Capturing the dynamics of the South African sunflower seed market in a partial equilibrium framework

by

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I declare that the dissertation that I hereby submit for the degree in Agricultural Economics at the University of Pretoria has not previously been submitted by me for degree purposes at any other university.

SIGNATURE:………..………………….. DATE: ………………………………

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To my parents, Fanie and Susan van Zyl: My love for you knows no bounds. Thank you so much for teaching me the value of hard work and perseverance.

Sakkie van Zyl
Pretoria, South Africa
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ABSTRACT

CAPTURING THE DYNAMICS OF THE SOUTH AFRICAN SUNFLOWER SEED MARKET IN A PARTIAL EQUILIBRIUM FRAMEWORK

by

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Department: Agricultural Economics, Extension, and Rural Development

Promoter: Dr Ferdinand Meyer

Sunflower is the most important oilseed crop in South Africa and accounts for approximately 60 % of all oilseeds produced locally. The primary by-products of the sunflower seed crushing industry provides high-value inputs towards the food and animal feed manufacturing sector in the form of edible oil and protein meal.

Prior to 1996, the South African sunflower seed complex market was controlled by the Oilseed Board, which operated a single-channel pool scheme and regulated the marketing of oilseeds and oilseed products. Since the liberalisation of the South African agricultural sector, role-players have been fully exposed to the dynamics and risks of the international oilseed complex market.

Over the years participants in the agricultural commodity markets have developed various instruments to assist them in their decision-making process – one of them being commodity modelling, which is described as a methodological technique that provides a powerful analytical tool for examining the complexities of commodity markets. In South Africa, many role-players in the various agricultural industries make use of a multi-sector commodity level partial equilibrium model better know as the BFAP sector model which is maintained by the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria. The objective of this study was to expand the coverage of the existing BFAP sector model by developing a comprehensive system

of equations for the total sunflower seed complex, which includes not only a partial equilibrium model for sunflower seed, but also sunflower oil and cake.

In this study much emphasis was not only placed on the formation of prices of the various products, but also the application of the most suitable model structures in order to trace the behaviour of the various prices under real market conditions as accurately as possible. This study applied the methodology developed by the Food and Agricultural Policy Research Institute (FAPRI) and further adapted by the Bureau for Food and Agriculture Policy (BFAP) to develop the partial equilibrium model of the South African sunflower complex. The single equations were estimated by mainly using ordinary least squares (OLS), but in cases where the results of the OLS were contradictory to the theory or where insufficient data was available, calibration techniques were employed and the equations were synthetically constructed.

The constructed model was applied to lay down a baseline projection for the total production and consumption blocks of sunflower seed, oil and oilcake. The baseline projections also formed part of the *ex post* validation of the model's performance. Finally the consistency of the model was evaluated in the form of scenario analysis. Various real-world market- and policy-related shocks were imposed and the results were compared to the baseline projections.

In general the model developed in this dissertation performed well and can be used to analyse the effects of economic, technological and policy changes on the South African sunflower seed complex. It also provides a sound structure for the development of a complete South African oilseed complex model that includes soybeans, canola, groundnuts, cotton and imported palm oil.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Sunflower is the most important oilseed crop and is grown in virtually all summer rainfall areas of South Africa (Pannar Seed, 2006). During the period 2002 to 2006, sunflower seed production contributed on average R 1.09 billion per annum the towards the total agricultural gross value, making it the most important field crop produced in South Africa after maize, sugarcane and wheat (NDA, 2008).

Prior to 1996, South African agricultural marketing policy was largely determined by the Marketing Act (Act 59 of 1968, as amended). The Act contained, *inter alia*, a list of potential policy instruments that could be used to control the marketing of a commodity (Kirsten & Vink, 2000). It also enabled the Minister of Agriculture to proclaim a marketing scheme and appoint a control board to control the marketing of a particular commodity in a prescribed manner. A total of 23 control boards, including the Oilseed Board, were established under the Act.

The Oilseed Board operated a single-channel pool scheme that regulated the marketing of oilseeds and oilseed products. The producer and selling prices of all oilseeds were determined by the Oilseed Board, taking into account the domestic supply and demand situation and the export pool prices. These prices then applied for the entire production season (Vink & Kirsten, 2002).

In 1996 the Marketing Act (Act 59 of 1968, as amended) was replaced with the Marketing of Agricultural Products Act, No. 47 of 1996, which eventually introduced the liberalisation of the South African agricultural sector. With the implementation of the new Marketing Act, the functioning of the Oilseed Board was terminated and the oilseed industry was no longer regulated. Since deregulation, sunflower oilseed has been formally traded on the Agricultural Marketing Division of the South African Futures Exchange (SAFEX). As a result, domestic sunflower oilseed producers and processors are now being fully exposed to international markets.

More forces now have a significant impact on the domestic sunflower oilseed industry than under the controlled marketing scheme of the previous regime. In a free market environment, the exposure to fluctuations in domestic and international markets and continuous changes in macro-economic variables pose a considerable risk to role-players and decision-makers in the sunflower oilseed sector. Successful participation in the sunflower seed market requires a comprehensive understanding of the intrinsic characteristics of sunflower oilseed and its primary product markets, as well as an accurate interpretation of the effects of changes in factors affecting these markets.

Over the years, participants in the agricultural commodity markets have developed various instruments to assist them in their decision-making processes – one of them being commodity modelling, which is describe as a methodological technique that provides a powerful analytical tool for examining the complexities of commodity markets (Meyer, 2002). Commodity modelling can be applied to scrutinise the economic and biological relationships between different variables within a sector, as well as the interrelationships between different sectors. According to Poonyth, Van Zyl and Meyer (2000), these models serve three important tasks, namely market analysis, forecasting of future market prices and quantities, and finally policy analysis.

Currently many role-players in the South African agricultural commodity sector use the South African agricultural sector model maintained by the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria (BFAP, 2008). This model can be classified as a large-scale multi-sector commodity-level simulation model that is used for annual baseline projections, as well as scenario and policy analysis (Meyer, 2006). Although the model covers various crop and livestock sectors, it lacks a well-constructed model of the sunflower seed complex market.

1.2 PROBLEM STATEMENT

1.2.1 GENERAL PROBLEM STATEMENT

The importance of the sunflower oilseed sector is clearly indicated by the fact that it is the single most important domestic oilseed crop and accounts for more than 60 % of all oilseeds produced in South Africa. Although the domestic sunflower oilseed sector contributes only 2 % towards the total domestic agricultural gross value, sunflower oilseed by-products are imperative components of the human food and animal feed markets. Sunflower seed is also one of the three oilseed crops proposed as bio-fuel feed stock contained in the recently published draft Bio-fuels Industrial Strategy of the Republic of South Africa (DME, 2007).

Several studies were conducted on different domestic agricultural sectors after deregulation, but only a few concentrated on the oilseed sector. In most of these studies the major oilseed crops sunflower oilseed, soybeans, cottonseed and groundnuts were analysed as a whole (Hallat, 2005; Van Schalkwyk, Taljaard & Van Schalkwyk, 2003). Although a large degree of similarity exists between different domestic oilseed crop sectors, some fundamental differences between the oilseed crops obligated a separate market analysis for each specific oilseed crop.

In the domestic oilseed market, sunflower oilseed is mainly produced as raw material for the production of sunflower oil for human consumption, while soybeans are processed for inclusion as full-fat soybean meal in animal feed rations. Less than 10 % of domestic soybeans are processed to soybean oil and soybean oilcake. Cotton is mainly produced for its fibre, and the cottonseed, the by-product of the fibre recovery process, is then processed to cotton oil and cotton oilcake. Groundnuts, on the other hand, are produced for the human edible market, and only a small percentage of the low-quality groundnuts are crushed for groundnut oil and oilcake.

Due to the dynamic nature of the agricultural sector and the complexity of the oilseed industry, role-players and policy-makers need comprehensive insight to understand the impact of macro- and micro-economic changes, as well as policy changes, on the sunflower seed complex. Quantitative analytical tools, for example partial equilibrium models, can prove very useful when the impacts of various exogenous shocks have to be analysed and projected for a specific sector. These analyses can be undertaken by means of the development of baseline projections, which serve as a benchmark against which alternative scenarios can be compared.

1.2.2 SPECIFIC PROBLEM STATEMENT

The agricultural sector is part of a constantly changing world. Some changes are expected and occur gradually over time, while others are abrupt and totally unexpected – a reality also faced by the domestic oilseed industry.

In the free market environment in which the domestic sunflower oilseed industry operates, micro- and macro-economic variables have a direct impact on the sunflower oilseed industry. Changes in macro-economic variables such as exchange rate fluctuations have a significant effect on domestic sunflower oilseed and oilseed product prices. A rise in consumers' disposable income is expected to alter the demand for vegetable oils, while the demand for animal protein is expected to increase and hence the demand for oilcake as a protein source in animal feed will also increase.

As a price taker on world markets, domestic sunflower oilseed prices are strongly affected by changes on the international oilseed market. Decisions taken by policy-makers and other role-players may affect the future of the sunflower oilseed industry. Hence, a quantitative analysing tool that takes the complexity of the oilseed sector into account and which can be used to forecast the impact of exogenous factor changes has become indispensable.

A well-structured and robust econometric model that explains the fine relationships existing between different components of the sunflower oilseed industry and which is able to forecast supply and demand behaviour under real market conditions will assist decision-makers and other role-players in the decision-making process.

1.3 OBJECTIVES OF THE STUDY

1.3.1 GENERAL OBJECTIVES

The main objective of this study was to construct a well-behaved econometric model of the South African sunflower oilseed industry, also referred to as the sunflower seed complex, for purposes of scenario and policy analysis. Once a rigorous model was constructed, it was incorporated in the framework of the existing BFAP sector model, originally developed by Meyer and Westhoff and now maintained within BFAP at the University of Pretoria. In other words, the objective of this study was to expand the coverage of the exiting BFAP sector model by developing a comprehensive system of equations for the total sunflower seed complex, which includes not only a partial equilibrium model for sunflower seed, but also sunflower oil and cake. In this study much emphasis was not only placed on the formation of prices of the various products, but also which model structure could be applied to trace the behaviour of prices under real market conditions as accurately as possible.

1.3.2 SPECIFIC OBJECTIVES

Through a comprehensive analysis of the domestic sunflower oilseed industry, major factors or drivers affecting the industry could be identified. The relevance and validity of the identified factors were tested and quantified in the construction of the econometric sunflower oilseed sector model. The model was used to generate baseline projections that served as a benchmark to analyse the impact of certain exogenous shocks on the sunflower seed complex. Through this the ability and accuracy of the model to simulate real-world effects was tested and the usefulness of this model to decision makers in the industry illustrated. Six scenarios were simulated and analysed in detail to illustrate the usefulness of the sunflower oilseed sector model.

South Africa experienced a sharp rise in agricultural commodity prices during 2001/2002 due to the drastic depreciation of the exchange rate. The higher sunflower oilseed prices affected local producers favourably, but were burdensome to consumers of sunflower oilseed products. The unexpected appreciation of the Rand to the current levels, which are the same the levels seen seven years ago, caused domestic sunflower prices to decline sharply and led producers into a financial dilemma since they had budgeted to sell at higher prices. Hence, in the first two scenarios the impacts of an exchange rate shock and a world price shock were analysed to test the model's ability to handle a typical macro-economic shock.

At certain points, policy-makers face the problem of being forced to implement new or adjusted policies without knowing what may be the outcome of their decisions. Uninformed policy decisions could hamper the profitability and the future of the domestic sunflower oilseed industry. It is therefore crucial for role-players to have a policy-analysing tool at hand to analyse and quantify the possible outcome of their policy decisions. For the third and forth scenario relative uncomplicated policy shocks were introduced in the model by changing the import tariffs of sunflower seed, oil and oilcake.

Prevailing high crude oil prices and environmental concerns are forcing the fuel industry to seek new sources of energy, one of these being a renewable fuel that is produced from vegetables oils and animal fats. The South African government recently signed the Kyoto Agreement and thereby committed itself to start implementing strategies to expand the use of environmentally friendly renewable fuels. Sunflower oil currently shows potential to serve as a source of bio-diesel. Therefore, in the fifth scenario the effect of higher demand for sunflower oil was analysed. The increased demand of sunflower oil was motivated by the potential use of sunflower oil in the bio-diesel industry. To compare this shock to the impact of a shock on sunflower oilcake, the last scenario presents the impact on the sunflower seed complex when the oilcake demand is increased.

1.4 OUTLINE OF THE STUDY

This dissertation is ordered into seven chapters. Chapter one serves as a brief background overview of the domestic sunflower oilseed industry and introduced the problem statement and objectives of the study. Chapter two is a general overview of the international and domestic sunflower complex market. A literature review on existing econometric modelling in the oilseed industry and other field-crop industries is provided in chapter three. Chapter four discusses the structure of the model and the properties of the data used in the model estimation. The empirical results of the model are presented in chapter five, while the results of the baseline projections and different simulations are discussed in chapter six. The final chapter is a summary of the study and contains some concluding remarks.

CHAPTER 2

THE SOUTH AFRICAN SUNFLOWER SEED COMPLEX MARKET FROM A GLOBAL PERSPECTIVE

2.1 INTRODUCTION

Sunflower seed is the most important oilseed crop produced in South Africa, but soybeans dominate the international oilseed market. In world terms, sunflower seed is regarded as a minor oilseed, as it comprises only about 7 % of the world's total oilseed output (Table 2.1).

Table 2.1: World production of major oilseeds (million tons)

Oilseed	2004	2005	2006	2007	Average
Copra	5.59	5.59	5.26	5.70	5.54
Palm kernel	9.54	9.97	10.19	11.05	10.19
Sunflower	25.45	30.04	29.81	27.18	28.12
Peanut	33.61	33.07	30.53	32.27	32.37
Cottonseed	45.45	43.44	45.83	45.51	45.06
Rapeseed	46.14	48.68	45.16	47.30	46.82
Soybean	215.76	220.53	236.56	218.80	222.91
World Total	**381.52**	**391.30**	**403.33**	**387.80**	**390.99**
Sunflower as % of total	*6.7 %*	*7.7 %*	*7.4 %*	*7.0 %*	*7.2 %*

Source: USDA (2008)

Although sunflower seed is primarily valued for its oil, it is also used in other markets. The hybrid oil type sunflower is utilised as a source of high-quality vegetable oil with the extracted meal utilised as a protein source in livestock feed. Confectionary sunflower is grown for human consumption and birdfeed (Warrick, 2000).

This chapter provides an overview of the international and local oilseed industry, organised into three sections. The circumference of the world and local sunflower seed production is reviewed in the first section. Section two provides insight into the sunflower seed processing industry, as well as the production and consumption of sunflower oil and oilcake. Some forces that currently have an influence on the local sunflower oil industry are presented in the final section.

2.2 SUNFLOWER SEED

Over the past five seasons, world sunflower seed production varied between 25 and 30 million tons per annum. The four largest sunflower producing countries account for about 71 % of the world total. The production of sunflower seed in the world is much more evenly distributed when compared to world soybean production, with North and South America producing more than 80 % of the world's soybean crop.

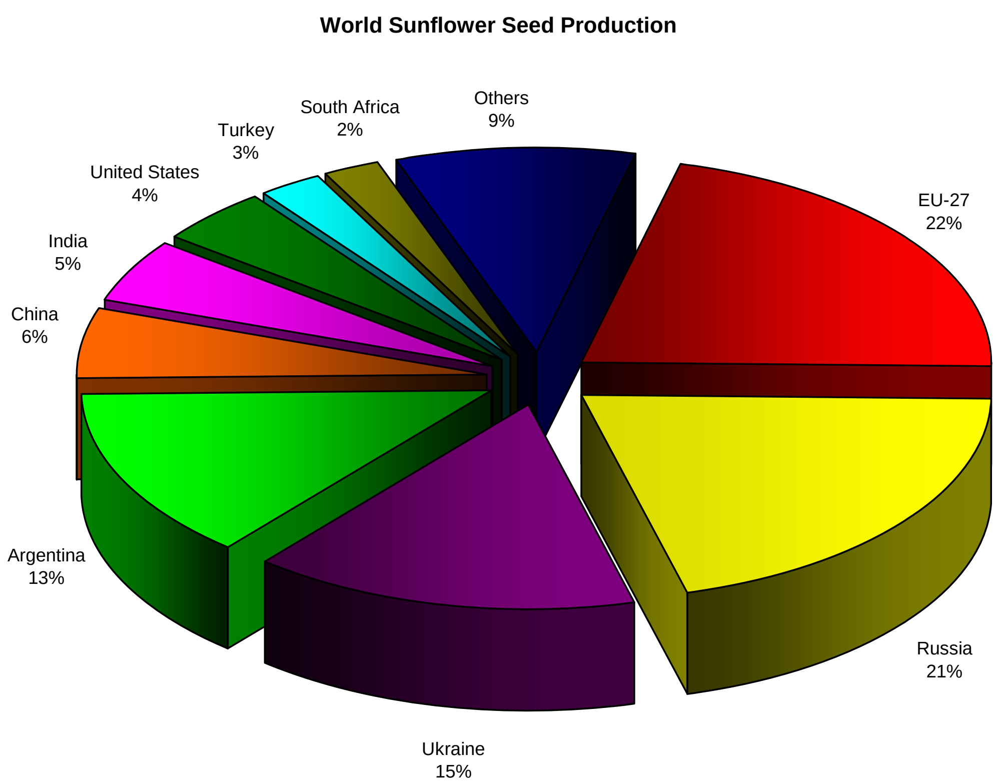


Figure 2.1: World's major producers of sunflower seed

Source: USDA (2008) and own calculations

The Russian Federation and the European Union are the two largest producers of sunflower seed and together they produce about 42 % of the world's sunflower seed crop (Figure 2.1). The Russian Federation and the European Union are followed by Argentina, Ukraine and China, which account for 15 %, 13 % and 6 % of world sunflower seed production respectively. South Africa is ranked ninth on the list of major sunflower seed-producing countries and contributes about 2 % toward the world's total.

Sunflower and other vegetable oils are mainly consumed in the human food chain, but the industrial use of vegetable oils, especially for the production of bio-diesel, is increasing. The oilcake is sold to the animal feed industry for inclusion in animal feed ratios as a source of protein. The oil and oilcake content of oilseeds is therefore economically important, because it affects the relative value of the oilseeds (Kruse, 2003)

Table 2.2 illustrates the oil and oilcake content of certain oilseeds. In the case of sunflower, the average crushing yield is 0.457 kilograms of meal and 0.398 kilograms of oil produced per 1 kilogram of sunflower seed crushed. Since sunflower seed is generally valued for its oil, and the price of sunflower oil has the most significant influence on the price of sunflower seed.

Table 2.2: Average oilseed crushing yields

Oilseed	Oilcake content	Oil content
Soybeans	79.1 %	18.0 %
Sunflower seed	45.7 %	39.8 %
Rapeseed	60.7 %	36.9 %

Source: Kruse (2003)

According to the Agricultural Research Council of South Africa (Loubser, 1999), sunflower is a crop that performs well under drought conditions compared to other crops and this is probably the main reason for the crop's popularity in the marginal areas of South Africa. The drought tolerance and the relatively low input cost of the crop are major advantages, while the short growth season of the crop renders it extremely suitable for producers who make use of adaptable crop rotation and/or fallow systems (Loubser, 1999).

The area planted to sunflower seed in South Africa has varied to a great extent over the past few seasons, ranging from a record 820 000 ha planted in 1998/99 to only 316 000 ha planted during the 2006/07 season (Figure 2.2). According to the Food Price Monitoring Committee's report (Vink & Kirsten, 2002) an important relationship exists between the area planted to maize and the area planted to sunflowers due to these crops' substitutability.

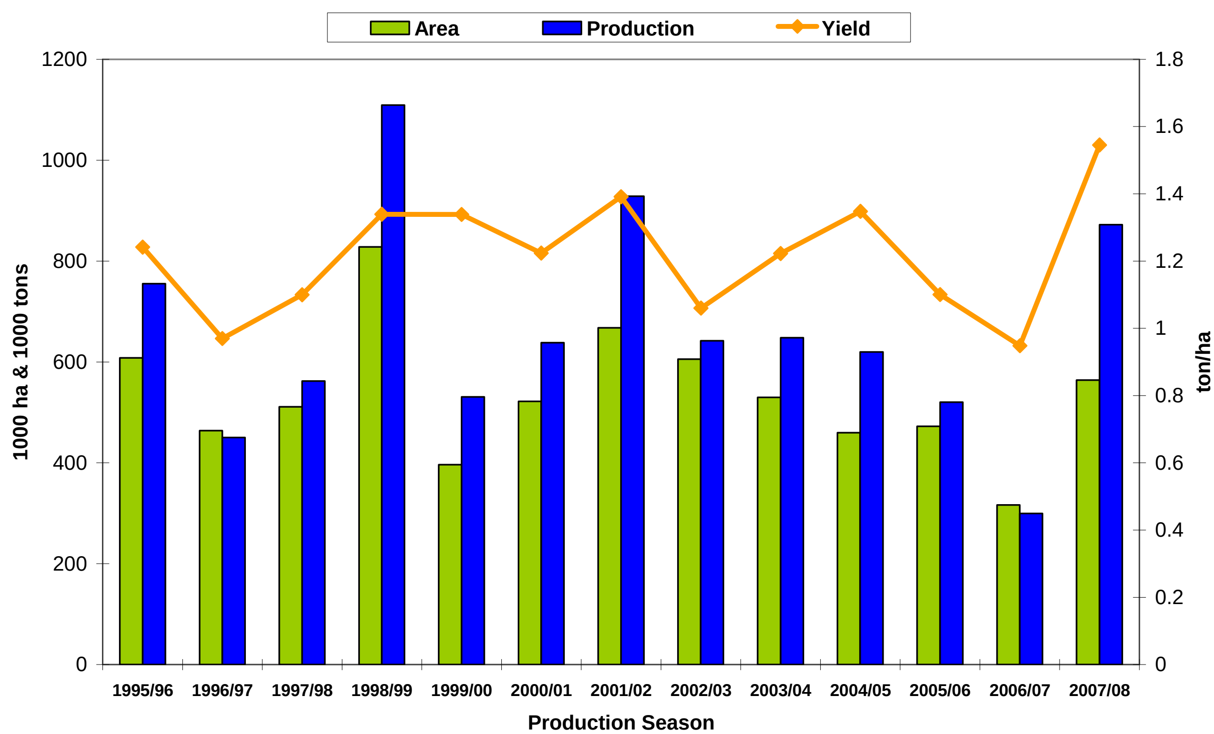


Figure 2.2: South African sunflower seed production

Source: NDA (2008)

Over the past 13 years the total domestic sunflower seed crop has varied between 1.1 million tons and 300 000 tons, with yields varying from 0.95 to 1.55 tons per ha (Figure 2.2). The Free State and North West provinces produce more than 80 % of the local sunflower crop (Table 2.3).

Table 2.3: Regional production of sunflower seed (production seasons)

Province	Area planted (Ha)			Production (Tons)		
	2006/07	2007/08	% share in 2007/08	2006/07	2007/08	% share in 2007/08
Western Cape	500	600	0.1%	300	540	0.1 %
Northern Cape	700	400	0.1%	1 320	960	0.1 %
Free State	135 000	270 000	47.8%	155 000	459 000	52.6 %
Eastern Cape	150	300	0.1%	180	360	0.0 %
Kwazulu-Natal	-	-	-	-	-	-
Mpumalanga	13 000	17 000	3.0 %	13 000	25 500	2.9 %
Limpopo	30 000	70 000	12.4%	12 500	77 000	8.8 %
Gauteng	7 000	6 000	1.1%	7 700	8 700	1.0 %
North-West	130 000	200 000	35.4%	110 000	300 000	34.4 %
RSA Total	**316 350**	**564 300**	**100.0%**	**300 000**	**872 060**	**100.0 %**

Source: NCEC (2008)

During the past five seasons the total oilseed crop produced in South Africa, consisting of sunflower seed, soybeans, groundnuts, cottonseed and canola, averaged 1.08 million tons annually. On average, sunflower seed contributed 63 % towards the total oilseed crop (Figure 2.3).

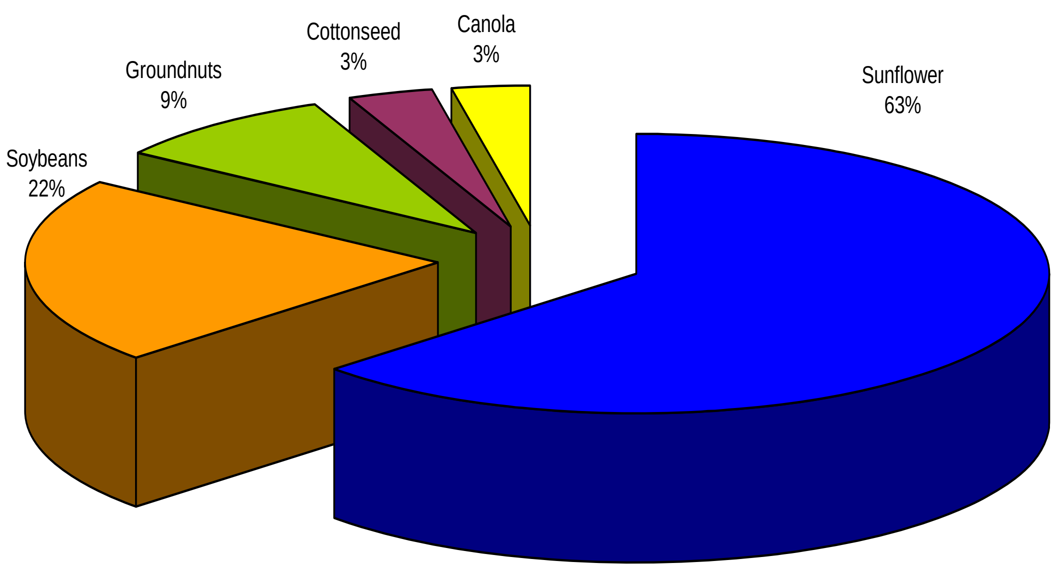


Figure 2.3: Production of oilseeds in South Africa

Source: NDA (2008)

Sunflower seed is the third most important commercial row crop produced in South Africa, but the volume produced is much less than the volume of maize and wheat produced every year. South African commercial row crop production is dominated by maize, and sunflower seed added only 5 % towards the total volume of grain and oilseed produced during the 2007/08 production season (Table 2.4).

Table 2.4: South African commercial grain and oilseed production (tons)

Crop	Marketing Season			% Share of total
	2005/06	**2006/07**	**2007/08**	**2007/08**
White maize	4 187 400	4 315 000	6 861 400	45 %
Yellow maize	2 430 600	2 810 000	4 736 200	31 %
Wheat	2 114 000	1 913 000	2 031 000	13 %
Sunflower seed	520 000	300 000	827 060	5 %
Sorghum	96 000	176 000	255 000	2 %
Soybeans	424 000	205 000	282 000	2 %
Barley	189 370	225 000	249 060	2 %
Groundnuts	74 000	58 000	85 360	0.6 %
Canola	44 200	36 500	39 840	0.3 %
Total	**10 079 570**	**10 038 500**	**15 366 920**	**100 %**

Source: NDA (2008)

Van Schalkwyk *et al.* (2003) pointed out that the importance of sunflower and other oilseeds relates to the fact that very little of the oilseeds produced is consumed in primary form. Processing oilseeds also provides inputs to various other sectors of the economy, including agricultural inputs in the form of animal feedstuffs.

Most of the sunflower seed cultivars planted in South Africa are the high-oil content hybrids and destined for the processing industry for the production of sunflower oil. Approximately 95 % of all the marketable sunflower seed is eventually processed into sunflower oil and oilcake. The remaining percentage consists mostly of speciality types of cultivars like low-oil-content cultivars that are consumed in the birdfeed and confectionary and health-food market (Hawkins, 2007).

The commercial sunflower seed processing industry mainly uses a combination of mechanical and chemical extrusion processes to extract the oil from the oilseeds. Typically, when the sunflower seed arrives at the processing plant, it will be cleaned to remove all foreign materials. After the cleaning process, the outer seed coat or hull will be removed to make the oil extrusion process more effective and to produce oilcake with lower fibre content. The de-hulled seeds will then be mechanically crushed with a continuous expeller or screw press to expel most of the oil. The products of this process are crude oil and oilcake that still contains 15 % to 18 % oil (Pretorius, 2000).

The remaining oil in the oilcake is then extracted through a solvent extraction process. The oil-containing solids are treated with a solvent such as hexane, which dissolves the oil from the so-called miscella, which is again separated from the solids. The remaining solids will typically contain less than 1 % oil after the solvent extraction process and will be sold as animal feed.

Heat or filtration technology is then applied to the solvent-oil mixture or miscella to separate the extracted oil and the solvent. All the crude oil is then filtered and refined. The refining process includes de-gumming and neutralisation. The de-gumming process, which makes use of hydration, removes the dissolved contents like lecithin that coagulate to form gums. The purpose of neutralising is to reduce the free fatty acid content to below 0.05 % and to bring about a paler, more desirable colour in the oil (Pretorius, 2000).

The sunflower seed crushing process is schematically presented in Figure 2.4.

