduces the real GDP by approximately 2%. McDonald and van Schoor (2005) found a higher elasticity of growth with respect to imported crude oil price; the GDP falls by 1% under a 20% increase. The distributive impact among industries seems to be primarily driven by the exchange rate depreciation effect. In both studies, it is the less traded (tertiary) sectors that see a relatively large fall in their output as they do not benefit from the currency depreciation. The petroleum industry witnesses the most significant adverse impact because of an important increase in its input cost (crude oil represents more than half of the total cost of the industry).

In Essama-Nssah *et al*. (2007), a decline in employment is recorded for the formal semi- and low- skilled labour categories particularly in the services sector that suffers the most. The majority of those who became unemployed belong to the bottom three income deciles. The paper reports that high-skilled workers gain from the shock compared to other skill categories. The results show a 1% increase in the poverty gap index meaning that the difference between actual income and income required in sustaining a minimum standard of living increased by 1%. Inequality increases after the shock. This is shown by the increase in Gini coefficients in both urban and rural areas. In contrast, McDonald and van Schoor (2005) found that the crude oil price shock benefits more the unskilled than the skilled workers and the rural than the urban households under the assumption that scarce factors, skilled workers and capital, are immobile across sectors.

The direct impacts of high oil price on the South African economy as pointed out by Fofana *et al*. (2007) appears to account for a smaller part of the total (direct and indirect) impacts of high oil prices, calling for the use of a framework that accounts for both direct and indirect impacts as done by McDonald and van Schoor (2005) and Essama-Nssah *et al*. (2007).

A well-developed synthetic fuels industry facilitated by South Africa's abundance of coal resources and offshore natural gas gives rise to a high coverage ratio of oil and oil products in the year 2000. As a consequence, it is expected that the elasticity of growth to imported crude oil price (McDonald and van Schoor, 2005) would be relatively higher than the elasticity of growth to imported and exported crude oil and refined petroleum prices (Essama-Nssah *et al*., 2007). Thus, a rigorous assessment of oil price shocks on the South African economy should account for its import and export structures of oil and oil products and should inform an analysis of the change in the import and export prices of both crude oil and refined petroleum products.

Although the latter studies provide interesting insights of the macro and distributive impacts of the recent oil price increases, they do not investigate the policy responses to the oil shock and their effects on the economy in order to provide meaningful guidance to government policy. In this study, we simulate inward policy response packages to the oil price shock as recommended by Mitra (1994).

3. The Analytical Framework

The CGE model used in this study is based on the neoclassical-structuralist specification as presented in Decaluwé *et al*. (2001). A CGE model is a multi-market model based on real world data of one or several economies. It simulates a working economy by incorporating various institutional and structural characteristics that simple analysis fails to capture. CGE models have been used widely in the Organisation of Economic Cooperation and Development (OECD) countries for economic and social policy orientation[2]. CGE models are primarily based on neoclassical theory of general equilibrium, first formulated by Leon Walras in 1877 and later formalised by Arrow and Debreu (1954) and McKenzie (1954, 1959, 1981). The model seeks to explain production, consumption and prices in a whole economy in which agents respond to relative prices as a result of profit and utility maximizing behaviours. Markets simultaneously adjust relative prices in order to reconcile endogenous supply and demand decisions, and thus, determining levels of production and consumption. Although most of the equations feature rigorous micro-economic foundations, the behaviour of economic agents must be consistent with the macro-economic framework.

CGE models provide interesting insights on the likely impacts of macro-economic shocks and policies on economic performance, income distribution and poverty. They are used when proposed policy measures, or expected changes in exogenous conditions, are likely to have general equilibrium effects, that is, significant indirect effects with potentially strong effects on the allocation of scare resources. Results generated by this type of model are often questioned on their validity and usefulness for policy decision making because of their underlying assumptions on optimizing behaviour, competitive markets and flexible relative prices. However, as mentioned by van der Mensbrugghe (1998), "the strength of this class of economic models is consistency with generally accepted microeconomic theory, significant structural detail, and the nature of general equilibrium, that is, that changes in any one area of economic activity may have measurable impacts in other areas". The lack of econometric estimation of key supply and demand parameters is also a weakness of CGE models. "This calls for undertaking significant sensitivity analysis to see which parameters are key in altering the results and their interpretation" (van der Mensbrugghe, 1998). As pointed out by Bergman and Henrekson (2003), "even if uncertainty about the numerical values of key parameters makes the magnitude of computed effects of policy changes uncertain, the analyst may be able to safely conclude that the effects in question are small or big".

A general review of earlier CGE models used in South Africa is found in Thurlow and van Seventer (2002). Woolard and Wilson (2004) provide a more recent review of CGE modeling in South Africa with a focus on labour demand projections. McDonald and Punt (2005) provide an overview of recent CGE models used to analyse agricultural issues while Mabugu and Chitiga (2008) review CGE models applied to trade liberalization issues in South Africa.

To our knowledge McDonald and van Schoor (2005) and Essama-Nssah *et al*. (2007) are the only studies that use a CGE model for the South African economy to assess the impacts of oil price shocks. On the technical aspects, the authors assumed low substitution between value added and intermediate inputs, on the one hand, and low substitution between various types of energy in the production technology, on the other hand. The previous studies do not allow for a special treatment of the energy sector and synthetic fuel industry which is intensive in coal input rather than crude oil as it is aggregated with petroleum industry. The literature on CGE modelling in energy and environmental issues, briefly discussed in next section, provides alternative specifications for the energy sector.

2. Devarajan and Robinson (2005) review the use of CGE models in the policy debate.

a. Applications of CGE modelling in Energy and Environmental Issues

CGE models are widely used for evaluation of policies related to energy and carbon dioxide emission. A survey by Bergman and Henrekson (2003) highlights their usefulness in environment and resource management modelling. The authors cluster the application of CGE modelling in this area into two categories: "Externality CGE Models" and "Resource Management CGE Models". They highlight that in terms of numbers, the former completely dominates the field of environmental CGE modelling.

Hudson and Jorgenson (1975) developed the first CGE model for energy policy analysis related to the oil price increases in 1973 and 1979. It was followed by the well-known ETA-MACRO model of Manne (1977). In the nineties, a number of single-country models for environmental policy and resource management analysis were developed (e.g. Hazilla and Kopp, 1990; Bergman, 1990). One of the most famous CGE modelling of energy and environmental issues is the GeneRal Equilibrium ENvironmental (GREEN) model developed at the OECD Development Centre (van der Mensbrugghe, 1994).

In energy and environmental CGE modelling, the supply and demand of energy fuel are explicitly elaborated. The modelling presents much disaggregated energy sectors and products in order to capture inter-fuel substitution possibilities and a certain specification of production functions. Energy and environmental CGE models distinguish various types of fuel, and separate energy input intensive sectors from non energy input intensive sectors. In general, a nested production function structure is the technology description used in most CGE models, including those designed for energy and environmental issues. They combine Constant Elasticity of Substitution (CES), Cobb-Douglas (CD) and Leontief production functions and require available information on the elasticities of substitution among productive factors.

In most energy and environment models (e.g. GREEN model), composite fuels and electricity are combined in a CES function with a relatively high elasticity of substitution. The former is often defined as a CES-aggregate of different types of fossil and non-fossil fuels with relatively high elasticities of substitution between them. Most CGE models assume an imperfect substitution between capital and energy in a capital-energy bundle with quite a low elasticity. Others suggest that capital and energy are complements. The capital-energy bundle in turn imperfectly substitutes for labour in the value added-energy composite. Finally, value added and energy and non-energy inputs are aggregated into the sectoral output.

The dynamic version of the GREEN model integrates an interesting feature called a vintage capital production structure. van der Mensbrugghe (1994) observes that "typically, substitution possibilities are greater with newer capital. In this way, GREEN can capture the possibility that energy and capital can be perfect complements in the short run (i.e. the substitution elasticity between capital and energy is zero), but that in the long run it may be possible to substitute capital for energy if the price of energy were to increase relative to the price of capital." The model accounts for five types of fuel (coal, crude oil, refined oil, gas and electricity) and the backstop components. Crude oil shows an infinite elasticity "reflecting the high degree of homogeneity of crude oil internationally and its relatively low transportation cost" (Van Der Mensbrugghe, 1994). Other energy products (coal and gas) are modelled as Armington goods because of "the more costly transportation margins, although natural gas, and perhaps to a lesser extent coal, are also relatively homogeneous goods" (Van Der Mensbrugghe, 1994). The model presents energy-related carbon emissions from the direct consumption of coal, oil and gas (and the "dirty" backstop fuel) and describes an energy efficiency improvement specification.

The GREEN model accounts for one aggregate representative household maximising a unitary extended linear expenditure system (ELES) utility function over four categories of goods, namely, food and beverage, energy, transport and communication, and other goods and services. A fixed proportion of energy is determined in each good consumed by households and split up into the fuel components. The nested structure of energy demand in consumption is identical to the structure in production.

Bussolo *et al*. (2003) present technical specifications of the regional and environmental general equilibrium model for India developed along the lines of the GREEN model. The paper provides the key structural and behavioural aspects of a model that assesses economic and environmental impacts of abatement policies. The model presents an interesting regional dimension in both comparative static and recursive dynamics models. The study uses a 35-industry SAM built from a 60 industry-Input-Output table for India for 1994/95. The energy specification of the SAM features 4 mining sectors (coal, crude oil, and crude gas industries), and 4 manufacturing sectors (coal products, oil products, electricity, gas and water manufacturing).

b. Core CGE Model

The core of the constructed model for South Africa is based on the neoclassical general equilibrium theory. It collapses a whole economy into three major parts: (i) the supply of goods and services[3] that includes production and trade activities; (ii) the demand of goods and services by institutional units[4]; and (iii) the macro-economic constraints. Then the model builds equations meant to capture the behaviour and interaction between the three components. The main behavioural assumptions embedded in the model are as follows:

- Producers maximise their profit under a given technology and independent prices (perfect competition assumption). Industry-specific producers are modelled as representative producers that are assumed to have a nested constant elasticity of substitution (CES) production technology.
- The relationship between the rest of the world and the domestic economy is determined by the substitutability between imported and domestic goods on the consumption side (Armington assumption), and by the substitutability between the domestic and international markets on the production side. The relative prices of foreign goods – defined by international fixed prices (small country hypothesis), the exchange rate, and government interventions (taxes, subsidies, and tariffs) – determine the allocation of supply and demand between domestic and international markets.
- Consumers maximise their utility under limited budgets and given market prices (perfect competition assumption). Households are modelled as representative agents that are assumed to have Stone-Geary type of preferences.
- Perfect competition prevails in the sense that producers and consumers take as given the relative prices that simultaneously clear all markets, that is, equalizing the quantity produced for each commodity to the quantity demanded for that commodity. Households' behaviour is rational which implies that in the presence of complete markets, there is a separation between their production and their consumption decisions (separability hypothesis).

The model specifies a number of structural features designed to reflect the characteristics of the South African economy. In the main, this is what distinguishes it from other standard models in this class of models. The structural features that are imposed on the model are listed next.

- Empirical evidence and special characteristics appeal for a better specification of the South African labour market that the standard analysis fails to capture. There is a general consensus among analysts that the labour market in South Africa is segmented. Each segment corresponds to a specific skill-level and behaves differently in terms of earnings, job opportunity, unemployment, and wage flexibility.[5] Therefore, workers and the labour market are distinguished into high-skilled (from hereon referred to as skilled workers), medium-skilled and low-skilled categories (from hereon referred to as unskilled workers). Each category in turn is separated by sex (male and female) and location (urban and rural areas). While education and experience are important determinants of earnings, other factors such as discrimination by race and gender and barriers to mobility (i.e. geographic location) are associated with larger differentials than usually found in studies for other countries (Fallon and Lucas, 1998)[6].
- Capital demand is industry-specific. Consequently, there are as many returns to capital as there are capital using industries in the economy. Capital supply is exogenous and institutional units are endowed with a single type of

3. Negative supplies of goods and services correspond to the demand of goods and services for intermediate consumption and include the demand for labour and capital services.
4. The negative demand corresponds to the supply of labour and capital services.
5. The country faces at the same time a shortage of skilled workers and a high unemployment rate among unskilled workers.
6. The model does not explicitly treat the rural-urban migration issue though. Furthermore, men and women tend to work in different sectors, some sectors are male-oriented (i.e. mining, food, beverage and tobacco heavy manufacturing and construction), while others are female-oriented (i.e. textile, privates services). Cockburn *et al*. (2007) further discuss the sex segmentation of the labour market in South Africa. We consider that racial discrimination is minor and individuals with identical education and work experience have the same opportunity to be hired regardless of the population group they belong to.

capital. Although the return to capital is industry-specific, each domestic institutional unit (urban households, rural households, firms and government)[7] receive an average return to their capital according to its distribution across industries. There is no return to capital use in general government services. Instead the government supports the cost of using such capital.

- The model explicitly treats the trade and transportation margins for commodities that enter the market sphere. A constant trade and transportation margins coefficient is added to each transaction and included in the purchasing price of commodities. Consequently, the generated revenues represent additional demands for trade, and transport services.

- There is a separation between production activities and commodities. A fixed proportional relationship between activity output and commodity domestic supply permits any activity to produce one or multiple commodities and any commodity to be produced by one or multiple activities.

CGE models differ primarily in the choices of closure rules which equilibrate commodity, factor and foreign exchange markets. They also differ in rules specified to reconcile the government budget constraint and in the mechanism used to equilibrate savings and investment levels in the economy. To this end, closure rules adopted in this study follow:

- All commodity markets follow the neoclassical market-clearing price system, in which jointly determined producer and consumer prices vary only by given tax, subsidy and margins rates.

- The labour market is assumed to be fully segmented. Workers are immobile between urban and rural areas according to the short term perspective of the analysis and the absence of explicit treatment of migration between the two areas. Skilled workers do not compete for unskilled jobs and unskilled workers similarly do not compete for skilled jobs. As a result, high-skilled, medium-skilled and low-skilled male and female workers in both urban and rural areas participate in different labour markets. Each category of labour is assumed to be perfectly mobile across industries. A single wage index prevails for each market.

- Skilled workers are fully employed in the economy although low rates of frictional unemployment8 are observed in urban and rural areas for this category. The skilled labour market is assumed to be perfectly competitive so that the prevailing wage rates equalize exogenous supplies and endogenous demands for high-skilled workers in both urban and rural areas. In contrast, there is imperfect competition in the unskilled labour markets where the total demand does not equal the total supply. There is an excess supply of labour which remains unemployed. The wage rate paid to unskilled male and female workers is fixed in real terms in both urban and rural areas.

- According to the characteristics of the labour market in South Africa and the short term perspective of the study, we assume that the employment decisions in general public administration are exogenously determined as government hiring possibilities are limited. Therefore, fixed indexed-wage rates prevail in the general government services, while other industries take the market wage rates as given.

- The supply of each category of labour is exogenous[9]. Household labour supply specification takes into account the existence of unemployment for low skilled labour categories. We assume that low skilled employment is rationed on the demand side and workers have the same opportunity (probability) to be hired regardless of the household to which they belong.

- The foreign exchange market equilibrates via adjustments of the real exchange rate. The current account balance is therefore exogenous and pre-specified at the base year level. Hence, with fixed foreign borrowing and transfers from abroad, higher imports of some goods will require lower imports and/or higher exports of other goods in order to

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7. The non resident agents do not own capital; instead they receive property transfers income (dividend, interest, etc.) from the resident agents.

8. Frictional unemployment exists because both jobs and workers are heterogeneous. A mismatch related to skills, payment, worktime, location, attitude and tastes can result between the supply and the demand of labor.

9. Allowing the supply of labour to be endogenously determined by households is not relevant in our study as long as we claim for a short term perspective of the analysis. Thus, new educated labour or/and skilled labour migrants will not play an important role in the model. With the presence of unemployment rationed on the demand side, high (low) employment will lead to low (high) participation to economic activity and will not necessary impact on the unskilled wage rates assumed fixed in real terms.

keep the current account balanced. Pressures to change export or import quantities (and hence, demand and supply of foreign currency) are therefore equilibrated by adjustments in the real exchange rate.

- Government is passive in the sense that it does not optimize any objective function. Its role is limited to that of regulating economic activity. Its earnings comprise revenues raised from indirect taxes, direct taxes, trade taxes and net foreign borrowing. Its expenses consist of subsidies, current expenditures on the services provided by the public sector, investment and transfers to households and firms. The simulations are performed under a rigidity of government current expenditures. This closure rule is motivated by the absence of explicit modelling of the macro and distributional effects of changes in government spending. The government deficit is covered by borrowing on the domestic credit market.

- Private savings are investment driven, i.e. investment is fixed at it base year level and adjustment is forced into the savings account. In a comparative static context, this means that the costs of the oil price increases and government interventions are not passed onto the future. In a context where private savings are endogenously determined - by exogenous constant rates for households and by residual for firms - government is forced to adjust its deficit. Thus, a compensatory lump-sum tax/subsidy on household incomes and welfares is integrated to maintain the government expenditures unchanged and to adjust its deficit in order to keep constant the volume of investment. The lump-sum tax/subsidy has to be interpreted as the current cost/benefit of maintaining unchanged the future welfare effects of government expenses and of investment, i.e. there is no inter-temporal free lunch situation.

- The model is homogenous of degree one in all prices and nominal values. The "numeraire" is the nominal exchange rate – however the real exchange rate remains endogenous through flexible domestic prices. All nominal values are thus measured relative to the price of internationally traded goods. The model solves for one-period equilibrium and results have to be interpreted in comparative static terms. A detailed presentation of the model using mathematical specifications is provided by the annexed document "The Energy Focused Computable General Equilibrium Model for Assessing the Impacts of Policy Responses to High Oil Prices in South Africa".

c. Energy Specificities of the CGE Model

The model differs from standard CGE models in two other main aspects: the energy supply and demand specification on the one hand, and the price setting method in the domestic oil market, on the other hand. The model has four types of energy namely, crude fuel, refined fuel products, coal, and electricity (including gas and renewable energy). The way energy is modelled features specific features that are outlined next.

An industry j's technology is presented as a nested CES function (Figure 1). The gross output consists of a Leontief function of the composite value added-energy and the non-energy input consumption. Leontief technology also determines the demand for non-energy commodities in the total non-energy input consumption. A CES function aggregates unskilled labour and the bundle of capital-energy and skilled labour in the value added-energy composite, with a high elasticity of substitution. The bundle of capital-energy and skilled labour is also a CES aggregation of capital-energy and skilled labour. However, the latter has a low elasticity of substitution. Each unskilled and skilled labour category is a fixed proportional (Leontief) relationship between urban and rural labour categories. A unitary elasticity of substitution (Cobb-Doublas) aggregates low- and medium- skilled male and female workers on the one hand, and high-skilled male and female workers, on the other hand. A CES function with a low elasticity demonstrates that capital and energy imperfectly substitute for each other (quasi-complementary) in the composite capital-energy.

Energy inputs are divided into four types which are imperfect substitutes of each other (Figure 2). Composite fuels and electricity are combined in a CES function with a relatively low elasticity of substitution, i.e. it is not easy for industries to adopt a better energy efficiency technology according to the short run perspective of the study. The former is defined as a CES-aggregate of coal and oil fuels, also with a relatively low elasticity of substitution between them. Finally, crude oil and refined oil products are assumed to be complements in the oil bundle. The demand for each energy commodity is shared between imports and domestically produced goods depending on their relative prices and assuming a high degree of substitutability between them.

The goods and services consumed by households are grouped by purpose, i.e. food, personal care, housing, etc. (Annexure 2). A single commodity category (e.g. petroleum product) enters into one or several groups of consumption by purpose (e.g. household fuel and transport). Representative urban and rural households maximise unitary utility functions over the group of consumption by purpose, subject to the constraint of their income. Thus, households' expenditure on commodities combine a Linear Expenditure System (LES) function over various groups of consumption by purpose, and a Cobb-Douglas (CD) function over commodity categories for each group of consumption by purpose.

d. Micro-simulation Model

An energy focused CGE framework has been developed in order to evaluate the impacts of high oil prices on the performance of the economy, on poverty and inequality reduction and, on the well-being of South Africans. However, the model accounts for only two representative household categories, that is, urban and rural whereas indicators used for the analysis of poverty and inequality generally use household or individual level data limiting its usefulness for the income distribution and poverty impact analysis of oil crisis. Therefore, micro-simulation modelling is essential in analysis of the distributional impacts of the macro shocks in order to reconcile the use of macro-models with distributional impacts analysis.

Figure 1: Structure of production by industry

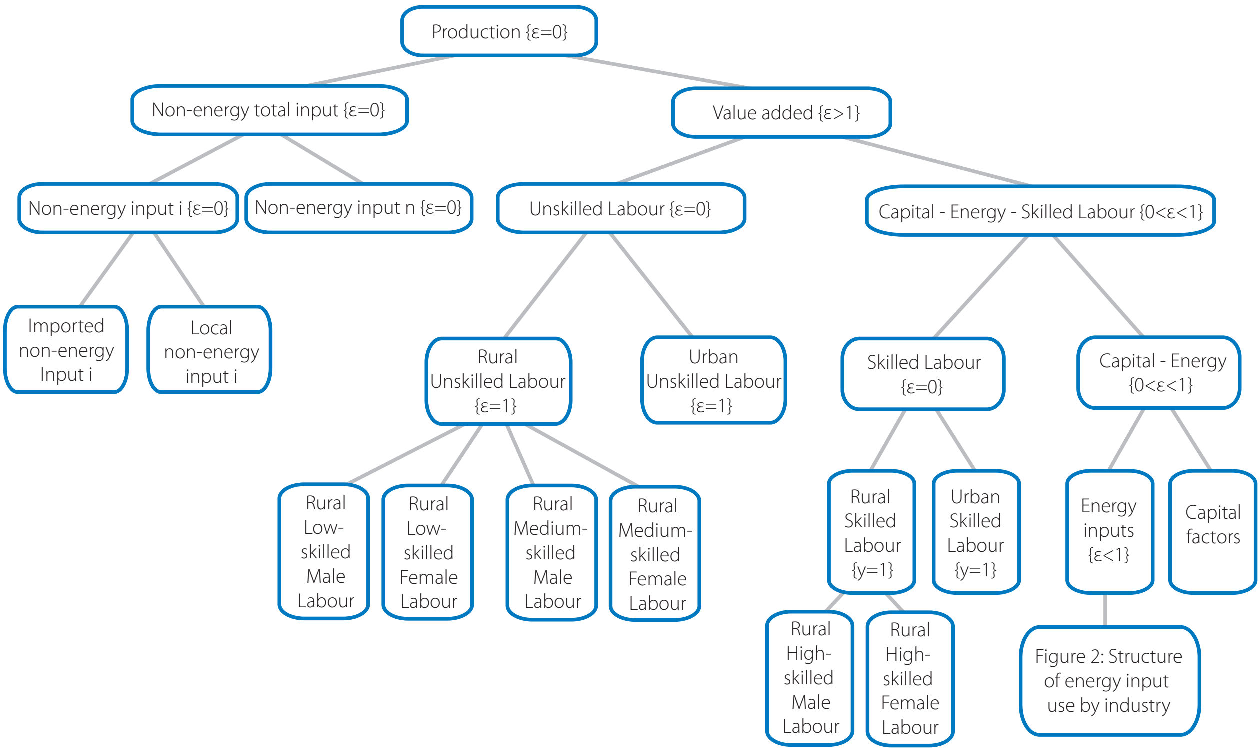
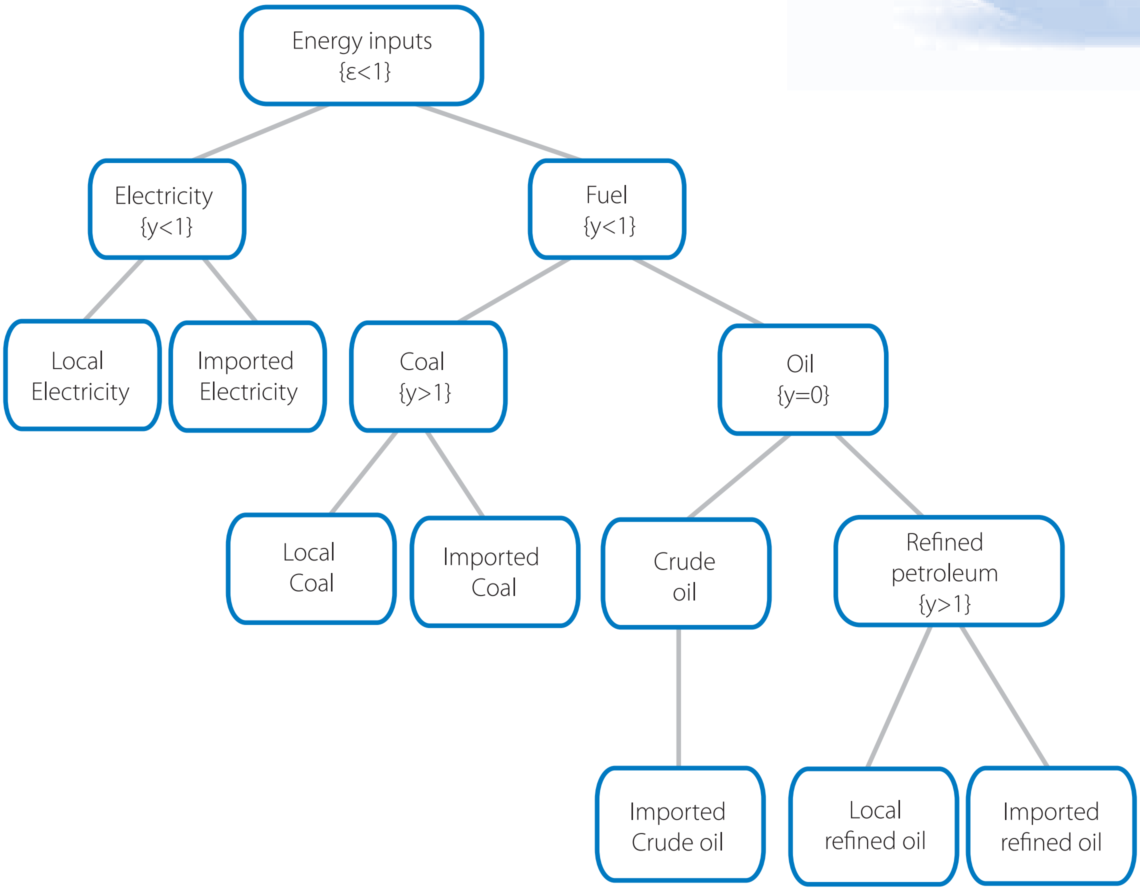


Figure 2: Structure of energy input use by industry



The study uses a two-layered macro-micro technique to analyse the income distribution and poverty impacts of the alternative policy responses to high oil prices in South Africa. The macro and micro modules are linked in a top-down fashion which does not account for the feed-back (second-order) effects from the micro component to the macro component of the model. Therefore, one should interprete the results as a first-round (prices and quantities) distributive impact analysis of the oil shocks. The following sections discuss the main features of the micro-household model and the survey information used. A detailed presentation is provided in the annexed document "*The Micro-Simulation Model for Analysing the Poverty and Inequality Impacts of Alternative Policy Responses to High Oil Prices in South Africa*".

The micro-simulation model developed in this study follows Ravallion and Lokshin (2004) and Ganuza *et al*. (2002) in accounting for both prices and reallocation effects of shocks. It takes CGE results on the employment and unemployment variables and on the return to factors as inputs. For each of the 12 segments of the labour market, the changes in employment or unemployment variables obtained from the CGE model are imposed onto the individuals in the survey. Unemployed individuals are randomly selected to join the pool of employees in a situation where employment increases. In the opposite case, we randomly select individuals remaining employed when retrenchment occurs. The selection process is repeated a large number of times to allow for the determination of confidence intervals of poverty and inequality indicators. Finally, the changes in wage rates are applied to salary and wage workers; the latter are aggregated to the real households-level. Business and transfer earnings are also adjusted by the changes in the return to capital and in the average economy-wide price, respectively, from the CGE model. Households' earnings, that is, wage, profit, and transfer, are computed and used for the measurement of the counterfactual income poverty and inequality indicators.

Individual regular income are drawn from the 2000 Income and Expenditure Survey (IES) and the September 2000 Labour Force Survey (LFS) both published by Statistics South Africa. Data on individuals' (thus, household) regular income, that is, salaries and wages, profits and net incomes, and transfer receipts are generated from the IES. Time spent by individuals on market activities, that is, salary and wage work, self-employment work, and unemployment, and many other pieces of information related to the employment status of individuals are missing from the IES 2000. Therefore, the latter is completed by information from the LFS 2000. The 18 sources of income from the IES are grouped into 3 categories according to the main source of income in the CGE model. Household earnings sum up the regular incomes generated by its members. There are 389 occupational groups aggregated into 3 skill levels using the Statistics South Africa classification in the 1998 SAM (Annexure 3).

A standard Mincerian wage regression imputes wages to unemployed and inactive individuals. Log wages are regressed on education and age (proxy of the experience), controlling for gender, employment status (full or part time), the marital status, and finally, the presence of children under 7 years old.

The IES and the September LFS are based on the same sample of households interviewed but a lot of mismatches have been observed between the two databases as pointed out by many analysts who work with these databases[10]. Important differences between income and expenditures within the IES have been raised. Indeed, there has been substantial inflation in South Africa between 1995 and 2000, whereas the 2000 household survey data shows that nominal household per-capita incomes have decreased since 1995, the year of the previous household survey. The 2000 sample contains a much larger African share and a much smaller white share. This may have generated in part by the above apparent anomalies. Therefore, we re-weight the survey sample to make it consistent with the 2001 census population shares.

A distinct advantage of the approach used here, that of accounting for all households in a survey, is that we are able to translate the policy effects to national poverty effects. In our study we use the existing poverty lines for South Africa to calculate various poverty indices that help to characterize poverty[11]. The base year households' regular incomes and income poverty indicators are computed as the former are proxies for the household's welfare. The Foster, Greer, and Thorbecke measures of poverty and the Gini coefficient measure of inequality are used.

e. Energy-focused SAM

This section briefly presents the procedure followed in constructing an energy-focused social accounting matrix for South Africa. The annexed document "The Energy-focused Social Accounting Matrix for South Africa" provides detailed information on this procedure. The supply and use tables and the integrated economic accounts are reconciled into a standard social accounting matrix. The latter is disaggregated to account for multiple factor and household categories. The procedure of integrating the energy specificity into the standard SAM is presented in three steps. First, the supply of "crude oil" is extracted from "other mining and quarrying". As there is no domestic production of "crude oil", the total supply is essentially satisfied by imports. Second, the petroleum industry is decomposed into synthetic fuel industry and refined oil industry. South Africa has large endowments of coal which have been converted into close substitutes of refined oil products by the well-developed synthetic fuel industry. Third, most SAM households' consumption are presented by product-category; the Energy-SAM rearranged the households' consumption by purpose and presents additional accounts for these.

In the standard SAM, crude oil is merged with other minerals such as diamonds and iron ore into one category named "Other mining". Previous SAM-based CGE analysis of oil price shocks on the South African economy[12] adjusted the standard SAM in order to separate the supply and the use of crude oil from other mining. Essama-Nssah *et al*. (2007) created a specific account named "crude or unrefined oil" in their 2003 SAM and assumed that the amount of other mining inputs used in the production of petroleum and basic chemicals equals the total use of crude oil. The latter is essentially imported without transaction fees, that is, tariff and other tax on products, and margins.

10. Mabugu and Chitiga (2008) and Pauw (2005) have provided useful discussions on these inconsistencies.
11. Some examples are FGT index, Watts's index, and Clark, Hemming and Ulph (CHU) index.
12. McDonald and Schoor, 2005; and Essama-Nssah *et al*., 2007.

In the 2000 Supply Use Tables, this is equivalent to an amount of R12.7 billion, more than half of the R24.3 billion officially reported by the South African Revenue Service (SARS) for the same year.[13] Furthermore, South Africa has a well-developed coal-input synthetic fuel industry which is represented in the structure of production by the "coal" and "other mining" (principally gas) inputs used in the refined petroleum. The following adjustment procedure aims to account for this discrepancy and the specificity of South Africa oil and petroleum industry.

We rely on the value of crude oil imports given by SARS (that is, R24.3 billion for the year 2000). There is no domestic production and supply of crude oil in 2000 according to the Energy Balance of South Africa and imports of crude oil are free of transaction fees. As a consequence, the total supply of crude oil is equal to its total import value of R24.3 billion and the total import of the "new" other mining account is adjusted residually.

The "new" other mining (essentially, gas) input use in the refined petroleum industry is estimated at R0.4bn using a ratio of gas to coal inputs (valued at 0.1 from the 2000 energy balance) and the coal input use in the refined petroleum industry (R3.9bn from the SAM). The crude oil input use in petroleum industries is arrived at as a residual after subtracting the gas input from the other mining inputs. Crude oil is also used in basic chemical industries and its input use is assumed to be equivalent to the other mining input use in these industries. There is no export of crude oil and the change in stocks rebalances the supply and use of the crude oil, as well as that of the "new" other mining.

In the standard SAM, the petroleum industry includes both the synthetic fuel industry and the refined oil industry. A closer look at the input-output table shows that the industry uses large proportions of both other mining input (mainly crude oil and natural gas) and coal input. The input of coal is essentially used in the synthetic fuel industry, while the input of crude oil is used in the refined oil industry. The input of other mining (such as natural gas) is also used in the synthetic fuel industry.

According to the 2000 Energy Balance for South Africa, synthetic fuel accounts for 30 percent share of total final consumption of energy in the year 2000. We assume that the value of domestic supply of synthetic fuel would be around the same proportion as long as their unit energy costs are close. This share is used to split up the value of domestic supply for petroleum products in the standard SAM between synthetic fuel and refined oil. The main input costs (coal and other mining inputs for the synthetic fuel industry, and crude oil input for the refined oil industry) are deducted from the estimated supply values. Then, the net values are distributed over the remaining inputs and value added components according to their distributive shares for the petroleum industry in the standard SAM. The production of both synthetic fuel and refined oil are proportionally supplied to the various petroleum related products.

The classification used by Statistics South Africa in the IES 2000 is based on consumption by purpose. Annexure 2 summarizes the different categories of consumption by purpose. It shows 13 groups of consumption by purpose which have been finally aggregated into 12 groups. Each of the 94 consumption commodities is distributed over these 12 groups of consumption by purpose using their distributive shares. Additional accounts are created to integrate this latter classification of consumption into the standard SAM. The latter feature presents an advantage in that it highlights household fuel and transport fuel items in the households' expenditures in the same way as if one were to decompose fuel products into several types (for example, petrol, LPG, diesel, etc).

The resulting Energy-SAM for the year 2000 is a detailed database that brings together in a single framework information on the South African economy from various sources. The SAM's industries and commodities are kept as disaggregated as possible in order to better track the multiple channels by which the economy might be impacted by oil price shocks. The Energy-SAM presents 6 institutional accounts consisting of 2 representative household categories (urban and rural), 2 representative corporation categories (financial and non financial), government, and the rest of the world. Its also has 16 productive factors, 12 types of labour and 4 capital categories. Three criteria are used to distinguish workers, namely, the residential area (urban and rural) and the skill category (high, medium and low skilled) and the sex of individuals (male and female). The capital factor is separated into public capital which is the capital endowed by the government and private capital endowed by other domestic institutional units. The latter is also distinguished by urban, rural and corporations' capital. There are 5 taxes and transfer accounts, mainly the taxes on revenue and wealth, the tax on production less

13. This inconsistency has also been addressed by McDonald and Schoor, 2005

subsidies, the import duties, the value added tax, and the other taxes on product less subsidies. The SAM accounts for 95 activities including 1 aggregate agriculture activity, 4 mining activities (including one crude oil represented by a domestic production of synthetic fuel), 80 industries (with one aggregate petroleum industry that combines synthetic fuel and refined oil industries) and 10 services (including one aggregate general government service). The commodity account presents the same decomposition. Finally, the 95 commodities are then clustered into 12 groups of consumption by purpose for each urban and rural household category.

The energy-focused SAM integrates separate accounts for synthetic petroleum and oil petroleum activities. The former uses coal and natural gas to produce refined petroleum products, while the latter transforms the imported crude oil into refined petroleum products. A separate account has been integrated into the SAM to separate crude oil products from other mining products. Thus, four energy related activities are represented in the Energy-SAM, namely coal, synthetic petroleum, oil petroleum, and electricity. There are also four energy related products namely coal, crude oil, refined petroleum (including synthetic petroleum and oil petroleum products), and electricity (including gas and renewable energies). Therefore, the output of synthetic petroleum and oil petroleum are combined into a single product named refined petroleum on the consumption side, i.e. the two products are perfect substitutes.

f. Non-calibrated parameters

Results from CGE models are sensitive to the value of supply and demand of key parameters. Many of these parameters, in particular the elasticities, are not calibrated in the model but estimated using econometrics techniques. When dealing with policy changes, it is important to use relevant elasticities, especially as far as trade elasticities are concerned. The lack of econometric estimation should call for undertaking sensitivity analysis of the results in order to determine values that alter the key results and their interpretation.

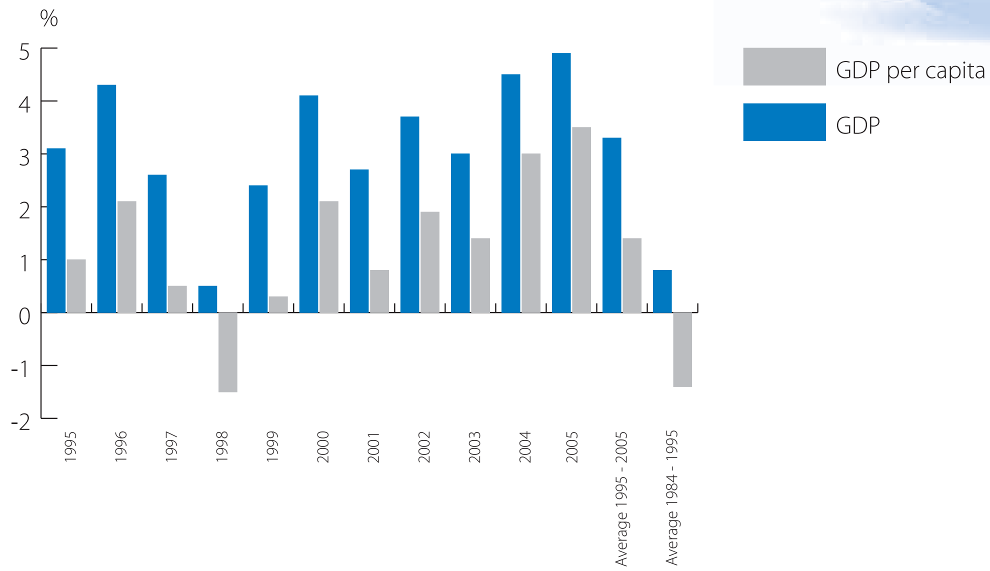
Our analysis distinguishes four sets of parameters that entered into the model: the trade parameters (import substitution or Armington elasticities, and export supply and demand elasticities), the production technology parameters (substitution elasticities between factors), the demand parameters for households (demand elasticity of income, and Frisch parameter), and the labour supply parameters (high skilled and low skilled unemployment rates).

Estimates of trade parameters, i.e. industry-level Armington elasticities and aggregate export supply and demand elasticities, are available for South Africa. According to the short term perspective of the analysis, our study uses the short-run Armington elasticities from Gibson (2003) and the low-bound export supply and demand elasticities from Behar and Edwards (2004). The values of trade parameters are presented in Annexure 12 and Annexure 13. Unemployment rates are drawn from the 2001 labour force survey report by Statistics South Africa (2001). To our knowledge, estimates for parameters in industries' production and households' demand are not available for South Africa. Therefore, our study borrows these values from the literature surveyed by Annabi *et al*. (2006), and analyses the sensitivity of the results with respect to these elasticities. In general, results are not significantly affected by "reasonable" changes in these values.

4. Macro-economic Structure of South Africa

The economic performance of post apartheid South Africa has been relatively impressive, averaging 3.3 percent for the real GDP growth rate and 1.4 percent in per capita terms for the period 1995 to 2005. This growth trend was an improvement, if one compares with the rates of the 1985 to 1994 period, where the respective average rates were 0.8 and –1.3 percent (Figure 3).

Figure 3: GDP and GDP per capita growth rates (constant 2000 prices)



Source: South African Reserve Bank (SARB) database (www.reservebank.co.za).

Final consumption by household and by government far outstripped the contributions made by the other components of GDP. It contributed 67 percent while net export and investment represented 20 and 13 percent, respectively of GDP in 2000 (Annexure 4). After a long period of increases, the unemployment rate has been declining over the last years (Annexure 5). Inflation recorded successively a period of increase and decrease and has been on the increase since 2004. The tertiary sector, with an average growth rate of 3.8 percent, substantially outperformed the primary and secondary sectors (Plessis and Smit, 2006). At the other end of the spectrum, the primary sector contributed the least to overall growth with an average real growth rate of only 0.4 percent. In 2000, the service sector (private and public) was the most important contributor to the GDP with 62 percent (Annexure 6). The manufacturing sector represented a relatively important share of 29 percent of GDP, while the primary sector (agriculture and mining) contributed less than 10 percent.

