Decision-making in Agriculture:
A Farm-level Modelling Approach

by

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God, the Creator and Master of the ultimate system. He allows us as humans and scientists to attempt to comprehend this ultimate system, and at the same time to enjoy it – to Him all the glory and praise!

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ABSTRACT

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In the past decade South Africa experienced major political and economic changes. In addition to these major changes, South Africa is a highly diverse country and a country of extremes in many respects. Within this dynamic and diverse environment the agricultural sector has to survive and grow financially. In order to survive and grow, good decision-making within the agricultural sector in terms of policies and business strategies is extremely important and necessary. However, within the dynamic and extreme environment it is very difficult for decision-makers to make correct decisions since the likely impact of changes in markets and policies is difficult to quantify.

The general objective of this dissertation is to identify and construct a type of farm-level model that will have the ability to quantify the likely impact of change in markets and policies on the financial viability of a representative farm. The specific objective is to construct a model of a representative grain and livestock farm in the Reitz district, Free State province, South Africa.

The approach to farm-level modelling that is followed is a positivistic approach since questions of "what is the likely impact" is asked, and not "what ought to be" questions. Apart from behavioural equations, this farm-level simulation model also

consists of accounting identities. The model is of a deterministic type since explanatory and descriptive types of questions need to be answered.

The development of this farm-level model contributes to research in the field of farm-level modelling in South Africa due to the fact that it has the ability to simulate the impact of changes in markets and policies on a representative farm's financial position. This is done by linking the farm-level model to a sector-level model developed by Meyer (2002) as well as outputs from several other institutions in terms of macro-economic variables and social variables. There are, however, several issues that became clear in this study. Firstly, positivistic simulation models have the disadvantage that validation and verification are difficult and time consuming due to lack of accurate and detailed data. Secondly, due to the positivistic nature of the model, the assumption is made that very little adjustment in terms of the farm structure takes place during the simulation process. One possible solution to this problem of not being able to simulate adaptation to changing conditions is to develop a model following a normative approach. The third problem with specifically the deterministic type of model is the fact that the model and simulation process assumes no risk. Lastly, in following the positivistic approach, the modeller needs theoretical as well as practical knowledge and understanding of the system modelled and simulated, in order to simulate reality as closely as possible.

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

South Africa is a diverse country and a country of extremes in many respects. This is evident from its wide range of topographic, climatic, social, political and economical characteristics. Topographically and climatically South Africa consists of winter and summer rainfall areas, tropical areas and deserts, mountains, coastal flats, escarpments and plateaus. In terms of social and political characteristics, South Africa is even more diverse as is evident from the fact that South Africa has eleven different official languages as well as a wide range of political parties representing many different views and opinions. The economic extremity is most evident in the large income distribution differences.

The South African economy's composition during 2001 in terms of primary, secondary and tertiary sectors was 10,8%, 38,1% and 51,1%, respectively (Absa, 2002: 13). Mining is the most important primary sector, construction and food the most important secondary sectors and finance, insurance and business services the most important tertiary sectors in terms of contribution to the total value of production of the South African economy. The direct contribution of the agricultural sector to gross domestic product (GDP) is an estimated 4,5% (National Department of Agriculture, 2001), which is relatively small. However, when the relative importance of agriculture in terms of job creation and livelihood is analysed, it is found that an estimated one million people are dependant on agriculture for a livelihood (National Department of Agriculture, 2001). This makes the agricultural sector relatively important for South Africa, especially in terms of the survival and growth of the South African economy.

During the period 1992 to 1997, the agricultural sector was transformed from a highly regulated sector to an extremely open sector. The regulation process started in 1912 with the promulgation of the Land Bank Act. In the following decades, several acts were promulgated, including the Marketing Act of 1937 that was eventually consolidated into the Marketing Act, No. 59 of 1968 (Vink & Kirsten, 2000: 5).

However, Vink (1993) indicates that the deregulation of the agricultural sector started outside agriculture in the late 1970s with the De Kock Commission's inquiry into the monetary system and monetary policy in South Africa. The deregulation of the agricultural sector gained greater momentum with the recommendations of the Kassier Committee in 1992, but it wasn't until after the first democratic elections held in 1994 that changes in the agricultural sector started to take place at a more rapid rate. The most significant changes took place when the government promulgated the Marketing of Agricultural Products Act, No. 47 of 1996. The effect of the 1996 Marketing Act was the total change of the management of marketing policy, which opened the sector to world markets and their influences (Vink & Kirsten, 2003: 4).

At present, the highly dynamic and unpredictable agricultural environment in which agribusinesses, farmers and government have to operate significantly increases the difficulty of making decisions in order to ensure attainment of objectives and financial survival and growth. Government needs to take decisions with regards to policy that will ensure the maximization of the welfare of the South African population and at the same time attaining the objectives set for land redistribution and black economic empowerment. Agricultural businesses and farmers need to take decisions in terms of production, procurement, marketing and financial management which will ensure the financial survival and growth of the agricultural business or farm. However, taking this range of decisions in order to attain the set goals and objectives within a highly dynamic and diverse environment is very difficult and in many instances almost impossible.

The scientific field of decision-making or decision-analysis offers a wide range of options in terms of different approaches, procedures and methods in order to facilitate better decision-making. Modelling and simulation forms part of these procedures and methods to facilitate better decision-making through better understanding of the impact of exogenous and/or endogenous change. Various types of models on industry level as well as farm level can serve the purpose of enhancing the understanding of different agricultural industries or systems on a micro as well as macro level. A better understanding of the different agricultural systems is likely to lead to better understanding of the underlying dynamics and risks inherent to each system and subsystem, thereby improving decision-making with regards to business strategy and government policy.

