Modelling the Market Outlook and Policy Alternatives for the Wheat Sector in South Africa

by

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ABSTRACT

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The South African agricultural sector has experienced a long history of state intervention. In the past decade, the marketing of agricultural products has been transformed from a highly regulated to an essentially free dispensation. South African agriculture is now exposed to an uncertain environment that is influenced by the dynamic changes in the world economy. The dynamic environment in which producers of agricultural products operate urges the need to understand the production and consumption patterns of the products that they produce. South Africa does not have a modelling system in place that can simulate the impact of economic policies and exogenous changes on commodity markets.

The general objective of this dissertation is to analyse the structure of the South African wheat market using economic theory and econometric modelling techniques. The specific objectives are to make baseline projections regarding the supply and use of wheat in South Africa and to analyse the impacts of various policy alternatives on the wheat sector for the period 2002 to 2008. The convenient and efficient methodology developed by the Food and Agricultural Policy Research Institute (FAPRI) for conducting policy analysis

research, is particularly pertinent to this study and hence underpins the approach used for modelling the market and policy alternatives for the South African wheat sector. Ordinary Least Squares (OLS) is used to estimate single equations, which are collapsed into one system and estimated simultaneously using the Two-Stage-Least-Squares (2SLS) modelling technique. After the validation of the model's performance, it is used to make baseline projections for the South African wheat sector during the period 2002 to 2008. In order to establish a baseline, a number of assumptions are made, relating to agricultural policies, the macroeconomic environment, and weather conditions. In the final part of this study, the constructed model is used to simulate the impacts of changes in policies, world markets and the production environment on domestic prices as well as levels of demand and supply. Three scenarios are analysed, the elimination of the import tariff for wheat, a twelve percent depreciation in the exchange rate, and the convergence of the elimination of the import tariff and the 12% depreciation in the exchange rate.

Although the model developed in this dissertation is for a South African specific case study and therefore, contributes significantly to the understanding of the South African wheat market, it also highlights a number of shortcomings in the structure, relevance and applicability of such models, that need to be considered and addressed. The first of which is that the model structure is based on the level of knowledge, understanding, and perception that the modeller has of the sector; therefore, the basic structure of the model could be bias. The second is that this particular model was not developed with the necessary interaction between the different commodity and livestock sectors and that this model should ideally be integrated into a larger model, incorporating a larger number of commodities and policy variables. Lastly, it is important to take the nature of the good being modelled into consideration by asking whether or not the relevant product is a homogenous good. Ideally, a model of this nature would include a supply and demand function for each type of wheat that could then be estimated as a single system of equations.

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INTRODUCTION

1.1 BACKGROUND

Wheat is the most important grain crop in South Africa after maize. During the past decade major changes in wheat marketing took place characterized by the transformation of a highly regulated dispensation to an essentially free one. As a result, the phasing out of the Wheat Board in 1997 has ensured that wheat producers are increasingly being exposed to international wheat markets. In addition, the economic policy in South Africa has changed dramatically, accompanying the almost global movement towards deregulation and liberalisation of the economy; resulting in a more market-based approach to both agricultural and macro-economic policy.

Due to this new and dynamic agricultural environment, roll players in the wheat sector and other commodity sectors need to make decisions concerning their respective pricing, distribution, production, and product policies, almost continuously. Requiring the acquisition, understanding and application of timely information, on various demand factors for the development and maintenance of efficient marketing strategies and effective decision-making. Once this is achieved, there will be a baseline for officious business control, strategic planning and forecasting within the commodity sectors. It is against this background that commodity modelling can play an important role to assist role players in decision-making.

Commodity modelling is a methodological and complete technique that provides a powerful analytical tool for examining the complexities of commodity markets. Generally, commodity models can be used for three levels of analysis, namely, market analysis, policy analysis, and as a forecasting tool (Belhassen, 1997). The development of commodity models and their applications have appeared in the economic literature, as a distinct area of economic research since the mid 1970's, raising the awareness for economists and policy analysts as to the value these models can add in trying to better understand and predict the movements in prices and the quantities demanded and supplied of various commodities.

In spite of the fact that the literature on crop econometric models for South Africa has been limited in terms of publications in professional journals, many of these models have been extensively applied within the country as a first-best approach to answering necessary and specific questions around agricultural policy. The specific approaches developed for commodity modelling in this study have not, as yet, been applied in South Africa, and may provide a systematic and comprehensive approach to analysing and forecasting the behaviour of commodity markets in the country. The application of this econometric modelling technique can be undertaken on a range of commodities and the econometric analysis of the wheat sector will thus only serve as an example of the usefulness of these kinds of modelling techniques.

1.2 PROBLEM STATEMENT

1.2.1 GENERAL PROBLEM STATEMENT

The South African agricultural sector has experienced a long history of state intervention. The Marketing Act's of 1937 and 1968 respectively, provided the impetus for a period of sixty years characterized by the controlled marketing of the major agricultural industries. Under the auspices of "orderly marketing" a single marketing channel was established with agricultural cooperatives acting as agents to the marketing boards. Farmers received fixed prices for their various products, irrespective of the transactions costs incurred due to varying distances to final destinations for the delivery of products. Farmers had full knowledge about the price they would receive for their product at the beginning of each production season. Domestic agricultural producers had to "compete" in a marketing environment that was isolated from international markets and hence world prices. Furthermore, agricultural producers benefited from access to subsidised sources of credit, making credit applications more affordable and less risky. This combination of guaranteed fixed prices and accessibility to affordable credit loans made it possible for farmers to cultivate marginal lands for the production of field crops. In hindsight, the perpetuation of this kind of behaviour has raised concerns within the South African agricultural industry as to the productivity of land, and the value of marginal crop production.

During the early 1980's there was a general decline in the use of price controls with a shift towards market-based pricing systems. GATT negotiations enhanced pressure for the abolition of quantitative import controls and the introduction of tariffs on agricultural commodities. In June 1991, the Minister of Agriculture appointed the Kassier Committee of Inquiry into the Marketing Act. Between the release of the Kassier report and the promulgation of the new Marketing of Agricultural Products Act in 1996, approximately ten of the existing Boards were abolished. The new 1996 Act set out to prevent rather than to promote undesirable interventions (Kirsten & Vink, 2000). The main objectives of the 1996 Act included, increased market access, the promotion of efficiency in the marketing of agricultural products, and enhancing the viability of the agricultural sector. As a result of the abolishment of the marketing boards farmers had to compete in an open-economy with world markets influencing the domestic crop prices. The majority of direct subsidies to agricultural producers were abolished, and South Africa's Production Support Equivalent (PSE) value moved in line with those of countries like New Zealand and Australia. The South African agricultural industry is now exposed to an uncertain environment that is influenced by the dynamic changes in the world economy. This exposure to world markets is largely due to increased regional integration resulting from the SADC free trade protocol, the European Union/RSA free trade agreement, and the general trend to liberalization in world agricultural trade.

1.2.2 SPECIFIC PROBLEM STATEMENT

As a price-taker, it is particularly critical for the South African agricultural industry to anticipate the future directions of the world market. The reason for this is that the health of the South African macro-economy is reliant to a fair extent on the agricultural sector. This relationship is, however, extremely complex and the consequential macroeconomic effects are not always well understood by decision-makers. Policy analysts and planners do not always have the necessary tools to analyse and understand commodity markets. Presently, South Africa does not have a modelling system in place that can simulate the impacts of economic policies and exogenous changes on commodity markets. The dynamic environment in which producers of agricultural products operate necessitates the understanding of the production and consumption patterns of the products that they produce. Consequently, the agricultural sector is characterised by a deregulated market with uninformed producers and consumers whom are no longer protected by marketing boards and policy analysts and planners who do not have the necessary tools to assist them with the implementation of much-needed policies.

South African decision-makers need an analytical system of econometric models that can be used to assess the potential outcomes of proposals made as part of future trade negotiations or simply to protect South African producers and consumers. This study aims to address this need by applying econometric analyses to the market structure of the South African wheat sector for the period 1975 to 2000. By modelling the structure of the South African wheat market, a better understanding of how the different components of the supply and demand blocks of this commodity respond to policy variables and prices will be gained. Thereby, facilitating and better-informing the decision-making behaviour of South African producers and consumers in the face of changing economic and trade policies or changing world markets.

The recent depreciation of the value of the Rand and the expectations of rising food prices illustrate how a system like this can potentially be used to better understand the decision-making behaviour of producers and consumers with respect to these events. The availability of quantitative information is imperative to the formulation of future government programs. These models can be used for the development of commodity-market forecasts and the analysis of welfare effects on different policies and market scenarios, including the simulation of the impacts of policy changes on domestic prices as well as levels of demand and supply.

1.3 OBJECTIVES OF THE STUDY

1.3.1 THE GENERAL OBJECTIVES

The general objective of the dissertation is to analyse the structure of the wheat market of South Africa using economic theory and econometric modelling techniques. A system of econometric models will be developed and estimated using historical information of the wheat market. The models will provide a system of economic intelligence for the wheat market, as well as, a barometer to measure the impact of policy changes on the wheat sector.

1.3.2 THE SPECIFIC OBJECTIVES

The model will be used to make baseline projections of the supply and utilization of wheat in South Africa, provided no economic changes take place and the current macroeconomic conditions prevail. The system of equations will also be used for policy analysis. Policy and business decisions, which have an impact on the wheat sector, can now be assessed using a range of *"what if"* questions. These "*what if*" questions may be based on changes in tariffs and world prices or the possible impacts of a depreciation in the exchange rate on the wheat sector. The model will give a best estimate about the likely outcome of a particular policy proposal. The models are designed to simulate the intra- and extra-sectoral effects of policy changes, and to model the implications for the major macro-economic aggregates.

The models will provide *ex ante* estimates of the impact of policy changes. The simulation exercises will produce estimates of the implications for production and consumption of wheat. The quantity of wheat consumed can thus be analysed and predicted by changing the macroeconomic and political environmental parameters. These changes must be made in such a way that they can easily incorporate the future expectations of the South African economy taking into consideration all the recent trends in the economy as well as the political environment.

1.4 OUTLINE OF THE STUDY

This dissertation is organized into eight chapters. The first chapter introduced the problem statement and the objectives of the study. The second chapter provides a general overview of the South African agricultural industry moving on to a specific historic overview of government intervention in the wheat sector. Chapter three contains a literature survey on crop modelling, particularly pertaining to field crops. A discussion on the theoretical background of supply, demand, and price expectations is included in Chapter four. Chapter five describes the structure of the wheat model and explains the process of model validation. Chapter six represents the empirical results of the model estimations, simulation, and the impact multiplier analysis. The policy simulation results and their implications are reported in Chapter seven. A summary of the study and concluding remarks are given in Chapter eight.

CHAPTER 2
SOUTH AFRICAN AGRICULTURE AND THE WHEAT SECTOR: AN OVERVIEW

2.1 INTRODUCTION

A sound understanding of the decision making behaviour of the producers and consumers in the wheat industry requires a conceptual understanding of the wider economic and political environment within which they operate. Without this basic understanding and acumen for the market, the model builder will have difficulty with the process of model specification. The process of model specification will be discussed in chapter five. The objective of this chapter is to present a general overview of the South African agricultural sector as well as a more specific analyses of the South African wheat sector. The chapter is organised into three sections, beginning with a general overview of the South African agriculture sector, including discussions on GDP contribution, hectares planted, total production and general trends; the second section provides a specific review and analysis of the South African wheat industry; and the third section presents an historic overview of the role of agricultural policies, and South African government interventions on the wheat to bread value chain. The chapter ends with discussions of the current situation facing the South African wheat industry.

2.2 AN OVERVIEW OF THE SOUTH AFRICAN AGRICULTURAL SECTOR

The South African agricultural economy is underpinned and supported by a framework of circumstances that determine its special nature and vitality. This framework includes agricultural institutions, policy, unique labour demographic patterns, natural resource factors and technological factors. The state of this framework determines how the agricultural sector will develop in the long-run.

The significance of South African agriculture to the whole South African economy mainly revolves around the production of food for the nation, job creation, and value added to the GDP, and as an earner of foreign exchange. Agriculture's contribution to the GDP for the year 2000 is estimated at 4.5 percent (NDA, 2001). This contribution has, however, diminished over the past few decades. In 1911, agriculture's contribution to the GDP was as high as 20 percent. This contribution decreased to 5 percent in 1990 and, as mentioned above, 4.5 percent in 2000. This decline has been interpreted by some as the normal patterns of economic development and others have attributed it to the interventions of distorted policies (Townsend, 1997). The fastest growing sectors have been manufacturing, construction and electricity. These results shown in figure 2.1 below, suggest that emphasis has shifted from the primary (agriculture and mining) sectors to the secondary and tertiary sectors.

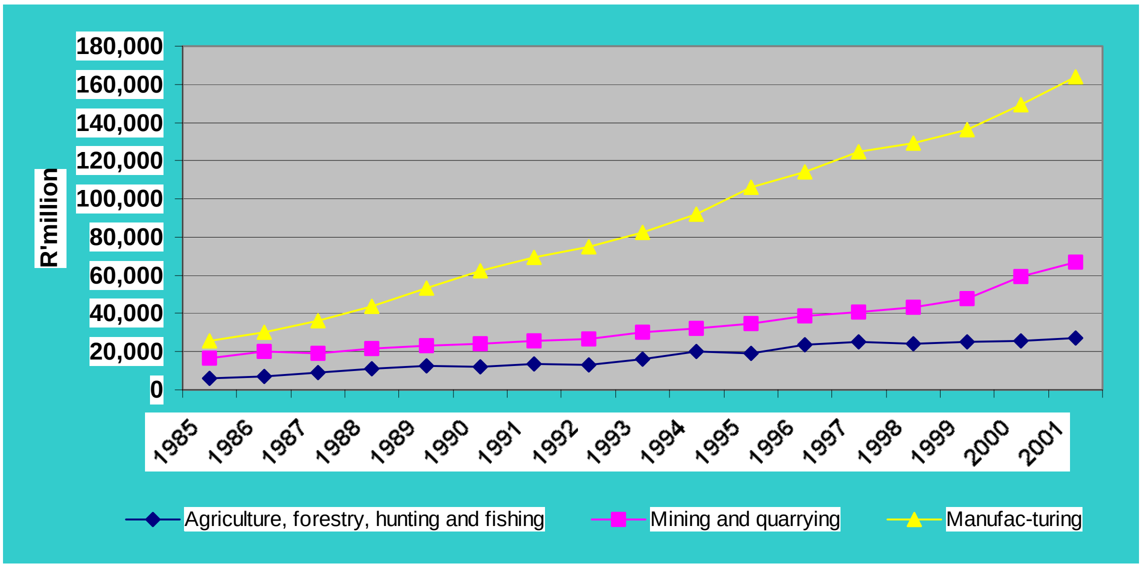

Figure 2.1: Gross Domestic Product of South Africa at constant 1995 Prices (Source: SARB, 2002)

In terms of contributions to employment, the South African agriculture industry currently provides livelihoods to more than one million farm workers, who represent more than ten percent of South Africa's total, employed labour force. Agriculture's proportionate contribution to employment is therefore roughly three times larger than the sector's proportionate contribution to the South African GDP. In the past two decades this employment figure has decreased form 1.3 million in 1985 to 1.05 million in 1992 (Development Bank of Southern Africa, 1997). Vink and Kirsten (1999) argued that the decline in the number of jobs provided by the South African agricultural sector over the past decades has been exacerbated by the same bad policies that inhibited export opportunities, the development of labour saving technology, and actively encouraged the adoption of capital-intensive farming practices. They conclude that the only way in which agriculture can become a major creator of employment opportunities for the country as a whole is through a wider and deeper export drive, supported by policies that encourage the employment of a larger workforce.

Agricultural land constitutes 99.1 million hectares of the total surface area of 122 million hectares in South Africa. Natural pastures, largely devoted to extensive cattle farming, occupy much of this land. Only 15.8 million hectares of this area is potentially arable, 81 million hectares are classified as permanent pastures, while forest and woodlands cover 8 million hectares. The total gross value of agricultural production for 1999/2000 is estimated at R45 102 million. The gross value of animal products contributes 44.4 percent to the total gross value of agricultural production, the gross value of field crops 29.3 percent and the gross value of horticultural products 26.3 percent respectively. Broilers slaughtered made the largest contribution to the gross value of agricultural production with 18 percent, followed by maize with 11.4 percent and cattle and calves slaughtered with 8.2 percent respectively (NDA, 2001).

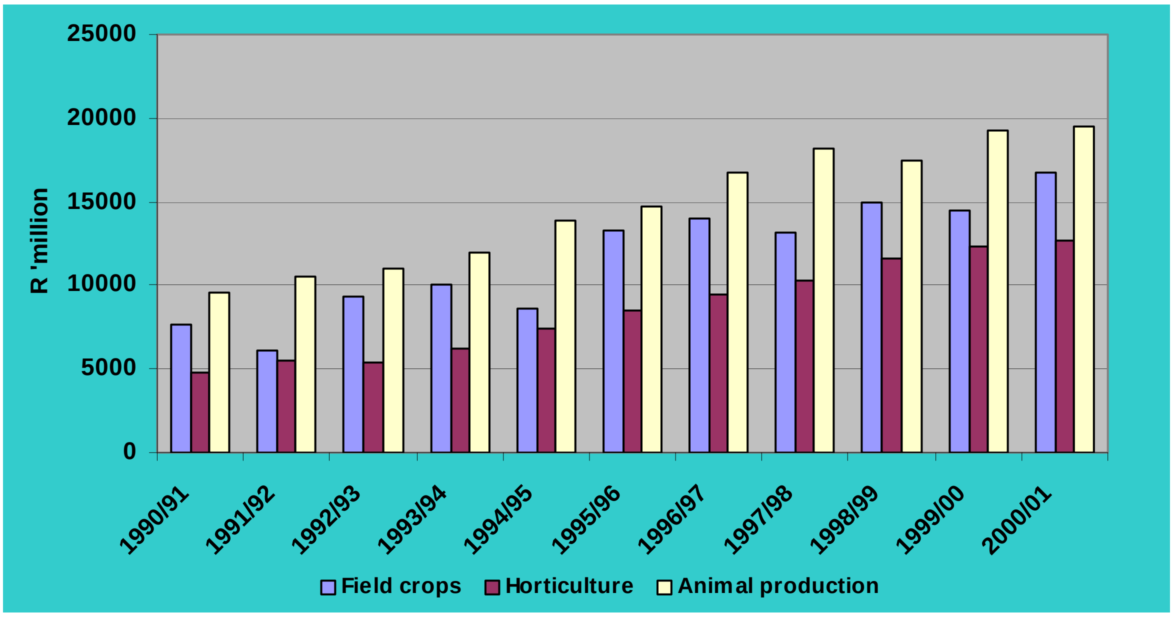

Figure 2.2: Gross Value of Agricultural Production at current Prices (Source: NDA, 2002)

Figure 2.2 above, illustrates the trends in production of the various agricultural sectors over the past decade. It is evident from this figure that the production of field crops has declined over the past five years. On the other hand, the production of horticulture as well as animal products has increased. A number of factors coincided to give rise to this phenomenon. The abolishment of the marketing boards created an atmosphere of risk and uncertainty. Dryland farmers now not only have to face the production risk of producing field crops but also the price risks associated with a free market. The depreciation of the Rand also encouraged farmers to produce crops that can be exported, leading to greater gains from the weak exchange rate. Livestock farming therefore appears to be the less risky option, as the levels of input costs are lower and the production risks are smaller. One striking example of the changing production structure, was the withdrawal of almost a million hectares of land planted under maize for an increase of 720 000 hectares of land planted to pasture, under the land conversion subsidy scheme, which was promulgated in October 1987. Farmers who participated in the land conversion scheme received a payment of R140/ha for every hectare of cropland that was successfully converted into pasture. Once the farmers had received the subsidy they were required to maintain the pasture for six years. These pressures of over a decade of policy reform have already resulted in extensive diversity across farm sizes in some parts of South Africa.

The gross farm income from all products for the year that ended on 30th June 2000 is estimated to be 3 percent lower than for the previous corresponding year (NDA, 2001). For the same period, gross farm income from field crops decreased by 18.1 percent, the income from horticultural products increased by 3.3 percent, and that from animal products by 2.8 percent. During the period 2000/2001, prices that farmers received for their products increased by 3.4 percent, while the prices that they had to pay for their inputs increased by 9.5 percent. The profit margins of field crops declined to such an extent, that it was not economically feasible to produce these crops, except where farms were situated on average to high potential soils. During the early nineties, the area under maize production in South Africa constituted almost 50 percent of the total field crop production area. Maize also provided close to 50 percent of the total carbohydrates consumed by South Africans and 59 percent of energy inputs required for livestock health ratios (Townsend, 1997). At the end of 2001 there was a steep increase in the producer price of all the major field crops. One of the major reasons for this steep increase was the depreciation of the Rand. The depreciation of the Rand also resulted in higher input prices. The relationship between the increase of input and product prices will determine the new level of profit margins on which the farmers will base their decisions.

Agriculture exports are ranked sixth in order of magnitude of turnover, while the imports are ranked fifth. Although its share has been declining, agricultural exports still play a critical role in facilitating development, through the provision of foreign exchange earnings required to offset the losses accumulated by the manufacturing sector in the primary stages of the economic development process. Table 2.1 below shows the value of agricultural imports and exports as a percentage of total imports and exports. From this table, it is evident that agricultural imports, as a percentage of total imports, have decreased over the past four years. For exports we find a small increase from 1997 to 1999 and in 2000 a major decrease.

Table 2.1: Value of Agricultural Imports and Exports as a percentage of total Imports and Exports

Year	TRADE - R millions					
	Imports			Exports		
	Total	Agriculture	%	Total	Agriculture	%
1990	44,141.50	2,203.30	4.99%	60,770.20	5,289.80	8.70%
1991	44,195.20	2,438.90	5.52%	61,146.50	5,448.40	8.91%
1992	52,594.40	4,489.50	8.54%	69,196.80	5,409.90	7.82%
1993	59,078.70	3,794.20	6.42%	80,938.10	5,481.40	6.77%
1994	79,541.60	4,847.10	6.09%	90,328.20	7,995.40	8.85%
1995	98,512.50	6,790.40	6.89%	101,503.10	8,029.60	7.91%
1996	115,537.50	7,696.80	6.66%	126,044.70	11,640.70	9.24%
1997	129,616.20	8,601.90	6.64%	143,440.70	12,258.50	8.55%
1998	146,805.10	9,345.20	6.37%	156,184.20	13,394.10	8.58%
1999	147,091.80	8,929.70	6.07%	163,180.80	14,373.40	8.81%
2000	227,918.00	9,643.69	4.23%	253,809.00	15,819.00	6.20%

Source: Abstract of Agricultural Statistics, 2001

The most important export products are sugar, citrus fruits, grapes, wine, apples, pears and quinces accounting for more than 54 percent of total agricultural exports. Rice; whiskies and other spirits; sunflower and cottonseed oil; tobacco and wheat were the most important import products, accounting for more than 45 percent of total agricultural imports.

2.3 OVERVIEW OF THE SOUTH AFRICAN WHEAT SECTOR

This section provides an overview of the South African wheat sector. In the first part of this section the production cycles and practices are presented and discussed. The second part of the section focuses on the consumption of wheat and presents the food balance sheet for wheat for the past decade.

2.3.1 WHEAT: AREA PLANTED AND PRODUCTION

In South Africa wheat is produced in both summer and winter rainfall regions. Although most of the wheat is grown in dryland conditions, wheat is also produced under irrigation, mainly in the Mpumalanga, Northern Cape, and Kwazulu-Natal province. The southwestern parts of the Cape Province, the Free State and the Northern Cape, together, is the largest contributing region to wheat production in the country. The Free State and the Cape Province produce more than 80 percent of the total wheat produced in South Africa. The production statistics for wheat are given in table 2.2 below.