The top industries in terms of contribution to GDP derived from the 2000 Energy-SAM are presented in (Annexure 7). It shows that "General Government" is by far the biggest contributor with 15.0 percent, followed by "Trade services" with 10.3 percent. "Petroleum industry" (including "Crude fuel") contributed 3.3 percent to GDP and ranked among the top eight contributors out of the 95 industries in the 2000 Energy-SAM.

Imports of oil and oil products represented roughly 5 percent of total imports in South Africa for the year 2000 (Table 1). Despite a positive trade balance value, South Africa recorded a deficit of its balance of payments (BoP) in 2000 corresponding to 1.1 percent of exports and 0.3 percent of GDP[14]. The coverage ratio (ratio of total exports to total imports) is estimated to be 1:13.

South Africa has a well-developed synthetic fuels industry facilitated by the country's abundance of coal resources and offshore natural gas. These permit the country to meet 35 to 40 percent of its domestic liquid petroleum requirements while 14 percent is exported. Thus, the country presented a high coverage ratio of oil and oil products in the year 2000 compared to a typical net oil-importing country. Petroleum was among the most export oriented industries in 2000 (Table 2). Results, discussed below, depend strongly on both import and export structures of oil and oil products in the economy.

14. Essentially, this is due to the capital (dividend, interest, etc.) payments to the rest of the world that surpass the capital income from the rest of the world in year 2000.

Table 1: Import value for selected products (year 2000)

SAM industries	Value (c.i.f.)	Share (%)	SAM industries	Value (c.i.f.)	Share (%)
Motor vehicles parts	18,277	9.5	Communications	3,458	1.8
Radio and television products	13,147	6.8	Other manufacturing	2,837	1.5
Motor vehicles	10,609	5.5	Pumps	2,618	1.4
Other mining products*	**7,814**	**4.0**	Mining machinery	2,551	1.3
Office machinery	7,719	4.0	**Petroleum products**	**2,459**	**1.3**
Other transport products	7,703	4.0	Other fabricated metal products	2,437	1.3
Optical instruments	6,396	3.3	Iron and steel products	2,331	1.2
Transport services	6,157	3.2	Other services / activities	2,316	1.2
Other special machinery	6,015	3.1	Other business services	2,263	1.2
Basic chemical products	5,993	3.1	Plastic products	2,240	1.2
Pharmaceutical products	5,367	2.8	Paper products	2,213	1.1
Accommodation	4,372	2.3	Textile products	2,123	1.1
Non-ferrous metals	4,206	2.2	Insurance services	1,942	1.0
Primary plastic products	4,114	2.1	Electricity apparatus	1,925	1.0
Other chemical products	4,108	2.1	Machine-tools	1,905	1.0
Agricultural products	3,494	1.8	Other products	41,977	22.0
All				**193,084**	**100.0**

Source: Compilation from the 2000 Final supply and use tables **Note:** * Crude oil import represents 84% of the total import of "Other mining products"

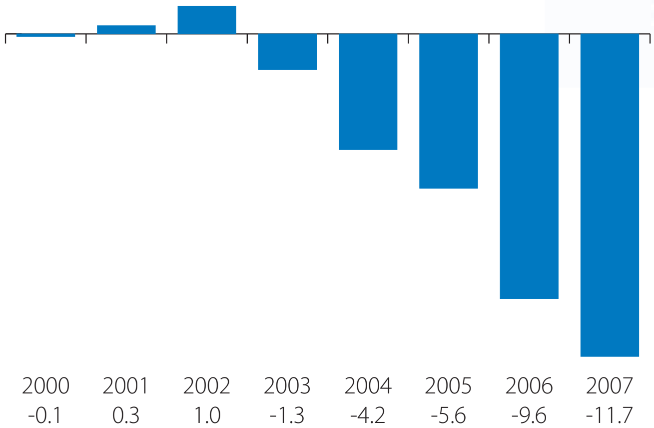
Table 2: Export value for selected products (year 2000)

SAM industries	Value (c.i.f.)	Share (%)	SAM industries	Value (c.i.f.)	Share (%)
Other mining products	33,234	15.3	Other transport products	2,701	1.2
Gold and uranium ore products	25,188	11.6	Furniture	2,585	1.2
Iron and steel products	17,948	8.2	Communications	2,419	1.1
Transport services	12,637	5.8	Wood products	1,996	0.9
Motor vehicles	9,262	4.3	Other manufacturing	1,,988	0.9
Non-ferrous metals	8,661	4.0	Sugar products	1,772	0.8
Coal and lignite products	8,524	3.9	Other special machinery	1,771	0.8
Petroleum products	**8,341**	**3.8**	Radio and television products	1,700	0.8
Basic chemical products	6,798	3.1	Primary plastic products	1,671	0.8
Insurance services	6,517	3.0	Other chemical products	1,594	0.7
Agricultural products	6,388	2.9	Jewellery	1,584	0.7
Accommodation	6,269	2.9	Fruit and vegetables products	1,574	0.7
Paper products	5,527	2.5	Other business services	1,394	0.6
Beverages and tobacco products	2,968	1.4	Other services / activities	1,365	0.6
Motor vehicles parts	2,910	1.3	Fish products	1,271	0.6
General machinery	2,816	1.3	Other products	191,373	12.0
All				**217,570**	**100.0**

Source: Compilation from the 2000 Final supply and use tables; Statistics South Africa (2003).

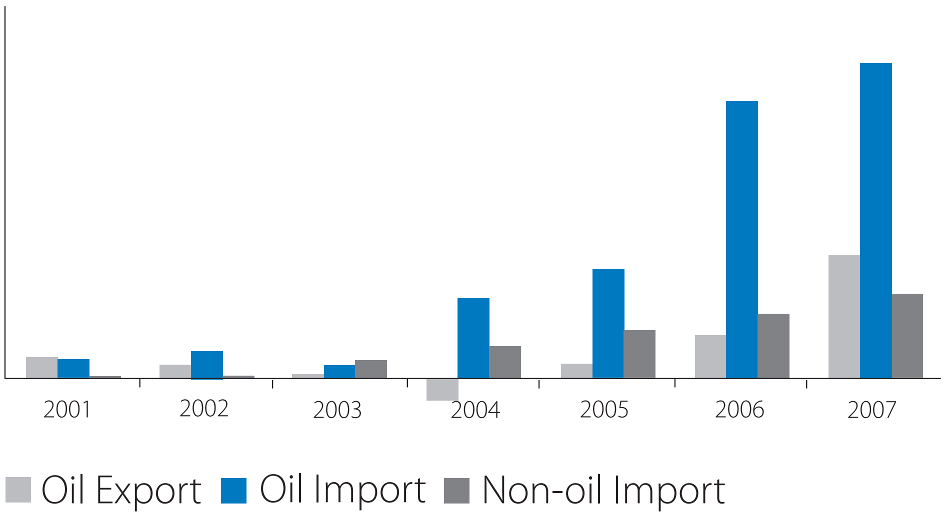
The **current account deficit** of the South African economy **has been** growing **sharply since 2003**, reaching twelve percent of its GDP in 2007 (Figure 4). The significant rise of the current account deficit means that the value of imports for goods and services has recorded a more important increase, in particular the import of oil and oil products, than the value of exports (Figure 5).

Figure 4: Change in the current account balance, percent of GDP



Source: Department of Trade and Industry (2008)

Figure 5: Change in external trade variables, percent of 2000 values



Source: Department of Trade and Industry (2008)

Oil intensity of an industry can be measured as oil and oil products input cost per unit of value added. The oil intensity ratio is computed for the aggregate industries recorded in the Input-Output (IO) table for the year 2000[15] (Table 3). It shows that "*primary plastic*" is largely the most oil input intensive industry in South Africa. The industry's oil input cost per unit of value added is estimated at 0.5. For simplicity, we focus on the top-ten and the bottom-ten oil input intensive industries after ranking them from the most to the least oil input intensity.

The top-ten group – referred to as "*high intensive oil input industries*" - have an oil input cost per unit of value added greater than 0.1, with an average of 0.2 for the entire group (Table 3). This group contributes 11 percent of the total value added and accounts for half (50 percent) of the total oil input cost. When we use the share of oil bill in total energy input – considering the principal sources of energy in South Africa (that is, coal, petroleum, and electricity) – as an indicator of inter-fuel substitution possibility, we found that most industries of this group have a very limited ability to substitute other

15. Final supply and use tables, 2000: an input-output framework/Statistics South Africa; Statistics South Africa, 2003

fuels for oil. The average share of oil and oil products input cost in the total energy input cost is 77 percent. Primary plastics, "Transport services" and "Agriculture" are the most vulnerable industries to high oil prices as they have the highest shares of oil input cost in total energy input cost. In contrast, "Non-ferrous metal", "Tyres", and "Gears" industries are more amenable to inter-fuel substitution possibilities as their average oil shares in energy are relatively low.

The bottom-ten groups – or *low intensive oil input industries* – presents an oil input cost lower than 0.01 per unit of value added (Table 3). They contribute 17 percent of the country's value added and account for 2 percent of the total oil input cost. The average oil intensity is very low as well as the share of oil in total energy input for this group of industries.

The electricity sector is among the least oil input intense sectors in South Africa with a share of oil in the total energy input of 2 percent and an oil intensity of 0.006 percent (Table 3). It is highly intensive in coal which represents more than 70 percent of the sectors' energy input cost. In contrast, transport sector is intensive in oil with an oil intensity of 0.2 ranking behind the primary plastics and, the paints industry (Table 3). With a high share of oil input cost in energy input cost, large-scale fuel substitution is less likely to occur in the transport sector without substantial financial support from the Government. Therefore, high petroleum-products prices are expected to impact more on the cost of transport services and primary plastics.

Table 3: Industry Energy Profile of South Africa in year 2000

	Value added		Oil		All energy		Oil intensity	Share of oil in total energy
	Value	***Share***	**Value**	***Share***	**Value**	***Share***		
High intensive oil-input industries								
Primary plastics	3,401	*0.4*	1,600	*4.8*	1,720	*2.6*	0.471	93.0
Paints	1,316	*0.1*	279	*0.8*	359	*0.5*	0.212	77.7
Transport services	49,729	*5.6*	9,728	*29.3*	10,998	*16.4*	0.196	88.4
Tyres	1,555	*0.2*	241	*0.7*	485	*0.7*	0.155	49.7
Pumps	638	*0.1*	91	*0.3*	113	*0.2*	0.142	80.2
Fertilizers	1,805	*0.2*	248	*0.7*	303	*0.5*	0.138	81.9
Non-ferrous metals	8,180	*0.9*	1,105	*3.3*	3,678	*5.5*	0.135	30.0
Gears	307	*0.0*	38	*0.1*	66	*0.1*	0.124	57.7
Basic chemicals	3,215	*0.4*	385	*1.2*	473	*0.7*	0.12	81.4
Agriculture	26,953	*3.0*	2,765	*8.3*	3,206	*4.8*	0.103	86.3
All	**97,100**	***10.9***	**16,480**	***49.6***	**21,401**	***32.0***	**0.17**	**77.0**
Low intensive oil-input industries								
Sugar	1,639	*0.2*	10	*0.0*	60	*0.1*	0.006	17.2
Electricity	20,469	*2.3*	126	*0.4*	6,130	*9.2*	0.006	2.1
Other paper	1,599	*0.2*	8	*0.0*	14	*0.0*	0.005	58.2
Containers of paper	2,266	*0.3*	11	*0.0*	47	*0.1*	0.005	22.5
Insurance	85,759	*9.7*	388	*1.2*	933	*1.4*	0.005	41.6
Beverages and tobacco	21,461	*2.4*	90	*0.3*	231	*0.3*	0.004	38.8
Wearing apparel	4,965	*0.6*	20	*0.1*	59	*0.1*	0.004	34.2
Publishing	6,404	*0.7*	21	*0.1*	71	*0.1*	0.003	28.9
Wire and cable	1,455	*0.2*	2	*0.0*	3	0.0	0.001	53.7
Other food	2,545	*0.3*	2	*0.0*	6	*0.0*	0.001	35.3
All	**148,563**	***16.7***	**678**	***2.0***	**7,555**	***11.3***	0.005	9.0
Other industries	642,394	*72.4*	16,094	*48.4*	37,982	*56.7*	0.025	42.4
All South Africa	**888,057**	***100.0***	**33,252**	***100.0***	**66,938**	***100.0***	**0.037**	**49.7**

Source: Compilation from the 2000 Final supply and use tables; Statistics South Africa (2003).

5. Experiments and Results

The study experiments with a sustained increase of import and export prices of crude oil and refined petroleum products under alternative government policy responses. It simulates a US $10 increase of import prices of crude oil. The shock is translated into a 50 percent increase of the cost of crude oil as compared to its (average) level in 2000. A simultaneous increase - but in a smaller amount of 25 percent - of the import and export prices of refined petroleum products is also simulated.[16] Our analysis should be taken as giving a short term perspective of the impact of recent oil price shocks.

We present the results for three scenarios. The first scenario assumes that the increase of the prices of crude oil and petroleum products imported by South Africa is fully transmitted to end-users through an increase of the purchasing prices. This is the current intervention of the government in the oil market which we assume is maintained. This scenario is referred to as the "*floating price scenario*". The alternative scenarios suppose that the government is willing to intervene and compensate for the increase of the consumption prices of petroleum products in order to protect consumers and producers. Thus, it decides to fully compensate the increase through the price subsidy mechanism. The purchasing prices of petroleum products are kept exogenous and the government fully compensates for an increase of their prices in the *sub-scenario 1*. The price subsidy mechanism is combined with a 50 percent tax on the profits of the synthetic petroleum industry in the *sub-scenario 2*. These scenarios are referred to as the "*fixed price scenarios*".

a. The floating price scenario

In this scenario, the oil price increase is fully transmitted to consumers and producers. It has differential impacts on industries' output and modifies the entire price structure and, consequently, factor reallocation. The impact on households depends on their factor endowments and their consumption patterns. The following sections trace in detail the impacts of the price shock as it channels through changes in macro-economic variables and the government budget, in activities' outputs, factor uses and prices, consumer prices, and the well-being of individuals.

- Macro-economic effects

The increase of the prices of crude oil (by 50%) and petroleum products (by 25%) increases the cost of imported crude. The crude oil import bill increases as its demand falls less (10.2%) than the increase in its prices (50.0%), i.e. the demand is inelastic with respect to the price (Table 4). Assuming that the economy faces a foreign reserve constraint in the sense that there are no spare reserves to spend and that it faces constraints on external borrowing[17], the increase of the import bill puts an upward pressure on the real exchange rate[18].

Under the small country assumption, i.e. fixed international prices, and a downward sloping export demand[19], an exogenous increase of the international prices of exported petroleum products boosts their exports by 4.9% and causes a depreciation of the real exchange rate. However, the increase of petroleum exports appears insufficient to compensate for the rise in the oil import bill. As a consequence, the real exchange rate increases in order to rebalance the external current account.

With a fixed "nominal" exchange rate chosen as the "numeraire" of the model, the increase in the real exchange rate has been permitted by a fall in the average domestic prices by 2.6%. Thus, total imports drop by 4.6% and total exports increase by 0.6%. The fall in domestic prices reduces business profits and wages and increases unemployment. As a consequence, incomes and real gross domestic production fall by 1.4% and 2.2%, respectively (Table 4).

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16. "At the end of the 1990s, oil traded below $20/barrel, while gasoline cost under $1.5 in the USA. In June 2008, crude traded at around $121 (after rising to over $135), while gasoline averaged $4.1. Oil prices rose by a factor of six, while gasoline prices rose by less than a factor of three." http://www.wikinvest.com/concept/Oil_Prices#_note-7
17. This assumption is translated by a fixed current account balance and a flexible real exchange rate in the model.
18. The real exchange rate is defined as the ratio of foreign average price (converted in local currency by the exchange rate) to domestic average price. The rise in the real exchange rate corresponds to the devaluation of the local currency.
19. The low bound values estimated by Behar and Edwards (2004) are chosen for the elasticity of export demand (Annexure 12 and Annexure 13).

Table 4: Change in macro-economic variables (percent)

Import of crude oil	-10.2
Export of petroleum products	4.9
Average domestic prices	-2.6
Total import	-4.6
Total export	0.6
Income	-1.4
Real GDP	**-2.2**

Source: Results of the experiments.

The fall in the GDP induced by high oil prices deteriorates the government fiscal revenue by 3.9% (Table 5). Under rigid government current expenditures, a compensatory tax on household incomes enables government spending and the economy-wide volume of investment to remain unchanged. Thus, the revenue gathered from the direct tax increases by 11.5% and government revenue by 7.6%. As a consequence, government deficit falls by 29.3%.

Table 5: Fiscal effects (percent)

	Initial share	Change in
Tax on imported goods	7.4	-4.7
Tax on local goods	23.4	-6
Tax on production	7.8	-6.8
Tax on income (Uncompensated)	46.7	-3.5
Capital revenue	8.6	0.4
In-transfer	6.1	-2.2
Uncompensated revenue	**100**	**-3.9**
Public expense	64.2	-0.9
Out-transfer	63.9	-2.2
Uncompensated deficit	**-28.1**	**11.8**
Tax on income (compensated)	-	11.5
Compensated revenue	-	7.6
Compensated saving	-	-29.3

Source: Results from the CGE model experiment

- Output effects

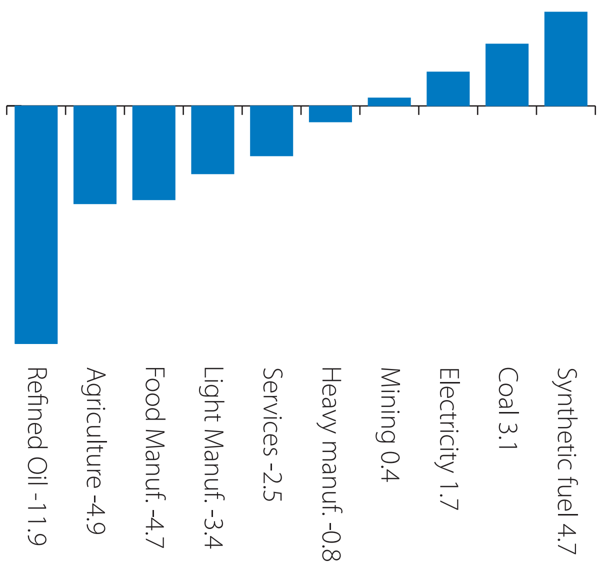
High oil and oil products prices modify the entire price structure and, consequently, commodity prices and factor returns in oil-importing countries such as South Africa. The differential impacts on activity production depend primarily on their oil input intensity which was measured as oil and oil products input cost per unit of value added (Table 3). An industry with high oil intensity is more likely to be adversely affected by higher oil prices. The structure of the demand also contributes to the distributional impacts of oil price shocks among industries. Indeed, high traded industries benefit more from an appreciation of the real exchange rate. Furthermore, the compensatory lump-sum tax on household income and wealth that keeps unchanged the government expenditures as well as the volume of investment is not sectoral-neutral. The tax-induced reduction of household income benefit less those industries producing for final consumption relative to investment goods oriented industries.

The oil price shock shows important distributional impacts amongst industries. It benefits disproportionately the alternative sources of energy that are close substitutes to oil and oil products. The price increase of imported crude oil reduces its imports as demand shifts in favour of locally produced petroleum, in particular the *synthetic petroleum* industry. As both products are close substitutes in the composite petroleum products, a $10 increase of crude oil price boosts the output of the *synthetic petroleum* industry by 4.7 percent (Figure 6). Its production uses coal and natural gas as input; hence, the increase of its output is more likely to have positive effects on the demand for coal (to a limited extent other mining industry). Furthermore, coal and electricity are close substitutes for petroleum products, the rise in the imported and exported petroleum price substantially increases the price of oil products and this diverts demand from these products towards alternative energy sources, namely coal and electricity. The demand for coal and electricity increases by 3.1 percent and 1.7 percent, respectively (Figure 6). A number of investment- and export- oriented industries, in particular mining and heavy manufacturing industries, also experience a relatively high output level (Annexure 14 and Annexure 15). The *transport services* also benefit from a sustained demand from expanding sectors and exports.

On the other hand, the petroleum industry with high oil input intensity relative to its value added witnesses a substantial fall in its output (11.9%). Final consumption-oriented industries ("*Household appliances*", "*Handbags*", "*Animal feeds*", "*Soap*", "*Activities services*", "*Bakeries*", "*Knitting mills*" "*Wearing apparel*" etc.) also contract due to a drop of their final demand. Furthermore, low input demand from the latter industries affects significantly the output of many other industries (e.g. "*Textiles articles*").

In aggregate, the mining industry also benefits from the increases of its exports as the real exchange rate rises while heavy manufacturing is least affected by the oil price shock. The severity of the impact is more pronounced on agriculture, light manufacturing (including food manufacturing), and private services.

Figure 6: Change in output (percent)



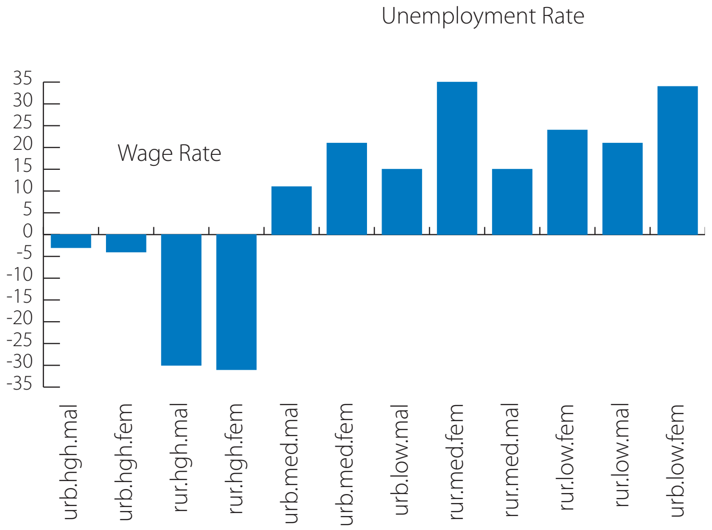
Source: Results from the CGE model experiments. **Note**: manuf. = Manufacturing

- Factor effects

This sub-section discusses how the output effects of an oil price shock influences factor prices and unemployment rates in South Africa. Factor prices are primarily driven by value-added prices. While value added price variations generally reflect those of output prices, their evolution is more positive when input costs rise less than output prices (Annexure 16 and Annexure 17). Value added prices generally fall the most among the highly intensive oil input sectors whereas they increase among sectors with low oil input use. It is noteworthy that alternative energy industries are among the sectors with the strongest increases in value added prices – "*synthetic petroleum*", "*electricity*" and "*coal*". This result indicates that, beyond the modest increase in their output prices, these sectors benefit relatively more from lower input costs. On the other hand, the higher input costs of the "*refined oil*" reduce the value added price despite an increase of the output price in this industry.

Whereas general government service workers are sector-specific with indexed wage rates, all private sector workers are mobile between sectors with wage rates that equalize across all sectors for high skilled workers and employment opportunities that change for medium and low skilled workers. The increase of oil prices has negative effects on the real wage and unemployment rates in both rural and urban areas (Figure 7). The wage rates fall in both urban and rural areas. In rural areas, male and female skilled workers witness a significant fall in their wage rates (29.5% and 31.5%); this fall is nearly ten times higher than that of their urban counterparts (3.3% and 3.8%). The increase in oil prices hits more female than male skilled workers. Unemployment rates also rise in both urban and rural areas (Figure 7). The rise in percentage points is more among low than medium skilled workers, and female than male workers. These results show that significant wage and employment distributional impacts of oil price shock are less harmful to urban and high skilled male workers. Rural workers are penalized by their lower involvement in energy activities for which value added prices have increased and the high dependency in agriculture which records a significant drop in output and value added. The other urban workers suffer more because of their higher dependency ratio on food and light non-food manufacturing activities whose output and prices also fall drastically.

Figure 7: Changes in wage and unemployment rates (percent)



Source: Results from the CGE model experiment. **Note:** Variations in real wage rate computed as percent changes; unemployment rate expressed as percentage point change, urb=urban; rur=rural; hgh=high skilled; med=medium skilled; low=low skilled; mal=male; fem=female.

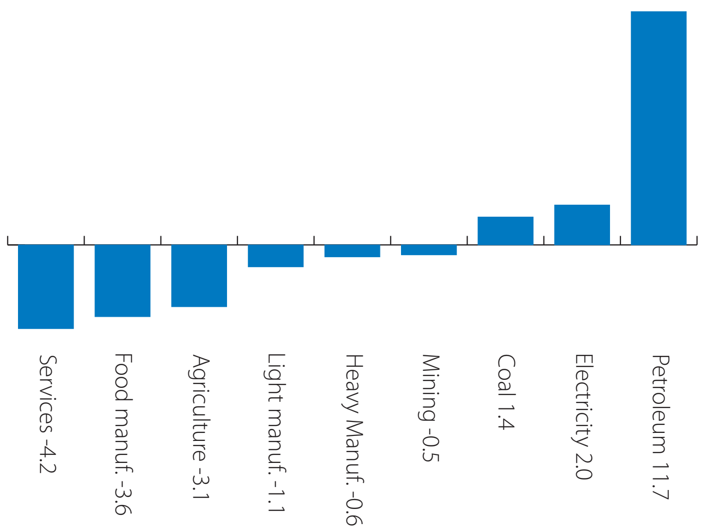
Capital is assumed to be sector-specific because of the short-term perspective of the analysis. As a result, variations in the rates of return to capital closely follow changes in the value-added prices of their respective sectors. These rates fall most in the oil input intensive industries and increase in the close oil substitute energy sectors (Annexure 18 and Annexure 19). The increase in the return to capital is particularly important for the "*Synthetic petroleum*" industry at 31.2%. The "*Electricity*" and the "*Coal*" industries also witness a rise in their return to capital by 5.6% and 5.0%, respectively. Few other industries - "*Other transport manufacturing*", "*Mining machinery*", "*Machine-tools*", "*General machinery*", "*Other chemicals*", "*Special machinery*" and

"*Structural metal*" - benefit from a fall in their input costs and sustained investment and export demand (Annexure 18 and Annexure 19). The above industries are the winners of the oil price shock. In contrast, "*refined petroleum*" industry records a significant fall in the return to capital by 34.6%. It is joined by many other industries that have been affected by a fall in the final and intermediate demands, among others, "*Soap*" and "*Fertilizer*", "*Animal feeds*", "*Household appliances*", "*Grain mills*", "*Pharmaceuticals*", "*Activities/services*", "*Textile articles*", "*Handbags*", "*Tyres*", "*Health and social work*", "*Meat*", "*Knitting mills*". The factor effects are important determinants of income distribution and, ultimately, the changes in poverty and inequality measures in South Africa.

- Price effects

In addition to its factor effects, the oil price shock influences household welfare by changing consumer prices (Annexure 20 and Annexure 21). The prices of commodities purchased by households is a weighted average of domestic and import prices, where the weight is the share of domestic-produced and imported commodities in the total demand. While non-oil import prices are kept constant, domestic prices fall for most of the products in particular for low import-substituting commodities. In contrast, purchasers' prices increase for energy products and high intensive energy input use products (Figure 8). Private services, food manufacturing and agriculture products experience the highest fall in the consumption prices attributed to their lowest import penetration rates. They are followed by light and heavy manufactured goods and mining products (Figure 8).

Figure 8: Change in purchaser price (percent)



Source: Compilation from CGE model experiments. **Note:** manuf. = Manufacturing

- Poverty and inequality effects

Table 6 shows the FGT and the Gini results of the oil price shock using the low bound poverty line (R322 per month) provided by Hoogeveen and Ozler (2004). The overall poverty headcount index increases by 1.2%. Further, the amount of money needed to bring poor people to the poverty line has also increased as seen in the poverty gap index. The poverty severity also increases more by 1.6%, i.e. the poorest suffer the most. These results are reflected when the group is disaggregated by region or by race. Poverty increases more in urban than rural areas. Although the oil price shock adversely affects more wages and employment in rural areas, the poverty indexes fall less in this area because of the high reliance of the rural middle-income class on transfers incomes (Annexure 10 and Annexure 11) - which values are kept fixed in real terms - and on high skilled labour income as compared to its counterpart in rural areas (Annexure 8 and Annexure 9). In terms of racial groups, the poverty indexes increase more among Coloured and African household groups. These two racial groups have the highest concentration of medium and low skilled workers who were shown to suffer more from the oil price shock in South Africa. In addition, the Coloured groups are generally more concentrated in urban than rural areas, hence they are worse off than their African counterparts.

Using the Gini coefficient, inequality increases by 0.7% with the floating prices scenario in all of South Africa. Upon decomposition, this inequality is attributed to the urban areas with a fall in rural areas by 0.5%. The greater dependency of rural poor households on transfer incomes compared to their urban counterparts appears to be the main explanation for the fall in inequality in rural areas (Annexure 8 to Annexure 11). Coloured and Asian households have the higher Gini coefficient, signifying greater inequality increases among these groups.

Table 6: Change in poverty and inequality (percent)

	Poverty			Inequality
	Head count	Gap	Severity	Gini coefficient
South Africa	**1.2**	**1.5**	**1.6**	**0.7**
Urban	1.3	1.6	1.7	0.7
Rural	1.1	1.3	1.4	-0.5
African	1.1	1.5	1.6	0.6*
Coloured	2.6	2.1	2.0	1.4
Asian	1.8*	1.3	1.2	1.2
White	0.6	0.6	0.6	0.6

Source: Results from the CGE model experiments; **Note:** * Not significant at 95% degree of confidence

b. The fixed price scenarios

This section discusses results drawn from the fixed price scenarios in which the consumption prices of petroleum products are kept constant. This implies that the price increase of oil and oil products is compensated through a full subsidy by the government in the second scenario. Revenue generated from a 50 percent tax on the windfall profit of the synthetic petroleum industry contributes to finance the government expenses in the third scenario. We compare results from the fixed price scenarios to those discussed earlier in the floating price scenario.

To implement its oil price support policy, the government guarantees a selling price to oil consumers. In a market-clearing context, there is zero excess supply so that the equilibrium price adjusts supply and demand. Therefore, the government provides a price policy support to oil consumers but it is still willing to let the market adjust to the market-clearing price. In that case, the price paid by oil consumers may be exogenous whereas the level of government subsidy is endogenously determined, depending on the fluctuation of the international oil prices[20]. The government will then have to arrange some method of financing the implied extra-expenses.

The increase of imported crude oil prices in a context of constant domestic petroleum prices puts more pressure on the real exchange rate appreciation discussed earlier in the floating price scenario, as oil imports increase relatively more (fall less in absolute terms). Thus, the changes in economic variables under the fixed price scenarios relative to the floating price scenario are mainly driven by the substantial fall in the domestic prices, i.e. increase of the real exchange (Table 7). As a consequence, GDP falls slightly more (2.4% and 2.5%) in the fixed price scenarios compared to the floating price scenario (2.2%). Thus, the economic performances deteriorates when the government taxes the windfall profit of the synthetic fuel industry as this transforms private savings into consumption contributing to deteriorating the trade balance.

20. Alternatively, the level of the subsidy can be made exogenous and the consumer price then becomes endogenous instead. In that case, the government supports the difference between the market clearing price and the selling price through a subsidy scheme.

Table 7: Comparison of the change in macro-economic variables (percent)

	Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Import of crude oil	-10.2	-7.9	-6.8
Export of oil products	4.9	2.6	0.4
Average export price of oil products	16.8	20.6	24.3
Average domestic price	-2.6	-3.3	-3.4
Total import	-4.6	-4.9	-4.9
Total export	0.6	0.8	0.8
Income	-1.4	-1.5	-1.6
GDP	**-2.2**	**-2.4**	**-2.5**

Source: Compilation from the experiments.

Government tax receipts fall drastically in the price setting scenarios (Table 8). The fall in government revenue is essentially induced by the drop of taxes and levies on domestic commodities. Of lesser importance is the contribution of taxes on imported goods to this decline. A full subsidy of oil price increase accentuates the government expenses; the latter combined with its revenue lost lead to a doubling of the public deficit from 12 to 22 percent. Thus, households continue to pay a higher cost (increase in the lump sum tax) in maintaining the public expenditure and the global investment remains unchanged (Table 8).

Table 8: Fiscal effects (percent)

	Initial share	Change in		
		Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Tax on imported goods	7.4	-4.7	-9.3	-10.2
Tax on local goods	23.4	-6.0	-16.2	-18.2
Tax on production	7.8	-6.8	-8.0	-8.3
Tax on income (uncompensated)	46.7	-3.5	-3.8	-4.0
Capital revenue (uncompensated)	8.6	0.4	0.9	0.7
In-transfer	6.1	-2.2	-2.8	-2.8
Uncompensated revenue	**100**	**-3.9**	**-6.8**	**-7.5**
Public expense	64.2	-0.9	-1.1	-1.2
Out-transfer	63.9	-2.2	-2.8	-2.8
Deficit (uncompensated)	**-28.1**	**11.8**	**21.6**	**24.0**
Tax on income (compensated)	-	11.5	14.7	15.1
Tax on windfall profit	-	-	-	0.9
Compensated revenue	**-**	**7.6**	**8.0**	**8.5**
Deficit (compensated)	**-**	**-29.3**	**-30.9**	**-33**

Source: Results from the CGE model experiments.

The changes in sectoral output in the fixed prices relative to the floating price scenarios are mainly driven by the real exchange rate effects. Domestic prices and incomes fall more, induced by rising pressures on the real exchange rate. As a consequence, the domestic demand falls driving a relatively lower output for most of the activities (Annexure 14 and Annexure 15).

In contrast, outputs in oil and synthetic fuel industries are relatively strong, as well as outputs in export-oriented industries (Table 9). They benefit from relatively low purchasing prices and a higher real exchange rate. However, the 50 percent tax on the synthetic petroleum profit lowered their output (Table 9). Synthetic petroleum is still the biggest winner of the oil price shock in the second scenario. Its output almost doubles when the government subsidizes the domestic fuel prices. The output of coal and electricity, which are petroleum substitutes, declines compared to the first scenario; petroleum production has become less expensive. The output of electricity falls because it is the sector with the least intermediate demand from the manufacturing industries while coal still benefits from increasing demand from the synthetic petroleum industry.

Table 9: Comparison of the change in output (percent)

Aggregate products	Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Refined petroleum	-11.9	-6.7	-4.4
Agriculture	-4.8	-5.4	-5.5
Food manufacturing	-4.6	-5.2	-5.4
Light manufacturing	-3.4	-3.7	-3.8
Services	-2.5	-2.7	-2.8
Heavy manufacturing	-0.8	-0.9	-1.0
Mining	0.4	0.6	0.6
Electricity	1.7	-0.5	-0.6
Coal	3.1	1.8	0.0
Synthetic petroleum	4.7	8.5	-1.0

Source: Results from the CGE model experiments.

Value added relative prices fall for most of the industries except the refined petroleum sector which witnesses a substantial increase under the second scenario (Annexure 16 and Annexure 17). However, it falls in the third scenario when government levies a 50 percent tax on the profit realised in the synthetic petroleum industries. Wage and unemployment rates deteriorate in these scenarios (Table 10) and the urban-rural gap rises significantly as well as the gender gap but to a limited extent. The average return to capital falls less from the first to the second scenarios and more in the third scenario. Synthetic petroleum is still the big winner while the effect is ambiguous for other industries when comparing the simulation scenarios (Annexure 18 and Annexure 19).

Table 10: Comparing the change in wage and unemployment rates (percent)

	Wage rate high skilled workers				Unemployment rate medium and low skilled workers							
					Urban				Rural			
	Urban		Rural		Medium skilled		Low skilled		Medium skilled		Low skilled	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Floating price Scenario	-3.3	-3.8	-29.5	-31.5	11.5	21.6	15.6	35.5	14.3	23.9	21.3	34.2
Setting price sub-scenario 1	-3.2	-3.9	-34.2	-36.6	14.4	24.6	18.9	40.9	17.8	27.0	26.3	39.3
Setting price sub-scenario 2	-3.4	-4.0	-35.4	-37.8	15.0	25.4	19.6	42.1	19.0	27.8	27.4	40.4

Source: Compilation from the CGE model experiments. **Note:** Percent change in the wage rates; percentage point change in the unemployment rates.

While the consumption prices of petroleum goods are kept constant, the reduction in consumption prices is more pronounced for other commodities (Annexure 20 and Annexure 21). The increasing pressure on the real exchange rate via the factor prices and the revenues, and ultimately the domestic demand has essentially driven the fall in consumption prices (Table 11). However, the relative changes in the purchasers' prices are less drastic compared to those of the wage and unemployment rates.

Table 11: Comparison of the change in purchasing prices (percent)

Aggregate products	Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Coal	1.4	0.0	-1.6
Crude oil	50.0	50.0	50.0
Synthetic petroleum	11.7	0.0	0.0
Refined petroleum	11.7	0.0	0.0
Electricity	2.0	-1.5	-1.8
Agriculture	-3.0	-4.0	-4.1
Mining	-0.5	-0.7	-0.8
Food manufacturing	-3.5	-4.4	-4.6
Light manufactuing	-1.1	-1.7	-1.7
Heavy manufacturing	-0.6	-0.9	-1.0
Services	-4.3	-5.2	-5.4

Source: Compilation from the CGE model experiments.

- Poverty and inequality effects

Poverty also increases in the fixed price scenarios (Table 12) and the changes in poverty gap and severity are similar to the results of the floating price case, although slightly higher. Indeed, incomes fall by more under the setting prices scenario relative to the floating price scenarios. Furthermore, in the case of a tax on windfall profits, the poverty results are worsened and the urban-rural gap increases once again. Coloured and African households are worst affected due to a substantial increase in the unemployment of medium and low skilled workers. Inequality increases more under the fixed price scenario than under the floating price scenarios. In terms of rural and urban inequality, the Gini coefficient increases in the urban areas but falls in the rural areas. Inequality increases most among Coloured and Asian households groups respectively.

Table 12: Comparison of the change in poverty and inequality (percent)

	Floating price scenario				Setting price sub-scenario 1				Setting price scenario 2			
	Poverty			Inequality	Poverty			Inequality	Poverty			Inequality
	Head count	Gap	Severity	Gini co-efficient	Head count	Gap	Severity	Gini co-efficient	Head count	Gap	Severity	Gini co-efficient
South Africa	1.2	1.5	1.6	0.7	1.1	1.6	1.8	1.2	1.2	1.7	1.8	1.1
Urban	1.3	1.6	1.7	0.7	1.2	1.9	2.0	1.3	1.4	2.0	2.1	1.2
Rural	1.1	1.3	1.4	-0.5	1.0	1.3	1.5	-0.4*	0.9	1.2	1.4	-0.7
African	1.1	1.5	1.6	0.6*	0.9	1.6	1.9	1.3	1.2	1.7	1.9	1.3
Coloured	2.6	2.1	2.0	1.4	3.2	2.5	2.2	2.1	2.5	2.4	2.2	1.8
Asian	1.8*	1.3	1.2	1.2	1.4*	1.7	1.5	1.1	-0.4*	0.9*	1.1*	0.9
White	0.6	0.6	0.6	0.6	0.8	0.9	0.8	1.2	0.8	1.0	1.0	1.1

Source: Results from the CGE model experiments. **Note:** * Value not significant at 95% degree of confidence.

6. Conclusion

Due to South Africa's dependence on imported oil, notably crude oil, recent oil price increases are likely to have negative impacts on the South African economy. This study examines the effects of alternative government policy responses to cope with these adverse impacts. Three scenarios are tested in the study. The first scenario, referred to as the "Floating Price Scenario" assumes that the increase of the prices of imported crude oil and petroleum products is fully passed onto end-users through an increase of the purchasing prices of petroleum products. The two other scenarios assume that the oil price increase is compensated through a price subsidy mechanism and is referred to as the "Fixed Price Scenario". This implies that the price increase of oil and oil products is compensated through a full subsidy by the government in the "fixed price" sub-scenario 1; while revenues generated from a 50 percent tax on the windfall profit of the synthetic petroleum industry contributes to minimise the loss in government revenue in the "fixed price" sub-scenario 2.

To understand and quantify the impacts of these simulation scenarios at the macro-, meso- and micro- levels, an Energy-focused Computable General Equilibrium model linked to a micro-simulation household model is used. The model specifies a number of structural features designed to reflect the characteristics of the South African economy. The distinguishing features of the model are the energy supply and demand specificities and the price setting rules in the domestic oil market. Energy activities are disaggregated into coal, synthetic petroleum, oil petroleum, and electricity; while energy related products account for coal, crude oil, refined petroleum (including synthetic and oil petroleum), and electricity (including gas, and renewable energy). South Africa's abundance of coal resources and offshore natural gas has facilitated a well-developed synthetic fuels industry. This permits the country to meet partially its domestic liquid petroleum requirements, and moreover, to export petroleum products. Petroleum industry was among the most export oriented sectors in year 2000, and results discussed in this paper depend strongly on both import and export structures of oil and oil products in the economy.

Starting with the macro-economic effects, the model predicts that GDP would fall by between 2.2 and 2.5 percent under the three scenarios. A key driver of these results is the exchange rate effect. The exchange rate depreciates more in the fixed price relative to the floatation price scenarios leading to a fall in the average domestic prices by 3.4 percent and 2.6 percent, respectively. The impact on the government deficit varies widely among the scenarios, ranging from a worsening of 12 to 22 percent in the floating prices and the fixed price scenarios, respectively. Unemployment increases among medium and low skilled workers.