1.2 PROBLEM STATEMENT

1.2.1 GENERAL PROBLEM STATEMENT

Decision-makers within the agricultural sector don't always know how change will affect the agricultural environment. Hence, the difficulty of making good decisions with regards to policy and business strategies increases significantly, especially in the case where the agricultural sector exists within a highly dynamic and diverse environment.

1.2.2 SPECIFIC PROBLEM STATEMENT

Decision-makers within the South African agricultural sector lack a tool to analyse the likely impact of change in policies and markets on the agricultural sector. The lack of analysis leads to a lack of understanding of the agricultural sector's environment, therefore increasing the difficulty of making decisions with regards to policy and business strategy.

1.3 OBJECTIVES OF STUDY

1.3.1 GENERAL OBJECTIVES

The general objective of this study is to develop a deterministic farm-level model of a grain and livestock farm. The farm-level model must serve the purpose of analysing the effect of changes in policy and markets on the financial viability of the farm. The effect of changes in policy and markets on the farm will be analysed and quantified by linking the farm-level model to an econometric sector-level model developed at the University of Pretoria (Meyer, 2002). The quantification of the impacts of change in different variables is likely to lead to a better understanding of the dynamics of the system leading to improved decision-making.

1.3.2 SPECIFIC OBJECTIVES

The specific objective of this study is to develop a representative farm of a study group in the Reitz district that is managed by Vrystaat Koöperasie Beperk (VKB), a co-operative active in the Free State province. The reason for selecting a farm in the Reitz district is twofold; firstly mostly grain and livestock are produced in the specific area and secondly high quality secondary data were available for the specific area from the VKB economic bureau.

The system of models, namely the linking of the sector-level model with the farm-level model, will be used to simulate and quantify the effect of different scenarios on the financial viability of the representative farm. Firstly, a scenario will be simulated quantifying the likely effect of a Rand/US dollar appreciation. The second scenario will analyse the impact of an alternative wheat import tariff and, thirdly, the impact of world trade liberalization will be simulated and analysed. Each of the three scenarios is discussed in detail in Chapter Seven of this study.

1.4 OUTLINE OF THE STUDY

The dissertation consists of eight chapters. The first chapter introduces the problem statement as well as the objectives of the study. Chapter Two aims to discuss the system theory and the application of the system theory to different approaches and methods to farm-level modelling. The purpose of studying the different approaches and methods of farm-level modelling is to identify an approach and method with the ability to simulate changes in markets and policies and the long-term effect it has on the financial viability of a representative farm in the Reitz district, Free State province. The third chapter takes a brief look at firm theory in terms of technology, profit maximization and cost minimization as well as the theory of financial statements and ratio analysis. The motivation for studying firm theory is to attempt to understand the underlying principles and dynamics of the farming system to be modelled and simulated. In the fourth chapter a literature study is done on the type of farm-level model that has been identified in Chapter Two as the suitable model for attaining the general and specific objectives outlined in Chapter One. Chapter Five develops the farm-level model structure, while Chapter Six presents the validation and verification results of the model. In Chapter Six Simetar software, developed by James Richardson at the University Texas A & M, is used to aid in statistically validating some of the output results of the simulation model. Chapter Seven reports on the baseline as well as the three different scenario simulation results. A summary and concluding remarks are provided in Chapter Eight.

CHAPTER 2
SYSTEM THEORY AND FARM SIMULATION MODELS

2.1 INTRODUCTION

Agriculture and the environment in which it operates have become increasingly complex, due to significant changes that have taken place over the past decades. During the early 20th Century, most agricultural products were produced by means of labour and the majority of the produce was used for own consumption. However, as time progressed labour was substituted for machines, production became more market-oriented and consequently the practice of farming transformed from " a way of living" to business enterprises run on business principles. At present, evidence of these changes can clearly be seen in everyday life: biotechnological products are produced, the world economy has become highly competitive and sensitive because of globalisation, precision farming is done by means of satellites and computers and specifically designed computer software is used to assist agribusiness managers in management decisions. The increasing complexity of agriculture, its environment and consequently agricultural systems, have made correct decision-making regarding production, marketing, finance and policies much more challenging and difficult.

Approaches and methods that were successful in analysing and explaining agricultural phenomena in the early 20th Century lost explaining power due to the increased complexity of agricultural systems. The result was that agricultural economists were forced to consider other approaches and methods to analyse and describe agricultural systems and their functioning in order to facilitate better decision-making. Consequently, the systems approach as well as the methodology and methods of constructing models and developing simulation techniques were adopted and further developed to be utilised in an agricultural context.

The objective of this chapter is to provide a general background on the system approach, the general system theory, and different types of systems in agriculture. The impact of the general system theory on the philosophy and methodology of modelling and simulation will be reviewed in terms of the two types of models, namely deterministic and stochastic models as well as the two different approaches towards modelling, namely normative and positive. The different methods of modelling that emanated from the two different approaches as well as the advantages and disadvantages of each of these methods will be discussed. The chapter ends with a summary and conclusion on which modelling approach and method is to be used in the study given the general and specific problem statement as specified in the previous chapter.

2.2 SYSTEM APPROACH IN AGRICULTURE

The basic principle of the general system theory is to study the relationships between objects or phenomena as they exist. The implication of the general system theory is that an object existing in reality can be studied correctly by studying the environment in which the object is situated as well as the factors that influence this object's environment.