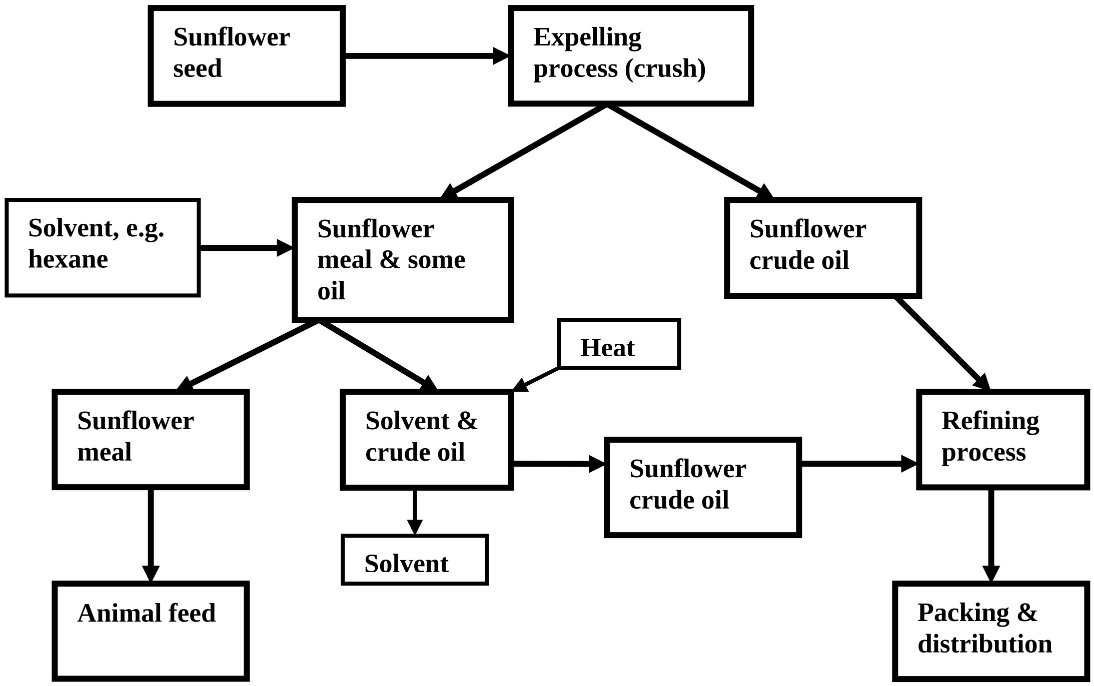


Figure 2.4: Crushing process of sunflower seed

Source: Prinsloo (2007)

2.3 SUNFLOWER OIL

The international vegetable oil market is dominated by soybean and palm oil, which accounts for more than 60 % of all vegetable oils produced globally. Sunflower oil contributes about 8 % to total world vegetable oil production (Figure 2.5).

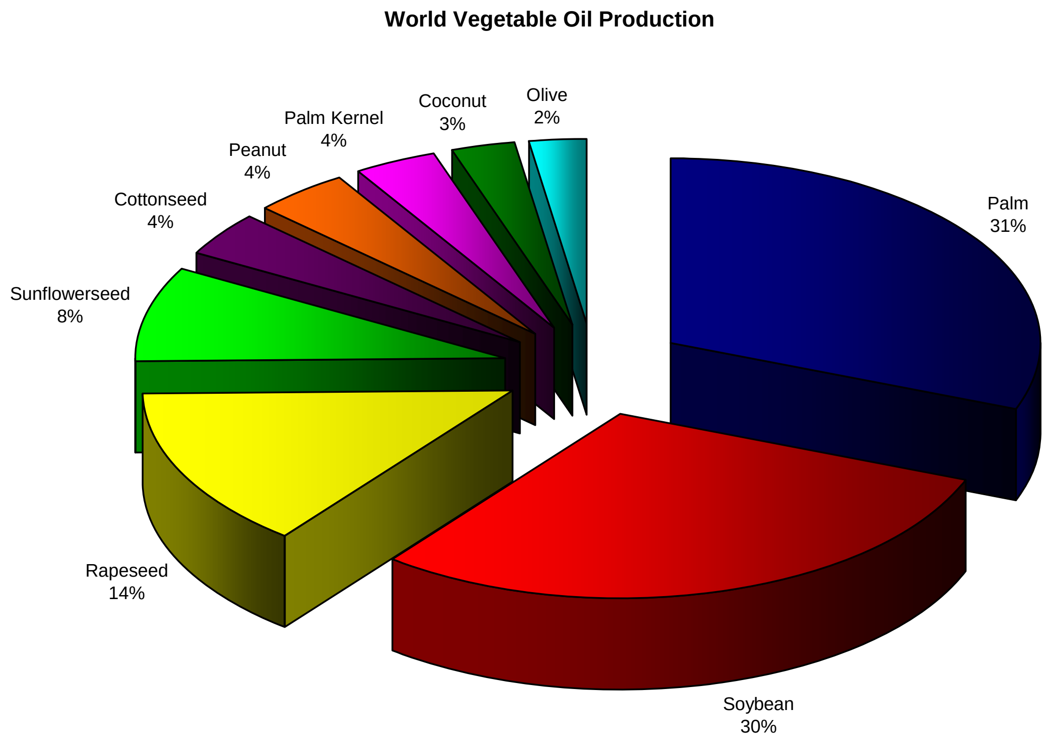


Figure 2.5: World vegetable oil production

Source: USDA (2008) and own calculations

The world's average production of sunflower oil during the period 2004 to 2007 totalled close to 9 million tons per year (Table 2.5). The European Union is not only the largest producer of sunflower oil, but also the largest consumer thereof. Between 2004 and 2007 the European Union produced on average 2.112 million tons and consumed 2.951 million tons of sunflower oil, making the region a relatively large net importer of sunflower oil.

Table 2.5: World sunflower oil production and consumption (thousand tons)

Country	Production ('000 ton)	Consumption ('000 ton)
EU-27	2 112	2 951
Russian Federation	2 068	1 772
Ukraine	1 657	371
Argentina	1 481	342
Turkey	490	692
India	454	526
China	257	296
Others	1 345	2 318
World Total	**9 864**	**9 268**

Source: USDA (2008) and own calculations

The European Union is followed by the Russian Federation, Ukraine and Argentina as the world's largest producers of sunflower oil (Table 2.6). Ukraine and Argentina are the world's largest exporters of sunflower oil and together they account for more than 70 % of the world's sunflower oil exports, most of which is exported to the European Union, Turkey, Egypt and Algeria.

Sunflower oil is regarded as a premium vegetable oil, with a healthier fatty acid composition compared to soybean and palm oil due to its lower saturated fatty acid content (Figure 2.6). Internationally, sunflower oil is primarily used directly as a salad or table oil, but some sunflower oil is processed into margarine (Kruse, 2003).

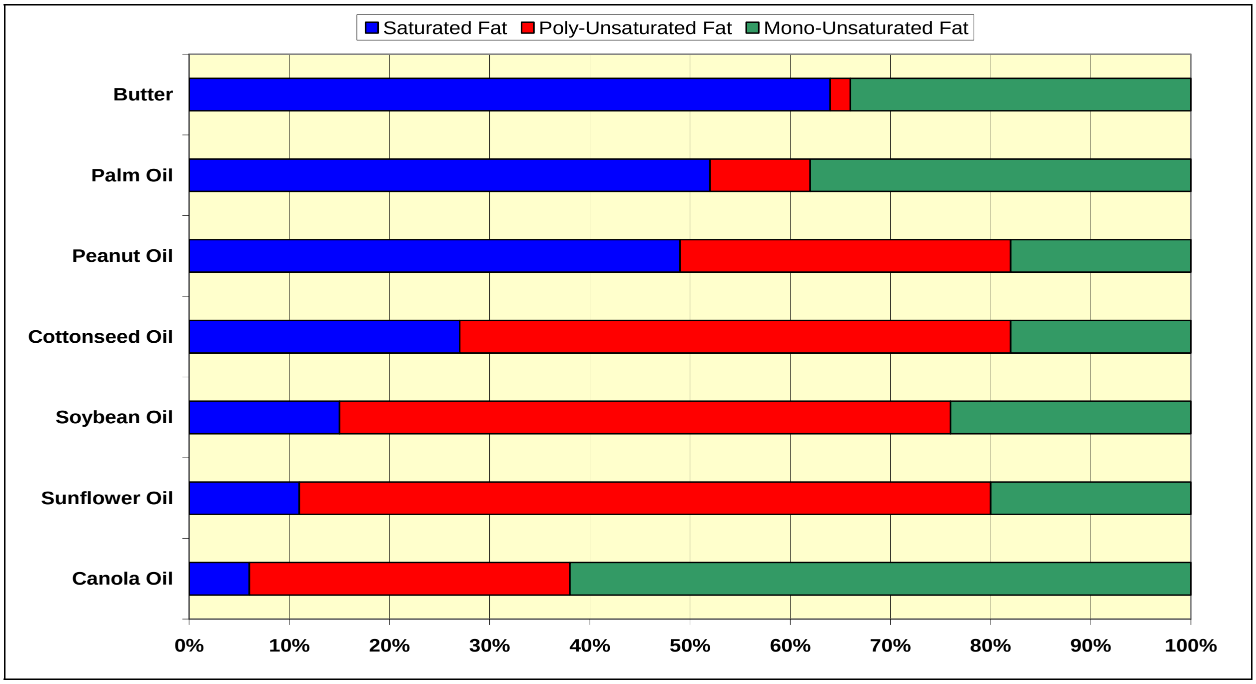


Figure 2.6: Percentage fatty acid by oil and fat

Source: NSA (2003)

In general, sunflower oil trades at a premium above soybean and palm oil on the world market, which can be attributed to its lower availability and its healthier fatty acid content. However, due to the high substitutability between vegetable oils, price plays an important role in whether or not a consumer will purchase a certain type of edible oil.

In South Africa, sunflower oil is regarded as a basic food product that is used on a large scale for cooking purposes. Apart from the consumption by most households, it is also used on large scale by restaurants, hotels and food-processing companies (Pretorius, 2000). It is also used to produce products such as margarines and sauces.

The current industrial consumption of vegetable oil in South Africa is insignificant compared to the food consumption, with recycled restaurant frying oil mainly being used for industrial consumption. Although sunflower seed is included in the Bio-fuels Industry Strategy, there is currently no large sunflower oil bio-fuels production plant in South Africa. Only a few sunflower seed producers produce sunflower oil-based bio-diesel for own consumption (Lemmer & De Villiers, 2007; Norval, 2007).

Calculations of Vink and Kirsten (2002) showed that the eight largest sunflower crushing plants in South Africa have a total crushing capacity of 1.075 million tons (Table 2.6). The average local sunflower seed crop over the past five seasons was less than 600 000 tons, which led to a crushing capacity utilisation rate of only 55 %. Vink and Kirsten (2002) noted that the surplus crushing capacity available makes the crushing industry highly competitive since the utilisation of crushing capacity is readily available to anyone in the business.

Table 2.6: Largest crushing plants in South Africa

Processor	Crushing capacity (tons)
Nola Industries	400 000
Epic	200 000
Epco	170 000
Willowton Oil Mills	100 000
Continental Oil Mills	100 000
Capital Oil Mills	50 000
Elangeni Oil & Cake Mills	30 000
Sealake Industries	25 000
Total	**1 075 000**

Source: Vink and Kirsten (2002)

In response to a questionnaire in 2005, Capital Oil Mills, Elangeni Oil & Cake Mills and Sealake Industries indicated that they had completely suspended their crushing activities due to the low production levels of sunflower seed over the past few years (Hallat, 2005). According to industry experts, in times of a local shortage of sunflower seed, the activities of crushing plants will be reduced and the refinery plants will import more crude oil since it is more cost effective to import crude oil than sunflower seed.

According to Whitehouse (2003) sunflower oil accounts for 82 % of all edible oils produced in South Africa prior to 2003. However, the volume of sunflower oil produced locally is directly related to the volume of the local sunflower seed crop. When shortages in the local production of sunflower seed occur, unrefined sunflower oil is imported, mainly from Argentina, and is refined and packed locally (Whitehouse, 2003).

The domestic market for total vegetable oil is calculated to be more than 900 000 tons annually of which approximately 30 % is sunflower oil. Over the past few years South Africa produced only 18 % tot 30 % of its annual consumption, making South Africa a net importer of vegetable oil (Table 2.7).

Table 2.7: Calculated availability and consumption of vegetable oil in South Africa

	2004	2005	2006	2007
	Tons			
Locally produced oil:				
Soybean	5 850	9 756	22 968	24 066
Sunflower	249 546	238 564	170 772	136 192
Canola	9 205	10 325	12 145	13 300
Groundnut	1,040	1,880	40	280
Total produced	**265 641**	**260 525**	**205 925**	**173 838**
Sunflower as % of total	*93.9 %*	*91.6 %*	*82.9 %*	*78.3 %*
Net imported oil:				
Soybean	173 945	217 826	253 508	271 981
Sunflower	82 852	19 391	102 322	156 674
Groundnut	-36	-103	8	-41
Palm	484 706	400 000	291 566	298 091
Palm kernel	-	-	38 119	32 688
Total imports	**741 467**	**687 114**	**685 523**	**759 393**
Sunflower as % of total	*11.17%*	*2.82%*	*14.93%*	*20.63%*
Total available and consumed:				
Soybean	179 795	227 582	276 476	296 047
Sunflower	332 398	257 955	273 094	292 866
Canola	9 205	10 325	12 145	13 300
Groundnut	1 004	1 777	48	239
Palm	484 706	400 000	291 566	298 091
Palm kernel	-	-	38 119	32 688
Total available	**1 007 108**	**897 639**	**891 448**	**933 231**
Sunflower as % of total	*33.0 %*	*28.7 %*	*30.6 %*	*31.4 %*

Source: SAGIS (2008), SARS (2008), DTI (2007) and own calculations

An interesting calculation made by Vink and Kirsten (2002) showed that, despite the fact that the Indian population makes up only 2.5 % of the total South African population, its expenditure on sunflower oil is estimated at 33 % of the total national expenditure on sunflower oil (Table 2.8). It is also estimated that the White population group is responsible for 25 % and the Coloured population group for 17 % of all expenditure on sunflower oil. This implies that a change in the population demographics or a significant change in the income of a specific population group could have an influence on the demand for sunflower oil.

Table 2.8: Usage spread of sunflower oil amongst the South African population

Population group	% Population	% Expenditure
African	76.79 %	14.08 %
White	10.86 %	24.88 %
Coloured	8.89 %	16.67 %
Indian	2.47%	33.10 %
Other	0.99 %	11.27 %

Source: Vink and Kirsten (2002)

2.4 SUNFLOWER OILCAKE

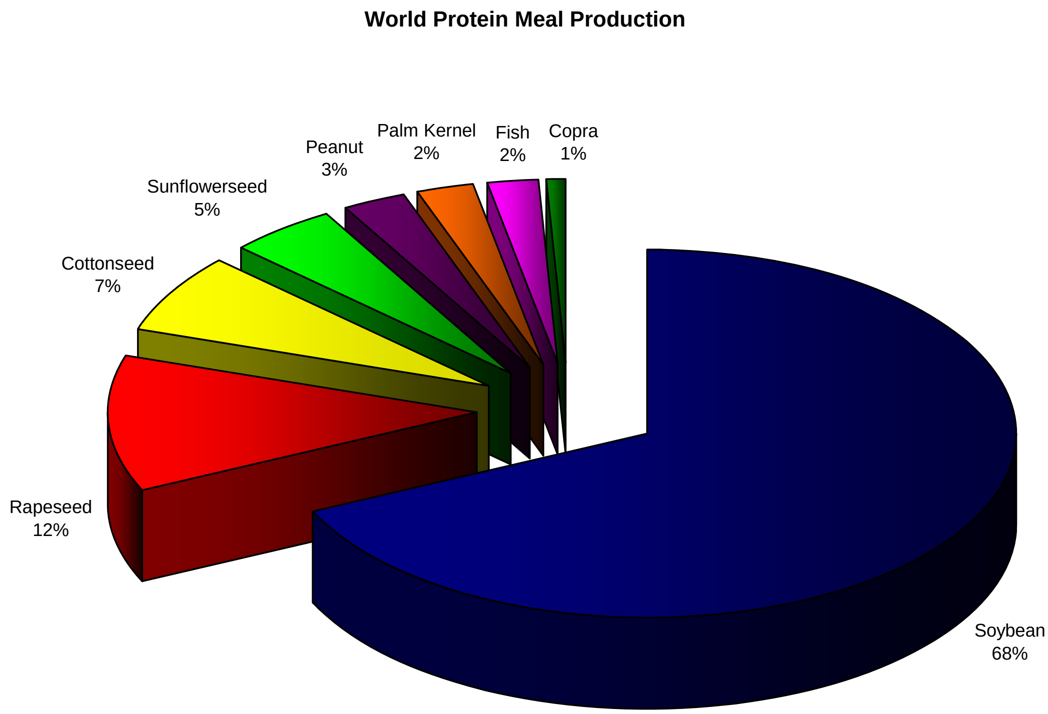


Figure 2.7: World protein meal production

Source: USDA (2008) and own calculations

Soybean oilcake is the protein meal with the largest production and accounts for 68 % of the world's total protein meal production. Rapeseed and cottonseed oilcake contribute 12 % and 7 % respectively, while sunflower oilcake contributes only 5 % to the total (Figure 2.7).

The European Union is also the largest producer of sunflower oilcake, followed by the Russian Federation, Ukraine and Argentina. Together these four countries produce 73 % and consume 63 % of the world's sunflower oilcake (Table 2.9).

Table 2.9: World sunflower oilcake production and consumption (thousand tons)

Country	Production ('000 ton)	Consumption ('000 ton)
EU-27	2,898	4,503
Russian Federation	1,859	1,229
Ukraine	1,631	448
Argentina	1,512	477
India	588	585
Turkey	447	758
China	392	401
Others	1,425	2,092
World Total	**10,752**	**10,492**

Source: USDA (2008) and own calculations

Oilcake or meals are primarily used in livestock feeds as a protein source and therefore the protein content and amino acid composition of the meal has the most important influence on the value thereof.

Table 2.10: Average crude protein and value of protein meals across livestock types

Protein meal	Crude Protein	Relative Value
Soybean meal	48.5 %	100 %
Sunflower meal	42.0 %	86.6 %
Rapeseed meal	36.0 %	74.2 %
Canola meal	38.0 %	78.4 %

Source: USDA (2008) and own calculations

The average crude protein content and the relative value of various oilseeds, compared to the value of soybean meal, are shown in Table 2.10. However, this calculation is only based on the protein content and does not take into account factors such as differences in the amino acid composition and the higher fibre content of the other oilcakes compared to soybean meal.

Due to the inclusion of protein meals in feed rations, the demand for protein meal or oilcakes is directly related to animal production. Table 2.11 shows the typical inclusion rates of sunflower oilcake in different types of feed in South Africa.

Table 2.11: Typical inclusion rates of sunflower oilcake in animal feed rations in South Africa

Feed ratio	Rate
Broilers	0% to 5%
Layers	0% to 15%
Pigs	0% to15%
Dairy cows	20% to 25%
Feedlots	20% to 25%

Source: Dunn (2007)

According to animal nutrition specialists, soybean oilcake is the preferred protein source in animal feed in South Africa due to its favourable nutritional composition (Griesel, 2007). The bulk of the locally consumed soybean oilcake needs to be imported, as South Africa's soybean crop is very small. The calculated availability and consumption of the different protein meals is presented in Table 2.12. This calculation shows a significant decrease in the consumption of sunflower oilcake, despite the increase in animal production over the same period.

Table 2.12: Calculated availability and consumption of protein meals in South Africa

	2004	2005	2006	2007
	Tons			
Locally produced oilcake:				
*Soybean**	125 840	196 000	276 400	260 480
Sunflower	275 814	263 676	188 748	150 528
Cotton	52 733	155 286	100 064	95 000
Canola	22 440	18 840	23 100	23 940
Groundnuts	1 378	2 491	53	371
Total	**478 205**	**636 293**	**588 365**	**530 319**
Sunflower as % of total	*57.7 %*	*41.4 %*	*32.1 %*	*28.4 %*
Net imported oilcake:				
Soybean	644 987	583 523	787 389	931 242
Sunflower	30 507	5 435	53 955	122 220
Cotton	89 808	91 845	106 819	111 345
Canola	15	18	25	-
Groundnuts	-	-	-	-
Other oilcakes	7 339	5 256	560	8 707
Total	**772 656**	**686 077**	**948 748**	**1 173 514**
Sunflower as % of Total	*3.9 %*	*0.8 %*	*5.7 %*	*10.4 %*
Total available and consumed:				
Soybean	770 827	779 523	1 063 789	1 191 722
Sunflower	306 321	269 111	242 703	272 748
Cotton	142 541	247 131	206 883	206 345
Canola	22 440	18 840	23 100	23 940
Groundnut	1 378	2 491	53	371
Other oilcakes	7 339	5 256	560	8 707
Total	**1 250 846**	**1 322 352**	**1 537 088**	**1 703 833**
Sunflower as % of Total	*24.5 %*	*20.4 %*	*15.8 %*	*16.0 %*

*including full-fat soybean meal

Source: SAGIS (2008), SARS (2008), DTI (2007) and own calculations

According to animal feed manufacturers, the decrease in the availability of sunflower oilcake is largely explained by the decrease in the local sunflower crop and crushing activities, resulting in the lower local availability of sunflower oilcake. However, factors such as the higher fibre content of sunflower oilcake limits it inclusion in high-density feeds such as poultry feeds, which showed a significant growth in demand over recent years, while inconsistencies in the quality of locally produced sunflower oilcake also played a role (Dunn, 2007).

According to industry role-players, the local sunflower oilcake price is largely determined by the local soybean oilcake price, which again is based on the landed price or import parity of imported soybean oilcake. However, the local supply and demand situation of sunflower oilcake plays a minor role in the local sunflower oilcake price. Sunflower oilcake can only be stored for a maximum of four months under favourable storing conditions (Prinsloo, 2007). If the crushing of sunflower seed is significantly increased and the production of oilcake exceeds the short-term demand, the price of oilcake will need to decrease in relation to soybean oilcake to stimulate the consumption of sunflower oilcake.

2.5 MAJOR FORCES INFLUENCING THE LOCAL SUNFLOWER INDUSTRY

The local supply of sunflower seed is one of the most important drivers of the South African sunflower seed complex market. As noted before, crushing plants reduce their crushing activities when not enough sunflower seed is available locally. South Africa’s sunflower seed production fluctuated over the past decade at between 300 000 tons and 1.1 million tons and, according to industry role-players, this fluctuation poses a major problem for crushing plants. It further makes long-term planning and investment decisions extremely difficult, as it is a highly capital-intensive industry that requires state-of-the-art technology to stay competitive.

Maize is the major summer crop produced in South Africa, and sunflower seed can be regarded along with other summer grains such as sorghum, soybeans and groundnuts as a secondary crop. Summer grain producers will normally first analyse the profitability of their maize production enterprise before making production decisions on alternative crops. Therefore, the area planted to sunflower seed is influenced not only by the expected profitability of sunflower seed production, but also to a large extent by the expected profitability of maize production.

South Africa can be regarded as a small nation in terms of world production consumption and trade and therefore a price-taker on the world market. Due to the openness of the South African agricultural market, price events on the international oilseed complex market will have a significant effect on local prices. A clear example is the recent sharp increase in international vegetable oil prices due to the growth in demand, which resulted in an increase of more than 100 % during 2008.

Prices on the international market are traded in terms of US Dollars per ton and therefore the Rand/Dollar exchange rate also has an influence on local prices. The fluctuation in the exchange rate can therefore either amplify or reduce any changes in the international market. The effect of a depreciation in the exchange rate on local agricultural commodity prices was illustrated in 2001 when the value of the Rand depreciated by 66 % against the US Dollar within a period of five months. During this period the SAFEX nearby month sunflower seed price increased by 41% while international sunflower seed prices increased by only 2.6 %.

The favourable economic conditions and the increase in household income over the past few years are expected to have a positive impact on the demand for especially processed food products. In a Trade and Industrial Policy Strategies (TIPS) working paper (Mather, 2005) it was also noted that the South African Development Community (SADC) will become a more important market for South African processed food exporters, which may also have a positive effect on the demand for locally produced vegetable oil.

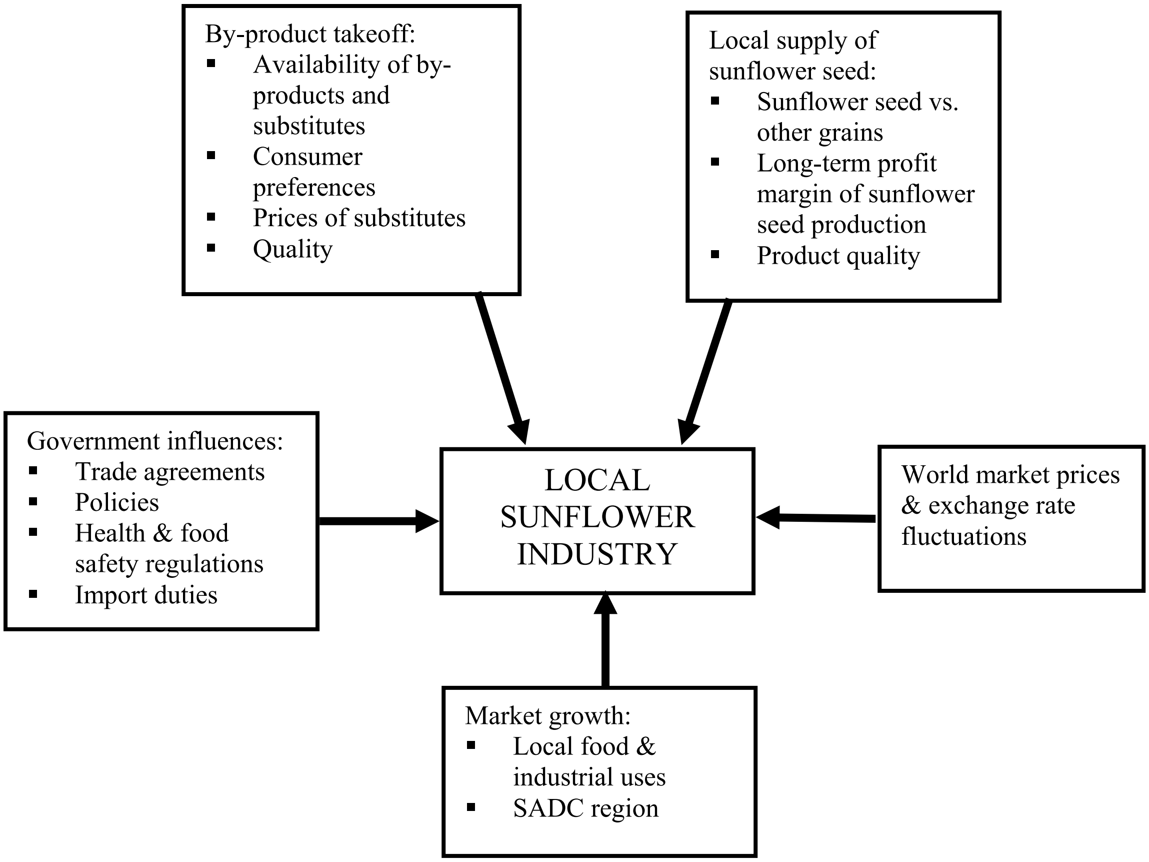


Figure 2.8: Major forces influencing the local sunflower industry

Source: Adapted from Continental Oil Mills (2000)

Trade-related government policies are known to have a significant effect on the agricultural sector. In 2008 the South African government came under tremendous pressure to put measures in place to ease the effect of the sharply rising food prices being experienced since the end of 2007. One option was to lower the import duties on agricultural goods. The sunflower oilseed crushing industry in South Africa is currently protected by a 10 % and 6.4 % *ad valorem* import duty levied on imported edible oils and oilcakes respectively.

During February 2008 the South African Oil Processors' Association called for a drop in the import duty on edible oils and oilseeds so that the savings could be passed on to consumers (www.bizcommunity.com). Although the reduction of the import duty might have a positive effect on the rising food prices on the short run, it might have a significantly negative impact in the long run, as it will have a negative impact on the crushing margin of the crushing plants, which will eventually have a depressing effect on the sunflower seed price.

Different vegetable oils can be substituted with one another to some extent, especially in the markets that make use of cheaper vegetable oil blends. In these markets, there is an increasing trend in the usage of vegetable oils like soybean and palm oils at the expense of sunflower oil due to the competitive prices of these oils. Industry experts regard the import of cheaper soybean and palm oil as one of the major threats to the local sunflower oil crushing industry.

Another point of concern for role-players in the sunflower oilseed crushing industry is the take-off of sunflower oilcake. In the years when the supply of locally produced sunflower oilcake was low due to the lower crushing of sunflower seed, feed manufacturers switched to imported soybean oilcake and, according to industry role-players, sunflower oilcake will need to trade at a significant discount to regain the lost market share in animal feeds.

2.6 CONCLUSION

Chapter two provides an overview over the South African sunflower complex industry from a global perspective. Although sunflower oilseed is regarded as a minor oilseed in world terms, it is the most important oilseed produced in South Africa. South Africa is a net importer of vegetable oils and protein meals and therefore, with regard to the world market, South Africa is a price-taker. The world price of sunflower oil and sunflower meal, as well as the exchange rate, will thus be key determinants of the local prices.

Major forces that currently have an influence on the sunflower oil industry include major year-on-year changes in the supply of sunflower seed, fluctuations in the international prices and the exchange rate, government policies with the regard to agricultural product imports, and increased competition from imported substitutes.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

According to Frances (1994) econometric techniques are usually developed and employed for answering practical questions dealing with economic issues. This relates to Vining, as quoted by Townsend (1997), who stated that econometrics developed out of a desire to further our understanding of economic phenomena and was conceived as being of the nature of a refinement, extension and quantitative expression of neoclassical economics.

The increase in globalisation and international trade resulted in a growing interdependence of the agricultural sectors of different countries. Policy changes or any shocks occurring in one major agricultural exporting country will have repercussions elsewhere in the world. This gives rise to a growing need to anticipate the impact of policy changes or shocks that may arise on the world agricultural sector. This resulted in the development of various econometric models.

These models are valuable tools in explaining the biological and economical complexities of industries and forecasting the possible effects of change on the industry. However, Townsend (1997) pointed out that all too often econometric results are used as the answer to everything, with more attention being given to the results than to the methodology of deriving the results. The clearer the methodology, the easier it will be to reproduce results that will add credibility to these results and, over time, to the agricultural economics profession at large (Townsend, 1997).

The first part of this chapter explores the different documented approaches followed in commodity modelling. The second section deals specifically with price formation. Different market regimes' equilibrium prices are reached in different ways and therefore price formation needs special attention.

3.2 APPROACHES TO COMMODITY MODELLING

In quantitative policy analysis models, national economies can be presented as single market models, a selected set of multi-markets or multi-sector systems, or as economy-wide models (Calcaterra, 2002). Van Tongeren, Van Meijl and Surry (2001) provided a comparative assessment of alternative modelling approaches applied to agricultural and trade policies. The approaches used are mainly categorised into economy-wide models on the one hand and partial equilibrium models focusing on agriculture on the other hand.