The meso-economic effects show important distributional impacts amongst industries. Synthetic petroleum, coal, and electricity which are alternative sources of energy to oil petroleum, benefit under the floating price scenario. Electricity does not benefit from high oil prices under the fixed price scenario, as refined petroleum products become less expensive and less substituted with the alternative source of energy compared to the floating price scenario. None of the energy industries expands its output when a 50 percent tax is levied on the profit of the synthetic petroleum industry. Except the mining sector that benefits from the exchange rate depreciation (appreciation of the real exchange rate), all other industries experience a fall of their production but with different magnitudes. Agriculture, food and light manufacturing and private services are the big losers of the high oil price shock being directly affected by a fall in the final demand.

There is a significant increase in the wage gap between urban and rural high skilled workers which is worsened under the fixed price scenario. Employment increases most among medium and low skilled in urban than rural area, accentuated when government subsidizes the oil price increase. In both areas, women are adversely affected relative to men by high oil prices. They are more intensively used in contracting industries (agriculture, food and light manufacturing and private services) and less in expanding industries (energy related activities and mining). There is no significant difference in male and female wages and employment opportunities among the three scenarios.

Poverty headcount ratio increases by 1 percent when the imported crude oil and oil products prices rise by 50 and 25 percent with respect to their values in year 2000, respectively. The poorest households are most adversely affected by the increase of oil prices. Although employment and wages drop more in rural areas, households in that area observe a lower increase in the poverty indexes because of their relatively lower dependency on factor revenues compared to their counterparts in urban areas. African and Coloured household categories record the highest increase in the poverty indexes as they rely heavily on low and medium skilled labour incomes. Inequality increases in urban areas while it falls in rural areas. Poverty and inequality increase slightly more in the fixed price scenarios relative to the floating price scenario.

Although previous studies provided interesting insights of the macro and distributive impacts of the recent oil price increases in South Africa, our analysis contributes to the debate in investigating the likely effects of policy interventions in response to the shock and aims at providing meaningful guidance to the government policy. Furthermore, unlike in the previous analyses, our study provides a special treatment to the energy sector and separate synthetic petroleum industry which is coal intensive from oil petroleum industry, intensive in crude oil. This allows us to account for the energy sectors specificities and the inter-fuel substitutability and complementarity that standard specification fails to capture.

Essama-Nssah *et al*. (2007) perform a 125% increase of the crude oil prices which corresponds to a nearly US $40 increase as compared to its average price of US $30 in 2003 (Annexe 1). This increase of crude oil price combined with a smaller increase of oil related products lead to a 2 percent fall of GDP. Our analysis gives rise to the same magnitude of adverse impact on GDP under a crude oil price scenario that is four times smaller and also combined with a smaller increase of the refined petroleum products. We conclude that the two results are heavily driven by the choice of the macro-closure rules, in particular the "saving-investment" equilibrium. In Essama-Nssah *et al*. (2007), investment is saving driven so that today's consumption is partially possible at the expense of future consumption through a fall in the investment capacities, a phenomenon referred to as inter-temporal free lunch. When one eliminates this transfer of revenue, the fall in the (today) consumption and macro-economic performances of South Africa is more significant.

Our results show that the indirect effects of oil and oil price shocks are very important in determining the distributional impacts among industries. The most oil-intensive industries ("*Transport services*" and "*Primary plastics*") which are more likely to be directly hurt by the oil price shock (Fofana, *et al*., 2007) do not appear among the most affected industries when account is taken for both direct and indirect effects. The previous studies (McDonald and van Schoor, 2005; and Essama-Nssah *et al*. 2007) stressed the importance of the exchange rate in the distributional impacts among industries of the oil price shock, the less traded (tertiary) sectors being more negatively affected. Our study demonstrates that besides the exchange rate effects, the macro-closure rules, in particular the saving-investment and the government fiscal policy are also crucial in the sense that the compensatory lump-sum tax on households' income and wealth integrated into the model to maintain the government expenditures and the economy-wide volume of investment unchanged is not industry-neutral. The fall in the tax-induced expenditure capacity of household affects more industries that produce final consumption goods and services, i.e. agriculture, light manufacturing including food processed products, and private services relative to investment goods oriented industries (i.e. heavy manufacturing). An alternative saving investment closure rule would have modified the distributional impacts among industries. Therefore, individuals' perception of the shock, i.e. whether it is temporary or permanent, would affect seriously their expenditure decision (final consumption vs. investment) in order to cope with the increase of oil prices. Consequently, this would ultimately affect the distributional impacts of the shock among industries. Given that the study is short run based and also given the implicit assumption that individuals and corporations consider the oil price shock as a temporary event, agents do not modify their investment plans following the shock.

Cognisant of the fact that only three alternative policy responses have been tested, that the analysis is only for the short run and that other interventions which may dampen the impact of oil price shocks on the economy have been held fixed, the results of this study suggest the following recommendations:

- Government should allow oil prices to continue to float in order to minimise the short term negative impacts on economic growth, on the budget deficit, and on the distributional impacts amongst industries and households.
- Government can minimise or eliminate the negative impact of high oil prices by designing and implementing efficient export-oriented trade policies that would contribute to reduce the exchange rate depreciation induced by high oil import cost.

- An efficient reallocation of government spending through appropriate fiscal policy toward domestic-oriented products and activities (agriculture, light manufacturing including food processed products and privates services) would also contribute to minimise the adverse impacts of high oil prices. In the same vain, temporarily subsidising vulnerable sectors in order to reduce the overall output loss and the distributional impacts among industries would save medium and low skilled jobs from mass retrenchments.

- To cushion households in general and poor household in particular, from negative effects of oil price increases in the short term, Government should target and support industries that mostly contribute to generate income for the poor and should spend on locally-produced commodities whose increase of prices affects mostly the cost of living of the poor.

- The amount of money needed to bring poor people to the poverty line has increased as seen in the poverty gap index. This calls for Government to put greater effort by providing short and medium term support services in the form of increases in social grants to vulnerable groups (especially women).

- Government should explicitly tax import substituting industries on their windfall profits to recoup revenue from oil price increases above the normal in order to minimise its revenue loss and support its spending programs on non-oil products and industries.

- Policy interventions to minimise the loss of output and welfare and protect vulnerable groups of society create further distortions on the economy with little pressure for energy efficiency and oil substitution that might be damaging for the environment. In contrast, pressures of higher oil prices lead to substitution towards other sources of energy that may be the least environmentally friendly and contribute to greenhouse gases emission and global warming. The short term fiscal policy responses should integrate the economic performance, the impacts on poor, and the environmental concerns and government faces the difficult task of managing these trade-offs.

- The short run fiscal policies are designed to support the economy and to protect various household groups in order to gradually adjust to the oil shock. Once the adjustment process is in place, government should gradually substitute the short run for medium and long run fiscal policies that will focus on reducing the vulnerability of the economy to the oil shock. In the longer term the choice of fuels and energy practices should be essentially driven by market incentives. Complementary policies encouraging energy efficiency and a switch from fossil-fuel energy toward renewable and environmentally friendly energy should be implemented in a form of a financial incentive.

20. Alternatively, the level of the subsidy can be made exogenous and the consumer price then becomes endogenous instead. In that case, the government supports the difference between the market clearing price and the selling price through a subsidy scheme.

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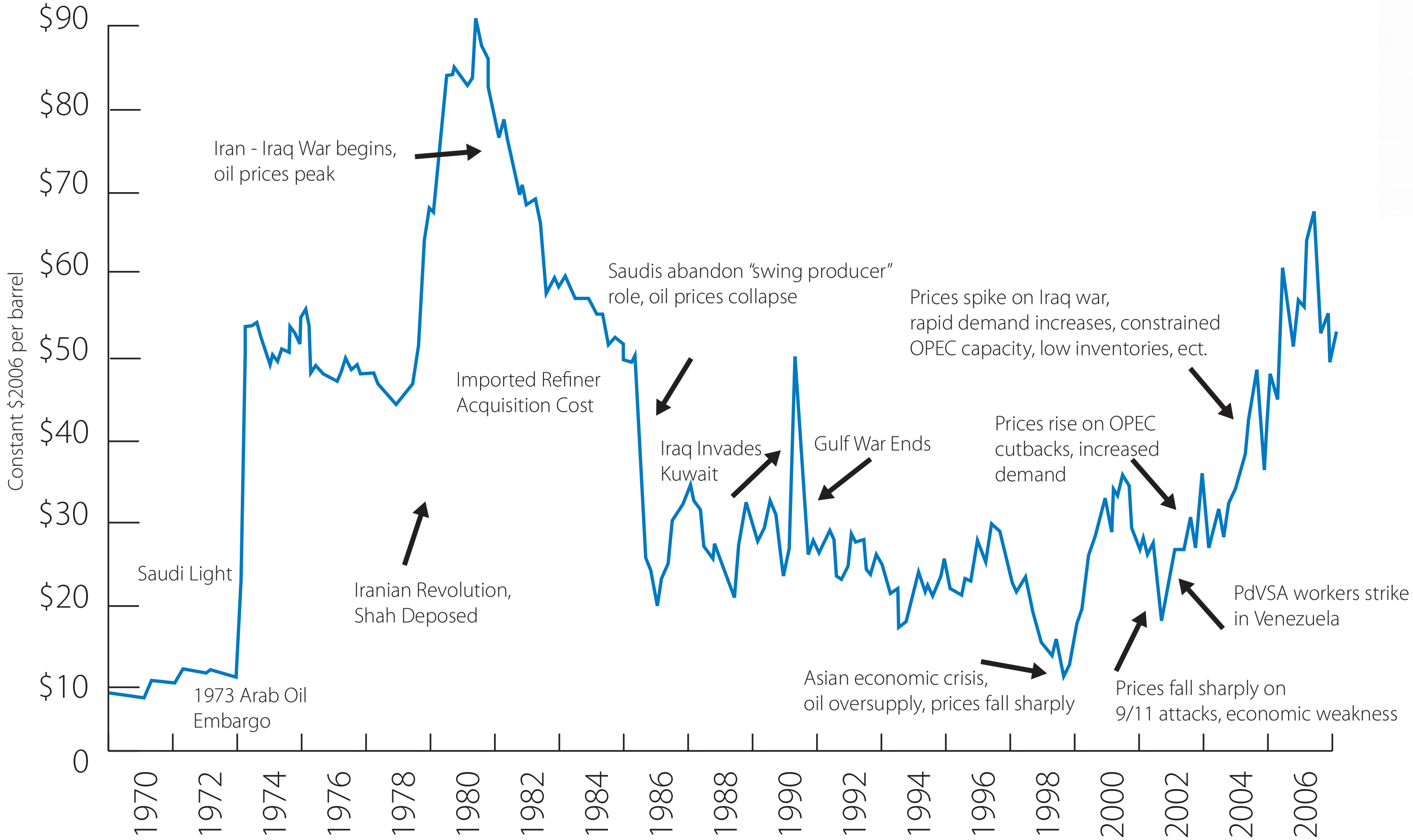
Annexure 1: Real World Oil prices 1970-2006 (US $2006 per barrel)



Source: Energy Information Administration - http://www.eia.doe.gov/cabs/AOMC/Overview.html. **Note:** Prices adjusted by CPI for all Urban Consumers, 2006

Annexure 2: Household expenditure by purpose of consumption

IES 2000		Energy SAM 2000	
1	Housing	1	Housing
2	Food and beverages	2	Food and beverages
3	Personal care	3	Household care
4	Household fuel	4	Household fuel
5	Clothing and footwear	5	Clothing and footwear
6	Household appliances and equipment	6	Household appliances and equipment
7	Transport	7	Transport
8	Education	8	Education
9	Health and social services	9	Health and social services
10	Computer and telecommunication	10	Computer and telecommunication
11	Recreation, entertainment and sport	11	Recreation, entertainment and sport
12	Miscellaneous	12	Miscellaneous
13	Household work		

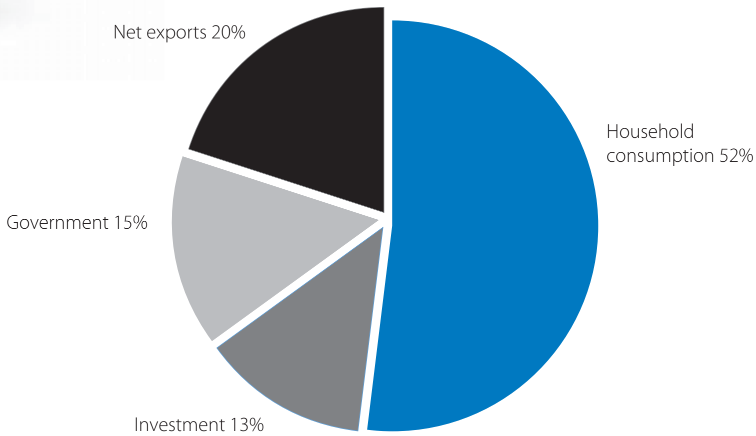
Source: compilation from the IES 2000 and the energy SAM 2000

Annexure 3: Major occupational and skill levels

Major occupational groups		Skill levels			
		SAM 1998		SAM 2000	
1	Legislators, seniors officials and managers	4	High skill	1	High skill
2	Professionals	4	High skill	1	High skill
3	Technicians and associate professionals	3	Skill	1	High skill
4	Clerks	2	Medium skill	2	Medium skill
5	Service workers and shop market sales workers	2	Medium skill	2	Medium skill
6	Skilled agricultural and fishery workers	2	Medium skill	2	Medium skill
7	Subsistence agricultural and fishery workers	2	Medium skill	2	Medium skill
8	Craft and related trades workers	2	Medium skill	2	Medium skill
9	Plant and machine operators and assemblers	2	Medium skill	2	Medium skill
10	Elementary occupations	1	Low skill	3	Low skill
11	Domestic and related helpers, cleaners and launderers	1	Low skill	3	Low skill
12	Occupation unspecified	1	Low skill	3	Low skill

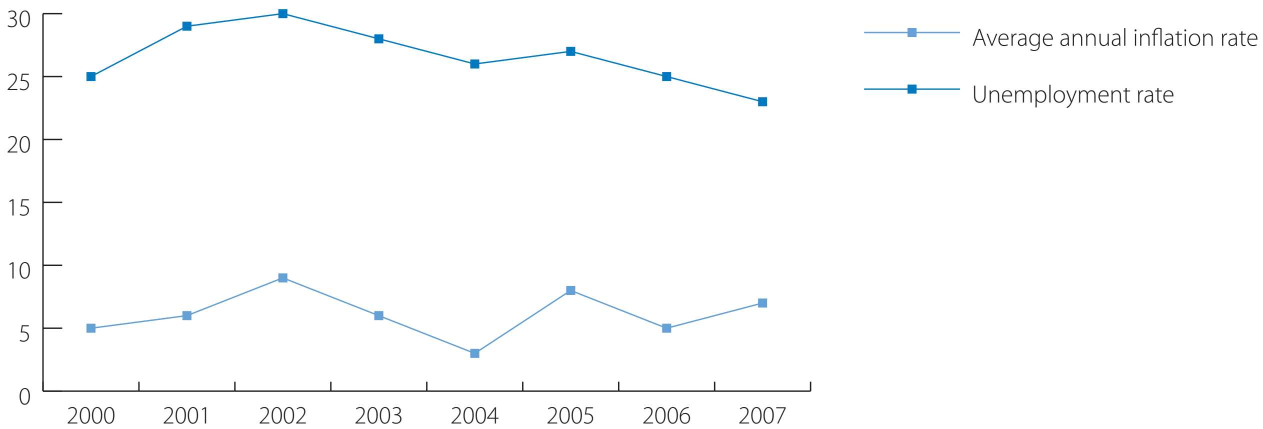
Source: Compilation from the 2000 Standard SAM and the 1998 SAM by Statistics South Africa (2002).

Annexure 4: Percentage share of GDP by expenditure (2000)



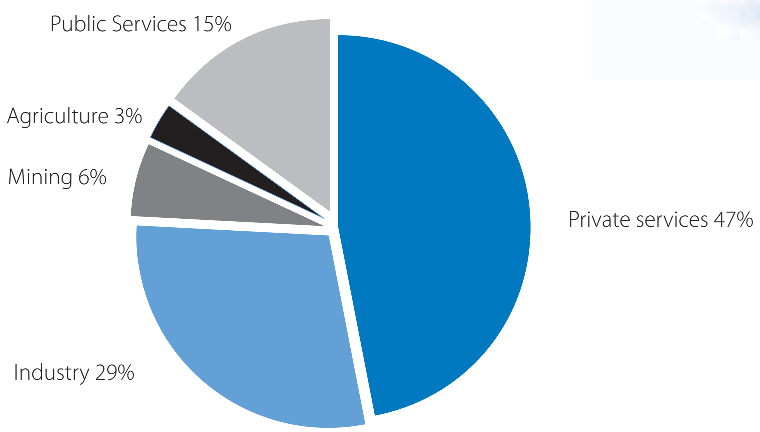
Source: Compilation from the 2000 Final supply and use tables; Statistics South Africa (2003).

Annexure 5: Unemployment and inflation rates



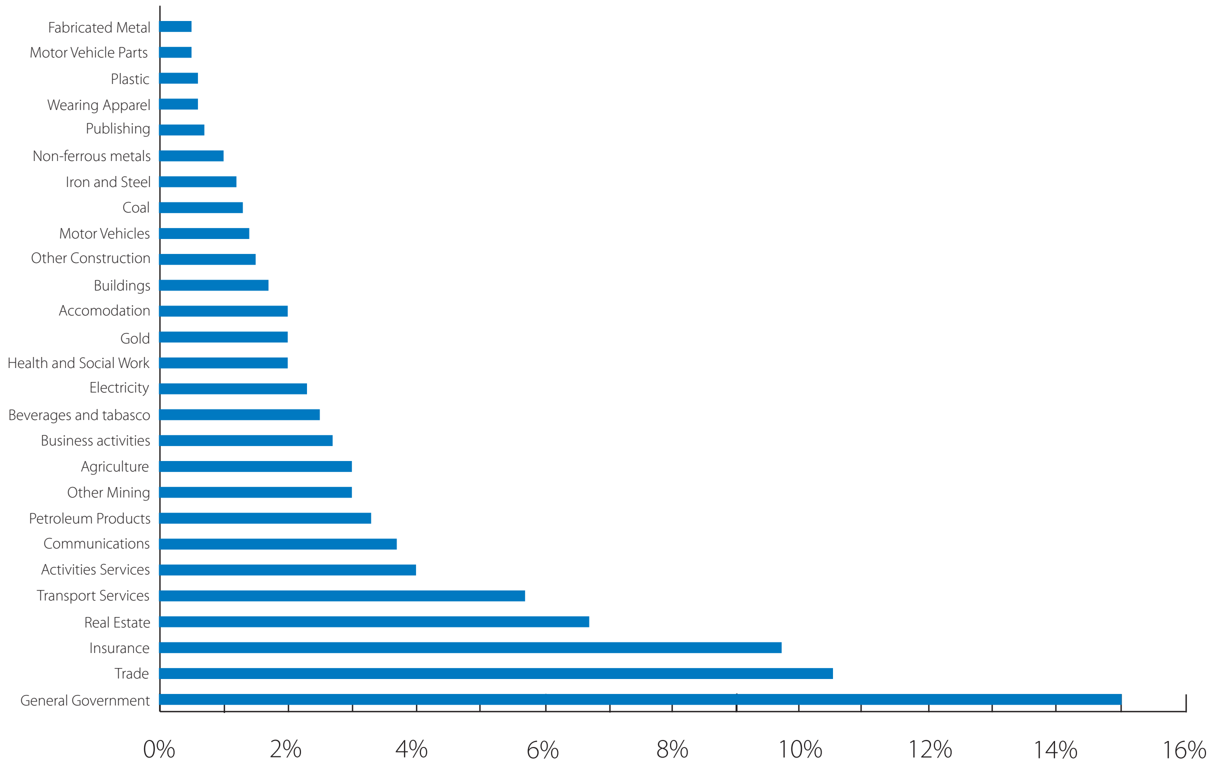
Source: Statistics South Africa (2008) and South Africa Reserve Bank (2008)

Annexure 6: Percentage share of GDP by sector (2000)



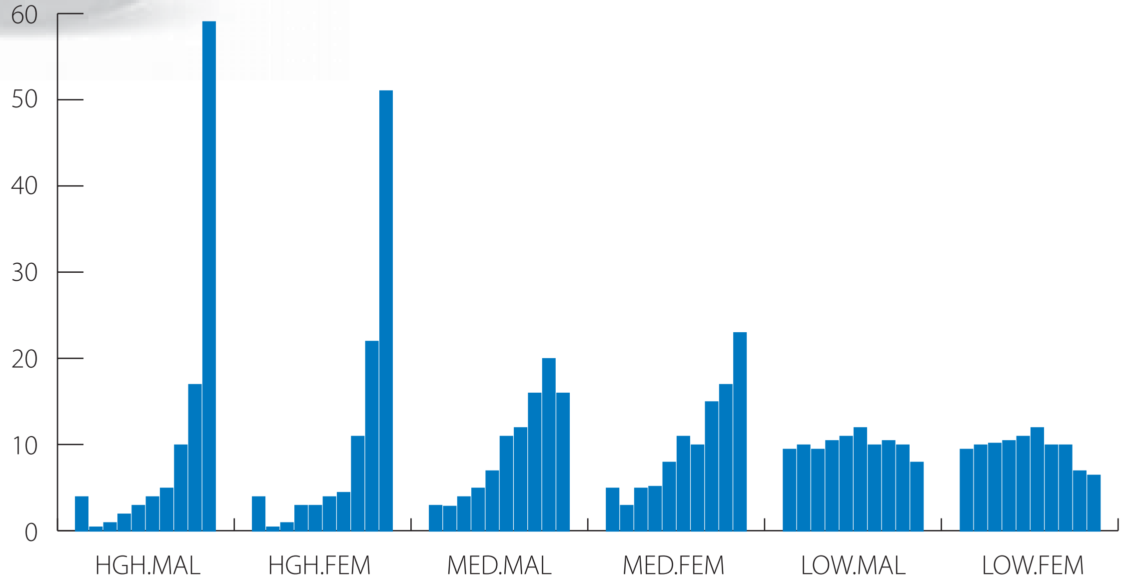
Source: Compilation from the 2000 Final supply and use tables; Statistics South Africa (2003).

Annexure 7: Sectoral contribution to GDP in 2000 (percent)



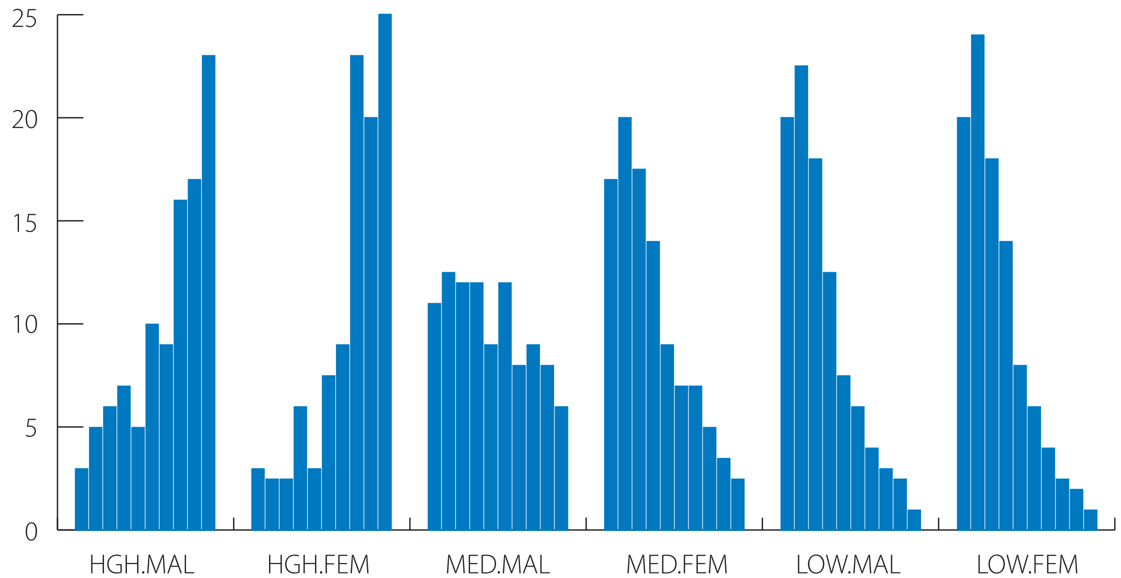
Source: Compilation from the 2000 Final supply and use tables; Statistics South Africa (2003).

Annexure 8: Distribution of workers by income decile in urban areas (percent)



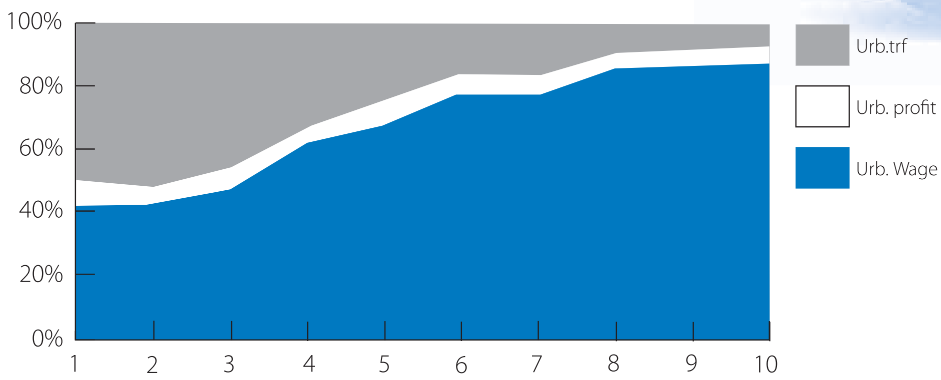
Source: 2000 September LFS. Note: hgh=high skilled; med=medium skilled; low=low skilled; mal=male; fem=female

Annexure 9: Distribution of workers by income decile in rural areas (percent)



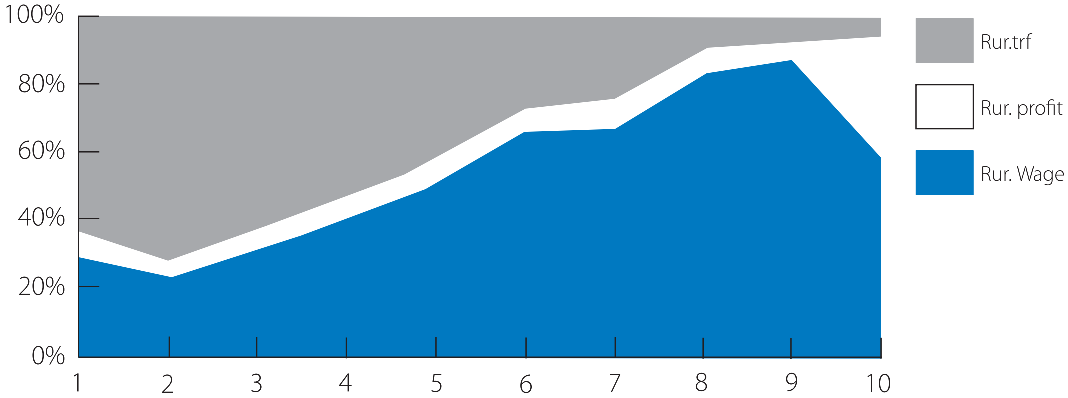
Source: 2000 September LFS. **Note:** hgh=high skilled; med=medium skilled; low=low skilled; mal=male; fem=female

Annexure 10: Distribution of household income in rural areas (percent)



Source: 2000 IES. **Note:** trf=transfer

Annexure 11: Distribution of household income in urban areas (percent)



Source: 2000 IES. **Note:** trf=transfer

Annexure 12: Trade elasticity

Industry	Armington Elasticity	Export supply elasticity		Export demand elasticity	
		Low bound	Upper bound	Low bound	Upper bound
Agriculture	1.273	0.7	1.3	3	6
Coal	2.771	0.7	1.3	3	6
Gold	2.771	0.7	1.3	3	6
Crude oil	0.730	0.7	1.3	3	6
other mining	2.771	0.7	1.3	3	6
Meat	0.937	0.7	1.3	3	6
Fish	0.937	0.7	1.3	3	6
Fruit	0.937	0.7	1.3	3	6
Oils	0.937	0.7	1.3	3	6
Dairy	0.937	0.7	1.3	3	6
Grain mills	0.937	0.7	1.3	3	6
Animal feeds	0.937	0.7	1.3	3	6
Bakeries	0.937	0.7	1.3	3	6
Sugar	0.937	0.7	1.3	3	6
Confectionery	0.937	0.7	1.3	3	6
Other food	0.937	0.7	1.3	3	6
Beverages and tabacco	1.570	0.7	1.3	3	6
Textiles	1.262	0.7	1.3	3	6
Textile articles	1.262	0.7	1.3	3	6
Carpets	1.262	0.7	1.3	3	6
Other textiles	1.262	0.7	1.3	3	6
Knitting mills	1.262	0.7	1.3	3	6
Wearing apparel	1.164	0.7	1.3	3	6
Leather	1.474	0.7	1.3	3	6
Handbags	1.474	0.7	1.3	3	6
Footwear	2.040	0.7	1.3	3	6
Wood	1.205	0.7	1.3	3	6
Paper	0.789	0.7	1.3	3	6
Containers of paper	0.789	0.7	1.3	3	6
Other paper	0.789	0.7	1.3	3	6
Publishing	0.083	0.7	1.3	3	6
Recorded media	0.083	0.7	1.3	3	6
Petroleum products	0.730	0.7	1.3	3	6
Basic chemicals	0.677	0.7	1.3	3	6
Fertilizers	0.677	0.7	1.3	3	6
Primary plastics	0.677	0.7	1.3	3	6
Pesticides	0.677	0.7	1.3	3	6
Paints	0.677	0.7	1.3	3	6
Pharmaceuticals	0.677	0.7	1.3	3	6
Soap	0.677	0.7	1.3	3	6
Other chemicals	0.792	0.7	1.3	3	6
Tyres	1.135	0.7	1.3	3	6
Other rubber	1.135	0.7	1.3	3	6
Plastic	0.275	0.7	1.3	3	6
Glass	0.942	0.7	1.3	3	6
Non-structural ceramics	0.655	0.7	1.3	3	6
Structural ceramics	0.655	0.7	1.3	3	6
Cement	0.655	0.7	1.3	3	6

Source: Gibson (2003) and Behar and Edwards (2004)

Annexure 13: Trade elasticity (continued)

Industry	Armington Elasticity	Export supply elasticity		Export demand elasticity	
		Low bound	Upper bound	Low bound	Upper bound
Cement	0.655	0.7	1.3	3	6
Other non-metallic	0.655	0.7	1.3	3	6
Iron and steel	0.447	0.7	1.3	3	6
Non-ferrous metals	0.595	0.7	1.3	3	6
Structural metal	0.747	0.7	1.3	3	6
Treated metals	0.747	0.7	1.3	3	6
General hardware	0.747	0.7	1.3	3	6
Fabricated metal	0.747	0.7	1.3	3	6
Engines	0.490	0.7	1.3	3	6
Pumps	0.490	0.7	1.3	3	6
Gears	0.490	0.7	1.3	3	6
Lifting equipment	0.490	0.7	1.3	3	6
General machinery	0.490	0.7	1.3	3	6
Agricultural machinery	0.490	0.7	1.3	3	6
Machine-tools	0.490	0.7	1.3	3	6
Mining machinery	0.490	0.7	1.3	3	6
Food machinery	0.490	0.7	1.3	3	6
Special machinery	0.490	0.7	1.3	3	6
Household appliances	0.490	0.7	1.3	3	6
Office machinery	0.944	0.7	1.3	3	6
Electric motors	0.944	0.7	1.3	3	6
Electricity apparatus	0.944	0.7	1.3	3	6
Wire and cable	0.944	0.7	1.3	3	6
Accumulators	0.944	0.7	1.3	3	6
Lighting equipment	0.944	0.7	1.3	3	6
Electrical equipment	0.944	0.7	1.3	3	6
Radio and television	0.441	0.7	1.3	3	6
Optical instruments	0.505	0.7	1.3	3	6
Motor vehicles	0.786	0.7	1.3	3	6
Motor vehicle parts	0.786	0.7	1.3	3	6
Other Transport	0.932	0.7	1.3	3	6
Furniture	1.075	0.7	1.3	3	6
Jewellery	0.417	0.7	1.3	3	6
Other manufacturing	0.417	0.7	1.3	3	6
Electricity	1.437	0.7	1.3	3	6
Water	1.437	0.7	1.3	3	6
Buildings	0.584	0.7	1.3	3	6
Other construction	1.280	0.7	1.3	3	6
Trade	0.603	0.7	1.3	3	6
Accommodation	0.420	0.7	1.3	3	6
Transport services	0.861	0.7	1.3	3	6
Communications	0.568	0.7	1.3	3	6
Insurance	0.616	0.7	1.3	3	6
Real estate	1.066	0.7	1.3	3	6
Business activities	1.066	0.7	1.3	3	6
General Government	1.153	0.7	1.3	3	6
Health and social work	1.040	0.7	1.3	3	6
Activities/ services	1.065	0.7	1.3	3	6

Source: Gibson (2003) and Behar and Edwards (2004)

Annexure 14: Demand structure and output effects, in percent

Industry	Oil input intensity	Oil input share	DI/Q	C/Q	EX/Q	FCF/Q	STK/Q	Change in ouput		
								Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Agriculture	4.7	38.4	71.1	28.3	10.2	0.0	-9.6	**-4.8**	**-5.4**	**-5.5**
Coal	1.5	22.0	63.0	1.1	40.6	0.0	-4.7	**3.1**	**1.8**	**0.0**
Gold	0.5	3.9	0.0	0.0	86.0	0.0	14.0	**0.3**	**0.5**	**0.5**
Other mining	1.3	16.2	100.0	0.0	0.0	0.0	0.0	**0.4**	**0.7**	**0.7**
Meat	5.6	16.4	42.6	0.0	64.1	0.0	-6.7	**-5.5**	**-5.9**	**-6.1**
Fish	1.6	16.3	20.7	105.7	2.7	0.0	-29.2	**-0.5**	**-0.4**	**-0.4**
Fruit	1.1	14.9	9.9	90.9	36.8	0.0	-37.6	**-3.4**	**-3.9**	**-4.0**
Oils	2.6	17.7	11.0	99.3	20.3	0.0	-30.7	**-6.5**	**-7.4**	**-7.6**
Dairy	1.3	17.6	52.5	80.4	4.2	0.0	-37.0	**-5.9**	**-6.7**	**-6.9**
Grain mills	1.2	15.0	16.7	117.9	2.1	0.0	-36.7	**-6.5**	**-7.5**	**-7.7**
Animal feeds	1.9	19.8	24.3	105.4	2.6	0.0	-32.3	**-6.9**	**-7.9**	**-8.1**
Bakeries	4.0	29.8	99.8	10.2	0.6	0.0	-10.5	**-6.8**	**-7.8**	**-8.0**
Sugar	0.3	7.6	3.0	135.6	0.6	0.0	-39.1	**-3.4**	**-3.7**	**-3.8**
Confectionery	0.8	14.6	40.3	67.7	27.9	0.0	-35.9	**-6.0**	**-7.0**	**-7.3**
Other food	0.0	15.7	6.1	115.5	8.7	0.0	-30.3	**-6.6**	**-7.6**	**-7.9**
Beverages and tobacco	0.4	17.3	42.3	86.1	6.1	0.0	-34.5	**-2.1**	**-2.3**	**-2.4**
Textiles	0.8	19.6	12.3	114.1	6.1	0.0	-32.5	**-4.4**	**-4.9**	**-5.0**
Textile articles	1.0	13.0	86.3	6.9	11.8	0.0	-4.9	**-10.5**	**-11.8**	**-12.2**
Carpets	4.2	27.0	37.7	58.0	3.7	0.0	0.6	**-4.5**	**-5.0**	**-5.1**
Other textiles	0.7	3.4	62.0	36.0	8.7	0.0	-6.7	**-1.8**	**-1.6**	**-1.7**
Knitting mills	1.9	7.4	76.6	16.2	14.2	0.0	-7.1	**-6.8**	**-7.6**	**-7.9**
Wearing apparel	0.3	15.2	19.7	65.5	12.9	0.0	1.9	**-6.2**	**-7.0**	**-7.2**
Leather	0.3	5.3	7.0	82.5	5.3	0.0	5.2	**-0.9**	**-0.8**	**-0.8**
Handbags	0.6	9.5	60.3	0.0	40.6	0.0	-0.9	**-9.5**	**-11.0**	**-11.4**
Footwear	0.5	22.0	5.3	73.5	8.0	0.0	13.2	**-6.8**	**-7.6**	**-7.8**
Wood	0.4	15.8	10.6	85.6	1.5	0.0	2.3	**-1.3**	**-1.3**	**-1.4**
Paper	0.7	16.6	78.7	1.4	17.2	0.2	2.5	**-1.6**	**-1.5**	**-1.6**
Containers of paper	0.2	10.0	75.8	0.0	35.8	0.0	-11.6	**-2.2**	**-2.2**	**-2.3**
Other paper	0.3	25.9	80.1	0.0	2.1	0.0	17.8	**-6.5**	**-7.3**	**-7.5**
Publishing	0.2	12.9	66.9	50.6	5.6	0.0	-23.2	**-5.7**	**-6.3**	**-6.5**
Recorded media	4.6	39.2	80.3	23.8	2.0	0.4	-6.5	**-4.4**	**-4.8**	**-4.9**
Coal petroleum	12.0	8.2	32.9	49.5	10.1	0.0	7.5	**4.7**	**8.5**	**-1.0**
Oil petroleum	135.8	86.2	56.3	38.2	14.1	0.0	-8.7	**-11.9**	**-6.7**	**-4.4**
Basic chemicals	19.1	65.6	70.7	0.6	35.2	0.0	-6.5	**-1.1**	**-1.6**	**-1.4**
Fertilizers	110.2	90.2	79.1	0.6	14.9	0.0	5.4	**-6.7**	**-6.9**	**-6.9**
Primary plastics	29.1	47.5	81.0	0.0	11.1	0.0	8.0	**-1.8**	**-1.2**	**-1.2**
Pesticides	1.0	35.7	75.6	18.2	20.8	0.0	-14.6	**-3.5**	**-3.8**	**-4.0**
Paints	10.8	34.6	85.0	0.0	3.8	0.0	11.2	**-1.8**	**-1.7**	**-1.9**
Pharmaceuticals	2.0	9.4	53.7	46.9	4.1	0.0	-4.7	**-4.9**	**-5.4**	**-5.6**
Soap	5.1	15.9	16.9	77.7	4.7	0.0	0.7	**-7.0**	**-7.6**	**-7.8**
Other chemicals	4.6	20.9	69.5	12.0	13.6	0.0	4.9	**0.5**	**0.0**	**0.1**
Tyres	8.9	22.1	36.6	66.5	13.1	1.4	-17.6	**-5.2**	**-5.3**	**-5.5**
Other rubber	1.0	17.5	86.5	2.5	10.6	0.0	0.4	**0.1**	**0.1**	**0.0**
Plastic	1.7	38.7	76.0	3.9	5.9	0.0	14.2	**-2.2**	**-2.4**	**-2.5**
Glass	0.9	18.2	93.7	4.5	10.4	0.0	-8.6	**-2.1**	**-2.4**	**-2.5**
Non-structural Ceramics	1.4	24.5	71.4	10.6	2.7	0.0	15.3	**-2.8**	**-2.4**	**-2.8**
Structural ceramics	2.2	19.3	92.9	0.0	3.4	0.4	3.3	**-0.2**	**-0.1**	**-0.1**
Cement	1.0	12.3	86.9	0.0	3.4	0.0	9.7	**-0.5**	**-0.4**	**-0.5**

Source: Compilation from the 2000 Final supply and use tables and results from the CGE model experiments. **Note:** Q= Absorption; STK=Changes in stocks; FCF=Fixed capital formation; EX=Export; C=Consumption; DI=Intermediate demand.