The system concept, also referred to as the system approach, was the result of mainly two gradual processes taking place in the scientific world during the 20th Century; firstly the integration of different scientific fields due to the interrelationship of fields and secondly a more practical approach to research in order to solve theoretical as well as practical problems (Csáki, 1976: 13 and Johnson & Rausser, 1977: 158).

Csáki (1976: 13, 14) argues that the system concept or approach originated from the general system theory – a theory developed by a Hungarian biologist named Ludwig von Bertalanffy in the late 1960s. Bertalanffy (1968: 12, 19) explains that the idea of a system approach and resultant general system theory started when he became puzzled by the gaps or shortfalls that existed in the research and theory of biology during the early 1920s. The shortfalls in the research were ascribed to the fact that the research of that time was based on analytical procedures. The application of analytical procedures was based on the argument that by breaking down an object into its different components, and then studying each of the components in isolation, one would be able to understand the original object better. However, in order to successfully apply analytical procedures, the following two assumptions have to apply: firstly, interaction between the different components of the object has to be absent or extremely weak and, secondly, the relationships between the different components of the object have to be linear. However, in most systems these two assumptions do not hold, and therefore a different approach from the analytical approach was needed. Hence, the idea of a general system approach or theory was born.

The concept of a general system approach, although not formally termed system approach, concurrently emerged in several fields while Bertalanffy developed the theory of the general system. This was evident from the development of cybernetics, information theory, game theory, decision theory, topology of relational mathematics and factor analysis, which all form part of a general system approach (Bertalanffy, 1968: 90).

One can argue that the economy, and therefore the agricultural economy, consists of a hierarchy of interrelated systems. In order to explain the relations between the different systems, as well as the interrelationships within each of these systems, one must be able to calculate and measure these relationships and interrelationships as well as the effects of changes in system elements and their relations to other elements and systems.

Since economics is defined as "the branch of knowledge concerned with the production, consumption and transfer of wealth" (South African Pocket Oxford Dictionary, 2002: 279), it implies in essence that economics and the science of economics, which includes agricultural economics, have become a theory of choice (Judge; Johnson and Rausser & Martin, 1977: XV). Thus, in order to explain and understand the different systems present in economics and agricultural economics, decisions and therefore choices have to be analysed and understood. The majority of decisions taken as a result of certain choices cannot simply be based on information that indicates that all variables influence all other variables, but rather on what the magnitude or probability of magnitude of the relationships between the different variables are and what direction these relationships take (Judge et al., 1977: XVI). Thus, decisions or choices need to be quantified in the study of systems.

2.3 SYSTEMS IN AGRICULTURE

Johnson et al. (1977: 158) wrote that extension, teaching and research in agriculture have gradually been moving toward a system approach since the late 1920s. However, during the late 1960s and 1970s with the formalization of the system approach, it started to play an increasingly important role in agricultural research, and provided a sound basis for advancement in teaching and research in agricultural economics (Johnson et al. 1977: 157 and Csáki, 1976: 14).

The South African Pocket Oxford Dictionary (2002: 923) defines a system as "a set of things working together as a mechanism or network." Csáki (1976: 16) assumes that determinative interrelations exist between the elements of the system when the word system is used. Johnson et al. (1977: 161) defines a system as a set of elements or components between which interrelationships exist, and of which the set has a specific or several purposes. Bertalanffy (1968: 55) defines a system as a set of objects between which relationships exist, and describes the characteristics of a system as "... wholeness, growth, differentiation, hierarchical order, dominance, control, competition…".

Taking the above definitions and characteristics into account, a system can thus be defined as a set of elements between which there exists dynamic and hierarchical interrelationships, and together these elements act as a system or organization towards one or several purposes. To define a system in an agricultural context therefore depends on the interrelationships, the characteristics and the purpose of the system.

Csáki (1976: 18) distinguishes between four agricultural systems based on the complexity of the system's interrelationships:

- Production systems. Production systems are the systems that refer to the physical production of a tangible agricultural product under specific climatic and physical conditions. This type of system is the simplest of the agricultural systems, since it only includes the physical processes of production. The agricultural production system is the closest to the biological system underlying agriculture. Examples of production systems are the production of livestock or the production of specific types of crops. Due to the difference in biological processes involved in the different types of agricultural products, production systems can be classified according to the type of product being produced such as livestock, grain, vegetables, etc. It can also be classified according to the climatic or natural conditions under which it is produced, for example tropical or Mediterranean, or the type of technology being applied in the production, for instance dry land or irrigation.

- Enterprise systems. Enterprise systems are systems that refer to the production of agricultural products within the confinements of a specific legal and economic system. The enterprise system represents a complex economic system, which includes different production, management, social, legal, technological and political systems. Enterprise systems are not necessarily involved in the production of agricultural commodities, but produce other products or services that are related to agriculture and agricultural production. An example of an enterprise system is a farm producing wheat in a specific region of a specific country.

- Regional and national systems. Regional systems are the transitional systems between the enterprise and the national systems. These systems account for a specific climatic area, provincial area or state within a country. The national system is the sum of all the regional systems within a country.

- International and global systems. International systems consist of national systems within a specific region or a trade block of the world, while the global agricultural system consists of all the different international systems in the world.

Johnson et al. (1977: 164) base the classification of systems on the types of components, relations and system purposes. They describe the following classes of systems:

- Stochastic or non-stochastic systems. A stochastic system contains random elements and therefore the majority of the relationships between the different elements in the system are also random. In a non-stochastic system, all values of all elements are definite, and therefore the relationships between the different elements in the system are definite as well.