An economy-wide model provides a complete representation of the national economy and accounts for the interactions between agricultural and non-agricultural sectors. Economy-wide models capture implications of international trade for the economy as a whole, covering the circular flow of income and expenditure and taking care of inter-industry relations. (Van Tongeren *et al.*, 2001). These models can be divided into three categories, namely macro-econometric models that deal with macro-economic aspects such as inflation and exchange rates, input-output models that explain inter-industry linkages, and applied general equilibrium models that are specifically concerned with resource allocation issues. Economy-wide models offer the advantage of being able to analyse the impact of policy changes and external shocks on the economy as a whole, as well as the change in production factor allocation between industries. However, it requires the development of extensive resources and data, and sometimes these models lack the ability to perform detailed industry-specific analysis.

Partial equilibrium models, on the other hand, deal with a specific market or sector – in this case the agricultural sector. It views the sector as closed and not linked to the rest of the economy. These models can be either single- or multi-product. Where single-product models look at only one product, multi-product models offer the benefit of being able to capture supply and demand interrelationships among agricultural products. Factors affecting the supply and demand of the specific product or products, such as technical change, population and household income, are normally incorporated into partial equilibrium models as exogenous variables.

Partial equilibrium models are commonly applied to specific products in detailed trade policy analysis (Meyer, 2002). However, most partial models of international trade in agriculture focus on trade in unprocessed or first-stage processed agricultural products, without taking into account the trade in processed food products, despite the fact that the latter represent an increasing share of world trade (Van Tongeren *et al.*, 2001).

Over the past decade several partial equilibrium models on the agricultural sector have been developed to analyse the simultaneous effects of policy or market condition changes on the agricultural sectors of specific countries or regions. One such model is the Food and Agricultural Policy Research Institute (FAPRI) modelling system, which is described as a partial equilibrium, global multi-commodity model that provides significant details on the most major importing and exporting countries or regions (Binfield, Donnellon & McQuinn, 1999). In this model macro-economic factors such as interest rate, exchange rate and growth rate for the general economy, population and various manufacturing producer price indexes are exogenous to the system.

The FAPRI modelling approach was also used to develop the South African agricultural sector model, generally referred to as the BFAP sector model. The BFAP sector model is maintained by the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria. The estimation of a system of equations as followed in the FAPRI and BFAP modelling approach offers a great deal of flexibility and allows specific policies and market conditions to be modelled.

Kruse (2003) used a similar approach in the development of the structural econometric model of the international oilseed sector for purposes of policy analysis. Despite the simultaneous nature of the system, the estimation of the equations was performed by using ordinary least squares and not two-stage or three-stage least squares. This was mainly due to data availability. In some cases synthetic equations were created by imposing specific elasticities when the statistical estimation produced results that disagreed with *a priori* expectations.

The model was used to simulate policy, macro-economic changes and technology for oilseed commodities and their primary by-products. Oilseed crops covered by the model included soybeans, sunflowers, rapeseed and palm oil for several countries including Canada, Mexico, Brazil, Argentina, the European Union, China, Japan, India, Malaysia and Indonesia. A Rest of World region was constructed to capture the remaining countries, with the exception of the United States of America (Kruse, 2003).

Kruse (2003) gave considerable attention to the critical equations to produce a well-behaved model. The effects of domestic policy on acreage decisions were included in the area-harvested equations. Gross crushing margins for each oilseed crop and country were determined depending on the crushing yields and the prices received and paid by the crushing plants. These margins were included as independent variables in the crushing demand equations. The total protein meal demand by the livestock sector and the total food demand for oil were estimated to derive the demand equations of the meal and oil respectively. In a second step the shares of each type of meal or oil were estimated as a percentage of the total demand. This approach produced relative elastic meal-demand equations, which allowed for a high degree of substitution between the different meals. However, in the case of oils, the overall demand elasticity was relatively inelastic.

Van Schalkwyk *et al.* (2003) estimated the demand relations for primary oilseeds in South Africa with the use of two econometric techniques, namely the Almost Ideal Demand System (AIDS) and the Error Correction Model (ECM). By using the results obtained from both models, the compensated, uncompensated and expenditure elasticities were calculated and compared. Both models produced relatively inelastic price elasticities, but the comparison of the compensated price elasticities of the two models revealed that the LA/AIDS model performed best, taking into consideration the significance of the individual elasticities.

With regard to cotton, the AIDS and ECM respectively calculated the expenditure elasticity as 0.996 and 1.064 and therefore cotton was classified as a luxury commodity. Sunflower seed was also regarded as a luxury commodity, as both models yielded expenditure elasticities that were larger than one. Groundnuts and soybeans were classified as normal commodities, as their expenditure elasticities ranged between zero and one.

The compensated, uncompensated and expenditure demand elasticities produced by the AIDS in the study of Van Schalkwyk *et al.* (2003) is shown in Table 3.1. The uncompensated or Marshalian elasticities include both the price and income effects, whereas the compensated or Hicksian elasticities contain only the price effects on demand. For this reason the uncompensated elasticities are larger in magnitude than the compensated elasticities.

Table 3.1: Calculated compensated, uncompensated and expenditure demand elasticities of oilseeds in South Africa

Compensated (Hicksian) elasticities				
	Sunflower	Soybeans	Groundnuts	Cotton
Sunflower	-0.013	-0.061	-0.077*	0.149*
Soybeans	-0.010	-0.579*	0.157*	0.102*
Groundnuts	-0.033*	0.408*	-0.210*	0.148*
Cotton	0.056*	0.232*	0.130*	-0.399
Uncompensated (Marshallian) elasticities				
	Sunflower	Soybeans	Groundnuts	Cotton
Sunflower	-0.588*	-0.292*	-0.533*	-0.356
Soybeans	-0.106*	-0.617*	0.081*	0.018*
Groundnuts	-0.281*	0.309*	-0.407*	-0.069
Cotton	-0.161*	0.145*	-0.042*	-0.589*
Expenditure elasticities				
	Sunflower	Soybeans	Groundnuts	Cotton
Expenditure	1.135*	0.454*	0.900*	0.996

Source: Van Schalkwyk *et al.* (2003)

All of the compensated own price elasticities possess a negative sign, as suggested by theory, but not all cross-price elasticities are positive. This implies that some oilseeds are complements and not substitutes. According to the calculated compensated cross-price elasticities, soybeans and groundnuts are complements while cotton is a substitute with respect to sunflower seed.

Over the years several econometric studies on the South African agricultural sector have been conducted and, due to the importance of the maize sector in South Africa, many of these studies have focused on the supply and demand of maize. Van Zyl (1991) used regression analysis to determine the supply of maize in the major production areas of South Africa. South Africa's maize production area was divided into four major areas, namely the Western Transvaal, North-Western Free State, North-Eastern Free State, and Transvaal Highveld. Ordinary least squares (OLS) was used to estimate single equations for the supply of each region.

Relatively poor statistical fits were obtained for the Western Transvaal and North-Western Free State, implying that no significant elasticities could be calculated for these areas. Although the equations for the North-Eastern Free State and Transvaal Highveld region were statistically sound, the calculated price elasticities for both regions were very low. For the North-Eastern Free State region the price elasticity of supply for maize was calculated at 0.026, while the cross-price elasticities with respect to wheat and sunflower were calculated as -0.602 and -0.151 respectively. This implies that the prices of secondary crops have a greater effect on the area planted to maize in the North-Eastern Free State than the price of maize itself (Van Zyl, 1991).

The calculated own price elasticity of 0.136 for the Transvaal Highveld region was higher compared to the North-Eastern Free State region, while the cross-price elasticity with respect to sunflower was calculated at -0.209. The calculated price elasticity 0.397 for intermediate inputs further implies that the price of intermediate inputs had a more significant effect on the maize area planted than the own price of maize in the Transvaal Highveld.

Due to the results obtained in the regression analysis, it was concluded that the prices of maize and its production substitutes do not seem to play a major role in determining the annual area planted to maize. Other factors such as price expectations and timely rainfall also play an important role in the determination of crop varieties, as well as what and how much to plant (Van Zyl, 1991).

Cleasby, Darroch and Ortmann (1993) identified the factors affecting the demand for and supply of South African yellow maize exports using a simultaneous-equation model estimated by two-stage least squares (2SLS). They estimated export demand as a function of the real Chicago Board of Trade (CBOT) maize futures price index, the real gross domestic products index for developed market economies, and the lagged exports. Economic theory suggested that export demand should have been negatively related to the CBOT maize price and positively related to real income of developed market economies. The lagged exports were included to account for the acceptance that foreign purchasers do not adjust their consumption immediately following price changes.

The signs of all the coefficients were according to *a priori* expectations, and the size of the calculated Durbin *h* statistic implied that there were no serial correlation problems. However, the overall fit of the equation was very poor, and the chosen variables explained only 18 % of the total variation in export demand. The lagged export coefficient was statistically significant at the 5 % significance level, implying that the exports realised during the previous marketing season had an effect on the export demand in the current season.

The coefficient of the real CBOT maize futures prices was found to be only statistically significant at a 20 % significance level, while the estimated real income coefficient was not statistically significant at reasonable significance levels. The short-run price elasticity derived from the estimated coefficient was calculated as -37.90, implying that the export demand for South African yellow maize was highly price elastic. However, the poor statistical fit of the equation might have had an impact on the calculated elasticity (Cleasby *et al.*, 1993).

The South African yellow maize export supply was specified as a function of the real domestic producer price, random shocks in yellow maize supplies and lagged exports. The “random shocks in yellow maize supply” variable was included to capture shocks in maize production due to variable weather conditions. The equation had a much better fit and explained 72 % of the variation in export supply. The estimated coefficients of the supply shock and the lagged exports were also statistically significant. The calculated price elasticity of 0.52 for export supply in the short run implied that export supply was relatively price inelastic and much more responsive to supply shocks.

The market equilibrium condition, which closed the simultaneous-equation model, was obtained where the sum of total domestic yellow maize production, imports and lagged inventories equalled total domestic yellow maize consumption, exports and inventories.

Schimmelpfennig, Thirtle and Van Zyl (1996) investigated the supply response of maize and sorghum in South African by using an error correction approach. According to the authors the dynamic error correction framework is an ideal setting for the analysis of supply response, as it avoids spurious regression problems and explicitly represents short-run adjustments to long-run equilibrium. They concluded that the maize area planted depends on two sets of variables, either in a direct way or indirectly by changing the supply environment.

The own price of maize and the price of sorghum, which is regarded as a substitute, were found to have both a short- and long-run effect on the area planted to maize. The price of sunflower was found to have a long-run effect only while the prices of complementary, intermediate input prices mattered in the short run. The second set of variables that change the supply environment included farmer education, research and development expenditure, co-operative extension (variables that develop and diffuse new technologies) and rainfall. All of these variables, with the exception of farmer education, were found to be important in both the long run and the short run. Farmer education had a short-run effect only.

It was also found that sorghum in South Africa was a secondary crop and that the supply response of sorghum depended on intermediate input prices and rainfall over both the short and the long run. The researchers noted that because maize was so dominant in the summer rainfall grain area and maize prices were virtually guaranteed by government at that stage, most cropping decisions with respect to other crops were dependent on movements of and expectations for the key variables of maize. They therefore suggested that it would be more appropriate to use price ratios of the individual crops to maize rather than the actual prices when specifying the supply equations of other crops (Schimmelpfennig *et al*., 1996).

However, Meyer (2002) noted that although the error correction model avoided the partial adjustment model's unrealistic assumption of a fixed target supply based on stationary expectations, one can argue that this model was better suited to time-series data with a high frequency, such as daily or monthly commodity prices, than to annual data.

Poonyth *et al.* (2000) estimated an econometric model of the South African maize and sorghum sector that was used to generate a market outlook for these crops under specified assumptions. They noted that although a single-equation approach might have been used for initial estimation, they eventually employed the 2SLS estimation technique to ensure cross-equation and cross-commodity consistency.

The developed models were built on the world corn model of FAPRI and consisted of a supply and a demand block. Total supply is equal to production plus imports and beginning stocks. Production is calculated by multiplying the area harvested with the yields, whereas the beginning stocks are equal to the lagged ending stocks. The total demand is the sum of domestic use, ending stocks and exports. In this study the net trade position was used to close the model, and the domestic prices were linked to the world price via a price linkage equation. Based on the results of the statistical tests it was concluded that the estimated model could be used for forecasting purposes. The various elasticities reported in the study are shown in Table 3.2.

Table 3.2: Calculated supply and demand elasticities of maize and sorghum in South Africa

Elasticities	Maize	Sorghum
Supply		
Own price: short run	0.12	-
Own price: long run	0.46	0.66
Cross-price		-0.52
Demand		
Own price	-	-0.29
Income	0.28	0.23
Stock-price	-0.56	-0.42

Source: Poonyth *et al.* (2000)

Maize is the main food staple in most countries that form part of the South African Development Community (SADC). In order to assist policy-makers in terms of the possible impact of market liberalisation and deregulation on the regional availability and consumption of maize, Calcaterra (2002) performed an econometric analysis of the structure of the regional maize sector in Southern Africa. Supply and demand data on maize for all countries other than South Africa where obtained from Food and Agricultural Organisation (FAO) statistics and the specified model equations where estimated using the 2SLS technique.

The model consisted of a supply block, a demand block and a price linkage block, while net trade position was used as the market clearing identity. The net trade positions of all the individual countries were then combined to provide a regional net trade position with respect to the Rest of the World. The results of the statistical validation tests performed on the model revealed that the model replicated the SADC maize sector relatively well and that it had satisfactory predictability power.

From the empirical results of the estimated model it was concluded that maize prices in the SADC region do respond to changes in world prices. The estimated own price elasticities for supply over the short run were between 0.0439 and 0.3605, while the long-run own price supply elasticities ranged between 0.0667 and 0.4484. The own price elasticity of demand ranged between -0.0006 to -0.1663, whereas income elasticities were in the range of 0.0004 to 0.3313, suggesting that maize is a basic necessity for SADC countries (Calcaterra, 2002).

Meyer (2002) used a partial equilibrium framework to develop an econometric model of the South African wheat industry. Due to the simultaneous nature of the system of equations in the model, the 2SLS technique was again employed to solve the system of equations to eliminate the simultaneous bias. The South African wheat area harvested was divided into the two main production regions, namely the summer and the winter rainfall areas. The wheat area planted in each region was estimated separately due to the differences in commodities that can be used as substitutes in that region.

The domestic price of wheat was modelled as a function of the import parity price and domestic wheat production, and the model was closed on net imports. The price transmission elasticity was calculated as 0.24, while the elasticity of the production variable in the equation was estimated as -0.33. This would eventually imply that the local production of wheat has a more significant effect on the domestic wheat price compared to the international price. This is a bit unexpected, as South Africa is a net importer of wheat, with imports accounting almost 30 % of the total supply. Due to South Africa's net import position one would expect that the domestic wheat price would mainly be determined by the import parity price of wheat and not domestic production. The developed model was finally used to present the market outlook and policy alternatives for the South African wheat industry.

3.3 PRICE FORMATION

Price plays a central role in the agricultural sector and in many instances it is a key driving force behind production and consumption. In a free market with attributes of perfect competition (i.e. many buyers and sellers, complete knowledge, homogenous product, and no price discrimination), price at a given point in time could be considered at equilibrium. The amount supplied to the market just equals the amount purchased for domestic consumption, storage, or export and is brought into balance by price (Ferris, 1998). Hence, a good understanding of how prices are formed is thus essential to understand the functioning of a commodity market.

From a modelling perspective, the way in which prices are discovered in a particular market will be determined by the technique used to close the model in a partial equilibrium framework. In markets where price formation takes place in the domestic marketplace, market equilibrium is reached where quantity demanded is equal to quantity supplied.

For simplicity's sake, if one assumes a market where the production is a function of past prices and production costs, where the quantity demanded is a function of price and income, and where the changes in stocks and international trade are so small they can be omitted, the following system of equations emerges:

Equation 3.1: $QD_t = a_0 + a_1 P_t + a_2 Y_t + e_t$ (Ferris, 1998)

Equation 3.2: $QS_t = b_0 + b_1 P_{t-1} + b_2 C_t + e_t$ (Ferris, 1998)

At equilibrium levels the quantity demanded equals the quantity supplied or $QD = QS$. With QS being predetermined, the following equation can be formed:

Equation 3.3: $-a_1 P_t = -QS_t + a_0 + a_2 Y_t + e_t$ (Ferris, 1998)

Rearranging equation 3.3 yields the following:

Equation 3.4: $P_t = -\frac{a_0}{a_1} + \frac{1}{a_1} QS_t - \frac{a_2}{a_1} Y_t + e_t$ (Ferris, 1998)

In this instance, where price formation takes place in the domestic market, the price is estimated as a function of production and income. In markets where stocks and international trade are imperative, the system of equations becomes more complex, and special care must to taken with the formulation of the equations to ensure that the model can still be solved.

If one considers, for example, a market with demand and supply equations as provided by equations 3.1 and 3.2 and where export demand is a function of the domestic price and the income in the nations receiving the exports (equation 3.5),

Equation 3.5: $QED_t = c_0 + c_1 P_t + c_2 YE_t + e_t$ (Ferris, 1998)

while the demand for ending stocks is a function of the domestic price and interest rates (equations 3.6),

Equation 3.6: $QEST_t = d_0 + d_1 P_t + d_2 IR_t + e_t$ (Ferris, 1998)

Then the equilibrium condition where total demand equals total supply will be represented as follows:

Equation 3.7: $QD_t + QED_t + QEST_t = QS_t + QEST_{t-1}$

$QEST_{t-1}$ is the ending stocks of the previous year that become the beginning stocks of the prevailing year. By carefully substituting equations 3.1, 3.5 and 3.6 into equation 3.7 (QS is predetermined and $QEST_{t-1}$ is known) the equilibrium price (P_t) can be solved as a function of production, the previous season's ending stocks, domestic income, the income in the countries receiving the exports, and the domestic interest rates. Although it becomes more complex when components like ending stock and export demand are included, the model is still solvable provided that the individual equations are formulated correctly.

The model closure technique where the equilibrium price is calculated by equating the local demand and supply will suit a market where the prices are formed internally and which is relatively isolated from shocks in the international price. From the perspective of the South African sunflower complex market, this approach might not be appropriate because of South Africa's net importing position with respect to oil and oilcake. Therefore, alternative model closure techniques and a different price forming mechanism need to be considered.

Since trade between South Africa and other countries is permitted, one would expect that prices among South Africa and its trading partners would be related. South Africa is regarded as a small nation in the international oilseed complex market, implying that changes in the local supply and demand situation will not have a significant effect on world prices. Hence the domestic price can be linked to world price through a price linkage equation and price transmission elasticities.

When domestic prices are defined by a single set of parameters (equations 3.4 and 3.5), trade is used to close the model under the import and export parity market regimes in the form of a residual of domestic supply and demand. Whether a country is a net exporter or net importer does not fundamentally change the model closure and price formation in a specific market. Domestic prices are still estimated as a function of world prices, transaction costs and policy variables. The only difference is that net exports (imports) will serve as closing identity when the market is trading at export (import) parity levels. This form of model closure can be presented as follows (net exports as closing identity):

Equation 3.8: $QNED_t = QEST_{t-1} + QS_t - QDD_t - QEST_t$ (Ferris, 1998)

where $QNED_t$ is the net export demand, $QEST_{t-1}$ and $QEST_t$ are the beginning and ending stocks, and QS_t and QDD_t represent the domestic demand and supply.

In theory, spatial price determination models suggest that if two models are linked by trade in a free market regime, excess demand or supply shocks will have an equal impact on price in both markets (Rapsomanikis, Hallam & Conforti, 2006). Given prices for a commodity in two spatially separated markets p_{1t} and p_{2t}, the Law of One Price and the Enke-Sammuelson-Takayama-Judge model postulates that, at all points in time, allowing for transfer cost c for transporting the commodity from market 1 to market 2, the relationship between prices is as follows:

Equation 3.9: $p_{1t} = p_{2t} + c_t$ (Rapsomanikis *et al.*, 2006)

Earlier studies analysing market integration or spatial price transmission relied on correlations between pairs of market prices in different regions (Abdulai, 2006). The following type of regression model has been used to study the relationship between markets:

Equation 3.10: $P_t^1 = \delta + \beta P_t^2 + \varepsilon_t$ (Abdulai, 2006)

where $P_t^i, (i = 1,2)$ is the price in region i at time t for homogenous goods, δ and β are parameters to be estimated and ε_t is a error term. This method to test for market integration and spatial price transmission imposed several shortcomings, as it failed to consider the dynamic relationship between prices in distant markets or the non-stationarity of price series data. Several authors eventually started to use co-integration techniques to address these problems in their studies (Abdulai, 2006).

Cluff (2003) reviewed spatial price transmission in multi-country multi-market models used for medium-term outlook projections. The FAO world food model links domestic and world prices in a linear price linkage equation with constant elasticity specifications as follows:

Equation 3.11: $$P_t^D = P_{t-1}^D.(\frac{P_t^W}{P_{t-1}^W})^\eta$$ (Cluff, 2003)

where P_t^D and P_t^W are domestic and world prices and η is the elasticity of price transmission. The shortcomings of this technique lie mainly in the fact that it does not account for the effect of transporting and other transaction costs or exchange rates.

Schimmelpfennig, Meyer, Beyers and Scheepers (2003) executed a study on price transmission in the South African maize market. An ECM approach was used to determine the short- and long-run equilibrium between the world price of maize (which included the cost of transportation to South Africa), the local producer and consumer prices of maize, and the exchange rate. This study only focused on long- and short-term shocks in the maize market, and the empirical model showed that exogenous shocks could affect the long-run equilibrium path of prices and create disequilibria through price stickiness. However, from the results obtained in the study, one can conclude that it might be appropriate to use an ECM approach to determine domestic prices when reliable data and enough observations are available.

The international oilseed model of the Center for Agricultural and Rural Development (CARD)/FAPRI, which consists of several countries, uses price transmission equations driven by estimated or consensus price transmission elasticities to link the world price in domestic currency and the domestic price for all products (FAPRI, 2008). Countries are regarded as either net importers or net exporters of the particular commodity. It is further assumed that each country in the model is a price-taker in the world market, which implies that the world price will have an effect on the domestic price in a particular country, but the supply and demand situation in that country will not have any impact on the world price. Assuming that an *ad valorem* tariff-only regime prevails, the estimation of the domestic price can be presented as follows:

Equation 3.12: $$P_t^D = \alpha + \beta P_t^W . r_t .(1 + d_t)$$ (FAPRI, 2008)

where P^d is the domestic price, P^w is the world price of the commodity including the cost of international transportation if the country is a net importer (if the country is an exporter, the free-on-board price is used), *r* is the exchange rate, and *d* summarises policy interventions between the world and domestic markets, expressed in *ad valorem* form (FAPRI, 2008). Parameter α captures the divergence of the domestic and border prices arising from other transaction or marketing costs that do not depend on the price. Parameter β allows imperfect transmission between world and domestic prices (FAPRI, 2008).

In South Africa the most recent study dealing with price formation and model closure was undertaken by Meyer, Westhoff, Binfield and Kirsten (2006). They presented the structure and closure of an econometric regime-switching model within a partial equilibrium framework. The study focused on equilibrium pricing conditions and the relevant model closure to enable the correct formation of prices under distinct trade regimes in a multi-commodity model, rather than just price transmission and market integration between distinct markets. Three distinct trade regimes, namely import parity, near-autarky and export parity, were defined and alternative model closure techniques were presented for each regime.

At near-autarky levels the level of net export demand is defined as a function relating the quantity of net export demand ($NEXD_t$) to the ratio of the domestic price ($P_{D,t}$) over the average of the import ($P_{IP,t}$) and export parity price ($P_{EP,t}$), and the local grain production ($PROD_t$) – consumption ($CONS_t$) ratio. The exchange rate, transaction cost and government trade policies are already factored into the import and export parity price calculations (Meyer *et al.*, 2006).

Equation 3.13: $NEXD_t = f(\frac{P_{D,t}}{Avg(P_{IP,t} \& P_{EP,t})}, \frac{PROD_t}{CONS_t}, e_t)$ (Meyer *et al.*, 2006)

Export supply EXS_t is calculated in the form of an identity.

Equation 3.14: $EXS_t = PROD_t - CONS_t - (BEGS_t - ENDS_t)$

The domestic equilibrium price is solved endogenously by means of a price equilibrator, and the new market clearing price is simulated by linking the old market price to the difference between $NEXD_t$ and EXS_t, and solving the model with the help of a Gauss Seidel algorithm. The new market equilibrium price is reached once the difference between $NEXD_t$ and EXS_t is zero (Meyer *et al.*, 2006).

Under an import/export parity market regime, domestic prices are predetermined by behavioural price linkage equations, which determine the relationship between import and export parity prices (with world prices, transaction costs, exchange rates and government trade policies taken into account) and domestic prices (Meyer *et al.*, 2006).

Equations 3.15 and 3.16 define the price linkage equation for the import parity and export parity regime respectively, where the domestic price $(P_{D,t})$ is estimated as a function of the import $(P_{IP,t})$ and export parity $(P_{EP,t})$ price and net export demand $(NEXD_t)$.

Equation 3.15: $P_{D,t} = f(P_{IP,t}, NEXD_t)$ (Meyer *et al.*, 2006)

Equation 3.16: $P_{D,t} = f(P_{EP,t}, NEXD_t)$ (Meyer *et al.*, 2006)

Under the parity regimes, the model is closed on net trade, which is represented in the form of the following identity:

Equation 3.17: $NT_t = BEGS_t + PROD_t - CONS_t - ENDS_t$

where net trade (NT_t) equals beginning stocks $(BEGS_t)$ plus local grain production $(PROD_t)$ minus local consumption $(CONS_t)$ minus ending stocks $(ENDS_t)$ (Meyer *et al*., 2006).

A regime-switch mechanism was included in the model to allow the model to switch between various model closure techniques, depending on the market regime. This allowed the model to capture a richer variety of market behaviour than standard models and therefore more accurately capture the likely effects of shocks on the domestic market (Meyer *et al*., 2006).

3.4 CONCLUSION

This chapter reviewed some of the literature relating to different approaches to agricultural commodity modelling and price formation. As pointed out by Van Tongeren *et al.* (2001), no single model can serve all purposes, encompassing all aspects of model specifications. It is also important to realise that no single model can fully capture the impact of complex shocks such as trade agreements (Westhoff, Fabiosa, Beghin & Meyers, 2004). The choice of theoretical framework, the extent of regional and sectoral desegregation, and the selection of datasets and estimation methodologies determine the application of the model (Meyer, 2002).

This study made use of the FAPRI and BFAP modelling approach, which enables institutional and structural constraints to be built into the econometric analysis of the South African sunflower complex market. By taking these constraints into account, it is believed that a market and policy analysing tool was constructed that represents the results of market participants' decisions more accurately following the occurrence of shocks.

CHAPTER 4

THEORETICAL FOUNDATION OF THE SOUTH AFRICAN SUNFLOWER SEED COMPLEX MODEL

4.1 INTRODUCTION

Tomek and Robinson (1995) remarked that prices play a central role in economic theory when it comes to guiding production and consumption. Producers will on the one hand most likely expand production when favourable price levels prevail, while consumers may either cut their spending on certain products or switch to cheaper alternatives when prices are high. An understanding of the concepts of economic theory thus provides a valuable insight into human behaviour and the way in which prices are determined (Tomek & Robinson, 1995). The main usefulness of the theory for empirical purposes is that it establishes a set of constraints that parameters must satisfy, thus limiting the number of independent parameters to be estimated and ensuring consistency in the results obtained (Sadoulet & De Janvry, 1995).

Chapter 4 is devoted to the theoretical foundation of the South African sunflower seed complex model and is presented in five parts. The first two sections deal with the theory of commodity supply and the theory of consumer demand respectively. The theory of input demand in the sunflower complex sector is assessed in the third part, and the calculation of elasticities is presented in part four. Finally the empirical sunflower seed complex model is presented along with a description of how the theoretical concepts discussed in the preceding four sections were used to identify the structure of the individual equations.

4.2 PRODUCER SUPPLY

According to Sadoulet and De Janvry (1995) there are two elements that determine a producer's response to changes in product and factor prices, in terms of technology and access to certain constraining factors to production. The first is the technological relation that exists between any particular combination of inputs and the resulting levels of outputs. This relationship is represented by the production function and can be illustrated by the following equation:

Equation 4.1: $Q = F(L, W, K)$

Q represents the level of output or quantity produced by the farm and is a function of the land (L), labour (W), and other inputs (K) used in the production of the specific commodity. Inputs like fertiliser, seeds and pesticides are variable inputs that can be purchased in the required quantity, while inputs like land and capital are in general fixed inputs that cannot be changed in the short run. In the long run the producer can choose the level of all inputs and therefore all inputs are variable inputs in the long run.

The second element that determines the producer's response is the producer's behaviour in terms of the choice of inputs given the level of market price for a commodity and factors that can be traded. The integration of the two elements leads to the definition of the profit or the cost function, which gives the maximum profit or the minimum cost that a farmer can obtain, given the environment (Sadoulet & De Janvry, 1995).

According to neo-classic theory, the producer is assumed to be a maximiser of profit or net returns, subject to some technical and institutional constraints (Meyer, 2006). A farmer will thus choose his level of output and set of inputs in such a way that a maximum profit ($Max \prod$) is realised. For the farmer with a production function as illustrated in equation 4.1, this can be represented as follows, where *p* represents the price of the commodity produced:

Equation 4.2: $Max \prod = p\,Q - C(L, W, K)$

If the rental price per unit of land is represented by *l* while *w* and *k* refer to the unit cost of labour and other inputs respectively, equation 4.2 can be rearranged so that the farmer's profit function is algebraically defined as follows:

Equation 4.3: $\prod (p, l, w, k, TFC) = Max \prod_{L,W,K} \left[pF(L,W,K) - lL - wW - kK - TFC\right]$

pF(L,W,K) denotes the expected revenue and *l*L, *w*W and *k*K represent the costs of rental land, labour, and capital and other inputs respectively.