Annexure 15: Demand structure and output effects, in percent (continued)

Industry	Oil input intensity	Oil input share	DI/Q	C/Q	EX/Q	FCF/Q	STK/Q	Change in ouput		
								Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Other non-metallic	1.1	15.8	83.8	0.0	10.3	0.0	5.9	**-0.1**	**0.0**	**0.0**
Iron and steel	2.8	5.7	55.3	0.0	41.4	0.0	3.3	**-0.2**	**-0.1**	**0.0**
Non-ferrous metals	6.1	13.4	59.0	0.0	34.6	0.0	6.4	**-0.5**	**-0.2**	**-0.2**
Structural metal	0.4	20.5	65.3	0.0	12.8	24.6	-2.7	**-0.2**	**-0.2**	**-0.2**
Treated metals	0.8	7.9	90.9	0.0	0.0	0.0	9.1	**-1.5**	**-1.7**	**-1.8**
General hardware	1.4	3.7	64.5	23.2	18.1	1.7	-7.4	**-1.6**	**-1.6**	**-1.5**
Fabricated metal	1.2	21.3	66.6	0.2	6.7	1.2	25.4	**-0.8**	**-0.7**	**-0.8**
Engines	4.5	22.7	84.4	0.0	3.6	17.1	-5.1	**-0.2**	**-0.3**	**-0.3**
Pumps	9.9	35.7	28.7	0.0	9.5	52.0	9.8	**0.3**	**0.8**	**0.8**
Gears	6.3	25.6	84.8	0.0	12.5	0.0	2.6	**0.5**	**0.8**	**0.8**
Lifting equipment	4.2	20.9	37.5	0.0	9.3	49.4	3.9	**-0.8**	**-0.7**	**-0.7**
General machinery	1.3	20.0	39.3	0.0	51.7	19.2	-10.2	**0.2**	**0.4**	**0.4**
Agricultural machinery	5.3	40.4	37.8	0.0	6.1	60.6	-4.4	**-0.7**	**-0.5**	**-0.5**
Machine-tools	0.6	7.6	26.8	0.0	8.6	65.3	-0.7	**0.1**	**0.2**	**0.2**
Mining machinery	1.2	30.1	43.5	0.0	13.0	44.7	-1.1	**0.3**	**0.3**	**0.1**
Food machinery	2.7	23.2	42.0	0.0	14.9	41.7	1.4	**-0.9**	**-0.6**	**-0.7**
Special machinery	0.4	42.8	39.5	0.0	13.9	54.1	-7.5	**-0.7**	**-0.6**	**-0.7**
Household appliances	1.8	30.1	14.5	79.9	4.4	15.9	-14.8	**-9.7**	**-10.8**	**-11.1**
Office machinery	8.1	30.0	12.5	16.3	0.7	74.4	-3.9	**0.3**	**1.2**	**1.3**
Electric motors	4.7	34.9	13.8	0.0	12.1	76.0	-1.9	**0.1**	**0.3**	**0.3**
Electricity apparatus	0.7	22.4	62.2	3.0	7.5	24.1	3.2	**0.0**	**-0.3**	**-0.4**
Wire and cable	0.1	23.9	93.8	0.0	4.6	1.1	0.5	**-0.6**	**-0.8**	**-0.9**
Accumulators	2.0	19.7	74.9	22.7	8.5	0.0	-6.2	**-0.2**	**-1.4**	**-1.4**
Lighting equipment	0.9	19.4	79.4	22.3	6.0	2.6	-10.3	**-2.9**	**-3.2**	**-3.3**
Electrical equipment	3.2	38.7	83.9	1.9	12.3	8.6	-6.8	**-0.4**	**-0.2**	**-0.2**
Radio and television	0.7	23.7	30.4	11.4	7.8	45.0	5.4	**-0.8**	**-0.9**	**-1.0**
Optical instruments	2.4	23.9	36.5	30.4	6.3	30.8	-3.9	**-1.6**	**-1.7**	**-1.7**
Motor vehicles	1.4	43.9	25.6	27.5	15.2	23.6	8.1	**-1.2**	**-1.7**	**-1.7**
Motor vehicle parts	0.5	24.1	74.1	7.3	7.5	0.0	11.1	**-0.8**	**-1.0**	**-1.1**
Other Transport	0.8	17.3	46.7	5.2	20.3	25.9	1.9	**0.4**	**0.5**	**0.6**
Furniture	0.5	10.4	13.4	55.8	17.6	8.0	5.2	**-5.8**	**-6.5**	**-6.6**
Jewellery	1.7	15.0	2.5	52.5	32.6	0.0	12.4	**-4.8**	**-5.3**	**-5.5**
Other manufacturing	3.5	37.0	37.1	30.7	18.1	1.1	13.0	**-1.5**	**-1.6**	**-1.6**
Electricity	0.3	0.9	65.6	35.7	2.9	0.0	-4.3	**1.7**	**-0.5**	**-0.6**
Water	0.6	3.0	81.1	22.7	0.0	0.0	-3.8	**-3.1**	**-3.5**	**-3.6**
Buildings	2.8	40.4	31.3	0.0	0.1	59.3	9.2	**-0.3**	**-0.3**	**-0.3**
Other construction	4.5	40.7	27.2	0.0	0.2	75.1	-2.5	**0.0**	**0.1**	**0.1**
Trade	0.9	25.7	64.2	26.2	1.2	0.0	8.4	**-4.3**	**-4.2**	**-4.3**
Accommodation	0.3	7.1	21.2	59.0	25.1	0.0	-5.3	**-2.3**	**-2.7**	**-2.8**
Transport services	8.8	39.3	53.9	32.0	15.4	0.0	-1.2	**-1.4**	**-1.5**	**-1.6**
Communications	1.3	25.5	57.3	29.3	4.2	0.0	9.2	**-3.7**	**-3.9**	**-4.0**
Insurance	0.2	18.5	53.2	32.5	5.1	0.0	9.2	**-3.2**	**-3.6**	**-3.7**
Real estate	0.4	23.8	31.8	55.9	0.2	5.3	7.0	**-0.5**	**-0.6**	**-0.6**
Business activities	1.2	41.2	77.2	4.3	2.6	0.8	15.1	**-2.0**	**-2.2**	**-2.3**
General Government	0.5	32.9	5.8	92.3	0.0	0.0	1.9	**0.0**	**-0.1**	**-0.1**
Health and social work	1.8	30.1	6.0	79.8	1.0	0.0	13.2	**-4.1**	**-4.5**	**-4.7**
Activities/ services	0.4	14.2	30.0	56.1	1.8	0.0	12.1	**-7.2**	**-8.4**	**-8.7**
ALL	**3.4**	**34.2**	**46.2**	**34.7**	**14.5**	**13.2**	**-8.6**	**-2.3**	**-2.4**	**-2.6**

Source: Compilation from the 2000 Final supply and use tables and results from the CGE model experiments. **Note:** Q= Absorption; STK=Changes in stocks; FCF=Fixed capital formation; EX=Export; C=Consumption; DI=Intermediate demand.

Annexure 16: Change in factor prices, in percent

Industry	Floating price scenario		Setting price sub-scenario 1		Setting price sub-scenario 2	
	Output price	Value added price	Output price	Value added price	Output price	Value added price
Agriculture	-2.9	-6.2	-3.9	-6.2	-4.1	-6.4
Coal	0.7	2.8	-0.4	1.8	-1.5	-0.2
Gold	-0.6	-0.3	-0.9	0.2	-0.9	0.2
Other mining	-0.7	0.0	-1.0	0.6	-1.1	0.6
Meat	-3	-6.1	-4.0	-5.6	-4.2	-5.7
Fish	-1.6	-1.0	-2.1	-0.6	-2.2	-0.6
Fruit	-2.6	-2.7	-3.2	-2.7	-3.4	-2.8
Oils	-2.7	-5.3	-3.5	-5.5	-3.7	-5.6
Dairy	-3.1	-4.0	-3.9	-4.2	-4.0	-4.3
Grain mills	-4.5	-9.9	-5.6	-11.1	-5.9	-11.4
Animal feeds	-3.8	-10.4	-4.8	-11.7	-5.0	-12.1
Bakeries	-3.5	-4.4	-4.4	-4.2	-4.6	-4.3
Sugar	-2.3	-1.7	-3.1	-1.7	-3.2	-1.7
Confectionery	-2.9	-3.0	-3.6	-3.3	-3.7	-3.4
Other food	-2.8	-2.7	-3.4	-3.2	-3.6	-3.3
Beverages and tabacco	-4.8	-7.0	-5.7	-7.9	-5.9	-8.2
Textiles	-1.3	-1.4	-1.8	-1.3	-1.9	-1.3
Textile articles	-2.1	-3.1	-2.8	-3.3	-2.9	-3.3
Carpets	-1.6	-2.3	-2.5	-1.8	-2.6	-1.8
Other textiles	-0.9	-1.2	-1.6	-0.8	-1.7	-0.8
Knitting mills	-1.7	-2.2	-2.2	-1.7	-2.3	-1.7
Wearing apparel	-1.8	-1.5	-2.2	-1.7	-2.3	-1.7
Leather	-2	-0.9	-2.7	-0.6	-2.8	-0.6
Handbags	-3.5	-6.1	-4.3	-6.9	-4.5	-7.1
Footwear	-2.2	-3.3	-2.8	-3.5	-2.9	-3.6
Wood	-1.5	-0.5	-2.0	-0.4	-2.0	-0.4
Paper	-2.1	-1.9	-2.7	-1.7	-2.8	-1.7
Containers of paper	-1.6	-2.3	-2.2	-2.3	-2.3	-2.3
Other paper	-3.1	-6.3	-3.7	-7.0	-3.9	-7.2
Publishing	-2.7	-3.4	-3.1	-3.7	-3.2	-3.8
Recorded media	-2.2	-3.7	-3.0	-3.4	-3.2	-3.5
Coal petroleum	9.4	26.2	14.2	48.0	17.4	-14.5
Oil petroleum	9.4	-29.6	14.2	-12.5	17.4	-3.2
Basic chemicals	0.9	-4.1	-0.5	-5.2	-0.4	-4.8
Fertilizers	10	-14.2	9.0	-14.8	8.9	-14.9
Primary plastics	0.1	-5.3	-1.7	-4.1	-1.8	-4.2
Pesticides	-1.9	-5.1	-2.5	-5.4	-2.6	-5.6
Paints	-0.3	-4.0	-1.5	-3.6	-1.6	-3.9
Pharmaceuticals	-3.5	-7.1	-4.4	-7.7	-4.5	-7.9
Soap	-3.4	-9.7	-4.6	-10.2	-4.8	-10.5
Other chemicals	-0.3	-1.0	-1.5	-1.4	-1.5	-1.4
Tyres	-1.3	-4.1	-2.2	-2.6	-2.3	-2.7
Other rubber	-0.8	-0.3	-1.5	0.0	-1.6	0.0
Plastic	-0.7	-1.1	-1.4	-0.9	-1.4	-1.0
Glass	-1.4	-0.8	-1.8	-0.6	-1.9	-0.6
Non-structural ceramics	-2.9	-4.4	-3.2	-3.5	-3.5	-4.2
Structural ceramics	-1.1	-0.8	-1.5	-0.4	-1.6	-0.4
Cement	-1.3	-1.2	-1.6	-0.9	-1.7	-0.9

Source: Compilation from the experiments.

Annexure 17: Change in factor prices, in percent (continued)

Industry	Floating price scenario		Setting price sub-scenario 1		Setting price sub-scenario 2	
	Output price	Value added price	Output price	Value added price	Output price	Value added price
Other non-metallic	-0.9	-0.5	-1.3	-0.2	-1.4	-0.2
Iron and steel	-0.7	-1.1	-1.2	-0.4	-1.3	-0.2
Non-ferrous metals	-0.1	-1.8	-0.8	-0.5	-0.9	-0.5
Structural metal	-0.5	-0.3	-0.8	-0.2	-0.8	-0.2
Treated metals	-1.6	-2.1	-2.2	-2.1	-2.3	-2.1
General hardware	-1.3	-2.9	-1.8	-2.5	-2.0	-2.4
Fabricated metal	-0.9	-1.4	-1.4	-1.2	-1.5	-1.2
Engines	-0.9	-1.4	-1.4	-1.0	-1.5	-1.0
Pumps	-0.3	-1.4	-1.0	0.0	-1.1	0.0
Gears	-1.5	-1.0	-2.3	0.1	-2.4	0.0
Lifting equipment	-1.3	-2.0	-1.9	-1.3	-2.0	-1.3
General machinery	-0.7	-0.5	-1.1	-0.2	-1.2	-0.2
Agricultural machinery	-1.5	-1.6	-2.2	-0.9	-2.3	-0.9
Machine-tools	-1.1	-0.7	-1.5	-0.5	-1.6	-0.5
Mining machinery	-0.7	-0.7	-1.0	-0.5	-1.1	-0.6
Food machinery	-1.3	-1.4	-1.8	-0.9	-1.9	-0.9
Special machinery	-0.7	-0.9	-1.0	-0.8	-1.0	-0.9
Household appliances	-2.5	-5.9	-3.2	-6.3	-3.3	-6.5
Office machinery	-2.4	-1.4	-3.3	0.1	-3.4	0.2
Electric motors	-0.6	-1.1	-1.1	-0.4	-1.1	-0.4
Electricity apparatus	-0.5	-0.2	-1.0	-0.2	-1.0	-0.3
Wire and cable	-0.3	-0.5	-0.9	-0.7	-0.9	-0.7
Accumulators	-1.4	-0.6	-2.1	-0.6	-2.2	-0.6
Lighting equipment	-0.9	-1.6	-1.4	-1.5	-1.5	-1.5
Electrical equipment	-0.6	-1.5	-1.1	-0.9	-1.1	-0.9
Radio and television	-1.7	-3.5	-2.0	-3.6	-2.1	-3.8
Optical instruments	-1.0	-1.5	-1.4	-1.1	-1.5	-1.1
Motor vehicles	-0.5	-2.0	-0.9	-2.4	-0.9	-2.5
Motor vehicle parts	-0.5	-0.6	-0.8	-0.6	-0.9	-0.6
Other Transport	-0.9	-1.3	-1.1	-1.1	-1.2	-1.2
Furniture	-1.7	-2.8	-2.2	-2.9	-2.3	-3.0
Jewellery	-1.1	-3.7	-1.5	-3.7	-1.6	-3.9
Other manufacturing	-1.1	-1.9	-1.6	-1.3	-1.7	-1.4
Electricity	1.9	3.1	-1.5	-1.5	-1.8	-1.5
Water	-4.3	-7.2	-5.3	-7.8	-5.6	-8.1
Buildings	-0.7	-0.7	-1.1	-0.1	-1.1	-0.1
Other construction	-0.7	-0.9	-1.1	-0.1	-1.2	-0.1
Trade	-3.5	-2.9	-4.0	-2.7	-4.1	-2.7
Accommodation	-3.4	-3.5	-4.1	-3.9	-4.2	-4.0
Transport services	-1.6	-3.2	-2.7	-2.4	-2.9	-2.6
Communications	-5.5	-7.0	-6.3	-7.4	-6.5	-7.6
Insurance	-6.3	-7.0	-7.2	-7.8	-7.4	-8.1
Real estate	-8.4	-10.1	-10.2	-12.0	-10.5	-12.4
Business activities	-2.3	-1.0	-2.9	-1.0	-3.0	-1.0
General Government	-0.9	-0.7	-1.1	-0.7	-1.2	-0.7
Health and social work	-5.4	-8.2	-6.5	-8.9	-6.7	-9.2
Activities/ services	-6.0	-7.4	-7.1	-8.4	-7.4	-8.7
ALL	**-2.4**	**-3.7**	**-3.0**	**-3.7**	**-3.1**	**-4.0**

Source: Compilation from the CGE model experiments.

Annexure 18: Changes in the return to capital, in percent

Industry	Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Agricultural products	-8.1	-8.0	-8.2
Coal and lignite products	5.0	3.5	0.4
Gold and uranium ore products	0.6	2.1	2.3
Other mining products	0.6	1.6	1.6
Meat products	-12.1	-10.8	-11.0
Fish products	0.1	1.3	1.4
Fruit and vegetables products	-3.9	-3.8	-3.8
Oils and fats products	-10.3	-10.5	-10.7
Dairy products	-7.7	-8.0	-8.2
Grain mill products	-16.4	-18.7	-19.2
Animal feeds	-17.5	-19.8	-20.4
Bakery products	-9.8	-9.2	-9.5
Sugar products	-3.1	-3.2	-3.2
Confectionary products	-6.4	-7.0	-7.2
Other food products	-5.8	-6.7	-6.9
Beverages and tobacco products	-9.0	-10.3	-10.6
Textile products	-3.9	-3.5	-3.6
Made-up textile products	-14.2	-15.0	-15.3
Carpets	-8.9	-5.5	-5.5
Other textile products	-2.1	0.8	1.1
Knitting mill products	-10.9	-8.2	-8.1
Wearing apparel	-4.4	-5.0	-5.1
Leather products	-0.6	0.0	0.1
Handbags	-13.7	-15.6	-16.2
Footwear	-6.6	-7.0	-7.2
Wood products	-0.2	0.3	0.3
Paper products	-2.4	-2.0	-2.1
Containers of paper	-3.1	-3.1	-3.2
Other paper products	-10.4	-11.7	-12.0
Published and printed products	-8.4	-9.4	-9.7
Recorded media products	-9.5	-8.1	-8.3
synthetic petroleum	31.2	56.9	-16.7
oil petroleum	-34.6	-14.4	-3.4
Basic chemical products	-4.8	-6.6	-5.8
Fertilizers	-21.2	-22.1	-22.2
Primary plastic products	-6.8	-4.7	-4.8
Pesticides	-10.1	-11.1	-11.5
Paints	-6.9	-5.8	-6.4
Pharmaceutical products	-16.3	-17.9	-18.4
Soap products	-23.8	-25.6	-26.3
Other chemical products	1.9	0.7	0.9
Rubber tyres	-13.1	-8.1	-8.2
Other rubber products	-0.1	0.9	0.9
Plastic products	-1.1	1.1	1.1
Glass products	-2.0	-1.3	-1.4
Ceramicware	-6.2	-4.8	-5.9
Ceramic products	-0.5	0.1	0.2
Cement	-1.1	-0.6	-0.6

Source: Compilation from the CGE model experiments.

Annexure 19: Changes in the return to capital, in percent (continued)

Industry	Floating price scenario	Setting price sub-scenario 1	Setting price sub-scenario 2
Other non-metallic products	-0.1	0.4	0.4
Iron and steel products	-1.0	0.0	0.4
Non-ferrous metals	-2.1	-0.1	0.0
Structural metal products	1.7	2.3	2.4
Treated metal products	-2.5	-2.4	-2.4
General hardware products	-4.6	-3.5	-3.1
Other fabricated metal products	-0.6	0.0	0.0
Engines	-0.5	0.6	0.7
Pumps	-0.6	3.3	3.4
Gears	0.7	3.5	3.5
Lifting equipment	-2.1	-0.3	-0.3
General machinery	2.3	4.3	4.5
Agricultural machinery	-1.8	1.7	1.8
Machine-tools	2.5	3.5	3.7
Mining machinery	2.9	3.7	3.6
Food machinery	-0.9	1.6	1.7
Other special machinery	1.7	2.0	2.1
Household appliances	-17.9	-19.3	-19.8
Office machinery	0.7	5.1	5.3
Electric motors	0.0	2.6	2.7
Electricity apparatus	0.0	-0.1	-0.2
Insulated wire and cable	-0.5	-0.8	-0.8
Accumulators	-1.2	-1.2	-1.3
Lighting equipment	-3.0	-2.9	-3.0
Other electrical products	-0.8	0.5	0.5
Radio and television products	-4.0	-4.5	-4.6
Optical instruments	-2.3	-0.9	-0.9
Motor vehicles	-1.8	-2.5	-2.6
Motor vehicles parts	0.1	0.2	0.2
Other transport products	6.3	7.6	8.0
Furniture	-7.3	-7.8	-8.0
Jewellery	-6.0	-5.7	-5.9
Other manufacturing	-1.9	-0.3	-0.3
Electricity	5.6	-1.4	-1.5
Water	-9.7	-10.6	-11.0
Buildings	-1.4	0.2	0.2
Other constructions	-1.5	0.8	0.8
Trade services	-5.0	-4.4	-4.4
Accommodation	-4.5	-5.1	-5.2
Transport services	-4.1	-2.6	-2.8
Communications	-10.4	-11.0	-11.3
Insurance services and FSIM	-9.9	-11.1	-11.5
Real estate services	-10.6	-12.8	-13.2
Other business services	-6.1	-6.2	-6.4
General Government services	7.3	8.3	8.7
Health and social work	-12.8	-14.1	-14.5
Other services / activities	-15.6	-18.6	-19.2
ALL	**-6.0**	**-5.9**	**-6.6**

Annexure 20: Consumption price effects, in percent

Products	IM/Q	Floating price scenario			Setting price sub-scenario 1			Setting price sub-scenario 2		
		dPD	dIM	**dPC**	dPD	dIM	**dPC**	dPD	dIM	**dPC**
Agricultural products	7.0	-3.2	-9.3	**-3.0**	-4.3	-11.3	**-4.0**	-4.4	-11.7	**-4.1**
Coal and lignite products	3.3	1.5	9.5	**1.4**	0.0	2.7	**0.0**	-1.6	-5.1	**-1.6**
Gold and uranium ore products	0.0	-0.7	-1.9	**-0.7**	-1.0	-2.7	**-1.0**	-1.0	-2.9	**-1.0**
Other mining products	40.3	-0.8	-2.3	**-0.5**	-1.1	-2.6	**-0.7**	-1.2	-3.1	**-0.7**
Meat products	6.9	-3.0	-8.4	**-2.8**	-4.0	-9.8	**-3.7**	-4.2	-10.1	**-3.9**
Fish products	66.4	-3.6	-10.7	**-1.2**	-4.5	-12.6	**-1.5**	-4.7	-13.1	**-1.5**
Fruit and vegetables products	7.8	-3.1	-8.9	**-2.8**	-3.9	-10.4	**-3.5**	-4.0	-10.8	**-3.7**
Oils and fats products	34.3	-3.1	-9.7	**-2.0**	-3.9	-11.3	**-2.6**	-4.0	-11.7	**-2.6**
Dairy products	8.2	-2.9	-8.7	**-2.6**	-3.7	-10.2	**-3.4**	-3.8	-10.6	**-3.5**
Grain mill products	12.9	-4.9	-11.2	**-4.3**	-6.2	-13.3	**-5.4**	-6.4	-13.7	**-5.6**
Animal feeds	4.4	-3.8	-10.1	**-3.7**	-4.9	-12.0	**-4.7**	-5.0	-12.4	-4.8
Bakery products	2.7	-3.4	-9.7	**-3.3**	-4.3	-11.4	**-4.2**	-4.5	-11.7	**-4.4**
Sugar products	4.9	-3.3	-9.4	**-3.1**	-4.2	-11.1	**-3.9**	-4.3	-11.4	**-4.1**
Confectionary products	12.1	-3.1	-9.6	**-2.8**	-3.9	-11.4	**-3.4**	-4.0	-11.8	**-3.5**
Other food products	10.6	-2.9	-9.6	**-2.6**	-3.6	-11.2	**-3.2**	-3.7	-11.6	**-3.3**
Beverages and tobacco products	5.2	-5.1	-10.3	**-4.6**	-6.1	-12.2	**-5.5**	-6.3	-12.6	**-5.7**
Textile products	33.6	-1.4	-7.2	**-0.9**	-1.9	-8.4	**-1.2**	-2.0	-8.6	**-1.3**
Made-up textile products	11.3	-2.5	-11.4	**-2.1**	-3.1	-13.3	**-2.7**	-3.3	-13.7	**-2.8**
Carpets	19.7	-1.9	-7.9	**-1.4**	-2.8	-9.7	**-2.2**	-2.9	-10.0	**-2.3**
Other textile products	58.1	-0.5	-5.0	**-0.2**	-1.3	-6.2	**-0.5**	-1.3	-6.5	**-0.5**
Knitting mill products	22.8	-2.2	-10.0	**-1.6**	-2.8	-11.6	**-2.0**	-2.9	-12.0	**-2.1**
Wearing apparel	15.9	-2.1	-9.5	**-1.7**	-2.5	-10.9	**-2.0**	-2.6	-11.3	**-2.1**
Leather products	37.2	-2.8	-7.2	**-1.7**	-3.5	-8.4	**-2.2**	-3.7	-8.7	**-2.3**
Handbags	49.4	-4.3	-15.6	**-2.1**	-5.4	-18.4	**-2.7**	-5.6	-19.1	**-2.8**
Footwear	33.8	-2.2	-11.0	**-1.4**	-2.8	-12.8	**-1.8**	-2.9	-13.2	**-1.8**
Wood products	14.5	-1.5	-3.6	**-1.3**	-2.0	-4.2	**-1.7**	-2.0	-4.4	**-1.7**
Paper products	27.5	-2.8	-6.2	**-2.0**	-3.4	-7.0	**-2.5**	-3.5	-7.2	**-2.6**
Containers of paper	0.6	-1.5	-3.9	**-1.5**	-2.0	-4.5	**-2.0**	-2.1	-4.6	**-2.1**
Other paper products	11.0	-3.8	-9.1	**-3.3**	-4.5	-10.3	**-3.9**	-4.7	-10.6	**-4.0**
Published and printed products	10.5	-2.8	-6.4	**-2.5**	-3.1	-7.1	**-2.8**	-3.3	-7.3	**-2.9**
Recorded media products	81.3	-3.5	-9.0	**-0.6**	-4.5	-10.1	**-0.8**	-4.7	-10.4	-0.9
Petroleum products	10.9	10.2	-19.7	**11.7**	17.9	-8.1	**0.0**	22.0	-6.6	**0.0**
Basic chemical products	49.5	2.9	-2.3	**1.5**	1.2	-2.5	**0.6**	1.5	-2.6	**0.7**
Fertilizers	22.1	14.2	2.7	**10.9**	13.4	1.8	**10.3**	13.1	1.5	**10.1**
Primary plastic products	33.1	0.0	-2.1	**0.0**	-2.1	-3.1	**-1.4**	-2.2	-3.3	**-1.5**
Pesticides	33.1	-2.5	-7.1	**-1.7**	-3.2	-8.3	**-2.1**	-3.4	-8.5	**-2.2**
Paints	8.8	0.0	-1.6	**0.0**	-1.3	-2.5	**-1.2**	-1.4	-2.7	**-1.2**
Pharmaceutical products	40.3	-3.9	-8.2	**-2.3**	-4.9	-9.4	**-2.8**	-5.0	-9.7	**-2.9**
Soap products	10.1	-3.9	-9.7	**-3.4**	-5.2	-11.2	**-4.6**	-5.4	-11.6	**-4.8**
Other chemical products	47.3	-1.1	-3.1	**-0.6**	-2.1	-4.1	**-1.1**	-2.2	-4.4	**-1.2**
Rubber tyres	24.3	-1.7	-7.8	**-1.2**	-2.7	-9.1	**-2.0**	-2.8	-9.4	**-2.1**
Other rubber products	51.8	-0.5	-1.4	**-0.2**	-1.0	-2.1	**-0.5**	-1.1	-2.4	**-0.5**
Plastic products	17.8	-0.5	-2.7	**-0.4**	-1.2	-3.1	**-1.0**	-1.2	-3.2	**-1.0**
Glass products	22.4	-1.5	-3.8	**-1.1**	-1.9	-4.4	**-1.5**	-2.0	-4.6	**-1.5**
Ceramicware	39.9	-2.9	-3.7	**-1.7**	-3.2	-4.0	**-1.9**	-3.5	-4.3	**-2.1**
Ceramic products	25.1	-0.8	-0.7	**-0.6**	-1.1	-0.9	**-0.9**	-1.2	-0.9	**-0.9**
Cement	2.4	-1.2	-1.4	**-1.2**	-1.6	-1.5	**-1.5**	-1.7	-1.6	**-1.6**

Source: Compilation from the 2000 Energy-SAM and the CGE model experiments. **Note:** IM/Q=Import penetration rates; dIM=Change in imports; dPD=Change in domestic prices; dPC: Change in consumption prices.

Annexure 21: Consumption price effects, in percent (continued)

Products	IM/Q	Floating price scenario			Setting price sub-scenario 1			Setting price sub-scenario 2		
		dPD	dIM	**dPC**	dPD	dIM	**dPC**	dPD	dIM	**dPC**
Other non-metallic products	10.8	-0.8	-0.7	**-0.7**	-1.1	-0.9	**-1.0**	-1.2	-0.9	**-1.1**
Iron and steel products	11.3	-0.6	-0.9	**-0.5**	-1.1	-1.2	**-1.0**	-1.3	-1.2	**-1.1**
Non-ferrous metals	26.9	-0.1	-0.8	**-0.1**	-0.9	-1.1	**-0.6**	-1.0	-1.2	**-0.7**
Structural metal products	2.9	-0.2	-0.4	**-0.2**	-0.4	-0.6	**-0.4**	-0.5	-0.6	**-0.5**
Treated metal products	0.0	-2.0	-	**-2.0**	-2.6	-	**-2.6**	-2.7	-	**-2.7**
General hardware products	61.7	-1.9	-4.4	**-0.7**	-2.7	-5.2	**-1.0**	-2.9	-5.5	**-1.1**
Other fabricated metal products	18.6	-1.0	-1.6	**-0.8**	-1.4	-1.9	**-1.1**	-1.5	-2.0	**-1.2**
Engines	30.2	-0.8	-0.6	**-0.5**	-1.3	-1.0	**-0.9**	-1.4	-1.1	**-0.9**
Pumps	60.9	-0.1	-0.4	**-0.1**	-0.9	-0.5	**-0.3**	-1.0	-0.6	**-0.4**
Gears	72.9	-1.4	-0.8	**-0.4**	-2.3	-1.1	**-0.6**	-2.4	-1.2	**-0.7**
Lifting equipment	35.4	-1.3	-1.6	**-0.8**	-1.9	-1.8	**-1.2**	-2.0	-1.9	**-1.3**
General machinery	45.8	-0.8	-1.6	**-0.4**	-1.1	-1.7	**-0.5**	-1.2	-1.9	**-0.6**
Agricultural machinery	55.5	-1.6	-2.1	**-0.7**	-2.3	-2.4	**-1.0**	-2.4	-2.5	**-1.1**
Machine-tools	83.7	-1.1	-1.0	**-0.2**	-1.4	-1.1	**-0.2**	-1.5	-1.2	**-0.2**
Mining machinery	45.0	-0.3	0.0	**-0.2**	-0.6	-0.2	**-0.3**	-0.7	-0.4	**-0.4**
Food machinery	57.6	-1.5	-2.3	**-0.6**	-2.0	-2.4	**-0.8**	-2.1	-2.5	**-0.9**
Other special machinery	76.2	-0.7	-1.9	**-0.2**	-0.9	-2.0	**-0.2**	-1.0	-2.1	-0.2
Household appliances	37.3	-3.0	-11.9	**-1.8**	-3.8	-13.5	**-2.2**	-3.9	-13.9	**-2.3**
Office machinery	94.2	-2.6	-2.3	**-0.1**	-3.5	-2.7	**-0.1**	-3.7	-2.8	**-0.1**
Electric motors	38.4	-0.5	-0.6	**-0.3**	-1.0	-1.0	**-0.6**	-1.1	-1.1	**-0.6**
Electricity apparatus	43.4	-0.4	-0.8	**-0.2**	-0.9	-1.5	**-0.5**	-1.0	-1.6	**-0.5**
Insulated wire and cable	10.3	-0.1	-0.7	**-0.1**	-0.6	-1.5	**-0.6**	-0.7	-1.5	**-0.6**
Accumulators	26.4	-1.4	-1.8	**-1.0**	-2.2	-3.8	**-1.6**	-2.3	-4.0	**-1.7**
Lighting equipment	45.3	-1.0	-4.0	**-0.6**	-1.6	-5.0	**-0.9**	-1.7	-5.1	**-0.9**
Other electrical products	36.8	-0.4	-1.4	**-0.3**	-0.9	-1.8	**-0.5**	-0.9	-1.9	**-0.6**
Radio and television products	80.1	-2.0	-2.7	**-0.4**	-2.3	-3.1	**-0.4**	-2.4	-3.2	**-0.4**
Optical instruments	85.8	-1.3	-4.3	**-0.2**	-1.7	-4.8	**-0.2**	-1.8	-5.0	**-0.2**
Motor vehicles	23.4	-0.4	-1.8	**-0.3**	-0.8	-2.7	**-0.6**	-0.9	-2.9	**-0.7**
Motor vehicles parts	70.0	-0.3	-1.5	**-0.1**	-0.5	-2.0	**-0.2**	-0.6	-2.1	**-0.2**
Other transport products	85.3	-0.9	-0.9	**-0.1**	-1.2	-1.1	**-0.2**	-1.3	-1.2	**-0.2**
Furniture	14.8	-2.7	-10.9	**-2.3**	-3.3	-12.5	**-2.8**	-3.5	-12.9	**-2.9**
Jewellery	15.1	-2.5	-9.8	**-2.1**	-3.1	-11.2	**-2.6**	-3.2	-11.6	**-2.7**
Other manufacturing	65.5	-2.1	-6.3	**-0.7**	-2.8	-7.2	**-0.9**	-2.9	-7.5	**-1.0**
Electricity	0.0	2.0	-	**2.0**	-1.5	-	**-1.5**	-1.8	-	**-1.8**
Water	0.4	-4.3	-9.1	**-4.3**	-5.3	-10.8	**-5.3**	-5.6	-11.3	**-5.6**
Buildings	0.5	-0.7	-0.7	**-0.7**	-1.1	-0.9	**-1.0**	-1.1	-1.0	**-1.1**
Other constructions	1.6	-0.7	-0.9	**-0.7**	-1.1	-1.4	**-1.0**	-1.1	-1.4	-1.1
Trade services	0.2	-3.4	-6.2	**-8.4**	-3.9	-6.4	**-11.9**	-4.0	-6.6	**-12.6**
Accommodation	24.8	-3.3	-5.3	**-2.5**	-4.0	-6.2	**-3.0**	-4.2	-6.4	**-3.1**
Transport services	7.3	-1.7	-3.1	**-1.8**	-2.9	-4.4	**-3.0**	-3.0	-4.7	**-3.2**
Communications	6.4	-5.6	-7.1	**-5.3**	-6.5	-7.8	**-6.0**	-6.7	-8.0	**-6.3**
Insurance services and FSIM	1.7	-6.2	-7.3	**-6.1**	-7.0	-8.2	**-6.9**	-7.3	-8.5	**-7.2**
Real estate services	0.9	-8.5	-9.8	**-8.4**	-10.2	-11.8	**-10.1**	-10.6	-12.2	**-10.5**
Other business services	4.4	-2.1	-4.4	**-2.0**	-2.7	-5.2	**-2.6**	-2.9	-5.4	**-2.7**
General Government services	0.0	-0.9	-	**-0.9**	-1.1	-	**-1.1**	-1.2	-	**-1.2**
Health and social work	1.2	-5.4	-9.6	**-5.4**	-6.5	-11.0	**-6.4**	-6.7	-11.4	**-6.6**
Other services / activities	3.2	-6.1	-12.1	**-5.9**	-7.2	-13.9	**-7.0**	-7.5	-14.4	**-7.3**
ALL	**12.0**	**-2.8**	**-3.9**	**-2.1**	**-3.5**	**-4.5**	**-3.2**	**-3.6**	**-4.7**	**-3.4**

Source: Compilation from the 2000 Energy-SAM and the CGE model experiments. **Note:** IM/Q=Import penetration rates; dIM=Change in imports; dPD=Change in domestic prices; dPC: Change in consumption prices.

Annex 1

An Energy-focused Social Accounting Matrix for South Africa

Abstract

We present a procedure of elaborating an energy-focused social accounting matrix for South Africa. First, the supply and use tables and the integrated economic accounts are reconciled into a standard social accounting matrix. The latter is disaggregated to account for multiple factor and household categories. The energy-focused SAM integrates separate accounts for synthetic petroleum and oil petroleum activities. The former uses coal and natural gas to produce refined petroleum products, while the latter transforms the imported crude oil into refined petroleum products.

A separate account has been integrated into the SAM to separate crude oil products from other mining products. Thus, four energy related activities are represented in the Energy-SAM, namely coal, synthetic petroleum, oil petroleum, and electricity. There are also four energy related products namely coal, crude oil, refined petroleum (including synthetic petroleum and oil petroleum products), and electricity (including gas and renewable energies). Therefore, the output of synthetic petroleum and oil petroleum are combined into a single product named refined petroleum on the consumption side, i.e. the two products are perfect substitutes.

The energy-SAM also presents 12 categories of consumption goods by purpose and these include "household fuel" and "transport" categories. The SAM features 12 categories of labour, 4 categories of capital, 2 representative household categories, 2 types of corporation, 6 tax and government accounts, 2 transfer accounts (property and other transfers), the rest of the world account, the trade and transport margins account, 94 accounts for activities, 95 product accounts (including crude oil), and 2 capital accounts (fixed capital formation and change in inventories).

Introduction

Computable General Equilibrium (CGE) models are widely used by economists to analyse the magnitude and distributional effects of external shocks and policies, such as oil price shocks, and ultimately to help formule policies. The model is **operationalized through the** calibration procedure which consists in finding parameters and permits equations to exactly reproduce the benchmark situation given by the Social Accounting Matrix (SAM).

The SAM is the presentation of the national accounts in a condensed matrix form with an important property that the sum of the row elements is equal to the sum of the corresponding column elements. It is a consistent quantitative macro-economic data framework representing the flows between different sectors and institutional units within an economy during a given period of time, in general, one year. The SAM is therefore consistent in the sense that it describes a general equilibrium of an economy.

The standard structure of a SAM does not necessarily provide detailed information on the energy sector of an economy. Therefore, additional data are used to disaggregate the framework in order to appropriately account for the energy sector and its linkages with the rest of the economy. This document discusses the procedure followed in elaborating an energy-focused SAM for South Africa in the year 2000. This procedure can be replicated in many other African countries wishing to construct energy focused SAMs to be used in understanding the effects of energy and environmental policies for example.

The rest of the paper describes in subsequent steps the procedures followed to build the energy-SAM. The national accounts tables are presented and reconciled into a single framework. The latter is disaggregated to account for multiple factor and institutional accounts. Next, the energy sector is disaggregated using external sources of data. Finally, the SAM's structure is illustrated.

The National Accounts Tables

The Standard SAM of South Africa for year 2000 is built up from the Supply and Use (SU) tables and the Integrated Economic Accounts (IEA) for the same year. Information found in a SAM (notably production, trade, consumption and investment), is primarily provided by the SU-tables. The rest of the flows, that is, inter-institutional transfer receipts and payments and savings are recorded in the IEA (Annexure 1).

The SU-tables are estimated by Statistics South Africa according to the recommendations of the 1993 System of National Accounts (SNA 93). Two separate and interdependent tables are presented: A supply table (Annexure 2) and a use table (Annexure 3). The SU-tables are a synthesized presentation of the economic data contained in the national accounts in terms of origin and destination of goods and services available in a given economy during a specific period. It is an accounting framework that insures the numerical consistency of data obtained from different sources (industrial surveys, household surveys, investment surveys, foreign trade statistics, etc.).

Resources available in the economy are produced locally and imported. Activity outputs and imports are valued at basic and cost, insurance, and freight (c.i.f) prices, respectively. Final demands are valued at purchasing prices. Therefore, the consistency between activity outputs and imports, and final demands is achieved by accounting for transaction charges, that is, levies, taxes and margins. In the SU-tables, resources are used for final consumption of households and government, intermediate consumption of activities, exports, and investment, that is, fixed capital formation and changes in stocks. The SU-tables incorporate an Input-Output matrix of intermediate consumption presenting product input use (in row) by activity (in column). The activity production and value added (compensation for employees, gross operating surplus and mixed income, taxes and subsidies on production) are also recorded in the SU-tables.

The supply table (Annexe 2) presents a matrix of 153 products and 94 industries (S5). Activity output consists of a primary product and, sometimes, one or several secondary products. Consequently, the domestic supply of a given product (S7) is sometimes imputed to more than one activity. The total supply of a product at basic prices (S4) is equal to the addition of the domestic production valued at basic price (S7) and the imports from abroad valued at c.i.f. price (S8). As the use table is valued at the purchaser's prices, there are columns added, that is, trade and transport margins (S3) and taxes less subsidies on products (S2), so as to arrive at total supply at purchasers' prices in order to balance with the use table at purchasers' prices. Furthermore, the supply table presents a c.i.f. / free on board (f.o.b.) adjustment on imports (S10) in order to adjust the total imports at c.i.f. price as recommended by the SNA 93. There is also an account for direct purchases of residents (S9) that adjust the total import.

The use table (Annexure 3) redraws the destination of domestically-produced and imported products recorded in the supply table (Annexure 2). The total output (U1) is used for intermediate consumptions (U2), exports (U5), final consumption of household (U7) and public administrations (U9), fixed capital formation (U10) and change in stocks (U11). A residual account (U12) records the difference between the total supply and total use for a given product. The use table also presents the structure of the activity production, in terms of input use by activity or input-output matrix (U2) and the value added (U3) imputed to the compensation for employees, the gross operating surplus and mixed income and the taxes and subsidies on production. The use table integrates 95 products accounts (in rows) and 94 industrial accounts (in column). It shows an account for the direct purchases of the non-residents (U6) and residents (U8) transactions recorded as exports and final consumption of households[2].

The IEA framework is a set of ordered economic accounts describing the process of income generation through distribution and accumulation of the institutional sectors. It gives a synthesis of the economic transactions of the institutional sectors grouped into five categories on the basis of their principal objective, function and behavior. The IEA summarizes the SU-tables transactions and adds information on inter-institutional transfers and savings-accumulations. The institutional sectors of the South African 2000 IEA are non-financial corporations, financial corporations, general government, households and non-profit institutions serving households (NPISHs) and the rest of the world[3].

The Standard Social Accounting Matrix

This section brings together the national accounts tables, that is, the SU-tables and the IEA into a single framework of the SAM. Below we discuss the procedures followed in order to reconcile the frameworks with the structure of the SAM.

The supply table presents 153 product accounts for 94 production accounts, whereas the use table has 95 product accounts for 94 production accounts. We reduce the product accounts of the supply table in order to match with the use table accounts. Therefore, the 153 products of the supply table are aggregated into 95 groups, based on the mapping of products in the supply and the use tables by Statistics South Africa[4].

Information from the IEA is used to break down factor receipts (compensation for employees, and gross operating surplus and mixed income) among institutional units. It also provides information on the inter-institutional transfers and the savings. The transfer receipts and payments are grouped into three categories: "property"[5], "social and miscellaneous current transfers"[6], and "current tax on income and welfare".