- Static or dynamic systems. Static systems do not have time as a factor influencing the elements and interrelationships of the system. In the practical world there are very little examples of such systems. However, much of the neoclassical economic theories, theories underlying modern economic theories and thoughts, were based on the assumption of static systems. Dynamic systems do contain time as a factor that influences relationships and elements in the system. Many of these systems have a "feedback" effect where information flows take place between different time periods, which make these systems sequential.

- Open or closed systems. Open systems are systems that are influenced by changes in the environment of the system. In a closed system, changes in the system's environment do not influence the elements or relationships in the system.

2.4 MODELLING AND SIMULATION: BACKGROUND

The history of science indicates that two approaches have been employed with respect to quantitative knowledge, namely postulation or logical argument, and experimentation or measurement (Judge et al., 1977: XVI). Judge et al. (1977: XVII) indicate that the result of the logical argument approach is economic theory and mathematical economics, but the problem with this approach is that although it provides the consequences of the system, it doesn't indicate the truthfulness of the knowledge relative to real-world phenomena. The measurement approach provides a basis to prove, refine or to modify the results of the logical route, as well as to assign magnitude and direction in terms of signs to the logical results. This can then be used as a basis for making decisions. However, the problem with the measurement approach is that the economic systems that are observed in order to draw conclusions are systems that are stochastic, simultaneous and dynamic, thus making inference from observed data to relations extremely difficult.

Based on the measurement approach, humans developed a scientific methodology of systems representation termed modelling and an experimental methodology termed simulation (Johnson et al., 1977: 161 – 162). The development of these two methodologies occurred in order to help decision-makers and researchers represent complex systems in a comprehensible form, so that experimentation can be done according to these systems in a simplified manner. The results of the experiments assist decision-makers and researchers in understanding and predicting the behaviour of the systems.

2.4.1 DEFINITION OF MODELLING AND SIMULATION

Various definitions and methods of modelling and simulation exist in literature. Modelling and simulation are defined by Johnson et al. (1977: 162) as follows: "… modelling is building a representation of a system, while simulation is defined as experimentation with the represented system by means of the model". Simulation therefore implies an experiment of which the objective is to represent or reproduce the relationships between objects or persons in a real-world system and to predict the likely behaviour or response of these objects or persons in the specific system (Csáki, 1976: 25).

2.4.2 THE PROCESS OF SIMULATION

In natural sciences, simulation is most often done by means of a physical model, but in the case of economics it is virtually impossible to build a physical model for experimental purposes. The reason is that there are too many variables, mainly social variables, that can't be captured in a physical economic model that influence the economic system significantly, rendering an economic experiment worthless if done by means of a physical economic model. In agriculture, many experiments are conducted by means of a physical model in the case of biology or agronomy, but in agricultural economics most experiments are conducted by means of computer models. The reason for the usage of computer models is the same as in the case of economics.

Since the main objective of simulation is to describe reality as realistically as possible, many different approaches to simulating agricultural problems exist. However, according to Csáki (1976: 36) the logic of simulating agricultural systems remains very similar in the majority of cases cited in literature (Fig. 2.1).

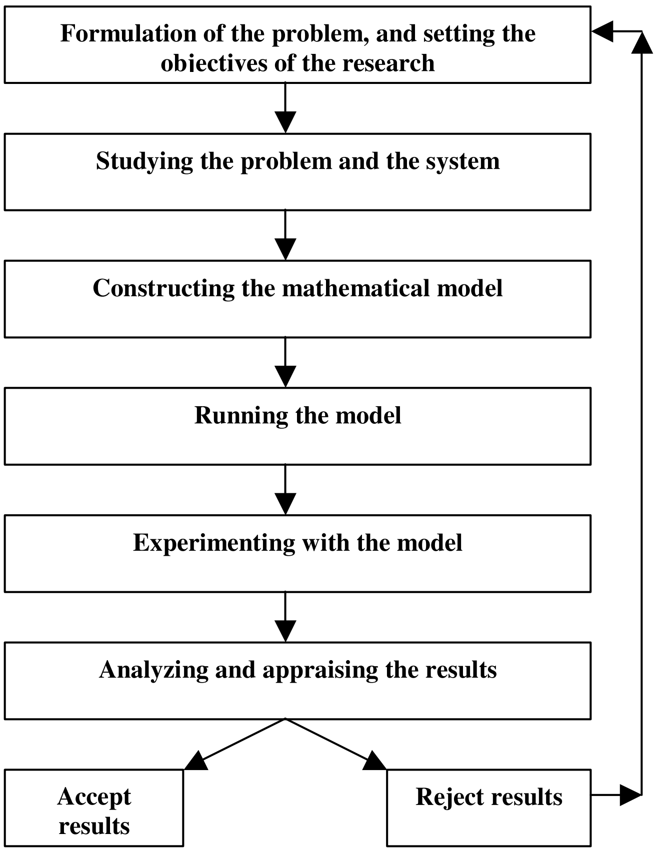

Figure 2.1: The order of implementation of simulating economic problems

2.4.3 DIFFICULTIES OF SIMULATION

Since humans form an integral part of all economic and most agricultural systems, it is important to include human behaviour or decision-making in the simulation of most agricultural systems. However, it is difficult to simulate and measure decision-making of humans, which makes relatively accurate simulation of agricultural systems difficult.

The study of human beings started from the time that humans were able to reason. However, the statistical basis of sociological research only gained impetus during 1662 with the publication of the book *Natural and Political Observations made upon the Bills Of Mortality* by John Graunt (Bernstein, 1996: 75). With the development and adoption of statistical methods and mathematical methods in the social sciences, criticism intensified against the use of mathematics in social sciences, especially from the nineteenth century onwards. The main argument that mathematics cannot play an essential role in the development of social sciences was that "…human beings are not amenable to mathematical law…" (Judge et al., 1977: XV). According to Judge et al. (1977: XV, XVI) it is important to be able to measure and to calculate social trends. The reason for that being that economics, and therefore economic research, has developed into a theory of choice, and thus to be able to understand the relations among economic variables, one has to have the ability to measure and to calculate.