Profits are maximised where the slope of the profit equation equals zero (Beattie & Taylor, 1993). This suggests that the derivative of the profit function with respect to the different inputs should be set equal to zero to calculate the optimal input level for maximum profits.

Equation 4.4:

$$p\frac{\partial Q}{\partial L} - l = 0,$$

$$p\frac{\partial Q}{\partial W} - w = 0,$$

$$p\frac{\partial Q}{\partial K} - k = 0$$

By rearranging equation 4.5, the following is obtained:

Equation 4.5:

$$p\frac{\partial Q}{\partial L} = l,$$

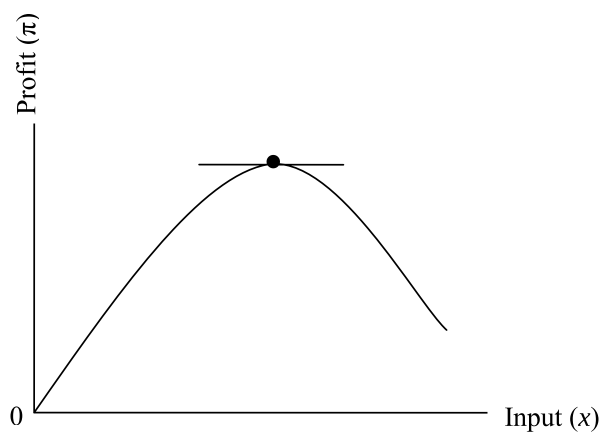
$$p\frac{\partial Q}{\partial W} = w,$$

$$p\frac{\partial Q}{\partial K} = k$$

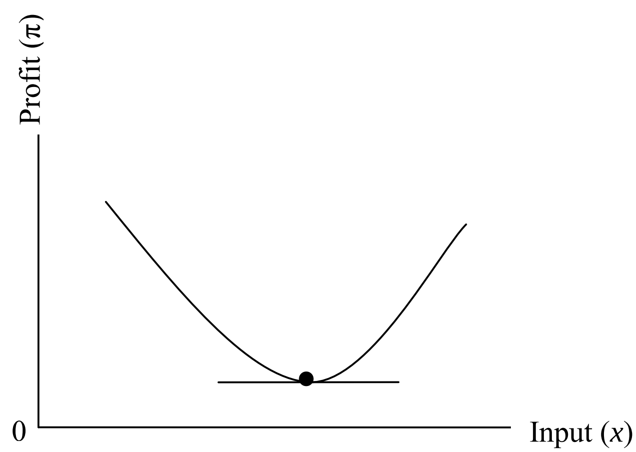
The partial derivative of the production function with respect to the inputs gives the marginal product of the inputs, or in simple terms, by how much the output will change if an additional unit of input is employed. The producer's rate of increase in revenue from additional inputs or marginal value productivity is equal to the marginal product times the product price (which can also be referred to as the marginal factor cost).

Equation 4.5 implies that the producer will maximise his profit at the point where the marginal value productivity equals the unit price of the input. Or, otherwise stated: the optimal input level can be determined by setting the partial derivative of the production function with respect to the inputs (which is the marginal product) equal to the ratio of the product and input prices.

However, the first-order condition is only a necessary condition and is not sufficient for maximum profit, as there is no assurance that the profit equation is concave or convex or has only one peak (Beattie & Taylor, 1993). This can be graphically illustrated as follows:



(a)



(b)

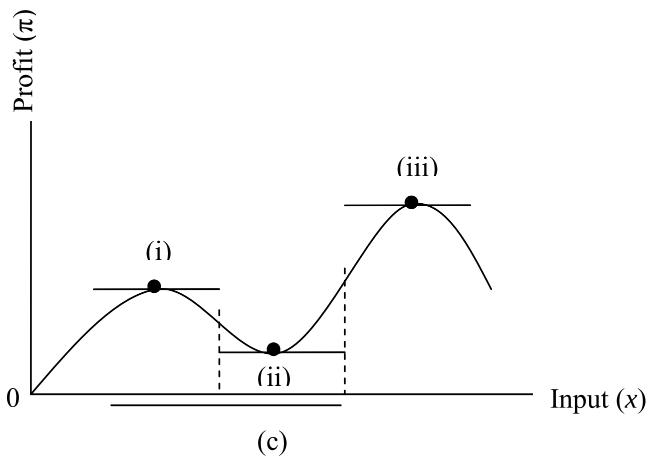


Figure 4.1: Various types of profit functions and interpretation of first-order conditions (adapted from Beattie & Taylor, 1993)

In graph (a) the solution to $\partial\Pi / \partial X = 0$ gives maximum profit, but in (b) the first-order condition gives the minimum profit. In graph (c) there are three solutions for $\partial\Pi / \partial X = 0$:
(i) is the local maximum, (ii) is the minimum, and (iii) is the global maximum profit.

From the above it is clear that for sufficiency, the second-order condition needs to be derived, and for maximum profit it must be smaller than zero. Thus, for sufficiency, the profit function must be strictly concave in the neighbourhood of the first-order condition and therefore the following requirements apply (Beattie & Taylor, 1993):

Equation 4.6:

$$\frac{\partial\Pi^2}{\partial L^2} < 0,$$

$$\frac{\partial\Pi^2}{\partial W^2} < 0,$$

$$\frac{\partial\Pi^2}{\partial K^2} < 0$$

The profit function has two interesting properties: its derivative with respect to the price of the product is equal to the supply function of that product; and its derivative with respect to the price of an input is equal to the negative of the demand function of that input (Sadoulet & De Janvry, 1995). This can be proven using the duality theory.

An important concept in duality is that of an indirect profit function defined as the maximum profit associated with given product and factor prices (Beattie & Taylor, 1993). This is obtained by rearranging the first-order condition for maximum profit, as calculated in equation 4.5, and by solving the amount of inputs used for maximum profit as a function of product and input prices. These are the optimal input demand functions (referred to in some of the literature as the factor demand functions) and are denoted as follows:

Equation 4.7: $L^*(p,l,w,k)$, $W^*(p,l,w,k)$ and $K^*(p,l,w,k)$

If the optimal demand functions are substituted back into the production function, as presented in equation 4.1, the output supply function can be derived (Meyer, 2002):

Equation 4.8: $Q^* = F(L^*, W^*, K^*)$,

Substituting the input demand functions (equation 4.7) and the output supply function (equation 4.8) back into the profit function (equation 4.3) gives the indirect profit function:

Equation 4.9: $\prod(p,l,w,k) = pF(L^*, W^*, K^*) - lL^* - wW^* - kK^*$

Another important concept in duality is the envelope theorem that encloses the concepts of Hotelling's lemma and Shepard's lemma and which is applied in profit maximisation and cost minimisation (Beattie & Taylor, 1993). In the case of profit maximisation, Hotelling's lemma can be exploited to prove that the partial derivative of the indirect profit function with respect to output prices results in the profit maximisation supply function (equation 4.10). In the same way it can be shown that the indirect profit function's partial derivative with respect to input prices equals the negative of the demand function of that input (equation 4.11 to 4.13).

Equation 4.10: $$\frac{\partial \Pi}{\partial p} = F(L, W, K)$$

Equation 4.11: $$\frac{\partial \Pi}{\partial pL} = -L(p, l, w, k)$$

Equation 4.12: $$\frac{\partial \Pi}{\partial pW} = -W(p, l, w, k)$$

Equation 4.13: $$\frac{\partial \Pi}{\partial pK} = -K(p, l, w, k)$$

A constraint of the output supply response function, as derived from the indirect profit function, is that the response is a function of actual prices. However, in the case of agricultural production, there is mostly a significant time difference between when the production decision was taken and when the crop is actually harvested. Producers will thus base their production decisions on expectations and not actual information. Another problem is that the observed quantities may differ from the desired ones, because adjustment lags in the reallocation of variable factors (Sadoulet & De Janvry, 1995). To account for the dynamics in supply response due to the time factor, supply analysts developed a number of alternative approaches.

According to Meyer (2006) the two most common approaches to analysing dynamic output supply response are the adaptive expectations approach and the partial adjustment approach. A third model that is commonly used in agricultural supply modelling is the Nerlovian supply model, which can be regarded as a combination of the first two models.

The adaptive expectations model postulates that changes in an independent variable are related to changes in the expected level of the explanatory variable (Pindyck & Rubinfeld, 1998). In the agricultural sector this can imply that producers base their decisions on their expectations of the price of their commodity at harvest time. The adaptive expectations model can be written as follows:

Equation 4.14: $S_t = \alpha + \beta P_t^e + u_t$

Where:

S_t is the current level of production

P_t^e is the expected price prevailing at time t.

The expectations of future prices are revised every period proportionally according to the difference between the observed prices and expected prices of the previous periods. This revision can be presented as follows:

Equation 4.15: $P_t^e - P_{t-1}^e = \gamma (P_{t-1} - P_{t-1}^e)$

Where:

P_t^e is the expected price prevailing at time t.

P_{t-1}^e is the expected price in the previous period

γ is the coefficient of expectation $(0 \leq \gamma \leq 1)$

P_{t-1} is the observed price in the previous period

If γ=0, then the actual prices will have no effect on the expected prices, and if γ=1, then expected prices will be equal to the last period's observed prices. This implies that the actual prices turned out exactly as anticipated.

Equation 4.15 can be rewritten to give:

Equation 4.16: $P_t^e = \gamma P_{t-1} + (1-\gamma) P_{t-1}^e$

This suggests that the expected price in period *t* is a weighted average of the observed level and the expected level for period *t*-1. The expected level of prices is adjusted every period by taking into account the observed price levels. The expected price at time *t* can now be expressed as a function of previous actual prices over a longer period of time.

Equation 4.17: $$P_t^e = \gamma P_{t-1} + \gamma(1-\gamma) P_{t-2} + \gamma(1-\gamma)^2 P_{t-3} + \gamma(1-\gamma)^3 P_{t-4} \ldots\ldots$$

or

$$P_t^e = \gamma \sum_{s=0}^{\infty} (1-\gamma)^s P_{t-s}$$

Equation 4.17 implies that producers base their price expectations solely on an extrapolation of past prices (Meyer, 2002).

The partial adjustment approach is based on the assumption that producers do not fully respond to price changes due to certain constraints in the short run. It is assumed that the change in production occurs gradually over time and the change from one period to another is adjusted in proportion to the difference between the output desired in the long-run equilibrium and the actual output. Equation 4.18 thus specifies that the change in the level of output will respond as follows:

Equation 4.18: $$S_t - S_{t-1} = \delta (S_t^* - S_{t-1})$$

Where:

S_t is the current level of output in year t

S_{t-1} is the level of output from the previous year

S_t^* is the desired long-run equilibrium level of output

δ is the coefficient of adjustment $(0 \leq \delta \leq 1)$

Equation 4.18 specifies that the change in the level of output will respond partially to the difference between the desired long-run equilibrium level of output and the previous year's level of output – the rate of the response being a function of γ (Pindyck & Rubinfeld, 1998).

Equation 4.18 can be rewritten to give:

Equation 4.19: $$S_t = (1-\delta)S_{t-1} + \delta S_t^*$$

If δ =1, then a complete adjustment in the level of output has taken place from the previous period to the current period, and the current level equals the desired long-run equilibrium level of output. If δ =0, then no adjustment has taken place and the current level of output is equal to the previous year's level of output.

Suppose the desired long-run equilibrium level of output is given by the following:

Equation 4.20: $$S_t^* = \alpha + \beta P_t + \varepsilon_t$$

Then, if equation 4.20 is substituted back into equation 4.19, the new equation is given by:

Equation 4.21: $$S_t = \alpha\delta + (1-\delta)S_{t-1} + \delta\beta P_t + \gamma\varepsilon_t$$

The coefficient of adjustment (δ) in the above equation can now be used to determine the short-run and long-run elasticities of supply response. The estimated coefficient of the price variable ($\delta\beta$) is equal to the short-run price elasticity. The long-term price effect (β) is calculated by dividing the short-term price effect by the adjustment coefficient.

As previously mentioned, the Nerlovian supply model is a combination of the adjusted expectations and the partial adjustment models. In this model, it is assumed that there is a desired level of supply (S_t^*) that is a function of an expected price level (P_t^e) and can be illustrated as follows:

Equation 4.22: $$S_t^* = \alpha + \beta P_t^e$$

If it is assumed that the actual output (S) adjusts towards the desired level according to the partial adjustment model, then the substitution of equation 4.22 (S_t^*) into equation 4.19 (S_t) yields the following:

Equation 4.23: $$S_t = \alpha\delta + (1-\delta)\, S_{t-1} + \delta\beta\, P_t^e + u_t$$

The adaptive expectations model can now be used to solve the expected prices by substituting equation 4.16 into equation 4.23, which gives the following:

Equation 4.24: $$S_t = \alpha\delta + (1-\delta)\, S_{t-1} + \delta\beta \left[P_{t-1} + (1-\gamma) P_{t-2} + ... \right] + u_t$$

Equation 2.24 now shows that the actual output in period *t* is a function of the previous year's level of output and the lagged prices.

4.3 CONSUMER DEMAND

The basic objective of the theory of consumer behaviour is to explain how a rational consumer chooses what to consume when confronted with various prices and a limited income (Sadoulet & De Janvry, 1995). The demand of an individual consumer forms the basis of the market demand for a product. An understanding of the buying behaviour of consumers will provide essential insight into the market demand for a product, which will eventually have an impact on the price of the product.

Consumer demand is defined as the various quantities of a particular commodity that an individual consumer is willing and able to buy as the price of that commodity varies, with all other factors that affect demand held constant (Tomek & Robinson, 1995). The demand for a product will decline as the price increases, which implies that the demand curve has a negative slope. The economic theory of the consumer assumes that consumers will choose the best bundle of goods they can afford (Varian, 1999). This assumption forms the basis of the theory of utility maximisation, which implies that the consumer will maximise his or her utility function subject to a given level of income. Mathematically this can be presented as follows:

Equation 4.25:

$$MAX\ U(x)$$
$$subject\ to$$
$$m = p'x$$

Where $U(x)$ is the consumer's utility function for a given bundle x, while $m = p'x$ signifies the consumer's budget constraint and consists of m, the consumer's available income, and p the vector for prices to each unit good x_i in the bundle x. If it is assumed that the utility function is twice-differentiable and is strictly concave, the utility maximisation problem can be solved through the use of the Lagrange multiplier. The following Lagrangian can be formed:

Equation 4.26:

$$L(x,\lambda) = U(x) - \lambda(p'x - m)$$

The first-order condition requires that the partial derivatives of the Lagrangian with respect to x_i and λ should be equal to zero and thus yields the following:

Equation 4.27:

$$\frac{\partial L}{\partial x_i} = \frac{\partial U(x_i)}{\partial x_i} - \lambda p_i = 0 \quad \text{for } i = 1,2,\ldots..n.$$

Equation 4.28:

$$\frac{\partial L}{\partial \lambda} = -[p'x - m] = 0$$

The simultaneous solution of equation 4.27 and equation 4.28 yields the consumer demand equation of the following form:

Equation 4.29:

$$x_i = x_i(p_1, p_2, \ldots., p_i, m), \quad i = 1,2\ldots, n$$

The consumer demand for good x_i is thus a function of its own price, complementary products or substitutes and the consumer's income.

4.4 INPUT DEMAND

A second important theoretical concept in the demand system for agricultural commodities is the demand for a factor of production or an input, and this differs from the derivation of the consumer's demand for an agricultural product. Some agricultural products are not consumed directly by consumers but are used by the manufacturing industry, such as feed and industrial manufacturers, as raw material in their production processes. The demand for agricultural commodities by the manufacturing sector is thus regarded as a demand for inputs or a demand for a factor of production.

The demand for a factor of production, like the demand for all goods and services, is a relationship between the quantity of the factor used and prices (Beattie & Taylor, 1993). In a same way as farmers do, manufacturers that use agricultural commodities as feedstock are assumed to be maximisers of profit and therefore the profit maximisation and duality theory discussed in the previous section can be used to derive the factor demand.

In the supply theory section it was illustrated that the producer (or in this case the manufacturer) will maximise his profit at the point where the marginal value productivity equals the unit price of the input. This is calculated from the first-order condition of the maximum profit function.

Equation 4.30: $$P_Q \frac{\partial Q}{\partial X} = P_x$$

Where:

P_Q is the price of the output

$\frac{\partial Q}{\partial X}$ is the marginal product for input X

P_x is the price of input X

Solving equation 4.30 for X as a function of P_Q and P_x eventually gives:

Equation 4.31: $X^* = X^*(P_Q, P_x)$ (Beattie and Taylor, 1993)

This illustrates that the demand for a factor of production is a function of the price of the output (the manufactured goods) and the price of the input factor.

4.5 ELASTICITIES

Economists use elasticities to summarise virtually all of the quantitative impacts that are of interest to them, and because such measures focus on the proportional effect of a change in one variable on another, they are unit-free (Nicolson, 2004). Sadoulet and De Janvry (1995) defined elasticities as the percentage change in the dependant variable due to a percentage change in the independent variable. For example if *y* is a function of *x* and other variables, then the elasticity of *y* with respect to *x* is defined as:

Equation 4.32:
$$e_{y,x} = \frac{\frac{\Delta y}{y}}{\frac{\Delta x}{x}} = \frac{\Delta y}{\Delta x} \cdot \frac{x}{y} = \frac{\partial y}{\partial x} \cdot \frac{x}{y}$$

Because elasticities are unit-free, they are convenient tools to express the relationship between variables in supply and demand equations. If the elasticity in the equation above is equal to $|1|$ it will imply that a 1 % change in *x* will result in a 1 % change in *y* and therefore the relationship between *y* and *x* is regarded as unitary. If the calculated elasticity is greater than $|1|$, the relationship between *y* and *x* is said to be elastic and a 1 % change in *x* will cause a change of more than 1 % in *y*. An elasticity of less than $|1|$ implies that *y* will change by less than 1 % should *x* change by 1 %. In this case the relationship between *y* and *x* is regarded as inelastic. Generally, four types of elasticities are important in econometric studies, namely: own price elasticity, cross-price elasticity, input price elasticity, and income elasticity (Calcaterra, 2002).

Own price elasticity refers to the effect of the price of the given product on the quantity produced or purchased. Mathematically this elasticity can be presented as follows:

Equation 4.33:

$$e_{Q,P_Q} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P_Q}{P_Q}} = \frac{\Delta Q}{\Delta P_Q} \cdot \frac{P_Q}{Q} = \frac{\partial Q}{\partial P_Q} \cdot \frac{P_Q}{Q}$$

In the case of own price elasticity of supply, the elasticity will measure the proportionate change in the output or the production of a commodity (Q) that is induced by a proportionate change in the price of the specific commodity (P_Q), *ceteris paribus*. The own price elasticity of demand can be interpreted as the percentage change in the quantity demanded given a small percentage change in the price of that commodity, other factors held constant (Tomek & Robinson, 1995). Since the slope of the supply curve is positive, the own price elasticity of supply has a positive sign whereas the own price elasticity of demand has a negative sign, which explains the inverse relationship between price and quantity demand.

Cross-price elasticity measures the responsiveness of the quantity supplied or purchased of one commodity due to changes in the price of another commodity. If it is assumed that the agricultural producer can produce two commodities, maize and sunflower, the cross-price elasticity of the supply for sunflower seed with respect to the price of maize can be interpreted as the percentage change in the quantity of sunflower seed produced given a one percent change in the price of maize. In the case of demand, the consumer has to choose between sunflower oil and soybean oil, and the cross-price elasticity of sunflower oil demand will measure the percentage change in the quantity of sunflower oil purchased if the soybean oil price changes by one percent.

The cross-price elasticity of commodity *Y* with respect to commodity *X* is denoted as follows:

Equation 4.34:

$$e_{Q_Y, P_X} = \frac{\frac{\Delta Q_Y}{Q_Y}}{\frac{\Delta P_X}{P_X}} = \frac{\Delta Q_Y}{\Delta P_X} \cdot \frac{P_X}{Q_Y} = \frac{\partial Q_Y}{\partial P_X} \cdot \frac{P_X}{Q_Y}$$

The sign of the cross-price elasticity will depend on the nature of the relationship between the two commodities. For commodities that are complements, the cross-price elasticity of supply will have a positive sign, while it will have a negative sign if the commodities are substitutes. In the case of demand, the cross-price elasticity will have a positive sign if the products are substitutes and a negative sign if they are complements. This implies that the quantity of commodity *Y* demanded moves in the opposite direction to the price of commodity *X*.

In terms of consumer demand, the symmetry or Slutsky's condition specifies the relationship between cross-price elasticities. This condition states that the cross-price elasticity of one good relative to another is proportional to its relative importance in consumer expenditures (Ferris, 1998). This can be presented as follows:

Equation 4.35:

$$e_{ij} = \frac{R_j}{R_i} * e_{ji} + R_j (e_{jy} - e_{iy})$$

Where:

e_{ij}, e_{ji} = cross-price elasticities

Ri = expenditure on *i* as a proportion of total expenditure

R_j = expenditure on *j* as a proportion of total expenditure

e_{iy}, e_{jy} = income elasticities

The third important elasticity is the input price elasticity, which measures the percentage change in the output if the price of inputs involved in the production or processing process changes by one percent. Equation 4.36 signifies the calculation of input price elasticities:

Equation 4.36:
$$e_{Q_Y,P_L} = \frac{\frac{\Delta Q_Y}{Q_Y}}{\frac{\Delta P_L}{P_L}} = \frac{\Delta Q_Y}{\Delta P_L} \cdot \frac{P_L}{Q_Y} = \frac{\partial Q_Y}{\partial P_L} \cdot \frac{P_L}{Q_Y}$$

The neo-classic theory stipulates that a negative relationship exists between the output of a commodity and the price of the inputs involved in the production and processing of the commodity.

The income elasticity of demand is a measure of the responsiveness of quantity to changes in income, other factors held constant (Tomek & Robinson, 1995). The relationship between quantity demanded and the level of income can be expressed algebraically as follows:

Equation 4.37:
$$e_{Q,I} = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta I}{I}} = \frac{\Delta Q}{\Delta I} \cdot \frac{I}{Q} = \frac{\partial Q}{\partial I} \cdot \frac{I}{Q}$$

When the sign of the income elasticity of demand is positive, the commodity or product is classified as a normal good. In the case of a normal good, if the elasticity is smaller than one, the expenditure share of the product will decline as income increases. This is usually the case for food consumption (Sadoulet & De Janvry, 1995). A negative income elasticity implies that the consumption of the particular product declines as income increases, and such a product is classified as an inferior product.

The Engel aggregation condition implies that the sum of the income elasticities of all items in a consumer’s budget weighted by the relative importance of each item equals one (Ferris, 1998). In other words, the consumer’s total expenditure should change proportionally to the change in the consumer’s income. The equation for *n* items can be denoted as follows:

Equation 4.38: $$R_1 * e_{1y} + R_2 * e_{2y} + ... + R_n e_{ny} = 1$$

Where:

e_{iy} = income elasticity for *i*

Ri = expenditure on *i* as a proportion of total expenditure

Finally, the homogeneity condition requires that the sum of the own price, cross- and income elasticity equals zero. This implies that if a commodity has either many substitutes or a large income elasticity, it must have a large own price elasticity. The homogeneity condition can be represented as follows

Equation 4.39: $$e_{ii} + e_{ij} + ... + e_{iy} = 0$$

Where:

e_{ii} = own price elasticity for *i*

e_{ij} = cross-elasticity for *i*

e_{iy} = income elasticity for *i*

Apart from the convenient way of expressing the relationship of dependent and independent variables within supply and demand equations, elasticities can be a helpful tool to define parameters in cases where historical data is insufficient or where the estimated regression coefficients are in contrast with *a priori* expectations. The expected elasticities can be used to impose coefficients synthetically into an equation.

4.6 EMPIRICAL FRAMEWORK OF THE SUNFLOWER SEED COMPLEX MODEL

The empirical framework of the sunflower seed complex sector is discussed in a supply and a demand block. Within each block the relevant set of equations of all three sub-sectors, i.e. the seed, oil and oilcake sub-sectors, is discussed. A flow diagram at the end of this section graphically illustrates the relationship between the seed, oil and oilcake sub-sectors and the equations (Figure 4.2).

4.6.1 TOTAL SUPPLY

Total supply $(TSUP_t)$ for a commodity or product in period t consists of beginning stocks (BEG_t), production $(PROD_t)$ and imports (IMP_t), which is an identity and can be expressed as follows:

Equation 4.40: $$TSUP_t = BEG_t + PROD_t + IMP_t$$

The beginning stocks are equal to the ending stocks of the previous year. In the case of sunflower oil and oilcake there is no ending, and thus no beginning stocks. South Africa is a large net importer of both oil and oilcake, and role-players will only import enough so that the total supply meets the total demand, and no inventories are kept.

The annual crop production is determined by the area harvested multiplied by the yield. The final production of sunflower seed thus also includes effects beyond the producer's decision-making powers or control, such as rainfall. It is therefore more appropriate to use the area harvested as a dependent variable to analyst the producer's response to price changes and not the final production. A separate equation with yield as dependent variable needs be estimated, which can then be multiplied with the estimated area harvested to give the estimated local production.

The Nerlovian approach, as discussed in the first section of this chapter, is applied to estimate the acreage response of producers with respect to sunflower plantings. The sunflower area planted is already captured in the existing BFAP sector model. Specific sections of the BFAP sector model, relating to the white maize, yellow maize and wheat, were documented by Meyer (2006). The sector model estimates the total grain area harvested in the summer rainfall area $(TGAH_t)$ which includes maize, wheat, sunflower, sorghum and soybean, as a function of previous season's grain area harvested, the weighted sum of all the crops' expected real gross returns $(EGRT_{All})$, rainfall (R_t) and the price of inputs $(P_{I,t})$.

Equation 4.41: $$TGAH_t = f(TGAH_{t-1}, EGRT_{All}, R_t, P_{I\,t})$$

The area harvested share of sunflower ($AHSH_t$) of the total area harvested is estimated as a function of the ratio between the expected real gross returns of the sunflower crop ($SSEGRT_t$) and the sum of expected real gross returns for the other crops ($SUM(EGRT_t)$):

Equation 4.42: $$AHSH_t = f(\frac{SSEGRT_t}{SUM(EGRT_t)})$$

The estimated sunflower seed area harvested is then calculated by multiplying the total area harvested with the area share of sunflower.

Equation 4.43: $$SSAH_t = AHSH_t * TGAH_t$$

The combination of equation 4.41 and equation 4.42 to form equation 4.43 eventually generates the sunflower area harvested as a function of the lagged area harvested, the expected sunflower price, the expected prices of alternative crops, rainfall and input prices.

The sunflower yield is calculated as a function of the rainfall in the summer grain area (*RAIN*) and the impact of technology (*TREND*):

Equation 4.44: $$YIELD = f(RAIN, TREND)$$

Finally, the production of sunflower seed is calculated as the product of the sunflower seed area harvested and the yield:

Equation 4.45: $$SSPROD = SSAH_t * YIELD_t$$

The local production of sunflower oil $(SOPROD)$ and sunflower oilcake $(SCPROD)$ is calculated by multiplying the amount of sunflower seed that is crushed $(SSCRUSH)$ by the respective crushing yields of sunflower oil $(SOYIELD)$ and oilcake $(SCYIELD)$.

Equation 4.46: $$SOPROD = SSCRUSH * SOYIELD$$

and

Equation 4.47: $$SCPROD = SSCRUSH * SCYIELD$$

The identification of the sunflower seed crushing function is explained in the demand block.

The third component of total supply is imports. Although the international trade volumes of sunflower seed in South Africa are relatively low and irregular, South Africa exported more sunflower seed in the past than it imported. Due to the low trade volumes and the net export position, the international trade of sunflower seed is modelled as net exports and not through separate import and export equations. The composition of the sunflower seed net export equation is discussed in the demand block section.

However, South Africa is a net importer of both sunflower oil and sunflower oilcake. Hence, the local prices are a function of the import parity prices and the calculation of imports of both products is used to close their respective models. The imports $(IMP)_t$ of oil and oilcake are calculated by subtracting the beginning stocks (BEG_t) and production $(PROD_t)$ from the total demand $(TDEM_t)$. This identity can be shown as follows:

Equation 4.48: $$IMP_t = TDEM_t - BEG_t - PROD_t$$

4.6.2 TOTAL DEMAND

The sum of domestic use $(DUSE_t)$, exports (EXP_t) and ending stocks (END_t) equals the total demand $(TDEM_t)$ for a commodity or product in period *t* and can be expressed as follows:

Equation 4.49: $TDEM_t = DUSE_t + EXP_t + END_t$

In the case of sunflower seed, the total domestic use $(SSDUSE_t)$ consists of the demand for crushing $(SSCRUSH_t)$ and other consumption $(SSOTH_t)$:

Equation 4.50: $SSDUSE_t = SSCRUSH_t + SSOTH_t$

The "other" consumption of sunflower seed includes feed, seed and unexplained consumption. Since other consumption of sunflower seed contributes only a small part to the total domestic use, it is included as an exogenous variable in the sunflower model.

The volume of sunflower seed demanded by the crushing industry is calculated by using the input demand approach. The crushing plants are assumed to be profit-maximising firms that use sunflower seed as feedstock in the manufacturing of sunflower oil and oilcake. The sunflower seed crushing demand $(SSCRUSH_t)$ is estimated as a function of the available crushing capacity $(SSCRCAP_t)$ and the crushing margin $(SSCRMAR_t)$ in period *t*.

Equation 4.51: $SSCRUSH_t = f(SSCRCAP_t, SSCRMAR_t)$

The average volume of sunflower seed crushed during the previous five years is taken as an approximation of the available crushing capacity. The crushing margin can be defined as the difference between the crushing plant's income from selling the sunflower oil and the oilcake, and the cost of procuring the sunflower seed. The crushing margin thus captures the effect of both the output and input prices in the input demand equation while the lagged crushing capacity captures the lagged output (sunflower oil and oilcake) and input (sunflower seed) price effects.