Table 2.2: Production Statistics of Wheat

Marketing Year	Yield (t/ha)	Area Planted (Million ha)	Production (Million tons)	Net Producer Price (R/t)	World Price ($/ton)
1990/91	1.10	1.55	1.71	515.14	107.87
1991/92	1.49	1.43	2.14	620.76	138.37
1992/93	1.78	0.74	1.32	713.09	134.75
1993/94	1.86	1.06	1.98	750.69	132.27
1994/95	1.77	1.04	1.84	754.91	145.87
1995/96	1.45	1.36	1.98	802.56	201.81
1996/97	2.10	1.29	2.71	909.44	179.15
1997/98	1.76	1.38	2.43	817.75	136.19
1998/99	2.53	0.75	1.89	808.19	113.08
1999/00	2.41	0.72	1.73	960.60	105.39
2000/01	2.72	0.86	2.34	1044.71	119.54
Average	1.91	1.11	2.01		

Source: SAGIS, Wheat Board, NDA, IFS, Grain SA

If normal weather conditions prevail, at least 1.25 million hectares of wheat must be planted to meet the domestic needs. Although the area planted under wheat has increased marginally in the period 2000/01, there has been a general decline in the area planted under wheat in the past few years, from 1.38 million hectares in 1997/98 to 860 000 hectares in 2000/01. The largest area planted under wheat in the history of South Africa was in 1988 when 1.98 million hectares were planted. In 1992 the area planted decreased by fifty percent due to a severe drought. Gradually, the number of hectares under planting increased again until 1998 when a record harvest in the United States coincided with South Africa's first year of free marketing in the wheat industry resulting in downward pressures on local wheat prices. Both these low producer prices and the impacts of poor rainfall influenced the area of land planted under wheat, resulting in a decline of the area planted from 1997 to 1998. Rainfall was particularly low during the months in which planting decisions were made further exacerbating the outcomes. This resulted in a decline in the area planted from 1.38 million hectares in 1997 to 750 000 hectares in 1998 (Troskie, 2001).

Currently South African wheat producers are facing increased exposure to international wheat markets, as a result of the phasing out of the Wheat Board in 1997. Market forces now determine the price of wheat. In light of the fact that the United States of America produces about 50 million tons of wheat per annum it is evident that the South African wheat industry has relatively little power to influence the world wheat market.

2.3.2 A FOOD BALANCE SHEET FOR WHEAT

During the 2000/01 growing season, 2.34 million tons of wheat were produced locally whereas up to the end of February 2001, 300 000 tons of wheat had been imported. Together with carry-over stocks of 480 000 tons as at 1 November 2000 (SA Grain, 2000), total availability was equal to 3.12 million tons of wheat for the 2000/01 season. The food balance sheet (Table 2.3) shows the quantities of exports and imports and domestic consumption of wheat per year in South Africa, allowing one to determine the levels of over or under supply. The average domestic utilization for the past decade is estimated at 2.39 million tons and has increased, especially over the past five years. Although the amount of wheat used for feed is very small, an increase over the past four years can be seen. One of the reasons for this is that the standard of grading has been adapted to better reflect the nutritional and economic value of these commodities, as a result, more and more wheat is graded suitable for feed consumption only.

Table 2.3: The Food Balance Sheet for Wheat in South Africa.

Marketing Years	Production (Million tons)	Imports (Million tons)	Exports (Million tons)	Domestic Consumption (Million tons)	Ending Stocks (Million tons)
1990/91	1.71	0.57	0.18	2.22	0.34
1991/92	2.14	0.14	0.23	2.20	0.35
1992/93	1.32	0.86	0.33	2.19	0.33
1993/94	1.98	0.25	0.24	2.30	0.27
1994/95	1.84	0.70	0.25	2.40	0.40
1995/96	1.98	1.01	0.47	2.52	0.29
1996/97	2.71	0.51	0.34	2.57	0.58
1997/98	2.43	0.47	0.08	2.33	1.07
1998/99	1.89	0.48	0.08	2.61	0.65
1999/00	1.73	0.62	0.07	2.45	0.48
2000/01	2.34	0.30	0.08	2.50	0.55
Average	2.01	0.54	0.21	2.39	0.48

Source: SAGIS, Wheat Board, NDA, IFS, Grain SA

Wheat can be classified as one of the top ten import commodities of South Africa. Over the past decade South Africa has imported an average of 540 000 tons annually. In the future the quantity imported will depend on local production capacity and output. Due to the fact that South Africa is a net importer of wheat, the local producer price for wheat will naturally always be influenced by the world price adjusted for the exchange rate.

2.4 AGRICULTURAL POLICIES AND GOVERNMENT INTERVENTION: AN HISTORIC OVERVIEW OF THE WHEAT TO BREAD VALUE CHAIN

This section presents an historic overview of the most important agricultural policies and government interventions in the South African agricultural sector. A review of the different components of the wheat to bread value chain will follow subsequently in section 2.4.2 to illustrate the impact of these policies and interventions on the value chain.

2.4.1 AGRICULTURAL POLICIES AND GOVERNMENT INTERVENTION[1]

South Africa has a long history of government intervention in the agricultural sector. This intervention of the state reached its peak around 1980. A body of policy instruments, that were initiated as early as 1910 when the Union of South Africa was established, set the scene for a comprehensive system of support measures to white farmers as well as the segregation of agriculture. Among the various legislations, the most important were the Land Bank Act of 1912, the Land Act of 1913 and the 1912 Land Settlement Act. In 1922 and 1939 the Co-operative Societies Acts were implemented. Other important legislations were the Natives Administration Act of 1927, the Land Act of 1936 and the Marketing Act of 1937.

The Marketing Act of 1937 became the foundation for commercial agriculture policy. This act was amended regularly and was finally consolidated into a new Marketing Act in 1968. The Kassier Committee (Kassier, 1992) argued that the main aim of this Act was the facilitation of "orderly marketing". This concept included factors like the reduction of marketing margins, increasing production and price stability. It was argued that incomes in agriculture were lower than they should be because of a combination of natural factors and exploitation by middlemen and speculators in the market. According to this committee the Act had not achieved all of these objectives it set out to achieve. As previously mentioned, between the release of the Kassier report and the promulgation of the new Marketing Act in 1996, some ten of the existing Marketing Boards, which were established under the Marketing Act of 1937, were abolished.

[1] Kirsten, J.F., and N. Vink (2000)

One of the major effects that illustrated the skewness and inefficiency of these policies was the fact that South Africa was exporting food "surpluses" while most of the population were living well under the minimum level of subsistence. Another important phenomenon was the fact that land prices were pushed up above the productive values of land due to the low or even negative real interest rates, which encouraged borrowing. According to Van Schalkwyk and Van Zyl (1995) the real price of land peaked in 1976, however, matched by an increase in real interest rates during the 1980's and the commencement of a process of deregulation, land prices started to decline.

A discussion on the change in agricultural policies can be divided into two time periods, the 1980's and the early 1990's and another distinctive time period from 1994 when the government of national unity came to power (Kirsten & Vink, 1999).

Kirsten and Vink (1999), further classify the main policy shifts in the 1980's as follows:

- Deregulation of the marketing of agricultural products in terms of the Marketing Act and other legislation.
- The government's budget that was allocated for the support of white farmers, declined by some 50 percent between 1987 and 1993. Changes in fiscal and monetary treatment of agriculture, including the abolition of many tax breaks that favoured the sector and a reduction in direct budgetary expenditure on the sector. The extension of the period within which capital purchases could be written off can serve as an example. This involved the extension of the period in which a farmer can write off his investment from taxable income from one to three years. The effect of monetary policy on the agricultural sector is important, especially with regard to the depreciation of the Rand exchange rate

as well as the farm debt problem and interest rate variability. Apart from the period between 1982-1984, a negative real interest rate mainly occurred during the 1980's. The reason for this being that the government followed an expansionary monetary policy that implies an increase in money supply. This gave rise to the depreciation of the Rand exchange rate, which resulted in the rise of the costs of imported components of machinery, implements, dips and sprays. The expansionary monetary policy resulted in a high inflation rate (represented by the CPI), which resulted in the negative real interest rate. However, in order to curb inflation the government started to implement a policy of positive real interest rates from 1988 onwards.

- A start to the processes of land reform and the shift away from settlement schemes and large-scale projects as the major instruments of agricultural development in the former homelands areas, in favour of, an approached based on the provision of farmer support services. These services included a well-designed infrastructure, extension services, research, and access to credit and markets. The process of land reform also triggered the introduction of legislation that governs the occupation rights of workers who live on farms.
- Reforms of labour legislation. This included the introduction of legislation that is governing the working condition and wage rates of labourers on the farm.

Policy shifts as from 1994 include:

- The promulgation of the Marketing of Agricultural Products Act, No 47 of 1996 which represents a radical departure form the marketing regime to which farmers had become accustomed in the period since the 1930's.
- Trade policy reform aimed at reversing decades of 'inward industrialisation' strategies.

- Labour market reform, which involves the continuous application of legislation that governs the occupation rights who live on farms.
- Reform of the state's approach to financial support to the agricultural sector

The process of trade policy reform by the South African government was characterized by a willingness to expose businesses in the country to tariffs that were often below the bound rates negotiated in the Uruguay Round of the GATT. The Marrakech Agreement also required that all trade policies and controls be in the form of tariffs. Under the previous Marketing Act (Act 1968) agricultural trade was managed through quantitative controls. These quantitative controls had to be abolished.

2.4.2 THE WHEAT TO BREAD VALUE CHAIN[1]

The broad policy trends discussed above are discussed in more detail with specific reference to the wheat sector. This section focuses on the impact of agricultural policies on every role player in the value chain from the wheat producer to the consumer of wheat products. Figure 2.3 below, summarises the main historical events and deregulatory activities impacting on the wheat to bread value chain (NAMC, 1999).

[1] This section relies heavily on a report by the NAMC in 1999: "The Wheat to Bread Value Chain"

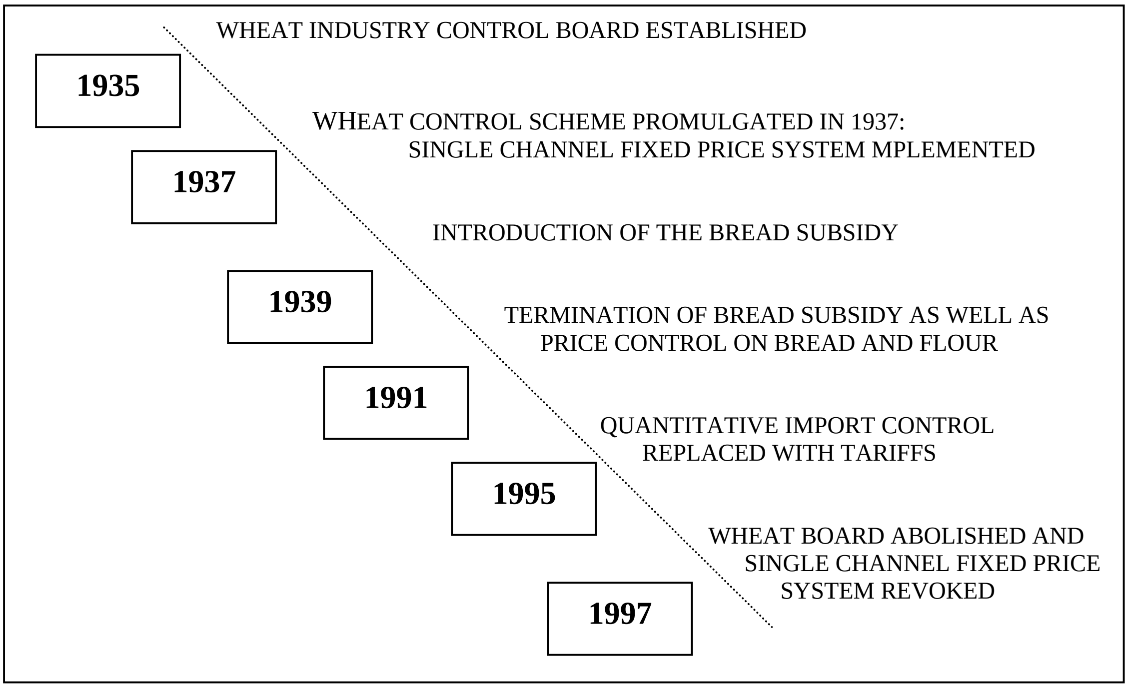

Figure 2.3: History and deregulation of the Wheat-to-Bread Value Chain (Source: NAMC, 1999)

2.4.2.1 THE PRODUCTION AND MARKETING OF WHEAT

After the establishment of the Union of South Africa in 1910, attention was focused on the production of wheat, it was argued that cheap food supplies were essential for the development of South Africa. It was proposed that the import duty on wheat should be doubled and that production should be expanded. During this time South African farmers were producing only fifty percent of the country's required demand for wheat. This led to the temporarily suspension of the import duty in 1920 when crop failure hit South African agricultural industry. After the wheat supply situation was investigated in 1917, seed was issued at cost price and greater measures were taken to make greater quantities of fertilizer and kraal manure readily available.

A Wheat Industry Control Board was established in 1935 to control the flow of wheat to the market by paying storage compensation in respect of wheat stored by co-operative societies and producers (NAMC, 1999). During the depression years, wheat was the most profitable component of dryland crop farming in South Africa.

In 1937, the Wheat Control Scheme was promulgated, vesting in the Wheat Board the sole right to sell wheat. In addition, subject to the minister’s approval, the Board could fix prices from the producer to consumer. For example: in the 1940/41-season the government paid a subsidy of two shillings per bag, of which the Wheat Board contributed fifty percent. These subsidies, in the form of direct payments, persisted until the end of the 1956/57-production season (NAMC, 1999).

Under the single channel marketing scheme, wheat farmers were guaranteed a fixed producer price at the beginning of the season. This fixed producer price was set as follows: the Wheat Board would propose a basic price, this proposal was sent to the minister for approval, once a basic price was approved, the producer price was calculated by deducting the storage costs from the basic price. The basic price was determined by the previous year’s basic price, adding the increase in production costs. Only from 1991 onwards did the Board take the world price into consideration when setting the basic price for wheat. This approach meant that farmers could anticipate with confidence what the producer price for their harvests would be at the start of the planting season, eliminating any price risks leaving only production risks to be mitigated. Once the crop was harvested farmers did not have to take care of the marketing of the crop themselves. The wheat board was their sole buyer of the crop and agricultural cooperatives were appointed as agents of the Wheat Board.

In 1992 the Kassier Committee (Kassier, 1992) indicated that they believed that the winter grain-marketing scheme was not serving the best interests of a large number of producers, millers, processors, bakers, and consumers. Their general recommendations included that the standards for grading wheat be adapted to better reflect the nutritional and economic value of these commodities. They also recommended that where boards followed unitary pricing policies, like the wheat board, these policies be immediately abolished and replaced by a pricing system that reflected comparative advantages, such as location advantages and quality differentials.

Two years after the Kassier Committee made its recommendations the Minister of Agriculture appointed the Basson Committee (1994) to advise on a framework for and the implementation of a future agricultural marketing policy. Their report stated that agricultural product prices should reflect comparative and competitive advantages derived from factors such as transport, storage and quality. The report also recommended that an urgent solution be found for the fixed price system and that adjustments to the marketing system include the implementation of an import tariff. The Wheat Forum was established and May 1994 was set as the target date by which the finalisation of aspects in view of submitting a tariff application to the department of trade and industry. These tariffs were implemented through the structure of a scale if the international price would drop below a level of $194/ton (Exchange rate R3.69 for $1 USA).

Although import tariffs already replaced quantitative import controls in 1995, it was not until February 1998 that the first import tariff was implemented. The import parity price of wheat dropped under R802 per ton and a R50 per ton import tariff was charged. In 1999, a new tariff structure for wheat was introduced and is still used today. This tariff calculation is based on the Hard Red Wheat (No.2) price in the USA and is calculated weekly. If the current price deviates by $10 per ton or more for three weeks from the average price of $157 per ton, the tariff is adjusted. The new tariff was set at R181 per ton.

In 1997, the single channel fixed price-marketing system was abolished in South Africa and the Wheat Board closed its doors, leading to a free market era. As previously mentioned, the Wheat Forum already existed at the time the Wheat Board was abolished. This Forum was established to represent the directly affected groups in the winter cereal industry. After deregulation, the Winter Cereal Research and Development Trust and the Winter Cereal General Trust were established. During 1998, statutory levies were implemented, namely R4.00 per ton for winter cereal to finance research and 50c per ton to finance information services. The current levy on wheat is R7.50/ton.

The deregulation of the agricultural sector took place over a very short period of time. Although a number of areas in the market are experiencing problems in adjusting from the regulated past sixty years of intervention, producers are gradually getting used to the unregulated market environment. A wide range of instruments have been developed that assist farmers in hedging themselves against the new market uncertainties under which they have to produce.

2.4.2.2 THE HANDLING AND STORAGE OF WHEAT

Following the report of the Clark Committee in 1918, two coastal and thirty-five inland silos were built with a total storage capacity of 100 950 tons. In 1952, the Minister of Agriculture announced a loan scheme to be operated by the Land Bank, to encourage the building of more silos by the agents of the Maize and the Wheat Boards. The program took off in the mid 1960’s when a Grain Silo Advisory Committee was appointed. Silos with a capacity of 15.4

million tons, of which 14.5 million tons were established at two hundred – and - twenty depots in the North (mainly on the Highveld) and approximately one million tons at forty-six depots in the south (Western Cape), were built within the set guidelines of the Grain Silo Committee. In most cases, cooperatives were the owners of silos and acted as agents for the Boards. They graded, handled, stored and fumigated grain. The Boards remunerated the owners for the capital costs of silos and the operational costs thereof, based on average calculations.

The regulated silo-building program was suspended in 1984, and finally terminated in 1990 (NAMC, 1999). During the process of deregulation a number of the cooperatives converted to companies. This led that the ownership of eighty-five percent of all grain storage capacity in South Africa, by a few small companies and institutions. Although this creates the potential for monopolistic behaviour by silo owners, they are held competitive by farmers through their behaviour trends towards increased on-farm storage and direct deliveries to processors.

2.4.2.3 THE MILLING OF WHEAT

In May 1941, "standard" meal and a standard loaf of bread were introduced. In this way a milling extraction of ninety-five percent was made compulsory and the use of sifted meal and flour was restricted. During the 1940/41 wheat season the Wheat Board paid a subsidy to millers for wheat milled specifically for the baking of bread. This subsidy was paid to keep the bread price as low as possible.

The Wheat Board implemented a restrictive registration on all millers and bakers. This restrictive registration of millers and bakers was abolished on 1 March 1991. The government set the miller's margins of flour and had credit control measures in place. These interventions were also terminated in 1991.

Since deregulation, the milling industry has experienced a drastic increase in procurement risks. Procurement in the deregulated environment is complex and requires expertise. The market has developed instruments like silo certificates, pre-season contracts and the South African Future Exchange (SAFEX) to assist in managing the risk. The increased access and hence entrance of small role-players in the market has led to higher per unit costs (NAMC, 1999)

2.4.2.4 THE BAKING OF BREAD AND THE RETAILER

The government did not only support the producers of wheat but also associated industries like the baking industry. In 1940/41 a subsidy was paid to the bakers to keep the bread price as low as possible. The bakers received breadflour subsidies from 1957/58 onwards. These subsidies were adjusted in May 1977, when only the flour intended for the baking of standard bread was subsidised. In a study by Nieuwoudt (1981), it was estimated that the subsidised price of bread was 27 percent below the consumer price in a free market.

In 1988, the cabinet decided in principle to phase out the bread subsidy gradually over three years. The Blignaut Report (1990), made recommendations regarding the phasing out of the subsidy and on the 1st of March 1991, the bread subsidy was terminated and the Wheat Board no longer regulated the price of bread. Together with the withdrawal of the subsidy; the restrictive registration of standard bread bakers; and the market sharing arrangements governed by the baking industry in terms of an exemption under the Competition Act, were terminated. This gave the opportunity to many small and in-house bakeries to enter the market with low delivery costs and the psychological advantage of the smell of fresh bread in the store.

In 1991 Value Added Tax (VAT) was imposed on white bread while brown bread was exempted. This gave retailers the opportunity to gain a higher retail margin on brown bread than on white bread. Small retailers then had the opportunity of attaining higher retail margins by adding convenience value to the standard loaf by trading longer hours and being closer to the consumer (NAMC, 1999)

2.5 THE CURRENT SITUATION IN THE WHEAT INDUSTRY

At a Wheat Forum meeting held on 25 October 2001, the Agricultural Business Chamber (ABC) and the National Department of Agriculture (NDA) made a presentation of their findings of a study on the wheat industry's international competitiveness. The results of the study showed that wheat was marginally competitive becoming increasingly competitive. On the value added side, however, wheat and flour were competitive but showed a declining trend. The term competitive here, was defined as the ability of the sector to trade at competitive prices within a global environment. The findings concluded by identifying the most enhancing factors for productivity as the following: quality, availability of labour, management skills, packaging material, physical policy and the structure of the company.

Wheat production in South Africa is unique in the sense that despite the fact that insufficient wheat is produced in the country, in the Western Cape Province, less than 40 percent of the locally produced wheat is consumed placing downward pressures on local wheat prices (Troskie, 2001). This dichotomy led to a steady decline in wheat production in the Western Cape. However, the recent depresiation of the Rand has undoubtedly brought new life to the wheat industry. In April 2002, the landed price for wheat in Randfontein was R2103/t. This landed price included an import tariff of R196/t. Interestingly, it is only in the past 6 months that producers have received prices, that are comparable with the price levels in 1981 and 1982. The world price of wheat has reached levels well above $190/ton and on September 24, 2002 the levy on wheat was published at zero Rand per ton.

A wheat crop of 2.4 million tons is expected for the current production season. This implies that imports will have to be in the range of 300 000 tons in order to meet total domestic demand. The National Crop Estimates committee has estimated a decrease in farmers intensions to plant wheat in the upcoming season, which may result in a smaller wheat crop for 2002/03. It is anticipated that a reduction in the area under wheat will take place in the summer rainfall regions where wheat can be substituted for maize. Maize is preferred as it yields a better gross margin, as maize prices are currently higher.

2.6 SUMMARY

As is the case with most agricultural commodities in South Africa, government intervention have played a major role in the wheat industry in South Africa. This chapter has presented an historic overview of the wheat sector in order to illustrate the impact of government policies on the sector at specific points in time. As mentioned, this background knowledge and understanding of the sector will prove invaluable in informing the specifications of the wheat model, developed in Chapter 5.

CHAPTER 3

MODELLING COMMODITY MARKETS: A LITERATURE REVIEW

3.1 INTRODUCTION

Commodity modelling is a methodological technique that provides a powerful analytical tool for examining the complexities of commodity markets. These models provide a systematic and comprehensive approach to analysing and forecasting market behaviour. The review of these methodological techniques highlights the importance of describing and reporting the approaches used in individual analyses and the process of deriving the final results. Far too frequently are econometric results accepted as the all encompassing answers with more attention being given to the results than to the methodology of deriving the results.

This chapter consists of two sections, an overview of commodity modelling and forecasting in general, and a review of commodity modelling in South Africa. The first section discusses the various econometric tools and techniques widely used for crop modelling, developed over the past few years. The second section explains the results as well as the shortcomings of some of the modelling work that has been conducted in South Africa.

3.2 COMMODITY MODELING AND FORECASTING

3.2.1 OVERVIEW

Agricultural commodity markets reflect a complexity of interrelationships between economic, technical, biological, and institutional factors. The development of econometric techniques, economic theory, and the computational capacity of computers has enthused agricultural economists and policy analysts to work at better understanding and predicting movements in prices; quantities demanded and supplied (due to the changes in market conditions); and policies. Tomek (1993) stressed, "The strength of agricultural economics rests on its capacity to combine theory, quantitative methods, and data to do useful analysis of problems faced by society".