2.5 FARM SIMULATION MODELS: TYPES AND PURPOSE OF MODELLING

The type of farm simulation model to be used depends on the *type of system* being modelled as well as the *purpose of modelling or simulating* the system (Johnson et al., 1977: 166). The literature distinguishes and discusses two basic types of models, namely deterministic and stochastic models, based on the type of agricultural system being modelled (France & Thornly, 1984: 12; Johnson et al., 1977: 171 and Richardson, 2003).

Furthermore, based on the purpose of modelling and simulation, Richardson (2003, Chapter 2: 2) describes two basic approaches to farm simulation namely a normative approach and a positive approach. The normative approach, in the context Richardson uses it, implies optimising a system or attempting to quantify "what ought to happen" to the system, while the positive approach implies describing a system or attempting to quantify "what is likely" to happen to a system. The following two sections attempt to give a more detailed description of the two basic types of models as well as the two different approaches.

2.5.1 DETERMINISTIC VS STOCHASTIC MODELLING

Deterministic models are models in which the probabilities of the different model variables' values are one, and in which the system relationships are constant. The output of a deterministic model is therefore definite. According to Richardson (2003: Chapter 2:2) deterministic models are models that don't incorporate risk because of the fixed nature of the variables' values and the fixed nature of the interrelationships in the system. Consequently, deterministic models are used to simulate specific outcomes given a set of specified inputs.

Stochastic models contain random variables and relationships, and therefore the output of the model consists of random elements or probability distributions. Stochastic simulation models incorporate risk by assigning probability distributions to specific exogenous and endogenous variables. Key output variables are simulated and represented by probability and cumulative distributions. The probability and cumulative distribution functions are used to quantify and compare the risks associated with different scenarios and decisions.

Johnson et al. (1977: 171) argue that a combination of a deterministic and stochastic model results in an adaptive model. Adaptive models are based on a system that adapts itself to internal and external change, and thus incorporates learning processes. In order to be adaptable, the system contains both elements of a deterministic as well as a stochastic nature. At the start of the simulation process, uncertainty exists regarding some variables and relationships while the probabilities of other variables' values and relationships are one. As the simulation process progresses through time, the stochastic elements in the model decrease as more information is obtained on these stochastic variables and relationships.

2.5.2 PURPOSE OF MODELLING: NORMATIVE VS POSITIVE

2.5.2.1 THE NORMATIVE APPROACH

The literature indicates that a number of methods have been developed and used when following a normative approach to farm simulation. Included in these methods are those described by Csáki (1976: 22):

- Mathematical programming
- Mathematical statistics
- Production functions
- Input-output analysis
- Network analysis

Mathematical programming models in general consist of mathematical relationships and constraints that are solved in order to calculate an optimal solution to a system given a set of constraints. In other words, the answers that are obtained are normative answers or “what ought to be” answers (Richardson, 2003: Chapter 2:2). A great body of literature exists on mathematical programming. During the 1970s mathematical programming developed in order to apply it to problems to reflect reality to a greater extent. Types of models that developed were linear-dynamic models, integer and non-linear programming (Csáki, 1976: 22).

Brockington (1979: 11) distinguishes between input-output models and mechanistic models. The purpose of the input-output model is to represent the system modelled as closely as possible, without explaining the internal relationships between the system’s elements in detail. The focus of an input-output model is thus on the results of the model given a set of inputs, and how closely these results represent the real outputs of the system being modelled. Conversely, mechanistic models focus more on the internal relationships of the system and how they occur in reality, and is therefore a much more detailed and data intensive type of model.

Dent & Blackie (1979: 10) indicate that although mathematical programming models are part of simulation models, there are several considerations that have to be taken into account before using mathematical programming as simulation models:

- As mathematical programming is based on a rigid framework, it imposes rigidity on the model structure.
- The need for detailed interactive data in order to define the different equations used in mathematical programming makes it a very difficult process, since there are often data shortages or data errors in many systems in agriculture.
- Many mathematical models render solutions for specific criteria, which is often not realistic in agricultural systems. The defining of multicriteria mathematical models in agriculture is complex and therefore is very difficult and time-consuming.
- It is very difficult to incorporate stochastic and dynamic elements into mathematical programming models. This has the implication that it is not a very realistic representation of the actual system being modelled.

Csáki (1976: 23) indicates that the analytical methods of mathematical programming, mathematical statistics, production functions, and input-output analysis and network analysis have shortcomings regarding certain practical and theoretical problems. According to Csáki input-output analysis, in its most general form, disregards time as a factor and therefore assumes that relationships and change in relationships take place at a given moment. Furthermore, he writes that although analytical methods resulted in considerable advancement of traditional logical calculation procedures, the optimising nature of these methods has certain shortcomings regarding certain problems, since it is not always possible to describe some problems analytically or calculate an optimal solution for an analytical problem. He therefore argues that other methods should be developed that can add to analytical procedures in order to solve economic problems. He concludes that a method that reflects reality as realistically as possible will be more useful than a process of calculation that leads to a certain optimal solution.