Human or food consumption $(SOFUSE_t)$ and industrial demand for bio-diesel manufacturing $(SOBDUSE_t)$ form the domestic use of sunflower oil $(SODUSE_t)$, which is presented by the following identity:

Equation 4.52: $SODUSE_t = SOFUSE_t + SOBDUSE_t$

The total human consumption of sunflower oil is divided by the total population to obtain the per capita consumption. The consumer demand theory is used to derive the per capita consumption of sunflower oil $(SOPCC_t)$ in period *t* and is estimated as a function of the sunflower oil price $(P_{SO,t})$ and the consumer income (INC_t):

Equation 4.53: $SOPCC_t = f(P_{SO,t}, INC_t)$

The estimated per capita consumption is then multiplied by the estimated population to derive the total human consumption of sunflower oil.

As in the case of the sunflower seed crushing industry, the bio-diesel manufacturing industry is assumed to be composed of profit-maximising firms. Hence the demand for sunflower oil by the bio-diesel manufacturing industry $(SOBDUSE_t)$ is derived by using input demand theory and is thus a function of the output or bio-diesel price $(P_{BD,t})$ and the sunflower oil price $(P_{SO,t})$, which is the input.

Equation 4.54: $SOBDUSE_t = f(P_{BD,t}, P_{SO,t})$

Sunflower oilcake in South Africa is only consumed by the livestock sector as feed and therefore the total domestic demand for sunflower oilcake equals the sunflower oilcake feed demand. The total consumption of sunflower oilcake as livestock feed is derived from the profit-maximisation condition of the livestock sector. Suppose the quantity of livestock produced (Q_{LSTOCK}) is a function of the quantity of grain (Q_{GRAIN}), sunflower oilcake (Q_{SFOC}) and soybean oilcake (Q_{SBOC}) utilised as feed, then the livestock production function can be signified as follows:

Equation 4.55: $Q_{LSTOCK} = f(Q_{GRAIN}, Q_{SFOC}, Q_{SBOC})$

By solving the first-order condition of the maximum profit function for livestock production, the demand for inputs, which in this case is sunflower or soybean oilcake, can be derived. Eventually, the demand for sunflower oilcake (Q_{SFOC}) can be expressed as a function of livestock prices (P_{LSTOCK}), its own price (P_{SFOC}) and the price of soybean oilcake (P_{SBOC}), which is a substitute. The demand for sunflower oilcake by the livestock sector as feed component can be represented as follows:

Equation 4.56: $Q_{SFOC} = f(P_{LSTOCK}, P_{SFOC}, P_{SBOC})$

An additional step is added to the sunflower oilcake feed demand equation by linking the sunflower oilcake feed demand to the level of livestock production by means of a feed demand index. The feed demand index is calculated from the quantity of livestock production by type, the feed conversion factor per livestock type, and the inclusion rate of sunflower oilcake in the various feed rations. This feed demand index thus implies that the demand for feed increases (decreases) as the livestock production sector expands (shrinks). The final sunflower oilcake feed demand is thus a function of the total feed demand (*TFD*), the own price (P_{SFOC}) and the price of the substitute (P_{SBOC}).

Equation 4.57: $Q_{SFOC} = f(TDF, P_{SFOC}, P_{SBOC})$

Export demand is the second component of the demand block. Economic theory suggests that the price in the given exporting nation compared to other exporting nations and the translation of those prices to the importing nation would be important considerations in forecasting export demand (Ferris, 1998). This gives the following equation:

Equation 4.58: $EXP_t = f(P_{Exp,t}, P_{\mathrm{Im}\,p,t})$

Where :

EXP_t = exports in period t

$P_{Exp,t}$ = price of commodity or product in the exporting nation in period t

$P_{\mathrm{Im}\,p,t}$ = price of commodity or product in the importing nation in period t

The forecasting of the export demand for South Africa's sunflower seed and products is a challenging task, and the empirical derived export demand relationships differ somewhat from those suggested by theory. This is mainly the result of the changes in the South Africa oilseed sector, the small size of the South African oilseed sector compared to the rest of the world, the generally complex relationships within the South African oilseed complex sector, and the availability of reliable local and regional price data.

South Africa's neighbouring countries are also net importers of vegetable oil, and every year South Africa exports small volumes of sunflower oil to its neighbouring countries. Therefore the type of vegetable oil imported by the neighbouring countries will be affected by the relative prices of the vegetable oils available on the international market. Apart from the effect of prices, the South African production of sunflower oil is found to have an effect on the exports of sunflower seed as a sudden short-term increase in the amount of sunflower seed crushed, which creates the opportunity to increase the amount of sunflower oil exported to neighbouring countries. The export demand for South African sunflower oil $(SOEXP_t)$ can thus be represented as a function of the price of sunflower oil $(P_{WSFO,t})$ and soybean oil $(P_{WSBO,t})$ and local production $(SOPROD)$:

Equation 4.59: $SOEXP_t = f(P_{WSFO,t}, P_{WSBO,t}, SOPROD)$

The amount of sunflower oilcake exported by South Africa is insignificant and is not modelled. Equation 4.48 can thus be seen as the estimation of the net imports of sunflower oilcake.

The last component of the demand block in the sunflower seed model is ending stocks. As mentioned before, no sunflower oil or oilcake stocks are kept, as only enough oil and oilcake will be imported to satisfy the local demand. However, in the case of sunflower seed, ending stocks or inventories play a decisive role in the total domestic supply and demand.

Referring to Bressler and King (1970), Meyer, (2006) noted that there are three motives for holding stocks: transaction demand, precautionary demand, and speculative demand. Transaction and precautionary demand are linked to the domestic supply and demand. Transactional demand depends on the level of production – a higher level of production will imply that stocks will rise and vice versa. Precautionary demand relates to the market's capacity to retain at least some stocks to deal with uncertainties in supply due to shocks in the supply following an event such as severe drought. Precautionary demand can also be referred to as a demand for buffer stock or a pipeline carryover.

Holding stocks due to transaction and precautionary demand can be presented as follows:

Equation 4.60: $S_t = \omega_1 + \omega_2 Q_t$ (Meyer, 2006)

S_t is the total stocks or inventories held at the end of period *t*. The stocks held due to precautionary demand are treated as a constant, represented by ω_1. Transactional demand is specified as a marginal fraction of production, which is given by ω_2 where Q_t denotes the total production in period *t*.

Speculative demand is related to market uncertainty, and speculators would hold stocks to benefit from expected higher future prices. Hence, expectations of future prices play an important role in speculative stockholding, which is specified as a function of the lagged ending stocks (which is also the beginning stocks in the prevailing period), the total production and the expected price in the next period (Equation 4.61).

Equation 4.61: $S_t = f(S_{t-1}, Q_t, P_{t+1})$ (Meyer, 2006)

In the sunflower seed model, ending stocks are estimated as follows:

Equation 4.62: $ENDS_t = f(PROD_t : CRUSH_t, P_{D,t})$

Ending stocks in period *t* depend on the beginning stocks in period *t*, the local production:crush ratio in period *t* and the market price. Stocks will rise if the local production increases relative to the local crushing of sunflower seed. In general, sunflower seed prices reveal a strong seasonality trend, reaching their lowest level during harvest time and rising as time passes. Producers and traders tend to hold stocks to sell at higher prices at a later stage and therefore stocks depend on price levels as well.

Although South Africa has imported relatively large volumes of sunflower products in the past, especially in very dry seasons, on average it has exported more sunflower seed than it has imported. Hence South Africa is regarded as a net exporter of sunflower seed, but it is necessary to mention that South Africa's sunflower seed exports are erratic and mainly depend on whether surplus sunflower seed exists locally.

The calculation of the net trade position serves as the market clearing identity, which is represented as follows:

Equation 4.63: $$SSNTR_t = SSBEGS_t + SSPROD_t - SSDUSE_t - SSENDS_t$$

Where:

$SSNTR_t$ = Sunflower seed imports in period t

$SSBEGS_t$ = Sunflower seed beginning stocks in period t

$SSPROD_t$ = Sunflower seed production in period t

$SSDUSE_t$ = Sunflower seed domestic use in period t

$SSENDS_t$ = Sunflower seed ending stocks in period t

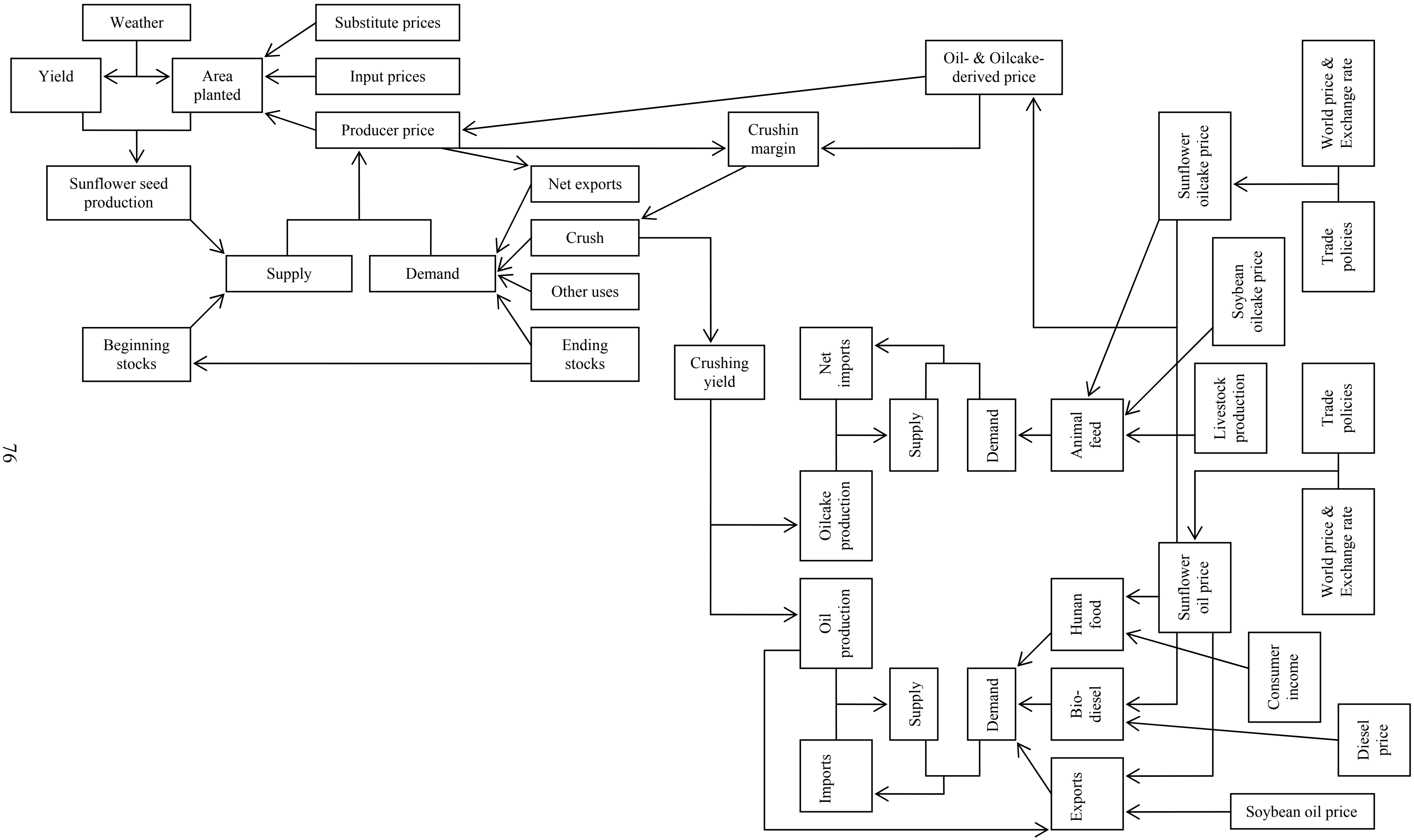


Figure 4.2: Flow diagram of the sunflower seed complex market

4.7 CONCLUSION

Chapter four discussed key theoretical concepts, including producer supply, consumer demand, input demand and elasticities, which were employed to define the structure of the South African sunflower seed complex model. In the final part of this chapter the structure of the model and the model's individual equations were identified. A flow diagram was used to graphically illustrate the linkages between the different components of the model. Chapter five discusses the data used, the methods employed to estimate the equations, as well as the empirical results of the model.

CHAPTER 5

ESTIMATION RESULTS OF THE SOUTH AFRICAN SUNFLOWER COMPLEX SECTOR MODEL

5.1 INTRODUCTION

This chapter introduces the South African sunflower seed sector model as developed after considering the theoretical framework laid down in Chapter 4. The chapter begins with an overview of the data and estimation methods used in the modelling process, followed by the results of the estimated single equations. The parameter estimates and the calculated elasticities are reported for all behavioural equations in table format. In addition, the p-values, R^2 value, F-statistic and Durbin-Watson statistic are reported where applicable. The discussion of the equations is organised in three sections starting with sunflower oilcake, followed by sunflower oil and then finally sunflower seed. Each section commences with a discussion of the price formation of that particular section followed by the supply and demand equations. The chapter concludes with a summary.

5.2 DATA

The main sources of sunflower seed data were the National Department of Agriculture (NDA, 2008) and the Southern African Grain Information Service (SAGIS, 2008). Since 2002 the sunflower seed price was obtained from the South African Futures Exchange. The rainfall data used in the yield equation was supplied by the South African Weather Service. Long-term data on domestic sunflower seed production, consumption and trade was available, since it had been collected and published by the Oilseed Board prior to deregulation. SAGIS has been performing this function since 1997.

However, the deregulation of the South African grain and oilseed industry in 1997 complicates the analysis of the sunflower seed data, as the price discovering and marketing mechanism of major grain and oilseed commodities changed completely with the abolishment of the marketing boards and the introduction of the futures market. This change had a significant impact in the way in which industry role-players reacted to changes in equilibrium conditions and therefore also the magnitude of the effect of change in one variable on another. Thus, although reliable long-term data on the supply and consumption of sunflower seed is available, one must in effect work with two sets of data – the data prior to deregulation and the data after the change in the market structure.

Unfortunately no official domestic data on the total South African production and consumption of sunflower oil and oilcake is published in South Africa. An institution like the Animal Feed Manufacturer's Association (AFMA) publishes every year the local availability of protein meals which is derived from the volume oilseeds crushed during the year as published by SAGIS and imports as reported by SARS. AFMA publishes some the protein meal consumption data but it is only the volumes consumed by its members and not by the total animal feed industry. The year on year changes in the consumption data published by AFMA might be affected by the affiliation of new members or the resignation of existing members.

Data published by STATS SA and international organisations like the FAO and the USDA was inconsistent if compared to information derived from the sunflower seed data published by the South African National Department of Agriculture and SAGIS. The reason why there are such major discrepancies between the data from the different sources is unclear, but it is expected to be due to the methodology used in the data collection, publishing processes and the fact that only some of the institutions undertake corrections and reconciliations on historic data as better information enters the market.

Eventually, with regard to the sunflower oil and oilcake, the local production is derived from the volume sunflower seed crushed which is published by SAGIS. Trade-related data on sunflower oil and oilcake up until 2004 was obtained from the South African Department of Trade and Industry, after which statistics from the South African Revenue Service (SARS, 2008), as published by SAGIS, was used. As no carryover stocks of sunflower oil and oilcake are kept, the local consumption is calculated from the local production, imports and exports. Price data were obtained from various industry role players.

5.3 ESTIMATION PROCEDURE

Ordinary Least Squares (OLS) is probably the most extensively used procedure in the estimation of parameters in single equations and its objective is to produce the best linear unbiased estimators. However, in simultaneous-equation models, the error terms of the equations are biased and inconsistent. Therefore, in a system of equations, alternative estimation methods such as two-stage least squares (2SLS) and three-stage least squares (3SLS) are normally used to solve the bias in simultaneous equations.

A good example of the application of the 2SLS estimation technique in agricultural econometric modelling is found in the study done by Meyer (2002). In this study the principal objective was to construct a system of econometric models using historical information of the wheat market, which was used to make baseline projections and to provide a measuring instrument for the possible impact of policy changes. Due to the nature of the study a lot of emphasis was placed on the diagnostic statistics of the estimated parameters and therefore the 2SLS method was used to obtain the values of the structural parameters in over-identified equations.

According to Gujarati (1995) a noteworthy feature of 2SLS is that the estimates obtained are consistent – that is, as the sample size increases indefinitely, the estimates converge to their true population values. The estimates may not satisfy small-sample properties, such as non-bias and minimum variance. Therefore the results obtained by applying the 2SLS method to small samples and the inferences drawn from them should be interpreted with due caution (Gujarati, 1995).

Kruse (2003) used OLS as estimation procedure in the specification development of the international oilseed sector model, despite the simultaneous nature of the system due to data availability. It was stated that while 2SLS or 3SLS could have been applied, the choice of instruments was made so that the results were nearly identical to OLS estimation. The ability to influence the outcome of these techniques made their application unproductive (Kruse, 2003).

As previously mentioned, the principle objective of this study was to construct a well-behaved econometric model of the South African sunflower seed complex industry that can be used for purposes of scenario and policy analysis. Both econometric and simulation techniques were employed to estimate the system of equations for the sunflower seed complex model.

Due to the data properties, the OLS estimation procedure was found to be the most appropriate procedure to apply in the econometrical estimation of the equations. With the main objective of this study in mind, more emphasise was placed on the signs and the derived elasticities than on the statistical significance of the parameters. This builds on Pindyck and Rubinfeld (1998) who stated that, in practice, it might be necessary to use specifications for some of the equations that are less desirable from a statistical point of view, but that this improves the model's ability to simulate well.

In some instances alternative procedures were followed and synthetic parameters were used when the statistical estimation produced was in contrast with *a priori* expectations or when insufficient data was available. When parameter estimates were imposed, the parameters imposed were not chosen randomly but rather in such a way that they were consistent with the underlying theory. This methodology was also applied by both Meyer (2006) and Kruse (2003) in their work to improve the model's ability to simulate real-world issues and to ensure that turning points are picked up.

5.4 ESTIMATION RESULTS

5.4.1 SUNFLOWER OILCAKE

5.4.1.1 Price formation

The local sunflower oilcake price is largely determined by the soybean oilcake price, which is based on the import parity price levels. As a rule of thumb, industry role-players calculate the sunflower oilcake price as approximately 65 % of the soybean oilcake import parity price. According to role-players the local production of sunflower oilcake depresses the price during periods of high crushing activity. Therefore sunflower oilcake production and the real soybean oilcake price are included as independent variables in the estimation equation of the real sunflower oilcake price.

Equation 5.1: *Real sunflower cake price (R/ton)*

Explanatory variable	**Parameter**	**P-value**	**Elasticity**
Intercept	246.109		
RSBCPSA	0.548	0.000	0.751
SCPROSA	-0.04	0.751	-0.008
DUM89	216.879	0.01	
$R^2 = 0.911$	F statistic = 81.432		Durbin-Watson = 0.851

Variable name	**Definition**	**Units**
RSCPSA	Real soybean oilcake price	R/ton
SCPROSA	Sunflower oilcake production	Thousand tons
DUM89	Indicator variable equal to 1 in 1989, otherwise 0	

At a 5 % confidence level, the coefficient of the real soybean oilcake price is statistically significant, but not the coefficient of sunflower oilcake production. It is therefore clear that the local supply of sunflower oilcake has a smaller effect on the local sunflower oilcake price than initially expected. The R^2 of 91.1 % and the high F-value suggest that the equation explains the variance in the endogenous variable to a large extent, but the low Durbin-Watson d-statistic provides strong evidence of positive serial correlation.

5.4.1.2 Supply

Currently, there is no data available on the domestic stock levels of sunflower oilcake. In general, South Africa produces less than 50 % of its annual protein oilcake consumption and the balance of the local demand is supplied by imports. According to industry role-players only enough oilcake is imported to ensure the total supply meets the domestic demand, and no significant inventory of sunflower oilcake is stored. As a result the total supply is calculated by adding up the local production and imports.

The local production is derived from the amount of seed crushed. Typically, the crushing of sunflower seed will yield 42 % oilcake, 38 % crude oil and 20 % hulls. The local production of sunflower oilcake is calculated by multiplying the volume of sunflower seed crushed, as estimated in equation 5.21, by 42 %.

Equation 5.2: *Sunflower oilcake production (thousand tons)*

SCPROSA = SSCRSA*42%

Variable name	Definition	Unit
SCPROSA	Sunflower cake production	Thousand tons
SSCRSA	Sunflower seed crush	Thousand tons

South Africa is a net importer of sunflower oilcake and exports only small quantities to neighbouring countries. In the sunflower oilcake model the net import position is the closing identity.

Equation 5.3: *Sunflower oilcake net imports (thousand tons)*

SCNISA = SCCSA - SCPROSA

Variable name	Definition	Units
SCNISA	Sunflower oilcake net imports	Thousand tons
SCCSA	Sunflower oilcake consumption	Thousand tons
SCPROSA	Sunflower oilcake production	Thousand tons

5.4.1.3 Demand

Sunflower oilcake is used as a source of protein in animal feeds and therefore the animal production industry can be regarded as a primary driver in the consumption of sunflower oilcake. To capture the effect of the different animal production sectors on the demand for sunflower oilcake, the feed demand index that is generated by the existing BFAP sector model is applied.

The feed demand index is generated by taking into account beef, poultry, pig, eggs and dairy production, as these sectors account for the largest share of sunflower oilcake take-up. The typical inclusion rates of sunflower oilcake in each of the feed rations were multiplied by the average feed conversion ratios and then by the level of production.

Usually feed manufacturers will try to keep the composition of their feed relatively stable and therefore sunflower oilcake consumption is estimated to also be a function of the lagged consumption. The sunflower oilcake price is also included in the equation, as the cost of a specific raw material will influence a feed manufacturer's decision whether or not to include it. The price effect of soybean oilcake was not included in the equation, as the sunflower oilcake price is largely determined by the soybean oilcake price.

Equation 5.4: *Sunflower oilcake consumption (thousand tons)*

Explanatory variable	**Parameter**	**P-value**	**Elasticity**
Intercept	-11.69	0.956	
Lag (SCCSA)	0.529	0.015	0.519
SCFDISA	0.716	0.949	0.611
RSCPSA	-0.018	0.855	-0.078
$R^2 = 0.67$	F statistic = 15.537		Durbin-Watson = 1.901

Variable name	**Definition**	**Units**
SCCSA	Sunflower oilcake consumption	Thousand tons
SCFDISA	Sunflower oilcake feed demand index	Thousand tons
RSCPSA	Real sunflower oilcake price	R/ton

The R^2 of 0.67, an F-value larger than 4 and a Durbin Watson d-statistic close to 2 imply that statistically, the equation as a whole performs relatively well. However, a look at the statistical significance of the individual parameters shows that only the parameter of the lagged sunflower oilcake consumption is statistically significant at a 5 % confidence level. The calculated elasticity also shows that sunflower oilcake consumption is highly price inelastic, which may be due to South Africa's net import position with regard to oilcake and the high correlation between oilcake prices.

5.4.2 SUNFLOWER OIL

5.4.2.1 Price formation

South Africa is a large net importer of sunflower crude oil imported from South America, and the local sunflower crude oil price is based on the import parity price of Argentinean sunflower crude oil. An import parity price for Argentinean sunflower oil was calculated by taking the Argentinean price, the exchange rate, freight rates, and the current ad valorem import tariff of 10% into consideration. Because South Africa is a major importer of sunflower crude oil, it can be expected that the local sunflower oil price should have a close to unitary elasticity with respect to the import parity price. In other words, changes in the import parity of the sunflower oil, whether due to a change in the Argentinean sunflower oil price or the Rand/Dollar exchange rate or even the shipping cost, will be transmitted almost perfectly to the local sunflower oil price.

Equation 5.5: *Real sunflower oil price (Rand per ton)*

Explanatory variable	Parameter	Elasticity
Intercept	100	
RSOIMPSA	0.97	0.95

Variable name	Definition	Units
RSOIMPSA	Real sunflower oil import parity price	R/ton

5.4.2.2 Supply

As in the case of sunflower oilcake there was no data available on the domestic sunflower oil stocks and, according to industry experts, only enough edible oil is imported to supply the shortfall in the local production. The total supply of sunflower oil therefore consists only of local production and imports.

The domestic production of sunflower crude oil is derived from the amount of sunflower seed that is crushed. According to industry role-players, 1 000 kg of sunflower seed generally yields approximately 380 kg of crude oil. For this reason, the amount of sunflower oil produced is equal to 38 % of the volume of sunflower seed crushed, as estimated in equation 5.21.

Equation 5.6: *Sunflower oil production (thousand tons)*

SOPROSA = SSCRSA*38%

Variable name	**Definition**	**Unit**
SOPROSA	Sunflower oil production	Thousand tons
SSCRSA	Sunflower seed crush	Thousand tons

The calculation of sunflower oil imports is used to close the sunflower oil model and is equal to the sunflower oil domestic demand plus the exports minus the local production.

Equation 5.7: *Sunflower oil imports (thousand tons)*

SOISA = SOCSA + SOEXSA - SCPROSA

Variable name	**Definition**	**Units**
SOISA	Sunflower oil imports	Thousand tons
SOCSA	Sunflower oil domestic use	Thousand tons
SOEXSA	Sunflower oil exports	Thousand tons
SOPROSA	Sunflower oil production	Thousand tons

5.4.2.3 Demand

The total demand for sunflower oil consists of total domestic demand and exports. The domestic demand for sunflower oil equals food consumption plus the volume used in the production of bio-diesel.

Until now, virtually all sunflower oil has been consumed in the human food chain, either directly as cooking oil or as vegetable oil-based products like margarine. There is hardly any formal data on domestic sunflower oil consumption that has been published. A historic database was constructed by deriving the level of domestic consumption from the amount of sunflower that has been crushed and the level of imports. The data was validated by comparing it the few historically observations that were actually reported. The constructed database was then used to develop a synthetic equation for the level of per capita consumption in the country. This synthetic equation can be presented as follows:

Equation 5.8: *Sunflower oil domestic per capita consumption (thousand tons)*

Explanatory variable	**Parameter**	**Elasticity**
Intercept	-5	
RSOPSA	-0.08	-0.311
Ln(RPCGDP)	1.5	0.206

Variable name	**Definition**	**Units**
RSOPSA	Real sunflower oil price	R/ton
RPCGDP	Real per capita GDP	R'000 / capita

Per capita consumption of sunflower oil is expressed as a function of the real sunflower oil price and the natural logarithm of the real per capita gross domestic product. Both the own price and income elasticities were selected to be inelastic. A 10 % increase in the real price of sunflower oil will lower the per capita consumption with 3.11 %. Likewise, a 10 % increase in the real per capita gross domestic product will raise consumption with 2.06 %.

The positive, but smaller than one, income elasticity thus suggests that sunflower oil in South Africa is a normal good. This is also in line with the income elasticities of most basic food products in South Africa, such as wheat, which is calculated to have an income elasticity of 0.13 (Meyer, 2006).

Equation 5.9: *Sunflower oil domestic food consumption (thousand tons)*

SODFCSA = SODFPCCSA*POP

Variable name	**Definition**	**Unit**
SODFCSA	Sunflower oil domestic food consumption	Thousand tons
SODFPCCSA	Sunflower oil domestic food per capita consumption	Kg / capita
POP	Population	Thousand

The annual domestic sunflower oil consumption in the food market is calculated by multiplying the annual per capita consumption by the population, which is an exogenous variable.

The South African bio-fuel industry is still in its development phase and the usage of sunflower oil to produce bio-diesel is limited to a few sunflower seed producers that produce bio-diesel for own consumption. The BFAP sector model already includes a bio-fuels model to analyse the possible effect of bio-fuel policies and large-scale production on the domestic grain and oilseed sectors.

In the South African sunflower seed complex model, the projected consumption of sunflower oil as feedstock for bio-diesel production is obtained from the existing BFAP bio-fuels sector model and is included in the sunflower model as an independent variable. Nevertheless, for the sake of completeness, the series of equations to derive the consumption of sunflower oil in the bio-diesel industry as estimated in the BFAP bio-fuels model is explained below.

Equation 5.10: *Sunflower oil domestic bio-diesel use (thousand tons)*

SOBDDUSA = BDCAPSO*BDCUSSO

Variable name	**Definition**	**Unit**
SOBDDUSA	Sunflower oil domestic bio-diesel use	Thousand tonnes
BDCAPSO	Bio-diesel from sunflower oil capacity	Thousand tonnes
BDCUSSO	Bio-diesel from sunflower oil capacity utilisation rate	Percentage

As indicated by equation 5.10, the volume of sunflower oil used for bio-diesel production is the product of the bio-diesel from sunflower oil capacity times the capacity utilisation rate. Since no historical data on bio-diesel from sunflower oil exists, all the parameters of the equations are imposed.

Equation 5.11: *Bio-diesel from sunflower oil capacity (thousand tons)*

Explanatory variable	Parameter
Lag(BDCAPSO)	0.8
Lag(BDMSO/GDPD)	15

Variable name	Definition	Units
BDCAPSO	Bio-diesel from sunflower oil capacity	Thousand tonnes
BDMSO	Real bio-diesel from sunflower oil margin	Rand / ton

The bio-diesel from sunflower oil capacity is a function of the lagged capacity and the lagged real bio-diesel from sunflower oil margin.

Equation 5.12: *Bio-diesel from sunflower oil capacity utilisation rate (thousand tons)*

Explanatory variable	Parameter
BDMSO	11

Variable name	Definition	Units
BDMSO	Real bio-diesel from sunflower oil margin	Rand/ton

The bio-diesel from sunflower oil capacity utilisation rate is only a function of the real bio-diesel from sunflower oil margin.

The bio-diesel from sunflower oil margin is calculated by subtracting all the costs (including the domestic sunflower crude oil price per ton, as well as the bio-diesel from sunflower oil variable and capital costs per ton) from the income from the sale of the bio-diesel manufactured from one ton of sunflower oil. The income from one ton of sunflower seed is calculated by multiplying the price of the bio-diesel realised at the plant, in SA cents per litre, by the sunflower oil to bio-diesel conversion rate. The bio-diesel price at plant again equals the retail price of bio-diesel minus the bio-diesel tax and other costs such as transport.

Equation 5.13: *Sunflower oil domestic demand (thousand tons)*

SOCSA= SODFUSA + SOBDDUSA

Variable name	**Definition**	**Unit**
SOCSA	Sunflower oil domestic use	Thousand tons
SODFUSA	Sunflower oil domestic food consumption	Thousand tons
SOBDDUSA	Sunflower oil domestic bio-diesel use	Thousand tons

The total domestic sunflower oil consumption is calculated as the sum of the food and bio-diesel use as estimated by equations 5.18 and 5.19.