Townsend (1997) referred to Morgan (1992) when stating, "quantitative expression through econometrics was regarded by its first practitioners as a creative synthesis of theory and evidence, with which almost anything and everything could, it seems, be achieved". The first macro-econometric models were already developed during the period of the Great Depression (1930s). According to Zalm (1998), a theory, a model or a structure was always needed, to offer possibilities that could reduce the economic hardship so many people faced. In 1936, Tinbergen developed the first macro-econometric model for the Dutch economy. These Keynesian models increased in scale as more econometricians followed Tinbergen's modelling approach. The advances made in computer technology improved the scope for developing models in this tradition. However, these policy-makers and model-users failed to recognise the limitations of these models and the difficulties of managing their construction and application (Zalm, 1998). During the fifties and sixties regression analysis was used frequently, relying far more on estimation procedures than test procedures. Applied economists and econometricians were criticised for data mining. Data mining refers to the process of running a large number of regression equations, which differ according to specification and included explanatory variables. The equation that was selected under this approach and used for reporting purposes, was the one that was considered to best support the theory under consideration (Townsend, 1998).

It was not until the early seventies that thinking around econometric methodology converged. Tremendous development in both the theoretical aspects and the applications of commodity modelling were evidenced. The need to determine the statistical properties of each time series for the variables in the equation was acknowledged. Resulting in an improvement in the predictive performance and forecasting ability of commodity models, to such an extent that commodity models can now be used for price and policy analysis with much more confidence. Commodity models, that are developed from a base of high quality empirical research, can be used to address three important levels of analysis namely, market analysis, forecasting of future market prices and quantities, and policy analysis (Poonyth, Van Zyl and Meyer, 2000).

3.2.2 COMMODITY MODELS OF WORLD GRAIN MARKETS

The continuing process of global integration carries with it implications for farmers and the related supplying and processing industries in many parts of the world, and impacts the world economy. An assessment of agricultural and trade policy impacts is bound to be complex and is often supported by quantitative policy analyses. The development of global models is now well established and has become an integrated part of world economies and world economic reviews. Van Tongeren et al. (2001)

performed a comprehensive review of the state of applied modelling used for examining the global impacts of agricultural and trade policies. In the following section this review will be used to sketch a broad overview of the classification of various models that are currently in use and to facilitate the conceptual understanding of the modelling approach that will adopted for this study.

The first distinction that is made in Figure 3.1 below, is between economy-wide models and partial equilibrium models. Partial models consider the agricultural system to be a closed system without linkages to the rest of the economy. Exogenous variables are used to capture the effects of the rest of the domestic and world economy. Supply and demand relationships are represented by means of behavioural equations, which are used to estimate the parameters of the independent variables. Partial models can be single or multi product models implying that demand and supply interrelationships among agricultural products are captured. These partial equilibrium models are commonly applied to detailed trade policy analysis for a specific product.

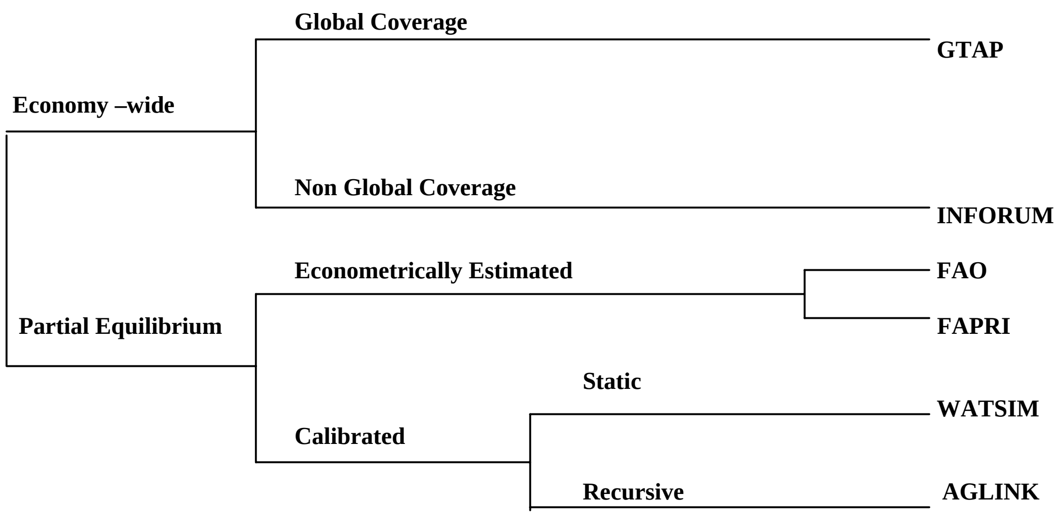

Figure 3.1: Classification of Commodity Models (Source: Van Tongeren *et.al.*, 2000)

Economy-wide models provide a complete representation of national economies and the inclusion of factor movements between sectors in the economy and international trade defines the essential general equilibrium features. Economy-wide models can be classified into three classes, namely, macro-economic models, input-output models and applied general equilibrium models. Examples of such models are the GTAP model developed by the University of Purdue, as well as the INFORUM model, developed by the University of Maryland.

The Food and Agricultural Policy Research Institute (FAPRI) modelling approach, classified as a partial equilibrium modelling approach, is used for this study. Therefore, the following discussion will only focus on the partial equilibrium modelling approach. The FAPRI model is a standard, recursive, and dynamic partial equilibrium model (Binfield et.al., 2000). The term "standard " implies that the basic theoretical assumptions of constant returns to scale, homothetic preferences, and perfect competition underlie this modelling approach. Dynamic models allow the estimation of adjustment processes of time. This implies that lagged independent variables can be used in the model. The most frequently used approach to incorporate dynamic features in equilibrium models is to specify a recursive sequence of temporary equilibria. This implies that the model is solved for an equilibrium in each time period, given the exogenous conditions prevailing for that period.

According to Figure 3.1 a final distinction needs to be made between the different approaches, which can be used for parameter estimations. Two approaches can be distinguished, econometric estimation and calibration. Econometric estimation of parameters should ideally be done using simultaneous equation estimation methods.

The estimated parameters can then be used to calculate elasticities (FAPRI approach). The calibration approach, on the other hand, uses the initial elasticities estimated with the econometric approach and adjusts certain other parameters in the given functional forms to the initial equilibrium dataset. The WATSIM and AGLINK models are examples of this type of modelling.

These two approaches differ with respect to the way in which they reflect trade policies. Econometric models are based on a tariff-equivalent representation of trade policies. Despite the observation that this is the most common approach to policy formulation, it is also regarded as the most effective. Policies are formulated at the commodity level or tariff-line level and it is at this level that policy makers require information. In the case of the calibration approach quantitative restrictions are used to represent trade policies. This is not always an adequate approach, as tariff equivalents tend to be zero, in cases where there is no evidence of a quota binding in the benchmark.

In summary, the estimation of a system of equations, as is the case in the FAPRI model, provides a great deal of flexibility, and allows specific policies to be modelled.

3.3 COMMODITY MODELING IN SOUTH AFRICA

3.3.1 BACKGROUND AND CONTEXT

The environment in which commodity modelling is conducted in South Africa has drastically changed over the past decade. The marketing of agricultural commodities has been transformed from a highly regulated to an essentially free dispensation in a short space of time. These drastic changes in the domestic market have re-emphasised the importance and necessity of tools or an analytical system, which can be used to measure or estimate the impact of these changes on the local market. The recent depreciation of the Rand can be used to illustrate this as questions are raised regarding the impacts of this depreciation on consumers and input markets within the broad economy. Given the current status of modelling work in South Africa, these questions can only be answered by analysing the impact of the depreciation of the Rand on consumers and producers separately, and not by solving simultaneous systems of equations.

Interestingly, the availability of a modelling system during the existence of the marketing boards could have provided invaluable information for evaluating and quantifying the impacts of alternative agricultural and macro-economic policies. Especially, during a time when their main focus was the implementation of agricultural policies and subsidies. The decision-making processes could have been greatly improved, if a modelling system had been initiated and developed, yet, virtually all of the modelling work that was conducted during that time focused solely on single equation estimations of demand and supply.

3.3.2 PREVIOUS STUDIES AND THEIR RESULTS

Frequent modelling work has been conducted on the maize and wheat sector of South Africa and virtually all the studies reviewed in this section were conducted for the maize or wheat sector during the time of a regulated and controlled market. Thus, the applicability of these models has several limitations.

Langley and du Toit (1976) estimated the supply of maize in the Western and Eastern Transvaal using econometric techniques. Using ordinary least squares (OLS) they estimated single equations for the area planted as well as the production of maize for each region. Their results indicted that the area planted influenced yields obtained per hectare. From this they drew the conclusion that an increase in an area planted is probably accompanied by the utilization of more marginal or sub-marginal soils, which together with more extensive cultivation practices, negatively affected yields per hectare. Further, they considered the lagged price (P_{t-1}) to be the expected price and decided that the inclusion of this lagged price, as an independent variable was realistic. This was due to the fact that controlled marketing by the boards succeeded, to a large extent, in eliminating large annual fluctuations or price-uncertainties. In hindsight, one can argue that this was not necessarily the most appropriate approach, as the boards used a fixed formula to calculate the producer price for the upcoming production season. At that time, farmers had to make their planting decisions and had full price knowledge or at least a strong suspicion of what the expected price for their products would be, during the approaching production season. Hence, researchers made some predictions based on single estimation equations but they were unable to use their results for the purposes of forecasting. Their calculated elasticities are presented in Table 3.1 below.

Van Zyl (1990) conducted a similar study when he estimated the demand and the supply for maize in South Africa. Instead of using only two regions, he split South Africa up into four major maize producing areas. Again, ordinary least squares (OLS) was used to estimate single equations for the demand as well as the supply of each region. Van Zyl (1990) showed that the price of maize and its production substitutes did not play a major role in determining the annual area planted under maize. Other factors, such as, timely rainfall and price expectations were seen to play a more important role on decisions around what and how much to plant. In general, the statistical fits for the Western Transvaal and North Western Free State were regarded as disappointing. This implied that no significant elasticities for these areas could be calculated. Significant elasticities could, however, be calculated for the Eastern Free State and Transvaal Highveld regions. The price elasticity of supply for the Eastern Free State was extremely low at $P_e = 0.026$. The cross-price elasticity between maize planted and wheat, and maize planted and sunflowers was estimated at -0.602 and –0.151, respectively, implying that the price of secondary crops in the region will have a greater impact on the area planted to maize than the maize price itself. The price elasticity of supply for the Transvaal Highveld region was calculated at 0.136. In this region, the cross-price elasticities were also greater than the own-price elasticities. These results appeared to contradict expected results as maize is the primary crop in these regions, and one would not expect prices of the secondary crops to have a greater influence on the production of maize, than the maize price, itself. The purpose of this study was to assess the performance of the South African maize marketing scheme and therefore the single equations estimated in this study could not be used to conduct forecasting analyses.

Table 3.1: Elasticities of Maize in South Africa

Reseachers	Supply: Area planted		Demand		
	Own Price(ST)	Cross Price(ST)	Own Price	Cross Price	Income
Langley,D.S. and J.P.F. du Toit					
Eastern Transvaal	0.715				
Western Transvaal	0.963				
Van Zyl, J.					
Eastern Free State	0.026	-0.602 (Wheat)			
		-0.151 (Sunflower)			
Transvaal	0.136	-0.209 (Sunflower)			
National: Animal Consumption			-2.198	1.25 (Hay)	
National: Human Consumption			-0.14	0.20 (Bread)	-0.24
National: Total Consumption			-0.22		0.39
Schimmelpfennig, Thirtle, Van Zyl					
National	0.64				
Poonyth, D.					
National	0.12		-0.25		0.281

Cleasby, Darroch and Ortmann (1993) specified a simultaneous-equation model containing yellow maize export demand and supply functions. Two Stage Least Squares (2SLS) was used to estimate the single equations, which were then used to run a system of equations. The market equilibrium condition of total demand equal to total supply was used to close the simultaneous-equation model. Although, this system of equations had the potential to be used for forecasting, it was recommended that it be applied with caution as the model only explained 18 percent of the variation in the export demand. The results indicated that the world price of maize, as well as the exports of the previous year had an influence on the export demand of yellow maize. The real Chicago Board of Trade corn price, which was used as the world price, was only statistically significant at the 20 percent significance level. It was also determined that climatic variation was the major determinant of export supply for yellow maize. The results supported the *a priori* expectations that local yellow maize producers are price takers on the world market and that export supply reacts sluggishly to changes in the lagged producer price of yellow maize. Many factors could have had a negative impact on the statistical significance level of this model and it was probable that one factor could have been the selection of instrumental variables, essential for 2SLS estimations.

Schimmelpfennig, Thirtle and Van Zyl (1996) used an error correction model to investigate South African long and short run supply responses of maize and sorghum. 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 for time-series data with a high frequency, such as, daily or monthly South African Futures Exchange (SAFEX) commodity prices, than for annual data. With this study the authors determined that the maize area planted in the short run or the long run depended on two sets of variables. The first set of variables changed the quantity of supply of maize directly, for example, own price, the price of substitutes like sorghum and sunflowers, and intermediate input prices. The second set of variables changed the supply environment characteristics such as, rainfall. Sorghum was found to be a secondary crop dominated by expected changes in the maize variables, while the area planted depended simply on intermediate input prices and rainfall over both the short and long run. The short run sorghum price had a positive effect on the size of the maize area planted. Sorghum and maize were found to be substitutes, implying that as the area planted under maize increased, the area under sorghum decreased, and the sorghum price increased. The authors also found maize to be the crop that drove the agricultural system in the summer rainfall regions of South Africa.

A review of modeling theory applied to the agricultural sector would be incomplete without the inclusion of the ground-breaking research carried out by Nieuwoudt. His early work (Nieuwoudt, 1982) used the Nerlove model to estimate the demand and supply functions for bread for the period 1948 to1981 in South Africa. This type of model uses the area planted estimated as a function of the lagged area planted as well as the yield per hectare. Based on this approach, Nieuwoudt was able to calculate the short and long term supply elasticities for wheat in South Africa. The short-term supply elasticity was estimated at 0.24, and the long-term supply elasticity was estimated at 0.86. On the demand side, *per capita* consumption of bread was estimated as a function of the real price of bread and real national income. The national price elasticity for the demand of bread was estimated at –0.23, and the income elasticity was estimated at 0.30. A review and comparison of these results with those of later studies is shown in Table 3.2 below. The single equations, estimated in the Nerlove study could not be used to forecast the market outlook for the wheat sector, but were nevertheless used to carry out policy analyses. This enabled, Nerlove to predict what the impact on the consumption of bread would be, if the bread subsidy was removed. His calculations suggested a decrease of 5.2 percent in the consumption of bread. He further predicted a 27 percent increase in the consumer price of bread under the assumption that free market condition would prevail.

Niebuhr (1991) conducted one of the most detailed studies for the wheat sector in South Africa. He used both a positive and a normative approach to analyse various marketing alternatives for the South African wheat sector. Ordinary Least Squares (OLS) was used in the positive approach to estimate demand and supply functions for the wheat sector. Niebuhr made use of the estimated functions to calculate elasticities, which he then plugged into a linear programming model to perform the necessary simulations. Table 3.2 captures these calculated elasticities. Similar to van Zyl (1991), Niebuhr struggled with the statistical significance of the models estimated on a provincial as well as national level. The elasticities calculated by Nieuwoudt and Niebuhr were similar on the production side, but on the consumption side they contradicted one another. Evidenced by Nieuwoudt's calculated income elasticity of 0.3 for wheat at a national level, implying that wheat was a normal commodity as compared to Niebuhr's estimated income elasticity of –0.12, which implied that wheat was an inferior good.

Table 3.2: Elasticities of Wheat in South Africa

Reseachers	Supply: Area planted			Demand for Bread		
	Own Price (ST)	Own Price (LT)	Cross Price	Own Price	Cross Price	Income
Nieuwoudt, W.L.						
National	0.24	0.86		-0.22		0.3
Summer Rainfall Region	0.4	0.87				
Winter Rainfall Region	0.18	0.75				
Niebuhr, H.G.						
Swartland	0.48	0.77	-0.20(Mutton)			
Ruens	0.12	0.39				
Free State	0.33	0.47	-0.72(Maize)			
National				-0.53		-0.12

The basic structure of a mathematical programming model, as depicted by Hazell and Norton, served as a guideline for the construction of the mathematical programming model for Niebuhr's study. A variance-covariance matrix was included in the model to take account of the production risk. Niebuhr only calculated the elasticities for the wheat sector, hence he used the elasticities estimated in previous studies by van Zyl (1991) and Nieuwoudt (1976), to complete the model. Various assumptions, regarding production relationships had to be made before the model could be used for simulation purposes. For a free-market environment, the model predicted a wheat producer price of 14.5 percent lower than the producer price at that time, as well as, a 13.4 percent decline in the area planted under wheat. These projections were made in 1991. The free market environment, for which Niebuhr was making estimations, became a reality in 1997 when the Wheat Board was abolished and free market conditions prevailed. Hence, 1996 can be regarded as the last year of a regulated market, whereas, 1997 was the first year of a free marketing environment. Based on what we now know, it is possible to make a simple comparison between the actual versus Niebuhr's projected percentage change in the area planted and price, by using the actual values of 1996 and 1997, depicted in table 3.3 below.

Table 3.3: Actual and Percentage change in Area Planted and Price of Wheat

	1996 (Actual)	1997 (Actual)	Actual % Change	Predicted % Change
Area planted (Ha)	1,293,799.94	1,382,300.25	6.84	-13.4
Producer Price (R/t)	909.44	817.75	-11.21	- 14.5

Although this is a very simplistic way of evaluating whether Niebuhr's predictions were accurate, some validation can be given based on the observed value of an 11.21 percent decrease in the producer price of wheat. This was not far removed from the predicted value of 14.5 percent. However, contradictory to what Niebuhr predicted with respect to the area planted, the actual area planted increased by 6.84 percent. As the production and consumption of wheat occurs in the same year, it is expected that farmers make their decisions to plant with the knowledge of producer prices, however, despite the fact that in 1997 prices were no longer fixed and wheat farmers made their decisions to plant based on this imperfect knowledge, the area planted under wheat was still increased. In 1998, however, the wheat market was shocked by the unexpected decrease in the areas planted under wheat, by almost 50 percent to that of the previous year. Mathematical programming models can be used to forecast such events but these models are limited by the selection of the base year, chosen prior to the running of model simulations. Hence, it is imperative that one determines with confidence which year is the base year in the agricultural sector.

Poonyth, Van Zyl and Meyer (2000) conducted the most recent study on the market outlook for maize and sorghum. They used the two-stage least squares estimation method to ensure cross-equation and cross-commodity consistency. The domestic demand and supply equations for maize and sorghum were developed. Net trade was used to close the model. This involved the linking of the domestic price with the world price via a price linkage equation. Short run supply elasticity was estimated at 0.12 and long run elasticity was estimated at 0.46. The own price elasticity of sorghum was estimated at 0.66. A market outlook for 1999/00 to 2006/2007 was generated under specific assumptions. Results indicated that both maize and sorghum consumption is expected to increase gradually with time.

3.4 SUMMARY

No model can serve all purposes, encompassing all aspects of model specification and variable inclusion (Van Tongeren et.al, 2000). The choice of theoretical frameworks; the extent of regional and sectoral desegregation and the selection of datasets; and estimation methodologies determine the applicability of the model. This study makes use of the FAPRI modelling approach in order to model the market outlook and policy alternatives for the wheat sector in South Africa. This structural econometric model can be used to enhance and support intermediate economic intelligence and forecasting inputs, as well as, provide a means by which alternative agricultural and macro-economic policies can be evaluated and quantified.

CHAPTER 4

THEORETICAL FOUNDATION

4.1 INTRODUCTION

This chapter introduces the theory of the firm and consumer theory as basis for the modelling process. The first section presents the theory of commodity supply, in both static and dynamic settings. The second section deals with the theory of the different components of the demand block. The objective of this chapter is to provide a theoretical foundation for the econometric modelling of a system of equations. It is important to take the underlying theoretical concept of supply and demand for agricultural commodities into consideration when the decision-making behaviour of producers and consumers is analysed.

4.2 SUPPLY THEORY

4.2.1 DERIVATION OF SUPPLY

According to neo-classic theory, the producer is assumed to be a maximiser of profit or net returns, which are subject to some technical and institutional constraints. In this regard, economic theory suggests that the supply of products to the next highest level of the market channel depends on the expected profits accruing to the decision maker. Varian (1984), referred to the firm's production plan as the firms technical constraints, which define the physical relationship between factor inputs and the maximum output level for the given technology, per unit of time. To illustrate this physical relationship between output and factor inputs, consider a farm that uses land -L, labour -W, and other inputs (fertilizer and capital) -K, in the production of the concerned commodity (for this study, wheat).

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

If the input-and output prices are taken into account let p denote the expected output price (wheat price), *l* the rental cost for land L, *w* be the cost of labour W, and *k* be the cost of other inputs K. Assume that output and the output prices are independently distributed random variables and that the farmer is risk neutral. The objective of the farmer is to maximise profit, which is the difference between total revenue from the sale of outputs and the expenditure on all factor inputs. The farmer's profit function is algebraically defined as follows:

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

thus

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

The expected revenue is represented by pF(L,W,K), *k*K refers to the costs of capital and other inputs, *l*L denotes the costs for land rental, *w*W represent the costs of labour and *TFC* is the total fixed costs. The profit maximisation or cost minimisation approach can now be used to derive the output supply response from the profit function by means of the first order conditions. According to Mas-Colell et.al. (1995), the production function must satisfy the following conditions, firstly, the production function has to be linearly homogenous, secondly, it must be increasing in fixed quantities and output prices and decreasing in input prices, and thirdly, it has to be twice differentiable and must satisfy the condition of convexity in prices. The first order conditions for profit maximization can be presented as follows:

Equation 4.3:

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

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

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

Rearranging Equation 4.3, we obtain,

Equation 4.4:

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

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

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

Equation 4.4 illustrates that the partial derivatives of the production function with respect to the inputs are the marginal products of these inputs. When the marginal product of a factor input is multiplied by the price, the value of the marginal product is calculated, which is the rate of increase of the producer's revenue form additional employment of an input. Therefore, Equation 4.4 implies that the expected value of marginal product is equal to input costs, i.e. a farmer who maximises profit will produce where the expected value of marginal product is equal to input cost. Equation 4.4 can also be rearranged in order for the marginal productivity to be equal to the ratio of input and output prices. However, the first order condition is not sufficient for profit maximisation and the second order condition needs to be derived. The requirements for the second order condition can be presented as follows:

Equation 4.5:

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

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

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

When it is assumed that the production function is concave and the profit function is convex, Equation 4.5 holds the requirements for the second order condition. The next step is to determine whether the optimum input demand functions are a function of input and output prices. This can be achieved by assuming that the production function is invertible.

Equation 4.6: $L*(p,l,w,k), \quad W*(p.l.w.k), \; and \quad K*(p,l,w,k)$

When we find the first order condition of the input demand functions in Equation 4.6, in terms of input and output prices, we are able to prove that these demand functions are homogenous of degree zero in input and output prices. Substituting the optimal input demand functions (Equation 4.6) back into the production function, as presented in Equation 4.1, the output supply function can be derived:

Equation 4.7: $Q* = F(L*, \; W*, \; K*)$

From the primal problem we obtained the input demand function (Equation 4.6) and the product supply function (Equation 4.7) using the concept of profit maximisation. Substituting these back into the direct profit function (Equation 4.2) we obtain the indirect profit function, as presented in Equation 4.8, which is also a function of output and input prices.

Equation 4.8: $\Pi(p,l,w,k) = pF(L*,W*,K*) - lL* - wW* - kK*$

The dual approach allows us to obtain product supply and factor demand equations with partial differentiation of the indirect profit function. The indirect profit function is defined as the maximum profit associated with the given product and factor prices. This implies that a set of input demands and output supply equations can be derived without invoking either the profit maximisation or cost minimisation processes.