2.5.2.2 POSITIVE APPROACH

Richardson (2003: Chapter 2:2) describes a non-optimising or positive approach to farm simulation models. When a positive approach is followed, farm-level simulation models, in general, consist of statistical relationships as estimated from historical data as well as accounting identities that are used to simulate a system in order to find positive answers (what the likely outcome of the system is). Basing the system's interrelationships on actual historical behaviour and then making assumptions on stability of interrelationships in future therefore bases this approach on the argument of Csáki of attempting to reflect reality as realistically as possible.

According to Dent et al. (1979:11) several advantages as well as disadvantages exist in using "free form models" instead of mathematical programming models. Free form models are models that are "run" rather than solved which implies that the operation and further development of the model is done by means of intensively studying the system through the model and making adjustments to the model to represent the system even more realistically. This implies that a thorough knowledge of the system being studied is needed, and a lot of time needs to be spent on studying and understanding the system. Both these implications can be advantageous and disadvantageous. Louw (1979: 64) argues that one shortcoming of free form or positivistic simulation models are the fact that no single optimum solution is obtainable from a typical simulation model. Therefore all simulations run by such a model is subjective since the researcher her/himself decides on the different alternative options to be simulated. A problem pointed out by Throsby (1974: 159) and Wright (1971: 24) is that the simulation process is in many instances costly and time consuming. Furthermore Louw (1979: 64) indicates that in the case of simulating an individual farm business, it is not practical enough. Other shortcomings are that a lot of time is spent on validating and verifying the model, and in many instances very little accurate historic data exist with which the model can be validated and verified. Since the purpose of a positivistic simulation model is to simulate reality as accurately as possible, validating and verifying the model is of the utmost importance before the model can be used to assist decision-making.

2.5.2.3 COMBINATION OF THE NORMATIVE AND POSITIVE APPROACH

Brockington (1979: 14) describes synthetic models, which is a form of mechanistic modelling. In synthetic modelling, according to Brockington, the system is broken into its different components. Each component is then modelled individually, after which the models and results of the individual components are added together in order to form a larger system of models in order to represent the system as a whole functioning entity. Brockington (1979: 17) distinguishes between two different types of synthetic models namely simulation models and optimising models. The general purpose of simulation models is to represent or imitate the real system as closely as possible, while the general purpose of optimising models is to search for or to calculate the "best" or optimal way to operate or manage the system. Brockington (1979: 17) argues that the use of both types of simulation models and optimising types of models are essential in the study of a system, since a system's behavioural description by means of a simulation model is an essential prelude to devising optimum management strategies by means of an optimising model.

2.5.2.4 DISTINCTIONS WITHIN EACH APPROACH

Several distinctions have been made in the literature within each of the normative and positive approach. The same distinctions are found in both approaches and therefore the distinctions are discussed once but apply to both approaches.

Judge et al. (1977: 166) describe the following types of models:

- Descriptive models. The researcher observes a specified system, and constructs a model that describes the realistic functioning of the system being studied.
- Explanatory models. According to Judge et al. (1977: 167) the objectives of an explanatory model are in essence the same as those of a descriptive model, with the only difference that the explanatory model is causal. Causal is defined by Judge et al in a statistical sense, thus if a variable (a) is a cause of another variable (b), variable (a) can be controlled directly by indirectly controlling (b).
- Prediction models. These models tend to focus more on forecasting accuracy than on internal working.
- Decision models. These models tend to be optimising models, since the problem or system analysed is a system for which an optimal solution is sought.

France and Thorniley (1984: 12) distinguish between empirical and mechanistic models based on the purpose of modelling and simulating the system. The purpose of an empirical model is to describe a system while the purpose of a mechanistic model is to describe but also add reason or understanding to the description.

Csáki (1976: 108) describes four different types of models:

- Production oriented models. These models are used to simulate farm production activities in more detail. It therefore describes the production processes of commodities in detail.
- "Budgeting" models. The basis of these models is the accounting system of the farm and the purpose is to describe the financial processes and relationships of the farm within a relatively simple framework of physical production of commodities.
- Simulation of farms based on the principles of industrial dynamics: The purpose of this type of model is to describe the basic management processes and relate these to the basic production processes by means of flow speeds, levels and delays.
- Enterprise simulation models incorporate the planning and decision-making processes involved in a specific enterprise of a complex farming system.

2.6 SUMMARY AND CONCLUSION

Agriculture and the environment in which it operates have become increasingly complex due to significant changes that have taken place over the past decades. Due to the increased complexity and interrelatedness, the general system theory or system approach was adopted in agricultural economics in order to improve research as well as practical problem-solving in order to improve decision-making. This led to the introduction as well as improvement of several different approaches and methods of modelling and simulation in agricultural economics.

The two basic types of models that exist based on the type of system being modelled are deterministic models and stochastic models. Additional to these two types of models, two different approaches exist in modelling based on the purpose of the modelling and simulation exercise, namely the normative or mathematical approach and the non-mathematical or positivistic approach. Within each of the two approaches several additional distinctions are made between different types of models.

The system that this study attempts to model and simulate is partly a deterministic system and a stochastic system, as well as an open, dynamic system since it is time-related and influenced by changes in its environment. From the objectives and problem statement of the study it is clear that the purpose of the study is to create a "tool" that will enhance understanding of a system, hence a descriptive as well as explanatory model should be constructed. Furthermore, the model and simulation results will be applied in terms of answering questions regarding "what if" scenarios, therefore the models should be more oriented towards behavioural variability. From this it can be concluded that a deterministic type of model will be built, following a positivistic approach that is based on actual behavioural trends as estimated from actual farm-level data. Since the focus of the farm-level models is on the financial viability of the farm, financial outputs will be needed, hence a budgeting type of model consisting of statistical relationships as well as accounting identities will be constructed.