The c.i.f.-fob adjustments are distributed across imported commodities according to the import weights to obtain c.i.f. margins on imports. The result is then subtracted from import values and added to import margins, that is, the trade and transport margins account. These margins increase the demand for transport and insurance services by the same aggregate amount.

The SU table identifies purchases by residents abroad and purchases by non residents in South Africa as separate items of household expenditure. It also identifies imports and exports of commodities. The purchases by residents abroad are

2. For details on the SU-tables, see South Africa (2003).
3. Details on the South African IEA are provided by Smith and National Account Division (2004).
4. Final supply and use tables, 2000: an input-output framework / Statistics South Africa. Pretoria: Statistics South Africa, 2003.
5. The property transfers include interest, dividends, property income attributed to insurance policy holders, and rent.
6. The other transfers consist of social benefits other than social transfers in kind, non-life insurance premium/claims, miscellaneous current transfer, current international co-operation, social transfer in kind, adjustment for change in net equity of households in pension funds, and capital transfer.

added to households' expenditures (accounting for only the imported goods and services), on the one hand, and to the import of goods and services, on the other hand. In the same vein, the total purchases of non-residents in South Africa is subtracted from households' expenditures (accounting for only the exported goods and services) and added to the export of commodities.

The sectoral allowance for depreciation of production assets is added to the gross operating surplus. Thus, capital revenues, incomes, and savings of institutional sectors include the allowance for depreciation. The national account's residual, which is disaggregated by commodity in the SU tables, is added to changes in inventories and household's savings[7]. The account **"Financial Services** Indirectly Measured" (FSIM) is added to the "Insurance services" account, resulting in 94 products categories.

The standard SAM for the year 2000 features 2 accounts for productive factors receipts and payments (compensation for employees and gross operating surplus and mixed income); 5 institutional sector accounts (households and NPISH, non-financial corporations, financial corporations, government, and rest of world); 94 accounts for industries, and 95 accounts for commodities; and 1 account for indirect taxes (import duties, value-added taxes, and other taxes on products).

The disaggregated Social Accounting Matrix

The structure and dimension of a SAM are determined by the purpose of the study and the data availability. Indeed, it gives flexibility to analysts in choosing the level of disaggregation of the national accounts. The standard SAM built from the national accounts is presented in an aggregate form for factors and institutional sectors, whereas industries and commodities are very detailed. This section discusses the steps followed in disaggregating the standard SAM. First, the single account for indirect tax is broken down into "import duties", "value-added taxes", and "other taxes on products" for consistency with the standard CGE framework. Then, the gross operating surplus and mixed income is subsequently imputed to factors, and to institutional units. Finally, labour income is broken down into several categories[8].

The tax information for year 2001 is used in breaking down the single account for indirect taxes into import duties, value-added taxes, and other taxes on products. We map the 50 products of the 2001 tax information with the 94 products of the 2000 standard SAM, and aggregate the latter into the corresponding 50 products. The shares of product-specific duty receipt are computed using the 2001 tax information and used with the indirect tax receipt from the 2000 SAM to calculate the tariff receipt for the aggregate 50 products of the 2000 SAM. The tariff receipts are distributed across the 94 products of the standard SAM using their shares in the indirect taxes. The same procedure is applied to the imputation of the VAT from other taxes on products (Annexure 4).

Household-level income and expenditure data is gathered from the income and expenditure survey (IES) and the September labour force survey (LFS) both for the year 2000. These are reconciled with the national accounts data and used to impute the gross operating surplus and mixed income to the institutional sectors, on the one hand, and the mixed income to self-employment work and own-used capital, on the other hand. Workers are decomposed into twelve categories (Annexure 5) based on three main criteria: geographic area (urban and rural), gender (male and female), and skill-level (high, medium, and low). Factor intensities and the income structure of institutional sectors are provided in annexures 6 to 8. Finally, the single household category is decomposed into urban and rural household categories using incomes and expenses information from the IES.[9]

The energy sector in the Social Accounting Matrix

The procedure of integrating the energy specificity into the standard SAM is presented in three steps. First, the supply of "crude oil" is extracted from "other mining and quarrying". As there is no domestic production of "crude oil", the total supply is essentially satisfied by imports. Second, the petroleum industry is decomposed into synthetic fuel industry and refined

7. A SAM balancing program (see Fofana *et al* (2002)) can be alternatively used to adjust the residual values.

8. The two financial accounts (FSIM and Insurance services) are merged in order to match the standard SAM's product and activity accounts.

9. Details on the micro-data handling are provided by Fofana *et al* (2008b).

oil industry. South Africa has large endowments of coal which have been converted into close substitutes of refined oil products by the well-developed synthetic fuel industry. While consumption accounts are presented by product-category in the standard SAM, the Energy-SAM integrates additional accounts for the households' consumption by purpose.

In the standard SAM, crude oil is merged with other minerals such as diamonds and iron ore into one category named "Other mining". Previous SAM-based CGE analysis of oil price shocks on the South African economy[10] adjusted the standard SAM in order to separate the supply and the use of crude oil from other mining. Essama-Nssah *et al*. *(2007)* created a specific account named "crude or unrefined oil" in their 2003 SAM and assumed that the amount of other mining inputs used in the production of petroleum and basic chemicals equals the total use of crude oil. The latter is essentially imported without transaction fees, that is, tariff and other tax on products, and margins.

In the 2000 SU-tables, this is equivalent to an amount of R12.7 billion, more than half of the R24.3 billion officially reported by the South African Revenue Service (SARS) for the same year (Annexure 9).[11] Furthermore, South Africa has a well-developed coal-input synthetic fuel industry which is represented in the structure of production by the "coal" and "other mining" (principally gas) inputs used in the refined petroleum. The following adjustment procedure aims to account for this discrepancy and the specificity of South Africa oil and petroleum industry.

We rely on the value of crude oil imports given by the SARS (that is, R24.3 billion for the year 2000 reported in Annexure 9). There is no domestic production and supply of crude oil in 2000 according to the Energy Balance of South Africa (Annexure 10) and imports of crude oil are free of transaction fees. As a consequence, the total supply of crude oil is equal to its total import value of R24.3 billion and the total import of the "new" other mining account is adjusted residually.

The "new" other mining (essentially, gas) input use in the refined petroleum industry is estimated at R0.4bn using a ratio of gas to coal inputs (valued at 0.1 from the 2000 energy balance; Annexure 10) and the coal input use in the refined petroleum industry (R3.9bn from the SAM). The crude oil input use in petroleum industries is arrived at as a residual after subtracting the gas input from the other mining inputs. Crude oil is also used in basic chemical industries and its input use is assumed to be equivalent to the other mining input use in these industries. There is no export of crude oil and the change in stocks rebalances the supply and use of the crude oil, as well as that of the "new" other mining.

In the standard SAM, the petroleum industry includes both the synthetic fuel industry and the refined oil industry. A close look at the input-output table shows that the industry uses large proportions of both other mining input (mainly crude oil and natural gas) and coal input. The input of coal is essentially used in the synthetic fuel industry, while the input of crude oil is used in the refined oil industry. The input of other mining (such as natural gas) is also used in the synthetic fuel industry.

According to the 2000 Energy Balance for South Africa, synthetic fuel accounts for 30 percent share of total final consumption of energy in the year 2000. We assume that the value of domestic supply of synthetic fuel would be around the same proportion as long as their unit energy costs are closed. This share is used to split up the value of domestic supply for petroleum products in the standard SAM between synthetic fuel and refined oil. The main input costs (coal and other mining inputs for the synthetic fuel industry, and crude oil input for the refined oil industry) are deducted from the estimated supply values. Then, the net values are distributed over the remaining inputs and value added components according to their distributive shares for the petroleum industry in the standard SAM. The production of both synthetic fuel and refined oil are proportionally supplied to the various petroleum related products.

The classification used by Statistics South Africa in the IES 2000 is based on consumption by purpose. Annexure 11 summarizes the different categories of consumption by purpose. It shows 13 groups of consumption by purpose which have been finally aggregated into 12 groups. Each of the 94 consumption commodities is distributed over these 12 groups of consumption by purpose using their distributive shares. Additional accounts are created to integrate this latter classification of consumption into the standard SAM. The latter feature presents an advantage in that it highlights

10. McDonald and Schoor, 2005; and Essama-Nssah *et al*., 2007.

11. This inconsistency has also been addressed by McDonald and Schoor, 2005.

household fuel and transport fuel items in the households' expenditures in the same way as if one were to decompose fuel products into several types (for example, petrol, LPG, diesel, etc).

The structure of the energy-focused Social Accounting Matrix

There are nine groups of accounts in the final energy SAM of South Africa for the year 2000 as depicted in annexures 12 to 14:

- Factors' accounts (12 categories of labour and 4 categories of capital);
- Current accounts of domestic institutions (2 representative household categories, 2 types of corporation, and 6 tax and government accounts);
- Current transfer accounts (property and other transfers);
- Rest of the world account;
- Trade and transport margins account;
- Activity accounts (94 activities);
- Product accounts (95 products);
- Consumption accounts (12 categories of consumption by purpose);
- Capital accounts (fix capital formation and change in inventories).

The productive factors' accounts include labour and capital. Labour and capital receive income (100%) from the sale of their services to production activities in the form of wages and rents. In turn, these revenues are distributed to households, in the form of labour income (100%) and distributed profits (35%), and to non financial (47%), financial (12%), and public (6%) corporations as retained profits.

Domestic institutions include households, financial and non financial firms and the government. The household account receives factor income (49% labour and 14% capital) as well as transfers (12% property and 25% others) from firms, government, and the rest of the world. Household expenditures consist of consumption of goods (64%), and transfer payments including direct taxes (10%), interests, dividends and rent payments (4%), and other transfer payments (14%). Residuals or savings (8%) are transferred to the accumulation account.

Financial and non financial firms receive gross profits (11% and 76%, respectively), and transfers income (56% property and 33% others for financial firms; 15% property and 8% others for non financial firms) from other domestic institutions and the rest of the world, and spend on transfers in the form of interest, dividends and other property payments (57% and 32%, respectively), direct tax payments (2% and 11%, respectively), other transfers (33% and 6%, respectively) to owners of financial assets, shareholders of corporations, and the government, with their residuals or savings (9% and 51%, respectively) imputed to the accumulation account.

The current transfer accounts receive from households, non financial and financial corporations, government, and the rest of the world, property payments (10%, 18%, 55%, 13% and 4%, respectively) and other transfer payments (32%, 4%, 34%, 30% and 0.2%, respectively). In turn, this is distributed as property income (26%, 9%, 55%, 2% and 9%, respectively) and other transfers income (58%, 5%, 33%, 2% and 2%, respectively) to the institutional sectors' accounts.

On the income side, the government receives tax revenues (net of subsidies) from a variety of sources, that is, direct taxes on households (35%) and financial and non financial corporations (2% and 9%, respectively); indirect taxes including production taxes (8%) and taxes on products (31%), capital income (9%) and property (3%) and other (3%) transfers from domestic institutions and from abroad. The government account allocates its expenditures to buying services (64%) provided by the commodities account, mainly public and administration services. Other government expenditures are interest payments (20%) and transfers and subsidies (44%) to households and companies, and the rest of the world. The balance of the government account (-28%) is transferred to the accumulation account.

Transactions with foreign residents are recorded in the rest of the world account. These transactions include, on the receipt side, the commodities' account expenditures (84%) on imports (final goods, as well as intermediate goods and raw materials), factor payments (13%) and current transfers to the rest of the World (3%). The domestic economy, in turn, receives income from the rest of the World for its exports (93%), as well as factor income (6%) and transfers (0.3%). The difference between total receipts and payments with the rest of the world is, by definition, the current account balance.

Trade and transport margins are generated from commodities sales and channelled to trade and transport activities as intermediate demands. The receipts of the production activities are derived from (100%) sales of their primary and secondary products on the domestic market. The expenditures of production activities include the purchase of raw material and intermediate inputs (50%) with the remainder constituting value added, which is distributed to factors of production in the form of wage payments (27%) and rent (22%), and indirect taxes (1%) payable to the government.

The commodity accounts buy products from domestic producers (85%) and foreigners (11%) in the form of imports, pays tax to the government (4%) and sells them to households (29%), Government (9%), production activities as inputs (43%), the capital account or investment (7%) and the rest of the world or exports (13%). The consumption accounts buy consumption commodities from product accounts and channel them to the household account by purpose of consumption.

The accumulation accounts consist of changes in inventories and fixed capital formation. On the income side, they collect savings from households (48%), and financial (23%) and non financial (78%) firms, and the government (-52%), as well as foreign savings (2%). They, in turn, channel these aggregate savings into investment.

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Annexure 1: Structure of a standard SAM

	Factors	Institutional Sectors	Activities	Commodities	Savings/Investment
Factors			Compensation for employees, gross operating surplus and mixed income (SU-tables)		
Institutional Sectors	Compensation for employees, gross operating surplus and mixed income (SU-tables)	Inter-institutional transfers (IEA)	Tax receipts on production (SU-tables)	Imports, Duty and other tax on products (SU-tables)	
Activities				Production at basic prices (SU-tables)	
Commodities		Final consumption and exports, at purchasing prices (SU-tables)	Intermediate consumption at purchasing prices (SU-tables)		fixed capital formation and changes in stocks at purchasing prices (SU-tables)
Savings/ Investment		Savings (IEA)			

Source: Authors

Annexure 2: Structure of the supply table of South Africa for year 2000

Total supply at purchasers' prices (S1)=S2+S3+S4	Taxes less subsidies on products (S2)	Trade and transport margins (S3)	Total supply at basic prices (S4)=S7+S8	Matrix of activities' output (S5)	Total domestic supply at basic prices (S7)=sum line S5	Imports (S8)	c.i.f./ f.o.b. adjustment on imports (S10)
				Total output at basic prices (S6)		Direct purchases residents (S9)	

Source: SU-tables 2000

Annexure 3: Structure of the use table of South Africa for year 2000

Total supply at purchasers' prices (U1)=U2+ U5+ U7+ U9+ U10+ U11+ U12	Intermediate consumption by industries (U2)	Exports (U5)	Household Consumption Expenditures (U7)	General Government Consumption Expenditures (U9)	Fixed Capital Formation (U10)	Change in inventories (U11)	Residual (U12)
	Gross Value Added/ GDP (U3)	Direct purchases non-residents (U6)	Direct purchases residents (U8)				
	Total output at basic prices (U4)						

Source: SU-tables 2000

Annexure 4: Initial and adjusted tax rates (percent)

Sector	Initial tax rate*	Tariff rate	VAT rate	Other tax rate	Sector	Initial tax rate*	Tariff rate	VAT rate	Other tax rate
Agricultural products	1.4	1.2	1.4	0.0	Other non-metallic products	0.9	1.8	0.5	0.2
Coal and lignite products	0.1	0.0	0.1	0.0	Iron and steel products	0.1	1.3	0.1	0.0
Gold and uranium ore products	0.0	0.0	0.0	0.0	Non-ferrous metals	0.0	0.0	0.0	0.0
Crude oil	0.0	0.0	0.0	0.0	Structural metal products	3.2	22.7	1.7	0.9
Other mining products	0.0	0.0	0.0	0.0	Treated metal products	0.4		0.2	0.1
Meat products	8.7	8.4	8.0	0.3	General hardware products	6.3	4.0	4.3	0.4
Fish products	7.5	2.5	7.0	0.2	Other fabricated metal products	2.0	3.0	1.4	0.1
Fruit and vegetables products	4.8	4.7	4.5	0.1	Engines	8.5	11.9	5.8	0.5
Oils and fats products	5.8	0.9	5.4	0.2	Pumps	4.2	2.1	2.9	0.3
Dairy products	7.2	6.6	6.7	0.2	Gears	1.1	0.5	0.8	0.1
Grain mill products	7.9	3.7	7.3	0.2	Lifting equipment	4.7	3.9	3.2	0.3
Animal feeds	0.4	0.5	0.4	0.0	General machinery	5.0	8.1	3.5	0.3
Bakery products	7.5	16.4	7.0	0.2	Agricultural machinery	3.9	2.2	2.7	0.2
Sugar products	3.8	8.7	3.5	0.1	Machine-tools	6.7	2.9	4.6	0.4
Confectionary products	4.5	2.0	4.2	0.1	Mining machinery	4.1	3.1	2.8	0.2
Other food products	5.9	3.1	5.5	0.2	Food machinery	4.2	3.2	2.9	0.3
Beverages and tobacco products	26.3	83.1	13.3	9.6	Other special machinery	5.8	2.8	4.0	0.3
Textile products	4.9	7.2	2.3	0.9	Household appliances	11.0	11.2	7.4	0.6
Made-up textile products	5.5	27.1	2.5	1.0	Office machinery	8.3	2.7	5.6	0.5
Carpets	4.8	16.5	2.2	0.9	Electric motors	9.6	7.7	2.8	4.3
Other textile products	4.5	3.9	2.1	0.8	Electricity apparatus	1.1	0.7	0.3	0.5
Knitting mill products	8.5	18.9	3.9	1.5	Insulated wire and cable	6.1	16.0	1.8	2.7
Wearing apparel	6.3	21.1	4.4	0.3	Accumulators	1.3	1.4	0.4	0.6
Leather products	0.8	0.7	0.2	0.5	Lighting equipment	2.2	1.6	0.7	1.0
Handbags	9.1	4.2	2.2	5.1	Other electrical products	9.3	11.2	2.8	4.1
Footwear	8.0	12.1	4.6	0.7	Radio and television products	10.5	2.8	4.3	4.2
Wood products	0.5	0.9	0.4	0.0	Optical instruments	7.1	0.5	2.7	4.2
Paper products	0.4	1.7	0.1	0.1	Motor vehicles	6.7	6.1	5.2	0.2
Containers of paper	0.2	30.4	0.1	0.0	Motor vehicles parts	1.8	0.6	1.4	0.1
Other paper products	5.7	36.5	1.4	0.9	Other transport products	5.8	0.0	1.0	4.8
Published and printed products	5.1	3.5	4.5	0.3	Furniture	5.3	6.9	4.2	0.7
Recorded media products	5.8	0.5	5.1	0.3	Jewellery	2.5	3.3	1.9	0.4
Petroleum products	42.0	0.7	15.2	26.8	Other manufacturing	9.4	2.8	7.0	1.6
Basic chemical products	1.2	1.2	0.7	0.2	Electricity	3.1		3.1	0.0
Fertilizers	0.3	0.5	0.2	0.0	Water	2.2	0.0	2.2	0.0
Primary plastic products	1.5	1.6	0.8	0.2	Buildings	3.8	0.0	3.8	0.1
Pesticides	1.4	2.0	0.8	0.2	Other constructions	3.9	0.0	5.3	-1.4
Paints	1.7	6.8	1.0	0.2	Trade services	3.2	0.0	3.2	0.0
Pharmaceutical products	4.4	5.1	2.8	0.3	Accommodation	4.5	0.0	0.0	4.5
Soap products	5.1	21.8	3.2	0.3	Transport services	-0.1	0.0	-0.1	0.0
Other chemical products	2.3	0.5	1.9	0.2	Communications	2.2	0.0	0.6	1.6
Rubber tyres	6.7	8.8	1.0	4.2	Insurance services	3.1	0.0	1.8	1.3
Other rubber products	9.3	4.8	1.3	5.8	Real estate services	4.4	0.0	4.3	0.0
Plastic products	2.5	1.5	0.3	1.9	Other business services	2.4	0.0	2.4	0.1
Glass products	2.4	1.6	0.3	1.8	General Government services	0.4		0.2	0.2
Ceramicware	2.7	1.5	1.6	0.6	Health and social work	4.8	0.0	2.4	2.4
Ceramic products	1.3	1.1	0.8	0.3	Other services / activities	2.8	0.0	2.7	0.1
Cement	0.8	7.7	0.5	0.2					

Source: Energy-SAM of South Africa for year 2000. **Note:** Standard SAM including all taxes on products

Annexure 5: Major occupational and skill levels, and labor categories

Geographic area	Gender	Skill level	Occupation (ISCO)
Urban	Male	High skill	Legislators, seniors officials and managers Professionals Technicians and associate professionals
		Medium skill	Clerks Service workers and shop market sales workers Skilled agricultural and fishery workers Subsistence agricultural and fishery workers Craft and related trades workers Plant and machine operators and assemblers
		Low skill	Elementary occupations Domestic and related helpers, cleaners and launderers Occupation unspecified
	Female	High skill	Legislators, seniors officials and managers Professionals Technicians and associate professionals
		Medium skill	Clerks Service workers and shop market sales workers Skilled agricultural and fishery workers Subsistence agricultural and fishery workers Craft and related trades workers Plant and machine operators and assemblers
		Low skill	Elementary occupations Domestic and related helpers, cleaners and launderers Occupation unspecified
Rural	Male	High skill	Legislators, seniors officials and managers Professionals Technicians and associate professionals
		Medium skill	Clerks Service workers and shop market sales workers Skilled agricultural and fishery workers Subsistence agricultural and fishery workers Craft and related trades workers Plant and machine operators and assemblers
		Low skill	Elementary occupations Domestic and related helpers, cleaners and launderers Occupation unspecified
	Female	High skill	Legislators, seniors officials and managers Professionals Technicians and associate professionals
		Medium skill	Clerks Service workers and shop market sales workers Skilled agricultural and fishery workers Subsistence agricultural and fishery workers Craft and related trades workers Plant and machine operators and assemblers
		Low skill	Elementary occupations Domestic and related helpers, cleaners and launderers Occupation unspecified

Source: Authors from September LFS 2000

Annexure 6: Sectoral structure of value added (percent)

	Urban High Skilled Male Workers	Urban High Skilled Female Workers	Urban Medium Skilled Male Workers	Urban Medium Skilled Female Workers	Urban Low Skilled Male Workers	Urban Low Skilled Female Workers	Rural High Skilled Male Workers	Rural High Skilled Female Workers	Rural Medium Skilled Male Workers	Rural Medium Skilled Female Workers	Rural Low Skilled Male Workers	Rural Low Skilled Female Workers	House-holds capital	Firms capital	ALL
I1	0.4	0.7	5.7	0.9	3.6	1.8	2.8	0.2	9.4	1.2	6.1	2.8	64.3	0.0	**100**
I2	7.6	0.4	19.9	0.6	1.3	0.1	0.4	0.0	5.8	0.3	0.9	0.0	14.5	48.1	**100**
I3	13.4	0.4	49.3	0.7	6.5	0.1	0.0	0.0	0.8	0.0	0.1	0.0	7.2	21.5	**100**
I4	7.6	0.4	19.9	0.6	1.3	0.1	0.4	0.0	5.8	0.3	0.9	0.0	14.5	48.1	**100**
I5	13.5	2.0	16.6	7.1	6.4	6.6	0.8	1.0	2.0	0.9	1.2	0.7	10.3	31.0	**100**
I6	13.5	2.0	16.6	7.1	6.4	6.6	0.8	1.0	2.0	0.9	1.2	0.7	10.3	31.0	**100**
I7	13.5	2.0	16.6	7.1	6.4	6.6	0.8	1.0	2.0	0.9	1.2	0.7	10.3	31.0	**100**
I8	13.5	2.0	16.6	7.1	6.4	6.6	0.8	1.0	2.0	0.9	1.2	0.7	10.3	31.0	**100**
I9	19.0	0.0	36.0	0.1	5.2	0.0	2.0	0.0	0.4	0.0	0.6	0.3	0.0	36.3	**100**
I10	21.1	3.6	11.8	1.9	3.1	0.5	0.7	0.0	2.0	0.8	0.5	0.2	13.6	40.1	**100**
I11	21.1	3.6	11.8	1.9	3.1	0.5	0.7	0.0	2.0	0.8	0.5	0.2	13.6	40.1	**100**
I12	7.7	0.9	21.8	7.6	9.4	3.0	0.3	0.0	4.7	0.7	1.1	1.4	12.9	28.5	**100**
I13	7.7	0.9	21.8	7.6	9.4	3.0	0.3	0.0	4.7	0.7	1.1	1.4	12.9	28.5	**100**
I14	7.7	0.9	21.8	7.6	9.4	3.0	0.3	0.0	4.7	0.7	1.1	1.4	12.9	28.5	**100**
I15	7.7	0.9	21.8	7.6	9.4	3.0	0.3	0.0	4.7	0.7	1.1	1.4	12.9	28.5	**100**
I16	18.9	1.4	4.7	1.5	1.8	0.1	0.0	0.0	0.6	0.3	0.2	0.1	18.4	52.1	**100**
I17	10.7	1.7	23.7	25.9	7.9	1.4	0.0	0.0	3.2	1.4	0.0	0.0	18.2	5.7	**100**
I18	17.7	5.0	19.9	24.4	8.4	2.7	0.0	0.4	1.3	2.7	0.9	0.9	15.7	0.0	**100**
I19	17.7	5.0	19.9	24.4	8.4	2.7	0.0	0.4	1.3	2.7	0.9	0.9	15.7	0.0	**100**
I20	17.7	5.0	19.9	24.4	8.4	2.7	0.0	0.4	1.3	2.7	0.9	0.9	15.7	0.0	**100**
I21	0.0	0.0	14.6	42.3	4.0	10.3	0.0	0.0	0.2	5.9	0.0	2.1	12.1	8.4	**100**
I22	9.3	12.7	11.7	36.9	3.9	5.3	0.1	0.5	1.2	5.1	0.0	0.1	13.1	0.0	**100**
I23	14.6	4.4	24.2	5.7	0.0	4.8	0.0	0.0	4.4	0.0	1.4	0.6	0.0	40.0	**100**
I24	14.6	4.4	24.2	5.7	0.0	4.8	0.0	0.0	4.4	0.0	1.4	0.6	0.0	40.0	**100**
I25	2.3	1.2	23.9	15.5	0.9	4.3	0.0	0.0	0.7	2.7	0.0	0.2	13.0	35.4	**100**
I26	7.8	2.2	37.8	5.9	5.2	0.6	0.4	0.0	9.0	1.2	2.5	1.0	26.6	0.0	**100**
I27	9.3	6.4	19.1	4.4	1.8	1.6	0.0	0.0	1.0	0.2	0.2	0.8	13.7	41.3	**100**
I28	9.3	6.4	19.1	4.4	1.8	1.6	0.0	0.0	1.0	0.2	0.2	0.8	13.7	41.3	**100**
I29	9.3	6.4	19.1	4.4	1.8	1.6	0.0	0.0	1.0	0.2	0.2	0.8	13.7	41.3	**100**
I30	25.4	12.9	21.7	9.8	4.2	1.2	0.0	0.5	0.7	0.3	0.2	0.0	8.9	14.3	**100**
I31	25.4	12.9	21.7	9.8	4.2	1.2	0.0	0.5	0.7	0.3	0.2	0.0	8.9	14.3	**100**
I32	8.6	0.4	5.8	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	24.5	60.4	**100**
I33	20.2	1.7	11.4	2.2	0.6	0.1	1.3	0.0	0.9	0.0	0.0	0.0	0.0	61.7	**100**
I34	20.2	1.7	11.4	2.2	0.6	0.1	1.3	0.0	0.9	0.0	0.0	0.0	0.0	61.7	**100**
I35	20.2	1.7	11.4	2.2	0.6	0.1	1.3	0.0	0.9	0.0	0.0	0.0	0.0	61.7	**100**
I36	40.3	9.2	5.9	2.5	3.0	3.7	0.0	0.0	1.2	0.3	0.3	0.1	0.0	33.5	**100**
I37	40.3	9.2	5.9	2.5	3.0	3.7	0.0	0.0	1.2	0.3	0.3	0.1	0.0	33.5	**100**
I38	40.3	9.2	5.9	2.5	3.0	3.7	0.0	0.0	1.2	0.3	0.3	0.1	0.0	33.5	**100**
I39	40.3	9.2	5.9	2.5	3.0	3.7	0.0	0.0	1.2	0.3	0.3	0.1	0.0	33.5	**100**
I40	40.3	9.2	5.9	2.5	3.0	3.7	0.0	0.0	1.2	0.3	0.3	0.1	0.0	33.5	**100**
I41	6.5	0.9	54.9	2.5	0.2	0.0	0.0	0.0	5.4	0.0	0.0	0.3	0.0	29.2	**100**
I42	6.5	0.9	54.9	2.5	0.2	0.0	0.0	0.0	5.4	0.0	0.0	0.3	0.0	29.2	**100**
I43	20.9	7.3	29.7	13.8	6.7	10.2	0.2	0.0	0.1	0.2	0.1	0.8	0.0	9.9	**100**
I44	7.7	0.0	47.5	4.2	7.1	0.0	0.0	0.0	4.3	0.4	0.0	0.0	7.5	21.3	**100**
I45	13.7	0.5	14.6	1.4	1.3	0.9	0.1	0.0	2.9	0.6	0.6	0.1	17.6	45.7	**100**
I46	13.7	0.5	14.6	1.4	1.3	0.9	0.1	0.0	2.9	0.6	0.6	0.1	17.6	45.7	**100**
I47	13.7	0.5	14.6	1.4	1.3	0.9	0.1	0.0	2.9	0.6	0.6	0.1	17.6	45.7	**100**
I48	13.7	0.5	14.6	1.4	1.3	0.9	0.1	0.0	2.9	0.6	0.6	0.1	17.6	45.7	**100**
I49	7.1	3.0	15.8	3.3	4.0	0.1	0.2	0.0	1.5	0.0	0.1	0.0	16.1	48.8	**100**
I50	7.1	3.0	15.8	3.3	4.0	0.1	0.2	0.0	1.5	0.0	0.1	0.0	16.1	48.8	**100**

Source: Energy-SAM of South Africa for year 2000.

Annexure 7: Sectoral structure of value added, continuous (percent)

	Urban High Skilled Male Workers	Urban High Skilled Female Workers	Urban Medium Skilled Male Workers	Urban Medium Skilled Female Workers	Urban Low Skilled Male Workers	Urban Low Skilled Female Workers	Rural High Skilled Male Workers	Rural High Skilled Female Workers	Rural Medium Skilled Male Workers	Rural Medium Skilled Female Workers	Rural Low Skilled Male Workers	Rural Low Skilled Female Workers	House-holds capital	Firms capital	**ALL**
I51	12.1	0.0	51.0	2.6	3.7	0.0	1.2	0.0	3.7	0.0	0.0	0.0	9.0	16.8	**100**
I52	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I53	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I54	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I55	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I56	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I57	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I58	25.0	9.2	22.7	1.1	4.4	0.1	0.0	0.1	0.9	0.4	0.1	0.0	9.1	26.9	**100**
I59	24.5	2.6	26.1	21.4	8.9	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.0	15.8	**100**
I60	36.7	1.0	29.8	3.2	5.0	0.0	0.0	0.0	4.2	0.0	0.0	0.2	0.0	19.9	**100**
I61	36.7	1.0	29.8	3.2	5.0	0.0	0.0	0.0	4.2	0.0	0.0	0.2	0.0	19.9	**100**
I62	36.7	1.0	29.8	3.2	5.0	0.0	0.0	0.0	4.2	0.0	0.0	0.2	0.0	19.9	**100**
I63	36.7	1.0	29.8	3.2	5.0	0.0	0.0	0.0	4.2	0.0	0.0	0.2	0.0	19.9	**100**
I64	36.7	1.0	29.8	3.2	5.0	0.0	0.0	0.0	4.2	0.0	0.0	0.2	0.0	19.9	**100**
I65	23.4	13.2	26.2	1.3	5.1	4.9	1.6	0.0	0.0	0.2	0.0	0.7	11.0	12.3	**100**
I66	47.9	0.0	9.7	0.0	8.3	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0	33.1	**100**
I67	33.9	0.0	13.1	26.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.5	**100**
I68	5.1	0.0	34.8	3.8	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.0	**100**
I69	6.1	0.0	27.6	2.8	0.4	1.0	0.0	0.0	0.0	1.1	2.6	0.0	0.0	58.4	**100**
I70	0.0	0.0	19.0	0.0	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.0	**100**
I71	3.4	0.0	0.0	9.3	0.0	4.5	0.0	0.0	34.8	0.0	0.0	0.0	0.0	47.9	**100**
I72	33.8	0.0	12.6	6.4	1.1	0.9	0.0	0.0	0.1	1.0	0.0	0.2	0.0	43.9	**100**
I73	13.4	51.0	3.1	3.7	0.5	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0	27.2	**100**
I74	22.5	3.1	0.7	37.5	3.6	2.8	0.0	0.0	1.2	0.0	0.0	0.0	0.0	28.6	**100**
I75	25.8	0.7	19.7	1.9	0.9	1.1	0.9	0.0	0.7	0.3	0.1	0.1	15.6	32.3	**100**
I76	13.1	2.0	33.3	5.5	7.2	0.8	0.3	0.0	3.4	0.0	0.0	0.0	10.5	23.9	**100**
I77	52.3	0.0	36.0	0.0	4.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	1.9	5.6	**100**
I78	24.7	0.5	28.0	6.0	6.6	0.0	0.0	0.0	5.7	0.2	0.3	0.6	9.1	18.1	**100**
I79	3.8	6.5	17.2	14.7	5.7	3.5	2.4	0.0	0.9	0.4	0.4	0.1	12.1	32.3	**100**
I80	3.8	6.5	17.2	14.7	5.7	3.5	2.4	0.0	0.9	0.4	0.4	0.1	12.1	32.3	**100**
I81	15.3	1.0	13.6	2.4	1.1	0.5	0.0	0.0	0.6	0.1	0.3	0.0	16.3	48.8	**100**
I82	15.5	0.0	8.4	1.3	0.0	0.2	0.9	0.0	4.4	1.4	1.5	0.4	16.6	49.6	**100**
I83	5.4	0.0	50.1	2.0	1.3	0.2	0.1	0.0	4.6	0.2	0.3	0.0	12.5	23.2	**100**
I84	7.6	0.5	20.5	1.4	20.8	0.2	0.3	0.0	4.9	0.2	4.3	0.2	26.8	12.3	**100**
I85	11.6	4.8	19.9	9.9	3.8	2.8	0.6	0.2	2.8	1.0	0.4	0.7	21.7	19.8	**100**
I86	3.8	2.7	8.6	8.8	0.7	0.9	0.2	0.0	2.2	1.2	0.2	0.4	34.5	35.7	**100**
I87	11.7	3.8	21.5	1.9	2.5	0.1	1.2	0.2	2.3	0.0	0.4	0.0	18.1	36.1	**100**
I88	20.6	2.9	7.0	8.1	0.6	0.1	0.1	0.0	0.1	0.4	0.2	0.1	15.1	44.7	**100**
I89	20.1	4.8	7.2	6.0	0.3	0.2	0.6	0.1	0.1	0.1	0.0	0.0	15.2	45.3	**100**
I90	4.5	1.8	0.3	0.5	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	23.8	68.6	**100**
I91	41.8	12.8	14.6	8.5	1.4	2.3	0.1	0.2	1.2	0.3	0.2	0.3	16.3	0.0	**100**
I92	22.6	6.9	34.0	13.9	2.9	1.3	0.8	0.2	3.9	0.7	0.7	0.6	2.9	8.5	**100**
I93	11.5	25.9	2.4	6.8	1.4	2.3	1.1	2.7	0.5	0.6	0.2	0.7	28.0	15.8	**100**
I94	21.2	24.3	4.3	4.4	1.2	11.3	2.6	4.8	0.7	0.4	0.2	2.4	6.2	16.0	**100**
ALL	**15.8**	**5.4**	**18.2**	**6.5**	**2.6**	**1.5**	**0.7**	**0.4**	**2.4**	**0.5**	**0.6**	**0.5**	**15.7**	**29.4**	**100**

Source: Energy-SAM of South Africa for year 2000.

Annexure 8: Income structure of institutional sectors (percent)

	Households and NPISH's	Non-financial corporations	Financial corporations	General government
Urban High Skilled Male Workers	14.2			
Urban High Skilled Female Workers	4.9			
Urban Medium Skilled Male Workers	16.4			
Urban Medium Skilled Female Workers	5.8			
Urban Low Skilled Male Workers	2.3			
Urban Low Skilled Female Workers	1.4			
Rural High Skilled Male Workers	0.6			
Rural High Skilled Female Workers	0.3			
Rural Medium Skilled Male Workers	2.1			
Rural Medium Skilled Female Workers	0.4			
Rural Low Skilled Male Workers	0.5			
Rural Low Skilled Female Workers	0.4			
Households capital	14.2			
Firms capital		76.4	11.1	8.6
Households and NPISH's				
Non financial corporations				
Financial corporations				
General government				
Current tax on income and welfare				46.7
Other tax on production less subsidies				7.8
Import duty				2.4
Other tax on product less subsidies				28.4
Property income	11.7	15.4	56.0	2.8
Social and miscellanous current transfers	24.7	8.2	32.9	3.2
ALL	**100.0**	**100.0**	**100.0**	**100.0**

Source: Energy-SAM of South Africa for year 2000.

Annexure 9: Import values of crude oil in 2000

Period	Value	Barrels	Price per barrel
2000/01	729,884,595	4,446,045	164
2000/02	2,272,392,967	13,833,139	164
2000/03	1,431,042,330	8,276,420	173
2000/04	1,342,838,052	7,337,773	183
2000/05	2,275,068,983	13,210,859	172
2000/06	1,358,438,623	7,209,586	188
2000/07	2,158,719,090	11,135,897	194
2000/08	2,139,451,981	10,347,601	207
2000/09	1,745,727,824	8,824,650	198
2000/10	2,718,265,881	12,878,648	211
2000/11	3,824,104,421	16,742,826	228
2000/12	2,267,026,349	9,703,894	234
TOTAL	**24,262,961,096**	**123,947,338**	**196**

Source: South African Revenue Service (SARS)

Annexure 10: Energy supply and consumption for RSA in 2000

Supply & Consumption (TJ)	Coal	Crude Oil	Petroleum	Gas
Indigenous Production	5,301,908	-	-	65,024
Import	34,390	781,529	20,291	-
Export	-1,957,457	-7,598	-259,997	-
Intl. Marine Bunkers	-	-	-113,479	-
Stock Changes	46,884	-	-	-
Total Primary Energy Supply	**3,425,725**	**773,931**	**-353,185**	**65,024**
Transfers	-	-	-	-
Statistical Differences	31,097	-	0	0
Public Electricity Plant	-1,886,291	-	-	-
Autoproducer Electricity Plant	-116,046	-	-	-
Public CHP Plant	-	-	-	-
Autoproducer CHP Plant	-	-	-	-
Public Heat Plant	-	-	-	-
Autoproducer Heat Plant	-	-	-	-
Heat pumps	-	-	-	-
Electric boilers	-	-	-	-
Gas Works	-133,407	-	-	39,857
Oil Refineries	-	-1,113,150	1,084,626	-27
Coal Transformation	-12,159	-	-	-
Liquefaction	-654,328	339,219	-	-65,024
Non-specified (Transformation)	-	-	-	-
Own Use	-	-	-	-
Distribution Losses	-	-	-	-
Total Final Consumption	**654,592**	**-**	**731,441**	**39,830**

Source: Energy Balance - RSA 2000 (Aggregated)

Annexure 11: Consumption by purpose

IES 2000		Energy-SAM 2000	
1	Housing	1	Housing
2	Food and beverages	2	Food and beverages
3	Personal care	3	Household care
4	Household fuel	4	Household fuel
5	Clothing and footwear	5	Clothing and footwear
6	Household appliances and equipment	6	Household appliances and equipment
7	Transport	7	Transport
8	Education	8	Education
9	Health and social services	9	Health and social services
10	Computer and telecommunication	10	Computer and telecommunication
11	Recreation, entertainment and sport	11	Recreation, entertainment and sport
12	Miscellaneous	12	Miscellaneous
13	Household work		

Source: Author using IES 2000

Annexure 12: Social Accounts Matrix of South Africa for year 2000 (Aggregate version, Rand millions current prices)

	Labor	Capital	Households and NPISH's	Non-financial corporations	Financial corporations	General government	Rest of the world	Property income	Social and miscellanous current transfers	Trade and transport margins	Industry	Product	Consumption	Saving/ investment	Changes in inventories	TOTAL
Labor											432,545					**432,545**
Capital											355,506					**355,506**
Households and NPISH's	432,545	123,962						102,621	216,256							**875,384**
Non-financial corporations		166,669						33,684	17,801							**218,154**
Financial corporations		42,557						214,385	125,775							**382,717**
General government		22,319	91,283	23,912	5,894			7,309	8,402		20,189	79,816				**259,124**
Rest of the world								35,212	7,654			218,146				**261,012**
Property income			39,054	70,289	217,427	51,251	15,190									**393,211**
Social and miscellanous current transfers			120,541	13,767	126,431	114,276	873									**375,888**
Trade and transport margins																
Industry												1,627,611				**1,627,611**
Product						166,330	242,632				819,370		556,652	131,848	8,741	**1,925,573**
Consumption			556,652													**556,652**
Saving/ investment			67,854	110,186	32,965	-72,733	2,317									**140,589**
Changes in inventories														8,741		**8,741**
TOTAL	**432,545**	**355,506**	**875,384**	**218,154**	**382,717**	**259,124**	**261,012**	**393,211**	**375,888**		**1,627,611**	**1,925,573**	**556,652**	**140,589**	**8,741**	**7,812,708**

Source: The Energy Focused Social Accounting Matrix of South Africa for year 2000 - R millions current prices; By I. Fofana, R. Mabugu ,and M. Chitiga (April 2008)

Annexure 13: Social Accounts Matrix of South Africa for year 2000 (Aggregate version, percent of total income)

	Labor	Capital	Households and NPISH's	Non-financial corporations	Financial corporations	General government	Rest of the world	Property income	Social and miscellanous current transfers	Trade and transport margins	Industry	Product	Consumption	Saving/ investment	Changes in inventories	TOTAL
Labor											100					**100**
Capital											100					**100**
Households and NPISH's	49	14						12	25							**100**
Non-financial corporations		76						15	8							**100**
Financial corporations		11						56	33							**100**
General government		9	35	9	2			3	3		8	31				**100**
Rest of the world								13	3			84				**100**
Property income			10	18	55	13	4									**100**
Social and miscellanous current transfers			32	4	34	30										**100**
Trade and transport margins												100				**100**
Industry												100				**100**
Product						9	13				43		29	7		**100**
Consumption			100													**100**
Saving/investment			48	78	23	-52	2									**100**
Changes in inventories														100		**100**
TOTAL	**6**	**5**	**11**	**3**	**5**	**3**	**3**	**5**	**5**		**21**	**25**	**7**	**2**		**100**

Source: The Energy Focused Social Accounting Matrix of South Africa for year 2000 - R millions current prices; By I. Fofana, R. Mabugu ,and M. Chitiga (April 2008)

Annexure 14: Social Accounts Matrix of South Africa for year 2000 (Aggregate version, percent of total expenses)

	Labor	Capital	Households and NPISH's	Non-financial corporations	Financial corporations	General government	Rest of the world	Property income	Social and miscellanous current transfers	Trade and transport margins	Industry	Product	Consumption	Saving/ investment	Changes in inventories	TOTAL
Labor											27					**6**
Capital											22					**5**
Households and NPISH's	100	35						26	58							**11**
Non-financial corporations		47						9	5							**3**
Financial corporations		12						55	33							**5**
General government		6	10	11	2			2	2		1	4				**3**
Rest of the world								9	2			11				**3**
Property income			4	32	57	20	6									**5**
Social and miscellanous current transfers			14	6	33	44										**5**
Trade and transport margins																
Industry												85				**21**
Product						64	93				50		100	94	100	**25**
Consumption			64													**7**
Saving/investment			8	51	9	-28	1									**2**
Changes in inventories														6		
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**		**100**	**100**	**100**	**100**	**100**	**100**

Source: The Energy Focused Social Accounting Matrix of South Africa for year 2000 - R millions current prices; By I. Fofana, R. Mabugu ,and M. Chitiga (April 2008)

Annex 2

The Energy Focused Computable General Equilibrium Model for Assessing the Impacts of Policy Responses to High Oil Prices in South Africa

Introduction

A Computable General Equilibrium (CGE) model is a multi-market model based on real world data of one or several economies. It simulates a working economy by incorporating various institutional and structural characteristics that simple analysis fails to capture. CGE models are widely used by economists to analyse the magnitude and distributional effects of external shocks and policies, such as oil price shocks, and consequently to help formulating policies. They are primarily based on neoclassical theory of general equilibrium, first formulated by Leon Walras in 1877 and later formalised by Arrow and Debreu (1954) and McKenzie (1954, 1959, 1981). Improvements in data collection and advances in computer technology and software have enhanced advanced methodology of applied policy work.