The envelope theorem forms an integral part of duality theory. Within the envelope theorem the very important concepts of Hotelling's Lemma and Shepard's Lemma, are used to handle specific cases of profit maximisation and cost minimisation respectively. Applying Hotelling's Lemma, the partial derivatives of the indirect profit function (Equation 4.8) are taken with respect to output and input prices in order to derive the following output supply (equation 4.9) and input demand (equation 4.10, 4.11, and 4.12) functions:

Equation 4.9: $$\frac{\partial \Pi}{\partial p} = F\,(L^*, K^*, W^*)$$

Equation 4.10: $$\frac{\partial \Pi}{\partial L} = -\,L^*(p, l, w, k)$$

Equation 4.11: $$\frac{\partial \Pi}{\partial W} = -W^*(p, l, w, k)$$

Equation 4.12: $$\frac{\partial \Pi}{\partial K} = -\,K^*(p, l, w, k)$$

Equation 4.9 represents the profit maximising supply function for a typical firm under conditions of perfect competition. Equations 4.10 to 4.12 represent the input demand functions at the level where the firm maximises its profit.

4.2.2 DYNAMIC SUPPLY

Dynamic relationships are particularly important in the modelling of supply and demand in the agricultural sector. Biological delays and cycles are inherent in the agricultural production process. Furthermore, agricultural producers might not recognise price changes, which implies that full adjustment in input use and output does not take place in one period of time. Since, agricultural production takes place under less than perfect certainty, time plays a crucial role. Time may be introduced explicitly in supply functions in several ways. This section illustrates and discusses various methods that have been used to represent dynamic output supply response.

4.2.2.1 THE DISTRIBUTED LAG MODEL

The first example is the famous Cobweb model of agricultural supply, which simply states that the level of current supply is dependent upon the price of the previous period, implying that farmers adjust their outputs to the prevailing prices. Since production takes place with a time lag, the adjustment may not be instantaneous but may become perceptible in the market only after a period of time. Algebraically the model can be presented as follows:

Equation 4.13: $$S_t = \alpha + \beta P_{t-1} + u_t$$

This is, however, only for one specific case where current supply is a function of the price of the previous period. The effect of one variable on another variable may endure through several time periods, giving a distributed lagged relationship such as:

Equation 4.14: $$S_t = \alpha + \beta_0 P_t + \beta_1 P_{t-1} + \beta_2 P_{t-2} .... + \beta_k P_{t-k} + u_t$$

One of the problems of estimating this equation, is that observations are lost, which implies that, the parameters are less reliable. Another major problem with this estimation procedure is the possibility that the successive lagged terms may be closely correlated, which results in a problem of multicollinearity. As a result, the Ordinary Least Squares (OLS) estimator will be biased and inefficient, hence, we have to draw upon alternative estimation methods. Maximum Likelihood Estimation (MLE) and instrumental variable estimation are estimation techniques that will yield estimates with desired properties. Although a model with a lagged dependent variable is a very useful tool in the estimation of supply response in the agricultural sector, the magnitude of the regression coefficient of the lagged dependent variable can determine the success of the model. If this regression coefficient takes on a value greater than unitary, we can refer to the model as an explosive model.

4.2.2.2 THE PARTIAL ADJUSTMENT MODEL

Movements from the current level of supply and demand to new equilibrium levels consequent upon changes in economic or technical conditions may not be instantaneous. The partial adjustment model is commonly used to model the gradual adjustment of agricultural producers to changes within the total production environment (Sadoulet et.al. 1995). The partial adjustment model is based on the principle that the change in a variable, for example supply (S) from one period to the next, can be expressed as some portion of the difference between the current level of supply and the desired level of supply. In other words, in each period actual output is adjusted in proportion to the difference between the output desired in the long-run equilibrium and the actual output (Boubaker, 1997). This can be illustrated as follows:

Equation 4.15: $$S_t - S_{t-1} = \delta\,(S_t^* - S_{t-1}) + u_t$$

or

$$S_t = (1-\delta)\, S_{t-1} + \delta\, S_t^* + u_t$$

S_t^* denotes the desired long-run equilibrium level of output, S_t represents the current level of output, and S_{t-1} signifies the level of output from the previous year. δ is an adjustment factor with a numerical value between 0 and 1. If δ =1, then a complete adjustment in the level of output has taken place from the previous period to the current period. However, if δ =0, then no adjustment has taken place and S_t^* = S_{t-1}.

However, the problem with Equation 4.15 is that it cannot be estimated since the long-run equilibrium output level, S_t^*, is unobservable. This level of output needs to be estimated as a function of some observed variable. For simplicity, assume the following relationship:

Equation 4.16: $$S_t^* = \alpha + \beta P_t^e$$

Equation 4.16 can now be substituted back into equation 4.15 and the result can be presented as follows:

Equation 4.17: $$S_t = \alpha\delta + (1-\delta)\, S_{t-1} + \delta\beta\, P_{t-1} + u_t$$

The adjustment coefficient (δ) can now be used to calculate a short- and long-term price effect. The short-term price effect is the estimated coefficient of the price variable, this is $\delta\beta$, and the long-term price effect is obtained by dividing the short-term price effect by the adjustment factor, this yields β.

Although the disturbance terms of Equation 4.17 are not serially correlated, the lagged dependent variable is stochastic and not fixed. We will not be able to use OLS estimation techniques because the results will be biased.

4.2.2.3 THE ADAPTIVE EXPECTATION MODELS

The models are based on the assumptions that agricultural producers base their decisions on certain expectations regarding the future values of relevant prices. Hence, cropping decisions are based on the expected prices at the time of harvest.

Equation 4.18: $$S_t = \alpha + \beta P_t^e + u_t$$

S_t denotes the current level of output and P_t^e represents the expected price to prevail at time t. In the adaptive expectation model prices of the previous period prevail and expectations are revised each period, with the revision proportional to the error in the previous expectations. This revision can be presented as follows:

Equation 4.19: $$P_t^e - P_{t-1}^e = \gamma\,(P_{t-1} - P_{t-1}^e)$$

or

$$P_t^e = \gamma\, P_{t-1} + (1-\lambda)\, P_{t-1}^e$$

Equation 4.19 illustrates the revision for period t. γ is called the coefficient of expectation. 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 last period's actual prices. This implies that the actual prices of the previous period have perfectly prevailed. The expected price at time t can now be expressed as a function of previous actual prices over a longer period of time.

Equation 4.20: $$P_t^e = \gamma\, P_{t-1} + (1-\lambda)\, P_{t-2} + \gamma(1-\lambda)^2\, P_{t-3} + \gamma(1-\lambda)^3\, P_{t-4} \ldots\ldots$$

Equation 4.20 shows that producers base their price expectations solely upon an extrapolation of past prices.

4.2.2.4 THE NERLOVE SUPPLY MODEL

This model is based on a combination of the partial adjustment model and the adaptive expectation model. The Koyck transformation is used to obtain the final form of the equation. In its simplest form the model assumes that there exists a desired level of supply (S_t^*), which depends on an expected price level (P_t^e). Algebraically it can be presented as follows:

Equation 4.21: $$S_t^* = \alpha + \beta P_t^e$$

Furthermore, it is also assumed that actual supply, S, adjusts towards the desired level according to the partial adjustment model (Equation 4.22) and the adaptive expectations model (Equation 4.23) is used to determine the expectations regarding the prices.

Equation 4.22: $$S_t = (1-\partial)\, S_{t-1} + \partial\, S_t^* + u_t$$

Equation 4.23: $$P_t^e = \gamma\, P_{t-1} + (1-\lambda)\, P_{t-1}^e$$

The first step is to substitute S_t^* into S_t. This will yield the following equation:

Equation 4.24: $$S_t = \alpha\delta + (1-\delta)\, S_{t-1} + \delta\beta\, P_{t-1}^e + u_t$$

The second step is to substitute Equation 4.23 into Equation 4.24. This substitution is presented in Equation 4.25:

Equation 4.25: $$S_t = \alpha\delta + (1-\delta)\, S_{t-1} + \delta\beta \left[P_{t-1} + (1-\gamma)P_{t-2} + \ldots.\right] + u_t$$

Again the application of OLS techniques to estimate Equation 4.25 will yield biased and inefficient estimators since the error terms are autocorrelated and the explanatory variables include a stochastic lagged dependent variable. As previously mentioned, Maximum Likelihood Estimation (MLE) and instrumental variable estimation are estimation techniques that will yield estimates with desired properties.

4.3 DEMAND THEORY

The "law of demand" states that the higher the prices, the less of a given good will be purchased (Ferris, 1998). This implies that the demand curve is downward sloping. For the ultimate buyer of food, demand could relate retail prices to amounts that will actually be consumed within a given time frame. However, the final consumer is not the only actor on the demand side. We can distinguish between two main categories of domestic demand, namely, demand for direct use and inventory demand. The demand for direct use consists of primary as well as derived demand. Primary demand can be signified as the demand at a retail level where the individual consumer can make decisions based on price and preference.

Derived demand can also be referred to as intermediate demand, for example, the demand of wheat for the baking of bread. Inventory demand strongly reflects expectations and consists of the demand for storage and the demand for speculation. Expectations are determined by the expected utilisation of the commodity (in our case wheat), product availability, and future changes in other market factors such as market prices and agricultural policies.

Although demand for direct use and inventory demand could be regarded as isolated from international markets, this is not the case since nations participate in an international market and also face export or import demand. This section presents and discusses the various components of demand.

4.3.1 CONSUMER DEMAND

Consumer demand is the demand for a commodity that is perishable and in its final form. For this study the consumer demand of bread will represent the final demand of wheat. To enable the derivation of the consumer demand function we have to make the assumption that the consumer has a rational, continuous, and locally non- satiated preference relation, and we take $U(x)$ to be a continuous utility function representing these preferences (Mas-Colell et.al., 1995). Suppose the consumer is faced with the problem of choosing a bundle of goods in order to maximize his or her utility subject to given prices and the level of income. Hence, the consumer will purchase a combination of goods, which will provide him with the highest level of satisfaction. This is also referred to as "the rational behaviour hypothesis". The Utility Maximisation problem can mathematically be presented as follows:

Equation 4.26:

$$MAX\ U\,(x_1, x_2, ...x_n)$$
$$\text{subject to}$$
$$m = \sum_{i=1}^{n} p_i x_i$$

$U\,(x_1, x_2, ...x_n)$ is the consumer's utility function. $m = \sum_{i=1}^{n} p_i x_i$ represents the budget constraint and consists of m, the consumer's total available budget and p_i, the unit price of commodity x_i. The utility function is a strictly quasi-concave and twice differentiable (Mas-Colell et.al., 1995). This problem is solved through the use of the Lagrange Multiplier. This method starts by defining an auxiliary function known as the Lagrangian.

Equation 4.27:

$$L = U(x_1, x_2, ..., x_n) - \lambda(\Sigma\, p_i x_i - m)$$

The new variable, λ, is called the Lagrange Multiplier since it is multiplied by the budget constraint. According to the Lagrange theorem an optimal choice or utility maximisation must satisfy the First Order Condition (FOC), which involves the partial derivation of Equation 4.27 with respect to x_i and λ.

Equation 4.28:

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

Equation 4.29:

$$\frac{\partial L}{\partial \lambda} = (\Sigma\, p_i x_i - m) = 0$$

The FOC simply sets the derivatives of the Lagrangian with respect to x_i and λ each equal to zero. Hence, Equation 4.29 is just the budget constraint that is set equal to zero. Solving the (n+1) FOC equations we can show that λ is equal to marginal utility divided by price for all commodities, which indicates the increased rate of satisfaction derived from spending an additional dollar on a particular commodity. The Lagrange Multiplier thus can be interpreted as the marginal utility of income.

The simultaneous solution of Equation 4.28 and Equation 4.29 yields the demand function of x_i, which is an implicit function of own prices, the prices of complement or substitute goods, and consumer's income. The demand function of x_i can be presented as follows:

Equation 4.30: $$x_i = x_i(p_1, p_2, ..., p_i, m), \quad i = 1,2..., n$$

This demand function represents the demand for x_i of every individual consumer and is homogenous of degree zero in prices and income. The aggregated retail demand for x_i is calculated by multiplying the individual demand for x_i by the number of consumers in the market. Assume x_i represents wheat. Hence, in its simplest form the retail demand for wheat can be expressed as follows:

Equation 4.31: $$Q^{Dw} = f(p_w, p_c, p_s, m)$$

4.3.2 FEED DEMAND

As mentioned in Chapter 2, the demand for wheat in the livestock sector constitutes only a very small portion of the total domestic consumption of wheat. The demand for wheat in the feed sector is derived from the profit maximisation condition of the livestock sector. Wheat can be regarded as a substitute product for maize and sorghum in the feed sector. For simplicity assume that the quantity of livestock production is a function of the quantity of maize, sorghum, and wheat. The livestock production function can thus be represented as follows:

Equation 4.32: $$Q_L = f(Q_m, Q_{sc}, Q_w)$$

The derived demand for wheat can be determined in a similar fashion as the derived demand for x_i in Equation 4.30. By setting the FOC equal to zero and solving the system of equations simultaneously the following derived demand function for wheat can be determined.

Equation 4.33: $$Q_w = g_1(P_L, P_m, P_s)$$

Therefore, the derived demand for wheat in the feed sector is a function of the price of the output (livestock), and the price of the two substitute commodities, maize and sorghum.

4.3.3 SEED DEMAND

The production process drives the demand for seed. Seed demand is also a derived demand and can be determined by solving the profit maximization problem of the producer, as presented in Equation 4.2. The simultaneous solution of this problem yields the functional form of the derived demand for inputs, which are used in the production process. Simplistically the demand for seed in the production of wheat can be defined as:

Equation 4.34: $$x_s = x_s(p_w, p_{oi})$$

Equation 4.34 illustrates that the demand for seed, x_s, is a function of the price of wheat, p_w, and the price of other inputs, p_{oi}.

4.3.4 CROP INVENTORY

Due to the biological nature of agricultural production many agricultural products are supplied to the market only at one specific period during a year whereas consumption occurs through out the whole year. Since inventories provide the constant supply of products throughout the year, they are an important component in the commodity models and play a decisive role in the determination of prices mainly of agricultural goods where production and consumption are relatively inelastic. Bressler and King (1970) identified three motives for holding stock: transaction demand, precautionary demand, and speculative demand.

The transaction and precautionary demand are related to domestic demand and supply. The transaction demand specifies that the level of stock is a fraction of the current production. A higher (lower) level of production implies that inventories should rise (decrease). The precautionary demand can also be referred to as the “buffer stock”. In the case of wheat, the wheat board retained a buffer stock to deal with difficulties in the local food balance sheet of wheat, which had the potential to occur due to unknown and unexpected demand and supply shocks. This buffer stock, also referred to as the “Josef Rule”, was sufficient to satisfy the demand for wheat over a period of three months. Whereas, transaction demand is specified as a fraction of varying production, precautionary demand is treated as a constant. Simplistically the first two reasons for holding stock can be presented as follows:

Equation 4.35: $$S_t = \omega_1 + \omega_2 Q_t$$

Q_t is the total production in period t, ω_2 represents the fraction of the production and ω_1 denotes a constant level of stocks.

The final reason for holding stock is speculative. It is assumed that stock operators are rational decision-makers. Due to market uncertainty, storage operators hold stock and position[1] themselves in the market so that they are able to benefit from future market condition. Speculative demand for stocks is thus based on expected prices in the next period t+1. Hence, expected prices also need to be included in the specification of stock behaviour. In summary, commodity stock holdings can be specified as follows:

Equation 4.36: $$S_t = S_t(S_{t-1}, P_t, Q_t, Q_{t+1})$$

In Equation 4.36 stock holdings are expressed as a function of beginning stock[2], the own current price, current production, and the production of the next period.

[1] Storage operators hedge their positions in the market by making use of future markets
[2] Beginning stock is equal to the ending stock of the previous year

4.4 SUPPLY AND DEMAND ELASTICITIES

The relationships between individual independent variables and the dependent variable in supply and demand equations can be classified as elasticities (Ferris, 1998). Elasticities are a convenient way of expressing the relationship within supply and demand equations. Supply elasticity is the ratio of percentage change in quantity supplied relative to the percentage change in an independent variable, in the supply relationship; whereas, demand elasticity is the ratio of percentage change in quantity purchased relative to the percentage change in an independent variable in the demand relationship. If an elasticity of less (greater) than $|1|$ is calculated, the relationship between the dependent and independent variable is referred to as being inelastic (elastic). This implies that if, for example, the price of wheat increases by one percent, the quantity of wheat demanded, will decrease by less than one percent. If an elasticity of $|1|$ is calculated, the relationship between the dependent and the independent variables is signified as unitary, which means that the percentage change in the dependent variable will equal the percentage change in the independent variable. In general, there are four types of elasticities, own price elasticity, cross price elasticity, input price elasticity, and income elasticity.

4.4.1 CALCULATION OF ELASTICITIES

Own-price elasticity refers to the effect of the price of the given product on the quantity. For example, the own price elasticity measures the proportionate change in the output of wheat (Q_w) that is induced by a proportionate change in the output price of wheat (P_w), ceteris paribus. Mathematically, it is presented as follows:

Equation 4.37:

$$E_{op} = \frac{\Delta Q_w}{\Delta P_w}\frac{P_w}{Q_w} = \frac{\partial Q_w}{\partial P_w}\frac{P_w}{Q_w}$$

The own-price elasticity is calculated by multiplying the ratio of the change in quantity demanded or supplied over the change in price by the ratio of the average price over the average quantity. According to neo-classical theory, the own price elasticity of a demand function has a negative sign, which explains the inverse relationship between price and quantity demanded, whereas, the own price elasticity of supply has a positive sign, explaining the positive relationship between price and the quantity supplied.

The cross-price elasticity refers to the effect of the price of a substitute or complement on the quantity demanded or supplied of a given product. For simplicity, suppose that in the case of supply the agricultural producer can produce only two commodities, wheat (w) and maize (m), in the case of demand the consumer can choose only between two goods, wheat (w) and potatoes (p). The cross price elasticity for demand and supply can be presented as follows:

Equation 4.38:

$$E_{cp} = \frac{\Delta Q_w}{\Delta P_p}\frac{P_p}{Q_w} = \frac{\partial Q_w}{\partial P_p}\frac{P_p}{Q_w}$$

In both cases the sign of the cross price elasticity depends on the nature of the relationship. If the independent variable is a substitute (complement) for the dependent variable, then the cross price elasticity will have a positive (negative) sign in the case of demand and a negative (positive) sign in the case of supply.

Similarly, the input price elasticity, for the inputs that are used in the production and the processing of an agricultural commodity, can be expressed as follows.

Equation 4.39:

$$E_I = \frac{\Delta Q_w}{\Delta P_I}\frac{P_I}{Q_w} = \frac{\partial Q_w}{\partial P_I}\frac{P_I}{Q_w}$$

The input price elasticity measures the proportionate change in output that is induced by the proportionate change in input prices. Neo-classic theory stipulates that there exists a negative relationship between the output of a commodity and the price of the inputs, which are involved in the production and processing of the commodity.

Finally, the income elasticity expresses the relationship between the quantity demanded or supplied and the relative level of income. The income elasticity is frequently used in demand equations to assist in the measurement of the relationship that exists between the level of income of the population and the consumption of a commodity over time. The income elasticity is presented in Equation 4.40:

Equation 4.40:

$$E_I = \frac{\Delta Q_w}{\Delta I}\frac{I}{Q_w} = \frac{\partial Q_w}{\partial I}\frac{I}{Q_w}$$

The income elasticity can take on a positive or negative sign. In the case of a demand equation, a positive income elasticity will signify a “normal good” and a negative income elasticity will represent an “inferior good”. This implies that the demand of an inferior good decrease as the income of the population increases. If the income elasticity is greater than one, the good is referred to as a luxury good.

4.4.2 CONDITIONS OF ELASTICITIES

When the demand of a commodity is estimated one has to take into account the influence that a range of possible substitutes and complements could have on the commodity. In time series analysis, measurement of various elasticities is restricted by the degrees of freedom. If a data set consists of thirty observations, only two or three elasticities can be estimated with single-equation techniques (Ferris, 1997). Hence, to enable the calculation of own, cross, and income elasticities of demand, certain conditions are imposed on the relationships between elasticities. Tomek and Robinson (1990) summarize the conditions as follows:

1. Homogeneity

   The sum of the own, cross, and income elasticities, equals zero. This implies that if a commodity has many substitutes it must have a large own-price elasticity. A large income elasticity also implies a large own-price elasticity.

Equation 4.41:

$$
\begin{aligned}
& E_{ii} + E_{iL} + ... + E_{ij} + E_{iy} = 0 \\
& where: \\
& E_{ii} = own - price\ elasticity\ for\ i \\
& E_{ij} = cross\ elasticity\ effect\ of\ j\ on\ i \\
& E_{iy} = income\ elasticity\ for\ i
\end{aligned}
$$

2. Symmetry

   The cross-price elasticity of one good relative to another is proportional to its relative importance in consumer expenditures. Intuitively, a price change on a major item in food expenditure is likely to have a greater effect on the consumption of a minor product than the price of a minor product on the consumption of a major product.

Equation 4.42:

$$
\begin{aligned}
& E_{ij} = (R_j / R_i) * E_{ij} + R_j * (E_{jy} - E_{iy}) \\
& where: \\
& E_{ij} = cross\ elasticity\ effect\ of\ j\ on\ i \\
& E_{iy} = income\ elasticity\ for\ i \\
& R_i = \exp enditures\ on\ i\ as\ ratio\ to\ total
\end{aligned}
$$

3. Engle Aggregation

The sum of income elasticities of all items in the consumer's budget weighted by the relative importance of each item equals one. This means that total expenditure should increase proportionally as the consumer's income increases. The level of expenditure on an item and its income elasticity determines the change in expenditure of the item.

Equation 4.43:

$$R_1 * E_{1y} + R_2 * E_{2y} + ...R_n * E_{ny} = 1$$
$$where:$$
$$E_{iy} = income\ elasticity\ \ for\ i$$
$$R_i = \exp enditures\ on\ i\ as\ ratio\ to\ total$$

4.5 SUMMARY

This chapter has laid down the theoretical foundations for this study by presenting the theory of supply, demand, and price expectations. These theoretical concepts will assist with the development and understanding of the different components of the supply block, the demand block, and the price linkage block. In chapter five, the structure of the wheat model will be developed, taking into consideration these theoretical concepts.

CHAPTER 5
STRUCTURE OF THE SOUTH AFRICAN WHEAT MODEL

5.1 INTRODUCTION

In this chapter the structure of the South African wheat model is presented and discussed and the concept of model validation is reviewed. The structure of the model is based on the theoretical foundation, as presented in Chapter four. In the first portion of this chapter a Flow Diagram and a Price-Quantity (P-Q) diagram is used to graphically illustrate the structure and the components of the South African wheat model. In the second section the different equations for every component of the South African wheat model are specified. Finally, the modelling procedures, as well as the estimation process and the validation of the model are discussed.

5.2 THE COMPONENTS OF THE SOUTH AFRICAN WHEAT MODEL

The Flow Diagram and a Price-Quantity (P-Q) diagram provide guidance towards the empirical estimation of the South African wheat model by means of illustrating the important economic and biological relationships, which are to be captured in the econometric model of the South African wheat sector. The model will have the ability to explain the behaviour of components on the production side as well as the consumption side. Once these models have been estimated, the responsiveness of each component to government interventions through price effects can be measured.

5.2.1 THE FLOW DIAGRAM

Figure 5.1 shows the flow of wheat through the market channel from the wheat producer to the ultimate consumer of the wheat product. While the model cannot replicate all the decisions occurring within the industry, the major behavioural relationships are captured. The wheat model is basically composed of three blocks namely, the supply block, the demand block, and the price linkage block. A unique relationship and interaction among variables exists which influences production and consumption within the demand and supply blocks. The diagram is used to facilitate the economic understanding of the relationship as well as the interaction among these variables.

