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# The Economic Impacts of Maize-based Bioethanol Production in South Africa:

A Social Accounting Matrix Analysis

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**Dedicated to**

Gezai Mekonnen

**Abstract**

In South Africa, the production and use of biofuels is increasingly being contemplated as a policy instrument to stimulate rural development and reduce poverty by creating sustainable income earning opportunities. By using social accounting matrix, this thesis examines economic gains, if any, in South Africa following maize-based bioethanol production using the country's surplus maize as feedstock. The findings suggest this particular biofuel policy leads to a moderate increase in domestic industries' production, value-added and foreign exchange earnings. However, the vast income inequality among the country's various population groups remains unchanged.

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## Abbreviations

| | |
|---|---|
| CGE | Computable General Equilibrium |
| DAFF | Department of Agriculture, Forestry and Fisheries |
| DME | Department of Minerals and Energy |
| EC | European Commission |
| EU | European Union |
| EUR | Euro |
| GDP | Gross Domestic Product |
| GHG | Green House Gases |
| GWh | Gigawatt Hour |
| I-O | Input-output |
| ROW | Rest of the World |
| SAGIS | South African Grain Information Services |
| SAM | Social Accounting Matrix |
| SAPIA | South African Petroleum Industry Association |
| SARB | South African Reserve Bank |
| SEK | Swedish Krona |
| Stats SA | Statistics South Africa |
| USA | United States of America |
| USD | United States Dollar |
| ZAR | South African Rand |

ZAR 1.00 = EUR 0.13 = SEK 1.17 = USD 0.16

Yearly average exchange rate for 2005 from http://www.oanda.com

# 1. Introduction

## 1.1. Background

The global transportation sector almost entirely relays upon gasoline and diesel for energy (Demirbas, 2007; Rajagopal & Zilberman, 2007). However, those conventional petroleum based fuels are not only scarce, exhaustible, unevenly distributed and increasingly costly but also responsible for one fifth of the total global GHG emissions (Creutzig et al., 2011; Balat & Balat, 2009). Phasing them out, therefore, is considered to lead to substantial economic and environmental benefits. And quite often, biofuels – renewable fuels made of biomass including but not limited to starchy crops and oilseeds – are singled out as the most feasible means (Liaquat et al., 2010; Balat & Balat, 2009; Rajagopal & Zilberman, 2007).

Thanks to their relative abundance and their rather familiar ignition characteristics, liquid biofuels have the unique capacity to substitute or, more commonly, compliment fossil fuels by providing adequate and affordable energy supply in the short- to medium-run without major technological adaptations (Demirbas, 2009; Charles et al., 2007; Fulton et al., 2004). Proponents argue being renewable, biodegradable, nontoxic, and water soluble; biofuels do so with a lesser environmental damage per liter of fuel consumption compared to traditional fuels (Fulton et al., 2004). Furthermore, within the developing world and Africa in particular, the production and use of biofuels is considered as a policy instrument in alleviating rural poverty. The expansion of biofuel production is deemed to bring about increased demand for local agricultural products that are no longer globally competitive; and considerable employment gains at the stages of feedstock cultivation, transportation and processing in addition to cheaper, sustainable and locally produced energy (Agba et al., 2010; Yan & Lin, 2009; Amigun et al., 2008; Demirbas, 2008; Rajagopal & Zilberman, 2007).

Consequently, global production of bioethanol – biofuel from starch crops – for instance rose from 17 billion liters in 2000 to 66 billion liters in 2008 (Kojima, 2010). During the same period, the production of biodiesel – biofuel from oilseed crops – rose even faster: from less than one billion liters to 12 billion liters (Kojima, 2010). By 2030, these two could provide up to 10% of the global transport sector's energy demand given projected oil and carbon prices, and technology hold true (Ravindranath et al., 2010).

In South Africa too there is a mounting interest to jump start the almost-non-existent local biofuel sector. The main rationale behind it, in line with other developing countries, is *'…to stimulate rural development and to reduce poverty by creating sustainable income-earning opportunities'* (DME, 2007). This is because despite recent progress, the *Rainbow* nation's economy is dual in nature: *'the first is advanced, sophisticated…which is becoming more globally competitive [while] the second is mainly informal, marginalized,…populated by the unemployed...'* (South Africa Info, 2011). Accordingly, the South African government issued various policy papers since the late 1990s that put biofuels forward as a tool in tapering this gap. Those strategies outline the government's approach to regulations and incentives regarding biofuel production and consumption in the country. Even if there are no large scale biofuel firms as of yet, there have been progress made in processing capacity thereafter (DME, 2014; Cartwright, 2007).

Despite the optimism in South Africa and elsewhere, there are legitimate concerns on the potential of biofuels as a long-run sustainable energy sources and development tools (Markevičius et al., 2010; Charles et al., 2007; Dufey, 2006). The growth of the sector may lead to severe shortages and, as a result, to price hikes in the already strained global food market now that edible agricultural products are used as feedstock in biofuel refineries. With the limited land and water resources available, the expansion of biofuel sector could also lead to the displacement of local farms and distraction of the already dwindling global biodiversity. Also, many of the social benefits of biofuel sector may not be met if the production is dominated by a few large multinational firms as it sometimes is the case.

Therefore, it is very imperative to thoroughly examine the financial, economic, social and environmental opportunities and costs associated with a particular biofuel policy at local, regional, national and global levels. There is also a need to identify trade-offs involved. *' [With] the vast array of issues involved, the lack of knowledge about many of these issues together with the different policy objectives and business interests associated with [it],… this is essential in order for the biofuel industry to develop without leading to a scenario in which [it] provides a solution to one specific problem while creating many more'* (Dufey, 2006).

### 1.2. Problem statement

Clear government policy regulations and incentives are a pre-requisite for the development of a sound biofuel industry (DME, 2007). South Africa's first notable biofuel action plan that sets out the government's general vision was the 1998's *White Paper on Energy Policy*. It recognized the potential of modern biofuels from many agricultural products, by-products and residuals as source of energy and economic development (DME, 1998). In the early years of the new millennium, the government proceeded by issuing the *Johannesburg plan of Implementation* and the more specific *White Paper on Renewable Energy* respectively that set a renewable energy target of 10,000 GWh in addition to the country's estimated existing renewable energy production of 115,278 GWh per annum (DME, 2003). A levy exemption for biodiesel producers followed promptly that ranges between 30% and 40% for firms and 100% for small-scale producers (DME, 2007).

However, South Africa's most recent and detailed biofuel policy is the *South African Biofuels Industrial Strategy.* It was adopted in 2007 by the country's Department of Minerals and Energy (DME) after going through a special task team and the general public for discussions and feedback. It targets a 2% penetration level of biofuels in the domestic liquid fuel supply from the use of local crops grown primarily on the underutilized land in the former homelands which were previously neglected by the apartheid system. The existing fuel levy exemptions for biodiesels were prolonged while a 100% fuel tax exemption for bioethanol was introduced (DME, 2007).

Rather controversially, the national strategy puts forward sugar cane, sugar beet, sunflower, and beans as the only feedstock permitted (DME, 2007). The use of maize in the production of bioethanol is intentionally left out due to food security concerns for it is the most important staple crop in the country. However, South Africa being a "surplus" maize producer managing to export up to three million tons a year, this notion i.e. using maize as feedstock may jeopardize food security, is rejected by some stakeholders. There are ongoing calls especially from grain farmers' unions to amend the strategy and include maize in the country's feedstock matrix (Esterhuizen, 2009; Cartwright, 2007).

To analysis the domino impacts of a new, or changes to existing developmental and poverty alleviation policies, such as this, contemporary economics prescribes I-O (Input-output), SAM (Social Accounting Matrix) or CGE (Computable General Equilibrium) models (Allan, 2011). They all have appropriate methodological framework to capture the *status quo* and estimate deviations as a result of intervention with ascending details respectively. Choice would depend on the availability of data, aim of study and assumptions made among others.

*This thesis uses a disaggregated SAM with comprehensive data on production and income to explore whether there is strong economic rationale in terms of structural change, value-added gain and income distribution for producing and exporting bioethanol from surplus maize in South Africa* with the aim of contributing to the ongoing debate. Using only surplus maize – the maize produce which is in excess of local consumption – implies there wouldn't be increased demand and, as a result, a demand-pull inflation in the domestic agricultural sector; and there wouldn't be a need for allocating additional land and water resources for maize production due to this particular policy change. The analysis is also carried out assuming the bioethanol produced is destined to the international market. This would result in an interesting scenario where instead of exporting a raw material, value-added is generated in the home economy and a finished product is exported.

The specific thesis questions raised and addressed, thus, are:

- Which sectors of the economy would grow following the policy change? Which would not? Why?
- Would the policy change lead to a net increase in the national economy? In other words, would the expansion of some sectors be able to offset the contraction of others?
- Which particular occupation types would gain or lose earnings following the policy change? Which population groups would be affected the most? Why?
- Would there be adjustments in labor and capital earnings i.e. value-added? What happens to income inequality?
- And finally, would the policy change lead to the creation of biofuel industry which is able to stimulate sustainable development in South Africa?

### 1.3. Outline

This thesis has seven chapters. Chapter 1 has made a brief *introduction* to the global biofuel industry as a background where current level of production, future trends, prospects and concerns of the industry were briefly presented. Problem statement followed by discussing South African biofuel policies and laid out specific questions the thesis aims to answer later on.

Chapter 2, appropriately called *literature review*, encapsulates analytical approaches used in most developmental and income distribution studies with the aim of familiarizing the reader with methodologies used in the subject matter. It also summarizes some empirical and scenario studies dealing with various countries; however, more attention is paid to those focusing on the developing world in general and South Africa in particular.

Chapter 3 shows the *methodology* in which the problem statement is to be analyzed along with the assumptions under which it is valid. It is rather deliberately theoretical.

Then in chapter 4, *data* is presented and interpreted. Furthermore, source materials are clearly stated, and adjustments made, if any, are specified. It is meant to compliment the previous chapter.

In *simulation*, the 5th chapter, the theoretical background presented earlier is used as a framework while data is simulated according to three policy scenarios. The details of those scenarios and calculations made are moreover described.

Chapter 6 discloses *results* obtained from the simulation and discusses them. By doing so, it presents each of the policy scenario's economic-wide consequences.

Chapter 7, the final chapter, makes a brief summary of the preceding chapters and builds upon the results obtained in chapter 6 to arrive at the author's *conclusion*.

With the aim of making the study thorough and easier to follow, *abbreviations* are made available in front while more data and result tables are presented in the *annex* part just following *references.*

# 2. Literature review

This chapter, first, provides with some broad guidelines one ought to consider when choosing an appropriate approach to analyze a certain policy scenario. Then, it gives a bird's-eye view of the most common analytical approaches used in developmental and income distribution studies. In the process, a suitable model is chosen for this particular thesis followed by explanations why. Finally, various biofuel-centric empirical and scenario studies are presented to further familiarize the reader with the approaches and, most importantly, their application. Studies dealing with the developing world in general and South Africa in particular are prioritized.

## 2.1. Analytical approaches

Caution should be taken when choosing an appropriate methodological framework to analyze a particular economic policy by taking into account not only the aim of the study, the soundness of economic theory and availability of data but also the simplicity of the model, the validity of the results and the ease with which they can be interpreted. It is with this notion one should choose from I-O, SAM and CGE models when analyzing structural and or income distribution changes purely expressed in monetary terms following an exogenous demand shock since they neatly capture complex transactions between various agents in an economy.

I-O models are the least complicated. They are based on the rather straightforward idea that any output requires corresponding inputs (Leeuwen & Nijkamp, 2009). Developed by Leontief in the 1930s, they are static models designed to explain or predict adjustments in the utilization of labor, capital and intermediate inputs by industries in response to a change in exogenous demand such as private investment or government spending assuming a homogeneous industrial output, constant returns to scale and no technological improvement during the analysis period which is usually one year (Leeuwen & Nijkamp, 2009; Lee & Mokhtarian, 2004). However, conventional I-O models do not take into account the income distribution effect of policies i.e. the link between output, factorial and household income, and consumption which is one of the aims of this thesis. Therefore, I-O models are outright not considered as a tool.