CHAPTER 3
THEORY OF THE FIRM, FINANCIAL STATEMENTS AND RATIO ANALYSIS

3.1 INTRODUCTION

Modelling and simulation can serve as tools to study a system or a set of interrelated systems. Based on the results from the study of a system, conclusions can be made in terms of understanding the system better but also predicting the behaviour of the system according to a specific set of assumptions. However, in order to study a system correctly, the system has to be defined and its characteristics in terms of interrelatedness should be well understood. Additional to defining and understanding the system, the purpose of studying the system has to be clearly defined, which means the questions to be answered from studying the system should be clearly set out and fully understood.

The first chapter of this study set out the general objective of creating a farm-level simulation model with the purpose of analysing the likely effects of changes in markets and policies on the financial viability of a grain and livestock farm. This implies that the outputs of the model should be financial outputs in terms of financial statements, financial quantities and financial ratios. These outputs can then be used to quantify the likely impact of changes in markets and policies on the financial position and thus the financial viability of the farm.

Chapter Two outlined the different approaches to modelling and simulation as well as the different types of models with the purpose of identifying the approach and type of model with the ability to model and simulate a farm and the impact of changes in markets and policies on its financial position. The conclusion in Chapter Two was that a positivistic modelling approach should be followed. The structure of the model should be based on actual behavioural trends as estimated from actual farm-level data, the model should be of a deterministic type since the purpose of the simulation is to describe and explain, and the model should be a budgeting type of model consisting of statistical relationships as well as accounting identities. Additional to the above characteristics, the farm-level model should have the ability to be linked to agricultural-sector level models as well as macro-economic models in order to be able to simulate the effects of changes in markets and policies.

The purpose of Chapter Three is to present some theoretical concepts on the behaviour of a firm, financial statements and ratio analysis. The reason for discussing these theoretical concepts is that it forms part of the underlying structure of the farm system, and to a great extent influences the interrelationships within the system as well as the interrelationship with other systems. By understanding the theoretical concepts, a better understanding will be gained of the farm system, especially the financial part of the system. The understanding of the theoretical concepts will serve as background for the literature study on positivistic simulation models in Chapter Four as well as the description and development of the farm-level model structure in Chapter Five.

3.2 THEORY OF THE FIRM

When producing a product or delivering a service, a firm utilises different production factors namely land, labour and capital (Varian, 1999: 314). In the production process the firm is faced with choices as well as constraints. These constraints are a result of the individual characteristics of the different production factors as well as the interaction between labour, capital and land within a framework of different states of nature. When choices or decisions have to be made in terms of production, these constraints have to be taken into consideration, since they have a direct and indirect impact on the production process.

The first sub-section will discuss the theory on constraints as imposed by nature, thus technology. The second and third sub-sections will discuss the theory of choice in terms of profit maximization and cost minimization.

3.2.1 TECHNOLOGY

The production process consists of inputs and outputs. Inputs to production are termed factors of production. In production theory, factors of production are classified in four broad categories namely land, labour, capital and raw materials. Capital is defined as inputs to production that are themselves produced goods (Varian, 1999: 315).

Nature imposes biological and physical constraints on the production process because only certain combinations of inputs are feasible combinations to produce a given amount of output. The firm that is part of the production process can therefore only limit itself to technologically feasible production plans. In order to describe technologically feasible production plans, all combinations of inputs and outputs that are technologically feasible are listed and called a production set. The boundary of a production set is described as a production function. A production function is defined as the maximum level of output given a specific level of inputs (Varian, 1999). Thus, in the situation where inputs have a cost, a maximum level of output will be produced given the constraint imposed by the cost of the inputs and therefore the amount or level of inputs attained in order to be used in the production process. Different kinds of technology exists namely fixed proportions, perfect substitutes and Cobb-Douglas.

Fixed proportion technology is described by the following equation:

Equation 3.1: $$f(x_1, x_2) = \min\{x_1, x_2\}$$

Where: x_1 = production factor 1

x_2 = production factor 2

The total number of output to be produced under a fixed proportion technology is determined by the minimum level of each of the individual inputs.

Perfect substitutes technology can be described as follows:

Equation 3.2: $$f(x_1, x_2) = x_1 + x_2$$

Where: x_1 = production factor 1

x_2 = production factor 2

The total number of inputs available therefore determines the total level of output. Different combinations of the two inputs will therefore result in different levels of output.

Cobb-Douglas technology is described by the following equation:

Equation 3.3: $$f(x_1, x_2) = Ax_1^a x_2^b$$

Where:

x_1 = production factor 1

x_2 = production factor 2

A = scale of production

a = output elasticity of x_1

b = output elasticity of x_2

The variable A in the Cobb-Douglas function describes the scale of production, thereby indicating the level of output that would be produced if one unit of each input were used. The variables a and b indicate how output will respond given a specific change in the input variable. Thus, if x_1 should change, how will the output or $f(x_1, x_2)$ change.

In the production process, the levels of the inputs can be changed in order to produce different levels of output. In order to describe the change in output due to a change in input levels, the marginal product of each of the inputs have to be described or analysed. The marginal product of an input is described by equation 3.4:

Equation 3.4: $$\frac{dy}{dx_1} = \frac{f(x_1 + dx_1, x_2) - f(x_1, x_2)}{dx_1}$$

Where:

dy = change in output due to change in input x_1

dx_1 = change in input x_1

Thus, the marginal product of an input is a rate of change of output when a change takes place on an input level.