In the supply block, the producer has to make the initial decision on the size of the area to be planted. Due to the unavailability of data on area planted, it has been common practice to begin crop modelling with area harvested, since area harvested is a good proxy for the area planted and it is also a reliable indicator of planned production. Using the area harvested in the determination of potential supply does however, also have some problems, as the total area planted is not always harvested. In South Africa, there has traditionally been little difference between the area planted and the area harvested. Wheat area harvested is essential for the calculation of wheat production, which is derived by multiplying wheat area harvested by the average yield. If data on the wheat area planted was available, modelling area planted, and then estimating area harvested as a function of area planted would have been used to commence the modelling procedure.

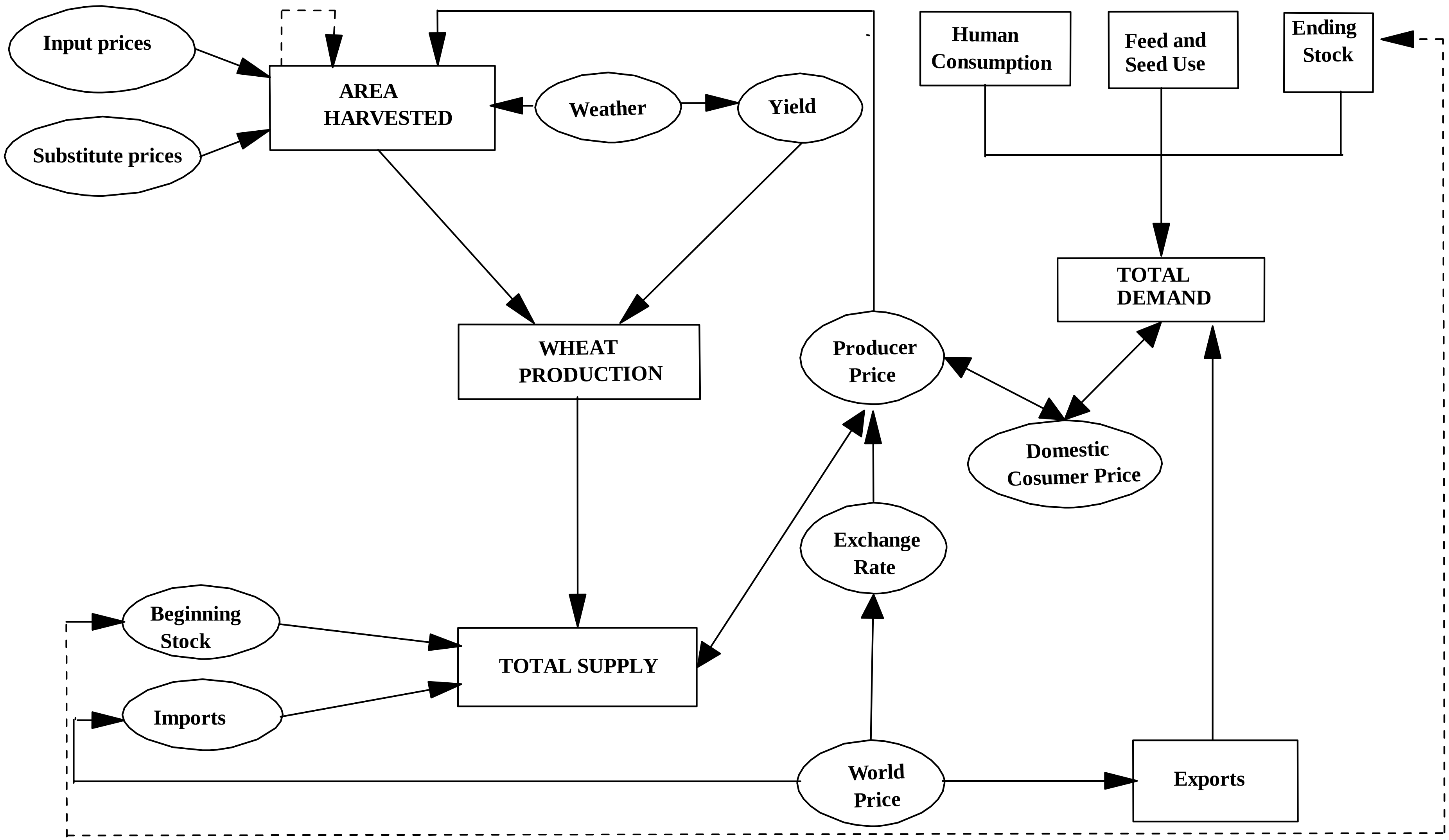

Figure 5.1: Flow Diagram of the South African Wheat Sector

In the wheat sector, total area harvested includes both the summer and winter areas harvested. The producer price of wheat, input prices, producer prices of substitutes and complements, the weather conditions, and the previous year's area planted will influence the wheat producer's decision. The previous year's area planted is included to capture the dynamics of the model and is specified by the dotted line. Fixed lines indicate the relationships between the area harvested and the producer price of wheat as well as sunflower. This implies that no lags exist in these relationships. During the time of the marketing boards farmers knew what the producer prices would be for the upcoming production season, at the same time they were making their planting decisions. The reason for this was that the boards used a fixed formula to calculate the producer prices.

Since 1997, the marketing boards have been abolished and producer prices are determined by market forces and strongly influenced by world prices and the exchange rate. Farmers now base their planting decisions on the producer prices of the previous year, which will influence their expectations regarding future prices or alternatively make use of the futures market to minimise price risks.

After the wheat producer has taken the decision to plant, the yield, which is also influenced by the weather conditions, will determine the total production of the crop. Figure 5.1 graphically illustrates how the wheat harvested and yield influence the total production of wheat. The total supply of wheat in South Africa is then calculated by adding the beginning stock and total imports to the total production of the country. Imports are determined by both the world price of wheat and local production figures.

In the demand block human consumption, feed and seed consumption, exports, and ending stocks determine the total demand for wheat in South Africa. Human consumption is influenced by the current consumer price and *via-versa*. A two-directional arrow illustrates this relationship. Feed consumption makes up less than five percent of the market and the data that reports on seed use is unreliable. As a result, these two categories are not estimated by means of behavioural equations but are included as exogenous variables in the calculation of total demand. Ending stocks in period t depend on the local production of wheat, the consumer price of wheat, and the beginning stocks in period t. Ending stocks in period t are equal to the beginning stocks for period t+1. Again, a dotted line is used to denote the lagged effect between ending stocks in period t and beginning stocks in period t+1. Exports are not estimated by means of a behavioural equation and are used as the market-clearing commodity.

The price linkage block formalises the interaction between the supply block and the demand block and also links the world price to the local producer price, which in turn is linked to the local consumer price. The one-direction arrow from the world price to the local producer price indicates that the local price is influenced by the world price, but the local price does not influence the world price. The reason for this is that South Africa is a price taker in the world wheat market. The two-direction arrow from the local producer price to the consumer price illustrates that the relationship between the producer price and the consumer price is simultaneous. The producer price influences the consumer price and visa-versa. This relationship is vital to enable the closure of the model.

The two-directional arrow from the supply block to the producer price only makes sense if the process of price determination during the time of the wheat board, is taken into consideration. As previously mentioned, the farmers could make their planting decision based on the producer prices they expect to receive at harvest time and hence, the level of supply would determine the producer price and *visa-versa*.

5.2.2 THE PRICE QUANTITY (P-Q) DIAGRAM

The P-Q diagram (Figure 5.2) and the flow diagram are closely related. The P-Q diagram reflects the different layers of the market. The P-Q diagram consists of two blocks. The first block is the supply block and consists of the total area harvested (summer and winter), the beginning stock, and imports. The second block is the demand block and consists of the total domestic consumption, the exports, and ending stock. It is important to note that the P-Q diagram depicts the economic relationships amongst the dependent and explanatory variables at different layers in the wheat market. This implies that each layer is influenced by its own price and the intersection of total demand and total supply yields the equilibrium price, i.e. the area harvested is influenced by the producer price, the total domestic consumption is influenced by the retail price, and exports are influenced by the world price. The nature of the relationships among the dependent and explanatory variables is depicted by means of the shifters (arrows). A rightward shifter is used to explain a positive relationship between the dependent and independent variable, i.e. the expected sign of the parameter associated with the variable in the estimated equation is positive. A negative sign is expected for a leftward shifter.

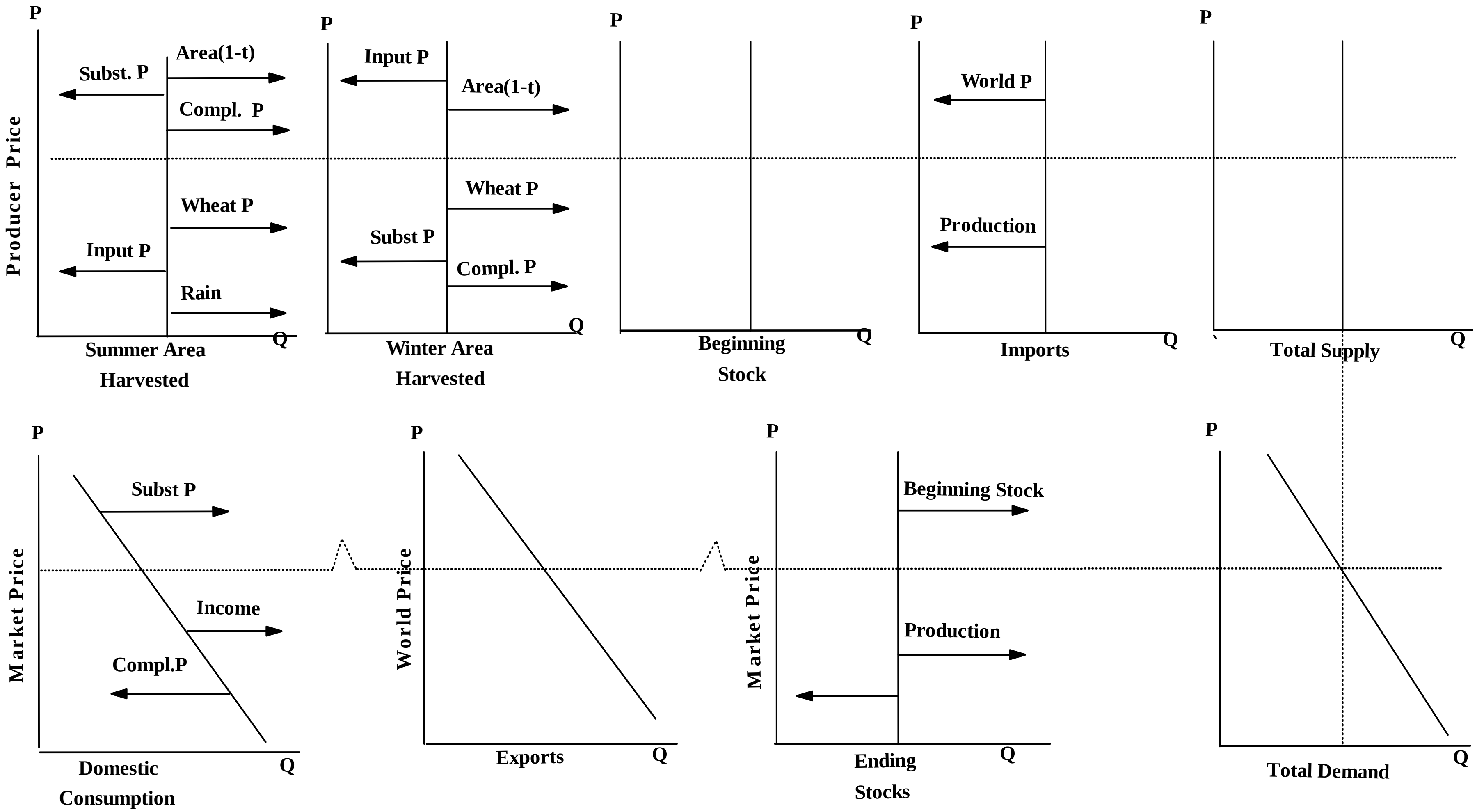

Figure 5.2: Price-Quantity Diagram for the Wheat Sector in South Africa

5.3 SPECIFICATION AND STRUCTURE OF THE SOUTH AFRICAN WHEAT MODEL

Based on the theoretical framework of supply and demand, the flow diagram, and the P-Q diagram, the following section presents the specification of the various equations for each component of the South African Wheat model.

As previously mentioned, the wheat area harvested is used as a proxy for the wheat area planted. The wheat area harvested equation, thus illustrates the wheat farmer's decision to plant and the postulated equation needs to take into account as many of the factors influencing the farmers' decisions, as possible. Based on the discussions of the input factors that the farmer uses and the derivation of the input derived demand in Chapter four, as well as taking into consideration the relevant wheat policies detailed in Chapter two, the wheat acreage response function can be postulated as:

Equation 5.1: $$WAHSA = f(WAHSA_{t-1}, P_{w,t}, P_{s,t-1}, P_{i,t}, R, G)$$

$WAHSA_{t-1}$ is the lagged area harvested, which indicates that the current area harvested is influenced by the previous periods' area harvested. The wheat area harvested equation is specified according to the partial adjustment model, and is defined as a function of the last years' area planted, the producer price of wheat ($P_{w,t}$), last years competing or complementing commodity price ($P_{s,t-1}$), the price of input's ($P_{i,t}$), rainfall (R) and government policies (G). In this study the wheat area is divided into two sub regions, winter and summer, due to agro-climatic-conditions. The aggregation of these two equations yields total area harvested.

Wheat production is an identity and it can be expressed as follows:

Equation 5.2: $WPROD = WAHSA_t * YLD_t$

Therefore, wheat production is calculated for each region by multiplying the area harvested by the average yield for that harvesting season. In this study, crop yields are treated exogenously due to data unavailability on all the important weather factors that have an impact on the yield. The total wheat production is the sum of the production for both regions.

In Equation 5.3 wheat imports are defined as a function relating the quantity of wheat imports to the current world price of wheat, the exchange rate, the current local production of wheat, and government trade policies.

Equation 5.3: $WIMP = f(P_{world,t}, EXCH_t, WPROD_t, G)$

The total supply of wheat is an identity and can be expressed as follows:

Equation 5.4: $WTSUP_t = WPROD_t + WIMP_t + WBEG_t$

$WPROD_t$ is the production of the current season, $WIMP_t$ the current wheat imports and $WBEG_t$ the level beginning stocks. The level of beginning stocks is equal to the level of ending stocks for the previous year.

In Equation 5.5 wheat per capita domestic use is specified based on the theory of retail demand, which implies that the consumers demand function is derived using the theory of utility maximisation, as discussed in Chapter four. The consumer maximises his/her utility or satisfaction, which is gained from the consumption of wheat, subject to his/her available income.

Equation 5.5: $$WPCC_t = f(P_{w,t}, P_{s,t}, INC_t, G)$$

$WPCC_t$ denotes the wheat per capita consumption, $P_{w\,t}$ denotes the consumer price of wheat, which is reflected by the price of wheat flour, $P_{s\,t}$ denotes the price of commodities that can be used as a substitute or as a complement product for wheat, *INC* denotes the level of income per capita, and *G* denotes government policies. These policies include direct subsidies on the consumer prices, as well as any other policies in the wheat-to-bread supply chain.

Equation 5.6: $$WTDU_t = WPCC_t * POP_t$$

The total domestic utilization of wheat is obtained by multiplying the wheat per capita consumption that was estimated in Equation 5.6, by the total population. Population is exogenous to the system.

Ending stocks are influenced by the crop’s current total production, beginning stocks or lagged ending stocks, and the commodity own price. In Chapter four it was mentioned that a part of ending stocks will be made up by stocks, which were retained on the basis of precautionary measures. The wheat board had to apply these precautionary measures and referred to it as the "Josef Rule". This implied that during the era of marketing boards only part of the ending stocks were free to be sold to the market. In the empirical part of this study, the estimation of free ending stocks will be discussed in detail. For the purpose of estimation, the following equation is postulated:

Equation 5.7: $$WENDS_t = f(WENDS_{t-1}, WPROD_t, P_{w,t})$$

$WENDS_t$ represents the ending stock of the current period, $WENDS_{t-1}$ represents the free ending stock of the previous period, $WPROD_t$ represents the current production of wheat, and $P_{w\,t}$ represents the current market price of wheat.

In this study, exports are used to close the model. They are defined as excess supply:

Equation 5.8: $$WEXP_T = WTSUP_T - WTDU_T - WENDS_T$$

$WTSUP_t$ signifies the total supply of wheat, $WTDU_t$ signifies the total domestic demand for wheat, and $WENDS_t$ represents the wheat ending stocks.

As discussed previously, the price linkage block consists of two equations. These equations determine the transmission relationships that exist between the world price of wheat, the local producer price, and the local consumer price. Equation 5.9 defines the first price transmission relationship as a function relating the local wheat producer price to the wheat world price, the exchange rate and government policies.

Equation 5.9: $$P_{w,t} = f(P_{world,t}, EXCH_t, G_t)$$

Equation 5.10: $P_{c,t} = f(P_{w,t})$

In Equation 5.10 the local consumer price, reflected by the price of bread, is linked to the local producer price by means of expressing the local consumer price as a function of the local producer price.

5.4 MODELLING APPROACH

From the previous discussions, it is evident that the South African wheat model consists of a supply block, a demand block, and a price linkage block. These blocks consist of behavioural equations as well as identities. The two area harvested equations, the import equation, the domestic use equation, the ending stock equation and the price linkage equation are all classified as behavioural equations. The formulation of behavioural equations is based on economic theory. Hence, we expect a positive sign for the output price and a negative sign for the input prices for the supply function, whereas, for the demand function we expect a negative sign for the own price as well as the price of a commodity, which can be regarded as a complement good. A positive sign is expected for the price of the commodity that can be regarded as a substitute good.

Behavioural equations contain both endogenous and exogenous variables. An exogenous variable can also be referred to as a predetermined variable, which implies that the variable is not solved within the system; as it is considered to be known. The yield variable, which is used in the area-harvested equation serves as a good example of an exogenous variable.

5.5 ESTIMATION PROCEDURES, MODEL SOLVING AND SIMULATION

A single – equation approach is used in the first stage of the estimation procedures. Ordinary Least Squares (OLS) produces the best linear unbiased estimators for a single equation (Pindyck and Rubinfeld, 1998) and thus will be used to estimate the parameters of the single equations in the first stage of the modelling process. Once the behavioural equations have been estimated, they will form part of a system of simultaneous equations that will express the interdependence of variables, which influence the supply and utilisation of wheat in South Africa.

In simultaneous-equation models, where endogenous variables in one equation feed back into variables in another equation, the error terms are correlated with the endogenous variables and least squares is both biased and inconsistent. Alternative estimation procedures, such as three stage least squares (3SLS), seemingly unrelated regression (SUR) and two stage least squares (2SLS), must be used to solve this system of equations to eliminate the simultaneous bias. Among these methods, the 2SLS method, which provides a very useful estimation procedure for obtaining the values of structural parameters in over-identified equations, is the most common to use. In the first stage, the method of ordinary least squares is used to determine the fitted value of the dependent variable. In the second stage the original dependent variable is replaced by the first-stage fitted dependent variable. The second stage will also use the method of ordinary least squares to estimate consistent and efficient parameters for predetermined variables in the supply and demand equations. For the purpose of this study, the 2SLS estimation method will be used. The results of this estimation procedure are reported in Chapter six.

After the parameters have been estimated by means of 2SLS, the next step is to simulate or solve the model. The process of simulation can simply be referred to as the mathematical solution of a set of different equations. In this study, the Gauss-Seidel algorithm is used to solve the model's simultaneous system of equations. This technique requires that the equations in the model be rewritten in such a manner that the endogenous variables are on the left hand side of the equation. Hence, given a model whose parameters have been estimated, given base-year values for the endogenous variables, and given time series for exogenous variables, the simultaneous solution of the equations in the model will yield a simulated time path for each of the endogenous variables (Ferris, 1998).

5.6 THE CONCEPT OF MODEL VALIDATION

Once the model has been solved, it will be used for making baseline projections and to conduct policy analyses. Therefore, serious validation procedures must be undertaken to ensure that the model reflects the real world as closely as possible. The validation procedures, as discussed by Ferris (1998) and Pindyck and Rubinfeld (1998), will be used as a guideline for the following discussion on the validation of the South African wheat model.

Before any validation statistics are computed the model is simulated over the historical period. By simulating the model for the period for which historical data for all variables are available (the period of estimation), a comparison can be made between the original data series and the simulated series for each endogenous variable. This mode of simulation is called an *ex post* or historical simulation and will provide a useful test of the validity of the model. Two basic types of *ex post* simulations can be conducted: static simulations and dynamic simulations. With static simulations, actual values of the lagged dependent variables are used to generate the endogenous variables over the period of estimation. Thus, in the static simulation process the actual values of both exogenous and endogenous variables are used over the period of estimation. With dynamic simulations, however, the solved values of the lagged endogenous variables are used to estimate the dependent variables of the system. This implies that the dynamic simulation uses the actual values of the exogenous variables for the whole period of estimation, but in the case of the endogenous variables only uses the actual values of the first period of estimation. This implies that the model "feeds" itself by generating estimates of the endogenous variables over the period of estimation. Both types of simulations will yield the same values for the endogenous variables in the first period, whereas, they differ thereafter. The dynamic process is regarded as a more powerful tool for simulation compared to the static procedure. The reason for this is that if an error takes place in one period, the dynamic simulation procedure carries the error over to the next period.

Once the static and dynamic simulation procedures have produced the simulated values, the model can be validated. Two of the most popular techniques that can be used for model validation are statistical measures for the goodness of fit and visual inspection of a graphical plot of the values that have been simulated (Pindyck and Rubinfeld, 1998).

One of the basic expectations of the results of a simulation model is that the historical simulation of endogenous variables tracks the actual behaviour of the endogenous variables in the real world rather closely. A quantitative measure, which can be used to measure how closely the simulated endogenous variables track their corresponding data series, is called the root-mean-square simulation error (*RMSE*). It is defined as follows:

$$RMSE = \sqrt{\frac{1}{T}\sum_{1}^{T} \left[WAHSA_t^S - WAHSA_t^A\right]^2}$$

$WAHSA_t^S$ denotes the simulated value of wheat area harvested in period t and $WAHSA_t^A$ denotes the actual value of the wheat area harvested. T denotes the number of periods in the simulation period. To enable an evaluation of the magnitude of this error, it has to be compared to the average size of the wheat area harvested (*WAHSA*). The root-mean-square percentage error (*RMSE %)* does this and is defined as follows:

$$RMSE\ \% = \sqrt{\frac{1}{T}\sum_{1}^{T} \left[\frac{WAHSA_t^S - WAHSA_t^A}{WAHSA_t^A}\right]^2}$$

A further two measures that can be used to evaluate the performance of historical simulations are the mean simulation error (*MSE*), defined as:

$$MSE = \frac{1}{T}\sum_{1}^{T} \left[WAHSA_t^S - WAHSA_t^A\right]^2$$

and the mean absolute error (*MAE*), defined as:

$$MAE = \frac{1}{T}\sum_{1}^{T} \left[\frac{WAHSA_t^S - WAHSA_t^A}{WAHSA_t^A}\right]^2$$

The closer the *MAE* gets to zero, the better the model fits the historical data. The problem with this measure is, however, that big positive errors can cancel out big negative errors, which will also yield a value close to zero. In this case the *RMSE* would be a better measure for the simulation performance of the model.