The final component of the sunflower oil demand block is sunflower oil exports. South Africa normally exports a relatively small amount of sunflower oil to neighbouring countries, as most of these countries are also net importers of vegetable oils. The amount of sunflower oil exported is influenced by the ratio between the international sunflower and soybean oil prices, since the local prices of both oil types are also determined by the international prices. The local production of sunflower oil also plays a role, since a higher local physical availability of sunflower oil will increase the share of sunflower oil in the total vegetable oil exports to neighbouring countries. The limited number of actual observations available was used to construct the following synthetic equation:

Equation 5.14: *Sunflower oil exports (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	5	
(SOPRNWE/SBOPRD)	-8.5	-0.829
SOPROSA	0.08	1.439

Variable name	Definition	Units
SOPRNWE/SBORD	International sunflower oil and soybean oil price ratio	Ratio
SOPROSA	Sunflower oil production	Thousand tons

The negative sign of the price ratio variable implies that if the sunflower oil price were to increase relative to the soybean price, less sunflower oil would be exported. The price elasticity of -0.829 indicates that if the international sunflower oil price were to increase by 10 % relative to the international soybean oil price, the South African exports of sunflower oil would decrease by 8.29 %. The South African export of sunflower oil is more elastic to a change in the local production sunflower oil, as a 10 % increase in the local production would result in a 14.39 % increase in exports.

5.4.3 SUNFLOWER SEED

5.4.3.1 Price formation

As explained previously, the South African sunflower seed price is mainly driven by the prices of sunflower oil and oilcake. The industry refers to a derived sunflower price where a value for seed is calculated by adding the value of the cake to the value of the oil that is extracted from the seed. This is the most basic indicator for any sunflower seed off takers to determine when the futures price for sunflower seed is overvalued or undervalued. In addition, industry experts also argue that the relative size of the local sunflower crop influences prices because when there is a big surplus of sunflower seed in the local market, the local crushing facilities do not take up all the available seed and the local prices move closer to export parity levels at which it can be exported.

As a consequence, the sunflower seed price is estimated as a function of the derived oil and oilcake prices and the sunflower seed production divided by the 5-year average level of crushing.

Equation 5.15: *Real sunflower seed producer price (R/ton)*

Explanatory variable	**Parameter**	**P-value**	**Elasticity**
Intercept	491.679		
42% RSCPSA +38% RSOPSA	0.383	0.016	0.540
SSPROSA/5year average SSCRSA	-33.637	0.712	-0.034
DUM07	442.12	0.023	
$R^2 = 0.606$	F statistic = 6.145		Durbin-Watson = 2.011

Variable name	**Definition**	**Units**
RSCPSA	Real sunflower oilcake price	R/ton
RSOPSA	Real sunflower oil price	R/ton
SSPROSA	Sunflower seed production	Thousand tons
SSCRSA	Sunflower seed crush	Thousand tons

Despite the fact that the data set contained only 16 observations, the regression function still yielded an estimation equation with an R^2 of 60.6 %, a statistically significant parameter for the derived oil and oilcake price variable, with all parameters having the correct signs.

Since South Africa is a net importer of oilseed products, it is expected that international prices in Rand terms would have the most significant effect on the South African sunflower price. The calculated elasticity of the derived sunflower oil and oilcake price suggests that the real sunflower seed producer price would change by 5.4 % should the derived price change by 10 %. This is much larger than the effect of the production/long-term average crush ratio, which has a calculated elasticity of only 0.034.

One might have expected a slightly higher elasticity for the production:crush ratio parameter, as industry experts pointed out that normally the local sunflower seed price would drop closer to export parity during harvest time and would move back to the sunflower oil- and oilcake-derived price after harvest pressure subsides. The larger the local sunflower crop, the longer harvest pressure will keep the local sunflower price at lower levels, which affects the average annual price for sunflower seed. Bearing this in mind, the calculated elasticity of the production:crush ratio parameter might be on the low side.

5.4.3.2 Supply

The total supply of sunflower seed in a specific marketing season equals the beginning stocks at the onset of the new marketing season, which is the ending stocks of the previous season, plus the domestic production and the total imports.

Domestic production again is the product of the area harvested times the yield. In South Africa there is no data available for area harvested, only for area planted, but producers have high intentions to harvest the planted acreage. Therefore the area planted can be used as a proxy for the area harvested.

As indicated in chapter 4, the existing BFAP sector model already caters for the estimation of the area planted under sunflowers. The existing equations in the BFAP sector model for the total grain area harvested and the sunflower seed share of the total grain area are adopted without any further adjustments

The sum of the total area planted to the six commercial grain and oilseed crops, including white maize, yellow maize, sorghum, sunflower and soybeans, is estimated as a function of the weighted sum of expected real gross market returns for all six crops, the rainfall in the summer production area during the planting season, and the real price of fuel. The real gross market returns are weighted according to the commodities’ share of the total area harvested.

Equation 5.16: *Total grain area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	4264.9	
LAG(G6REGMW)	0.710	0.22
RASAD	1.575	0.12
RFUEL	-466.40	-0.11
SHIFT98	-733.13	

Variable name	Definition	Units
G6REGMW	Weighted sum of expected real gross market return – 6 crops	R/ton
RASAD	Rainfall: summer grain area decision	mm
RFUEL	Real fuel price index	Index
SHIFT98	Indicator variable equal to 1 from 1998 onwards	

All the crops in the model are expressed as a share of the total grain area harvested and estimated as behavioural equations, with the exception of white maize. The sunflower seed area harvested share of the total grain area harvested is modelled as a function of the ratio of the real expected gross market return for sunflower seed divided by the sum of the expected gross market return for the remaining five crops. This implies that if the gross market return of sunflower seed production increases in relative terms, more significantly compared to the other five crops, the share of sunflower seed plantings in the total grain area will increase and vice versa.

Equation 5.17: *Sunflower seed share of total grain area (percentage)*

Explanatory variable	Parameter	Elasticity
Intercept	-0.02709	
LAG(SSRGMSA)	0.11678	0.78
SHIFT97	0.05655	
DUM00	0.05688	

Variable name	Definition	Units
SSRGMSA	Sunflower seed expected real gross market return / Sum of 5 grains real expected market return	Percentage
SHIFT97	Indicator variable equal to 1 from 1998 onwards	
DUM00	Indicator variable equal to 1 in 2000, otherwise 0	

The elasticity shows that the sunflower area harvested share is relatively inelastic. Nevertheless, the elasticity is much higher compared to the calculated elasticities reported by Meyer (2006) for yellow maize area planted (0.37) and wheat area planted (0.57). Yet, taking the recent fluctuating trends in the sunflower area planted into consideration, this relatively large elasticity seems plausible.

The sunflower seed area harvested is the product of the total grain area harvested and the share of sunflower seed, which is calculated in equations 5.16 and 5.17 respectively.

Equation 5.18: *Sunflower seed area harvested (thousand hectares)*

SSAHSA = G6AHSA*SSAHSH

Variable name	**Definition**	**Units**
SSAHSA	Yellow maize area harvested	Thousand hectares
G6AHSA	Total grain area harvested	Thousand hectares
SSAHSH	Sunflower seed area harvested share	Percentage

The BFAP sector model also consists of a sunflower yield equation which is adopted for the purpose of this study. The sunflower yield is estimated as a function of the rainfall in the summer grain area and the log of a normal trend variable.

Equation 5.19: *Sunflower seed yield (t/ha)*

Explanatory variable	**Parameter**	**Elasticity**
Intercept	-3.202	
RASPRD	0.000086	0.337
LNTREND	0.092458	0.281

Variable name	**Definition**	**Units**
RASPRD	Rainfall summer grain production	mm
LNTREND	Logarithmic trend variable	

The estimated elasticity for the effect of rainfall implies that a 10 % increase in the rainfall of the summer grain area will increase national sunflower yields by 3.37 %. As expected, the elasticity of rainfall on sunflower yields is lower when compared to white and yellow maize, which was estimated by Meyer (2006) as 0.62 and 0.82 respectively. This is also supported by the general belief that sunflower is a more drought-tolerant crop than maize.

The sunflower seed production is finally calculated in the form of an identity where the area harvested is multiplied by the yield.

Equation 5.20: *Sunflower seed production (thousand tons)*

SSPROSA = SSAHSA*SSYSA

Variable name	Definition	Unit
SSPROSA	Sunflower seed production	Thousand tons
SSAHSA	Sunflower seed area harvested	Thousand hectares
SSYSA	Sunflower seed yield	Ton/hectare

5.4.3.3 Demand

Total demand equals domestic consumption plus exports and ending stocks. Domestically, sunflower seed is mainly consumed in the crushing industry to produce sunflower oil and oilcake. Small quantities of the seed are also consumed in the confectionary and health food markets, as bird feed and for some other unexplained uses. However, over the past ten years, the combined usage of sunflower seed in the market other than in the crushing industry was never more than 4 % of the total domestic consumption. Therefore all other domestic uses of sunflower seed are combined and included as an exogenous variable in the sunflower seed model.

It is calculated that South Africa has an oilseed crushing capacity of more than one million tons, but the largest volume of sunflower seed crushed since deregulation was 814 000 tons in 2000. Since then, the volume crushed has fluctuated between 369 300 and 798 900 tons. The volume of sunflower seed crushed depends largely on the available crushing capacity and the real crushing margin.

In the sunflower seed model the average amount of sunflower seed crushed during the previous five years is used as an approximation of the available crushing capacity. The crushing margin is calculated by subtracting the actual sunflower seed price from the derived sunflower seed price. The derived sunflower seed price is calculated as the sum of 38 % of the sunflower oil price and 42 % of the sunflower oilcake price.

Equation 5.21: *Sunflower seed crushed (tons)*

Explanatory variable	**Parameter**	**Elasticity**
Intercept	44.69	
LAG(5 year average SSCRSA)	0.595	0.6
SSCRMAR/GDPD	63.936	0.475

Variable name	**Definition**	**Units**
SSCRSA	Sunflower seed crushed	Thousand tons
SSCRMAR/GDPD	Sunflower seed real crushing margin	R/ton

As indicated in equation 5.8, the parameter of the five-year average crush variable has an elasticity of 0.6, which implies that if the average volume of sunflower seed crushed during the previous five years were to increase by 10 %, the amount of sunflower seed crushed in the prevailing season would be 6 % higher. At 0.475, the elasticity of the real crushing margin is slightly lower than the five-year average sunflower seed crushed variable, which means that if the real crushing margin were to increase by 10 %, the volume of sunflower seed would increase by 4.75 %.

The sunflower seed ending stock is influenced by the sunflower seed production:crush ratio and the real sunflower seed price. No meaningful statistical results were obtained when the estimation was conducted and the signs of the variables were not making economic sense. Therefore, synthetic parameter estimates are imposed to ensure economic sound behaviour by the equation.

The parameters are selected to ensure that sunflower ending stocks are relatively inelastic with respect to change in the production:crush ratio and the real sunflower price.

Equation 5.22: *Sunflower seed ending stocks (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	211	
SSPROSA/SSCRSA	120	0.433
RSSPPSA	-0.0525	-0.197

Variable name	Definition	Units
SSPROSA/SSCRSA	Sunflower seed production:crush ratio	Thousand tons
RSSPPSA	Real sunflower seed SAFEX price	R/ton

The calculation of the sunflower seed net import position provides the market clearing identity of the sunflower seed model, as shown in equation 5.11.

Equation 5.23: *Sunflower seed net trade (thousand tons)*

SSNTRSA = SSDUSA + SSENDSA - LAG(SSENDSA) - SSPROSA

Variable name	Definition	Units
SSNTRSA	Sunflower seed net trade position	Thousand tons
SSDUSA	Sunflower seed domestic use	Thousand tons
SSENDSA	Sunflower seed ending stocks	Thousand tons
SSPROSA	Sunflower seed production	Thousand tons

5.5 SUMMARY

Chapter 5 presented the structure of the South African sunflower seed complex model. The model is made up of 25 equations of which 11 are behavioural equations and the other 14 are identities. In the case where the existing BFAP sector model already consisted of meaningful estimations of relevant endogenous variables, these equations were adopted. In general terms, the crushing of one ton of sunflower seed produces 420 kg of oilcake and 380 kg of oil. These ratios are used to derive the local sunflower oil and oilcake production from the volume of sunflower seed crushed.

The local sunflower oilcake price is a function of the local soybean oilcake price, which again is determined by the import parity of Argentinean soybean oilcake, and the local sunflower oilcake production. In both the sunflower oil and oilcake models, the calculation of the imports is used to close the model. Sunflower oilcake is used as feedstock for the animal feed manufacturing industry. Local sunflower oilcake consumption is estimated as a function of the lagged consumption, the price of sunflower oilcake, and the feed demand index.

South Africa is a large net importer of sunflower oil and therefore the local sunflower oil price is determined by the import parity of Argentinean sunflower oil. Sunflower oil is mainly used in the human food market, and the calculated income elasticity showed that sunflower oil can be regarded as a normal good. However, it may be classified as a more luxury good if the income elasticity of sunflower oil is compared to the income elasticities of foodstuffs like white maize and wheat. Provision is also made for the analysis of the possible effects of the production of bio-diesel from sunflower oil on the sunflower complex industry by linking the sunflower oil model to the BFAP bio-fuels sector model.

The South African sunflower seed price was found to be a function of the sunflower oil- and oilcake-derived prices, as well as the lagged production:consumption ratio. The share of sunflower plantings as part of the total summer grain crop area is mainly determined by producers' expected gross market return for sunflower relative to the other summer grain crops. The estimated local sunflower production is calculated as the product of the area harvested times the projected yield. The yield is a function of the rainfall in the summer grain production region and the trend variable, which can be regarded as a variable for the improvement of technology over time.

The sunflower seed crop is the input to the sunflower seed crushing industry that produces sunflower oil and sunflower oilcake. The volume of sunflower seed that is crushed is determined by the available sunflower seed crushing capacity and real crushing margin. Sunflower ending stocks are estimated as a function of the production:crush ratio and the real producer price. The calculation of the sunflower seed net trade position closes the sunflower seed part of the model.

The true simulation capability and performance of the new sunflower seed complex partial equilibrium model is analysed in the next chapter, when it is incorporated in the existing BFAP sector model in order to generate baseline projections and analyse the impact of various shocks on the sunflower complex.

CHAPTER 6

BASELINE PROJECTIONS AND SCENARIO ANALYSIS

6.1 INTRODUCTION

Chapter 6 presents the baseline projections for the sunflower seed complex market and explores the model's ability to generate reliable estimates and projections under real-world conditions. Hence, this chapter also serves as an *ex post* evaluation of the performance of the developed model.

The chapter is divided into two parts: The first part presents the baseline for the South African sunflower complex market based on the specific conditions and assumptions regarding exogenous variables. In the second part, the performance of the model is evaluated on the basis of certain exogenous shocks occurring in the economic or trade policy environment or in the world markets, or a sudden shift in consumption trends.

Six scenarios were evaluated. The first two scenarios assessed the respective impacts of a 20 % depreciation of the local exchange rate against the US Dollar and a shock in the international oilseed and oilseed product prices. Scenarios three and four evaluated the impact of a change in the import tariffs of sunflower seed, oilcake and oil, while the final two scenarios analysed the effects of a shift in the demand for sunflower oil and oilcake respectively.

6.2 BASELINE PROJECTIONS

The generated baseline projections for the South African sunflower market complex can be considered as a reference scenario or a plausible market outlook based on a certain set of assumptions. These assumptions relate to agricultural policies, economic market conditions, the weather and international prices, which are exogenous to the model. Due to the inherent uncertainties of these variables and the occurrence of any unforeseen market disruption, it is unlikely that the future will match the baseline projections and therefore the baseline should not be seen as a forecast. It is important to take into consideration that the empirical work of this chapter was undertaken at the beginning of 2009 when the actual data for 2008 was not yet available and baseline projections for 2009 of the various institutions like FAPRI and BFAP had not been published

The relevant assumptions with regard to the macro-economic variables, the input and the world market prices used in the generation of the baseline and presented in table 6.1 were obtained from Bureau for Food and Agricultural Policy (BFAP)'s baseline projections in June 2008. Thus, the BFAP baseline was published at the time where most of the commodity prices in the world had already reached their highest point and were starting to back down.

The exchange rate was projected to continue its relatively large depreciation during 2008 into 2009 before further weakening against the Dollar but at a lower and decreasing rate. The real gross domestic product (GDP) per capita was forecasted to increase with 3 % per year in 2008 and 2009 before starting to grow more rapidly and eventually reaching a growth rate of 5.82 % in 2013. Farm input prices were forecasted to increase gradually during the forecasting period. The world prices of oilseeds and oilseed products were projected to decline significantly in 2009 after a steep increase during 2008. From 2010 onwards it is expected that these prices will fluctuate within a more defined price band.

By the time the baselines were generated, there was already a good indication that the 2008 season would be above average in terms of rainfall, but for the rest of the forecasting period normal weather and trend yields were assumed. It was further assumed that the current agricultural trade policies would remain unchanged during the forecasting period, which implies *ad valorem* import tariffs of 6.6 %, 10 % and 6 % on the free on-board price of sunflower seed, oil and oilcake respectively.

Table 6.1: Macro-economic assumptions and world price forecasts, 2008 – 2013

Variable	Unit	Actual	Projections					
		2007	2008	2009	2010	2011	2012	2013
MACRO VARIABLES								
Total population of SA	millions	47.45	47.63	47.79	47.96	48.13	48.31	48.51
Exchange rate	SA cent/USD	709.98	828.83	921.99	971.31	1018.78	1063.27	1106.44
Real GDP per capita	Rand	17492.16	18016.92	18557.43	19299.73	20264.71	21410.20	22655.41
GDP deflator	index '95	235.08	256.48	271.10	286.08	300.38	314.75	329.08
CPI: Food	index '95	224.99	245.47	259.46	273.80	287.49	301.24	314.95
Ave. annual prime rate	%	12.50	15.00	15.00	14.00	13.00	13.00	13.00
PPI: Agricultural goods	index '95	218.02	237.87	251.43	265.32	278.59	291.91	305.20
Freight rate	US$/t	95.00	98.14	66.13	68.92	68.36	67.30	66.63
Discharge costs	R/ton	127.44	139.04	146.97	155.09	162.84	170.63	178.40
Transport costs - Durban to Randfontein	R/ton	201.22	219.54	232.05	244.88	257.12	269.42	281.68
INPUT VARIABLES								
Fuel	index '95	395.55	605.19	695.97	728.17	760.96	793.57	825.99
Fertiliser	index '95	294.22	450.16	517.68	542.43	568.01	593.37	618.56
Farm requisites	index '95	278.85	304.23	321.57	339.34	356.31	373.35	390.35
Intermediate goods	index '95	283.99	434.51	499.68	523.57	548.27	572.75	597.06
WORLD PRICES								
Sunflower seed: EU CIF Lower Rhine	US$/t	401.00	542.80	381.48	391.70	358.65	394.60	379.44
Sunflower cake (pell 37/38 %): Arg CIF Rott	US$/t	178.00	298.00	224.25	232.37	213.23	238.47	221.89
Sunflower oil: Arg. FOB	US$/t	751.00	1032.86	824.47	797.21	783.55	832.75	862.56
Soybean seed: Arg. CIF Rott	US$/t	335.00	476.10	360.13	413.07	378.87	419.72	403.08
Soybean cake (pell 44/45 %): Arg CIF Rott	US$/t	276.00	445.00	394.21	380.41	341.63	379.40	353.02
Soybean oil: Arg. FOB	US$/t	684.00	1185.00	738.84	791.00	790.05	833.37	860.20

Source: BFAP (2008)

Table 6.2 presents the baseline projections for the South African sunflower seed sector for the period 2008 to 2013. The area planted to sunflower was projected to rebound after the drought struck 2007 due to the high 2007 sunflower seed prices and the relatively better profitability of sunflower compared to other substitutable crops. The good sunflower seed prices projected for 2008 would have ensured that producers kept their 2009 sunflower plantings at approximately the same levels as in 2008. Lower sunflower plantings were projected for the rest of the outlook period, as sunflower production was projected to be less profitable compared to maize production.

Table 6.2: Baseline projections for the South African sunflower seed market

	2007	2008	2009	2010	2011	2012	2013
				Thousand hectare			
Sunflower area harvested	316.4	**564.3**	564.9	488.5	485.5	495.4	496.3
				t/ha			
Sunflower average yield	0.94	**1.55**	1.39	1.42	1.45	1.48	1.51
				Thousand tons			
Sunflower production	296.6	**872.0**	785.5	694.4	704.9	734.4	750.5
Sunflower crush	369.3	**696.8**	711.0	694.4	653.0	740.9	767.1
Sunflower domestic use	372.3	**714.3**	726.7	708.3	667.1	755.6	782.1
Sunflower ending stocks	94.9	**189.9**	132.3	121.1	128.8	119.1	115.3
Sunflower net trade	9.2	**-62.7**	-116.3	2.9	-29.9	11.7	27.9
				R/ton			
Sunflower domestic price	3,459.4	**4,165.9**	3,455.0	3,599.7	3,859.0	4,015.3	4,337.8

Sunflower seed crushing plants were projected to respond to the improved crushing margin by increasing their crushing activity over the baseline period. The lower projected domestic sunflower seed price in 2009 should stimulate exports, and South Africa was projected to be a net exporter of seed in 2009. From 2010, South Africa's net trade position will depend on the supply and demand situation.

The drought in 2007 caused the domestic sunflower seed price to move closer to import parity. The higher seed prices put pressure on the sunflower seed crushing margin and forced crushing plants to reduce crushing activities. The higher 2007 sunflower seed prices led to an increase in

2008 plantings and, together with above-average rainfall, local sunflower seed production was projected to be almost three times higher in 2008.

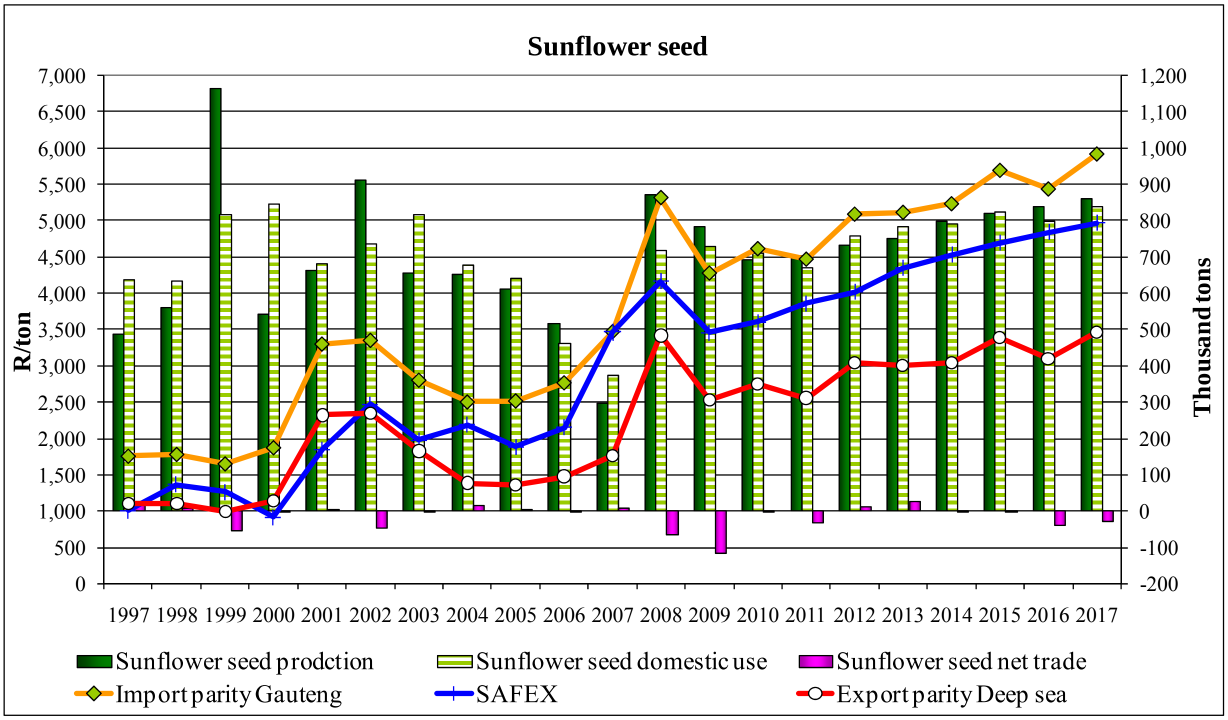


Figure 6.1: Price band for sunflower seed, 1997 – 2017

The sharp increase in production was projected to cause prices to move to levels between import and export parity (Figure 6.1). For the rest of the baseline period prices were projected to trade closer to import party than export parity, which is attributed to the reinstatement of the local crushing capacity.

Table 6.3: Baseline projections for the South African sunflower oilcake market

	2007	2008	2009	2010	2011	2012	2013
			Thousand tons				
Sunflower oilcake production	155.1	**292.7**	298.6	291.7	274.3	311.2	322.2
Sunflower oilcake consumption	277.3	**302.6**	320.3	333.1	345.0	354.9	366.8
Sunflower oilcake net imports	122.2	**9.9**	21.6	41.4	70.7	43.7	44.5
			R/ton				
Sunflower oilcake domestic price	1,897.3	**2,723.3**	2,587.6	2,646.3	2,589.5	2,899.6	2,852.2

Despite the increase in the local production of sunflower oilcake over the baseline period in line with the crushing of sunflower seed, South Africa was projected to remain a net importer of sunflower oilcake. Consumption was projected to outpace local production because of the higher demand for protein meal by the growing animal feed sector.

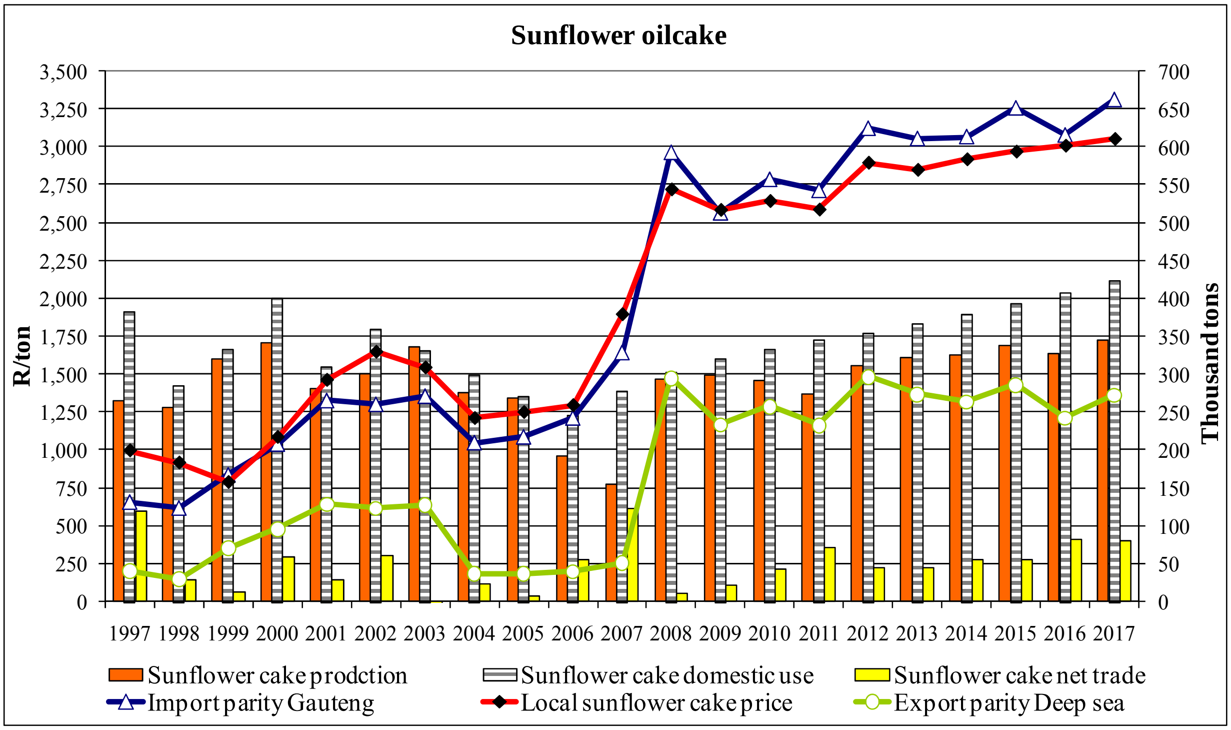


Figure 6.2: Price band for sunflower oilcake, 1997 – 2017

Prior to 2008 the local sunflower oilcake price seemed to trade on average at slightly higher prices than the calculated import parity delivered in the Gauteng Province. The calculation of the import parity of sunflower oilcake in Gauteng might not be entirely correct, as Gauteng is not the single most important consumption hub of sunflower oilcake. However, the calculation of a weighted average import parity based on the location of the largest feed mills would become too complicated, as information on transportation costs in South Africa is not readily available. Hence, Gauteng is kept as reference point for the calculation of the import parity of sunflower oilcake.

The local sunflower oilcake price was projected to decline relative to the calculated import parity of sunflower oilcake delivered in Gauteng from 2008 onwards (Figure 6.2). This is attributed to the projected larger local production of sunflower oilcake.

Table 6.4: Baseline projections for the South African sunflower oil market

	2007	2008	2009	2010	2011	2012	2013
				Thousand tons			
Sunflower oil production	145.9	**275.2**	280.9	274.3	257.9	292.6	303.0
Sunflower oil net imports	151.1	**38.0**	61.3	76.3	98.5	65.0	57.1
Sunflower oil food use	287.1	**295.2**	325.0	333.0	339.9	338.4	340.1
Sunflower oil bio-diesel use	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0
Sunflower oil domestic use	287.1	**295.2**	325.0	333.0	339.9	338.4	340.1
				R/ton			
Sunflower oil domestic price	7,186.1	**10,742.4**	9,546.3	9,785.2	10,104.7	11,122.2	11,938.2

The domestic production of sunflower oil was projected to increase over the baseline period according to the increase in the crushing of sunflower seed. The domestic use of sunflower oil was also projected to increase due to the increase in population and the growth the real per capita income. No sunflower oil was projected to be commercially consumed by the bio-diesel industry, as current bio-fuels policy and projected price situations do not render it profitable. South Africa was projected to remain a net importer of sunflower oil over the baseline period and therefore the local sunflower oil price was projected to be closely linked to the import parity price levels (Figure 6.3).