Combining comprehensive data on production, income generation and expenditure; SAMs took static policy analysis several steps forward after they were initially developed in the 1960s. They are tools not only to analyze production i.e. the adjustments in the utilization of labor, capital and intermediate inputs by industries but also production-income and income-expenditure linkages in a given economic area so that the distributional effects of a change in exogenous demand can be captured accordingly (Leeuwen & Nijkamp, 2009). They assume constant prices, unconstrained factor resources and unchanged consumption patterns.

In recent economics literature, CGE models are more prominent. By incorporating SAMs as a core dataset in addition to a number of behavioral and structural functions, these models are a standard tool of empirical analysis widely used to trace welfare and distributional impacts of policies (Leeuwen & Nijkamp, 2009; Grassini, 2007, Wing 2004). CGEs allow commodity and factor prices to change, thus, they are able to capture consumption and production decisions by households and firms more realistically when compared to the first two models. They may also describe how demand and supply decisions made by different economic actors determine the prices of commodities and factors (Grassini, 2007).

However, one is better of using carefully constructed SAMs than CGE models, it can be argued, if the policy change i.e. the exogenous demand change we examine presumably results in no to small changes in commodity prices since the latter, notwithstanding their usefulness, contain a large number of variables and parameters, and tend to be overly structurally complex. This thesis presumes no demand-pull price hikes because only the maize produce which is in excess of local consumption is to be allocated as biofuel feedstock and the resulting bioethanol is to be exported leaving the domestic market intact. Thus, a relatively simple to carry out and interpret yet valid SAM is developed. But, it should be reiterated I-O and CGE models are a powerful tool of economic analysis at regional, national and even global levels. Hence, they continue to be intensively studied and empirically applied.

### 2.2. Empirical and scenario studies

Evaluating the long term implications of a biofuel policy is both complex and technically challenging. Despite that, numerous papers have been published using various models to estimate changes in GDP, employment and poverty rates subsequent to a certain biofuel policy.

Cunha and Scaramucci (2007) is an excellent example of biofuel feasibility studies. It uses an I-O model to assess the socioeconomic after-effect of increasing Brazil's biofuel production by 104.6 billion liters in 20 years so as to replace 5% of the estimated global gasoline demand. In the simulation carried out, sugarcane is considered as the major feedstock to be grown in the country's extensive unused land excluding protected reserves. The findings suggest such a policy move would result in 11% increase in GDP and more than five million in job creation.

Neuwahl et al. (2008), another I-O analysis, looks at the aftermath of EU biofuel policies in the union's labor market by considering biofuel penetration scenarios outlined by the so-called *Biofuels Progress Report* (EC, 2007a) and *Renewable Energy Road Map* (EC, 2007b). The study's conclusion is positive but modest. It shows accelerated job creation standing in hundreds of thousands in the agriculture, food and biofuel sectors but the gains are almost entirely offset by jobs lost in the energy and transportation sectors.

Arndt et al. (2008), a CGE model based study, shows allocating land for sugarcane plantations in Mozambique for bioethanol and small-scale jatropha farms for biodiesel production increase the average annual economic growth rate of the country by 0.6% and reduces poverty incident by 6% points in 12 years. Jatropha is found to be much more strongly pro-poor due to greater use of unskilled labor in its cultivation. Welfare and food security broadly increases as well due to enhanced purchasing power.

Using very similar method of analysis to that of Arndt et al. (2008), Arndt et al. (2010) evaluates various biofuel production scenarios in Tanzania that vary by type of feedstock and biofuel produced, scale of feedstock production, the ways in which yield of feedstock is expanded, and scale of biofuel production. The findings state using sugarcane, molasses and cassava as feedstock both at small-scale and large-scale plantations in Tanzania increases GDP and factor returns. Cassava and jatropha are found to be more effective at raising the country's poor households' income in comparison to maize.

South Africa conducted a feasibility study prior to adopting the national biofuel strategy (Cartwright, 2007; DME, 2007). Applying a SAM, the study analyzes the impact of a 2% biofuel penetration in the national liquid fuel supply using local sugar cane, sunflower, canola and soya beans from underutilized and some additional land as feedstock. The study shows the policy would not only be able to create 25,000 jobs reducing unemployment by 0.6% but also boost economic growth by 0.05% (DME, 2007). Hence, the study concludes, a biofuel sector could have a long term growth prospect. The study, however, is criticized as it provides no data whatsoever on the quality of the jobs created, and concerns are prevalent that these jobs may largely pay poorly (Maltitz & Brent, 2008). It don't also include maize in the analysis.

Finally, a comparative robust regression analysis of physical output, values and inputs of various candidate biofuel feedstock in South Africa that includes maize to estimate employment and poverty effects by Ngepah (2011) arrives at mixed conclusions. The paper states using maize as feedstock increases net employment but insignificantly. When it comes to the severely poor, the finding is quite worrisome: increase in the price of maize, a staple food for the poor, because of a rise in feedstock demand could lead to the very poor allocating higher proportion of their income to food consumption, thus, increasing poverty incidence. If a biofuel strategy's intent is to promote poverty reduction, sugarcane should be prioritized for bioethanol and groundnut for biodiesel recommends the paper. Unlike Mozambique and Tanzania, the poverty reduction comes because of employment in commercial farms.

Although they deal with different countries and policies, the consensus of these studies is that biofuel policies generally tend to lead to GDP increase albeit modestly. This is because the significant gain in GDP due to the expansion of the biofuel-feedstock-providing agriculture and biofuel sectors is offset mainly by the contraction of oil refineries and the transportation sector. The same goes for net employment gains. Cunha and Scaramucci (2007) seems to be the exception but the estimated economic growth and employment opportunity is for the entire two decades which regrettably translates yet again to modest yearly gains. Also, the studies indicate biofuel production generally leads to poverty reduction if the feedstock is mainly produced by the poor. However, biofuel based on staple crops can exacerbate poverty.

# 3. Methodology

The previous chapter introduces SAMs and establishes them as the preferred model of analysis for this particular thesis. But, it hardly went to the nitty-gritty of these models. Hence, this chapter, first, takes a closer look on SAMs and their components by using both figurative and tabular representations. Then, it proceeds to their inner-workings in detail by explaining how the so-called SAM multiplier formula is derived, what it actually does, under which assumptions it is valid and further computations needed to make it a more convenient analytical tool. The chapter is theoretical by design.

### 3.1. A closer look on SAMs

As seen in figure 1, a given economy is composed of complex transactions between various economic agents where ones income is another's expenditure. A SAM is simply a systematic tabular representation of those transactions with extensive data on production, income and expenditure (table 1). Each cell in the table represents a flow of funds from a column to a row which we call "account". The underlying principle of double-entry accounting makes sure, for each account in the SAM, total revenue equals total expenditure.

The first account is goods and services. The column records the value of commodities supplied to the economy i.e. domestic supply (R2,C1) and imports (R7,C1). After adding sales taxes and import tariffs (R5,C1) to these two, we get total supply of commodities at market prices (R8,C1). On the other hand, the row shows how the total supply is used by accounts as intermediate input (R1,C2), and final demand which constitutes households' consumption demand (R1,C4), government's recurrent spending (R1,C5), private enterprises' investment demand (R1,C6) and exports (R1,C7).

The activities account depicts the production of goods and services by domestic sectors. This is explicitly shown in table 1 where activities pay for intermediate inputs (R1,C2) and factors, to the later in the form of wage and rent altogether referred as value-added (R3,C2), to produce various commodities (R8,C2). The corresponding row shows the same value but in terms of income i.e. activity income (R2,C8) which is equal to domestic supply (R2,C1).

Households are the ultimate owners of factors of production, and hence receive the income earned by factors of production (R4,C3). In addition, they receive social transfers from the government (R4,C5) and remittances from abroad (R4,C7). Their expenses are consumption of goods and services (R1,C4), and direct taxes (R5,C4). They, then, retain the remaining income as private saving (R6,C4). The government, the second institution, receives direct taxes (R5,C4), indirect taxes (R5,C1) and foreign loans and grants (R5,C7) as total income which then are used to pay for recurrent consumption spending (R1,C5) and social transfers (R4,C5) to households in need. The difference between total revenue and total expenditure is called fiscal surplus (R6,C5) and is the government's saving.

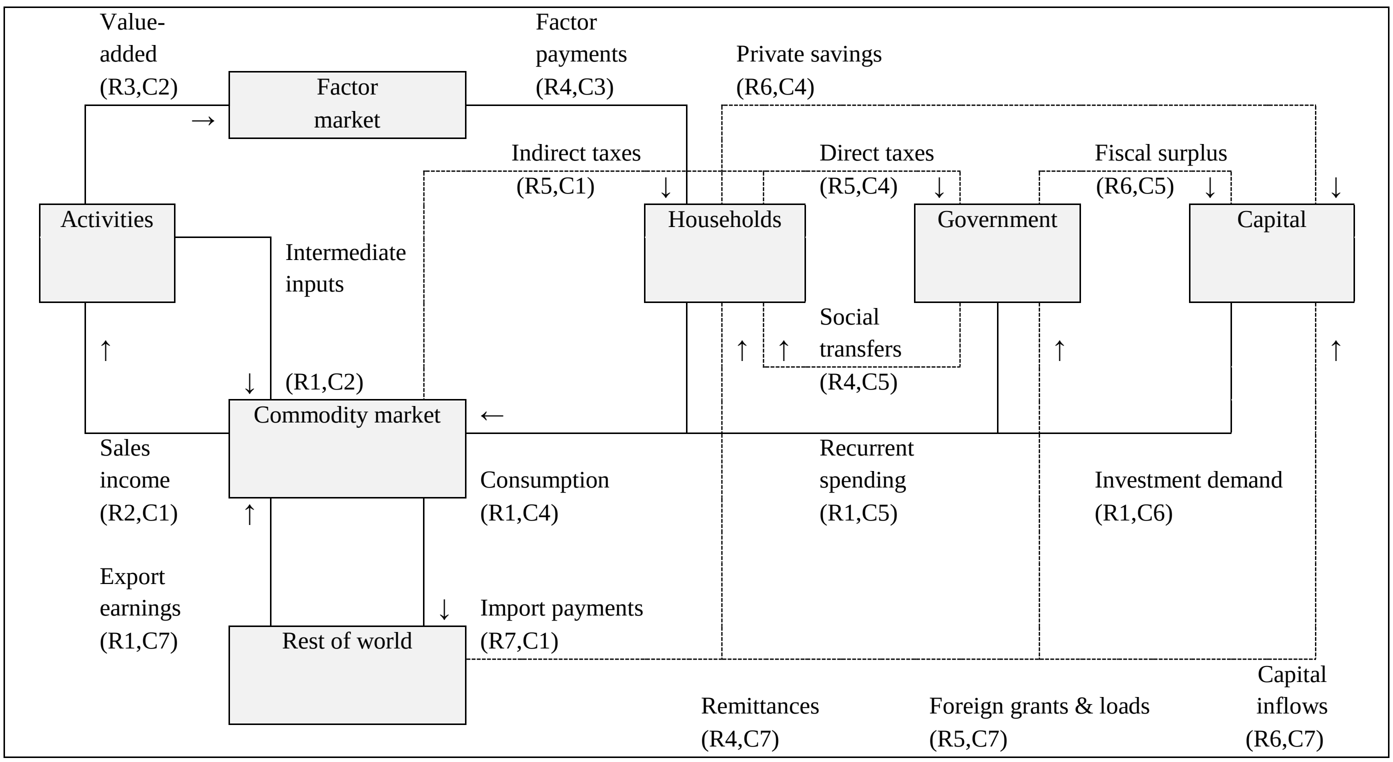


Figure 1. Transactions in an economy

Source: Breisinger et al. (2009)

The remaining accounts are capital and the rest of the world. The former often also known as investment account deals with wealth rather than income, and includes gross capital formation and inventories. As seen in table 1, besides data on total domestic saving and total investment demand, this account shows current account balance (R6,C7). The later i.e. rest of the world account, shows the economic tie of the country to the outside world and consequently its main components are import payments (R7,C1) and export earnings (R1,C7).