If the model has been designed for forecasting purposes, further criteria need to be taken into consideration to evaluate the performance of the model. Theil's inequality coefficient can be used for the evaluation of *ex post* forecasts. To evaluate the performance of the *ex post* forecasts, the forecast results can be compared to the actual values of the original corresponding data series. Theil's inequality coefficient is postulated as follows:

$$U = \frac{\sqrt{\frac{1}{T}\sum_{1}^{T}\left[WAHSA_t^S - WAHSA_t^A\right]^2}}{\sqrt{\frac{1}{T}\sum_{1}^{T}\left[WAHSA_t^A\right]^2}\ \sqrt{\frac{1}{T}\sum_{1}^{T}\left[WAHSA_t^S\right]^2}}$$

U can take on values between 0 and 1. If *U* = 0, there is a perfect fit, whereas, if *U* = 1, the predictive performance of the model is as bad as can be. Theil's inequality coefficient can be decomposed into three proportions of inequality; U^M represents the bias portion, U^S denotes the variance portion, and U^C defines the covariance portion. U^M measures the extent to which the average values of the simulated and actual values of the variable differ. A value of close to zero is desirable. A large value for U^M is an indication of the presence of systematic errors. U^S must also have a value as close to zero as possible. If U^S is not close to zero, it means that the actual series have fluctuated considerably while the simulated series shows little fluctuation. In contrast to the previous two portions, ideally we want the covariance portion (U^C) to take on a value of 1.

As mentioned previously, a judgment on the performance of the model cannot be based on the measurement of the goodness of fit alone. Amongst the most popular techniques utilized for model validation is to plot the actual and simulated values on a graph and conduct a visual inspection of how well the model simulates the turning points in the data. The ability of a model to pick up the turning points or rapid changes in the actual data is an important criterion for model evaluation. Even if the simulated model tracks the actual historical data very closely, and as a consequence has low *RMSE*, it does not imply that this model is well suited to conduct policy analyses or to use it for forecasting purposes. Depending on the purposes of the model, it can sometimes be necessary to substitute new equation forms, which may have a poorer statistical fit, but improve the model's ability to simulate the dynamic environment of the real world.

5.7 SUMMARY

This chapter has postulated the structure of the South African wheat model. In the first section, the structure of the wheat model was illustrated by making use of a flow diagram and a P-Q diagram. The second part of this chapter presented the specification of the various equations for each component of the supply block, the demand block, and the price linkage block. The final section discussed the modelling procedures, the estimation process and the validation of the model. Chapter six presents the empirical results of the estimations, and the performance of the models is evaluated.

CHAPTER 6
RESULTS AND PERFORMANCE OF MODEL

6.1 INTRODUCTION

This chapter presents the empirical results of the model, and discusses the performance of the model based on the validation procedures as discussed in Chapter five. The first section briefly discusses the various sources of data and the final database that was used. The estimated equations are reported and discussed in the second section. This will include the parameter estimates as well as the calculated elasticities. The validation of the model will be conducted in the final section of the chapter.

6.2 THE DATA

The data used in this study are from various sources. The Abstract of Agricultural Statistics, a publication of the National Department of Agriculture (NDA), provided the data for the quantity supplied and demanded, as well as the producer price. The Statistical Office (STATSSA) provided the data for consumer prices. To ensure consistency in the data, which was used for empirical estimations, the data from the Abstract of Agricultural Statistics were compared with the data from the Wheat Board and the South African Grain Information System (SAGIS). The Wheat Board published production, utilisation and price data in the annual report. With the abolishment of the Wheat Board in 1997, SAGIS took over the responsibility for publishing data for all field crops in South Africa. With the transition from the Wheat Board to SAGIS, some discrepancies were inherent, especially with respect to data on the wheat area harvested. Hence, the historical data from the NDA, ranging from 1975 to 1996, were crosschecked with the data of the Wheat Board. The data from the NDA, ranging from 1996 to 2000, were crosschecked with the data from SAGIS. Table 6.1 illustrates that from 1975 to1996 the Wheat Board data were used for the empirical estimations, and from 1996 to 2000 the SAGIS data were used for the empirical estimations.

Table 6.1: Sources of Data for Wheat Area Harvested

	Wheat Board	NDA	SAGIS	Data series used in the model
1975	1.788	1.839	na	1.788
1976	1.867	1.959	na	1.867
1977	1.705	1.828	na	1.705
1978	1.880	1.895	na	1.880
1979	1.901	1.903	na	1.901
1980	1.623	1.627	na	1.623
1981	1.787	1.812	na	1.787
1982	1.934	2.013	na	1.934
1983	1.798	1.819	na	1.798
1984	1.919	1.942	na	1.919
1985	1.951	1.983	na	1.951
1986	1.926	1.946	na	1.926
1987	1.729	1.749	na	1.729
1988	1.985	2.009	na	1.985
1989	1.830	1.843	na	1.830
1990	1.551	1.563	na	1.551
1991	1.434	1.436	na	1.434
1992	0.743	0.750	na	0.743
1993	1.065	1.075	na	1.065
1994	1.039	1.048	na	1.039
1995	1.363	1.363	na	1.363
1996	1.294	1.294	1.242	1.294
1997	na	1.382	1.382	1.382
1998	na	0.748	0.748	0.748
1999	na	0.718	0.718	0.718
2000	na	0.854	0.860	0.860

Data on the import and exports of wheat was obtained from the South African Customs Excise. Exchange rate data was taken from the International Financial Statistics Yearbook (IFS) of the International Monetary Fund (IMF, 2001). The Consumer Price Index (CPI) and the Consumer Price Index for food items (CPIF) are from the Reserve Bank of South Africa. Population data was obtained from STATSSA. The complete dataset is presented in Appendix 1.

6.3 EMPIRICAL RESULTS

The equations reported in this section form the South African wheat model and are taken from the 2SLS estimations. The estimated results include the parameter estimates, t-statistics in parenthesis, short-term elasticities in brackets, and long-term elasticities in square brackets. The R^2, DW, and DH statistics are reported for every equation. The elasticities were calculated at the mean values of the corresponding variables. In order to better understand and interpret the economic significance of the variables used in the equations, a detailed description of all the variables is included underneath every equation.

The South African wheat model consists of the following ten equations, six behavioural equations and four identities. The supply block is composed of equations 6.1 to 6.5, the demand block is composed of equations 6.6 to 6.8, and the wheat model is closed with the market clearing identity in equation 6.9. The price linkage block is given by equation 6.10.

6.3.1 THE SUPPLY BLOCK

The wheat area harvested in South Africa can be split up into two main production regions namely, the summer and the winter rainfall regions. Although the summer region also includes the wheat area harvested under irrigation, the nature of the commodities, which can be used for substitutes, is very similar to those of the dryland summer area harvested. Wheat summer area harvested (WSAHSA) was estimated as a function of the lagged wheat summer area harvested, the own price, the price of sunflower, the price of all farming requisites, and rainfall. Wheat winter area harvested (WWAHSA) was estimated as a function of the lagged wheat winter area harvested, the own price, the price of mutton and the price of all farming requisites.

Under the regulated marketing system, the wheat board guaranteed the wheat farmers a fixed producer price at the beginning of the season. The fact that the farmers knew what the price of the following production season would be, the price risk that is normally associated with the practice of growing crops was ruled out. The farmer could thus base the decision to plant on the current price level. In 1997, the single channel fixed price system was revoked and prices are now determined in a free market environment. Raising the question as to what prices wheat farmers respond? In April or May, when the farmer needs to make a decision, a futures contract for wheat is traded on the South African Futures Exchange (SAFEX) for the month of December. This implies that the farmer knows what the current price for the December futures contract is and can thus reduce the price risk to a large extent by using hedging strategies at these price levels. The question still remains whether the majority of wheat farmers make use of the futures market or whether they react to the price levels of the previous year. If it is the case that the majority of farmers respond to the futures price, one can draw the conclusion that the reaction of the farmers to the price of wheat has not changed since 1997 after all. Farmers still respond to current prices. If however, the majority of farmers respond to the prices of the previous season, this implies that a special price variable needs to be formulated, which includes the current price up to 1997 and the lagged price from 1997 onwards. It was decided that this is the correct price variable to use for this study. To enable the generation of this special price variable, a shift variable was used. The SHIFT97 variable was defined to take on a value of 1 in the pre 1997 period and a 0 in the post 1997 period.

Using this special price variable in the model, a long-run price elasticity of 1.4 and a short-run price elasticity of 0.31 was calculated for the wheat summer rainfall region. Using the same price variable for the wheat winter rainfall region, the short and long run price elasticities were calculated at 0.21 and 1.08 respectively. The short-run price elasticities compared well with the results obtained from previous studies. Niebuhr (1991) estimated a short and long run own price elasticity of 0.18 and 0.39 for the Ruens area, which forms part of the winter rainfall region. It was expected that the elasticities for the summer rainfall area would be higher than the elasticities for the winter rainfall area. The reason for this is that the farmers in the summer rainfall region have more commodities to choose from, which can be planted instead of planting wheat. The farmers in the winter rainfall region only have a few options and thus are unable to react to a change in the price of wheat immediately. Appendix two, graphically compares the simulated values to the actual values. This graphical illustration of the areas harvested supports the argument of a much higher variation in the area harvested in the summer rainfall region compared to the area harvested in the winter rainfall region.

Equation 6.1: WHEAT SUMMER AREA HARVESTED

$$WSAHSA_t = 0.062 + 0.812\ WSAHSA_{t-1}$$

(7.91)

$$+ 0.036\ ((SHIFT97*(WPPSA)+(1-SHIFT97)*LAG(WPPSA))/\ RESA$$

(3.13)
<0.31>
[1.4]

$$-0.028\ (SPPSA/PPIA)_{t-1} + 0.0015RAIN$$

(-1.60) (4.51)
<-0.21>
[-1.08]

$$-0.50\ DUM92 + 0.22\ DUM95 - 0.41\ DUM98$$

(-4.57) (2.39) (-4.22)

$R^2 = 0.938$ Adj. $R^2 = 0.912$ F Value = 34.96 D.H = 0.422

WSAHSA	:Wheat Summer Area harvested, 1000 000ha
LAG(WSAHSA)	:Wheat Summer Area harvested lagged by one year, 1000 000ha
WPPSA	: Wheat Producer Price South Africa , R/ton

SPPSA	: Sunflower Producer Price South Africa, R/ton
RESA	: Requisites Index, 1995=100
PPIA	: Producer Price Index of Agricultural goods, 1995=100
RAIN	: Average Rainfall of Summer Wheat Production Area for first four months of production season (March, April, May, June) when the planting decision is taken.
DUM92	: Dummy variable in 1992
DUM95	: Dummy variable in 1995
DUM98	: Dummy variable in 1998

Equation 6.2: WHEAT WINTER AREA HARVESTED

WWAHSA = 0.56 + 0.32 LAG(WWAHSA)
(1.59)

+ 0.017 ((SHIFT97*(WPPSA)+(1-SHIFT97)*LAG(WPPSA))/ RESA
(1.83)
<0.18>
[0.22]

-0.016 LAG (MPPSA/GDPD) -0.23 SHIFT90
(-1.54) (3.29)
<-0.17>
[-0.21]

R^2 = 0.925 Adj. R^2 = 0.905 F Value = 44.97 D.W = 1.795 D.H = 0.823

WWAHSA	:Wheat Winter Area Harvested, 1000 000ha
LAG(WWAHSA)	:Wheat Winter Area Harvested lagged by one year, 1000 000ha
WPPSA	: Wheat Producer Price South Africa , R/ton
MPPSA	: Mutton Producer Price South Africa, c/kg
RESA	: Requisites Index, 1995=100
GDPD	: GDP deflator, 1995=100
SHIFT90	: Shift variable in 1990

The results also show that South African wheat competes with sunflowers in the summer rainfall region and with mutton in the winter rainfall region with short run cross price elasticities of -0.21 and -0.17 and long run cross price elasticities of –1.08 and -0.21 respectively. Niebuhr (1991) reported cross price elasticities of -0.20 for the Swartland area, where wheat also competes with mutton. The price of mutton was lagged because it takes time for farmers to respond to this price. The current price of mutton was also used in the model and it proved to be a complement of the area harvested under wheat. This makes economic sense because wheat farmers will let their sheep graze on the harvest stalks. The more harvest rests the farmer has available, the more sheep he will be able to keep.

The rainfall variable used in the model represents the sum of the rainfall for the months March, April, and May. The rainfall of these three months will influence the farmers planting decision. Drastic changes in the rainfall patterns of these three months are captured by dummy variables. DUM 92 was used to represent the severe drought in 1992 that resulted in a reduction in the area harvested under wheat by fifty percent compared to 1991. This also resulted in the lowest level of wheat production in the past thirty years. In the years that followed the area harvested increased gradually but never recovered to the levels that were attained before this severe drought. Again, in 1998 the area harvested under wheat was reduced by fifty percent compared to 1997. Various factors led to this drastic decline in the area harvested. The Wheat Board was abolished in 1997. This gave rise to a general feeling of uncertainty in the market. For the first time farmers were faced with price risks. In 1998, the average rainfall of the summer rainfall region, for the months when the planting decision was taken, was only half of the previous years rainfall. This decline in the area harvested is represented by DUM 98.

The rainfall variable for the winter rainfall area was found to be statistically insignificant. The reason for this was that the decision by the farmers to plant was taken before the first significant rainfalls for the winter season, implying that they planted in the dry soil and waited for the first rains to come. The SHIFT90 variable was used to represent the structural shift[1] that took place in the wheat sector in 1990, when for the first time the Wheat Board took the world price into consideration when setting the basic price for wheat. This approach meant that farmers could anticipate with confidence what the producer price for their harvests would be at the start of the planting season, eliminating any price risks leaving only production risks to be mitigated. The structural shift had a major impact on the wheat area harvested in the winter rainfall region. Since the structural shift occurred, the area harvested in the winter rainfall region never recovered to the levels of the highs experienced during the late eighties.

Equation 6.3*:* **WHEAT PRODUCTION**

WPROSA = (WSAHSA + WWAHSA)*WYSA

WPROSA	:Wheat Production in South Africa, 1000 000tons
WSAHSA	:Wheat Summer Area Harvested, 1000 000tons
WWAHSA	:Wheat Winter Area Harvested, 1000 000tons
WYSA	: Wheat Average Yield per Hectare, tons/ha

Wheat production is an identity equal to the sum of summer and the winter area harvested multiplied by the average yield. The variables used for the summer and winter areas harvested in equation 6.3 were estimated in equation 6.1 and 6.2. Yield was treated as an exogenous variable and was thus not estimated.

[1] Refer to Chapter 2 for discussion on Structural Shift

Equation 6.4: WHEAT PER CAPITA IMPORTS

$$WPCISA = 22.16 - 737.82\ (WPPKC*EXCH/100)/CPIF$$

(-1.22)
<-0.60>

$$-\ 0.103\ (WPROSA/POP)*1000 \quad +\ 18.58\ DUM95$$

(-1.48) (2.00)
<-0.79>

$R^2 = 0.746$ Adj.$R^2 = 0.693$ F Value = 13.98 D.W. = 1.981

WPCISA	:Wheat Imports Per Capita of South Africa, kg/capita
WPPKC	: Kansas City Wheat Price, Hard Red no.2, $/ton
EXCH	: Exchange rate, SA cent/USD
CPIF	:Consumer Price Index of Food, 1995 = 100
WPROSA	: Wheat Production South Africa, 1000 000tons
POP	: Population in South Africa, 1000 000 people

South African wheat imports per capita were modelled as a function of the Kansas City price of hard red winter wheat no.2 multiplied by the exchange rate as well as the local wheat production. Interestingly, better simulation results were obtained from modelling the imports on a per capita basis, instead of modelling it on the usual basis of the amount of tons imported. South Africa is a net importer of wheat. The exports of wheat only reached significant levels in the years in which the country produced bumper crops, for example in 1988, 1.3 million tons of wheat were exported. The results indicate a price elasticity of -0.60. No previous studies have estimated a similar import function, as a result, this elasticity cannot be compared to that of previous studies. However, taking into consideration, the fact that wheat imports are modelled as a function of the Kansas City wheat price multiplied by the exchange rate, this price elasticity does not seem to be unrealistic at all.

The negative coefficient for wheat production can also be explained by economic theory. The more wheat is produced in South Africa, the less needs to be imported. An elasticity of –0.79 was calculated. This implies that imports will decrease by 0.79 percent for every one percent increase in the production of local wheat.

In 1995 quantitative import controls were replaced by import tariffs. This tariff shift is regarded as one of the most important factors in the relationship between the quantity of imports and the world price and is represented by the DUM95. These tariffs would be implemented by means of a sliding scale if the international price drops below a level of $194/ton. Although import tariffs had already replaced quantitative import controls in 1995, it was not until February 1998 that the first import tariff was implemented.

Equation 6.5: WHEAT TOTAL SUPPLY

WTSSA = WPROSA + WBSSA + (WPCISA*POP)/1000

WTSSA	:Wheat Total Supply of South Africa, 1000 000 tons
WPROSA	: Wheat Production of South Africa, 1000 000tons
WBSSA	: Wheat Beginning Stock, 1000 000tons
WPCISA	: Wheat Per Capita Imports, kg/capita

Wheat total supply as presented in equation 6.5, is an identity and was defined as the beginning stock of the production season plus the total production plus the imports.

6.3.2 THE DEMAND BLOCK

Domestic use of wheat consists of food, seed, and feed use. On average, less than two percent of local consumption is used for animal feed, which implies that the major portion of South African wheat is used for human consumption. Wheat will only be used for animal feed if the quality of the wheat is very poor. Seed consumption makes up less than five percent of the market and the reported data is unreliable. For this reason, the model did not estimate a category for feed and seed use. Only a per capita domestic consumption equation was estimated. Wheat per capita consumption was defined as the wheat gross human consumption[1] divided by the population and was estimated in equation 6.6 as a function of the adjusted real wheat producer price, the real potatoes retail price, and the real per capita gross domestic product (PCGDP). All variables proved to be statistically significant at a 95 percent level of confidence and a R^2 value of 85 percent was obtained.

Equation 6.6: WHEAT PER CAPITA CONSUMPTION

$$WPCCSA = 9.63 - 2.597\,((7.06*WPPSA/1000*100)/CPIF) + 12.76\,(PRPSA/CPIF)$$

(-2.09) (2.43)

<-0.32> <0.31>

$$+\ 0.003\,(PCGDP/CPIF) - 11.70\ SHIFT90$$

(2.47) (-3.34)

<0.61>

$R^2 = 0.854$ Adj.$R^2 = 0.824$ F Value = 27.95 D.W = 1.550

WPCCSA	: Wheat per Capita Consumption, kg/capita/year
WPPSA	: Wheat Producer Price, R/ton
CPIF	: Consumer Price Index, 1995=100
RPRPSA	: Potatoes Retail Price, c/kg
PCGDP	: Per Capita Gross Domestic Product

To enable the calculation of the adjusted wheat producer price that was used in equation 6.6, the wheat flour retail price was estimated as a function of the wheat producer price. No intercept term was estimated in this equation. A coefficient of 7.06 was estimated for the wheat producer price variable. This factor can now be used as an adjustment factor to adjust the wheat producer price to the wheat consumer price. To enable the complete adjustment from the producer price to the consumer price the wheat producer price was adjusted from R/ton to c/kg and was multiplied by the factor 7.06. This adjusted real wheat producer price

[1] This is the total amount of wheat used for human consumption and not only the consumption of bread

was found to be significant at a 95 percent level of confidence, and produced an own price elasticity of –0.32 compared to the –0.53 reported by Niebuhr (1991) and –1.13 reported by Elliot (1991). Although, both Elliot and Niebuhr, estimated the demand for bread, Elliot included bread rolls and high protein loaves, which could be regarded as luxury goods, compared to white and brown bread. This may explain the higher own price elasticity, which was reported by Elliot. It is difficult to contextualise these elasticities within this study due to the fact that the total consumption of wheat was estimated in this study. This consumption not only includes all kinds of bread, but also the consumption of pasta and cake flour. Furthermore, it should also be kept in mind that an adjusted producer price was used in the estimation of the per capita consumption of wheat.

In the discussion of cross price elasticities and income elasticities, it is also important to take into account whether the consumption of bread or the total consumption of wheat is estimated. The results of equation 6.6 show that wheat competes with potatoes on a retail level, with a cross price elasticity of 0.31. Contrary to what was expected, maize meal was not found to be a substitute for wheat. This result is also supported by the findings of Elliot (1991), in which he explains the nature of the various carbohydrates. According to Elliot, rice and potatoes are the substitutes for maize meal and not bread. The income elasticities, which he calculated, support these findings. For maize meal, potatoes, and rice the income elasticities were calculated as 0.14, 0.15, and 0.15, whereas, the income elasticity for bread was calculated as 0.23. Hence, it is evident that wheat falls into a different category. It can almost be regarded as a "comfortable" staple food because it can be bought and directly consumed, contrary to the use of maize meal, rice and potatoes.

In this study, per capita income was also found to have a positive effect on domestic wheat utilization with an income elasticity of 0.61. This is higher than the income elasticity of 0.30 reported by Nieuwoudt (1981). As discussed previously, this study estimated total wheat consumption, which implies that the income elasticity is expected to be higher than the income elasticity estimated by Nieuwoudt. Niebuhr (1991) also estimated the demand for white and brown bread and his results differed from those of Nieuwoudt. He calculated an income elasticity of –0.12, which implied that bread was an inferior good.

The Blignaut report (1990) made recommendations regarding the phasing out of the bread subsidy. Finally on the 1st March 1991, the bread subsidy was terminated and the Wheat Board no longer regulated the price of wheat. Shift90 was used to illustrate this structural shift in the wheat consumers market. With the initial estimation process, a trend variable was used to account for changes in consumer tastes and preferences. Although the decline in the consumption of wheat over the past decade was captured by this trend variable, it proved to be statistically insignificant and consequently was dropped from the equation.

Equation 6.7: WHEAT ENDING STOCKS

$$WENDSA = -0.55 + \underset{(3.93)}{0.80\ WENDSAAD} + \underset{(2.99)}{0.32\ WPROSA} - \underset{(-2.58)}{0.87\ DUM88}$$

$R^2 = 0.729$ Adj.$R^2 = 0.655$ F Value = 9.73 D.W. = 1.934

WENDSA	: Wheat Ending Stocks in South Africa, 1000 000tons
WENDSAAD	: Adjusted Wheat Ending Stocks, 1000 000tons
WPROSA	: Wheat Production in South Africa, 1000 000tons
DUM88	: Dummy variable in 1988

In Equation 6.7 the ending stocks were estimated as a function of the adjusted wheat ending stocks and total production. During the reign of the wheat board 25 percent of the annual wheat crop had to be retained by the board. This was an unofficial policy, which was implemented by the government to ensure sufficient supply of wheat in a state of emergency for at least three months. Adjusted wheat ending stocks were defined as the free lagged ending stocks plus 25 percent of the current production, which was retained. Free lagged ending stocks were calculated by deducting the retained stocks from the ending stocks. These stocks were available for marketing.

Initially wheat domestic prices and Free on Board (FOB) export prices were used as explanatory variables, but then dropped from the equation. Both produced wrong signs and were found to be statistically insignificant. These findings suggested that South African wheat stocks are perfectly inelastic with respect to their own price.

DUM88 was used to account for the huge ending stocks in the 1987/88-production season. In 1988 South African wheat farmers produced 3.5 million tons of wheat. This was the biggest wheat crop in the history of South Africa.

Equation 6.8: WHEAT TOTAL DOMESTIC USE

WDUSA = WPCCSA*POP

WDUSA : Wheat Domestic Use, 1000 000tons
WPCCSA :Wheat Per Capita Consumption, kg/capita
POP : Population, million

South African domestic wheat use is an identity defined as wheat per capita consumption times total population.

Equation 6.9: WHEAT MARKET CLEARING IDENTITY

WESA = WTSSA - WDUSA - WENDSA

WTSSA	: Wheat Total Supply of South Africa, 1000 000tons
WDUSA	: Wheat Domestic Use, 1000 000tons
WENDSA	: Wheat Ending Stock, 1000 000tons
WESA	: Wheat Exports, 1000 000tons

Wheat exports were used as the market clearing identity. In other words, they were used to close the wheat model. They were defined as total wheat supply minus wheat domestic use minus wheat ending stocks. The market clearing identity is reached at an equilibrium price in the market. The equilibrium price is now linked to the world price.