A CGE model is a system of equations, which simulates the working of a market economy. The prices and quantities of all goods and factors are determined simultaneously in every market - hence G for "general" - by the need to equate supply with demand - hence E for "equilibrium". The system of equations is simultaneously solved using a numerical database arranged in a matrix format called a Social Accounting Matrix (SAM), and a computer with appropriate software - hence C for "computable". Most of the equations in CGE models feature rigorous microeconomic foundations specifying how the quantities supplied and demanded in each market respond to price changes. There are also a few macro-economic equations to make everything add up correctly such that the behaviours of economic agents are consistent with the macro-economic framework.

The principal advantage of using a CGE model in policy analysis is that it permits taking into account interactions throughout the economy. If something is changed in only one part of the economy, such as the oil sector, due to oil prices and government policy response, then there will be effects on the other parts of the economy, and these are automatically taken into account when one computes direct and indirect effects using a general equilibrium model. Hence this approach has both a sound theoretical structure as well as an exhaustive accounting strategy.

CGE models require a benchmark data presented in the form of a Social Accounting Matrix (SAM). The latter is a set of accounts written in a condensed matrix form with an important property that the sum of the row elements is equal to the sum of the corresponding column elements. The SAM is therefore consistent in the sense that it describes a general equilibrium of the economy in question from which counterfactual analysis can be carried out[1].

The calibration of CGE models consists in finding parameters which permit equations to exactly reproduce the benchmark situation given by the SAM. The model is designed to mimic the working of a specific economy by incorporating various institutional and structural characteristics such as rigidities and constraints in different markets that simple theoretical analysis fails to capture. The model is later used to develop several counterfactuals - "*what if*"- scenarios that provide interesting insights on the likely impacts of macro-economic shocks and policies on economic performance and income distribution.

In general, CGE models are used when proposed policy measures, or expected changes in exogenous conditions, are likely to have general equilibrium effects, that is, significant indirect effects with potentially strong effects on the allocation of scare resources. They have been used widely in the Organisation of Economic Cooperation and Development (OECD) countries for economic and social policy orientation[2]. A general review of earlier CGE models used in South Africa is found in Thurlow and van Seventer (2002). Woolard and Wilson (2004) provide a more recent review of CGE modeling in the country with a focus on labour demand projections. McDonald and Punt (2005) provide an overview of recent CGE models used to analyse agricultural issues while Mabugu and Chitiga (2008) review CGE models applied to trade liberalization issues in South Africa.

Results generated by CGE models are often questioned on their validity and usefulness for policy decision making because of their underlying assumptions on optimizing behaviour, competitive markets and flexible relative prices. However, as mentioned by van der Mensbrugghe (1998), "the strength of this class of economic models is consistency with generally

1. Details on the SAM are provided by Fofana *et al*. (2008a).
2. Devarajan and Robinson (2005) review the use of CGE models in the policy debate.

accepted microeconomic theory, significant structural detail, and the nature of general equilibrium, that is, that changes in any one area of economic activity may have measurable impacts in other areas". The lack of econometric estimation of key supply and demand parameters is also a weakness of CGE models. "This calls for undertaking significant sensitivity analysis to see which parameters are key in altering the results and their interpretation" (van der Mensbrugghe, 1998). As pointed out by Bergman and Henrekson (2003), "even if uncertainty about the numerical values of key parameters makes the magnitude of computed effects of policy changes uncertain, the analyst may be able to safely conclude that the effects in question are small or big".

This present document aims at providing detailed discussions on the technical aspects of the energy CGE model elaborated and calibrated to the South African economy for the year 2000. Section 1 starts with a discussion of the application of CGE models to energy issues so as to set the scene. Sections 2 and 3 provide the basic structure and hypothesis of the model and specify the energy aspects of the model. A detailed presentation of the model using mathematical specification is provided in section 4. Finally section 5 discusses the full procedure of calibrating the model to the South African database.

Applications of CGE modelling in Energy and Environmental Issues

CGE models are widely used for evaluation of policies related to energy and carbon dioxide emission. A survey by Bergman and Henrekson (2003) highlights their usefulness in environment and resource management modelling. The authors cluster the application of CGE modelling in this area into two categories: "Externality CGE Models" and "Resource Management CGE Models". They highlight that in terms of numbers, the former completely dominates the field of environmental CGE modelling.

Hudson and Jorgenson (1975) developed the first CGE model for energy policy analysis related to the oil price increases in 1973 and 1979. It was followed by the well-known ETA-MACRO model of Manne (1977). In the nineties, a number of single-country models for environmental policy and resource management analysis were developed (e.g. Hazilla and Kopp, 1990; Bergman, 1990). One of the most famous CGE modelling of energy and environmental issues is the GeneRal Equilibrium ENvironmental (GREEN) model developed at the OECD Development Centre (van der Mensbrugghe, 1994).

In energy and environmental CGE modelling, the supply and demand sides of energy fuel are explicitly elaborated. The modelling presents much disaggregated energy sectors and products in order to capture inter-fuel substitution possibilities and a certain specification of production functions. Energy and environmental CGE models distinguish various types of fuel, and separate energy input intensive sectors from non energy input intensive sectors. In general, a nested production function structure is the technology description used in most CGE models, including those designed for energy and environmental issues. They combine Constant Elasticity of Substitution (CES), Cobb-Douglas (CD) and Leontief production functions and require available information on the elasticities of substitution among productive factors.

In most energy and environment models (e.g. GREEN model), composite fuels and electricity are combined in a CES function with a relatively high elasticity of substitution. The former is often defined as a CES-aggregate of different types of fossil and non-fossil fuels with relatively high elasticities of substitution between them. Most CGE models assume an imperfect substitution between capital and energy in a capital-energy bundle with quite a low elasticity. Others suggest that capital and energy are complements. The capital-energy bundle in turn imperfectly substitutes for labour in the value added-energy composite. Finally, value added and energy and non-energy inputs are aggregated into the sectoral output.

The dynamic version of the GREEN model integrates an interesting feature called a vintage capital production structure. van der Mensbrugghe (1994) observes that "typically, substitution possibilities are greater with newer capital. In this way, GREEN can capture the possibility that energy and capital can be perfect complements in the short run (i.e. the substitution elasticity between capital and energy is zero), but that in the long run it may be possible to substitute capital for energy if the price of energy were to increase relative to the price of capital." The model accounts for five types of fuel (coal, crude oil, refined oil, gas and electricity) and the backstop components. Crude oil shows an infinite elasticity "reflecting the high degree of homogeneity of crude oil internationally and its relatively low transportation cost" (Van Der Mensbrugghe, 1994). Other energy products (coal and gas) are modelled as Armington goods because of "the more costly transportation margins, although natural gas, and perhaps to a lesser extent coal, are also relatively homogeneous goods" (Van Der Mensbrugghe, 1994). The model presents energy-related carbon emissions from the direct consumption of coal, oil and gas (and the "dirty" backstop fuel) and describes an energy efficiency improvement specification.

The GREEN model accounts for one aggregate representative household maximising a unitary extended linear expenditure system (ELES) utility function over four categories of goods, namely, food and beverage, energy, transport and communication, and other goods and services. A fixed proportion of energy is determined in each good consumed by households and split up into the fuel components. The nested structure of energy demand in consumption is identical to the structure in production.

Bussolo *et al*. (2003) present technical specifications of the regional and environmental general equilibrium model for India developed along the lines of the GREEN model. The paper provides the key structural and behavioural aspects of a model that assesses economic and environmental impacts of abatement policies. The model presents an interesting regional dimension in both comparative static and recursive dynamics models. The study uses a 35-industry SAM built from a 60 industry-Input-Output table for India for 1994/95. The energy specification of the SAM features 4 mining sectors (coal, crude oil, and crude gas industries), and 4 manufacturing sectors (coal products, oil products, electricity, gas and water manufacturing).

The Core Model

The core of the constructed model for South Africa is based on the neoclassical general equilibrium theory. The model seeks to explain production, consumption and prices in the South African economy in which agents respond to relative prices as a result of profit and utility maximizing behaviours. Markets simultaneously adjust relative prices in order to reconcile endogenous supply and demand decisions, and thus, determining levels of production and consumption.

Our model collapses a whole economy into three major parts: (i) the supply of goods and services[3] that includes production and trade activities; (ii) the demand of goods and services by institutional units[4]; and (iii) the macro-economic constraints. Then the model builds equations meant to capture the behaviour and interaction between the three components. The main behavioural assumptions embedded in the model are as follows:

a) Producers maximise their profit under a given technology and independent prices (*perfect competition assumption*). Industry-specific producers are modelled as representative producers that are assumed to have a nested constant elasticity of substitution (CES) production technology.

   The relationship between the rest of the world and the domestic economy is determined by the substitutability between imported and domestic goods on the consumption side (*Armington assumption*), and by the substitutability between the domestic and international markets on the production side. The relative prices of foreign goods – defined by international fixed prices (*small country hypothesis*), the exchange rate, and government interventions (taxes, subsidies, and tariffs) – determine the allocation of supply and demand between domestic and international markets.

b) Consumers maximise their utility under limited budgets and given market prices (*perfect competition assumption*). Households are modelled as representative agents that are assumed to have Stone-Geary type of preferences.

c) *Perfect competition* prevails in the sense that producers and consumers take as given the relative prices that simultaneously clear all markets, that is, equalizing the quantity produced for each commodity to the quantity demanded for that commodity. Households' behaviour is rational which implies that in the presence of complete markets, there is a separation between their production and their consumption decisions *(separability hypothesis)*.

3. Negative supplies of goods and services correspond to the demand of goods and services for intermediate consumption and include the demand for labour and capital services.
4. The negative demand corresponds to the supply of labour and capital services.

The model specifies a number of structural features designed to reflect the characteristics of the South African economy. In the main, this is what distinguishes it from other standard models in this class of models. The structural features that are imposed on the model are listed next.

a) Empirical evidence and specificities appeal for a better specification of the South African labour market that the standard analysis fails to capture. There is a general consensus among analysts that the labour market in South Africa is segmented. Each segment corresponds to a specific skill-level and behaves differently in terms of earnings, job opportunity, unemployment, and wage flexibility.[5] Therefore, workers and the labour market are distinguished into high-skilled (from hereon referred to as skilled workers), medium-skilled and low-skilled categories (from hereon referred to as unskilled workers). Each category in turn is separated by sex (male and female) and location (urban and rural areas). While education and experience are important determinants of earnings, other factors such as discrimination by race and gender and barriers to mobility (i.e. geographic location) are associated with larger differentials than usually found in studies for other countries (Fallon and Lucas, 1998)[6].

b) Capital demand is industry-specific. Consequently, there are as many returns to capital as there are capital using industries in the economy. Capital supply is exogenous and institutional units are endowed with a single type of capital. Although the return to capital is industry-specific, each domestic institutional unit (urban households, rural households, firms and government)[7] receive an average return to their capital according to its distribution across industries. There is no return to capital used in general government services. Instead the government supports the cost of using such capital.

c) The model explicitly treats the trade and transportation margins for commodities that enter the market sphere. A constant trade and transportation margins coefficient is added to each transaction and included in the purchasing price of commodities. Consequently, the generated revenues represent additional demands for trade, and transport services.

d) There is a separation between production activities and commodities. A fixed proportional relationship between activity output and commodity domestic supply permits any activity to produce one or multiple commodities and any commodity to be produced by one or multiple activities.

CGE models differ primarily in the choices of closure rules which equilibrate commodity, factor and foreign exchange markets. They also differ in rules specified to reconcile the government budget constraint and in the mechanism used to equilibrate savings and investment levels in the economy. To this end, closure rules adopted in this study follow:

a) All *commodity markets* follow the neoclassical market-clearing price system, in which jointly determined producer and consumer prices vary only by given tax, subsidy and margins rates.

b) The *labour market* is assumed to be fully segmented. Workers are immobile between urban and rural areas according to the short term perspective of the analysis and the absence of explicit treatment of migration between the two areas. Skilled workers do not compete for unskilled jobs and unskilled workers similarly do not compete for skilled jobs. As a result, skilled, and unskilled male and female workers in both urban and rural areas participate in different labour markets. Each category of labour is assumed to be perfectly mobile across industries. A single wage index prevails for each market.

   Skilled workers are fully employed in the economy although low rates of frictional unemployment[8] are observed in urban and rural areas for this category. The skilled labour market is assumed to be perfectly competitive so that the

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5. The country faces at the same time a shortage of skilled workers and a high unemployment rate among unskilled workers.

6. The model does not explicitly treat the rural-urban migration issue though. Furthermore, men and women tend to work in different sectors, some sectors are male-oriented (i.e. mining, food, beverage and tobacco heavy manufacturing and construction), while others are female-oriented (i.e. textile, privates services). Cockburn *et al.* (2007) further discuss the sex segmentation of the labour market in South Africa. We consider that racial discrimination is minor and individuals with identical education and work experience have the same opportunity to be hired regardless of the population group they belong to.

7. Frictional unemployment exists because both jobs and workers are heterogeneous. A mismatch related to skills, payment, worktime, location, attitude and tastes can result between the supply and the demand of labor.

8. The non resident agents do not own capital; instead they receive property transfers revenue (dividend, interest, etc.) from the resident agents.

prevailing wage rates equalize exogenous supplies and endogenous demands for high-skilled workers in both urban and rural areas. In contrast, there is imperfect competition in the unskilled labour markets where the total demand does not equal the total supply. There is an excess supply of labour which remains unemployed. The wage rate paid to unskilled male and female workers is fixed in real terms in both urban and rural areas.

According to the characteristics of the labour market in South Africa and the short term perspective of the study, we assume that the employment decisions in general public administration are exogenously determined as government hiring possibilities are limited. Therefore, fixed indexed-wage rates prevail in the general government services, while other industries take the market wage rates as given.

The supply of each category of labour is exogenous[9]. Household labour supply specification takes into account the existence of unemployment for low skilled labour categories. We assume that low skilled employment is rationed on the demand side and workers have the same opportunity (probability) to be hired regardless of the household to which they belong.

c) The *foreign exchange market* equilibrates via adjustments of the real exchange rate. The current account balance is therefore exogenous and pre-specified at the base year level. Hence, with fixed foreign borrowing and transfers from abroad, higher imports of some goods will require lower imports and/or higher exports of other goods in order to keep the current account balanced. Pressures to change export or import quantities (and hence, demand and supply of foreign currency) are therefore equilibrated by adjustments in the real exchange rate.

d) *Government* is passive in the sense that it does not optimize any objective function. Its role is limited to that of regulating economic activity. Its earnings comprise revenues raised from indirect taxes, direct taxes, trade taxes and net foreign borrowing. Its expenses consist of subsidies, current expenditures on the services provided by the public sector, investment and transfers to households and firms. Government expenditure, i.e. transfers, current expenditures and investment expenditures), is rigid. The government deficit is covered by borrowing on the domestic credit market.

e) *Private savings are investment driven*. Savings are generated by exogenous constant rates for households and by residual savings from firms. Saving of the rest of the world is exogenous. Private savings are equal to net savings available after government borrowing is covered.

f) The model is homogenous of degree one in all prices and nominal values. The "numeraire" is the nominal exchange rate – however the real exchange rate remains endogenous through flexible domestic prices. All nominal values are thus measured relative to the price of internationally traded goods. The model solves for one-period equilibrium and results have to be interpreted in comparative static terms.

The Energy Specificity of the Model

The model differs from standard CGE models in two other main aspects: the energy supply and demand specification on the one hand, and the price setting method in the domestic oil market, on the other hand. The model has four types of energy namely, crude fuel, refined fuel products ("*petroleum*"), coal, and electricity (including gas and renewable energy). The way energy is modelled features specific aspects that are outlined next.

a) An industry *j*'s technology is presented as a nested CES function (Figure 1). The gross output consists of a Leontief function of the composite value added-energy and the non-energy input consumption. Leontief technology also determines the demand for non-energy commodities in the total non-energy input consumption. A CES function aggregates unskilled labour and the bundle of capital-energy and skilled labour in the value added-energy composite, with a high elasticity of substitution. The bundle of capital-energy and skilled labour is also a CES aggregation of capital-energy and skilled labour. However, the latter has a low elasticity of substitution. Each unskilled and skilled

9. Allowing the supply of labour to be endogenously determined by households is not relevant in our study as long as we claim for a short term perspective of the analysis. Thus, new educated labour or/and skilled labour migrants will not play an important role in the model. With the presence of unemployment rationed on the demand side, high (low) employment will lead to low (high) participation to economic activity and will not necessary impact on the unskilled wage rates assumed fixed in real term.

labour category is a fixed proportional (Leontief) relationship between urban and rural labour categories. A unitary elasticity of substitution (Cobb-Doublas) aggregates unskilled male and female workers on the one hand, and skilled male and female workers, on the other hand. A CES function with a low elasticity demonstrates that capital and energy imperfectly substitute for each other or are quasi-complementary in the composite capital-energy.

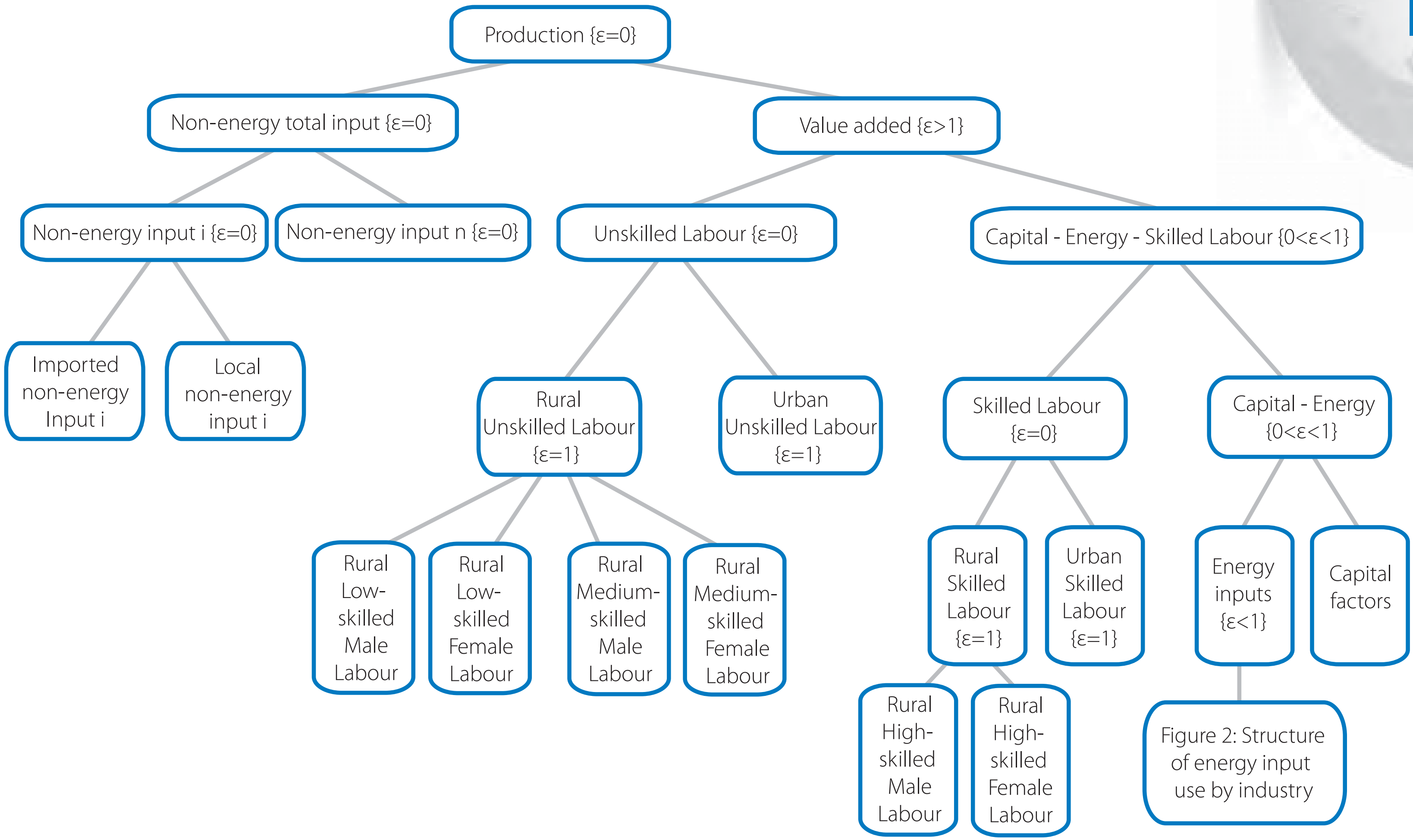
Energy inputs are divided into four types which are imperfect substitutes of each other (Figure 2). Composite fuels and electricity are combined in a CES function with a relatively high elasticity of substitution. The former is defined as a CES-aggregate of coal and oil fuels with a relatively high elasticity of substitution between them. Finally, crude oil and refined oil products are assumed to be complements in the oil bundle. The demand for each energy commodity is shared between imports and domestically produced goods depending on their relative price and the degree of substitutability between them.

b) The goods and services consumed by households are grouped by purpose (food, personal care, housing, etc.). A single commodity category (e.g. petroleum product) enters into one or several groups of consumption by purpose (e.g. household fuel and transport). Representative urban and rural households maximise unitary utility functions over the group of consumption by purpose, subject to the constraint of their revenue. Thus, households' expenditure on commodities combine a Linear Expenditure System (LES) function over various groups of consumption by purpose, and a Cobb-Douglas (CD) function over commodity categories for each group of consumption by purpose.

c) To implement oil price support policy, the government guarantees a selling price to oil consumers. In a market-clearing situation, there is zero excess supply so that the equilibrium price adjusts supply and demand. Therefore, the government provides a price policy support to oil consumers but it is still willing to let the market adjust to the market-clearing price. In that case, the price paid to oil consumers may be exogenous whereas the level of subsidies paid to them is endogenously determined, depending on the fluctuation of the international oil prices[10]. The government will then have to arrange some method of financing the implied extra-expenses in the short to medium term.

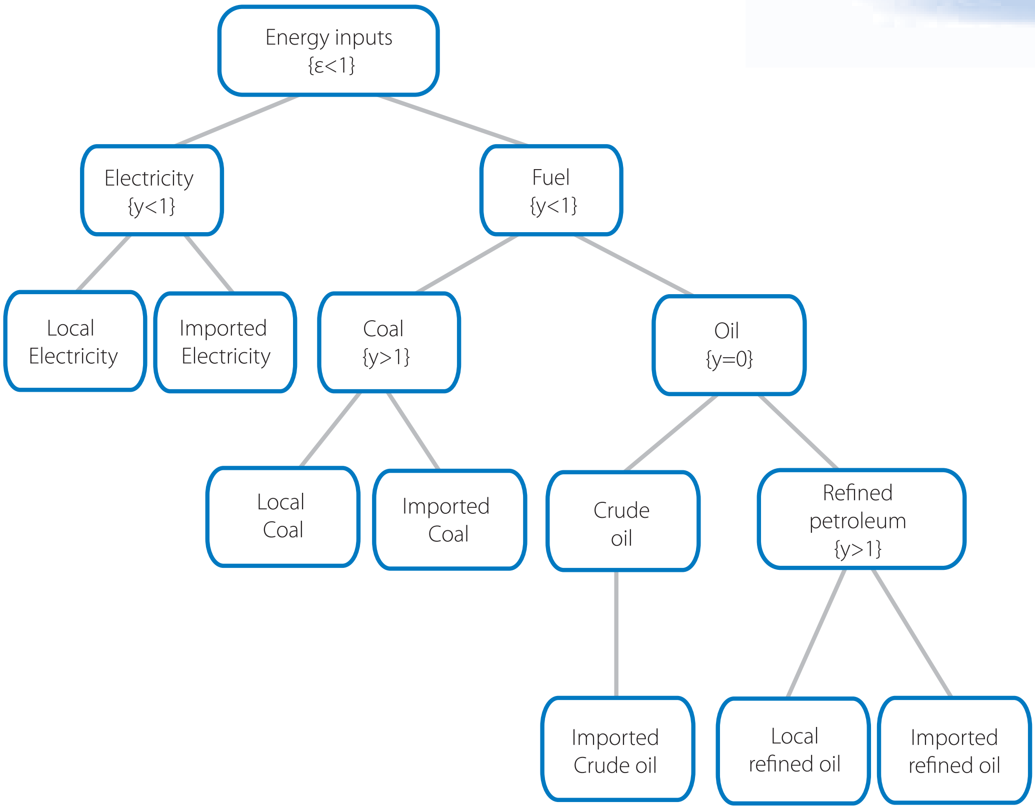
10. Alternatively, the level of the subsidy can be made exogenous and the consumer price then becomes endogenous. In that case, the government supports the difference between the market clearing price and the selling price through a subsidy scheme.

Figure 1: Structure of production by industry



Source: Authors

Figure 2: Structure of energy input use by industry



Source: Authors

The Model Equations

The model is presented in three major blocks of equations: *supply block* (production and trade), *demand block* (income, savings and demand), and *macro-economic block* (macro-economic constraints and price setting rules). The full definition of parameters, variables, and sets are provided in annexes 1 to 5.

a. Supply block

- Production

A constant return to scale production technology is assumed, and presented in seven-level nested CES functions[11]. At the first level, industry *j* output (*XS*) is a fixed proportional relationship between Value Added (*VA*) and composite intermediate consumption (*CI*), where *alpha1* and *rho1* represent the fixed input-output coefficients (01 and 02).

$$\langle 01 \rangle \quad \mathrm{VA(J)} = \mathrm{alpha1(J)} \times \mathrm{XS(J)}$$
$$\langle 02 \rangle \quad \mathrm{CI(J)} = \mathrm{rho1(J)} \times \mathrm{XS(J)}$$

11. Leontief and Cobb-Douglas functional forms are two specific cases of CES function implying zero and unitary (one) elasticity of substitution, respectively.

Intermediate demand (*DI*) for non energy commodity *i* by industry *j* is also derived from the Leontief input-output function, with *beta2* being the fixed input-output coefficients (03). A CES function is used to represent the substitution between industry composite unskilled labour (*LNQ*) and the bundle of capital, energy, and skilled labour (*KEL*) in the value added function (*VA*) (04); A, ρ, and σ represent scale, share, and elasticity parameters, respectively, in all equations. Assuming all firms in the sector strive to maximise profits and face perfect competition in both input and output markets, the conditional relative demand derived from the first order conditions is given by equation (05) where *Pkel* and *Wlnq* are the average prices of *KEL* and *LNQ*, respectively.

$$\langle 03 \rangle \quad \mathrm{DI(I,J) = beta2(I,J) \times CI(J)}$$

$$\langle 04 \rangle \quad \mathrm{VA(J)} = \mathrm{A2(J)} \times \left(\mathrm{alpha2(J)} \times \mathrm{LNQ(J)}^{\text{-rho2(J)}} + \left(1\text{-alpha2(J)}\right) \times \mathrm{KEL(J)}^{\text{-rho2(J)}} \right)^{\frac{-1}{\text{rho2(J)}}}$$

$$\langle 05 \rangle \quad \frac{\mathrm{LNQ(J)}}{\mathrm{KEL(J)}} = \left(\frac{\mathrm{alpha2(J)}}{\left(1\text{-alpha2(J)}\right)} \right)^{\text{sigma2(J)}} \times \left(\frac{\mathrm{Pkel(J)}}{\mathrm{Wlnq(J)}} \right)^{\text{sigma2(J)}}$$

In industries where skilled labour (*LQ*) is initially positive, the bundle of capital, energy, and skilled labour (*KEL*) is also a CES function of skilled labour (*LQ*) and composite capital-energy good (*KE*) (06); and yields the conditional relative demand in equation 07 with *Pke* and *Wlq* being the average prices of *LQ* and *KE*, respectively. In industries where LQ is initially nil, the bundle of capital, energy, and skilled labour (*KEL*) is solely equal to composite capital-energy good (*KE*) (08). Unskilled labour composite is a fixed proportional relationship (Leontief) between urban and rural labour categories (*LNQ*) (09 and 10).

$$\langle 06 \rangle \quad \mathrm{KEL(J)} = \mathrm{A3(J)} \times \left(\mathrm{alpha3(J)} \times \mathrm{LQ(J)}^{\text{-rho3(J)}} + \left(1\text{-alpha3(J)}\right) \times \mathrm{KE(J)}^{\text{-rho3(J)}} \right)^{\frac{-1}{\text{rho3(J)}}}$$

$$\langle 07 \rangle \quad \frac{\mathrm{LQ(J)}}{\mathrm{KE(J)}} = \left(\frac{\mathrm{alpha3(J)}}{\left(1\text{-alpha3(J)}\right)} \right)^{\text{sigma3(J)}} \times \left(\frac{\mathrm{Pke(J)}}{\mathrm{Wlq(J)}} \right)^{\text{sigma3(J)}}$$

$$\langle 08 \rangle \quad \mathrm{KEL(J) = KE(J)}$$

$$\langle 09 \rangle \quad \mathrm{LNQ\_URB(J) = beta3(J) \times LNQ(J)}$$

$$\langle 10 \rangle \quad \mathrm{LNQ\_RUR(J)} = \left(1\text{-beta3(J)}\right) \times \mathrm{LNQ(J)}$$

A CES function aggregates an energy bundle (*ENE*) and composite capital (*KAD*) in the capital-energy composite good (*KE*) (11). The conditional relative demand derived from the first order conditions is given by equation 12; *Pene* and *r* are the average price of energy bundle (*ENE*) and the industry-specific return to capital (*KAD*). The conditional demands for low- and medium- skilled male and female workers that maximise the profit of the firm are derived from a Cobb-Douglas function. The wage paid to any labour category is a fixed share (*beta4*) of the total wage bill paid to unskilled workers in both urban and rural areas (13 and 14).

$$\langle 11 \rangle \quad \mathrm{KE(J)} = \mathrm{A4(J)} \times \left(\mathrm{alpha4(J)} \times \mathrm{ENE(J)}^{\text{-rho4(J)}} + \left(1\text{-alpha4(J)}\right) \times \mathrm{KAD(J)}^{\text{-rho4(J)}} \right)^{\frac{-1}{\text{rho4(J)}}}$$

$$\langle 12 \rangle \quad \frac{\mathrm{ENE(J)}}{\mathrm{KAD(J)}} = \left(\frac{\mathrm{alpha4(J)}}{\left(1\text{-alpha4(J)}\right)} \right)^{\text{sigma4(J)}} \times \left(\frac{\mathrm{r(J)}}{\mathrm{Pene(J)}} \right)^{\text{sigma4(J)}}$$

$$\langle 13 \rangle \quad \mathrm{LLD(LLU,J) \times wnq(LLU,J) = beta4\_urb(LLU,J)} \times \left(\mathrm{Wlnq\_urb(J) \times LNQ\_URB(J)} \right)$$

$$\langle 14 \rangle \quad \mathrm{LLD(LLR,J) \times wnq(LLR,J) = beta4\_rur(LLR,J)} \times \left(\mathrm{Wlnq\_rur(J) \times LNQ\_RUR(J)} \right)$$

Skilled labour composite is a fixed proportional relationship (Leontief) between urban and rural labour categories (*LQ*) (15 and 16). In electricity-input using industries, electricity (*ELEC*) and fuels energy (*FUEL*) imperfectly substitute in the energy bundle (*ENE*) (17). The conditional relative demand, with *Pfuel* being the average price of fuel and *PC("electricity")* the relative price of electricity, is given by equation 18. In non electricity-input using industries, the energy bundle (*ENE*) is solely equal to the fuels energy (*FUEL*) (19).

$$\langle 15\rangle \quad \text{LQ\_URB(J)} = \text{beta4(J)} \times \text{LQ(J)}$$

$$\langle 16\rangle \quad \text{LQ\_RUR(J)} = \left(\text{1-beta4(J)}\right) \times \text{LQ(J)}$$

$$\langle 17\rangle \quad \text{ENE(J)} = \text{A5(J)} \times \left(\text{alpha5(J)} \times \text{ELEC(J)}^{\text{-rho5(J)}} + \left(\text{1-alpha5(J)}\right) \times \text{FUEL(J)}^{\text{-rho5(J)}}\right)^{\frac{-1}{\text{rho5(J)}}}$$

$$\langle 18\rangle \quad \frac{\text{ELEC(J)}}{\text{FUEL(J)}} = \left(\frac{\text{alpha5(J)}}{\left(\text{1-alpha5(J)}\right)}\right)^{\text{sigma5(J)}} \times \left(\frac{\text{Pfuel(J)}}{\text{PC("electricity")}}\right)^{\text{sigma5(J)}}$$

$$\langle 19\rangle \quad \text{ENE(J)} = \text{FUEL(J)}$$

The conditional demands for high-skilled male and female workers are derived from a Cobb-Douglas function (20 and 21). The wage paid to a skilled male or female worker is a fixed share (*beta5*) of the total wage bill paid to skilled workers in both urban and rural areas. The capital used in industry *j* is a linear aggregation of capital from various sources, i.e. firms, government, urban households, and rural households (22). In coal-input using industries, coal and oil imperfectly substitute in the fuel energy (23). The conditional relative demand, with *Poil* being the average price of oil and *PC("coal")* the relative price of coal, is given by equation 24. In non coal-input using industries, the fuel energy is solely equal to oil energy (25).

$$\langle 20\rangle \quad \text{LHD(LHU,J)} \times \text{wq(LHU,J)} = \text{beta5\_urb(LHU,J)} \times \left(\text{Wlq\_urb(J)} \times \text{LQ\_URB(J)}\right)$$

$$\langle 21\rangle \quad \text{LHD(LHR,J)} \times \text{wq(LHR,J)} = \text{beta5\_rur(LHR,J)} \times \left(\text{Wlq\_rur(J)} \times \text{LQ\_RUR(J)}\right)$$

$$\langle 22\rangle \quad \text{KAD(J)} = \text{SUM}\left(\text{K,KD(K,J)}\right)$$

$$\langle 23\rangle \quad \text{FUEL(J)} = \text{A6(J)} \times \left(\text{alpha6(J)} \times \text{COAL(J)}^{\text{-rho6(J)}} + \left(\text{1-alpha6(J)}\right) \times \text{OIL(J)}^{\text{-rho6(J)}}\right)^{\frac{-1}{\text{rho6(J)}}}$$

$$\langle 24\rangle \quad \frac{\text{COAL(J)}}{\text{OIL(J)}} = \left(\frac{\text{alpha6(J)}}{\left(\text{1-alpha6(J)}\right)}\right)^{\text{sigma6(J)}} \times \left(\frac{\text{Poil(J)}}{\text{PC("coal")}}\right)^{\text{sigma6(J)}}$$

$$\langle 25\rangle \quad \text{FUEL(J)} = \text{OIL(J)}$$

Composite oil energy input in industry *j* is a fixed proportional relationship between crude oil (CRU) and refined oil (REF), where *alpha7* and *rho7* represent the fixed input-output coefficients (26 and 27).

$$\langle 26\rangle \quad \text{CRU(J)} = \text{alpha7(J)} \times \text{OIL(J)}$$

$$\langle 27\rangle \quad \text{REF(J)} = \text{rho7(J)} \times \text{OIL(J)}$$

- Trade

There is a separation between production activities *j* and commodities *i*; a matrix of activity-commodity (*DS*) allocates the industries' production (*XS*) to commodities in a fixed proportion *rho_ds* (28). The supply for any commodity (*DD*) is a linear relationship among various production sources (29). This specification permits any activity to produce one or multiple commodities and any commodity to be produced by one or multiple activities.

$$\langle 28 \rangle \quad \text{DS(J,I)} = \text{rho\_ds(J,I)} \times \text{XS(J)}$$

$$\langle 29 \rangle \quad \text{DD(I)} = \text{SUM}\left[\text{J,DS(J,I)}\right]$$

The model allows for imperfect substitution in consumption and production between domestic and foreign goods. In exportable sectors, locally produced goods (*DD*) are allocated between the export (*EXS*) and the local (*D*) markets according to a constant elasticity of transformation (CET) function (30). Export supply is derived from profit maximization subject to the CET function, where σ is the CET elasticity of transformation, *PE* and *PD* are the prices for export and local sales, respectively (31). For non-exportable commodities, all domestic supply is sold on the local market (32).

$$\langle 30 \rangle \quad \text{DD(I)} = \text{B\_E(I)} \times \left(\text{beta\_e(I)} \times \text{EXS(I)}^{\text{kappa\_e(I)}} + \left(\text{1-beta\_e(I)}\right) \times \text{D(I)}^{\text{kappa\_e(I)}}\right)^{\frac{1}{\text{kappa\_e(I)}}}$$

$$\langle 31 \rangle \quad \frac{\text{EXS(I)}}{\text{D(I)}} = \left(\frac{\text{beta\_e(I)}}{\left(\text{1-beta\_e(I)}\right)}\right)^{\text{tau\_e(I)}} \times \left(\frac{\text{PE(I)}}{\text{PD(I)}}\right)^{\text{tau\_e(I)}}$$

$$\langle 32 \rangle \quad \text{DD(I)} = \text{D(I)}$$

For import-competitive commodities, locally produced commodities *D* and imports (*IM*) are assumed to be imperfect substitutes in total supply (*Q*) to the domestic market following the Armington assumption specified by a CES function (33). The demand for imports relative to locally produced goods is derived from cost minimization subject to the CES function; where *sigma_m* is the Armington elasticity, and *pm* and *pd* the import and domestic good prices (34). For non-importable sectors, only domestic goods are consumed (35).

$$\langle 33 \rangle \quad \text{Q(I)} = \text{A\_M(I)} \times \left(\text{alpha\_m(I)} \times \text{IM(I)}^{\text{-rho\_m(I)}} + \left(\text{1-alpha\_m(I)}\right) \times \text{D(I)}^{\text{-rho\_m(I)}}\right)^{\frac{-1}{\text{rho\_m(I)}}}$$

$$\langle 34 \rangle \quad \frac{\text{IM(I)}}{\text{D(I)}} = \left(\frac{\text{alpha\_m(I)}}{\left(\text{1-alpha\_m(I)}\right)}\right)^{\text{sigma\_m(I)}} \times \left(\frac{\text{PD(I)}}{\text{PM(I)}}\right)^{\text{sigma\_m(I)}}$$

$$\langle 35 \rangle \quad \text{Q(I)} = \text{D(I)}$$

b. Demand block

- Incomes and savings

Households' gross income (*Y*) adds up the skilled (*LH*) wage earnings, the unskilled (*LL*) wage earnings, the capital (*K*) revenues, and the indexed transfer (*TR*) incomes (36). Households receive fixed shares *lambda_wq*, *lambda_wnq*, and *lambda_r* of the total income paid to each category of skilled and unskilled workers, and capital factors. Disposable income (*YD*) is equal to their gross income net of an income tax at rate *ty* and indexed household transfer out (*OUTRF*) (37). Households' saving (*S*) is a fixed proportion of its disposable income (38); mps represents its marginal propensity to save.