### 3.2. Multiplier analysis

In addition to being a resourceful national accounting framework capturing transactions within the economy, SAM is also a macroeconomic analysis tool. This is because using the so-called SAM multiplier formula, the economy-wide impacts of a change in an exogenous demand can be estimated. Since government, capital and the rest of the world (C5-C7) are generally considered to be the only exogenous accounts, the three possible sources of exogenously determined change are: government recurrent spending, investment demand and export demand (Breisinger et al., 2009). Hence, SAM multiplier formula estimates the economy-wide impacts of a change in export demand, government spending and or investment demand, or any other policy which results in these changes. One way of driving the SAM multiplier formula used by the likes of Arita et al. (2011) and Sinha et al. (2000) is as follows:

Table 1. Basic structure of a SAM

| | Expenditure | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|---|
| | | Goods & services | Activities | Factors | Households | Government | Capital | Rest of world | Total |
| | | G | A | F | H | E | | | |
| R1 | Goods & services | | Intermediate inputs | | Consumption spending | Recurrent spending | Investment demand | Export earnings | Demand |
| | G | | $R$ | | $C$ | | $E_c$ | | $Z$ |
| R2 | Activities | Domestic supply | | | | | | | Activity income |
| | A | $X$ | | | | | | | $X$ |
| R3 | Factors | | Value-added | | | | | | Factor income |
| | F | | $V$ | | | | | | $V$ |
| R4 | Households | | | Factor payment to households | | Social transfers | | Foreign remittances | Household income |
| | H | | | $V$ | | | $E_h$ | | $Y$ |
| R5 | Government | Sales taxes & import tariffs | | | Direct taxes | | | Foreign grants & loans | Government income |
| R6 | Capital | | | | Private savings | Fiscal surplus | | Current account balance | Savings |
| R7 | Rest of world | Import payments | | | | | | | Foreign exchange outflow |
| | E | | | | | | | | $E$ |
| R8 | Total | Supply | Output | Factor spending | Households spending | Government expenditure | Investment spending | Foreign exchange inflow | |
| Income | | $Z$ | $X$ | $V$ | $Y$ | | $E$ | | |

Source: Breisinger et al. (2009)

We begin by dividing each endogenous column (C1-C4) in table 1 by its column total, as seen in equation 1-4, to derive a coefficient matrix called "$M$-matrix" (equation 5).

$$a = \frac{R}{X} \tag{1}$$

$$v = \frac{V}{X} \tag{2}$$

$$b = \frac{X}{Z} \tag{3}$$

$$c = \frac{C}{Y} \tag{4}$$

$$M = \begin{bmatrix} 0 & a & 0 & c \\ b & 0 & 0 & 0 \\ 0 & v & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

Then, table 1 can be written as equation 6 in a matrix form. The first vector is total income (C8) while the last is the sum of the three exogenous accounts (C5-C7). The $4 * 4$ matrix is $M$-matrix.

$$\begin{bmatrix} Z \\ X \\ V \\ Y \end{bmatrix} = \begin{bmatrix} 0 & a & 0 & c \\ b & 0 & 0 & 0 \\ 0 & v & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} Z \\ X \\ V \\ Y \end{bmatrix} + \begin{bmatrix} E_c \\ 0 \\ 0 \\ E_h \end{bmatrix} \tag{6}$$

Denoting the total income and exogenous vectors as $Y_t$ and $E$ respectively, we get:

$$Y_t = MY_t + E \tag{7}$$

As seen below, we proceed to solving for $Y_t$ to get the SAM multiplier formula (equation 8). The formula shows the inverse of the difference between identity and coefficient matrices multiplied by the exogenous vector gives the total income vector assuming *(i) fixed prices, (ii) unconstrained factor resource, (iii) unchanged input coefficients, and (iv) unchanged consumption patterns.*

$$Y_t - MY_t = E$$

$$Y_t(I - M) = E$$

$$Y_t = (I - M)^{-1}E \tag{8}$$

Thus, more specifically, when there is a new exogenous demand vector $E$ following a change in government spending, investment demand and or export demand; the resulting new levels of total income vector $Y_t$ i.e. total demand, and total incomes of activity, factor and household can be estimated using SAM multiplier formula by just multiplying the inverse of the difference between identity and coefficient matrices by the new exogenous demand vector.

### 3.3. Incorporating a new activity

Sometimes there is a need to conduct a what-if analysis and see the impacts of introducing a new activity into an economy. To do so, we can use the so called final-demand approach (Miller & Blair, 1985). Even though the approach was initially developed using I-O, it can be applied to SAM framework (Allan, 2011).

First, from a SAM coefficient table for another country or from surveys, we estimate what the inputs will be from the existing activities per a dollar or other currency worth of the new activity's output i.e. the new activity's intermediate unit production costs per a dollar, or simply intermediate input coefficients. Let that be denoted by $a_n$.

Now, assume the new activity's targeted total output in value is $\overline{X}$. Then, $a\overline{X}$ – inputs from the existing activities per a dollar worth of the new activity's output multiplied by the new activity's total output in value – gives us the additional demand for the existing commodities that arise due to the introduction of the new activity. We can view this new demand for commodities as exogenous demand change denoted by $\Delta E$ imposed on the original activities in addition to $E$. Consequently:

$$\Delta E = \begin{bmatrix} a\overline{X} \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (9)$$

Finally, the changes in total income vector denoted by $\Delta Y_t$ following changes in the exogenous account vector – itself the aftermath of the introduction of a new activity – is given by equation 10 which is derived from equation 8. Similarly, the new total income vector following the introduction of the new activity would be the sum of the initial total income vector and the change in total income (equation 11). These formulas are valid only if *(i) the existing activities' output can be used by the new activity and (ii) the new activity's output is only used to satisfy exogenous final demand* (Miller & Blair, 1985).

$$\Delta Y_t = (I - A)^{-1} \Delta E \quad (10)$$

$$Y_{tn} = Y_t + \Delta Y_t \quad (11)$$

# 4. Data

Both aggregated and disaggregated versions of South Africa's updated 2005 SAM is the main sources of data. For the first and most part, this chapter presents and discusses the accounts of the SAM in order to articulate the composition of the South African economy. It roughly follows the framework set in the first section of the pervious chapter. Then, the SAM is modified – some accounts are disaggregated, others aggregated – for the sole purpose of analysis.

### 4.1. An overview of South Africa's SAM

South Africa's updated SAM for 2005 was constructed by Stats SA (2010) based on data from national supply and use tables, national accounts, different household surveys, and published and unpublished reports from the South African Reserve Bank (SARB). It provides reliable data on the composition of the South African Economy: the goods and services, activities, factors of production, institutions, capital and external balance (annex 1).

In the disaggregated SAM, the goods and services account is divided into nine broad categories: agriculture, mining, manufacturing, electricity and water, construction, trade, transportation and communication, finance and business, and governmental, health and social services which all are further disaggregated into 27 subcategories (annex 2). In 2005, as seen in table 2, 47% and 33% of those goods and services available in the economy were used as intermediate inputs by activities, and as finished products by households and the government respectively. Household consumption spending alone was one third – over ZAR 1.1 trillion – of the entire goods and services account out of which 70% was spent on manufactured products, and financial and business services. As seen in figure 2, the dominance of those sectors was true in all the four recognized population groups of the country (annex 3).

The South African activities account is also classified into nine broad categories with 27 subcategories. As seen in table 3, domestic activities produced ZAR 3.2 trillion worth goods and services, the lion share of which came from manufacturing, and finance and business services with 32% and 17% shares respectively. The significance of other services such as trade, and transport and communication with shares of 11% and 10% respectively indicate a maturing economy. But, well-endowed with gold, chrome, iron ore and coal; the country's mineral production – worth double its agricultural sector – is still important.

Table 2. Goods and services account

| Row | | ZAR mil. | Column | ZAR mil. |
|---|---|---|---|---|
| Intermediate inputs | | 1,847,084 | Domestic supply | 3,248,151 |
| Household consumption | 990,774 | | Taxes | 175,667 |
| Government spending | 305,732 | | Subsidies | (5,652) |
| Final consumption | | 1,296,506 | Imports | 437,559 |
| Gross fixed capital formation | 263,754 | | | |
| Changes in inventories | 18,376 | | | |
| Investment demand | | 282,130 | | |
| Exports | | 430,169 | | |
| Residual | | (164) | | |
| Total | | 3,855,725 | | 3,855,725 |

Source: Stats SA (2010)

Table 3. Activities account

| Row | | ZAR mil. | Column | | ZAR mil. |
|---|---|---|---|---|---|
| Agriculture | 84,524 | | Intermediate inputs | | 1,847,084 |
| Mining | 189,495 | | Net value-added | 1,213,277 | |
| Manufacturing | 1,029,868 | | Consumption of fixed capital | 187,790 | |
| Electricity & water | 67,253 | | Gross value-added | | 1,401,067 |
| Construction | 144,967 | | | | |
| Trade services | 367,192 | | | | |
| Transport & com. | 308,285 | | | | |
| Finance & business | 551,634 | | | | |
| Gov., health & social | 408,557 | | | | |
| Other | 96,376 | | | | |
| Domestic supply | | 3,248,151 | | | |
| Total | | 3,248,151 | | | 3,248,151 |

Source: Stats SA (2010)

Table 4. Factors account

| Row | | ZAR mil. | Column | ZAR mil. |
|---|---|---|---|---|
| Compensation of employees | 699,018 | | Net generated income | 1,210,561 |
| Net operating surplus | 514,259 | | Compensation of employees to ROW | 6,618 |
| Domestic value-added | | 1,213,277 | | |
| Compensation of employees from ROW | | 3,902 | | |
| Total | | 1,217,179 | | 1,217,179 |

Source: Stats SA (2010)

The factors account of the disaggregated SAM, on the other hand, consists of employee compensation to labor – which is presented based on the four population groups and 11 occupations (annex 4); and net operating surplus to capital. In the year 2005, total value-added for South Africa stood at around ZAR 1.2 trillion. Even though labor accounted for about 60% of the total value-added; agriculture, mining, transport and communication, and finance and business services stood out as capital intensive. Also, looking at figure 4, one can notice the unevenness of employee compensation to white and black South Africans, and its immense magnitude. Even though white South Africans accounted only for 9% of the total population, they received 45% of the national employee compensation. Agriculture, manufacturing, and finance and business were even more unequal where white employees earned well above 50% of the sectorial compensation. On the other end of the spectrum, black South Africans received 40% of the total employee compensation although they accounted close to 80% of the total population. Mining – possibly because of influential labor unions – and governmental jobs were more equitable to blacks.

The SAM identifies households, non-financial corporations, financial corporations and government as institutions. They are stated in the accounts of allocation of primary income, secondary distribution of income and allocation of income (annex 1). The former shows how income is distributed to institutions as a consequence of their direct involvement in the process of production or ownership of factors of production whereas the second shows the further redistribution of income among resident institutions and between them and the rest of the world. The last summarizes how households and the government allocate income on goods and services, or saving. Those accounts therefore present data on property income, current transfers and saving in addition to the value-added introduced earlier. Detail of each account is presented in table 6.