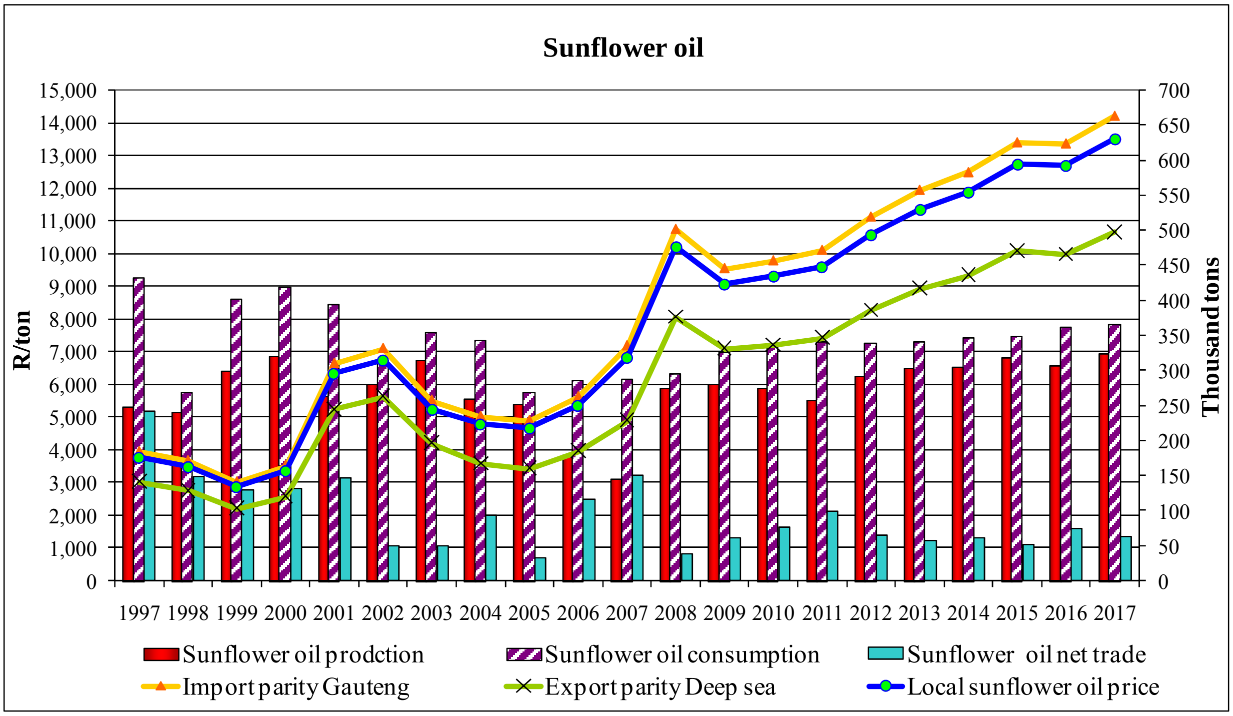


Figure 6.3: Price band for sunflower oil, 1997 – 2017

6.3 SCENARIO ANALYSIS

This section evaluates the constructed model in terms of how it responds to external shocks and whether it can be used as a policy and scenario appraisal tool. Various external shocks were introduced and the model was solved. The results were then compared to the initial baseline, which was generated without any changes in policies, world markets and production environment.

6.3.1 EXCHANGE RATE SHOCK

In 2001 the Rand depreciated sharply against the US Dollar within a short period of time, which eventually caused a sharp rise in local food prices. This event emphasised the need for a tool to quantify the responses of producers and consumers to external shocks. The first scenario analysed the impact of a 20 % depreciation in the Rand against the US Dollar in 2009 on the sunflower oil, oilcake and seed market.

Table 6.5: Impact of a 20 % depreciation in the exchange rate on the South African sunflower oilcake market

Sunflower oilcake	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Scenario production	1000 tons	**292.7**	353.4	298.0	281.2	318.8	330.7
Absolute change	1000 tons	**0.0**	54.7	6.3	6.9	7.6	8.5
% change	%	**0.0%**	18.3%	2.2%	2.5%	2.4%	2.6%
Baseline domestic use	1000 tons	**302.6**	320.3	333.1	345.0	354.9	366.8
Scenario domestic use	1000 tons	**302.6**	316.7	331.6	344.9	354.9	367.1
Absolute change	1000 tons	**0.0**	-3.6	-1.4	-0.1	0.0	0.3
% change	%	**0.0%**	-1.1%	-0.4%	0.0%	0.0%	0.1%
Baseline net imports	1000 tons	**9.9**	21.6	41.4	70.7	43.7	44.5
Scenario net import	1000 tons	**9.9**	-36.7	33.7	63.6	36.1	36.3
Absolute change	1000 tons	**0.0**	-58.3	-7.7	-7.1	-7.6	-8.2
% change	%	**0.0%**	-269.6%	-18.7%	-10.0%	-17.4%	-18.5%
Baseline oilcake price	R/ton	**2723.3**	2587.6	2646.2	2589.5	2899.6	2852.2
Scenario oilcake price	R/ton	**2723.3**	3003.2	2643.7	2587.4	2897.6	2850.2
Absolute change	R/ton	**0.0**	415.7	-2.5	-2.0	-1.9	-2.0
% change	%	**0.0%**	16.1%	-0.1%	-0.1%	-0.1%	-0.1%

The local sunflower oilcake price trades close to the import parity price levels and consequently a change in the exchange rate has a significant effect on the local oilcake price. A 20 % depreciation in 2009 was projected to result in a 16.1 % increase in the local sunflower oilcake price, thus improving the crushing margin of sunflower seed and allowing crushers to start utilising more of the excess crushing capacity available. Local sunflower oilcake production was projected to increase due to the higher crushing activity, but consumption was projected to decrease marginally due to the higher price, thus leading to a temporary local surplus of sunflower oilcake being exported to neighbouring countries. The 269.6 % change in the net import might appear odd, but a closer look reveals it to be due to South Africa's shift from a net import situation of 21 600 tons to a net exporting position of 36 700 tons.

Although the local sunflower oilcake price tracks the import parity closely, the 20 % depreciation in the exchange rate was not transmitted in full to the local price. This is mainly explained by the depressing effect of the higher production:consumption ratio due to the larger local production and lower consumption compared to the baseline levels.

Table 6.6: Impact of a 20 % depreciation in the exchange rate on the South African sunflower oil market

Sunflower oil	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Scenario production	1000 tons	**275.2**	332.3	280.2	264.5	299.8	311.0
Absolute change	1000 tons	**0.0**	51.5	5.9	6.5	7.2	8.0
% change	%	**0.0%**	18.3%	2.2%	2.5%	2.4%	2.6%
Baseline net imports	1000 tons	**38.0**	61.3	76.3	98.5	65.0	57.1
Scenario net import	1000 tons	**38.0**	-12.9	70.8	92.5	58.4	49.8
Absolute change	1000 tons	**0.0**	-74.2	-5.4	-6.0	-6.6	-7.4
% change	%	**0.0%**	-121.0%	-7.1%	-6.1%	-10.1%	-12.9%
Baseline domestic use	1000 tons	**295.2**	325.0	333.0	340.0	338.4	340.1
Scenario domestic use	1000 tons	**295.2**	298.1	333.0	340.0	338.4	340.1
Absolute change	1000 tons	**0.0**	-26.9	0.0	0.0	0.0	0.0
% change	%	**0.0%**	-8.3%	0.0%	0.0%	0.0%	0.0%
Baseline oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.1	11938.1
Scenario oil price	R/ton	**10742.4**	11370.9	9785.2	10104.7	11122.1	11938.1
Absolute change	R/ton	**0.0**	1824.6	0.0	0.0	0.0	0.0
% change	%	**0.0%**	19.1%	0.0%	0.0%	0.0%	0.0%

The local sunflower oil price is determined by the import parity, and the exchange rate shock is therefore almost fully transmitted to the local sunflower oil price. As evident from Table 6.6, a 20% depreciation in the exchange rate in 2009 was projected to cause an increase of 19.1 % in the local sunflower oil price.

The higher local sunflower oil price was projected to add to the improved crushing margin and result in the production of more sunflower oil due to the higher crushing activities. The local production of sunflower oil was projected to increase by 51 500 tons or 18.3 % over the baseline period. As local production meets local consumption, no imports are needed, and with normal exports of sunflower oil to neighbouring countries South Africa was projected to be in a net exporting position with regard to sunflower oil in 2009.

The improved crushing margin of sunflower seed due to the higher local sunflower oil and oilcake prices received by crushing plants would increase the local demand for sunflower seed.

Accordingly, 130 300 tons or (17.9 %) more sunflower seed would be crushed compared to the baseline projections. Ending stocks would be 26 650 tons lower, while exports would drop from 116 300 tons in the baseline period to only 12 600 tons in the scenario.

Table 6.7: Impact of a 20 % depreciation in the exchange rate on the South African sunflower seed market

Sunflower seed	Unit	2008	2009	2010	2011	2012	2013
Baseline area harvested	1000 ha	**564.3**	564.9	488.5	485.5	495.4	496.3
Scenario area harvested	1000 ha	**564.3**	564.9	503.2	495.9	498.3	497.1
Absolute change	1000 ha	**0.0**	0.0	14.6	10.5	2.9	0.8
% change	%	**0.0%**	0.0%	3.0%	2.2%	0.6%	0.2%
Baseline production	1000 tons	**872.0**	785.5	694.4	704.9	734.4	750.5
Scenario production	1000 tons	**872.0**	785.5	715.2	720.3	738.7	751.8
Absolute change	1000 tons	**0.0**	0.0	20.8	15.3	4.3	1.3
% change	%	**0.0%**	0.0%	3.0%	2.2%	0.6%	0.2%
Baseline domestic use	1000 tons	**714.3**	726.7	708.3	667.1	755.6	782.1
Scenario domestic use	1000 tons	**714.3**	857.0	723.7	684.0	773.8	802.4
Absolute change	1000 tons	**0.0**	130.3	15.4	16.8	18.2	20.3
% change	%	**0.0%**	17.9%	2.2%	2.5%	2.4%	2.6%
Baseline ending stocks	1000 tons	**189.9**	132.3	121.1	128.8	119.1	115.3
Scenario ending stocks	1000 tons	**189.9**	105.6	122.0	128.3	117.0	112.5
Absolute change	1000 tons	**0.00**	-26.65	0.92	-0.46	-2.15	-2.81
% change	%	**0.0%**	-20.1%	0.8%	-0.4%	-1.8%	-2.4%
Baseline net trade	1000 tons	**-62.7**	-116.3	2.9	-30.0	11.6	27.9
Scenario net trade	1000 tons	**-62.7**	-12.6	25.07	-29.94	23.77	46.31
Absolute change	1000 tons	**0.0**	103.63	22.16	0.02	12.12	18.37
% change	%	**0.0%**	-89.1%	763.3%	-0.1%	104.1%	65.7%
Baseline producer price	R/ton	**4165.9**	3455.0	3599.7	3858.9	4015.3	4337.8
Scenario producer price	R/ton	**4165.9**	3797.9	3600.9	3861.7	4020.2	4342.8
Absolute change	R/ton	**0.0**	342.9	1.2	2.7	4.9	5.1
% change	%	**0.0%**	9.9%	0.0%	0.1%	0.1%	0.1%

The local sunflower seed price was projected to rise in absolute terms by R 342.90 per ton (9.9 %) because of the higher sunflower oil and oilcake prices (Table 6.7). At first glance the 9.9 % might seem to be on the low side when compared to the 19.1 % and 16.1 % increases for sunflower oil and oilcake respectively. However, it should be kept in mind that the sunflower seed price is not only affected by the derived seed price (39 % of oil price plus 42 % of oilcake price), but also by local production, which was projected to remain unchanged in 2009.

The higher 2009 sunflower seed producer price was projected to cause a marginal increase in sunflower seed plantings and production in 2010 compared to the baseline. The model projected a 763.3 % increase in imports during 2010. However, the increase is from a very low base and in absolute terms is only 22 160 tons more than the baseline. Although small, the increase in imports is still slightly surprising, but it might be explained by the market's aspiration to restore stock levels at more comfortable levels after the lower ending stocks projected at the end of 2009.

6.3.2 INTERNATIONAL PRICE SHOCK

South Africa's agricultural sector can be classified as relatively open and well integrated with the world market. Shocks occurring on the world market will therefore have a direct impact not only on South Africa's agricultural commodity prices but also on food prices.

The second scenario analysed the effects of an abrupt 20 % increase in international oilseed and oilseed product prices during 2009. All international prices were raised by 20 % for 2009 only and were kept on the same levels as the baseline for the rest of the forecasting period.

Tables 6.8, 6.9 and 6.10 indicate that a 20 % increase in international prices would have a very similar effect on the local sunflower complex market as in the case of a 20 % depreciation in the exchange rate.

Table 6.8: Impact of a 20 % increase in international prices on the South African sunflower oilcake market

Sunflower oilcake	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Scenario production	1000 tons	**292.7**	350.3	298.0	280.7	318.3	330.2
Absolute change	1000 tons	**0.0**	51.7	6.4	6.4	7.2	8.1
% change	%	**0.0%**	17.3%	2.2%	2.3%	2.3%	2.5%
Baseline domestic use	1000 tons	**302.6**	320.3	333.1	345.0	354.9	366.8
Scenario domestic use	1000 tons	**302.6**	316.9	331.0	343.8	354.2	366.3
Absolute change	1000 tons	**0.0**	-3.4	-2.0	-1.2	-0.7	-0.5
% change	%	**0.0%**	-1.1%	-0.6%	-0.3%	-0.2%	-0.1%
Baseline net imports	1000 tons	**9.9**	21.6	41.4	70.7	43.7	44.5
Scenario net imports	1000 tons	**9.9**	-33.5	33.0	63.1	35.8	36.1
Absolute change	1000 tons	**0.0**	-55.1	-8.4	-7.6	-7.9	-8.5
% change	%	**0.0%**	-254.7%	-20.3%	-10.8%	-18.0%	-19.1%
Baseline oilcake price	R/ton	**2723.3**	2587.6	2646.3	2589.5	2899.6	2852.2
Scenario oilcake price	R/ton	**2723.3**	3007.8	2643.8	2587.5	2897.8	2850.3
Absolute change	R/ton	**0.0**	420.2	-2.5	-2.0	-1.8	-1.9
% change	%	**0.0%**	16.2%	-0.1%	-0.1%	-0.1%	-0.1%

Table 6.9: Impact of a 20% increase in international prices on the South African sunflower oil market

Sunflower oil	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Scenario production	1000 tons	**275.2**	329.5	280.3	264.0	299.4	310.6
Absolute change	1000 tons	**0.0**	48.6	6.0	6.1	6.7	7.6
% change	%	**0.0%**	17.3%	2.2%	2.3%	2.3%	2.5%
Baseline net imports	1000 tons	**38.0**	61.3	76.3	98.5	65.0	57.1
Scenario net import	1000 tons	**38.0**	-8.4	70.8	92.9	58.8	50.2
Absolute change	1000 tons	**0.0**	-69.7	-5.5	-5.6	-6.2	-7.0
% change	%	**0.0%**	-113.6%	-7.2%	-5.7%	-9.5%	-12.2%
Baseline domestic use	1000 tons	**295.2**	325.0	333.0	339.9	338.4	340.1
Scenario domestic use	1000 tons	**295.2**	300.0	333.0	339.9	338.4	340.1
Absolute change	1000 tons	**0.0**	-25.0	0.0	0.0	0.0	0.0
% change	%	**0.0%**	-7.7%	0.0%	0.0%	0.0%	0.0%
Baseline oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.2	11938.2
Scenario oil price	R/ton	**10742.4**	11240.5	9785.2	10104.7	11122.2	11938.2
Absolute change	R/ton	**0.0**	1694.1	0.0	0.0	0.0	0.0
% change	%	**0.0%**	17.7%	0.0%	0.0%	0.0%	0.0%

Table 6.10: Impact of a 20 % increase in international prices on the South African sunflower seed market

Sunflower seed	Unit	2008	2009	2010	2011	2012	2013
Baseline area harvested	1000 ha	**564.3**	564.9	488.5	485.5	495.4	496.3
Scenario area harvested	1000 ha	**564.3**	564.9	523.2	487.6	495.8	496.7
Absolute change	1000 ha	**0.0**	0.0	34.7	2.1	0.3	0.4
% change	%	**0.0%**	0.0%	7.1%	0.4%	0.1%	0.1%
Baseline production	1000 tons	**872.0**	785.5	694.4	704.9	734.4	750.5
Scenario production	1000 tons	**872.0**	785.5	743.7	708.0	734.9	751.1
Absolute change	1000 tons	**0.0**	0.0	49.3	3.1	0.5	0.6
% change	%	**0.0%**	0.0%	7.1%	0.4%	0.1%	0.1%
Baseline domestic use	1000 tons	**714.3**	726.7	708.3	667.1	755.6	782.1
Scenario domestic use	1000 tons	**714.3**	849.8	724.5	682.5	772.6	801.3
Absolute change	1000 tons	**0.0**	123.1	16.2	15.4	17.1	19.2
% change	%	**0.0%**	16.9%	2.3%	2.3%	2.3%	2.5%
Baseline ending stocks	1000 tons	**189.9**	132.3	121.1	128.8	119.1	115.3
Scenario ending stocks	1000 tons	**189.9**	106.9	126.7	126.4	116.5	112.6
Absolute change	1000 tons	**0.00**	-25.33	5.61	-2.40	-2.59	-2.75
% change	%	**0.0%**	-19.2%	4.6%	-1.9%	-2.2%	-2.4%
Baseline net trade	1000 tons	**-62.7**	-116.3	2.9	-29.9	11.7	27.9
Scenario net trade	1000 tons	**-62.7**	-18.5	0.70	-25.62	28.04	46.40
Absolute change	1000 tons	**0.0**	97.73	-2.21	4.33	16.39	18.46
% change	%	**0.0%**	-84.1%	-76.0%	-14.4%	140.6%	66.0%
Baseline producer price	R/ton	**4165.9**	3455.0	3599.7	3859.0	4015.3	4337.8
Scenario producer price	R/ton	**4165.9**	3778.9	3596.3	3863.4	4020.5	4342.7
Absolute change	R/ton	**0.0**	323.9	-3.4	4.4	5.2	4.9
% change	%	**0.0%**	9.4%	-0.1%	0.1%	0.1%	0.1%

It is interesting to note that the change in local prices is somewhat lower compared to the effect of a 20 % depreciation of the exchange rate in scenario 1, the reason for this being the fact that if the exchange rate depreciates, this results in an increase in the cost, insurance and freight (CIF) costs to South Africa in Rand terms. The cost of buying the commodities or their products (FOB price) constitutes the majority share of the CIF price and therefore a 20 % increase in international prices would still have a very similar but slightly smaller effect.

Another interesting aspect that appears when the effects of a 20 % increase in international prices are compared to the effects of a 20 % depreciation of the exchange rate is the increased likelihood of producers to plant more sunflower seed in the case of a 20 % increase in international prices.

In the first scenario producers planted 3 % more sunflower seed in the season following the shock, whereas they increased sunflower plantings by 7.1 % in scenario two after the price shock, despite the relatively small difference in price changes. This is because when the exchange rate depreciates it also has a positive impact on the local prices of other commodities like maize. The relative profitability of sunflower production compared to other commodities is thus lower when the exchange rate depreciates compared to when the international price is shocked by the same percentage. It can thus also be concluded that an exchange rate shock would have a more widespread effect on the agricultural sector compared to a shock in international prices of only sunflower seed, oilcake and oil. This is an important aspect that policymakers should keep in mind when new macro-economic policies are formulated.

6.3.3 EFFECT OF THE ELIMINATION OF IMPORT TARIFFS

Currently the South African sunflower industry is only protected by *ad valorem* import duties of 10 %, 6.6 % and 9.4 % on oil, oilcake and seed respectively. However, since 2006, the international prices of most agricultural commodities have risen, and the South African government has received calls from various groups to abolish the import duties on agricultural products in an attempt to lower the impact of rising international prices on food inflation. The third scenario analysed the effect on the local sunflower complex market if all import duties on oilcake, oil and seed were to be eliminated as from 2009 onwards.

Table 6.11: Impact of the elimination of import tariffs on the South African sunflower oilcake market

Sunflower oilcake	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Scenario production	1000 tons	**292.7**	277.6	268.8	249.5	282.3	289.6
Absolute change	1000 tons	**0.0**	-21.1	-22.9	-24.8	-28.9	-32.5
% change	%	**0.0%**	-7.1%	-7.9%	-9.0%	-9.3%	-10.1%
Baseline domestic use	1000 tons	**302.6**	320.3	333.1	345.0	354.9	366.8
Scenario domestic use	1000 tons	**302.6**	321.1	334.4	346.5	356.6	368.6
Absolute change	1000 tons	**0.0**	0.9	1.3	1.5	1.7	1.8
% change	%	**0.0%**	0.3%	0.4%	0.4%	0.5%	0.5%
Baseline net imports	1000 tons	**9.9**	21.6	41.4	70.7	43.7	44.5
Scenario net import	1000 tons	**9.9**	43.6	65.7	97.0	74.3	79.0
Absolute change	1000 tons	**0.0**	21.9	24.3	26.3	30.6	34.4
% change	%	**0.0%**	101.4%	58.6%	37.2%	70.1%	77.3%
Baseline oilcake price	R/ton	**2723.3**	2587.6	2646.3	2589.5	2899.6	2852.2
Scenario oilcake price	R/ton	**2723.3**	2481.6	2541.1	2493.3	2785.0	2743.5
Absolute change	R/ton	**0.0**	-106.0	-105.2	-96.1	-114.6	-108.7
% change	%	**0.0%**	-4.1%	-4.0%	-3.7%	-4.0%	-3.8%

The simulation results obtained showed that if the import tariff on all oilcake were to be eliminated, the local sunflower oilcake price would be approximately 4 % lower compared to the baseline projections (Table 6.11). This would lead to lower local production, and more imports would be needed to satisfy the growing demand for oilcake. Local consumption was projected to be only marginally higher than the baseline projections.

Since the local sunflower oilcake price trades more closely to import parity, the removal of the import tariff on sunflower oil would have a proportionally greater effect on the local sunflower oil price compared to the effect as in the case of sunflower oilcake. According to the simulation results, the local sunflower oil price would be approximately 8 % lower compared to the baseline (Table 6.12). The lower price would cause an erosion of the crushing margin, and crushing activities would be reduced. Subsequently, imports of sunflower oil would increase in order to meet the growing demand for vegetable oil.

Table 6.12: Impact of the elimination of import tariffs on the South African sunflower oil market

Sunflower oil	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Scenario production	1000 tons	**275.2**	261.0	252.8	234.6	265.5	272.4
Absolute change	1000 tons	**0.0**	-19.8	-21.5	-23.3	-27.2	-30.6
% change	%	**0.0%**	-7.1%	-7.9%	-9.0%	-9.3%	-10.1%
Baseline net imports	1000 tons	**38.0**	61.3	76.3	98.5	65.0	57.1
Scenario net import	1000 tons	**38.0**	90.8	107.0	130.6	101.3	97.1
Absolute change	1000 tons	**0.0**	29.4	30.7	32.1	36.3	39.9
% change	%	**0.0%**	48.0%	40.2%	32.6%	56.0%	69.9%
Baseline domestic use	1000 tons	**295.2**	325.0	333.0	339.9	338.4	340.1
Scenario domestic use	1000 tons	**295.2**	336.2	343.8	350.6	349.7	351.8
Absolute change	1000 tons	**0.0**	11.2	10.9	10.7	11.4	11.8
% change	%	**0.0%**	3.4%	3.3%	3.1%	3.4%	3.5%
Baseline oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.2	11938.2
Scenario oil price	R/ton	**10742.4**	8786.2	9010.9	9306.5	10236.7	10983.8
Absolute change	R/ton	**0.0**	-760.2	-774.3	-798.3	-885.4	-954.4
% change	%	**0.0%**	-8.0%	-7.9%	-7.9%	-8.0%	-8.0%

At first, the effect of no import tariffs on sunflower seed appears to be relatively minor. The local price was projected to be between 3.5 % and 3.9 % lower than the baseline over the projection period due to the lower sunflower oil and oilcake prices (Table 6.13). From 2010 onwards the sunflower area harvested and total production is estimated to be about 3 % lower than the baseline projection due to the lower producer price. A reduction in the local crushing activity is projected due to the weaker crushing margin.

Table 6.13: Impact of the elimination of import tariffs on the South African sunflower seed market

Sunflower seed	Unit	2008	2009	2010	2011	2012	2013
Baseline area harvested	1000 ha	**564.3**	564.9	488.5	485.5	495.4	496.3
Scenario area harvested	1000 ha	**564.3**	564.9	474.3	471.0	481.2	481.0
Absolute change	1000 ha	**0.0**	0.0	-14.2	-14.4	-14.2	-15.3
% change	%	**0.0%**	0.0%	-2.9%	-3.0%	-2.9%	-3.1%
Baseline production	1000 tons	**872.0**	785.5	694.4	704.9	734.4	750.5
Scenario production	1000 tons	**872.0**	785.5	674.2	684.0	713.3	727.4
Absolute change	1000 tons	**0.0**	0.0	-20.2	-21.0	-21.1	-23.1
% change	%	**0.0%**	0.0%	-2.9%	-3.0%	-2.9%	-3.1%
Baseline domestic use	1000 tons	**714.3**	726.7	708.3	667.1	755.6	782.1
Scenario domestic use	1000 tons	**714.3**	676.6	653.4	607.7	686.4	704.2
Absolute change	1000 tons	**0.0**	-50.2	-54.9	-59.4	-69.2	-78.0
% change	%	**0.0%**	-6.9%	-7.8%	-8.9%	-9.2%	-10.0%
Baseline ending stocks	1000 tons	**189.9**	132.3	121.1	128.8	119.1	115.3
Scenario ending stocks	1000 tons	**189.9**	144.6	129.8	139.6	129.9	126.9
Absolute change	1000 tons	**0.00**	12.29	8.72	10.76	10.78	11.58
% change	%	**0.0%**	9.3%	7.2%	8.4%	9.0%	10.0%
Baseline net trade	1000 tons	**-62.7**	-116.3	2.9	-29.9	11.7	27.9
Scenario net trade	1000 tons	**-62.7**	-154.1	-35.37	-66.40	-36.46	-26.10
Absolute change	1000 tons	**0.0**	-37.88	-38.28	-36.45	-48.11	-54.05
% change	%	**0.0%**	32.6%	-1316.8%	121.7%	-412.9%	-193.4%
Baseline producer price	R/ton	**4165.9**	3455.0	3599.7	3859.0	4015.3	4337.8
Scenario producer price	R/ton	**4165.9**	3322.9	3466.9	3722.0	3860.0	4171.6
Absolute change	R/ton	**0.0**	-132.1	-132.7	-137.0	-155.4	-166.2
% change	%	**0.0%**	-3.8%	-3.7%	-3.5%	-3.9%	-3.8%

The growth in the local crushing industry was projected to eventually be significantly smaller compared to the situation where the crushing industry has a weak safeguard from imports in the form of low import tariffs. A reduction in acreage would not be enough to counteract the effect of lower levels of local crushing, and South Africa was projected to be in a net exporting situation during the five-year projection period.

It is interesting to note that although a lower sunflower seed price is projected, the price does not drop towards export parity despite the net export situation. The explanation for this can be found in the fact that only an annual average price for sunflower seed is reported. According to industry role-players, the local sunflower seed price will be at its lowest levels during the harvesting season, normally returning to the oil- and oilcake-derived price after completion of the harvest.

The larger the local crop, the greater the drop in the seed price during harvest and the longer the price remains at these low levels before rising again. In cases where a surplus crop is harvested, the local sunflower seed price drops to export parity price or even lower. Traders will then use this opportunity to lock in deep-sea export business. Once the harvest is completed and the seeds are actually exported, the local price moves higher and closer to oil- and oilcake-derived prices. Hence, although South Africa would be in a net exporting position in that specific year, the calculated average sunflower seed price for the season might be even closer to import parity than export parity.

The above scenario shows that if all import tariff on oilseeds and their primary products were to be eliminated, the crushing industry in particular would be adversely affected. Locally produced sunflower oil and oilcake would be substituted by higher level of imports and the local crushing industry would have to scale down. The price of sunflower oilcake and crude oil would be lower, but due to the structure and length of the sunflower complex value chain, one could expect most of the lower prices to be absorbed within the value chain. Ultimately, consumers might not benefit significantly from the abolition of import tariffs.

6.3.4 EFFECT OF A SIGNIFICANT INCREASE IN IMPORT TARIFFS

South Africa's current applied *ad valorem* import tariffs on oilseeds and products are much lower than the bound rates for developing countries allowed by the World Trade Organisation (WTO). This gives rise to the question of what would happen in the local sunflower seed complex market should the South African government were to use higher tariffs as a tool to protect the local food manufacturing industries against import competition. The fourth scenario analysed the impact on the local sunflower complex market should the South African government decide to raise the *ad valorem* import tariffs on oilseed products to 25 %.