6.3.3 THE PRICE LINKAGE BLOCK

The final equation in the South African wheat model is the price linkage equation as illustrated in equation 6.10. The local wheat producer price is estimated as a function of the Kansas City wheat price, local wheat production, and a trend variable. The results show a price transmission elasticity of 0.24. This implies that the local price will increase by 0.24 percent for every one percent increase in the wheat price in Kansas City. Further more, the wheat price is also influenced by the local wheat production. An elasticity of –0.33 was calculated. This implies that the wheat price will decrease by 0.33 percent for a one percent increase in the local production of wheat.

Equation 6.10: WHEAT PRICE LINKAGE EQUATION

$$\underset{\substack{(1.88)\\ \langle 0.24\rangle}}{WPPSA = 160.70 + 0.33\,(WPPKC*EXCH/100)} - \underset{\substack{(-2.54)\\ \langle -0.33\rangle}}{78.21\,WPROSA} + \underset{(6.11)}{29.36\,TREND}$$

$R^2 = 0.965$ Adj.$R^2 = 0.961$ F Value = 289.56 D.W. = 1.25

WPPKC	: Wheat Producer Price South Africa, R/ton

WPPKC :Kansas City Wheat Price, Hard Red No.2, $/ton
EXCH : Exchange rate, SA cent/USD
WPROSA : Wheat Production in South Africa, 1000 000tons

6.4 THE PERFORMANCE OF THE MODEL

This section will complete the process of model development by validating the estimated system of equations based on five criteria. These are: the graphical examination of actual values plotted against predicted and simulated values of the endogenous variables; the Root Mean Square (*RMSE %)* error's; the Mean Error percentages; Theil's Inequality Statistics; and finally the response of the system to exogenous shocks, which is referred to as impact multipliers. As previously discussed, the dynamic process[1] is regarded as a more powerful tool for simulation compared to the static procedure and consequently it was decided to report only the validation of the dynamic simulation results.

6.4.1 VISUAL INSPECTION AND GOODNESS-OF-FIT

A visual inspection is a basic but very effective way to determine the simulating and forecasting performance of a model. The simulated values are plotted against the actual values and a visual inspection is carried out to determine how well the model simulates the turning points in the data. The simulation results are graphically presented in Appendix 2**.** The graphs show that the model has succeeded in tracking the general underlying trend of the endogenous variables. It also captures most of the turning points in the actual data. Based on the first validation criterion, visual inspection, one can thus draw the conclusion that this model has the ability to simulate the dynamic environment of the real world and can thus be used for forecasting and conducing policy analyses.

[1] Lagged Endogenous variables are internally generated from the model

Before a final judgment on the performance of the model can be made, we also have to take into consideration the measurements for the goodness of fit. In Table 6.1 the measurements are presented. Results indicate that only two of the equations had percentages for the Root Mean Squared Error (RMSE%), which were significantly higher than ten percent. This implies that the simulated endogenous variables track their corresponding data series very closely. The Mean Error percentages also proved to be very low with WENDSA having the highest value of 1.65 percent.

Table 6.2: Measurements for the Goodness of Fit

Variable	Mean Error	Mean Error%	Mean A.Error	RMSE	RMSE%
WSAHSA	-0.0032	-0.2999	0.0675	0.0837	15.276
WWAHSA	-0.0001	1.3537	0.0498	0.0581	10.993
WPRODSA	-0.0110	0.2239	0.1243	0.1530	8.9219
WENDSA	-0.0218	0.5878	0.1111	0.1581	24.645
WPCCSA	-0.0292	0.3347	4.8119	5.3514	8.0988
WPCISA	0.0507	1.6500	4.3114	5.0563	4.2530
WDUSA	0.0013	0.3117	0.1537	0.1720	7.7000
WTSSA	-0.0298	-1.0200	0.1571	0.2062	6.8079
WPPSA	0.8615	0.7129	40.613	50.149	11.677
WESA	-0.0094	.	0.1461	.	0.1834

The final criterion to determine the goodness-of-fit of the model is Theil's inequality coefficient, as presented in table 6.2. U can take on values between 0 and 1. If $U = 0$, there is a perfect fit, whereas, if $U = 1$, the predictive performance of the model is as bad as can be. With the highest value of 0.24181 for Wheat Exports (WESA), these results also suggest that the *ex post* forecast of the model has performed well and consequently the model can be used for forecasting purposes as well as policy analyses.

Table 6.3: Theil's inequality Coefficients

Variable	Inequality Coefficient (U)
WSAHSA	0.0439
WWAHSA	0.0469
WPRODSA	0.0352
WENDSA	0.1384
WPCCSA	0.0388
WPCISA	0.2155
WDUSA	0.0379
WTSSA	0.0339
WPPSA	0.0428
WESA	0.2481

6.4.2 IMPACT MULTIPLIERS

A final step in the validation process is to subject the system of equations to changes in exogenous variables and evaluate the response of each endogenous variable. Short and long run multipliers capture this response. Although one may anticipate what the response of each individual equation might be to an exogenous shock, the system when shocked may not produce results that would have been expected *a priori*. To enable the creation of impact multipliers a baseline was generated that holds all exogenous variables constant at the 2000 level. The model was solved for as many periods as necessary to reach a long-run equilibrium. The period, where the model obtains a long-run equilibrium, will now be referred to as period one. Giving a once off or sustained shock to one of the exogenous variables in the first period and again solving the model infinitely generates the impact multipliers for a long-run equilibrium.

In this section once off and sustained shocks are performed on important exogenous variables within the system to examine short-run as well as long-run impacts on all endogenous variables. These impacts will be presented in the form of percentages. Although percentages provide a very clear idea of what the total effect of a shock on the system is, it may sometimes occur that relative percentage changes turn out to be very large. If one would take these percentage changes and apply them to the current level of the endogenous variable, the results would be misleading. The percentage change in imports serves as a good illustration of this fact. Table 6.3 illustrates a 51 percent decrease in per capita imports. This value cannot be applied to the 2000 level of per capita imports. At a current level (2000) of 11.23kg/capita, it would imply that per capita imports decrease by approximately 5kg/capita. This is however not the case. Initially the model was solved over a long period until equilibrium was reached. At this point the levels of endogenous variables proved to be quite different to what they were in 2000. For example, the per capita imports of wheat would take on a value of 2kg/capita in long-run equilibrium. This is the level where the shock occurred and now the 51 percent decrease does not seem to be unrealistic. Furthermore, the elasticities reported in Section 6.3, are calculated at the mean values of the variables over the period from 1977 to 2000. This implies that these elasticities are not well suited for the evaluation of the impact multipliers.

A drastic change in the level of yield could potentially have a major influence on the wheat sector. Table 6.3 shows the percentage changes in the endogenous variables resulting from a once off 20 percent increase in yield in period one. In period two, yield returns back to the 2000 level and maintains this level for the rest of the period. The increase in yield results in a 20 percent increase in wheat production, which in turn will increase the total supply of wheat by 8.5 percent, and the level of exports by 21.4 percent. Due to the higher level of production wheat per capita imports decrease by 51.7 percent. The higher level of production also forces market prices down by 10.78 percent. Lower prices will increase per capita consumption by 1.74 percent and the domestic use of wheat by 1.69 percent. In period two farmers respond to lower producer prices and the total area harvested decreases, which will cause the production to decrease by 1.4 percent. Although the level of production decreases, the total supply of wheat still increases by 2.44 percent. The reason for this increase is the high level of stocks that were carried over from the first period. In the long run the wheat summer area harvested decreases by 0.01 percent, while the wheat winter area harvested increases by 0.001 percent. In the long run wheat per capita consumption will decrease by only 0.006 percent while the producer price of wheat will increase by 0.004 percent.

Table 6.4: Percentage change in Endogenous Variables from a 20% increase in Yield in Period one

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 10	Infinity
WPCCSA1	1.741243	-0.12227	-0.07282	-0.04957	-0.03616	-0.0272	-0.009353	-0.00067
WSAHSA1	0	-1.22149	-0.90877	-0.68904	-0.52652	-0.40361	-0.140405	-0.01007
WWAHSA1	0	-2.12214	-0.54298	-0.08827	0.031667	0.054424	0.0256233	0.001851
WPROSA1	20	-1.40313	-0.83507	-0.56809	-0.4142	-0.31148	-0.107043	-0.00768
WENDSA1	6.008559	4.373942	3.247364	2.431012	1.826029	1.373287	0.4383546	0.022517
WPCISA1	-51.7701	3.645295	2.175585	1.483219	1.083239	0.815641	0.2810761	0.020189
WDUSA1	1.690081	-0.11868	-0.07068	-0.04811	-0.03509	-0.0264	-0.009078	-0.00065
WTSSA1	8.550054	2.447586	1.872469	1.41913	1.071342	0.807238	0.2571223	0.012751
WPPSA1	-10.7847	0.757804	0.451547	0.307464	0.224336	0.168794	0.0580754	0.004168
WESA1	21.46424	1.018732	0.953114	0.770346	0.593061	0.447974	0.1377404	0.005192

Table 6.5: Percentage change in Endogenous Variables from a sustained 20% increase in Yield

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 10	Infinite
WPCCSA1	1.741243	1.59613	1.511905	1.455615	1.41511	1.38499	1.3220681	1.292545
WSAHSA1	0	-1.22149	-2.11311	-2.77964	-3.28285	-3.6643	-4.468716	-4.84686
WWAHSA1	0	-2.12214	-2.63786	-2.70372	-2.65681	-2.59232	-2.424659	-2.34218
WPROSA1	20	18.31624	17.33739	16.68277	16.21175	15.86157	15.130426	14.78744
WENDSA1	6.008559	10.24671	13.31211	15.55326	17.19898	18.40922	20.783844	21.66662
WPCISA1	-51.7701	-47.585	-45.1686	-43.5571	-42.3977	-41.5349	-39.72992	-38.8827
WDUSA1	1.690081	1.549235	1.467488	1.412854	1.373541	1.344306	1.2832352	1.254581
WTSSA1	8.550054	10.83223	12.5534	13.83491	14.78388	15.48462	16.863222	17.37266
WPPSA1	-10.7847	-9.89223	-9.37482	-9.02918	-8.78047	-8.59548	-8.208922	-8.02753
WESA1	21.46424	22.07581	22.75017	23.30633	23.72783	24.03682	24.60913	24.75642

Table 6.4 depicts the percentage changes in the endogenous variables when yield increases by 20 percent in the first period and is infinitely sustained. The production of wheat again increases by 20 percent in the first period and this time it maintains a long-run increase of 14.78 percent. The total area harvested decreases by a higher percentage every year (4.84 percent infinitely). Wheat exports follow a similar trend. In the long-run equilibrium, the producer price of wheat will decrease by 8.02 percent and in turn per capita consumption will

increase by 1.29 percent. Due to a sustained increase in the level of production, per capita imports will decrease infinitely by 38.88 percent.

When the results from exchange rate shocks are compared to the results of yield shocks they prove to be less substantial to the wheat sector. Table 6.5 portrays the percentage changes in endogenous variables when the exchange rate depreciates by 20 percent in period one and then in period two shifts back to the 2000 level. The depreciation of the exchange rate directly influences the per capita imports (decrease by 19.38 percent) due to a higher import parity price. The local producer price is linked to the import parity price and consequently will increase by 7.74 percent. In the first period the total supply of wheat will decrease by 0.37 percent due to the reduction of imports. Higher prices will force down the per capita consumption by 1.25 percent. In the second period wheat producers will respond to higher wheat prices and will increase the area harvested[1]. It is assumed that the yield will not be affected and consequently the production of wheat will increase by one percent, due to the higher level of area harvested. Increased production will in turn increase exports by 1.07 percent and will cause the producer price to decrease by 0.54 percent. In long run equilibrium, producer prices will decrease by 0.003 percent while production will increase by 0.005 percent. Exports will infinitely increase by 0.032 percent and per capita imports will infinitely decrease by 0.01 percent.

Table 6.6 depicts the impact on the wheat system when a 20 percent depreciation in the exchange rate is sustained infinitely. In long-run equilibrium, per capita imports will decrease by 28.13 percent and exports will increase by 5.07 percent. The producer price of wheat will increase by six percent. Farmers will respond to the higher producer price and infinitely

[1] Area harvested is a proxy for the area planted

increase the summer area harvested by 3.62 percent and the winter area harvested by 1.75 percent, which will in turn increase the total production of wheat by 3.24 percent.

Table 6.6: Percentage change in Endogenous Variables from a 20% depreciation in the Exchange Rate in Period one

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 10	Infinity
WPCCSA1	-1.2512	0.087862	0.052328	0.035617	0.02598	0.019543	0.006721	0.000482
WSAHSA1	0	0.877726	0.653016	0.495127	0.378342	0.290019	0.100891	0.007238
WWAHSA1	0	1.524905	0.39017	0.063425	-0.02276	-0.03911	-0.01841	-0.00133
WPROSA1	0	1.008249	0.600057	0.40821	0.297633	0.223821	0.076918	0.005517
WENDSA1	0	0.300274	0.417304	0.453831	0.45055	0.42642	0.272856	0.050737
WPCISA1	-19.3819	-2.6194	-1.56331	-1.0658	-0.77838	-0.58609	-0.20197	-0.01451
WDUSA1	-1.21444	0.08528	0.050791	0.034571	0.025217	0.018969	0.006524	0.000468
WTSSA1	-0.3705	0.428706	0.40681	0.385298	0.357637	0.325258	0.19324	0.033982
WPPSA1	7.749579	-0.54454	-0.32447	-0.22093	-0.1612	-0.12129	-0.04173	-0.003
WESA1	-0.26058	1.076646	0.764509	0.608981	0.506979	0.427558	0.214171	0.032032

Table 6.7: Percentage change in Endogenous Variables from a sustained 20% depreciation in the Exchange Rate

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 10	Infinity
WPCCSA1	-1.2512	-1.16323	-1.11083	-1.07515	-1.04913	-1.02955	-0.98772	-0.96699
WSAHSA1	0	0.877726	1.529845	2.02377	2.400891	2.689798	3.312654	3.621593
WWAHSA1	0	1.524905	1.91536	1.979062	1.956525	1.917584	1.809105	1.752245
WPROSA1	0	1.008249	1.60752	2.014768	2.311475	2.534481	3.010528	3.246139
WENDSA1	0	0.300274	0.715183	1.164324	1.608602	2.02791	3.329234	4.56184
WPCISA1	-19.3819	-22.0524	-23.6605	-24.7632	-25.5714	-26.1811	-27.4886	-28.1385
WDUSA1	-1.21444	-1.12906	-1.07819	-1.04357	-1.01831	-0.99931	-0.95871	-0.93859
WTSSA1	-0.3705	0.060576	0.467068	0.850345	1.204961	1.526707	2.477288	3.330475
WPPSA1	7.749579	7.20929	6.88786	6.669156	6.509615	6.38957	6.132888	6.005626
WESA1	-0.26058	0.817633	1.578128	2.180788	2.680644	3.101066	4.213552	5.078228

6.5 SUMMARY

This chapter reported the empirical results and the performance of the model was validated. Five criteria were used for the validation process and some results proved to be more significant than others. The evaluation criteria become more complicated with a multi-equation simulation models. Pindyck and Rubinfeld (1998) stated, “In practice, it may be necessary to use specifications for some of the equations that are less desirable from a statistical point of view but that improve the ability of the model to simulate well”. This chapter showed that the wheat system is well suited for the purpose of forecasting and policy analyses when all of the statistical tests and validation criteria are taken into account. In the next chapter the estimated model will be used to produce baseline projections and analyse the implication of policy alternatives and market scenarios on the South African wheat sector.

CHAPTER 7
BASELINE AND POLICY ANALYSIS

7.1 INTRODUCTION

This chapter consists of two sections, the baseline projections for the South African wheat sector, and the analysis of the implication of different policy alternatives and shifts that will result in a change in the macroeconomic environment. In the first section of the chapter the specific conditions and assumptions, which enable the simulation of a baseline, are specified and discussed, and the baseline for the wheat sector is presented. In the second section, the model will be used to simulate the impacts of changes in policies, world markets and the production environment on domestic prices as well as levels of demand and supply. Three scenarios are analysed, the elimination of the import tariff for wheat, a twelve percent depreciation in the exchange rate, and the convergence of the elimination of the import tariff and the 12% depreciation in the exchange rate.

7.2 THE BASELINE

When the impact multipliers were generated in chapter six the model was solved for many future periods, holding the exogenous variable constant at the 2000 level. To facilitate the generation of a baseline, the model also needs to be solved for a specific period in the future, but in this case various assumptions are made regarding future values for exogenous variables. The baseline projections are considered as a commodity market outlook rather than as forecasts because they are produced conditional on a number of assumptions. These assumptions relate mainly to agricultural policies, the macroeconomic environment, and weather conditions.

The baseline assumes that no changes will take place in the agricultural policies currently in force. This implies that the policy on the import tariff will stay in place for the baseline period. Projections for the following macroeconomic variables were obtained from FAPRI's 2002 baseline: the World Price of Wheat and Sunflower, the Exchange Rate, the Gross Domestic Product Deflator (GDPD), and Population. The wheat world price is projected to gradually increase to a level of $148.05/ton in 2008. The exchange rate is expected to consistently depreciate against the US dollar to a level of 1544 SA cents/USD in 2008. The population is assumed to decline at an increasing rate from 0.1 percent in 2003 to 1 percent in 2008. GDPD is projected to increase at a decreasing rate from 7.6 percent in 2001 to 3.5 percent in 2005. It will then again start to increase at an increasing rate up to 2008. The projected percentage change of the world price of sunflower was used to calculate the projected local sunflower producer price.

The baseline projections assume trend yields and normal weather conditions. A simple equation was estimated to provide the forecast values for wheat yields. Wheat yield was estimated as a function of the trend variable. The estimation results are presented in Equation 7.1:

Equation 7.1: WHEAT YIELD EQUATION

$$\text{YIELD} = 0.9805 + \underset{(8.36)}{0.0023}\ \text{LOG (TREND)}$$

$R^2 = 0.76$ Adj.$R^2 = 0.75$ F Value = 69.87 D.W. = 1.86

The estimated parameter is used to calculate a trend yield for the period 2002-2008. Normal weather conditions imply that rainfall is held constant at the average rainfall level over the past ten years.

Projections for some of the exogenous variables, needed to generate the baseline, were not available from FAPRI's 2002 baseline. These variables were calculated by means of using the projected percentage changes of GDPD for every period. For example, the projected increase of GDPD is 3.3 percent for the period of 2003-2004. Hence, per capita income will also increase by 3.3 percent for the period 2003-2004. This methodology was used to calculate the projected values for the general level of inflation (CPIF), the potatoes retail price, the mutton producer price, per capita income, and the general level of input prices (requisites).

Table 7.1: Market Outlook for the South African Wheat Sector

Variable	Units	2002	2003	2004	2005	2006	2007	2008
Summer Area	mill. ha	0.510	0.480	0.491	0.514	0.547	0.587	0.643
Winter Area	mill. ha	0.410	0.445	0.462	0.469	0.471	0.472	0.475
Production	mill. tons	2.321	2.337	2.412	2.491	2.583	2.690	2.844
Ending Stock	mill. tons	0.631	0.638	0.667	0.716	0.785	0.875	0.996
Consumption	kg/capita	54.770	54.191	53.987	53.983	53.833	53.955	53.934
Domestic Use	mill. tons	2.494	2.466	2.448	2.434	2.410	2.394	2.370
Total Supply	mill. tons	3.273	3.277	3.330	3.417	3.524	3.675	3.895
Producer Price	R/ton	1588.464	1706.475	1782.003	1844.786	1928.167	2002.066	2036.327
Exports	mill. tons	0.148	0.174	0.214	0.266	0.330	0.405	0.528
Imports	kg/capita	7.254	6.965	6.337	5.887	5.179	4.623	4.131

Table 7.1 presents baseline projections for the South African wheat sector over the period 2002 to 2008. The projected values for the wheat area harvested in the summer and winter rainfall regions, as well as the total supply and total demand of wheat are graphically depicted in Figures 7.1, 7.2, 7.3, and 7.4. Appendix 3 contains the graphical illustration of the remaining endogenous variables.

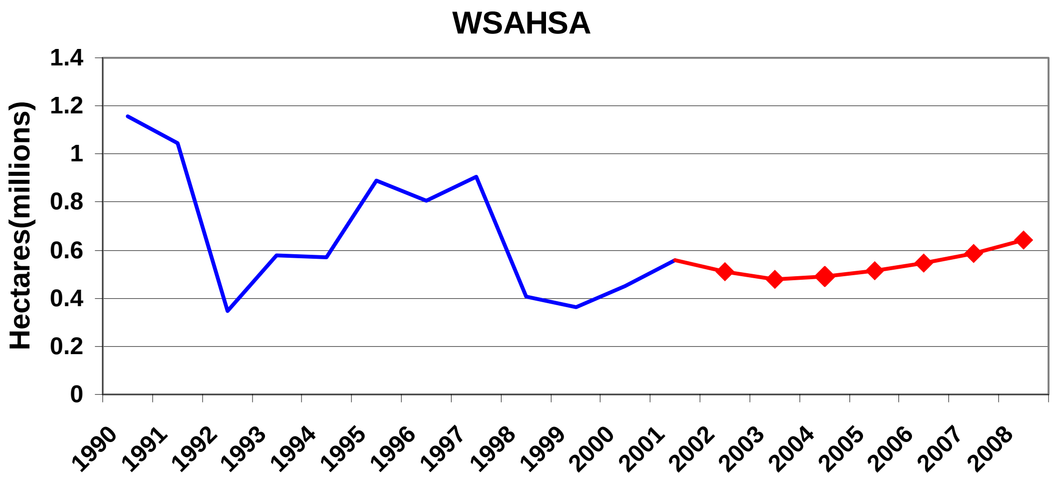

Figure 7.1: Wheat Summer Area Harvested

The wheat area harvested in the summer rainfall region decreases in 2003 but then gradually increases to a projected level of 643 000 hectares in 2008. The reason for the initial decrease in the area harvested is the impact of the high sunflower producer price. Wheat producers will respond to these high prices and substitute the area harvested under wheat for sunflower. However, as soon as the wheat price starts to increase wheat producers will switch back to wheat production. The wheat area harvested in the winter rainfall region increases consistently to reach 475 000 hectares in 2008. This projection can be explained by the fact that mutton producer prices[1] do not increase as drastically as sunflower producer prices and wheat producers will thus base their decision on higher wheat producer prices and increase the area harvested in the winter rainfall region.

[1] Chapter six showed that mutton is a substitute good of wheat in the winter rainfall region

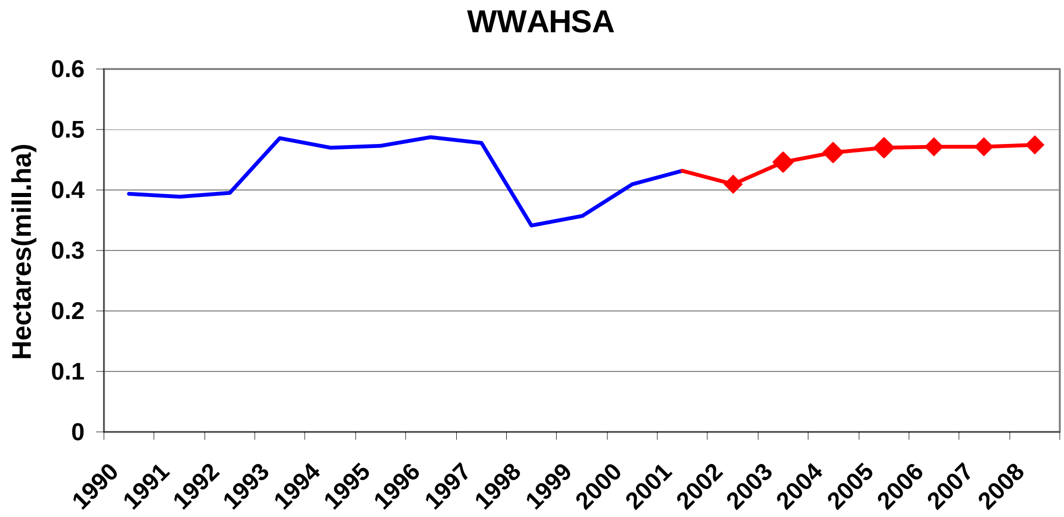

Figure 7.2: Wheat Winter Area Harvested

Despite the initial decline in the area harvested in the summer rainfall region the production of wheat increases consistently over the projection period to reach 2.84 million tons in 2008. This growth in production is expected to result from higher yields and the increase in the area harvested from 2004 onwards.