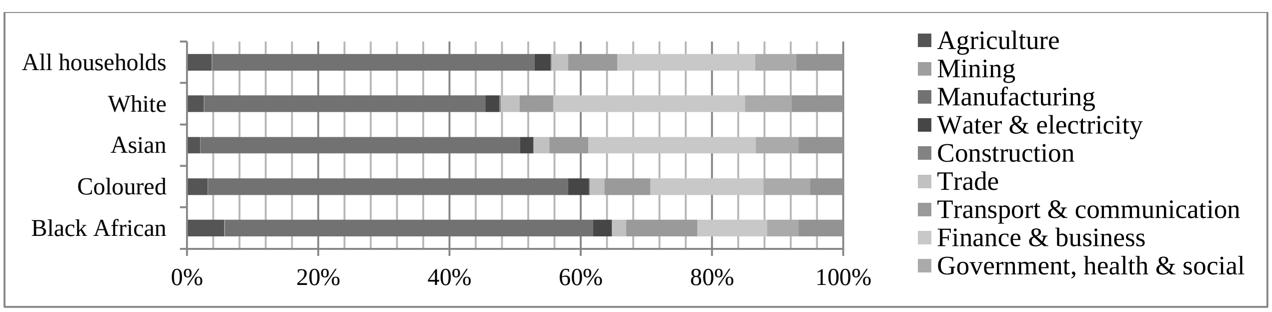


Figure 2. Household consumption expenditure on goods and services of population groups

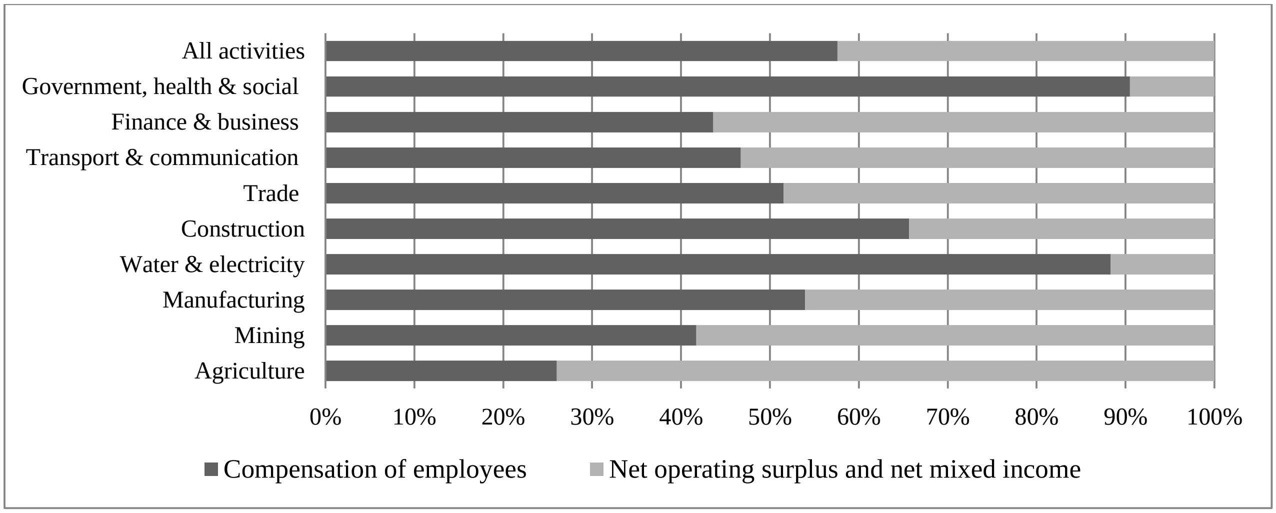


Figure 3. Labor and capital shares in value-added

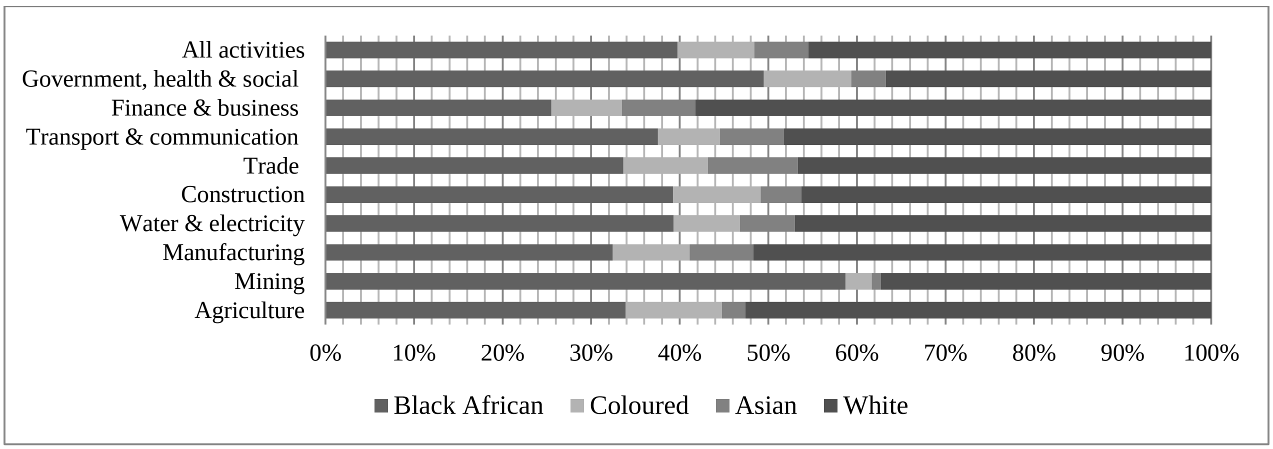


Figure 4. Distribution of employee compensation to population groups

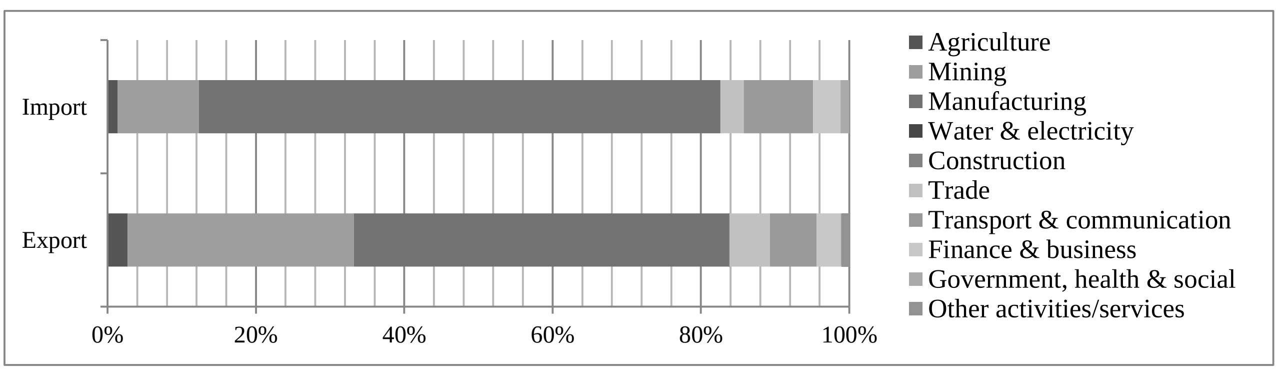


Figure 5. Export and import components

Table 5. Capital and financial accounts

| Row | ZAR mil. | Column | ZAR mil. |
|---|---|---|---|
| *Capital:* | | | |
| Net saving | 39,845 | Changes in inventories | 18,376 |
| Borrowing | 708,868 | Net fixed capital formation | 75,964 |
| Capital transfer from ROW | 283 | Lending | 654,566 |
| | | Capital transfer to ROW | 90 |
| Total | 748,996 | | 748,996 |
| Consumption of fixed capital | 187,790 | Gross fixed capital formation | 263,754 |
| Net fixed capital formation | 75,964 | | |
| Total | 263,754 | | 263,754 |
| *Financial:* | | | |
| Lending | 654,566 | Borrowing | 708,868 |
| Net lending of ROW | 54,302 | | |
| Total | 708,868 | | 708,868 |

Source: Stats SA (2010)

Table 6. Institutions' income and expenditure

| Row | ZAR mil. | Column | | ZAR mil. |
|---|---|---|---|---|
| *Allocation of primary income:* | | | | |
| Net generated income | 1,210,561 | Property income | | 480,226 |
| Tax less subsidies | 170,015 | Net national income | | 1,351,867 |
| Property income | 480,226 | Property income to ROW | | 54,357 |
| Property income from ROW | 25,648 | | | |
| Total | 1,886,450 | | | 1,886,450 |
| *Secondary distribution of income:* | | | | |
| Net national income | 1,351,867 | Current transfer | | 601,216 |
| Curr. taxes on inc., wealth & curr. transf. | 601,216 | Net disposable income | | 1,336,187 |
| Curr. taxes on inc., wealth & curr. transf. from ROW | 4,542 | Curr. taxes on inc., wealth & curr. transf. to ROW | | 20,222 |
| Total | 1,957,625 | | | 1,957,625 |
| *Use of income:* | | | | |
| Net disposable income | 1,336,187 | Household consumption | 990,774 | |
| Adjustments | 57,031 | Government spending | 305,732 | |
| Residuals | 164 | Final consumption | | 1,296,506 |
| | | Adjustments | | 57,031 |
| | | Net saving | | 39,845 |
| Total | 1,393,382 | | | 1,393,382 |

Source: Stats SA (2010)

GDP=Compensation of employees + Net operating surplus + Consumption of fixed capital + Tax less subsidies=ZAR 1.6 trillion

In addition to capital i.e. changes in inventory and fixed capital formation, the South African SAM includes financial account. It is simply a capital account of the four institutions that deal with transactions in financial instruments such as securities and bank deposit. The additions here are national borrowing and lending which stood at ZAR 708.9 and 654.6 billion respectively (table 5).

Finally, the rest of the world account shows the export and import of the country categorized into current and capital flows based on the nature of the transaction. As seen in table 7, South Africa earned around ZAR 430.1 billion from exports. As seen in figure 5, at 51% share, South Africa's main exports were manufactured products with basic iron taking the lead. Exporting considerable amounts of gold and coal, minerals with 31% were the second important. Other major exports include services such as transport and communication, fiancé and business, and trade. On the other hand, the country imported ZAR 437.6 billion worth goods and services. The main imports were manufactured goods at staggering 70%, transport equipment and petroleum. Crude oil – destined to refineries – and other mineral imports accounted for about 11%.

Table 7. The Rest of the world account

| Row | ZAR mil. | | ZAR mil. | Column | ZAR mil. | | ZAR mil. |
|---|---|---|---|---|---|---|---|
| *Current:* | | *Capital:* | | *Current:* | | *Capital:* | |
| Imports | 437,559 | Transf. to ROW | 90 | Exports | 430,169 | Transf. from ROW | 283 |
| Comp. emp. to ROW | 6,618 | Curr. ext. bal. | 54,495 | Comp. of emp. from ROW | 3,902 | Net lending of ROW | 54,302 |
| Prop. income to ROW | 54,357 | | | Prop. income from ROW | 25,648 | | |
| Curr. taxes… to ROW | 20,222 | | | Cur. taxes … from ROW | 4,542 | | |
| | | | | Curr. ext. bal. | 54,495 | | |
| Total | 518,756 | | 54,585 | Total | 518,756 | | 54,585 |

Source: Stats SA (2010)

All in all, the SAM confirms the dual nature of the South African economy. The prominence of manufactured products in the household consumption matrix, the domestic activities and export; the significant presence of financial and business services; and the capital intensiveness of agriculture and mining indicate an advanced economy. The continuing disfranchisement of the majority black Africans evidenced by their low share in compensation of employees, however, indicates otherwise: a structurally flawed economy that leaves much to be desired.

### 4.2. Modifying South Africa's SAM

It is a common practice to modify – mostly to disaggregate, occasionally to aggregate – accounts of a source SAM for the soundness of analysis. By the same token, disaggregating the categories of agriculture, mining and manufacturing in the original SAM of South Africa is necessary since it does not show maize, crude oil, petroleum, food and feed – sectors a biofuel policy is likely to affect most – separately. And, the institutions in the original SAM – households, non-financial corporations, financial corporations and the government – are found scattered in the three separate accounts of primary income, secondary distribution of income and allocation of income i.e. all the institutions are mentioned three times. They need to be collected into a single account for each in order to identify the endogenous and the exogenous accounts of the SAM with ease.