$$\langle 36\rangle\ Y(H) = SUM\left[LH, lambda\_wq(H,LH) \times SUM\left(J, Wq(LH,J) \times LHD(LH,J)\right)\right]$$
$$+SUM\left[LL, lambda\_wnq(H,LL) \times SUM\left(J, Wnq(LL,J) \times LLD(LL,J)\right)\right]$$
$$+SUM\left[K, lambda\_r(H,K) \times SUM\left(J, r(J) \times KD(K,J)\right)\right]$$
$$+SUM\left[TR, Pindex \times INTRF(H,TR)\right]$$
$$\langle 37\rangle\ YD(H) = \left(1\text{-}ty(H)\right) \times Y(H)\text{-}SUM\left(TR, Pindex \times OUTRF(H,TR)\right)$$
$$\langle 38\rangle\ S(H) = mps(H) \times YD(H)$$

Firms' income (*Y(FRM)*) is equal to the sum of their share *lambda_r* in capital (*KD*) incomes plus the sum of their in-transfers (*INTRF*) (39). After *firms* pay income tax at rate *ty* to government and make out-transfers (*OUTRF*) to other agents that are fixed in real terms, their remaining income constitutes their savings (*S(FRM)*) (40).

$$\langle 39\rangle\ Y(FRM) = SUM\left[K, lambda\_r(FRM,K) \times SUM\left(J, r(J) \times KD(K,J)\right)\right]$$
$$+SUM\left[TR, Pindex \times INTRF(FRM,TR)\right]$$
$$\langle 40\rangle\ S(FRM) = \left[1\text{-}ty(FRM)\right] \times Y(FRM)\text{-}SUM\left[TR, Pindex \times OUTRF(FRM,TR)\right]$$

Government revenue is composed of direct taxes on household income and firm earnings, of export taxes and import tariff receipts, of indirect taxes on imported and locally produced products, indirect taxes on production, of share *lambda_r* of capital earnings, and indexed transfer receipts, i.e. including dividends, concessionary sales, foreign aid, etc. (41). Government saving (*S(GOV)*) is equal to government income less its consumption and its indexed transfer payments. Note that government spending is exogenous in real terms, although nominal expenditures are endogenous as a result of price changes (42).

$$\langle 41\rangle\ Y(GOV) = SUM\left(H, ty(H) \times Y(H)\right)$$
$$+SUM\left(FRM, ty(FRM) \times Y(FRM)\right)$$
$$+SUM\left(I, te(I) \times PE(I) \times EXS(I)\right)$$
$$+SUM\left(I, tm(I) \times PWM(I) \times e \times IM(I)\right)$$
$$+SUM\left(I, tx(I) \times (1+mrg(I) \times cmrg(I)) \times PM(I) \times IM(I)\right)$$
$$+SUM\left(I, tx(I) \times (1+mrg(I) \times cmrg(I) \times PD(I) \times D(I)\right)$$
$$+SUM\left(J, tp(J) \times P(J) \times XS(J)\right)$$
$$+SUM\left[K, lambda\_r(GOV,K) \times SUM\left(J, r(J) \times KD(K,J)\right)\right]$$
$$+SUM\left(TR, Pindex \times INTRF(GOV,TR)\right)$$
$$\langle 42\rangle\ S(GOV) = Y(GOV)\text{-}SUM\left(I, PC(I) \times CG(I)\right)\ \text{- } SUM\left(TR, Pindex \times OUTRF(GOV,TR)\right)$$

- Demand

Household consumption is a nested LES functions. First, consumption by purpose (*Z*) is modelled by a LES and subject to its budget constraint. Consequently, the total consumption by purpose (*CH*) specifies an (exogenous) minimum consumption level (*C_MIN*) and a vector of household-specific consumer prices (*PCH*) (43). Consumption by purpose is a CD aggregation of individual product (*C*) consumed by households (44). Total intermediate demand (*DIT*) is equal to the sum of sectoral demands (*DI*) (45). Investment expenses by product (*INV*) is a fixed share, *mu,* of total investment (*IT*) (46). Export supply is constrained by export demand, which is assumed to have a finite elasticity reflecting the competitiveness of local products on the international market. Consequently, export demand (*EXD*) depends on the initial export demand (*EXDO*), world prices for the exports in question (*PWE*), the domestic border price of South African exports (*PFOB*), and the export demand elasticity *sigma_x* (47).

$$\langle 43 \rangle \ \text{CH(H,Z)} = \text{C\_MIN(H,Z)+gamma\_ch(H,Z)} \times \frac{\left[\text{1-mps(H)}\right] \times \text{YD(H) - SUM}\left[\text{ZZ,C\_MIN(H,ZZ)} \times \text{PCH(H,ZZ)}\right]}{\text{PCH(H,Z)}}$$

$$\langle 44 \rangle \ \text{C(H,Z,I)} = \text{gamma\_h(H,Z,I)} \times \frac{\text{CH(H,Z)} \times \text{PCH(H,Z)}}{\text{PC(I)}}$$

$$\langle 45 \rangle \ \text{DIT(I)} = \text{SUM}\left[\text{J,DI(I,J)}\right]$$

$$\langle 46 \rangle \ \text{INV(I)} = \frac{\text{mu(I)} \times \text{IT}}{\text{PC(I)}}$$

$$\langle 47 \rangle \ \frac{\text{EXD(I)}}{\text{EXDO(I)}} = \left[\frac{\text{PWE(I)}}{\text{PFOB(I)}}\right]^{\text{sigma\_x(I)}}$$

c. Equilibrium block

- Basic prices

Export demand (*EXD*) and supply (*EXS*) balance through adjustments in the export free on board (f.o.b.) prices (48). The foreign exchange market balances via adjustments in the real exchange rate. The current account balance (*CAB*) is exogenous and set equal to its base year level. Hence, with fixed foreign capital transfers in (*INTRF*) and out (*OUTRF*), higher imports (*IM*) of some good will require higher exports (*EXS*) and/or lower imports of other goods in order to keep the current account balanced. Pressures to change export or import quantities - demand and supply of foreign currency - are accommodated by adjustments in the real exchange rate (49).

$$\langle 48 \rangle \ \text{EXS(I)} = \text{EXD(I)}$$

$$\begin{aligned} \langle 49 \rangle \ \text{CAB} = {} & \text{SUM}\left[\text{I,PWM(I)} \times \text{e} \times \text{IM(I)}\right] \text{ - SUM}\left[\text{I,PFOB(I)} \times \text{e} \times \text{EXS(I)}\right] \\ & \text{+SUM}\left[\text{TR,Pindex} \times \text{INTRF(ROW,TR)}\right] \text{ - SUM}\left[\text{TR,Pindex} \times \text{OUTRF(ROW,TR)}\right] \end{aligned}$$

Skilled labour is assumed to be fully employed in the economy although fixed low rates of frictional unemployment (*UQ*) are observed for this category (*LH*) (50). Thus, skilled labour market is assumed to be perfectly competitive; the prevailing **skilled wage rates** (*wq*), paid by all private sectors are those equalizing exogenous supplies *LHS* and endogenous demands (*LHD*) (51). Wage rates in general government are fixed in real terms, i.e. maintained at their initial levels (*wqo*) and indexed to the economy wide average price (*Pindex*) (52).

$$\langle 50 \rangle \ \text{UQ(LH)} = 1 - \frac{\text{SUM}\left[\text{J,LHD(LH,J)}\right]}{\text{SUM}\left[\text{H,LHS(H,LH)}\right]}$$

$$\langle 51 \rangle \ \text{wq(LH,J)} = \text{wqu(LH)}$$

$$\langle 52 \rangle \ \text{wq(LH,J)} = \text{wqo(LH,J)} \times \text{Pindex}$$

There is imperfect competition in the unskilled labour markets where the total demand (*LLD*) does not equal the total supply (*LLS*); thus, there is an excess supply of labour (*UNQ*) which remains unemployed (53). The **unskilled wage rates** (*wnq*) are fixed in real terms, i.e. maintained at their initial levels in private (54) and public (55) sectors and indexed to *Pindex*.

$$\langle 53\rangle \ \mathrm{UNQ(LL)} = 1-\frac{\mathrm{SUM}\left[\mathrm{J,LLD(LL,J)}\right]}{\mathrm{SUM}\left[\mathrm{H,LLS(H,LL)}\right]}$$

$$\langle 54\rangle \ \mathrm{wnq(LL,J)} = \mathrm{wnqu(LL)} \times \mathrm{Pindex}$$

$$\langle 55\rangle \ \mathrm{wnq(LL,J)} = \mathrm{wnqo(LL,J)} \times \mathrm{Pindex}$$

All **commodity markets** follow the neoclassical market-clearing price system in which simultaneously determined producer and consumer prices vary only by given tax/subsidy and margins rates. Each market is cleared when supply (*Q*) equals demand - final household consumption (*C*), final government consumption (*CG*), intermediate demand (*DIT*), demand for fixed capital formation (*INV*) and change in stock (*STK*) (56), and demand for energy-specific products, i.e. *COAL*, *CRU*, *REF*, and *ELECT* (57 to 60).

$$\langle 56\rangle \ \mathrm{Q(I)} = \mathrm{SUM}\left[\mathrm{(H,Z),C(H,Z,I)}\right]\mathrm{+CG(I)+DIT(I)+INV(I)+STK(I)}$$

$$\langle 57\rangle \ \mathrm{Q(\text{"Coal"})} = \mathrm{SUM}\left[\mathrm{(H,Z),C(H,Z,\text{"Coal"})}\right]\mathrm{+CG(\text{"Coal"})+DIT(\text{"Coal"})+SUM(J,COAL(J))+INV(\text{"Coal"})+STK(\text{"Coal"})}$$

$$\langle 58\rangle \ \mathrm{Q(\text{"Crude"})} = \mathrm{SUM}\left[\mathrm{(H,Z),C(H,Z,\text{"Crude"})}\right]\mathrm{+CG(\text{"Crude"})+DIT(\text{"Crude"})+SUM(J,CRU(J))+INV(\text{"Crude"})+STK(\text{"Crude"})}$$

$$\langle 59\rangle \ \mathrm{Q(\text{"Fuel"})} = \mathrm{SUM}\left[\mathrm{(H,Z),C(H,Z,\text{"Fuel"})}\right]\mathrm{+CG(\text{"Fuel"})+DIT(\text{"Fuel"})+SUM(J,REF(J))+INV(\text{"Fuel"})+STK(\text{"Fuel"})}$$

$$\langle 60\rangle \ \mathrm{Q(\text{"Electricity"})} = \mathrm{SUM}\left[\mathrm{(H,Z),C(H,Z,\text{"Electricity"})}\right]\mathrm{+CG(\text{"Electricity"})+DIT(\text{"Electricity"})+SUM(J,ELECT(J))+INV(\text{"Electricity"})+STK(\text{"Electricity"})}$$

- Transaction costs

Import prices (*PM*) are equal to world prices converted into domestic prices by the exchange rate (*e*) and adjusted for import taxes (*tm*) (61). **Export prices** (*PE*) are equal to the border world prices for exports (*PFOB*) converted into domestic prices by the exchange rate (*e*) and tax on exports (*te*) where these apply (62).

$$\langle 61\rangle \ \mathrm{PM(I)} = \mathrm{PWM(I)} \times \mathrm{e} \times \left[\mathrm{1+tm(I)}\right]$$

$$\langle 62\rangle \ \mathrm{PE(I)} = \frac{\mathrm{PFOB(I)} \times \mathrm{e}}{\left[\mathrm{1+te(I)}\right]}$$

We explicitly model **trade and transportation margins** for commodities that enter the market sphere. Constant trade and transportation margins coefficients (*mrg)* are added to the price of all locally produced and imported commodities sold on the domestic market (63). As the margins coefficients are negative for the trade and transport (*tt*) and positive for other sectors (*ntt*), the generated revenues constitute a demand for the trade and the transport sector. An endogenous margin rates (*cmrg*) balances the demand from other industries (ntt) and the supply of trade and transport (64). The change in the revenue from the trade and transport margins is proportionally distributed to the trade and to the transport sector using a uniform parameter *umrg.*

$$\langle 63\rangle \ \mathrm{SUM}\left[\mathrm{tt,cmrg(tt)}\times\mathrm{mrg(tt)}\times\left(\mathrm{PD(tt)}\times\mathrm{D(tt)}+\mathrm{PM(tt)}\times\mathrm{IM(tt)}\right)\right]=\mathrm{SUM}\left[\mathrm{ntt,cmrg(ntt)}\times\mathrm{mrg(ntt)}\times\left(\mathrm{PD(ntt)}\times\mathrm{D(ntt)}+\mathrm{PM(ntt)}\times\mathrm{IM(ntt)}\right)\right]$$

$$\langle 64\rangle \ \mathrm{cmrg(tt)}=\mathrm{umrg}$$

The **purchasing price** (*PC*) is defined as the weighted average of domestic and import prices, the weights being the share of domestic and imported volumes in the composite commodity, adjusted by trade and transportation margins and sales taxes at rates *mrg* and *tx* (65). The **local price** (*PI*) is equal to a weighted average of domestic price (*PD*) and export price (*PE*); the weights are equal to the respective volume shares of local and export sales in total supply (66). The average **producer price** (*P*) is equal to a weighted average of local prices of produced commodities; the weights are equal to the respective shares of commodity in total production (67). The **value-added price** (*PV*) is the ratio of total output (*XS*) valued at factor costs less intermediate input (*DI*) costs, to the volume of value added (*VA*) in the industry; the output at factor cost being equal to its value at basic cost (*P*) net of production tax at rate *tp* (68).

$$\langle 65\rangle \ \mathrm{PC(I)}=\frac{\left[1+\mathrm{tx(I)}\right]\times\left[1+\mathrm{mrg(I)}\times\mathrm{cmrg(I)}\right]\times\left[\mathrm{PD(I)}\times\mathrm{D(I)}+\mathrm{PM(I)}\times\mathrm{IM(I)}\right]}{\mathrm{Q(I)}}$$

$$\langle 66\rangle \ \mathrm{PL(I)}=\frac{\left[\mathrm{PD(I)}\times\mathrm{D(I)}+\mathrm{PE(I)}\times\mathrm{EXS(I)}\right]}{\mathrm{DD(I)}}$$

$$\langle 67\rangle \ \mathrm{P(J)}=\frac{\mathrm{SUM}\left[\mathrm{I,\ PL(I)}\times\mathrm{DS(J,I)}\right]}{\mathrm{XS(J)}}$$

$$\langle 68\rangle \ \mathrm{PV(J)}=\frac{\left[\mathrm{P(J)}\times\left[1\text{-}\mathrm{tp(J)}\right]\times\mathrm{XS(J)}\ \text{-}\ \mathrm{SUM}\left[\mathrm{I,DI(I,J)}\times\mathrm{PC(I)}\right]\right]}{\mathrm{VA(J)}}$$

- Factor prices

The cost of composite **unskilled labour** in urban (*Wlnq_urb*) and rural (*Wlnq_rur*) areas is an average weighted cost of unskilled labour (LLD) (69 and 70). The cost of composite unskilled labour (*Wlnq*) is an average weighted cost of unskilled urban (*LNQ_URB*) and rural (*LNQ_RUR*) labour (71). The cost of composite **skilled labour** in urban (*Wlq_urb*) and rural (*Wlq_rur*) areas is an average weighted cost of skilled labour (*LHD*) (72 and 73). The cost of composite skilled labour (*Wlq*) is an average weighted cost of skilled urban (*LQ_URB*) and rural (*LQ_RUR*) labour (74).

$$\langle 69\rangle \ \mathrm{Wlnq\_urb(J)}=\frac{\mathrm{SUM}\left[\mathrm{LLU,\ Wnq(LLU,J)}\times\mathrm{LLD(LLU,J)}\right]}{\mathrm{SUM}\left[\mathrm{LLU,\ LLD(LLU,J)}\right]}$$

$$\langle 70\rangle \ \mathrm{Wlnq\_rur(J)}=\frac{\mathrm{SUM}\left[\mathrm{LLR,Wnq(LLR,J)}\times\mathrm{LLD(LLR,J)}\right]}{\mathrm{SUM}\left[\mathrm{LLR,\ LLD(LLR,J)}\right]}$$

$$\langle 71\rangle \ \mathrm{Wlnq(J)}=\frac{\mathrm{Wlnq\_urb(J)}\times\mathrm{LNQ\_URB(J)}+\mathrm{Wlnq\_rur(J)}\times\mathrm{LNQ\_RUR(J)}}{\mathrm{LNQ(J)}}$$

$$\langle 72\rangle \ \mathrm{Wlq\_urb(J)}=\frac{\mathrm{SUM}\left[\mathrm{LHU,\ Wq(LHU,J)}\times\mathrm{LHD(LHU,J)}\right]}{\mathrm{SUM}\left[\mathrm{LHU,\ LHD(LHU,J)}\right]}$$

$$\langle 73\rangle \ \mathrm{Wlq\_rur(J)}=\frac{\mathrm{SUM}\left[\mathrm{LHR,Wq(LHR,J)}\times\mathrm{LHD(LHR,J)}\right]}{\mathrm{SUM}\left[\mathrm{LHR,\ LHD(LHR,J)}\right]}$$

$$\langle 74\rangle \ \mathrm{Wlq(J)}=\frac{\mathrm{Wlq\_urb(J)}\times\mathrm{LQ\_URB(J)}+\mathrm{Wlq\_rur(J)}\times\mathrm{LQ\_RUR(J)}}{\mathrm{LQ(J)}}$$

The cost of the bundle of capital, energy and skilled labour (*PKEL*) is the ratio of total value added less the cost of unskilled labour (*LNQ*) to the volume of capital, energy and labour (*KEL*) in the industry (75). The cost of capital-energy composite (*Pke*) is the ratio of the cost of the bundle of capital, energy and skill labour (*KEL*) less the cost of skilled labour (*LQ*) to the volume of capital-energy (*KE*) in the industry (76). The **return to capital** (*r*) is the ratio of the energy-capital (*KE*) cost net of the cost of energy input (*ENE*) to the volume of capital (*KAD*) in the industry (77). The average cost of energy inputs (*Pene*) is the ratio of the cost of electricity (*ELEC*) and fuel energy (*FUEL*) to the volume of input energy (*ENE*) used in the industry (78). The average cost of fuel energy (*Pfuel*) is the ratio of the cost of coal and oil to the volume of fuel input (*FUEL*) (79). The average cost of oil input (*Poil*) is the ratio of the cost of crude (*CRU*) and refined (*REF*) oil to the volume of oil energy (*OIL*) used in the industry (80).

$$\langle 75\rangle\ \mathrm{PKEL(J)} = \frac{\left[\mathrm{VA(J)}\times\mathrm{PV(J)} - \mathrm{Wlnq(J)}\times\mathrm{LNQ(J)}\right]}{\mathrm{KEL(J)}}$$

$$\langle 76\rangle\ \mathrm{Pke(J)} = \frac{\left[\mathrm{PKEL(J)}\times\mathrm{KEL(J)} - \mathrm{Wlq(J)}\times\mathrm{LQ(J)}\right]}{\mathrm{KE(J)}}$$

$$\langle 77\rangle\ \mathrm{Pene(J)} = \frac{\left[\mathrm{PC(\text{"Electricity"})}\times\mathrm{ELEC(J)}+\mathrm{Pfuel(J)}\times\mathrm{FUEL(J)}\right]}{\mathrm{ENE(J)}}$$

$$\langle 78\rangle\ \mathrm{r(J)} = \frac{\left[\mathrm{Pke(J)}\times\mathrm{KE(J)} - \mathrm{Pene(J)}\times\mathrm{ENE(J)}\right]}{\mathrm{KAD(J)}}$$

$$\langle 79\rangle\ \mathrm{Pfuel(J)} = \frac{\left[\mathrm{PC(\text{"Coal"})}\times\mathrm{COAL(J)}+\mathrm{Poil(J)}\times\mathrm{OIL(J)}\right]}{\mathrm{FUEL(J)}}$$

$$\langle 80\rangle\ \mathrm{Poil(J)} = \frac{\left[\mathrm{PC(\text{"Crude"})}\times\mathrm{CRU(J)}+\mathrm{PC(\text{"Fuel"})}\times\mathrm{REF(J)}\right]}{\mathrm{OIL(J)}}$$

- Aggregate prices

The household-specific consumer prices (*PCH*) is an average weighted price of individual consumption (81). The value added price index (*Pindex*) is the weighted average of domestic value added prices, where the weights are given by the share *delta* of each sector in the total volume of value added (82). The investment cost (*Pinv*) is a dual price of a Cobb-Douglas investment function defined over commodities *i*; where *mu* is the share of commodities *i* in total investment by product (83).

$$\langle 81\rangle\ \mathrm{PCH(H,Z)} = \frac{\mathrm{SUM}\left[\mathrm{I},\ \mathrm{PC(I)}\times\mathrm{C(H,Z,I)}\right]}{\mathrm{SUM}\left[\mathrm{I},\ \mathrm{C(H,Z,I)}\right]}$$

$$\langle 82\rangle\ \mathrm{Pindex} = \mathrm{SUM}\left[\mathrm{J},\ \mathrm{PV(J)}\times\mathrm{delta(J)}\right]$$

$$\langle 83\rangle\ \mathrm{PINV} = \mathrm{SUM}\left[\mathrm{I},\ \mathrm{PC(I)}\times\mathrm{mu(I)}\right]$$

- Saving-Investment equilibrium

Total investment, i.e. the fixed capital formation (*IT*) and the changes in stocks (*STK*), is equal to the savings (*S*) of domestic institutional - household, firm, and government – plus the foreign saving (*CAB*) converted to the local currency by the exchange rate (*e*) (84). Total investment in value (*IT*) is converted in volume (*ITVOL*) using an aggregate investment price (*PINV*) (85).

$$\langle 84\rangle \; \text{IT+SUM}\left[\text{I, STK(I)} \times \text{PC(I)}\right] = \text{SUM}\left[\text{DINS, S(DINS)}\right] + \text{CAB}$$

$$\langle 85\rangle \; \text{ITVOL} = \frac{\text{IT}}{\text{PINV}}$$

- Exogenous variables

International imports (*PWM*) and exports (*PWE*) prices are rigid - small country hypothesis (86 and 87). Imports and exports of non traded commodities remain equal to zero (88 and 89).

$$\langle 86\rangle \; \text{PWM.FX(I)} = \text{PWMO(I)}$$

$$\langle 87\rangle \; \text{PWE.FX(I)} = \text{PWEO(I)}$$

$$\langle 88\rangle \; \text{IM.FX(I)\$(IMO(I) eq 0)} = \text{IMO(I)}$$

$$\langle 89\rangle \; \text{EXS.FX(I)\$(EXSO(I) eq 0)} = \text{EXSO(I)}$$

Public expenditure is rigid while government public savings remain endogenous (90). The model is saving driven with endogenous investment – fixed capital formation - volume and exogenous changes in stocks (91). The current account balance is exogenous, the exchange rate insuring its equilibrium (92).

$$\langle 90\rangle \; \text{CG.FX(I)} = \text{CGO(I)}$$

$$\langle 91\rangle \; \text{STK.FX(I)} = \text{STKO(I)}$$

$$\langle 92\rangle \; \text{CAB.FX} = \text{CABO}$$

Labor supply and capital supply are both inelastic (exogenous) (93, 94 and 95). The demand for capital (K) is industry-specific (96). Skilled workers are fully employed with fixed unemployment rates (*uqo*) with flexible wage clearing of the respective labour market segment (97). The wage rates paid to unskilled workers are fixed at the initial value (*wnquo*) while unemployment rates clear the supplies and demands in each segment of the labour market (98).

$$\langle 93\rangle \; \text{LHS.FX(H,LH)} = \text{LHSO(H,LH)}$$

$$\langle 94\rangle \; \text{LLS.FX(H,LL)} = \text{LLSO(H,LL)}$$

$$\langle 95\rangle \; \text{KS.FX(INS,K)} = \text{KSO(INS,K)}$$

$$\langle 96\rangle \; \text{KD.FX(K,J)} = \text{KDO(K,J)}$$

$$\langle 97\rangle \; \text{uq.FX(LH)} = \text{uqo(LH)}$$

$$\langle 98\rangle \; \text{wnqu.FX(LL)} = \text{wnquo(LL)}$$

The transfers in (*INTRF*) and out (OU*TRF*) (99 and 100) are exogenous, fixed at their initial SAM-levels. The aggregate value added - i.e. factor price or GDP deflator – (*Pindex*), is arbitrarily set as "numeraire" (101).

$\langle 99 \rangle$ INTRF.FX(INS,TR) = INTRFO(INS,TR)

$\langle 100 \rangle$ OUTRF.FX(INS,TR) = OUTRFO(INS,TR)

$\langle 101 \rangle$ Pindex.FX = PindexO

Data and Model calibration

The calibration parameters and the model variables use the same symbol with the difference that the former take the letter "O" at the end of the symbol.

∞ *Benchmark*

We import the SAM values using mainly Gams Data Exchange (GDX) facilities. The variable and table names are first defined using the specialised word "*Parameter*". Then, special syntaxes are used to import data from the SAM giving their location[12].

```
"Parameter"

DIO,DSO,TABPRD,TABSUP,TABUSE,TRADELAS,LHDO,LLDO,KDO,LHSO,LLSO,KSO,INTRFO,OUTRFO,OTHE
XP;

$CALL GDXXRW energy_final_sam.xls Par=DIO rng=A2:CR97 Par=DSO rng=A100:CR195 Par=TABPRD
rng=A198:CR199 Par=TABSUP rng=A202:CR206 Par=TABUSE rng=A209:H304 Par=TRADELAS rng=A307:F402

$GDXIN energy_final_sam.gdx
$LOAD DIO DSO TABPRD TABSUP TABUSE TRADELAS

$CALL GDXXRW energy_final_sam.xls Par=LHDO rng=A405:CR409 Par=LLDO rng=A412:CR420 Par=KDO
rng=A423:CR426 Par=LHSO rng=A429:E435 Par=LLSO rng=A438:I444 Par=KSO rng=A447:D453

$GDXIN energy_final_sam.gdx
$LOAD LHDO LLDO KDO LHSO LLSO KSO

$CALL GDXXRW energy_final_sam.xls Par=INTRFO rng=A456:C462 Par=OUTRFO rng=A465:C471 Par=OTHEXP
rng=A474:G476

$GDXIN energy_final_sam.gdx
$LOAD INTRFO OUTRFO OTHEXP
```

We also use a *prn* format to import consumption expenditures data as we could not find an efficient way to import them using GDX format.

```
$include energy_final_sam.prn
```

We import the value for non calibrated parameters. As we did not find an estimate of income elasticity for South Africa, we arbitrarily chose a low income-elasticity (0.5) for *food*, *fuel*, *transport*, and *housing*; a unitary income-elasticity (1.0) for *personal care*, *health*, and *clothing and footwear*, and a high income-elasticity (1.5) for others consumption by purpose, i.e. *Furniture and equipment*, *Computer and telecommunication*, *Education*, *Recreation, entertainment and sport*, and *Miscellaneous expenditure*.

12. See http://www.gams.com/docs/excel for further discussions on GDX facilities for importing and exporting data.

yelas(H,Z)	= 1.5
yelas(H,"Z01")	= 0.5
yelas(H,"Z03")	= 0.5
yelas(H,"Z07")	= 0.5
yelas(H,"Z12")	= 0.5
yelas(H,"Z02")	= 1.0
yelas(H,"Z04")	= 1.0
yelas(H,"Z06")	= 1.0

The estimate of the Frisch parameter for Sub-Saharan Africa and other developing countries provided by *Hertel et al.* (1997) are used for the urban and rural representative household groups.

frisch("urbh")	= -3.34
frisch("rurh")	= -5.85

We use the Armington elasticity for South Africa from *Gibson* (2003) and the low bound elasticity of export supply and demand estimated for South Africa by *Behar and Edwards* (2004)[13].

sigma_m(I)	= TRADELAS(I,"Armington");
sigma_x(I)	= TRADELAS(I,"Expsuplow");
tau_e(I)	= TRADELAS(I,"Expdemlow");

We use high elasticity between unskilled labour and composite of capital-energy-skilled labour, the highest value estimation surveyed by Annabi *et al*. (2006). Low elasticities between skilled labour and the composite of capital-energy are used corresponding to the lowest values estimation surveyed by Annabi *et al*. (2006). Low elasticity between capital and energy, and high elasticity between electricity and fuel energy are used, and high elasticity between coal and oil energy are also used. The (official) unemployment rate among skilled and unskilled workers was informed by the official definition by Statistics South Africa from the Labor Force Survey in September 2001.

sigma2(J)	= 2.5
sigma3(J)	= 0.25
sigma4(J)	= 0.25
sigma5(J)	= 2.5
sigma6(J)	= 2.5
uqo(LH)	= 0.001
unqo(LL)	= 0.264

The initial value of one is assigned to the free prices.

eo	= 1.0
wquo(LH)	= 1.0
wnquo(LL)	= 1.0
PDO(I)	= 1.0
PWMO(I)	= 1.0
PWEO(I)	= 1.0

∞ *Parameters calibration*

13. The high bound elasticity of export supply and demand estimated for South Africa by Behar and Edwards (2004) are also used for a sensitivity analysis.

The parameters DIO(I,J), KDO(K,J), LLDO(LL,J), and LHDO(LH,J) use a direct assignment procedure. Values are assigned to the energy parameters *CRUO*, *REFO*, *COALO*, and *ELECO* and a zero value is assigned to their input-output counterparts. The aggregate energy parameters *OILO, FUELO,* and *ENEO* are calculated. The other production variables are also calculated.

```
CRUO(J)         = DIO("C04",J)
DIO("C04",J)    = 0
REFO(J)         = DIO("C33",J)
DIO("C33",J)    = 0
COALO(J)        = DIO("C02",J)
DIO("C02",J)    = 0
ELECO(J)        = DIO("C82",J)
DIO("C82",J)    = 0
OILO(J)         = CRUO(J)+REFO(J)
FUELO(J)        = COALO(J)+OILO(J)
ENEO(J)         = ELECO(J)+FUELO(J)
KADO(J)         = SUM[K,KDO(K,J)]
KEO(J)          = ENEO(J)+KADO(J)
LQ_URBO(J)      = SUM[LHU,LHDO(LHU,J)]
LQ_RURO(J)      = SUM[LHR,LHDO(LHR,J)]
LQO(J)          = LQ_URBO(J)+LQ_RURO(J)
KELO(J)         = LQO(J)+KEO(J)
LNQ_URBO(J)     = SUM[LLU,LLDO(LLU,J)]
LNQ_RURO(J)     = SUM[LLR,LLDO(LLR,J)]
LNQO(J)         = LNQ_URBO(J)+LNQ_RURO(J)
VAO(J)          = LNQO(J)+KELO(J)
PTAXO(J)        = 0
PTAXO(J)        = TABPRD("ptx",J)
CIO(J)          = SUM[I,DIO(I,J)]
XSO(J)          = VAO(J)+CIO(J)+PTAXO(J)
```

The parameter DSO(J,I) uses a direct assignment; the supply and use table TABSUP and TABUSE are used to assign the value of import and export volumes, as well as the trade tax receipts. The net domestic supply and the total supply (absorption) are then computed.

```
XTAXO(I)        = 0
XTAXO(I)        = TABSUP("xtx",I)
MTAXO(I)        = 0
MTAXO(I)        = TABSUP("mtx",I)
EXSO(I)         = TABUSE(I,"ROW")
IMO(I)          = TABSUP("ROW",I)
DDO(I)          = SUM(J,DSO(J,I))
DO(I)           = DDO(I)-[EXSO(I)-XTAXO(I)]
QO(I)           = DO(I)+IMO(I)+MTAXO(I)
```

The trade and transport margins and the receipt from the taxes and levies on products are imported using the supply table TABSUP. They are used to calibrate the rates of trade and transport margins, the rates of import and export taxes, and the rates of product taxation, and finally the rates of activities taxations.

$$
\begin{array}{ll}
\text{TTM(I)} & = 0 \\
\text{TTM(I)} & = \text{TABSUP("mrg",I)} \\
\text{ITAXO(I)} & = 0 \\
\text{ITAXO(I)} & = \text{TABSUP("stx",I)} \\
\text{mrg(I)} & = \text{TTM(I)}/\left[\text{DO(I)+IMO(I)+MTAXO(I)}\right] \\
\text{tm(I)\$(IMO(I) ne 0)} & = \text{MTAXO(I)}/\text{IMO(I)} \\
\text{te(I)\$(EXSO(I) ne 0)} & = \text{XTAXO(I)}/\left[\text{EXSO(I)-XTAXO(I)}\right] \\
\text{txo(I)} & = \text{ITAXO(I)}/\left[\text{DO(I)+IMO(I)+MTAXO(I)+TTM(I)}\right] \\
\text{tp(J)} & = \text{PTAXO(J)}/\text{XSO(J)}
\end{array}
$$

Products prices are calculated and used in estimating their initial volumes.

$$
\begin{array}{ll}
\text{PFOBO(I)} & = \text{PWEO(I)} \\
\text{PEO(I)} & = \text{PFOBO(I)} \times \text{eo/(1+te(I))} \\
\text{PLO(I)} & = \left[\text{PDO(I)} \times \text{DO(I)+PEO(I)} \times \text{EXSO(I)}\right]/\text{DDO(I)} \\
\text{PO(J)} & = \text{SUM}\left[\text{I,PLO(I)} \times \text{DSO(J,I)}\right]/\text{XSO(J)} \\
\text{PMO(I)} & = \text{PWMO(I)} \times \text{(1+tm(I))} \times \text{eo} \\
\text{PCO(I)} & = \left[\text{1+txo(I)}\right] \times \left[\text{1+mrg(I)}\right] \times \left[\text{PDO(I)} \times \text{DO(I)+PMO(I)} \times \text{IMO(I)}\right]/\text{QO(I)} \\
\text{DIO(I,J)} & = \text{DIO(I,J)}/\text{PCO(I)} \\
\text{CRUO(J)} & = \text{CRUO(J)}/\text{PCO("Crude")} \\
\text{REFO(J)} & = \text{REFO(J)}/\text{PCO("Fuel")} \\
\text{COALO(J)} & = \text{COALO(J)}/\text{PCO("Coal")} \\
\text{ELECO(J)} & = \text{ELECO(J)}/\text{PCO("Electricity")} \\
\text{XSO(J)} & = \text{XSO(J)}/\text{PO(J)} \\
\text{PVO(J)} & = \left[\text{PO(J)} \times \left[\text{1-tp(J)}\right] \times \text{XSO(J)-SUM}\left[\text{I,PCO(I)*DIO(I,J)}\right]\right]/\text{VAO(J)} \\
\text{wnqo(LL,J)} & = \text{wnquo(LL)} \\
\text{LLDO(LL,J)} & = \text{LLDO(LL,J)}/\text{wnqo(LL,J)}
\end{array}
$$

$$\text{Wlnq\_urbO(J)\$}\left[\text{SUM}\left[\text{LLU,LLDO(LLU,J)}\right] \text{ NE 0}\right] = \text{SUM}\left[\text{LLU,wnqo(LLU,J)} \times \text{LLDO(LLU,J)}\right]/\text{SUM}\left[\text{LLU,LLDO(l}\right.$$

$$\text{Wlnq\_rurO(J)\$}\left[\text{SUM}\left[\text{LLR,LLDO(LLR,J)}\right] \text{ NE 0}\right] = \text{SUM}\left[\text{LLR,wnqo(LLR,J)} \times \text{LLDO(LLR,J)}\right]/\text{SUM}\left[\text{LLR,LLDO(L}\right.$$

$$\text{WlnqO(J)\$(LNQO(J) NE 0)} = \left[\text{Wlnq\_urbO(J)} \times \text{LNQ\_URBO(J)+Wlnq\_rurO(J)} \times \text{LNQ\_RURO(J)}\right]/\left[\text{LNQ\_URBO(J)+LN}\right.$$

$$
\begin{array}{ll}
\text{VAO(J)} & = \text{VAO(J)}/\text{PVO(J)} \\
\text{PKELO(J)} & = \left[\text{PVO(J)} \times \text{VAO(J)-WlnqO(J)} \times \text{LNQO(J)}\right]/\text{KELO(J)} \\
\text{wqo(LH,J)} & = \text{wquo(LH)}
\end{array}
$$

The institutional sectors' income and savings parameters are calibrated here.
The parameters LHSO, LLSO, KSO, INTRFO(INS,TR) and OUTRFO(INS,TR) use a direct assignment procedure.

$$\mathrm{LHSO(H,LH)} = \mathrm{LHSO(H,LH)} / \left[\mathrm{1\text{-}UQO(LH)} \right]$$

$$\mathrm{LLSO(H,LL)} = \mathrm{LLSO(H,LL)} / \left[\mathrm{1\text{-}UNQO(LL)} \right]$$

$$\mathrm{lambda\_wq(H,LH)} = \mathrm{LHSO(H,LH)} / \mathrm{SUM}\left[\mathrm{HH,LHSO(HH,LH)} \right]$$

$$\mathrm{lambda\_wnq(H,LL)} = \mathrm{LLSO(H,LL)} / \mathrm{SUM}\left[\mathrm{HH,LLSO(HH,LL)} \right]$$

$$\mathrm{lambda\_r(INS,K)} = \mathrm{KSO(INS,K)} / \mathrm{SUM}\left[\mathrm{INSS,KSO(INSS,K)} \right]$$

$$\mathrm{DTAXO(H)} = 0$$

$$\mathrm{DTAXO(H)} = \mathrm{OTHEXP("ytx",H)}$$

$$\mathrm{CO(H,Z,I)} = \mathrm{CONS(H,Z,I)}$$

$$\mathrm{CO(H,Z,I)} = \mathrm{CO(H,Z,I)} / \mathrm{PCO(I)}$$

$$\mathrm{CHO(H,Z)} = \mathrm{SUM}\left[\mathrm{I,CO(H,Z,I)} \right]$$

$$\mathrm{PCHO(H,Z)} = \mathrm{SUM}\left[\mathrm{I,CO(H,Z,I)} \times \mathrm{PCO(I)} \right] / \mathrm{CHO(H,Z)}$$

$$\begin{aligned} \mathrm{YO(H)} = {} & \mathrm{SUM}\left[\mathrm{LH,lambda\_wq(H,LH)} \times \mathrm{SUM}\left[\mathrm{J,wqo(LH,J)} \times \mathrm{LHDO(LH,J)} \right] \right] \\ & +\mathrm{SUM}\left[\mathrm{LL,lambda\_wnq(H,LL)} \times \mathrm{SUM}\left[\mathrm{J,wnqo(LL,J)} \times \mathrm{LLDO(LL,J)} \right] \right] \\ & +\mathrm{SUM}\left[\mathrm{K,lambda\_r(H,K)} \times \mathrm{SUM}\left[\mathrm{J,ro(J)} \times \mathrm{KDO(K,J)} \right] \right] \\ & +\mathrm{SUM}\left[\mathrm{TR,INTRFO(H,TR)} \right] \end{aligned}$$

$$\mathrm{ty(H)} = 0$$

$$\mathrm{ty(H)\$}\left[\mathrm{YO(H)\ NE\ 0} \right] = \mathrm{DTAXO(H)/YO(H)}$$

$$\mathrm{YDO(H)} = \mathrm{YO(H)} \times \left[\mathrm{1\text{-}ty(H)} \right] \text{-} \mathrm{SUM}\left[\mathrm{TR,OUTRFO(H,TR)} \right]$$

$$\mathrm{SO(H)} = \mathrm{YDO(H)\text{-}SUM}\left[\mathrm{(Z,I),CO(H,Z,I)} \times \mathrm{PCO(I)} \right]$$

$$\mathrm{mps(H)} = 0\ ;$$

$$\mathrm{mps(H)\$}\left[\mathrm{YDO(H)\ NE\ 0} \right] = \mathrm{SO(H)} / \mathrm{YDO(H)}$$

$$\mathrm{DTAXO(FRM)} = 0$$

$$\mathrm{DTAXO(FRM)} = \mathrm{OTHEXP("ytx",FRM)}$$

$$\mathrm{YO(FRM)} = \mathrm{SUM}\left[\mathrm{K,lambda\_r(FRM,K)} \times \mathrm{SUM}\left[\mathrm{J,ro(J)} \times \mathrm{KDO(K,J)} \right] \right] + \mathrm{SUM}\left[\mathrm{TR,INTRFO(FRM,TR)} \right]$$

$$\mathrm{ty(FRM)} = 0$$

$$\mathrm{ty(FRM)\$}\left[\mathrm{YO(FRM)\ NE\ 0} \right] = \mathrm{DTAXO(FRM)} / \mathrm{YO(FRM)}$$

$$\mathrm{SO(FRM)} = \mathrm{YO(FRM)} \times \left[\mathrm{1\text{-}ty(FRM)} \right] \text{-} \mathrm{SUM}\left[\mathrm{TR,OUTRFO(FRM,TR)} \right]$$

$$\mathrm{CGO(I)} = \mathrm{TABUSE(I,"GOV")}$$

$$\mathrm{CGO(I)} = \mathrm{CGO(I)/PCO(I)}$$

$$\begin{aligned} \mathrm{YO(GOV)} = {} & \mathrm{SUM}\left[\mathrm{I,MTAXO(I)} \right] + \mathrm{SUM}\left[\mathrm{I,XTAXO(I)} \right] + \mathrm{SUM}\left[\mathrm{I,ITAXO(I)} \right] + \mathrm{SUM}\left[\mathrm{J,PTAXO(J)} \right] \\ & + \mathrm{SUM}\left[\mathrm{H,DTAXO(H)} \right] + \mathrm{SUM}\left[\mathrm{FRM,DTAXO(FRM)} \right] \\ & + \mathrm{SUM}\left[\mathrm{K,lambda\_r(GOV,K)} \times \mathrm{SUM}\left[\mathrm{J,ro(J)} \times \mathrm{KDO(K,J)} \right] \right] + \mathrm{SUM}\left[\mathrm{TR,INTRFO(GOV,TR)} \right] \end{aligned}$$

$$\mathrm{SO(GOV)} = \mathrm{YO(GOV)\text{-}SUM}\left[\mathrm{TR,OUTRFO(GOV,TR)} \right] \text{-} \mathrm{SUM}\left[\mathrm{I,CGO(I)} \times \mathrm{PCO(I)} \right]$$

We calibrate parameters in the production functions.