Table 6.14: Impact of an increase in import tariffs on the South African sunflower oilcake market

Sunflower oilcake	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Scenario production	1000 tons	**292.7**	333.8	319.0	303.5	345.4	360.5
Absolute change	1000 tons	**0.0**	35.2	27.3	29.3	34.2	38.3
% change	%	**0.0%**	11.8%	9.4%	10.7%	11.0%	11.9%
Baseline domestic use	1000 tons	**302.6**	320.3	333.1	345.0	354.9	366.8
Scenario domestic use	1000 tons	**302.6**	317.9	330.0	341.7	351.2	363.1
Absolute change	1000 tons	**0.0**	-2.4	-3.1	-3.3	-3.7	-3.7
% change	%	**0.0%**	-0.8%	-0.9%	-1.0%	-1.0%	-1.0%
Baseline net imports	1000 tons	**9.9**	21.6	41.4	70.7	43.7	44.5
Scenario net import	1000 tons	**9.9**	-16.0	10.9	38.1	5.8	2.7
Absolute change	1000 tons	**0.0**	-37.6	-30.5	-32.6	-37.9	-41.8
% change	%	**0.0%**	-173.8%	-73.6%	-46.1%	-86.7%	-93.9%
Baseline oilcake price	R/ton	**2723.3**	2587.6	2646.3	2589.5	2899.6	2852.2
Scenario oilcake price	R/ton	**2723.3**	2885.5	2861.7	2787.3	3135.5	3076.8
Absolute change	R/ton	**0.0**	297.9	215.4	197.9	236.0	224.6
% change	%	**0.0%**	11.5%	8.1%	7.6%	8.1%	7.9%

The prevailing *ad valorem* tariff on sunflower and soybean oilcake equals 6.6 % of the free-on-board (FOB) value of it, and the scenario analysed the effect of an increase to 25 % from 2009 onwards. The 2009 increase in the local price of sunflower oilcake was projected to be 11.5 % higher than the baseline projections (Table 6.14). Over the rest of the baseline period the price effect was projected to be lower, with the local sunflower price projected to be only 7.9 % higher than the baseline projections in 2013.

The smaller increase in the price could mainly be attributed to the increase and further growth in the local production of sunflower oilcake caused by the higher prices. In 2013 it is expected that the local production of sunflower oilcake will be 38 300 tons or 11.9 % higher compared to the baseline projections. As a result of the higher local production, imports are expected to decline, and in 2013 South Africa might be nearly self-sufficient with regard to its sunflower oilcake demand. The slightly higher price is expected to lower the local consumption by approximately 1 % compared to the baseline projections.

Table 6.15: Impact of an increase in import tariffs on the South African sunflower oil market

Sunflower oil	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Scenario production	1000 tons	**275.2**	313.9	300.0	285.5	324.8	339.0
Absolute change	1000 tons	**0.0**	33.1	25.7	27.5	32.2	36.0
% change	%	**0.0%**	11.8%	9.4%	10.7%	11.0%	11.9%
Baseline net imports	1000 tons	**38.0**	61.3	76.3	98.5	65.0	57.1
Scenario net imports	1000 tons	**38.0**	14.1	41.8	62.5	24.0	12.2
Absolute change	1000 tons	**0.0**	-47.2	-34.5	-36.0	-40.9	-44.9
% change	%	**0.0%**	-77.0%	-45.2%	-36.6%	-63.0%	-78.6%
Baseline domestic use	1000 tons	**295.2**	325.0	333.0	339.9	338.4	340.1
Scenario domestic use	1000 tons	**295.2**	308.2	322.1	329.3	327.0	328.3
Absolute change	1000 tons	**0.0**	-16.8	-10.9	-10.7	-11.4	-11.8
% change	%	**0.0%**	-5.2%	-3.3%	-3.1%	-3.4%	-3.5%
Baseline oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.2	11938.2
Scenario oil price	R/ton	**10742.4**	10686.6	10559.6	10903.0	12007.6	12892.6
Absolute change	R/ton	**0.0**	1140.2	774.3	798.3	885.4	954.4
% change	%	**0.0%**	11.9%	7.9%	7.9%	8.0%	8.0%

As a result of the better crushing margin due to the higher local sunflower oil and oilcake prices, the domestic use of sunflower seed was projected to increase by 83 700 tons to a total of 810 500 in 2009. The crushing capacity was projected to increase over the baseline period, with 873 800 tons of sunflower seed being consumed locally in 2013, which is 11.7 % more than the initial baseline projection.

The local sunflower seed price was projected to be R 220.40 per ton or 6.4 % higher than the baseline in 2009, and R 185.80 per ton or 4.3 % higher in 2013. The higher sunflower seed price would in turn lead to an increase in the hectares planted to sunflower and the production thereof. According to the scenario, sunflower plantings and production would be 4.8 % higher in 2010 and 3.5 % higher in 2013 compared to the baseline projections. However, the increase in local consumption would be higher than the increase in production. Consequently, South Africa can be expected to be a constant net importer of sunflower seed over the projection period. The scenario shows net imports of 92 960 tons in 2013 (65 020 tons more than the 27 900 tons forecast in the baseline projections).

Table 6.16: Impact of an increase in import tariffs on the South African sunflower seed market

Sunflower seed	Unit	2008	2009	2010	2011	2012	2013
Baseline area harvested	1000 ha	**564.3**	564.9	488.5	485.5	495.4	496.3
Scenario area harvested	1000 ha	**564.3**	564.9	512.2	502.3	511.5	513.6
Absolute change	1000 ha	**0.0**	0.0	23.7	16.9	16.0	17.3
% change	%	**0.0%**	0.0%	4.8%	3.5%	3.2%	3.5%
Baseline production	1000 tons	**872.0**	785.5	694.4	704.9	734.4	750.5
Scenario production	1000 tons	**872.0**	785.5	728.0	729.4	758.1	776.6
Absolute change	1000 tons	**0.0**	0.0	33.6	24.5	23.7	26.1
% change	%	**0.0%**	0.0%	4.8%	3.5%	3.2%	3.5%
Baseline domestic use	1000 tons	**714.3**	726.7	708.3	667.1	755.6	782.1
Scenario domestic use	1000 tons	**714.3**	810.5	774.1	737.3	837.4	873.8
Absolute change	1000 tons	**0.0**	83.7	65.8	70.1	81.9	91.7
% change	%	**0.0%**	11.5%	9.3%	10.5%	10.8%	11.7%
Baseline ending stocks	1000 tons	**189.9**	132.3	121.1	128.8	119.1	115.3
Scenario ending stocks	1000 tons	**189.9**	114.4	113.4	117.9	108.1	103.7
Absolute change	1000 tons	**0.00**	-17.86	-7.65	-10.90	-11.07	-11.59
% change	%	**0.0%**	-13.5%	-6.3%	-8.5%	-9.3%	-10.0%
Baseline net trade	1000 tons	**-62.7**	-116.3	2.9	-29.9	11.7	27.9
Scenario net trade	1000 tons	**-62.7**	-50.4	45.27	12.49	69.63	92.96
Absolute change	1000 tons	**0.0**	65.89	42.36	42.44	57.98	65.02
% change	%	**0.0%**	-56.7%	1457.4%	-141.7%	497.6%	232.7%
Baseline producer price	R/ton	**4165.9**	3455.0	3599.7	3859.0	4015.3	4337.8
Scenario producer price	R/ton	**4165.9**	3675.4	3749.4	4013.3	4191.4	4523.6
Absolute change	R/ton	**0.0**	220.4	149.7	154.4	176.1	185.8
% change	%	**0.0%**	6.4%	4.2%	4.0%	4.4%	4.3%

From the results of this scenario, it can be concluded that changes to the import tariffs would affect the crushing industry more than the primary producers. Significantly higher import tariffs may lead to greater utilisation of the local sunflower seed crushing capacity due to the improved crushing margins. If the import tariffs of sunflower oil and oilcake were to be raised to 25 %, South Africa may become self-sufficient with regard to sunflower oil and oilcake.

6.3.5 EFFECT OF AN INCREASE IN THE CONSUMPTION OF SUNFLOWER OIL

Consumers' buying behaviour and preferences change over time due to changes in their income and tastes. Internationally and locally there is a general trend amongst consumers to eat more healthily. Sunflower oil is regarded as a healthier alternative to palm and soybean oil due to its fatty acid composition. It can thus be expected that if the prices of vegetable oils remain constant, consumers will increase their consumption of sunflower oil over time. The fifth scenario assesses the possible effect of a 36 % increase in the projected per capita consumption of sunflower oil from 2009 to 2013.

Table 6.17: Impact of a shift in the consumption of sunflower oil on the South African sunflower oil market

Sunflower oil	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Scenario production	1000 tons	**275.2**	280.9	274.3	257.9	292.6	303.0
Absolute change	1000 tons	**0.0**	0.0	0.0	0.0	0.0	0.0
% change	%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
Baseline net imports	1000 tons	**38.0**	61.3	76.3	98.5	65.0	57.1
Scenario net imports	1000 tons	**38.0**	85.2	124.3	170.7	161.6	178.4
Absolute change	1000 tons	**0.0**	23.9	48.0	72.2	96.6	121.3
% change	%	**0.0%**	39.0%	62.9%	73.3%	148.8%	212.3%
Baseline domestic use	1000 tons	**295.2**	325.0	333.0	339.9	338.4	340.1
Scenario domestic use	1000 tons	**295.2**	348.9	380.9	412.1	435.0	461.4
Absolute change	1000 tons	**0.0**	23.9	48.0	72.2	96.6	121.3
% change	%	**0.0%**	7.4%	14.4%	21.2%	28.6%	35.7%
Baseline oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.2	11938.2
Scenario oil price	R/ton	**10742.4**	9546.3	9785.2	10104.7	11122.2	11938.2
Absolute change	R/ton	**0.0**	0.0	0.0	0.0	0.0	0.0
% change	%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%

The results show that an increase in the domestic use due to increased per capita food consumption from 2009 onwards would only affect the net imports of sunflower oil (Table 6.17). As pointed out previously, South Africa is currently a relatively large net importer of sunflower and other vegetable oils, and local sunflower oil already trades at import parity. A gradual increase in the local consumption over time would not push the local price beyond import parity, which can be viewed as the upper price band. Prices would therefore remain unaffected despite an increase in consumption, and local crushing would consequently also remain unaffected. Any steady increase in the local consumption of sunflower oil, whether in the form of higher food or industrial consumption, would not affect local prices and crushing activities compared to the baseline projections. Hence, all additional demand would be serviced by higher imports.

6.3.6 INCREASE IN THE FEED CONSUMPTION OF SUNFLOWER OILCAKE

This scenario compared sunflower oilcake to soybean oilcake, with sunflower oilcake being the less preferred protein source in the monogastric animal feeds industry due to its relatively high fibre content. According to industry role-players, more sunflower oilcake will be used in poultry and pig feeds if technology is developed to reduce the fibre content of sunflower oilcake. The final scenario looked at the impact of a 30 % increase in the inclusion rates of sunflower oilcake in pig and poultry feeds from 2009 onwards.

Table 6.18: Impact of a shift in the consumption of sunflower oilcake on the South African sunflower oilcake market

Sunflower oilcake	Unit	2008	2009	2010	2011	2012	2013
Baseline production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Scenario production	1000 tons	**292.7**	298.6	291.7	274.3	311.2	322.2
Absolute change	1000 tons	**0.0**	0.0	0.0	0.0	0.0	0.0
% change	%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%
Baseline domestic use	1000 tons	**302.6**	320.3	333.1	345.0	354.9	366.8
Scenario domestic use	1000 tons	**302.6**	364.5	401.4	427.0	445.4	463.3
Absolute change	1000 tons	**0.0**	44.3	68.4	82.0	90.5	96.5
% change	%	**0.0%**	13.8%	20.5%	23.8%	25.5%	26.3%
Baseline net imports	1000 tons	**9.9**	21.6	41.4	70.7	43.7	44.5
Scenario net imports	1000 tons	**9.9**	65.9	109.8	152.7	134.2	141.0
Absolute change	1000 tons	**0.0**	44.3	68.3	82.0	90.5	96.5
% change	%	**0.0%**	204.7%	165.1%	116.0%	207.1%	216.6%
Baseline oilcake price	R/ton	**2723.3**	2587.6	2646.3	2589.5	2899.6	2852.2
Scenario oilcake price	R/ton	**2723.3**	2587.6	2646.3	2589.5	2899.6	2852.2
Absolute change	R/ton	**0.0**	0.0	0.0	0.0	0.0	0.0
% change	%	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%

From the results of the scenario as indicated in Table 6.18, it can be seen that a 30 % increase in the inclusion rate of sunflower oilcake in pig and poultry feeds would lead to an increase of 44 300 tons or 13.8 % in the total consumption of sunflower oilcake above the projected baseline totals. In 2013, total sunflower oilcake consumption will be 96 500 tons or 26.3 % more than the baseline. This is attributed to the significant increase projected over the baseline period for the local broiler production sector by the BFAP sector model.

In the initial baseline projections, South Africa was already in a net import situation with respect to sunflower oilcake, with the local sunflower oilcake price already close to import parity. Additional demand for sunflower oilcake would not push the local price higher than the prices projected in the baseline. Since the local sunflower oilcake price is not affected by higher oilcake consumption, the crushing of sunflower seed does not differ from the baseline projections. All additional demand due to higher growth in the animal feed sector would thus need to be imported (Table 6.18).

6.4 SUMMARY

This chapter formed part of the *ex post* validation procedure of the developed sunflower seed market complex model. A baseline projection based on certain assumptions was generated for use as a reference scenario to analyse the effects of external changes or market disruptions. Six scenarios were produced to evaluate the simulation capability and performance of the model.

The results of the projections, after the various shocks had been introduced, showed that the model produces reliable projections under real-world conditions and can be successfully used as a tool to perform market and policy analysis. The next chapter presents the conclusions of the study and the recommendations with respect to future research.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The primary objective of this study was to build a well-behaved econometric model of the South African sunflower seed complex market that can be used as a tool to analyse policy and market changes. The specific objectives were to generate baseline projections for sunflower seed, oil and oilcake and to analyse the impact of various exogenous changes on the sunflower complex market over the period 2009 to 2013.

The first part of this study provided an overview of theoretical concepts that form the basis of econometric modelling. This included an overview of literature relating to the various modelling techniques used in similar international and local studies. The structure of the sunflower complex was depicted by using a flow chart of the industry, which formed the backbone of the sunflower market model.

The modelling process commenced with the estimation of single equations. The structure of these equations originated from the underlying theories such as the theories of commodity supply, and consumer or input demand. The equations were estimated mainly though the use of Ordinary Least Squares (OLS), but in cases where the results of the OLS were contradictory to the theory or where insufficient data was available, calibration techniques were employed and synthetic parameters were imposed. The results of the estimated equations that were reported include the parameter estimates, p-values, R^2, Durban-Watson (DW) statistics, and elasticities. The empirical results of each equation were followed by a short discussion.

In total the sunflower seed complex model consists of 11 estimated equations and 14 identities. The model is divided into three sections: the sunflower oil, oilcake and seed sections. Each section can be regarded as an individual model with its own price formation equation and market clearing identity.

The oil and oilcake sections are linked to the seed part through the sunflower seed crushing equations, as the volume of sunflower seed crushed determines the amount of oil and oilcake produced locally. Local sunflower oil prices are estimated as a function of the import parity, while the oilcake price is determined by the import parity of soybean oilcake and the local production.

Both the oil and oilcake sections are closed by the calculation of net imports. The sunflower oil and oilcake sections are then linked back to the sunflower seed section via the sunflower seed price estimation equation. The local sunflower seed price is estimated as a function of the local sunflower oil and oilcake prices, as well as the sunflower production and long-term consumption ratio. The calculation of the net trade position provides the market clearing identity.

The final section of the study deals with the validation process of the model. Firstly, baseline projections were stimulated to test whether the constructed sunflower seed complex model provides truthful projections given the assumptions. The consistency of the model was then evaluated in the form of scenario analysis. Various real-world market- and policy-related shocks were imposed and the results were compared to the baseline projections.

The first scenario analysed the impact of a 20 % depreciation of the exchange rate, while the second scenario assessed the effects of a 20 % increase in international oilseed and product prices. The results showed that the depreciation of the exchange rate would have a slightly more significant effect compared to a 20 % increase in international prices, as the exchange rate also has an effect on aspects such as transport costs. Scenarios three and four dealt with the effects of policy changes.

All seed, oil and oilcake import tariffs were eliminated in the third scenario, and in the forth scenario the import tariff was reinstated and increased to 25 %. Both scenarios showed that the sunflower seed crushing industry would be more significantly affected by changes in import protection tariffs than primary producers or end users. The last two scenarios evaluated the effects of a shift in consumption patterns of sunflower oil and oilcake. The results of both scenario showed that higher consumption would have no effect on the sunflower seed industry, because South Africa is already in a net importing position with respect to sunflower oil and oilcake. Local sunflower oil and oilcake prices are already at import parity price level, and any additional demand would be supplied by additional imports.

To conclude, the results prove that the sunflower seed complex model does simulate realistic results and can be applied as a tool to perform various market and policy analyses. It can thus be concluded that the objective of the study was achieved. This study not only contributes to the modelling of the South African oilseed industry, but also provides valuable insights into the functioning of the sunflower complex market.

However, no study is without shortcomings and there will be always room for improvement. The relative importance of sunflower oil in terms of consumption compared to other vegetable oils in South Africa arises from the days when the oilseed industry was regulated by the Oilseeds Board. Oilseed products are generally highly substitutable, and it can be expected that over time the availability of other vegetable oils, whether locally produced or imported, will add to changing consumer patterns. Hence, the sunflower seed complex cannot be viewed as an industry on its own, but should be analysed as part of the total oilseed complex market. It is therefore suggested that the sunflower seed model developed in this study should form part of a larger South African oilseed model that includes other oilseeds like soybeans, cotton oilseed, groundnuts, canola, and palm oil. This type of model would more effectively incorporate the substitute effect between oilseeds and oilseed products.

The price formation structure of the current model is set up as if South Africa will always be a net importer of sunflower oil and oilcake. This assumption may not hold in the long term. In further studies this may be addressed by introducing a regime switch mechanism, as developed and described by Meyer (2006). The regime switch mechanism will greatly enhance the model's scenario analysis ability under various trade regimes.

Although the study has accomplished its original goals, it should be viewed as another step in the research process. As new and better trade and price data becomes available, new and better approaches need to be explored.

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APPENDIX

Table A1.1: Exogenous variables

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
MACRO VARIABLES															
US refiners' acquisition oil price	US $/barrel	15.53	17.23	20.69	19.11	12.58	17.42	28.21	22.95	24.00	28.60	36.91	50.40	60.44	68.27
Total population of SA	millions	38.63	39.48	40.58	41.23	42.13	43.05	43.60	44.50	45.40	46.40	46.50	46.80	47.30	47.45
Exchange rate	SA cent/USD	354.97	362.70	429.64	460.73	553.16	611.31	693.53	977.93	943.89	707.61	622.28	639.44	676.72	709.98
Real GDP per capita	R	13,786.00	13,920.00	14,218.00	14,291.00	14,099.27	14,086.35	14,287.00	14,321.00	14,772.69	14,996.27	15,499.94	16,069.14	16,653.82	17,492.16
GDP deflator	index '95	90.70	100.00	108.09	116.85	125.86	134.76	146.64	157.88	174.49	182.53	193.09	202.27	216.13	235.08
CPI: Food	index '95	91.99	100.00	106.18	116.22	123.54	129.80	139.81	147.52	170.38	184.37	188.74	193.13	206.85	224.99
Average annual prime rate	%	16.25	18.00	19.80	19.25	22.65	18.68	14.50	13.77	15.75	14.95	11.29	10.62	11.16	12.50
PPI: Agricultural goods	index '95	87.70	100.00	105.30	113.10	116.50	116.60	123.20	139.96	180.49	192.81	184.92	169.65	200.45	218.02
Freight rate (Argentina - SA)	US$/t	23.00	29.94	29.20	24.50	17.00	14.35	22.58	24.00	22.24	24.14	43.85	45.30	53.00	95.00
Discharge costs	R/ton	35.56	39.51	43.90	48.78	54.20	54.20	54.20	66.00	66.56	92.00	104.00	110.85	117.17	127.44
Transport costs – Randfontein	R/ton	75.45	83.84	93.15	103.50	115.00	115.00	115.00	118.00	130.00	139.00	168.00	172.00	185.00	201.22

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
INPUT VARIABLES															
Fuel	index '95	96.10	100.00	123.10	142.20	133.70	149.30	209.00	241.50	256.44	256.86	278.81	294.69	363.66	395.55
Fertiliser	index '95	84.60	100.00	118.20	125.60	132.50	137.10	160.75	200.46	240.32	234.05	234.86	255.91	270.50	294.22
Requisites	index '95	91.90	100.00	115.60	128.60	133.50	141.76	160.23	182.82	218.87	231.85	239.38	245.15	256.37	278.85
Intermediate goods	index '95	92.00	100.00	117.40	130.80	134.90	143.16	163.39	186.43	222.70	233.97	242.14	246.72	261.10	283.99

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
WORLD PRICES															
Yellow maize, Argentinean, FOB	US$/t	109.48	158.24	125.62	108.45	96.96	93.08	83.85	89.90	102.07	109.47	89.50	97.84	148.65	152.90
Yellow maize, US No. 2, FOB	US$/t	109.44	169.28	120.86	109.44	104.21	92.86	94.21	92.75	102.46	104.00	96.00	102.99	159.44	164.00
Sunflower seed, EU, CIF	US$/t	309.00	312.00	266.00	309.00	257.00	214.00	219.00	287.00	300.00	325.00	321.00	313.00	326.89	401.00
Sunflower cake (37/38%), Arg. FOB	US$/t	103.00	151.00	138.00	103.00	76.00	102.00	118.00	110.00	110.00	149.00	119.00	120.00	128.41	178.00
Sunflower oil, EU FOB	US$/t	691.00	617.00	545.00	730.00	560.00	413.00	428.00	587.00	650.00	663.00	675.00	637.49	693.61	846.00
Soybean seed: Arg. CIF Rott	US$/t	248.00	304.00	307.00	259.00	225.00	208.00	200.00	203.00	240.00	309.00	247.00	258.00	287.64	335.00
Soybean cake (44/45%): Arg, FOB	US$/t	184.00	256.00	278.00	197.00	150.00	180.00	188.00	174.00	183.00	258.00	205.00	212.00	224.59	276.00
Soybean oil: Arg. FOB	US$/t	642.00	575.00	536.00	633.00	483.00	356.00	336.00	412.00	585.00	570.00	475.00	469.00	645.24	684.00

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
POLICIES & PRICE PREMIUMS															
Sunflower Seed Import Tariff: 9.4%	R/ton	0.00	0.00	0.00	122.84	124.42	114.38	127.67	241.04	245.71	199.52	161.63	160.42	173.70	203.61
Sunflower Cake Import Tariff: 6.6%	R/ton	0.00	0.00	0.00	23.80	21.48	35.26	43.55	55.34	54.51	58.14	30.77	31.43	33.58	38.78
Sunflower Oil Import Tariff: 10%	R/ton	0.00	0.00	0.00	325.05	300.37	243.70	281.17	550.57	592.54	452.06	392.75	378.67	433.51	533.19
Sorghum Import Tariff: 3%	R/ton	0.00	0.00	0.00	15.13	17.29	17.03	19.60	27.21	29.01	23.56	17.55	17.90	33.39	34.50
Soybean Import Tariff: 8%	R/ton	0.00	0.00	0.00	86.17	91.77	94.42	98.14	139.62	163.94	160.77	100.83	108.48	126.65	135.91
Soybean Cake Import Tariff: 6.6%	R/ton	0.00	0.00	0.00	52.30	48.41	66.63	75.49	96.52	99.85	108.89	65.99	70.14	76.41	84.56
Soybean Oil Import Tariff: 10%	R/ton	0.00	0.00	0.00	291.64	267.18	217.63	233.03	402.91	552.18	403.34	295.58	299.90	436.65	485.63

Table A1.2: Local prices and balance sheets

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
LOCAL PRICES															
White maize SAFEX price	R/t	330.00	410.00	483.97	580.00	694.21	787.68	672.88	1303.89	1539.75	1004.39	823.00	854.00	1422.44	1798.52
Yellow maize SAFEX price	R/t	330.00	410.00	483.97	580.00	656.11	796.60	691.41	1168.31	1293.08	1047.09	863.00	794.00	1414.55	1852.07
Wheat SAFEX price	R/t	754.90	802.56	909.44	817.75	808.19	960.60	1044.71	1437.00	1889.75	1546.00	1486.59	1439.39	1522.95	2267.21
Sorghum producer price	R/t	357.00	482.00	475.00	520.00	550.00	730.00	520.00	760.00	1500.00	1450.00	900.00	675.14	1202.37	1377.05
Sunflower SAFEX price	R/t	898.00	980.00	870.00	1003.74	1364.17	1257.80	915.70	1850.00	2470.00	1974.00	2185.00	1881.52	2149.61	3459.44
Sunflower cake price: Local	R/t	769.00	675.00	1012.00	996.00	916.00	787.00	1085.00	1463.00	1649.00	1545.00	1210.00	1250.00	1295.62	1897.30
Sunflower oil price	R/t	2639.77	2446.18	2575.41	3953.56	3679.92	3027.32	3526.89	6648.62	7106.69	5526.18	5030.39	4906.38	5629.99	7186.08
Soybean SAFEX price: Local	R/t	859.00	930.00	1200.00	1391.46	1095.51	1202.65	1285.54	1242.54	2010.95	2250.00	1850.00	1496.66	1814.78	2825.96
Soybean cake selling price	R/t	893.00	847.00	1256.00	1428.00	1248.00	1084.00	1398.00	1748.00	1970.00	2150.00	1740.00	1735.00	1993.26	2539.71
Soyoil price	R/t	2545.95	2401.65	2663.90	3579.75	3307.55	2735.67	2990.02	5002.85	6656.20	4982.64	3949.44	4030.50	5664.88	6656.43
Local fishmeal price: ex factory	R/t	1740.00	1955.00	2615.00	2994.00	3382.00	2472.00	2742.00	3534.00	4778.00	4230.00	4820.00	4253.00	5822.50	6350.00

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SUNFLOWER SEED															
Area planted	1000 ha	411.00	540.00	608.00	464.00	511.00	828.00	396.00	521.70	667.51	628.00	530.00	460.00	472.40	316.35
Yield	t/ha	0.89	1.00	1.29	1.06	1.10	1.41	1.38	1.27	1.37	1.38	1.23	1.34	1.09	0.94
Production: Seed	1000 tons	366.00	539.00	784.00	490.00	561.00	1167.00	545.00	665.00	914.00	656.00	651.40	614.30	517.00	296.60
Begin stock: Seed	1000 tons	202.12	204.68	243.00	324.00	207.00	148.00	450.00	153.00	147.00	283.00	125.30	119.70	100.40	161.40
Imports: Seed Qty (Mt)	1000 tons	4.00	0.00	0.00	26.00	10.88	3.86	4.34	8.00	2.00	2.00	18.00	6.00	2.80	9.20
Total supply: Seed	**1000 tons**	**572.12**	**743.68**	**1027.00**	**840.00**	**778.88**	**1318.86**	**999.34**	**826.00**	**1063.00**	**941.00**	**794.70**	**740.00**	**620.20**	**467.20**
Bird seed, Feed and On-farm use	1000 tons	15.16	15.00	15.00	2.00	20.88	52.86	30.34	8.00	21.00	16.60	17.60	1.00	2.00	3.00
Crushers	1000 tons	352.28	485.68	637.00	631.00	609.00	760.00	814.00	670.00	713.00	798.90	656.70	638.60	456.70	369.30
Sunflower domestic use	1000 tons	367.44	500.68	652.00	633.00	629.88	812.86	844.34	678.00	734.00	815.50	674.30	639.60	458.70	372.30
Exports: Seed Qty (Mt)	1000 tons	0.00	0.00	51.00	0.00	1.00	56.00	2.00	1.00	46.00	0.20	0.10	0.00	0.10	0.00
End stock: Seed	1000 tons	204.68	243.00	324.00	207.00	148.00	450.00	153.00	147.00	283.00	125.30	120.30	100.40	161.40	94.90
Total demand: Seed	**1000 tons**	**572.12**	**743.68**	**1027.00**	**840.00**	**778.88**	**1318.86**	**999.34**	**826.00**	**1063.00**	**941.00**	**794.70**	**740.00**	**620.20**	**467.20**

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SUNFLOWER CAKE															
Imports: Oilcake Qty (Mt)	1000 tons	8.74	79.72	73.81	118.70	28.74	13.09	58.53	28.38	60.20	0.00	28.49	6.30	54.67	122.75
Cake Production	1000 tons	147.96	203.99	267.54	265.02	255.78	319.20	341.88	281.40	299.46	335.54	275.81	268.21	191.81	155.11
Total supply: Oilcake	**1000 tons**	**156.70**	**283.70**	**341.35**	**383.72**	**284.52**	**332.29**	**400.41**	**309.78**	**359.66**	**335.54**	**304.30**	**274.51**	**246.48**	**277.86**
Domestic Cons. of Cake	1000 tons	156.68	283.68	341.33	383.22	284.17	331.95	400.31	309.68	359.62	331.54	298.23	269.98	245.76	277.33
Exports: Cake Qty (Mt)	1000 tons	0.01	0.02	0.02	0.50	0.35	0.34	0.10	0.10	0.04	4.00	6.07	0.00	0.72	0.53
Total demand: Oilcake	**1000 tons**	**156.70**	**283.70**	**341.35**	**383.72**	**284.52**	**332.29**	**400.41**	**309.78**	**359.66**	**335.54**	**304.30**	**269.98**	**246.48**	**277.86**

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SUNFLOWER OIL															
Imports: Oil Qty (Mt)	1000 tons	202.04	183.64	140.50	240.77	147.50	129.75	131.70	146.05	50.17	49.10	93.19	32.74	116.36	151.07
Oil Production	1000 tons	139.15	191.84	251.62	249.25	240.56	300.20	321.53	264.65	281.64	315.57	259.40	252.25	180.40	145.87
Total supply	1000 tons	**341.19**	**375.48**	**392.12**	**490.02**	**388.06**	**429.95**	**453.23**	**410.70**	**331.80**	**364.66**	**352.59**	**284.99**	**296.76**	**296.94**
Sunflower oil domestic use	1000 tons	327.41	362.07	361.81	431.78	267.41	401.17	419.00	392.83	313.71	353.34	342.25	268.60	284.32	287.09
Exports: Oil Qty (Mt)	1000 tons	13.774	13.412	30.301	58.236	120.647	28.779	34.230	17.869	18.092	11.319	10.334	16.389	12.432	9.85
Total demand	1000 tons	**341.19**	**375.48**	**392.12**	**490.02**	**388.06**	**429.95**	**453.23**	**410.70**	**331.80**	**364.66**	**352.59**	**284.99**	**296.76**	**296.94**