The first important modification is creating a separate maize commodity in the goods and services account. To that end, agriculture is first disaggregated into grains and horticulture, forestry, live animals and fishery using a supply and use table prepared by Stats SA (2005). Then, data from the South African Grain Information Service (SAGIS, 2011) on the country's white and yellow maize supply – deliveries both from stock and farms, and imports – and demand – intermediate use, withdrawal by producers, release to end-consumers and exports – for 2005 is multiplied by their respective prices given by the Department of Agriculture, Forestry and Fisheries (DAFF, 2011). White maize and yellow maize are separated from the grain and horticultural category by using the resulting supply and demand in value for the two maize types to complete their corresponding columns and rows respectively (annex 5). In the activities account, the agricultural sector is disaggregated into agriculture, forestry, and live animals and fishery using just the supply and use table by Stats SA (2005).

Crude oil is included in the other mining category of the source SAM's goods and services account. South African Petroleum Industry Association (SAPIA) reported crude oil imports to be ZAR 41.7 billion in 2005 and domestic crude oil production was reported to be 3.3% of total crude oil use (Punt, 2008). At that time, there was no import tariff levied on crude oil before it reached refineries (Punt, 2008). Based on these, the supply side of crude oil is calculated. It is also explicitly stated that all crude oil was solely used by petroleum refineries as intermediate input. Thus, the demand side is completed accordingly. Then, using the calculated demand and supply, crude oil is made into a separate SAM account of its own.

Similarly, there is no separate category for either petroleum fuel – presented along with a wide range of products including chemicals, paints, fertilizer and pharmaceutics – or human food – presented with animal feed simply as food – in the original SAM. Thus, a separate subcategory is constructed for each both at the goods and services, and activities accounts using the supply and use table by Stats SA (2005).

Moreover, in order to use the final demand approach to introduce a biofuel activity into the economy, intermediate input coefficients of the new activity i.e. bioethanol need to be estimated. The unit production costs per rand associated with bioethanol production are not available for South Africa. Therefore, a detailed cost of a representative country should be used. According to Zhou and Kojima (2011), USA can represent South Africa. As seen in table 8, unit cost of production per rand i.e. input coefficients of bioethanol for the US *vis-à-vis* South Africa consists of intermediate input coefficients – which are needed to apply the final demand approach – and factor coefficients. These coefficients show that feedstock is the main cost of bioethanol production whereas animal feed as a production by-product brings in revenue.

Finally, the structure of the institutional accounts is adjusted to reflect the income and expenditure of the four institutions by adding their respective values in allocation of primary income, secondary distribution of income and use of income. No additional data is required.

After all the modifications, we arrive at a workable 126-by-126 SAM with 35 goods and services, 31 activities, one capital, 44 labor – four population groups by 11 occupation types – and four institution subcategories. The capital, financial and ROW accounts of the original SAM are kept. See annex 6 for the modified aggregated SAM.

Table 8. Maize-based bioethanol input coefficients for 2004

| Goods & services, factors | Coefficients ($a$) | |
|---|---|---|
| Maize | 0.68 | |
| Feed | (0.25) | |
| Chemical | 0.06 | |
| Energy | 0.20 | |
| Intermediate input coefficient | | 0.69 |
| Labor | 0.11 | |
| Capital | 0.20 | |
| Value-added coefficient | | 0.31 |
| Total | | 1.00 |

Sources: Zhou & Kojima, (2011)

# 5. Simulation

> Now that we have established a clear method of analysis in chapter three and presented all the necessary data in chapter four, we can proceed to addressing our problem statement under various scenarios. Simply put, this chapter puts forward those scenarios and describes steps taken to simulate each of them.

We aim to explore whether there is a strong economic rationale for producing and exporting bioethanol from surplus maize in South Africa using SAM. Because there are two types of maize, simulation can be carried out under the following three scenarios: *(1) bioethanol is produced from surplus white maize, (2) bioethanol is produced both from surplus white maize and yellow maize, and (3) bioethanol is produced only from surplus yellow maize*.

The simplest part of simulating the policy scenarios is calculating the SAM multiplier formula (equation 8). First, out of the 126 rows and columns of the SAM, four are identified as exogenous accounts. These are government, capital, financial and ROW. Then, column of these accounts are aggregated in *Excel* to get an exogenous vector $E_0$. Meanwhile, each of the remaining 116 columns that include the institutions of households, non-financial corporations and financial corporations is divided by its column total, again in *Excel*, to derive a 116-by-116 coefficient matrix $M_0$ (equation 1-5). After importing vector $E_0$ and matrix $M_0$ into *Stata*, a 116-by-116 identity matrix $I_0$ is created. Applying equation 8 i.e. the inverse of the difference between $I_0$ and $M_0$ is multiplied by $E_0$ to calculate total income matrix $Y_{t0}$. This is of course the SAM multiplier formula and, up to this point, it captures the relation between total income, coefficient matrix and exogenous vector before any policy shocks.

White maize export is close to 2 million tons worth ZAR 1.3 billion (annex 5). The value of bioethanol that can be produced from surplus white maize if its export is suspended is ZAR 1.9 billion because, as seen in table 8, for every ZAR 0.68 maize input ZAR 1 worth bioethanol can be produced. Thus, the new activity's total output in scenario 1 $\overline{X}_1$ is ZAR 1.9 billion. Multiplying the intermediate coefficients for maize-based bioethanol in table 8 i.e. (0.25), 0.06 and 0.20 by ZAR 1.9 billion gives the additional exogenous demand that arises due to the introduction of bioethanol for the existing commodities of feed, other petroleum – chemicals are found in other petroleum category, and electricity – assuming the bioethanol plant's energy source is electricity (equation 9). The additional exogenous demand for white maize, however, is zero since it is offset by the proportional decrease in export demand. Thus, for scenario 1, the change in exogenous demand vector following the introduction of bioethanol $\Delta E_1$ consists of ZAR (0.5), 0.1 and 0.4 billion corresponding to the rows of feed, other petroleum and electricity respectively (annex 7). The remaining rows are zero. Multiplying the inverse of the difference between $I_0$ and $M_0$ by $\Delta E_1$ gives total income change in scenario 1 following the introduction of bioethanol activity: $\Delta Y_{t1}$ (equation 10). The negative change in the exogenous demand for feed shows the demand for feed activity decreases because there is a new supplier in the market: the bioethanol activity.

Total maize export is ZAR 1.5 billion. Bioethanol worth ZAR 2.2 billion can be produced from surplus maize if the export of both white maize and yellow maize is suspended. Thus, for scenario 2, the new activity's total output $\overline{X}_2$ is ZAR 2.2 billion. Similar to scenario 1, the additional demand for the existing commodities that arise due to the introduction of bioethanol activity $\Delta E_2$ is calculated by multiplying maize-based bioethanol coefficients in table 8 by $\overline{X}_2$. The rows of $\Delta E_2$ corresponding to feed, other petroleum and electricity as a result are ZAR (0.6), 0.2, and 0.5 billion respectively. Here too, multiplying the inverse of the difference between $I_0$ and $M_0$ by $\Delta E_2$ gives total income change in scenario 2 following the introduction of bioethanol activity: $\Delta Y_{t2}$.

Export of yellow maize at about ZAR 0.3 billion is much lower than that of white maize. Around ZAR 0.4 billion worth of bioethanol can be produced from it. Thus, the new activity's total output in scenario 3 $\overline{X}_3$ is ZAR 0.4 billion. The additional demand for feed, other petroleum and electricity that arise due to the introduction of the new activity are ZAR (93), 24 and 75 million respectively. Just like the other two scenarios, multiplying the inverse of the difference between $I_0$ and $M_0$ by $\Delta E_3$ is the total income change in scenario 3 following the introduction of bioethanol activity: $\Delta Y_{t3}$.

Now, looking at the three scenarios' change in total income vector i.e. $\Delta Y_{t1}$, $\Delta Y_{t2}$, and $\Delta Y_{t3}$, one can identify the positively and the negatively affected sections of the South African economy as a result of producing and exporting bioethanol using maize that was initially intended for exports as feedstock. Likewise, a conclusion can be made on the benefits or lack thereof, of the bioethanol policy in general.

# 6. Results

Subsequent to simulating the policy scenarios outlined in chapter five, the next step is to present the results. Thus, the impact of the policy shock on domestic supply of goods and services, value-added and institutions' income are presented and discussed in this chapter. Changes in foreign exchange earnings as a consequence are also included. The change in the demand of goods and services is, however, deferred to the annex section.

## 6.1 Activities

The existing domestic activities respond to the introduction of bioethanol differently: some expand, some contract and others are barely affected. Whether they are a major source of intermediate input for the new activity or not determinants in which way they respond.

The biggest decline is seen in agriculture: by ZAR 48, 58 and 10 million in scenarios 1, 2 and 3 respectively (table 9). The rationale is the demand for grains as a source of feed declines since the new activity's by-product can be used as a substitute. Remember, there is ZAR 0.25 worth feed as by-product for every ZAR 1 bioethanol produced (table 8). On the contrary, the domestic production of coal increases by ZAR 61, 73 and 12 million in the three scenarios respectively. This comes as no surprise because coal is the main source of energy in South Africa and energy is the second important intermediate input, just behind feedstock, in bioethanol production. In percentage terms, the increase in coal is more than double than that of the decrease in agriculture. The other primary sectors of forestry, gold and other mining are barely affected in all instances exhibiting disconnect from the bioethanol sector.

There is a decline in food production too: by ZAR 264, 317 and 53 million in scenarios 1, 2 and 3 respectively (table 10). It is as a result of the decline in agricultural commodities, a major intermediate input. Similarly, feed production decreases by ZAR 77, 92 and 16 million in the three scenarios respectively. Just like agriculture, it is negatively affected by bioethanol's production by-product. The remaining manufacturing sectors, however, expand. The significant increase understandably is witnessed in other petroleum sector – ZAR 57, 68 and 13 million – where chemicals, the third important intermediate input for bioethanol production, are included. Increase in domestic production of basic iron, electrical machinery and transportation equipment are also witnessed to satisfy increased demand from setting up a new activity.

Table 9. Impact of bioethanol production on agriculture and mining

| Activities | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Agriculture | 71,783 | -48 | -0.07 | -58 | -0.08 | -10 | -0.01 |
| Forestry | 10,971 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Fishing | 1,770 | -1 | -0.07 | -1 | -0.08 | 0 | -0.01 |
| Coal | 37,042 | 61 | 0.16 | 73 | 0.20 | 12 | 0.03 |
| Gold | 29,748 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Other mining | 122,705 | 2 | 0.00 | 3 | 0.00 | 0 | 0.00 |

The remaining sectors overwhelmingly respond positively. Electricity for example increases by whooping ZAR 379, 456 and 77 million in scenarios 1, 2 and 3 respectively mainly due to the new sectors dependency on electricity for energy, coal-based electricity that is. To coup up with the increased business transactions following the new activity's entry, services such as financial intermediation, transportation and communication flourish in descending order (table 11).

Table 10. Impact of bioethanol production on manufacturing

| Activities | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Food | 178,091 | -264 | -0.15 | -317 | -0.18 | -53 | -0.03 |
| Feed | 2,023 | -77 | -3.80 | -92 | -4.57 | -16 | -0.77 |
| Textiles | 35,908 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 |
| Footwear | 5,350 | 0 | 0.01 | 0 | 0.01 | 0 | 0.00 |
| Petroleum | 78,597 | 7 | 0.01 | 8 | 0.01 | 1 | 0.00 |
| Other petroleum | 168,289 | 57 | 0.03 | 68 | 0.04 | 13 | 0.01 |
| Glass, ceramics, cement | 30,942 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Basic iron/steel | 198,878 | 12 | 0.01 | 14 | 0.01 | 2 | 0.00 |
| Electrical machinery | 28,182 | 12 | 0.04 | 15 | 0.05 | 2 | 0.01 |
| Radio | 11,951 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Transport equipment | 150,695 | 6 | 0.00 | 7 | 0.00 | 1 | 0.00 |
| Other manufacturing | 140,964 | -5 | 0.00 | -6 | 0.00 | -1 | 0.00 |

Over all, in order to produce bioethanol, additional chemical and energy is needed than what is currently available in the domestic market. When the production of chemicals and energy is increased to that end, it triggers the expansion of even more sectors ranging from mining to services. However, the by-product of bioethanol production that can be used as feedstock substitute results in reduced exogenous demand for feed, in the form of decrease investment demand for instance, which in return leads to reduced agricultural production and food. Thanks to the significant increase in electricity, the net increase in domestic production of goods and services remains positive and is valued at ZAR 200, 240 and 44 million in scenarios 1, 2 and 3 respectively.