IO relationship between VA and CI in the production function XS

$$\text{rho1(J)} = \text{CIO(J)} / \text{XSO(J)}$$

$$\text{alpha1(J)} = \text{VAO(J)} / \text{XSO(J)}$$

CES between LNQ and KEL in the value added function

$$\text{rho2(J)} = \left(\text{1-sigma2(J)}\right) / \text{sigma2(J)}$$

$$\text{alpha2(J)} = \left[\left(\text{Wlnqo(J)} / \text{PKELo(J)}\right) \times \left(\text{LNQO(J)} / \text{KELO(J)}\right)\right]^{\left(\frac{1}{\text{sigma2(J)}}\right)}$$

$$\text{alpha2(J)} = \text{alpha2(J)} / \left(\text{1+alpha2(J)}\right)$$

$$\text{A2(J)} = \text{VAO(J)} / \left[\text{alpha2(J)} \times \text{LNQO(J)}^{\text{-rho2(J)}} + \left(\left(\text{1-alpha2(J)}\right) \times \text{KELO(J)}^{\text{-rho2(J)}}\right]^{\text{-1/rho2(J)}}$$

CES between LQ and KE in the bundle of capital-energy and skilled labour KEL

$$\text{rho3(J)} = \text{(1-sigma3(J))/sigma3(J)}$$

$$\text{alpha3(J)} = \left[\left(\text{Wlqo(J)/Pkeo(J)}\right) \times \left(\text{LQO(J)/KEO(J)}\right)\right]^{\text{(1/sigma3(J))}}$$

$$\text{alpha3(J)} = \text{alpha3(J)/(1+alpha3(J))}$$

$$\text{A3(J)} = \text{KELO(J)} / \left[\text{alpha3(J)} \times \text{LQO(J)}^{\text{-rho3(J)}} + \left(\left(\text{1-alpha3(J)}\right) \times \text{KEO(J)}^{\text{-rho3(J)}}\right]^{\text{-1/rho3(J)}}$$

CES between ENE and KAD in the bundle of capital-energy KE

$$\text{rho4(J)} = \text{(1-sigma4(J))/sigma4(J);}$$

$$\text{alpha4(J)} = \left[\left(\text{Peneo(J)/ro(J)}\right) \times \left(\text{ENEO(J)/KADO(J)}\right)\right]^{\text{(1/sigma4(J))}}$$

$$\text{alpha4(J)} = \text{alpha4(J)/(1+alpha4(J))}$$

$$\text{A4(J)} = \text{KEO(J)} / \left[\text{alpha4(J)} \times \text{ENEO(J)}^{\text{-rho4(J)}} + \left(\left(\text{1-alpha4(J)}\right) \times \text{KADO(J)}^{\text{-rho4(J)}}\right]^{\text{-1/rho4(J)}}$$

CES between ELEC and FUEL in the bundle of energy ENE

$$\text{rho5(J)} = \text{(1-sigma5(J))/sigma5(J)}$$

$$\text{alpha5(J)} = \left[\left(\text{PCO("Electricity")/Pfuelo(J)}\right) \times \left(\text{ELECO(J)/FUELO(J)}\right)\right]^{\text{(1/sigma5(J))}}$$

$$\text{alpha5(J)} = \text{alpha5(J)/(1+alpha5(J))}$$

$$\text{A5(J)} = \text{ENEO(J)} / \left[\text{alpha5(J)} \times \text{ELECO(J)}^{\text{-rho5(J)}} + \left(\left(\text{1-alpha5(J)}\right) \times \text{FUELO(J)}^{\text{-rho5(J)}}\right]^{\text{-1/rho5(J)}}$$

CES between COAL and OIL in the bundle of fuel energy FUEL

$$\text{rho6(J)} = \text{(1-sigma6(J))/sigma6(J);}$$

$$\text{alpha6(J)} = \left[\left(\text{PCO("Coal")/Poilo(J)}\right) \times \left(\text{COALO(J)/OILO(J)}\right)\right]^{\text{(1/sigma6(J))}}$$

$$\text{alpha6(J)} = \text{alpha6(J)/(1+alpha6(J))}$$

$$\text{A6(J)} = \text{FUELO(J)} / \left[\text{alpha6(J)} \times \text{COALO(J)}^{\text{-rho6(J)}} + \left(\left(\text{1-alpha6(J)}\right) \times \text{OILO(J)}^{\text{-rho6(J)}}\right]^{\text{-1/rho6(J)}}$$

IO relationship between crude oil and refined oil in the aggregate oil product

$$\text{alpha7(J)} = \text{CRUO(J)/OILO(J)}$$

$$\text{rho7(J)} = \text{REFO(J)/OILO(J)}$$

IO relationship among products I in the total intermediate demand of industry J

$$\text{beta2(I,J)} = \text{DIO(I,J)/CIO(J)}$$

IO relationship between urban and rural unskilled labour in the aggregate unskilled labour

$$\text{beta3(J)} = \text{LNQ\_URBO(J)/LNQO(J)}$$

CD function among unskilled labour categories LL in the aggregate unskilled urban labour

$$\text{beta4\_urb(LLU,J)} = \text{LLDO(LLU,J)} \times \text{WnqO(LLU,J)/LNQ\_URBO(J)} \times \text{Wlnq\_urbO(J)}$$

CD function among unskilled labour categories LL in the aggregate unskilled rural labour

$$\text{beta4\_rur(LLR,J)} = \text{LLDO(LLR,J)} \times \text{WnqO(LLR,J)/LNQ\_RURO(J)} \times \text{Wlnq\_rurO(J)}$$

IO relationship between urban and rural skilled labour in the aggregate skilled labour

$$\text{beta4(J)} = \text{LQ\_URBO(J)/LQO(J)}$$

CD function among skilled labour categories LL in the aggregate skilled urban labour

$$\text{beta5\_urb(LHU,J)} = \text{LHDO(LHU,J)} \times \text{WqO(LHU,J)/LQ\_URBO(J)} \times \text{Wlq\_urbO(J)}$$

CD function among skilled labour categories LL in the aggregate skilled rural labour

$$\text{beta5\_rur(LHR,J)} = \text{LHDO(LHR,J)} \times \text{WqO(LHR,J)/LQ\_RURO(J)} \times \text{Wlq\_rurO(J)}$$

We adjust the elasticity in order to respect Engel aggregation in LES demand system.

$$\text{YELAS(H,Z)} = \frac{\text{YELAS(H,Z)}}{\text{SUM}\left[\text{ZZ,YELAS(H,ZZ)} \times \text{PCHO(H,ZZ)} \times \text{CHO(H,ZZ)}\right] \Big/ \left[\left(\text{1-mps(H)}\right) \times \text{YDO(H)}\right]}$$

$$\text{gamma\_ch(H,Z)} = \frac{\text{PCHO(H,Z)} \times \text{CHO(H,Z)} \times \text{YELAS(H,Z)}}{\left(\text{1-mps(H)}\right) \times \text{YDO(H)}}$$

$$\text{V\_MIN(H)} = \text{SUM}\left[\text{Z,PCHO(H,Z)} \times \text{CHO(H,Z)}\right] \times \left[1 + \frac{1}{\text{FRISCH(H)}}\right]$$

$$\text{C\_MIN(H,Z)} = \text{CHO(H,Z)-gamma\_ch(H,Z)} \times \frac{\left(\text{1-mps(H)}\right) \times \text{YDO(H)-V\_MIN(H)}}{\text{PCHO(H,Z)}}$$

$$\text{gamma\_h(H,Z,I)} = \frac{\text{PCO(I)} \times \text{CO(H,Z,I)}}{\text{PCHO(H,Z)} \times \text{CHO(H,Z)}}$$

Trade parameters are also calibrated.

Activity-product relationship

$$rho\_ds(J,I) = DSO(J,I)/XSO(J)$$

Export

$$kappa\_e(I) = (1+tau\_e(I))/tau\_e(I);$$

$$beta\_e(I) = 1\Big/\left[1+PDO(I)/PEO(I)\times\left(EXSO(I)/DO(I)\right)^{kappa\_e(I)-1)}\right]$$

$$B\_E(I) = DDO(I)\Big/\left[beta\_e(I)\times EXSO(I)^{kappa\_e(I)}+(1-beta\_e(I))\times DO(I)^{kappa\_e(I)}\right]^{\left(\frac{1}{kappa\_e(I)}\right)}$$

Import

$$rho\_m(I) = (1-sigma\_m(I))/sigma\_m(I)$$

$$alpha\_m(I) = \left[\left(PMO(I)/PDO(I)\right)\times\left(IMO(I)/DO(I)\right)\right]^{\left(\frac{1}{sigma\_m(I)}\right)}$$

$$alpha\_m(I) = alpha\_m(I)/(1+alpha\_m(I));$$

$$A\_M(I) = QO(I)\Big/\left[alpha\_m(I)\times IMO(I)^{-rho\_m(I)}+(1-alpha\_m(I))\times DO(I)^{-rho\_m(I)}\right]^{-\frac{1}{rho\_m(I)}}$$

Finally, we calibrate and compute other parameters, prices and related volumes.

$$STKO(I) = 0$$

$$STKO(I) = TABUSE(I,"stk")$$

$$INVO(I) = 0$$

$$INVO(I) = TABUSE(I,"fcf")$$

$$ITO = SUM(I,INVO(I))$$

$$STKO(I) = STKO(I)/PCO(I)$$

$$INVO(I) = INVO(I)/PCO(I)$$

$$mu(I) = \left(PCO(I)\times INVO(I)\right)\Big/ITO$$

$$delta(J) = \left(PVO(J)\times VAO(J)\right)\Big/SUM\left[JJ,PVO(JJ)\times VAO(JJ)\right]$$

$$PindexO = SUM\left[J,PVO(J)\times delta(J)\right]$$

$$EXDO(I) = EXSO(I)$$

$$CABO = eo\times SUM\left[I,PWMO(I)\times IMO(I)\right] - eo\times SUM\left[I,PFOBO(I)\times EXSO(I)\right] +SUM\left[TR,INTRFO(ROW,TR)\right] - SUM\left[TR,OUTRFO(ROW,TR)\right]$$

$$PINVO = SUM\left[I,PCO(I)\times mu(I)\right]$$

$$ITVOLO = ITO/PINVO$$

Annex 1: Variable definition

- Production variables

XS(J)	Production of sector J
VA(J)	Value added in sector J
CI(J)	Total intermediate consumption of sector J
DI(I,J)	Demand of good I for intermediate consumption by sector J
LNQ(J)	Demand for composite unskilled labour in industry J
LNQ_URB(J)	Demand for composite urban unskilled labour in industry J
LNQ_RUR(J)	Demand for composite rural unskilled labour in industry J
LLD(LL,J)	Demand for unskilled labour L in industry J
LQ(J)	Demand for composite skilled labour in industry J
LQ_URB(J)	Demand for composite urban skilled labour in industry J
LQ_RUR(J)	Demand for composite rural skilled labour in industry J
LHD(LH,J)	Demand for skilled labour L in industry J
KAD(J)	Demand for composite capital in industry J
KD(K,J)	Demand for capital type K in industry J
KEL(J)	Composite capital-energy and skilled labour in industry J
KE(J)	Composite capital-energy input in industry J
ENE(J)	Aggregate energy product input in industry J
FUEL(J)	Aggregate fuel energy input in industry J
OIL(J)	Aggregate oil products input in industry J
ELEC(J)	Demand for electricity product by Industry J
COAL(J)	Demand for coal by Industry J
CRU(J)	Demand for crude oil by Industry J
REF(J)	Demand for refined oil by Industry J

- Trade variables

DS(J,I)	Production of commodity I by Industry J
DD(I)	Domestic supply of product I
IM(I)	Imports of product I
EXS(I)	Exports supply of product I
D(I)	Net domestic supply of product I
Q(I)	Total supply of composite product I

- Incomes and savings

LHS(H,LH)	Skilled labour supply (volule)
LLS(H,LL)	Unskilled labour supply
KS(INS,K)	Capital supply
Y(DINS)	Gross income
YD(H)	Disposable income
S(DINS)	Savings
INTRF(INS,TR)	Transfer in
OUTRF(INS,TR)	Transfer out

- Demand variables

C(H,Z,I)	Household H consumption of product I for purpose Z (volume)
CH(H,Z)	Household H aggregate consumption Z (volume)
DIT(I)	Total demand of product I for intermediate consumption (volume)
CG(I)	Total demand of product I for public consumption (volume)

INV(I)	Demand of product I for fixed capital formation (volume)
IT	Total fixed capital formation (value)
ITVOL	Total fixed capital formation (volume)
STK(I)	Change in stock of product I (volume)
EXD(I)	Exports demand of product I
CAB	Current account balance

- Prices

e	Exchange rate
r(J)	Return to capital in industry J
wq(LH,J)	Wage rate of skilled worker L in industry J
wnq(LL,J)	Wage rate of unskilled worker L in industry J
PV(J)	Value added price for industry J
PKEL(J)	Average price of aggregate capital-energy-skilled labour in industry J
Pke(J)	Average price of aggregate capital-energy in industry J
Pene(J)	Average price of aggregate energy in industry J
Pfuel(J)	Average price of aggregate fuel in industry J
Poil(J)	Average price of aggregate oil in industry J
Wlnq(J)	Average price of composite unskilled labour in industry J
Wlnq_urb(J)	Average price of composite unskilled labour in industry J
Wlnq_rur(J)	Average price of composite unskilled labour in industry J
Wlq(J)	Average price of composite skilled labour in industry J
Wlq_urb(J)	Average price of composite skilled labour in industry J
Wlq_rur(J)	Average price of composite skilled labour in industry J
P(J)	Producer price of product I
PL(I)	Local price of product I
PD(I)	Basic price of product I
PC(I)	Purchasing price of product I
PM(I)	Domestic price of imported product I
PE(I)	Domestic price of exported product I
PWM(I)	International price of import I (foreign currency)
PWE(I)	International price of export I (foreign currency)
PFOB(I)	Export fob price (foreign currency)
PINV	Aggregate price index of investment
Pindex	Aggregate value added price
PCH(H,Z)	Household H average consumption price

- Other variables

tx(I)	Indirect tax rate on product I
uq(LH)	Unemployment rate for skilled labour L
unq(LL)	Unemployment rate for unskilled labour L
wqu(LH)	Uniform wage rate for skilled labour
wnqu(LL)	Uniform wage rate for unskilled labour
cmrg(I)	Margin adjustment parameter
umrg	Uniform margin adjustment parameter

Annex 2: Parameter definition

- Production parameters

alpha1(J)	share parameter in fixed proportional relationship between VA and CI in XS
rho1(J)	share parameter in fixed proportional relationship between VA and CI in XS
A2(J)	scale parameter in CES between LNQ and KEL in VA
alpha2(J)	share parameter in CES between LNQ and KEL in VA
rho2(J)	elaticity of substitution in CES between LNQ and KEL in VA
sigma2(J)	elaticity parameter in CES between LNQ and KEL in VA
A3(J)	scale parameter in CES between LQ and KE in KEL
alpha3(J)	share parameter in CES between LQ and KE in KEL
rho3(J)	elaticity of substitution in CES between LQ and KE in KEL
sigma3(J)	elaticity parameter in CES between LQ and KE in KEL
A4(J)	scale parameter in CES between KAD and ENE in KE
alpha4(J)	share parameter in CES between KAD and ENE in KE
rho4(J)	elaticity of substitution in CES between KAD and ENE in KE
sigma4(J)	elaticity parameter in CES between KAD and ENE in KE
A5(J)	scale parameter in CES between Electricity and Fuel in KE
alpha5(J)	share parameter in CES between Electricity and Fuel in KE
rho5(J)	elaticity of substitution in CES between Electricity and Fuel in KE
sigma5(J)	elaticity parameter in CES between Electricity and Fuel in KE
A6(J)	scale parameter in CES between Coal and Oil in Fuel
alpha6(J)	share parameter in CES between Coal and Oil in Fuel
rho6(J)	elaticity of substitution in CES between Coal and Oil in Fuel
sigma6(J)	elaticity parameter in CES between Coal and Oil in Fuel
alpha7(J)	share parameter in fixed proportional relationship between Crude oil and refined oil in Oil
rho7(J)	share parameter in fixed proportional relationship between Crude oil and refined oil in Oil
beta2(I,J)	share parameter in fixed proportional relationship among non energy (INE) inputs (DI) in CI
beta3(J)	share parameter between urban and rural unskilled workers in the IO function
beta4_urb(LLU,J)	share parameter between urban unskilled labour category LLU in the CD function
beta4_rur(LLR,J)	share parameter between rural unskilled labour category LLR in the CD function
beta4(J)	share parameter between urban and rural skilled workers in the IO function
beta5_urb(LHU,J)	share parameter between urban skilled labour category LHU in the CD function
beta5_rur(LHR,J)	share parameter between rural skilled labour category LHR in the CD function

- Trade parameters

rho_ds(J,I)	Fixed parameter in activity-product relationship
B_e(I)	Scale parameter in export CET function
beta_e(I)	Share parameter in export CET function
kappa_e(I)	Transformation parameter in export CET function
tau_e(I)	Transformation elasticity in export CET function
sigma_x(I)	Export demand elasticity
A_m(I)	Scale parameter in import CES function
rho_m(I)	Substitution parameter in import CES function
alpha_m(I)	Share parameter in import CES function
sigma_m(I)	Substitution elasticity in import CES function

- Income-saving and demand

YELAS(H,Z)	Income elasticity of consumption Z
V_MIN(H)	Minimum consumption value (temporary variable)
C_MIN(H,Z)	Minimum consumption of consumption Z (LES consumption function)

FRISCH(H)	Frisch parameter (LES consumption function)
lambda_r(INS,K)	Share of sectoral capital income received by agent
lambda_wnq(H,LL)	Share of sectoral unskilled labour income received by household
lambda_wq(H,LH)	Share of sectoral skilled labour income received by household
mps(H)	Propensity to save for household
gamma_ch(H,Z)	Marginal share of consumption Z in household consumption
gamma_h(H,Z,I)	Marginal share of consumption Z in household consumption

- Tax rates

tm(I)	Import duties on good M
te(I)	Export tax on good X
tp(J)	Production tax rate on good I
txo(I)	Indirect tax rate on good I
ty(DINS)	Household direct tax rate
mrg(I)	Parameter for trade and transport margins
ttm(I)	Trade and transportation margins

- Other parameters

delta(J)	Share of sector J in total value added
mu(I)	Share of sector J in total investment

Annex 3: Set definition

Define the commodity *I*, industry *J* and consumption *Z* sets. The complete list of commodity/industry and consumption by purpose is given by annexes 4 and 5. There are 12 categories of labour *L* divided into 4 skilled *LH* and 8 unskilled *LL* groups of workers. The skilled group is then distinguished in 2 urban *LHU* and 2 rural *LHR* categories, the unskilled group in 4 urban *LLU* and 4 rural *LLR* categories. Capital factors are aggregated into four groups *K* defined by their owners, i.e. corporations, government, urban households, and rural households. Two groups of transfer *TR* are identified, the property transfers (interests, dividends and rents), and other transfer (social, kind, international cooperation, etc.). There are 6 groups of institutional sectors *INS*, including 5 domestic institutions *DINS* and 1 non domestic institution (the rest of the world). The domestic institutions comprise 2 types *FRM* of corporations (financial and non financial) and 2 representative groups *H* of households (urban and rural), and 1 general government.

I	Product / C01*C95 /
J	Industry / I01*I95 /
Z	Consumption / Z01*Z12 /
L	Labor / urbhghmal,urbhghfem,rurhghmal,rurhghfem,urbmedmal,urbmedfem urblowmal,urblowfem,rurmedmal,rurmedfem,rurlowmal,rurlowfem /
LH(L)	High skilled labor / urbhghmal,urbhghfem,rurhghmal,rurhghfem /
LHU(LH)	Urban high skilled labor / urbhghmal,urbhghfem /
LHR(LH)	Rural high skilled labor / rurhghmal,rurhghfem /
LL(L)	Low skilled labor / urbmedmal,urbmedfem,urblowmal,urblowfem,rurmedmal, rurmedfem,rurlowmal,rurlowfem /
LLU(LL)	Urban low skilled labor / urbmedmal,urbmedfem,urblowmal,urblowfem /
LLR(LL)	Rural low skilled labor / rurmedmal,rurmedfem,rurlowmal,rurlowfem /
K	Capital / kurbh,kruh,kfrm /
TR	Transfers / trfprp,trfoth /
INS	All Institutions / fcop,nfcop,gov,urbh,rurh,row /
DINS(INS)	Resident institutions / fcop,nfcop,gov,urbh,rurh /

FRM(DINS)	Corporations / fcop,nfcop /
H(DINS)	Households / urbh,rurh /

The transaction and investment sets *TAX* and *CAP* are introduced in order to import data when using DGX facilities - details are provided in the calibration section. We distinguish public *PUB* and private *NPUB* sectors, as well as privates other services *SCE* and other products *NSC*, trade and transport services *MG* and non trade and transport services *NMG* and finally non fuel products *INO*.

TAX	Transaction costs / ptx,mtx,xtx,stx,ytx,mrg /
CAP	Investment / fcf,stk /

PUB(J)	General government services
NPUB(J)	Private industries
NSC(I)	n-1th products
SCE(I)	nth product
MG(I)	Products with margins
NMG(I)	Product without margins
INO(I)	Non petroleum products

PUB(J) = no; PUB("I93") = yes;
NPUB(J) = yes; NPUB("I93") = no;
MG(I) = no; MG("C86") = yes; MG("C88") = yes;
NMG(I) = yes; NMG("C86") = no; NMG("C88") = no;
NSC(I) = yes; NSC("C95") = no; NSC("C02") = no; NSC("C04") = no; NSC("C33") = no; NSC("C82") = no;
SCE(I) = no; SCE("C95") = yes; SCE("C02") = no; SCE("C04") = no; SCE("C33") = no; SCE("C82") = no;
INO(I) = yes ; INO("C33") = no;

The following sets are used for the output files and group non agriculture products and industries into 4 categories, i.e. food, light manufacturing, heavy manufacturing, and services.

FPRD(I)	Food products	/ C06*C17 /
LPRD1(I)	Light products	/ C18*C32 /
LPRD2(I)	Light products	/ C34*C49 /
HPRD1(I)	Heavy products	/ C50*C81 /
HPRD2(I)	Heavy products	/ C83*C85 /
SPRD(I)	Services	/ C86*C95 /

FIND(J)	Food manufacturing	/ I06*I17 /
LIND1(J)	Light manufacturing	/ I18*I32 /
LIND2(J)	Light manufacturing	/ I34*I49 /
HIND1(J)	Heavy manufacturing	/ I50*I81 /
HIND2(J)	Heavy manufacturing	/ I83*I85 /
SIND(J)	Activity of service	/ I86*I95 /

Finally, the commodities, industry, institutions, households and consumption sets are redefined as followed:

ALIAS (I,II)
ALIAS (J,JJ)
ALIAS (INS,INSS)
ALIAS (H,HH)

ALIAS (Z,ZZ)

Annex 4: Definition of consumption by purpose

Definition	Code
Food	Z01
Personnel care	Z02
Fuel	Z03
Clothing and footwear	Z04
Furniture and equipment	Z05
Health	Z06
Transport	Z07
Computer and telecommunication	Z08
Education	Z09
Recreation, entertainment and sport	Z10
Miscellaneous expenditure	Z11
Housing	Z12

Source: Energy Final SAM 2000

Annex 5: Definition of products and industries

Definition	Code		Definition	Code	
	Industry	Product		Industry	Product
Agriculture	I01	C01	Other non-metallic	I49	C49
Coal	I02	C02	Iron and steel	I50	C50
Gold	I03	C03	Non-ferrous metals	I51	C51
Crude fuel	I04	C04	Structural metal	I52	C52
Other mining	I05	C05	Treated metals	I53	C53
Meat	I06	C06	General hardware	I54	C54
Fish	I07	C07	Fabricated metal	I55	C55
Fruit	I08	C08	Engines	I56	C56
Oils	I09	C09	Pumps	I57	C57
Dairy	I10	C10	Gears	I58	C58
Grain mills	I11	C11	Lifting equipment	I59	C59
Animal feeds	I12	C12	General machinery	I60	C60
Bakeries	I13	C13	Agricultural machinery	I61	C61
Sugar	I14	C14	Machine-tools	I62	C62
Confectionery	I15	C15	Mining machinery	I63	C63
Other food	I16	C16	Food machinery	I64	C64
Beverages and tobacco	I17	C17	Special machinery	I65	C65
Textiles	I18	C18	Household appliances	I66	C66
Textile articles	I19	C19	Office machinery	I67	C67
Carpets	I20	C20	Electric motors	I68	C68
Other textiles	I21	C21	Electricity apparatus	I69	C69
Knitting mills	I22	C22	Wire and cable	I70	C70
Wearing apparel	I23	C23	Accumulators	I71	C71
Leather	I24	C24	Lighting equipment	I72	C72
Handbags	I25	C25	Electrical equipment	I73	C73
Footwear	I26	C26	Radio and television	I74	C74
Wood	I27	C27	Optical instruments	I75	C75
Paper	I28	C28	Motor vehicles	I76	C76
Containers of paper	I29	C29	Motor vehicle parts	I77	C77
Other paper	I30	C30	Other Transport	I78	C78
Publishing	I31	C31	Furniture	I79	C79
Recorded media	I32	C32	Jewellery	I80	C80
Petroleum	I33	C33	Other manufacturing	I81	C81
Basic chemicals	I34	C34	Electricity	I82	C82
Fertilizers	I35	C35	Water	I83	C83
Primary plastics	I36	C36	Buildings	I84	C84
Pesticides	I37	C37	Other construction	I85	C85
Paints	I38	C38	Trade	I86	C86
Pharmaceuticals	I39	C39	Accommodation	I87	C87
Soap	I40	C40	Transport services	I88	C88
Other chemicals	I41	C41	Communications	I89	C89
Tyres	I42	C42	Insurance	I90	C90
Other rubber	I43	C43	Real estate	I91	C91
Plastic	I44	C44	Business activities	I92	C92
Glass	I45	C45	General Government	I93	C93
Non-structural ceramics	I46	C46	Health and social work	I94	C94
Structural ceramics	I47	C47	Activities/ services	I95	C95
Cement	I48	C48			

Source: Energy Final SAM 2000

Annex 3

The Micro-Simulation Model for Analysing the Poverty and Inequality Impacts of Alternative Policy Responses to High Oil Prices in South Africa

Introduction

An energy focused Computable General Equilibrium (CGE) framework has been developed in order to evaluate the impacts of high oil prices on the performance of the economy, on poverty and inequality reduction and, on the well-being of South Africans (Fofana *et al*. 2008). The model features 94 economic activities for the same number of products; the latter are then aggregated into 12 consumption type by purpose. There are also 12 categories of workers and consequently the labour market is segmented. There are 4 types of capital. However, the model accounts for only two representative household categories, that is, urban and rural whereas indicators used for the analysis of poverty and inequality generally use household or individual level data limiting its usefulness for the income distribution and poverty impact analysis of oil crisis. Therefore, micro-simulation appears to be essential in modelling the distributional impacts of the macro shocks but its inability to model prices and macro variables inspires an increasing number of analysts to opt for both macro- and micro- models in order to reconcile the use of macro-models with distributional impacts analysis.

This paper uses a two-layered macro-micro model to analyse the income distribution and poverty impacts of the alternative policy responses to high oil prices in South Africa. The macro and micro modules are linked in a top-down fashion which does not account for the feed-back (second-order) effects from the micro component to the macro component of the model. Therefore, one should interprete the results as a first-round (prices and quantities) distributive impact analysis of the oil shocks.

This technical note is divided into two sections. Section 1 briefly discusses the micro-simulation techniques used in income distribution and poverty analysis and presentes the model used in analysing the distributive impacts of oil crisis in South Africa. The required surveys data to aperationalize the model is analysed in section 2.

The micro-simulation model

Micro-simulation models differ primarily in two aspects: the type of effects encountered and the mechanism of linkage with the macro-model. As mentioned by Essama-Nssah *et al*. (2007), one can identify the following three types of effects to track the distributional impact of macro-economic shocks and policies: *the price effects* or change in prices of endowed and purchased resources; *the reallocation effects*, i.e. change in the occupation of resource; *endowment effects* or change in the available quantity of resources.

Ravallion and Lokshin (2004) use the envelope theorem to track the distributional welfare impacts of the price changes imputed to agricultural trade reform in Morocco. The authors evaluated the first-order approximation to the welfare impact in a neighbourhood of the household's optimum by the weighted sum of proportionate changes in prices, the weights being the initial quantities (envelope property)[1]. As a short term effect, the analysis does not account for either reallocation or endowment effects.

In addition to the price effects, several studies have accounted for the reallocation in recent years (Robilliard *et al*. 2001; Bourguignon and Ferreira 2005). The micro-econometric specification developed in this study accounts for three types of behaviour: an allocation of individuals across occupations using a multinomial logit model; a model of earnings; and a household income generation rule. Change in the labour market can also be replicated by a random selection procedure (Barros and Leite, 1998; and Ganuza *et al*. 2002)

Models that endogenize endowments (various labour and capital categories) through human capital development, fertility, migration, and saving behaviour, as well as household formation, on the basis of econometric estimation are still underexploited in developing countries. According to Bourguignon *et al*. (2002), it is not easy to develop multi-layered macro-micro models in a truly dynamic framework. The methodology that endogenizes labour supply and saving behaviour is discussed in Bourguignon *et al*. (2001a).

Three procedures are identified in linking of the macro- and the micro- components of the model. The integrated approach is one way. The technique is equivalent to developing a CGE model in which the number of household categories equals

1. For more details refer to Ravallion and Lokshin (2004).

the number of participants in the household surveys, eliminating the assumption of representative agents (Cogneau and Robillard, 2000; Cockburn, 2001). The method, also referred to as a multi-households CGE modelling, is appropriate in analyzing the price effects and the first-order approximation of welfare impacts attributed to macro-economic shock. However, it seems to be technically limited to account for micro-econometric behaviour specifications of households in order to account for the reallocation and endowment effects after the shock.

This limitation is corrected in the layered methods, that is, the "top-down" and the "top-down/bottom-up" approaches, in which the macro- and micro components are solved sequentially. In the "top-down" approach the macro-model is solved first and provides prices and macro variables to the micro-model. The approach has the advantage of being able to perform micro-econometric behaviour modelling and also integrates more richness and heterogeneity in the distributional impact analysis. Its disadvantage lies in the lack of feed-back from the micro to the macrocomponent; that is, a lack of heterogeneity in the determination of prices and quantities from the macro-module. Results from this model should be interpreted as a first-round (prices and quantities) distributive impact analysis.

The "top-down/bottom-up" approach (Savard, 2005; Essama-Nssah *et al*, 2007) corrects for the lack of feed-back from the micro-component. The macro- and micro- models are run sequentially until the two produce consistent results. The "top-down/bottom-up" method is a promising avenue for macro-micro modelling although the complexity of its procedure does not always insure a satisfactory convergence.

The micro-simulation model developed in this paper follows Ravallion and Lokshin (2004) and Ganuza *et al*. (2002) in accounting for both prices and reallocation effects of shocks. It takes CGE results on the employment and unemployment variables and on the return to factors as inputs.The changes in employment or unemployment variables obtained from the CGE model are imposed onto the individuals in the survey. Unemployed individuals are randomly selected to join the pool of employees in a situation where employment increases. In the opposite case, we randomly select individuals remaining employed when retrenchment occurs. The selection process is repeated a large number of times to allow for the determination of confidence intervals of poverty and inequality indicators. Finally, the changes in wage rates are applied to salary and wage workers; the latter are collapsed over the households. Business and transfer earnings are also adjusted by the CGE changes for the return to capital and the average economy-wide price, respectively. Households' earnings, that is, wage, profit, and transfer, are computed and used for the measurement of poverty and inequality indicators.

We discuss in the following section the procedure of building of the vectors of individual regular income from the 2000 Income and Expenditure Survey (IES) and the September 2000 Labour Force Survey (LFS) both published by Statistics South Africa.

Data Analysis

Households' incomes and expenditures data for South Africa are drawn from the 2000 IES. The survey accounts for 26265 households and 104 153 individuals representative of the South African population in 2000. The Income and Expenditure Survey (IES) 2000 data are in four files as follows:

- PERSON: Individuals' characteristics and incomes;
- WORKER: Characteristics and cost of private domestic services;
- HOME GROWN PRODUCTS: Households' self-production of agriculture goods;
- GENERAL: Household's incomes and expenditures;

Data on individuals' (thus, household) regular income, that is, salaries and wages, profits and net incomes, and transfer receipts are generated from the "PERSON" file. For simplicity we do not gather information on other (non regular) income[2] at the household-level from the "GENERAL" file, as well as the data on expenditures and savings of households provided by the "WORKER", "HOME GROWN PRODUCTS", and "GENERAL" files.

2. Non regular incomes are exogenous, i.e. they remain unchanged in our analysis; thus we do not find necessary to gather this information.

Time spent by individuals on market activities, that is, salary and wage work, self-employment work, and unemployment, and many other pieces of information related to the employment status of individuals are missing from the IES 2000. Therefore, the latter is completed by information from the LFS 2000. The LFS 2000:2 accounts for 30,000 households and 105,371 individuals. It is based on the same sample of interviewed households as the IES 2000. The questionnaire consists of three sections recorded in separate files as they refer to different entities:

- PERSON: record for every individual of the household;
- WORKER: record economic activities for person 15 years and above in the household;
- HOUSE: Household variables.

Data on income are collected in different steps. The "PERSON", "WORKER" and "HOUSE" files from the LFS are merged in a single database of individuals' employment variables. The 18 sources of income for individuals (Table 1) are gathered from the "PERSON" file of the IES 2000. Individual's income and employment variables are merged using the IES and the LFS.[3] This adjustment fixes up the final sample to 102,716 individuals and 25,963 households.

Table 1: Mapping 2000 NAM and 2000 IES sources of income

SAM	Individual-level
Primary income	
Salary and wages	1- Salaries and wages 2- Bonuses and income 3- Commission and director's fees 4- Part-time work and cash -allowances
Gross operating surplus and mixed income	5- Net profit
Property income	7- Interest received 8- Dividends on shares 9- Investments annuities 6- Net income from letting of fixed property
Secondary income	
Social transfers	10- Employment pension 11- Old age and war pensions 12- Disability grants 13- Unemployment insurance 14- Family and other allowances 15- Alimony, maintenance and similar allowances 16- Regular allowances 17- Royalties
Private transfer	18- Other

The 18 sources of income are grouped into 3 categories according to the main source of income in the CGE model and given by the mapping presented in Table 1. Household earnings sum up the regular revenues generated by its members. There are 389 occupational groups aggregated into 3 skill levels using the Statistics South Africa classification in the 1998 SAM (Table 2).

3. We drop observations that are not observed in both databases, for individual as well as its corresponding households. The numbers involved are small relative to the overall sample size and hence can conveniently be dropped without compromising the credibility of the sampling procedure

Table 2: Major occupational and skill levels

Major occupational groups		1998 SAM Skill level	2000 SAM Skill level	
1	Legislators, seniors officials and managers	4	1	High skill
2	Professionals	4	1	High skill
3	Technicians and associate professionals	3	1	High skill
4	Clerks	2	2	Medium skill
5	Service workers and shop market sales workers	2	2	Medium skill
6	Skilled agricultural and fishery workers	2	2	Medium skill
7	Subsistence agricultural and fishery workers	2	2	Medium skill
8	Craft and related trades workers	2	2	Medium skill
9	Plant and machine operators and assemblers	2	2	Medium skill
10	Elementary occupations	1	3	Low skill
11	Domestic and related helpers, cleaners and launderers	1	3	Low skill
12	Occupation unspecified	1	3	Low skill

A standard Mincerian wage regression imputes wages to unemployed and inactive individuals. Log wages are regressed on education and age (proxy of education), controlling for gender, employment status (full or part time), the marital status, and finally, the presence of children under 7 years old.

The IES and the September LFS are based on the same sample of households interviewed but a lot of mismatches have been observed between the two databases as pointed out by many analysts who work with these databases[4]. Important differences between income and expenditures within the IES have been raised. Indeed, there has been substantial inflation in South Africa between 1995 and 2000, whereas the 2000 household survey data shows that nominal household per-capita incomes have decreased since 1995, the year of the previous household survey. The 2000 sample contains a much larger African share and a much smaller white share. This may have generated the above apparent anomalies. Therefore, we re-weight the survey sample to make it consistent with the 2001 census population shares.

A distinct advantage of the approach used here, that of accounting for all households in a survey, is that we are able to translate the policy effects to national poverty effects. In our study we use the existing poverty lines for South Africa to calculate various poverty indices that help to characterize poverty[5]. The Foster, Greer, Thorbecke (FGT) measure of poverty is used in our study. This is because it is a more general index. Given y_i, the income for individuals of a population, the FGT index is:

$$P(z;\alpha) = \int_0^1 g(p\ ,z)^{\alpha}\, dp$$

where α≥0, is the degree of aversion, z is the poverty line. When α=0, the FGT index indicates the proportion P_0 of the poor [see Ravallion 1994].

The FGT indexes are decomposable, and this helps us to analyse the contributions of different groups of households to global poverty. The contribution of each socio economic group to global poverty is given by:

$$C_j = K_j P_{x_j} \,/\, P_\alpha$$

where $P_{x,j}$ is the poverty index for group j, K_j the proportion of the population in group j; P_a is the poverty index of the entire population. This knowledge of the groups' contributions in total index could be useful for formulating more precise economic policies towards vulnerable groups.

4. Mabugu and Chitiga (2007) and Pauw (2005) have provided useful discussions on these inconsistencies.
5. Some examples are FGT index, Watts's index, and Clark, Hemming and Ulph (CHU) index.

Conclusion

We use the methods proposed by Ravallion and Lokshin (2004) and Ganuza *et al*. (2002) to build a micro-simulation model for income distribution and poverty analysis in South Africa. Our model is based on the individuals' regular income data gathered from the 2000 income and expenditure survey (IES), and the 2000 September labor force survey (LFS) . First, the two surveys based on the same sample of surveyed households are merged in a single database. As we import changes in prices (factors and consumption) and macro-variables (employment and unemployment) from the CGE model, we do not attempt to reconcile the macro (or the SAM) and the household (or the survey) data. Then, the eighteen categories of individual regular revenue items encountered in the IES 2000 are grouped into three categories, i.e. wage, profit and transfer. The base year households' regular revenues and poverty indicators are computed with the former being proxies for the household's welfare. First, the micro-simulation model proceeds by estimating the shadow wages of unemployed workers and non economically active individuals. Second, the CGE model changes in the labour market variables (employment and unemployment) are replicated into the micro-simulation model by randomly selecting current workers that remain employed when the employment falls or the current unemployed individuals becoming employed when the employment increases, that is, the unemployment decreases. Third, the changes in wage rates are then assigned to employed individuals and the labour earnings are aggregated at the household level. Fourth, changes in the return to capital and the economy-wide prices are inputs from the CGE model and used in estimating changes in the households' capital and transfer revenues respectively. Fifth, the total regular earnings are computed for the household as are the new poverty indicators.

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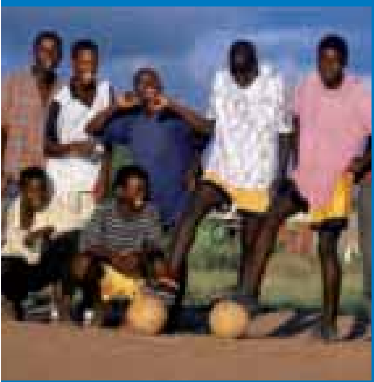

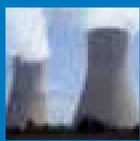

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