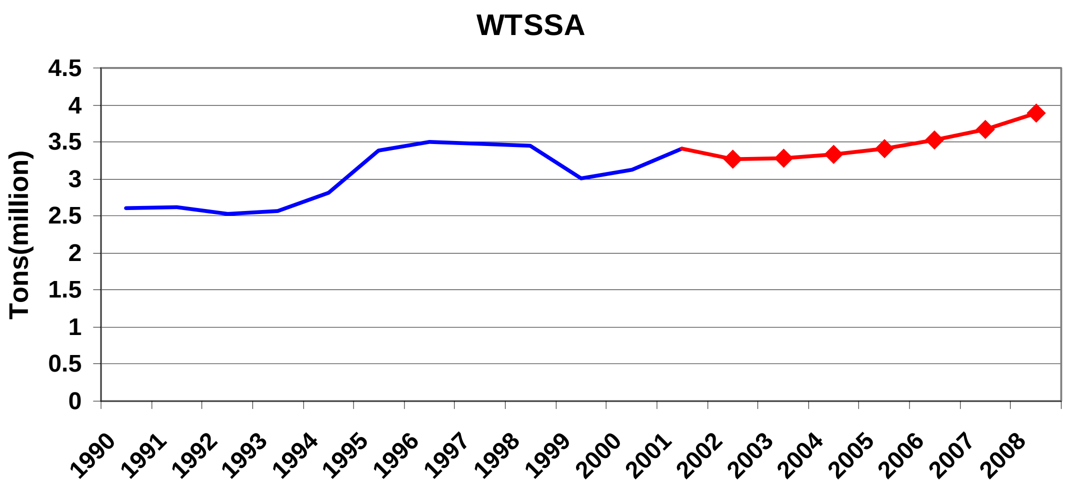

Figure 7.3: Total Supply of Wheat

Despite a decline in the wheat imports per capita, the total supply of wheat increases to reach 3.8 million tons in 2008. This increase is a result of the higher levels of production. Higher levels of production also enhance exports over the projected period of time to reach a level of 528 000 tons in 2008. As the world price of wheat increases and the exchange rate depreciates, the import parity price increases, which will force the imports per capita to decrease to 4.131 kilograms per capita in 2008. The wheat producer price is also influenced by the world price and the exchange rate and will consequently increase drastically over the projected period of time. The projected wheat producer price of 2002 (R1588.46/ton) does not project the actual current producer price (R1980/ton) very well. The reason for this is that the Kansas City price is currently much higher (approximately \$145/ton) than what the FAPRI 2002 baseline projects (\$130/ton), which is used for the simulation of this baseline. The current draught in the United States has mainly caused this drastic increase in the Kansas City price, which has recently occurred.

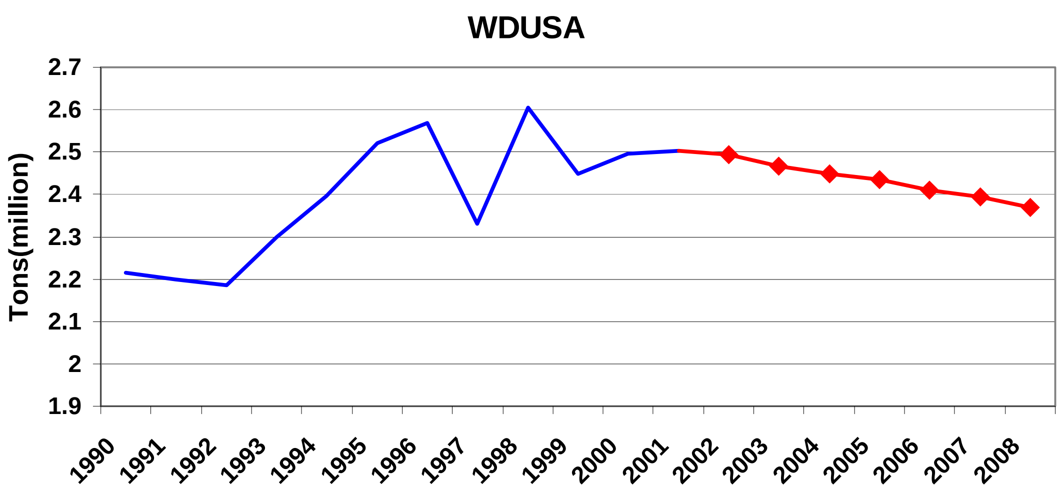

Figure 7.4: Domestic Consumption of Wheat

Per capita consumption decreases over the projected period as the wheat producer price increases. The domestic use of wheat decreases at a faster rate than the wheat consumption per capita. This can be explained by the fact that the projected population declines at an increasing rate.

Since the Crop Estimate Committee (CEC) has recently released the second estimate for the wheat area planted as well as the wheat production for the production year of 2002, these estimated values can be compared to the projected values of this study. The published figures of the CEC report a total area planted of 480 000 hectares in the summer rainfall region and a total area planted of 433 500 hectares in the winter rainfall region. The projections of this study are slightly too high for the summer rainfall region and slightly to low for the winter rainfall region, when they are compared to the estimates of the CEC. The reason for this is that the estimated equation for the summer rainfall region takes into account the sunflower producer price, which is lagged by one year. Currently the sunflower producers prices are very high and wheat farmers could already have responded to these high price levels and substituted wheat with sunflower. The model takes this substitution effect only into account in 2003.

7.3 THE WHEAT SECTOR OUTLOOK FOR VARIOUS SCENARIOS

In this section, the constructed model will be used to make projections taking into account different policy shifts that will result in a change in the macroeconomic environment. Policy and business decisions can now be assessed using a range of *"what if"* questions. Not all of the scenarios that will be discussed are the direct result of policy shifts, but, are rather, the results of a convergence of a range of events on the political as well as economic scene. All the shifts in the political and economic environment are introduced in 2003. The model is solved and the results are compared to the initial baseline, which was generated without any changes in policies, world markets and the production environment.

7.3.1 SCENARIO ONE: THE ELIMINATION OF THE IMPORT TARIFF

As previously mentioned, import tariffs replaced quantitative import controls in 1995. These tariffs are usually implemented by means of a gliding scale where the international price drops below a level of $194/ton (Exchange rate R3.69 for $1 USA). It was not until February 1998, that the first import tariff was implemented. The import parity price of wheat dropped under R802 per ton and a R50 per ton import tariff was charged. In 1999, a new tariff structure for wheat was announced with a new reference price of $157 per ton. This tariff structure is still in place. The tariff is calculated according to the Hard Red Wheat (No.2) price in Kansas City on a weekly basis. If the current price deviates for three weeks by $10 per ton or more from the average price of $157 per ton, the tariff is adjusted. The wheat tariff is currently published at R196 per ton, which implies that it makes up almost ten percent of the current import parity price. It is therefore, appropriate to consider the case where no import tariff is in place as a policy scenario.

Chapter six illustrated the scenario where the import tariff was not included in the empirical estimation of the wheat producer price and wheat imports. They were instead, estimated as a function of the Kansas City wheat price and not the import parity price, as one would expect. The reason for this was that insufficient data was available for the calculation of the import parity price over a long period of time. So, to enable an analysis for a scenario where the wheat tariff is not in place an important assumption needs to be made. It must be assumed that the projected wheat price in Kansas City will decrease by the amount of the import tariff as currently published, for the period 2003 to 2008. Results of this scenario are presented in Table 7.2 below.

Table 7.2 Impacts of the Elimination of the Import Tariff on the Wheat Sector

	2002	2003	2004	2005	2006	2007	2008
Summer Area Harvested							
Baseline	0.510	0.480	0.491	0.514	0.547	0.587	0.643
No Tariff	0.510	0.480	0.479	0.493	0.519	0.555	0.607
% Change	0.000	0.000	-2.494	-4.120	-5.068	-5.514	-5.581
Winter Area Harvested							
Baseline	0.410	0.445	0.462	0.469	0.471	0.472	0.475
No Tariff	0.410	0.445	0.457	0.462	0.464	0.465	0.469
% Change	0.000	0.000	-1.163	-1.422	-1.436	-1.378	-1.323
Production							
Baseline	2.321	2.337	2.412	2.491	2.583	2.690	2.844
No Tariff	2.321	2.337	2.367	2.421	2.495	2.591	2.736
% Change	0.000	0.000	-1.849	-2.833	-3.388	-3.671	-3.771
Supply							
Baseline	3.273	3.277	3.330	3.417	3.524	3.675	3.895
No Tariff	3.273	3.315	3.327	3.375	3.446	3.563	3.754
% Change	0.000	1.169	-0.090	-1.231	-2.231	-3.046	-3.626
Domestic Use							
Baseline	2.494	2.466	2.448	2.434	2.410	2.394	2.370
No Tariff	2.494	2.498	2.478	2.462	2.435	2.418	2.393
% Change	0.000	1.297	1.193	1.115	1.054	0.991	0.965
Producer Price							
Baseline	1588.464	1706.475	1782.003	1844.786	1928.167	2002.066	2036.327
No Tariff	1588.464	1640.671	1719.686	1784.502	1869.205	1943.986	1978.910
% Change	0.000	-3.856	-3.497	-3.268	-3.058	-2.901	-2.820
Exports							
Baseline	0.148	0.174	0.214	0.266	0.330	0.405	0.528
No Tariff	0.148	0.180	0.196	0.231	0.281	0.346	0.460
% Change	0.000	3.655	-8.345	-13.140	-14.677	-14.587	-12.876
Imports per Capita							
Baseline	7.254	6.965	6.337	5.887	5.179	4.623	4.131
No Tariff	7.254	7.829	7.279	6.862	6.167	5.606	5.125
% Change	0.000	12.408	14.854	16.562	19.070	21.264	24.069

The results indicate that the producer price of wheat immediately decreases by 3.85 percent in comparison to the baseline, which would affect the area harvested under wheat for the following production season (2004) because producers respond on the lagged producer prices. Compared to the baseline, the area harvested in the summer rainfall region decreases by 2.49 percent and the area in winter rainfall region decreases by 1.1 percent. The major impact on the wheat sector can however be seen on the imports of wheat. The imports of wheat will increase by 12.4 percent above the baseline in 2003. In 2008 wheat imports are projected to be 24 percent higher than the baseline projection at a level of 5.1 kg/capita. Wheat exports reach a level of 460 000 tons in 2008. This is 12.8 percent lower than the projected level of the baseline.

7.3.2 SCENARIO TWO: 12% DEPRECIATION OF THE EXCHANGE RATE

The recent events around the value of the Rand and the expectations of rising food prices have emphasized the desperate need for quantitative evidence to better understand the decision-making behaviour of producers and consumers. In this scenario the projected exchange rate[1] is depreciated by 12 percent in 2003. The impacts of this depreciation on the wheat sector are shown in Table 7.3. As expected, the wheat producer price increases, and this is passed on to the area harvested for the next production season. A higher level of area harvested will on its turn cause the production of wheat to increase. Production is projected to reach a level of 2.9 million tons is 2008, which is 4.66 percent higher than the baseline projection. Higher wheat prices also cause the domestic consumption of wheat to decrease. A weaker exchange rate is the source of more expensive imports and consequently imports decrease to 12.33 percent below the baseline in 2003. Imports consistently decrease to reach a level of 2.78kg/capita in 2008. Exports consistently increase to reach a level of 610 000 tons in 2008, which is 15.4 percent higher than the baseline projection. A value of 2.33 million tons is projected for the domestic use of wheat in 2008, which is 1.3

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[2] FAPRI Baseline projected an exchange rate of 1220 SA cent/ USD for 2003

percent lower when compared to the baseline. This decline in the domestic use of wheat is caused by the higher wheat prices.

Table 7.3 Impacts of a 12% Exchange Rate Depreciation on the Wheat Sector

	2002	2003	2004	2005	2006	2007	2008
Summer Area Harvested							
Baseline	0.510	0.480	0.491	0.514	0.547	0.587	0.643
12% Depreciation	0.510	0.480	0.503	0.536	0.577	0.625	0.687
% Change	0.000	0.000	2.480	4.315	5.545	6.364	6.798
Winter Area Harvested							
Baseline	0.410	0.445	0.462	0.469	0.471	0.472	0.475
12% Depreciation	0.410	0.445	0.468	0.476	0.479	0.480	0.483
% Change	0.000	0.000	1.156	1.519	1.634	1.709	1.777
Production							
Baseline	2.321	2.337	2.412	2.491	2.583	2.690	2.844
12% Depreciation	2.321	2.337	2.456	2.565	2.679	2.805	2.976
% Change	0.000	0.000	1.838	2.981	3.735	4.290	4.664
Supply							
Baseline	3.273	3.277	3.330	3.417	3.524	3.675	3.895
12% Depreciation	3.273	3.239	3.329	3.456	3.603	3.793	4.055
% Change	0.000	-1.163	-0.016	1.158	2.228	3.231	4.103
Domestic Use							
Baseline	2.494	2.466	2.448	2.434	2.410	2.394	2.370
12% Depreciation	2.494	2.434	2.416	2.403	2.377	2.361	2.338
% Change	0.000	-1.289	-1.306	-1.306	-1.363	-1.384	-1.374
Producer Price							
Baseline	1588.464	1706.475	1782.003	1844.786	1928.167	2002.066	2036.327
12% Depreciation	1588.464	1771.900	1850.204	1915.400	2004.383	2083.152	2118.095
% Change	0.000	3.834	3.827	3.828	3.953	4.050	4.015
Exports							
Baseline	0.148	0.174	0.214	0.266	0.330	0.405	0.528
12% Depreciation	0.148	0.167	0.232	0.302	0.382	0.472	0.610
% Change	0.000	-3.634	8.026	13.525	15.752	16.511	15.405
Imports per Capita							
Baseline	7.254	6.965	6.337	5.887	5.179	4.623	4.131
12% Depreciation	7.254	6.106	5.322	4.773	3.958	3.325	2.781
% Change	0.000	-12.337	-16.021	-18.925	-23.589	-28.088	-32.673

7.3.3 SCENARIO THREE: ELIMINATION OF THE IMPORT TARIFF AS WELL AS 12% DEPRECIATION OF THE EXCHANGE RATE

As previously explained, if the current Hard Red Wheat (No.2) price in Kansas City deviates by $10 per ton or more for three weeks from the average price of $157 per ton, the tariff is adjusted. Over the past six months the Kansas City price has in fact increased dramatically and already a lower tariff rate has been published. This scenario assumes that the Kansas City price will continue to increase, which will result in the elimination of the import tariff on wheat. The elimination of the import tariff will effectively decrease the level of the import parity price for wheat. At the same time it is also assumed that depreciation of the exchange rate will persist, which will increase the import parity price for wheat. For this scenario, the model is used to simulate for the projected impacts of the convergence of events on the political as well as economic scene of the first two scenarios. The results are presented in Table 7.4.

The results suggest that the impacts of these two events cancel out one another to a large extent. In 2003 and 2004 the producer price for wheat will be slightly lower, when compared to the baseline. Due to lower producer prices production decreases, which on its turn increases imports and decreases exports. However, from 2005 producer prices start to increase again, which results in a higher level of production. Per capita imports are projected to reach a level of 3.89 kg/capita in 2008, which is 5.71% lower than the baseline projection. This is the single highest percentage deviation from the baseline. The rest of the variables have a deviation of less than 1%. Therefore, one has to draw the conclusion that if the exchange rate depreciates by a further 12% and no import tariff is charged, only a minor change in the behaviour of producers and consumers will take place over time.

Table 7.4 Impacts of the elimination of the Import Tariff as well as 12% Exchange Rate Depreciation on the Wheat Sector

	2002	2003	2004	2005	2006	2007	2008
Summer Area Harvested							
Baseline	0.510	0.480	0.491	0.514	0.547	0.587	0.643
No Tariff & 12% Exch. deprecation	0.510	0.480	0.489	0.513	0.546	0.588	0.646
% Change	0.000	0.000	-0.314	-0.300	-0.132	0.188	0.547
Winter Area Harvested							
Baseline	0.410	0.445	0.462	0.469	0.471	0.472	0.475
No Tariff & 12% Exch. deprecation	0.410	0.445	0.462	0.469	0.471	0.473	0.476
% Change	0.000	0.000	-0.146	-0.074	0.026	0.166	0.296
Production							
Baseline	2.321	2.337	2.412	2.491	2.583	2.690	2.844
No Tariff & 12% Exch. deprecation	2.321	2.337	2.406	2.486	2.581	2.695	2.856
% Change	0.000	0.000	-0.233	-0.192	-0.059	0.178	0.440
Supply							
Baseline	3.273	3.277	3.330	3.417	3.524	3.675	3.895
No Tariff & 12% Exch. deprecation	3.273	3.282	3.326	3.409	3.515	3.668	3.897
% Change	0.000	0.147	-0.117	-0.221	-0.271	-0.181	0.042
Domestic Use							
Baseline	2.494	2.466	2.448	2.434	2.410	2.394	2.370
No Tariff & 12% Exch. deprecation	2.494	2.470	2.449	2.433	2.405	2.388	2.363
% Change	0.000	0.163	0.031	-0.057	-0.182	-0.274	-0.293
Producer Price							
Baseline	1588.464	1706.475	1782.003	1844.786	1928.167	2002.066	2036.327
No Tariff & 12% Exch. deprecation	1588.464	1698.199	1780.409	1847.882	1938.345	2018.103	2053.788
% Change	0.000	-0.485	-0.089	0.168	0.528	0.801	0.857
Exports							
Baseline	0.148	0.174	0.214	0.266	0.330	0.405	0.528
No Tariff & 12% Exch. deprecation	0.148	0.174	0.211	0.263	0.327	0.406	0.534
% Change	0.000	0.460	-1.321	-1.192	-0.686	0.174	0.984
Imports per Capita							
Baseline	7.254	6.965	6.337	5.887	5.179	4.623	4.131
No Tariff & 12% Exch. deprecation	7.254	7.074	6.376	5.865	5.064	4.426	3.895
% Change	0.000	1.561	0.616	-0.376	-2.231	-4.272	-5.716

7.4 CONCLUSION

Chapter seven provides the reader with a better understanding of the decision-making behaviour of South African wheat producers and consumers in the face of the changing economic and trade policies, and changing world markets. A baseline was presented and the impacts of three market scenarios were analysed.

CHAPTER 8

SUMMARY AND CONCLUSION

The general objective of this dissertation was to analyse the structure of the wheat market of South Africa using economic theory and econometric modelling techniques. The specific objectives were to make baseline projections regarding the supply and use of wheat in South Africa and to analyse the impact of various policy alternatives on the wheat sector over the 2002 to 2008 period.

The first part of this dissertation provided the theoretical foundation that was required to develop econometric models. In the following chapters a structural econometric model was developed for the wheat sector and the underlying structure of this sector was conveyed by means of a flow diagram as well as a P-Q diagram. Capturing the underlying structure of each sector proved essential to successfully build a robust econometric model. The model building process began with the estimation and evaluation of single equations. After the single equations were evaluated they were collapsed into one system and estimated simultaneously using the Two-Stage-Least-Squares modelling technique. Endogenous variables were simulated and plotted over time to determine the tracking ability of the model as well as its ability to capture the turning points in the data. Theil's inequality coefficient and the RMSE percentage error validated the goodness-of-fit of the model. The final step in the validation process was the generation of impact multipliers. Impact multipliers provided the changes that occur in endogenous variables from shocking the important exogenous variables in the model.

The next step was to make baseline projections. The input values for the exogenous variables over the projected period were obtained from FAPRI's 2002 baseline. A number of assumptions were made mainly relating to agricultural policies, the macroeconomic environment, and weather conditions, which implied that the baseline projections were associated with a number of uncertainties.

In the final part of this dissertation, these uncertainties were investigated by means of a scenario analysis, which meant that the constructed model be used to make projections, taking into account different policy shifts that would result in a change in the macroeconomic environment. The impacts of these policy options were assessed through the comparison of the results obtained under each scenario with the baseline projections. For the first scenario analysis, the import tariff for wheat was eliminated and for the second scenario analysis the exchange rate was depreciated by twelve percent in 2003. The category of scenario analysis thus ranged from a direct policy shift in the first scenario to a shift in the macroeconomic environment in the form of an exchange rate devaluation in the second scenario. Importantly, scenario analyses must be conducted in such a way that they easily accommodate future expectations of the South African economy, taking into consideration all the recent trends in the economy as well as the political environment. By conducting this kind of scenario analysis the model provided quantitative evidence, which could potentially prove to be valuable in the formulation of future government programs. Policy and business decisions can now be assessed using a range of *"what if"* questions.

Although the model developed in this dissertation contributes significantly to the modelling and understanding of the South African wheat market, there are several issues regarding specifically the modelling itself and the relevance and application of such models that need to be addressed. The first, is the nature of the knowledge and understanding that the modeller has of the sector, he or she is about to model. Without this basic understanding and intuition for the market, the model builder will have difficulty specifying the model.

A thorough understanding of the decision-making behaviour of the producers and consumers in the wheat industry requires a conceptual understanding of the wider economic and political environment within which they operate. It is only when simulation models are developed with the necessary background knowledge and understanding of the industry that they will be able to satisfy the requirements of the market, with respect to the provision of quantitative information, and to serve as a policy analysis tool. If the dependent and independent variables are not chosen correctly for the estimation process, the models will be worthless for any form of policy analysis work. Once the estimation process has commenced it is important that the modeller work closely with industry specialists, who can assist with frequent "reality checks". The whole debate regarding the price to which wheat producers respond, illustrates the necessity of a "reality check" What happens in reality? Do the majority of farmers use the futures markets to hedge their price levels or do they base their decisions to plant on the previous years' price. There are opportunities for future research to address this issue.

The second important issue to take into consideration is the fact that this model was not developed with the necessary interaction between the different commodity and livestock sectors. Other sectors are regarded as exogenous to the system. The model developed here should ideally be integrated into a larger model, which incorporates many more policy variables. This would enable one to perform a more complete analysis. Sunflower and mutton are the substitute commodities for wheat in the summer and winter rainfall region respectively. It would, therefore, be appropriate to develop similar models for the oilseed and livestock sector to enable the full integration between the wheat, oilseed, and livestock sector. Producers want to maximize their profit and thus will allocate their resources to the activity, which generates the highest level of profit. Fully integrated models will have the ability to capture this alternative use of resources. Limited alternative uses of resources will decrease the elasticity of demand and supply functions.

Therefore one may question whether wheat is just some homogenous product? If the characteristics of the raw product (in this case wheat) could be changed, would it not be possible to service a series of new demand functions? What is the relevance of this model, if wheat is considered to be a homogenous commodity? The ideal would be to have a supply and demand function for every form of wheat and then collapse all of these equations into a single system of equations. This is, however, not possible since the differentiation of wheat increases consistently as more cultivars are developed for the production of specific products and value gets added to the product in order to suit the needs of the consumer. Hence, sufficient time series data is unavailable for econometric modelling techniques. Future studies should, however, make a distinction between bread, flour, and animal feed by means of estimating a demand equation for each of these commodities and then include them in a system of equations.

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