Table 11. Impact of bioethanol production on electricity, water, construction and services

| Activities | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Electricity | 48,141 | 379 | 0.79 | 456 | 0.95 | 77 | 0.16 |
| Water | 19,111 | -1 | 0.00 | -1 | 0.00 | 0 | 0.00 |
| Construction | 144,967 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 |
| Trade | 282,620 | 3 | 0.00 | 4 | 0.00 | 1 | 0.00 |
| Hotels & restaurants | 84,572 | 2 | 0.00 | 3 | 0.00 | 1 | 0.00 |
| Transport services | 176,365 | 11 | 0.01 | 13 | 0.01 | 2 | 0.00 |
| Communications | 131,920 | 5 | 0.00 | 6 | 0.00 | 1 | 0.00 |
| Financial intermediation | 227,151 | 26 | 0.01 | 32 | 0.01 | 6 | 0.00 |
| Real estate | 157,990 | 4 | 0.00 | 5 | 0.00 | 1 | 0.00 |
| Business activities | 166,493 | 6 | 0.00 | 7 | 0.00 | 1 | 0.00 |
| General government | 333,543 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 |
| Health & social work | 75,014 | 3 | 0.00 | 3 | 0.00 | 1 | 0.00 |
| Other services | 96,376 | -2 | 0.00 | -3 | 0.00 | 0 | 0.00 |

Table 12. Impact of bioethanol production on value-added

| Value-added | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Compensation of employees | 702,919 | 79 | 0.01 | 94 | 0.01 | 16 | 0.00 |
| Net operating surplus & net mixed income | 514,259 | -9 | 0.00 | -11 | 0.00 | -1 | 0.00 |

Table 13. Impact of bioethanol production on compensation of black employees

| Occupation | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Legislators | 51,731 | 6 | 0.01 | 7 | 0.01 | 1 | 0.00 |
| Professionals | 34,524 | 5 | 0.01 | 5 | 0.02 | 1 | 0.00 |
| Technicians | 21,767 | 6 | 0.03 | 7 | 0.03 | 1 | 0.01 |
| Clerks | 26,302 | 1 | 0.01 | 2 | 0.01 | 0 | 0.00 |
| Service workers | 44,479 | -1 | 0.00 | -1 | 0.00 | 0 | 0.00 |
| Skilled agricultural workers | 2,743 | -1 | -0.03 | -1 | -0.03 | 0 | -0.01 |
| Craft workers | 27,237 | 9 | 0.03 | 11 | 0.04 | 2 | 0.01 |
| Plant & machine operators | 26,172 | 3 | 0.01 | 4 | 0.02 | 1 | 0.00 |
| Elementary occupations | 12,979 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Domestic workers | 9,643 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Occupation unspecified | 21,712 | 2 | 0.01 | 3 | 0.01 | 0 | 0.00 |
| Total | 279,288 | 31 | 0.01 | 37 | 0.01 | 6 | 0.00 |

### 6.2. Value-added

Following bioethanol production, the country's value-added changes as well. The extent of the change is mainly determined by bioethanol production intermediate inputs and whether they are labor or capital intensive. Since labor is disaggregated based on race and occupation type, the resulting change can be discussed in these terms.

In general terms, labor income i.e. compensation of employees increases following the policy change by ZAR 79, 94 and 16 million and return of capital decreases by ZAR 9, 11 and 1 million in scenarios 1, 2 and 3 respectively (table 12). The increase in compensation of employees can be attributed to the labor intensiveness of chemical and energy production, two of bioethanol production's intermediate inputs. The decrease in return of capital is as a consequence of the decrease in domestic agricultural production which is, as seen in figure 3, capital intensive.

In regards to labor in terms of population groups, compensation of employees to black Africans increases by ZAR 31, 37 and 6 million in the three policy scenarios (table 13). The highest increase both in value and percentage is in craft workers and technicians. This is because they are involved in producing coal, electricity and chemicals (table 9-11). Legislators, a category that includes government officials and corporation chief executives, and professionals also enjoy rise in income because they are involved in the now expanded trade, transportation and financial intermediation services. On the opposite, skilled agricultural workers and service providers loss ZAR 1 million each in scenarios 1 and 2 due to the decrease in agriculture and food respectively. The service occupations most negatively affected should be in hotels, restaurants and catering businesses because of their strong link to food activity. Domestic workers that are disconnected from biofuel production chain, as one might expect, neither benefit nor are harmed.

Compensation of employees to coloured South Africans increases by the same percentage to that of black Africans (table 14). High skill level occupations here too achieve income increase of ZAR 1 and 2 million in scenarios 1 and 2 due to their involvement in business, transportation and financial intermediaries. Also, technicians and craft workers experience income increases similar to that of legislators and professionals in scenarios 1 and 2. Scenario 3 shows no change both in value and percentage in this particular population group and barely changes in the others because the bioethanol produced is minimal and thus causes no to small economic linkage.

Table 14. Impact of bioethanol production on compensation of coloured employees

| Occupation | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Legislators | 11,608 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Professionals | 8,020 | 1 | 0.02 | 2 | 0.02 | 0 | 0.00 |
| Technicians | 5,642 | 1 | 0.02 | 1 | 0.02 | 0 | 0.00 |
| Clerks | 7,508 | 0 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Service workers | 7,859 | 0 | 0.00 | 0 | 0.01 | 0 | 0.00 |
| Skilled agricultural workers | 721 | 0 | -0.04 | 0 | -0.05 | 0 | -0.01 |
| Craft workers | 6,054 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Plant & machine operators | 4,291 | 0 | -0.01 | -1 | -0.01 | 0 | 0.00 |
| Elementary occupations | 2,629 | 0 | -0.01 | 0 | -0.01 | 0 | 0.00 |
| Domestic workers | 1,439 | 0 | -0.01 | 0 | -0.01 | 0 | 0.00 |
| Occupation unspecified | 5,309 | 0 | 0.01 | 0 | 0.01 | 0 | 0.00 |
| Total | 61,081 | 4 | 0.01 | 5 | 0.01 | 1 | 0.00 |

Just like the previous population groups, the highest increase in compensation of employees to Asians is seen in legislators, professionals, technicians and craft workers (table 15). The reasons are also similar: legislators and professionals due to their involvement in services; and technicians and craft workers due to their involvement in bioethanol production chain. However, agricultural workers in this population group are not negatively affected like the rest. The reason behind is this population group's inclination towards business, service and professional jobs i.e. they are not that much involved in agricultural production to begin with (figure 4).

Table 15. Impact of bioethanol production on compensation of Asian employees

| Occupation | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Legislators | 12,438 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Professionals | 8,220 | 2 | 0.02 | 2 | 0.02 | 0 | 0.00 |
| Technicians | 4,353 | 1 | 0.01 | 1 | 0.02 | 0 | 0.00 |
| Clerks | 4,902 | 0 | 0.01 | 0 | 0.01 | 0 | 0.00 |
| Service workers | 4,232 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Skilled agricultural workers | 44 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Craft workers | 2,711 | 1 | 0.04 | 1 | 0.04 | 0 | 0.01 |
| Plant & machine operators | 1,758 | 0 | 0.01 | 0 | 0.01 | 0 | 0.00 |
| Elementary occupations | 712 | 0 | 0.02 | 0 | 0.02 | 0 | 0.00 |
| Domestic workers | 142 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Occupation unspecified | 3,291 | 0 | 0.01 | 1 | 0.02 | 0 | 0.00 |
| Total | 42,802 | 5 | 0.01 | 6 | 0.01 | 1 | 0.00 |

White South Africans that already take most of the nation's value-added would see their income grow by ZAR 39, 47 and 8 million in scenarios 1, 2 and 3 respectively following the bioethanol policy's implementation. The gains are, again, in craft workers, technicians, legislators and professionals. As seen in table 16, when compared to the other population groups, white craft workers' compensation of employee increases more in percentage and value. This can be an indication that South Africans with European descendant have high-skill jobs thus, higher return. The same can be said about white plant and machine operators. To the contrary, being more than proportionally involved in South Africa's mechanized agricultural sector, the contraction in this sector hurts them the most. Hence, white skilled agriculture workers' value-added decreases by 0.06%, 0.07% and 0.01% in scenarios 1, 2 and 3 respectively, the highest decrease seen in labor income.

Table 16. Impact of bioethanol production on compensation of white employees

| Occupation | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Legislators | 103,059 | 8 | 0.01 | 9 | 0.01 | 2 | 0.00 |
| Professionals | 69,216 | 4 | 0.01 | 5 | 0.01 | 1 | 0.00 |
| Technicians | 39,714 | 8 | 0.02 | 9 | 0.02 | 2 | 0.00 |
| Clerks | 23,814 | 3 | 0.01 | 4 | 0.02 | 1 | 0.00 |
| Service workers | 20,639 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Skilled agricultural workers | 3,461 | -2 | -0.06 | -2 | -0.07 | 0 | -0.01 |
| Craft workers | 21,937 | 10 | 0.04 | 12 | 0.05 | 2 | 0.01 |
| Plant & machine operators | 5,348 | 3 | 0.06 | 4 | 0.07 | 1 | 0.01 |
| Elementary occupations | 4,817 | 0 | -0.01 | 0 | -0.01 | 0 | 0.00 |
| Domestic workers | 356 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Occupation unspecified | 27,387 | 5 | 0.02 | 6 | 0.02 | 1 | 0.00 |
| Total | 319,748 | 39 | 0.01 | 47 | 0.01 | 8 | 0.00 |

In general, tables 13 through 16 show the biofuel policy change would result in up to 0.01% increase in compensation of employees to each of the four population groups. The similarity does not end there; technicians, craft workers, legislators and professionals – engaged in bioethanol intermediate input production and or employed in services that expanded as a result of bioethanol production – are the main beneficiaries and, consequently, account for the major gain. On the other hand, skilled agricultural workers loose the most though to different degree. The net value-added gain following the policy implication would be ZAR 69, 83 and 15 million in scenarios 1, 2 and 3 respectively.

### 6.3. Institutions

The changes in activities and value-added following the bioethanol policy lead to changes in endogenous institutions' income i.e. households' income and firms' income. Also, domestic foreign exchange reserve available for institutions changes since export of one good – maize – is substituted by export of a product – bioethanol.

As seen in table 17, households' income increases by ZAR 200, 242 and 43 million in scenarios 1, 2 and 3 respectively. The ZAR 79, 94 and 16 million of the increase is from compensation of employees, as seen in table 12; the remaining should be incoming transfers from other institutions. Going through table 11, one can notice the increase in income of financial intermediation following the biofuel policy change. Table 17 is a reaffirmation: financial firms' income increases by ZAR 16, 19 and 4 million in scenarios 1, 2 and 3 respectively. Non-financial firms' income, however, decreases by ZAR 5, 6 and 1 million mainly due to the contradiction in firms involved in agriculture, food and feed activities.

The last impact of the bioethanol policy calculated is the change in foreign exchange earnings. Suspending maize exports and exporting the more expensive bioethanol in its place leaves domestic institutions with more foreign exchange earnings: the equivalent of ZAR 593, 713 and 120 million in scenarios 1, 2 and 3 respectively (table 18). For a country with negative balance of trade, the benefit of extra foreign earning reserve should not be underestimated.

Table 17. Impact of bioethanol production on institutions

| Institutions | Base | Δ Scenario 1 | | Δ Scenario 2 | | Δ Scenario 3 | |
|---|---|---|---|---|---|---|---|
| | ZAR mil. | ZAR mil. | % | ZAR mil. | % | ZAR mil. | % |
| Households | 3,321,471 | 202 | 0.01 | 242 | 0.01 | 43 | 0.00 |
| Non-financial | 425,845 | -5 | 0.00 | -6 | 0.00 | -1 | 0.00 |
| Financial | 589,261 | 16 | 0.00 | 19 | 0.00 | 4 | 0.00 |

Table 18. Impact of bioethanol production on foreign exchange earnings

| Foreign exchange earning gain, loss | Scenario 1 ZAR mil. | Scenario 1 ZAR mil. | Scenario 1 ZAR mil. |
|---|---|---|---|
| *Gain* | | | |
| Bioethanol for export | 1,854 | 2,228 | 374 |
| *Loss* | | | |
| White maize export | (1,261) | (1,261) | - |
| Yellow maize export | - | (254) | (254) |
| Net | 593 | 713 | 120 |

## 7. Conclusion

This thesis, using South Africa's disaggregated SAM, has set sail to calculate the economic impacts of producing and exporting bioethanol from "surplus" maize i.e. maize that was meant for export. It has the common constraints of static studies such as assuming constant prices and fixed technology. However since the domestic market is not directly tempered with – the policy change is concerned with exports, the assumption that the price of commodities are not to change at least not significantly due to the biofuel policy appear plausible. Hence, some valid conclusions can be drawn from the simulation carried out.

First, producing and exporting maize-based bioethanol instead of just exporting raw maize leads to expansion in South Africa's activities by up to ZAR 240 million. Especially, sectors producing intermediate inputs to bioethanol such as chemical and energy do well. So do services such as financial intermediation, transportation and communication that benefit from the increased economic transaction in the economy. But not agriculture and food. The by-product of maize-based bioethanol can be used as feedstock, thus, the production of grains, the traditional sources of feed, decreases. The decrease in grain production then leads to a subsequent decline in food.

Secondly, value-added increases by up to ZAR 83 million. It is so as a result of increase in compensation of employees in the production of chemicals and energy, two of bioethanol's intermediate inputs which are labor intensive. Labor income to the four population groups of South Africa i.e. Africans, coloured, Asians and whites increase at similar rate: no income redistribution. The same is not true in regard to occupation types: technical and professional jobs – engaged in bioethanol intermediate input production and employed in services that expanded as a result of bioethanol production respectively – gain the most. On the other hand, because of the decrease in agricultural production which is capital intensive, return of capital decreases.

Finally, the net gain in activities and value-added following the bioethanol policy induce changes in endogenous institutions' income: household and financial firms' income increase by up to ZAR 242 and 19 million respectively. Non-financial firms' income, however, decreases by up to 6 million mainly as a result of the contradiction in firms involved in agriculture, food and feed activities. Also, suspending maize exports and exporting the more expensive bioethanol in its place brings in the equivalent of ZAR 713 million additional foreign exchange earnings.

The thesis's findings are in line with Arndt et al., (2010), and Cunha and Scaramucci (2007) concerning biofuel policies' tendency, in general, to boost the domestic activities of the producing country. Likewise, the result that biofuel policies tend to lead to modest increase in labor return and, thus, household income stands in agreement with Neuwahl et al. (2008) and Arndt et al. (2010). However, there is a stark contrast to the point of being polar opposites in regards to which activities benefit and in which activities the most value-added is attained. For instance, Neuwahl et al. (2008) finds accelerated job creation in agriculture and food sectors but loss in energy and transportation. The difference boils down to the framing of problem statement: Neuwahl et al. (2008) looks at the economic impact of producing bioethanol from increased feedstock production – expands the agriculture sector – to be used domestically – lowers the use of conventional fuel – while this thesis assumes already produced maize to be redirected from exports to bioethanol production and then export the product.

While the economic gains are welcome, the fact this is achieved by expanding the use of coal and petroleum is a point of concern. A comprehensive study perhaps an environmental CGE model that quantifies and compares the positives of using bioethanol in a destination country against the coal use increase in South Africa would be needed. Also, the decrease in agriculture and food, however small, is unsettling. Especially in light of Ngepah (2011) findings concerning biofuel policies possible negative consequences on the poor. Since the main reason behind the decrease is triggered by bioethanol production by-product lowering the demand for domestic agricultural products, exporting the by-product too would avoid that. The feasibility of finding international market for both bioethanol and feed is another issue that needs addressing.

Still, the calculations carried out suggest, producing and exporting bioethanol from surplus maize in South Africa leads to increased domestic economic activities, value-added, institutions' income and foreign exchange earnings. But, experiencing the same rate of growth in value-added, income inequality between the country's racial population groups is not narrowed. It rather slightly grows the economic pie. Therefore, with the concerns and limitations in mind, it can be concluded the bioethanol policy's *raison d'être* could be to generate some value-added and foreign exchange earnings for South Africa by exporting a finished product rather than a commodity; not to induce a long term sustainable development.

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## Annex

### 1. Aggregated SAM for 2005 (ZAR million)

| | Goods & services | Activities | Factors | Allocation of primary income | Secondary distribution of income | Use of income | Capital | | Financial | ROW | | Residuals | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Goods & services | | *Intermediate input* 1,847,084 | | | | *Final consumption expenditure* 1,296,506 | *Changes in inventories* 18,376 | *Gross fixed cap. form.* 263,754 | | *Exports* 430,169 | | (164) | 3,855,725 |
| Activities | *Domestic supply* 3,248,151 | | | | | | | | | | | - | 3,248,151 |
| Factors | | *Net value-added* 1,213,277 | | | | | | | | *Compensation of emp. from ROW* 3,902 | | - | 1,217,179 |
| Allocation of primary Income | *Taxes less subsidies* 170,015 | | *Net income* 1,210,561 | *Property income* 480,226 | | | | | | *Property income from ROW* 25,648 | | - | 1,886,450 |
| Secondary distribution of income | | | | *Net national income* 1,351,867 | *Current taxes on inc., wealth & curr. transf.* 601,216 | | | | | *Current taxes on inc.,wealth & current transfer from ROW* 4,542 | | - | 1,957,625 |
| Use of income | | | | | *Net disposable income* 1,336,187 | *Adj. for change in net equity of HH on pension funds* 57,031 | | | | | | 164 | 1,393,382 |
| Capital | | | | | | *Net saving* 39,845 | *Capital transfer* - | | *Borrowing* 708,868 | | *Cap. transf. from ROW* 283 | - | 748,996 |
| | | *Consump. of fixed capital* 187,790 | | | | | *Net fixed cap. form.* 75,964 | | | | | - | 263,754 |
| Financial | | | | | | | *Lending* 654,566 | | | | *Net lending of ROW* 54,302 | - | 708,868 |
| ROW | *Imports* 437,559 | | *Comp. of emp. to ROW* 6,618 | *Property income to ROW* 54,357 | *Current taxes on inc., wealth & curr. transf. to ROW* 20,222 | | | | | | | - | 518,756 |
| | | | | | | | *Cap. transf. to ROW* 90 | | | *Current external balance* 54,495 | | - | 54,585 |
| Total | 3,855,725 | 3,248,151 | 1,217,179 | 1,886,450 | 1,957,625 | 1,393,382 | 748,996 | 263,754 | 708,868 | 518,756 | 54,585 | - | |

Source: Stats SA (2010)

## 2. Description of goods and services, activities

| Category | Goods & services, activities | Description |
|---|---|---|
| Agriculture | Agriculture[α] | Agriculture, forestry, fishery |
| Mining | Coal | Coal, lignite |
| | Gold | Gold, uranium ore |
| | Other mining[β] | Other mining |
| Manufacturing | Food[γ] | Meat, fish, fruit, vegetable, oil & fat, dairy, grain mill, animal feeds, bakery, sugar, other food, beverages, tobacco |
| | Textiles | Made-up textile, carpet & rugs, other textile, wearing apparel, leather products, handbags |
| | Footwear | Footwear |
| | Petroleum[δ] | Fuel, basic chemicals, paints, fertilizer, pesticides, plastic, rubber, pharmaceutics, soap |
| | Other non-metallic minerals | Glass products, non-structural ceramics, structural ceramics products, cement, other non-metallic |
| | Basic iron & steel | Iron & steel, non-ferrous metals, structural metal, treated metal, general hardware, other fabricated metal, engines, pumps, gears, lifting equipment, general machinery, agricultural machinery, mining machinery, other special machinery, household appliances, office machinery |
| | Electrical machinery | Electric motors, electricity apparatus, wire & cable, accumulators, lighting equipment, other electrical |
| | Radio | Radio, television, optical instrument |
| | Transport equipment | Motor vehicles, motor vehicle parts, other transport |
| | Other manufacturing | Wood, paper, containers of paper, other paper, published & printed, recorded media, furniture, jewelry |
| Water & electricity | Electricity | Electricity |
| | Water | Water |
| Construction | Construction | Building construction, other construction |
| Trade services | Trade | Trade |
| | Hotels & restaurant | Hotel & restaurant |
| Transport & communication Services | Transport services | Transportation |
| | Communications | Communication |
| Finance & business Services | Financial intermediation | Indirectly measured financial services, insurance |
| | Real estate | Real estate |
| | Business activities | Business services |
| Government, health & social services | General government | General government |
| | Health & social work | Health & social work |
| | Other services | Other activities |

Source: Stats SA (2010)

[α] disaggregated to (i) white maize, (ii) yellow maize, (iii) other grains & horticulture, (iv) forestry, (v) live animals and (vi) fishery in goods & services; and (i) agriculture, (ii) forestry, (iii) live animals and fishery in activities

[β] disaggregated to (i) crude oil and (ii) other mining

[γ] disaggregated to (i) food and (ii) feed in both goods & services, and activities

[δ] disaggregated to (i) petroleum and (ii) other petroleum

**3. Population groups**

| Population group | Number | % of total population |
|---|---|---|
| African | 37,205,700 | 79 |
| Coloured | 4,148,800 | 9 |
| Asian | 1,153,900 | 3 |
| White | 4,379,800 | 9 |
| Total | 46,888,200 | 100 |

Source: Stats SA (2010)
these are the standard population classification terms used in South Africa

**4. Standard classification of occupation groups**

| Level | Category | Occupations included |
|---|---|---|
| 4 | Legislators | Legislators; other government officials; directors , chief executives & managers; traditional chiefs & head of village |
| 4 | Professionals | Physicist, chemists & related professionals; statisticians & mathematicians; computing professionals; architects, engineers & related professionals; health professionals & other life science professionals; social science professionals; higher institutions' teachers; writers; creative artists; other professionals |
| 3 | Technicians | Natural & engineering science technicians; electronic equipment operators; ship & aircraft controllers; financial & sales associate professionals; customs & tax associate professionals; associate teachers; police inspectors & detectives; social work associate professionals; religious associates |
| 2 | Clerks | Secretaries; numerical clerks; cashiers & tellers |
| 2 | Service workers | Travel attendants & related workers; restaurant service workers; protective service workers; other personal services workers |
| 2 | Skilled agricultural Workers | Market-oriented gardeners & crop growers; market-oriented animal producers; fishery workers; subsistence agricultural workers |
| 2 | Craft workers | Miners, stone cutters & carvers; metal molders & sheet-metal workers; electrical & electronic equipment mechanics; painters; wood teeters; printing & related traders workers; food processing workers; textile & garment workers |
| 2 | Plant & machine operators | Mining & mineral processing plant operators; metal processing plant operators; wood-processing & papermaking plant operators; locomotive engine drivers & related workers; motor vehicle drivers & related workers; agricultural & other plant operators |
| 1 | Elementary occupation | Street vendors; shoe-cleaning & other street services occupations; window cleaners; doorkeepers; garbage collectors & related workers; elementary sales & services; manufacturing, mining & construction laborers; agricultural, fishery & related laborers |
| 1 | Domestic workers | Domestic & related helpers |
| 1 | Occupation unspecified | Armed forces; unemployed persons; children; foreign visitors; occupations unspecified |

Source: Stats SA (2010)

## 5. Maize supply and demand for 2005

| Component | *White maize* Quantity (t) | Farm-gate price (ZAR/t) | Value (ZAR) | *Yellow maize* Quantity (t) | Farm-gate price (ZAR/t) | Value (ZAR) |
|---|---|---|---|---|---|---|
| Deliveries from stock | 101,000 | 630.00 | 63,630,000 | (122,000) | 630.00 | (76,860,000) |
| Deliveries from farms | 6,108,000 | 630.00 | 3,848,040,000 | 3,947,000 | 630.00 | 2,486,610,000 |
| Imports | - | - | - | 360,000 | 630.00 | 226,800,000 |
| Imports destined for exports | | - | - | 3,000 | 630.00 | 1,890,000 |
| Total supply | 6,209,000 | | 3,911,670,000 | 4,188,000 | | 2,638,440,000 |
| | | Margins | 307,461,102 | | Margins | 207,235,418 |
| | | Tax | 163,862,796 | | Tax | 110,447,061 |
| | | Value at gross price | 4,382,993,898 | | Value at gross price | 2,956,122,479 |

| Component | *White maize* Quantity (t) | | Gross price (ZAR/t)$^{\varepsilon}$ | Value (ZAR) | *Yellow maize* Quantity (t) | | Gross price (ZAR/t)$^{\varepsilon}$ | Value (ZAR) |
|---|---|---|---|---|---|---|---|---|
| Processed for food | 3,559,000 | | | | 266,000 | | | |
| Gristing | 84,000 | | | | 16,000 | | | |
| Processed for feed | 543,000 | | | | 2,994,000 | | | |
| Processed for biofuel | - | | | | - | | | |
| Intermediate use | | 4,186,000 | 705.91 | 2,954,938,389 | | 3,276,000 | 705.86 | 2,312,382,340 |
| Withdrawn by producers | | 101,000 | 705.91 | 71,296,889 | | 214,000 | 705.86 | 151,053,059 |
| Released to end-consumers | | 71,000 | 705.91 | 50,119,595 | | 269,000 | 705.86 | 189,875,107 |
| Exports | 1,786,000 | | | | 357,000 | | | |
| Maize product exports | 58,000 | | | | 36,000 | | | |
| Re-exported | - | | | | 3,000 | | | |
| | | 1,844,000 | 705.91 | 1,301,697,656 | | 396,000 | 705.86 | 279,518,744 |
| Sundries | | 7,000 | 705.91 | 4,941,369 | | 33,000 | 705.86 | 23,293,229 |
| Total demand | | 6,209,000 | 705.91 | 4,382,993,898 | | 4,188,000 | 705.86 | 2,956,122,479 |

Source: DAFF (2011) & SAGIS (2011)

$\varepsilon$ decimal rounded to the nearest tenth; the values are however calculated multiplying quantity by the non-rounded price

## 6. Modified aggregated SAM for 2005 (ZAR million)

| | | Goods & services | Activities | Factors | | Institutions | | | | Capital | | Financial | ROW | | Resid. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Labor | Capital | Households | Non fin. firms | Fin. firms | Gov. | | | | Current | Capital | | |
| Goods & Services | | | *Intermediate inputs* 1,847,084 | | | *Household consumption* 990,774 | | | *Gov. spending* 305,732 | *Changes in inventories* 18,376 | *Gross fixed cap. form.* 263,754 | | *Exports* 430,169 | | (164) | 3,855,725 |
| Activities | | *Domestic supply* 3,248,151 | | | | | | | | | | | | | - | 3,248,151 |
| Factors | Labor | | *Comp. of employees* 699,018 | | | | | | | | | | *Comp. of emp. from ROW* 3,902 | | - | 702,920 |
| | Capital | | *Net op. surplus* 514,259 | | | | | | | | | | | | - | 514,259 |
| Institutions | Hous. | | | *Net income* 696,302 | 171,484 | *Domestic transfers* 1,979,727 | 91,417 | 295,029 | 69,908 | | | | *Transfer from ROW* 17,563 | | 40 | 3,321,470 |
| | Non fin. firms | | | | 258,418 | 52 | 122,821 | 44,447 | - | | | | | | 107 | 425,845 |
| | Fin. firms | | | | 54,105 | 204,834 | 73,640 | 186,539 | 58,442 | | | | 11,683 | | 18 | 589,261 |
| | Gov. | *Tax - sub.* 170,015 | | | 30,252 | 127,637 | 82,060 | 36,287 | 453,686 | | | | 944 | | (1) | 900,880 |
| Capital | | | | | | *Net savings* 1,142 | 17,560 | 26,959 | (5,816) | | | *Borrowing* 708,868 | | *Cap. transf. from ROW* 283 | - | 748,996 |
| | | | *Cons. of fixed capital* 187,790 | | | | | | | *Net fixed cap. form.* 75,964 | | | | | - | 263,754 |
| Financial | | | | | | | | | | *Lending* 654,566 | | | | *Net lending of ROW* 54,302 | - | 708,868 |
| ROW | | *Imports* 437,559 | | *Comp. of emp. to ROW* 6,618 | | *Transfers to ROW* 17,304 | 38,347 | | 18,928 | *Cap. Transfer to ROW* 90 | | | *External balance* 54,495 | | - | 573,341 |

## 7. Exogenous demand change calculation

| Row in SAM | Goods & services | $\Delta E_1 =$ $a_1$ | * | $\overline{X}_1$ | $\Delta E_3 =$ $a_3$ | * | $\overline{X}_3$ | $\Delta E_3 =$ $a_3$ | * | $\overline{X}_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | white maize | *0.00* | * | *1.9* | *0.00* | * | *1.9* | *0.00* | * | *0.4* |
| 2 | yellow maize | *0.00* | * | *1.9* | *0.00* | * | *0.4* | *0.00* | * | *0.4* |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |
| 12 | feed | - *(0.25)* | * | *1.9* | - *(0.25)* | * | *2.2* | - *(0.25)* | * | *0.4* |
| | | 0.00 | * | 1.9 | 0.00 | * | 2.2 | 0.00 | * | 0.4 |
| | | 0.00 | * | 1.9 | 0.00 | * | 2.2 | 0.00 | * | 0.4 |
| | | 0.00 | * | 1.9 | 0.00 | * | 2.2 | 0.00 | * | 0.4 |
| 16 | other petroleum | *0.06* | * | *1.9* | *0.06* | * | *2.2* | *0.06* | * | *0.4* |
| | | 0.00 | * | 1.9 | 0.00 | * | 2.2 | 0.00 | * | 0.4 |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |
| 23 | electricity | *0.20* | * | *1.9* | *0.20* | * | *2.2* | *0.20* | * | *0.4* |
| | | 0.00 | * | 1.9 | 0.00 | * | 2.2 | 0.00 | * | 0.4 |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |
| | | . | | | . | | | . | | |

$a_1$,$a_2$, $a_3$ are production coefficients of maize-based bioethanol in scenarios 1,2, 3 ; $\overline{X}_1$, $\overline{X}_2$, $\overline{X}_3$are bioethanol production in scenarios 1,2,3 in ZAR billion; $\Delta E_1$, $\Delta E_2$, $\Delta E_3$are the change in exogenous demand in scenarios 1,2,3

## 8. Stata commands used

Do-file Editor - commandf.do

File Edit Tools View

commandf.do | Untitled.do

```
mkmat var1-var116, matrix(M_0) // to create the 116*116 coef matrix
mkmat var117, matrix(E_0) // to create the exo vector
matrix I_0=I(116) // to introduce a 116*116 identity matrix
matrix Inv_0=inv(I_0-M_0) // to create the inverse of identity less coef
matrix Y_t0=Inv_0*E_0 // to calculate the SAM multiplier formula
mkmat var118, matrix(dE_1) // changed exo vector due to new industry - scenario 1
matrix dY_t1=Inv_0*dE_1 // change in total income following change in exo - scenario 2
mkmat var119, matrix(dE_2) // changed exo vector due to new industry - scenario 2
matrix dY_t2=Inv_0*dE_2 // change in total income following change in exo - scenario 2
mkmat var120, matrix(dE_3) // changed exo vector due to new industry - scenario 3
matrix dY_t3=Inv_0*dE_3 // change in total income following change in exo - scenario 3
```

**9. Impact of Bioethanol production on goods and services account**

| Goods & services | Base ZAR mil. | Δ scenario 1 ZAR mil. | % | Δ scenario 2 ZAR mil. | % | Δ scenario 3 ZAR mil. | % |
|---|---|---|---|---|---|---|---|
| White maize | 4,383 | -5 | -0.13 | -7 | -0.15 | -1 | -0.03 |
| Yellow maize | 2,956 | -4 | -0.15 | -5 | -0.18 | -1 | -0.03 |
| Other grains & horticulture | 60,950 | -37 | -0.06 | -44 | -0.07 | -7 | -0.01 |
| Live animals | 21,907 | -15 | -0.07 | -17 | -0.08 | -3 | -0.01 |
| Forestry | 11,866 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Fishery | 2,535 | -2 | -0.07 | -2 | -0.08 | 0 | -0.01 |
| Coal | 40,065 | 69 | 0.17 | 83 | 0.21 | 14 | 0.03 |
| Crude oil | 43,102 | 5 | 0.01 | 6 | 0.01 | 1 | 0.00 |
| Gold | 28,632 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Other mining | 130,856 | 2 | 0.00 | 3 | 0.00 | 0 | 0.00 |
| Food | 276,853 | -63 | -0.02 | -75 | -0.03 | -12 | 0.00 |
| Feed | 12,405 | -486 | -3.91 | -583 | -4.70 | -98 | -0.79 |
| Textiles | 84,038 | 3 | 0.00 | 4 | 0.00 | 1 | 0.00 |
| Footwear | 13,555 | 1 | 0.01 | 1 | 0.01 | 0 | 0.00 |
| Petroleum | 126,503 | 11 | 0.01 | 14 | 0.01 | 2 | 0.00 |
| Other petroleum | 249,870 | 118 | 0.05 | 142 | 0.06 | 26 | 0.01 |
| Glass, ceramics, cement | 51,245 | -1 | 0.00 | -1 | 0.00 | 0 | 0.00 |
| Basic iron/steel | 332,597 | 17 | 0.01 | 21 | 0.01 | 4 | 0.00 |
| Electrical machinery | 45,514 | 24 | 0.05 | 29 | 0.06 | 5 | 0.01 |
| Radio, TV, medical appliance | 62,898 | 3 | 0.00 | 4 | 0.01 | 1 | 0.00 |
| Transport equipment | 242,354 | 7 | 0.00 | 9 | 0.00 | 2 | 0.00 |
| Other manufacturing | 148,511 | -6 | 0.00 | -8 | -0.01 | -1 | 0.00 |
| Electricity | 49,970 | 394 | 0.79 | 474 | 0.95 | 80 | 0.16 |
| Water | 20,062 | -1 | 0.00 | -1 | 0.00 | 0 | 0.00 |
| Construction | 145,997 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 |
| Trade | 37,829 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Hotels & restaurants | 54,483 | 2 | 0.00 | 3 | 0.01 | 0 | 0.00 |
| Transport services | 181,009 | 11 | 0.01 | 13 | 0.01 | 2 | 0.00 |
| Communications | 102,948 | 3 | 0.00 | 4 | 0.00 | 1 | 0.00 |
| Financial intermediation | 260,124 | 31 | 0.01 | 38 | 0.01 | 7 | 0.00 |
| Real estate | 193,854 | 5 | 0.00 | 6 | 0.00 | 1 | 0.00 |
| Business activities | 241,307 | 4 | 0.00 | 5 | 0.00 | 1 | 0.00 |
| General government | 335,084 | 1 | 0.00 | 1 | 0.00 | 0 | 0.00 |
| Health & social work | 75,457 | 3 | 0.00 | 3 | 0.00 | 1 | 0.00 |
| Other activities/services | 141,910 | -4 | 0.00 | -4 | 0.00 | -1 | 0.00 |
| Trade & transport margins | 0 | | | | | | |
| Direct purchase | 22,097 | -1 | -0.01 | -2 | -0.01 | 0 | 0.00 |