In order to obtain a specific level of output, different combinations of inputs can be used to obtain the same level of output. The tool to analyse the different combinations of inputs in order to produce the same level of output is defined as the technical rate of substitution. The technical rate of substitution is defined as follows:

Equation 3.5: $$TRS(x_1, x_2) = \frac{dx_2}{dx_1} = -\frac{MP_1(x_1, x_2)}{MP_2(x_1, x_2)}$$

Where: $TRS =$ technical rate of substitution

$dx_2 =$ change in input x_2

$dx_1 =$ change in input x_1

$MP_1 =$ marginal product of x_1

$MP_2 =$ marginal product of x_2

According to Varian (1999: 320), the technical rate of substitution measures the trade-off between the two inputs of production. It therefore measures the rate of substitution between the two inputs in order to produce a specific level of output.

Due to the constraints of nature, technology exhibits the characteristics of being monotonic and convex. This implies that a higher level of input will not necessarily have the same impact on the increase in output. Thus, marginal products of the different inputs as well as the technical rate of substitution between the different inputs display the characteristic of diminished effects as inputs increase or decrease above or below a certain level. This is defined as the law of diminishing marginal product and diminishing technical rate of substitution (Varian, 1999: 321).

3.2.2 PROFIT MAXIMIZATION

An operating firm or farm faces the choices of what to produce, the amount to produce and the method of production to be employed. However, the underlying principle on which all of these choices are based is the principle of profit maximization. Thus the firm has to choose a production plan that is likely to maximize profits. Varian (1999: 328) defines profits as revenue minus costs. This can be expressed in mathematical terms as follows:

Equation 3.6: $$\pi = \sum_{i=1}^{n} p_i y_i - \sum_{i=1}^{m} w_i x_i$$

Where:

$\pi =$ profit

$p_i =$ price per unit of output y_i

$y_i =$ unit of output y_i

$w_i =$ price of unit of input x_i

$x_i =$ unit of input x_i

The first term describes the revenue and the second term the cost.

In the production process, time is a fundamental factor influencing production decisions. The reason is that costs incurred in order to produce are either fixed or variable due to fixed and variable factors of production. Varian (1999: 330) defines fixed factors of production as factors of which the quantity being used in the production process is fixed, while variable factors of production are factors of which the quantities can be changed in the production process. Therefore, in the short run both fixed and variable factors of production are used and since there are costs linked to factors of production, the costs are also fixed and variable. However, Varian (1999: 330) indicates that over the long run, all costs are variable since all factors of production are variable. This creates the problem of how to maximize profits over the short run and how to maximize profits over the long run due to the variability and fixed nature of different factors of production and therefore costs.

The problem of maximizing profits in the short run can be represented mathematically as follows:

Equation 3.7: $$\frac{\max}{x_1} pf(x_1, \ddot{x}_2) - w_1 x_1 - w_2 \ddot{x}_2$$

Where: $\ddot{x}_2 =$ fixed input unit x_2

The problem of maximizing profits in the short run entails that the level of production factor x_2 is fixed in the production process. Therefore, in order to maximize profits the output price times the marginal product of input factor x_1 should equal the input price of x_1. Thus, the value of the marginal product of factor x_1 should equal its price. Mathematically it can be represented as follows:

Equation 3.8:

$$pMP_1(x_1, \ddot{x}_2) = w_1$$

$$VMPx_1 = w_1$$

The problem of maximizing profit in the long run entails that all levels of inputs are free to vary, and thus no fixed levels of inputs occur. The problem can be represented mathematically as follows:

Equation 3.9:

$$\frac{\max}{x_1, x_2} pf(x_1, x_2) - w_1 x_1 - w_2 x_2$$

At the optimal point of production, the point of profit maximization, the value of the marginal product of each factor should equal that specific factor's price.

A question following from the problem of profit maximization is the question of what the relationship is between profit maximization and the return to scale. In the case of a firm's production function exhibiting constant returns to scale, the implication is that a doubling in input levels should double the output level and therefore the profit level. However, this implies that the firm is not at a profit maximizing point before the doubling in inputs. This statement thus contradicts the statement that the firm is at a profit maximizing point. Underlying this statement is the assumption that profit levels were positive before the change in inputs. Thus, a firm of which the production function exhibits constant returns to scale should, at all levels of output, record zero profits over the long run. The implication of this argument is that if a firm tries to expand, the scale of operation will increase to such a point where the firm will become inefficient due to management constraints.

3.2.3 COST MINIMIZATION

Given the choices in terms of profit maximization and constraints that the firm faces in the production process, the firm attempts to produce a specific level of output but at the same time attempts to minimize costs. The cost minimization problem is described mathematically as follows:

Equation 3.10:

$$\min_{x_1, x_2} w_1 x_1 + w_2 x_2$$

$$\text{Such that } f(x_1, x_2) = y$$

From Equation 3.10 it is evident that the solution to the cost minimization problem is dependant on the costs of the factors of production, w_1 and w_2, as well as the level of output, y. Thus, given the constraints that the firm is facing with regards to technology as well as the choices and costs related to the choices, the solution to the cost minimization problem is described by Varian (1999: 345).

The cost of producing an output is represented mathematically by Equation 3.11:

Equation 3.11:

$$w_1 x_1 + w_2 x_2 = C$$

If the above equation is rearranged, the following equation results:

Equation 3.12:

$$x_2 = \frac{C}{w_2} - \frac{w_1}{w_2} x_1$$

In order to minimize costs, the firm needs to find the point of production where the specific combination of inputs results in a specific level of output but at the same time where costs are at a minimum. This entails the combination of the cost function as well as the production function of the firm. Mathematically the combination of the cost function and the production function in order to minimize costs is derived as follows:

In the production process the combination of inputs can be changed, but the level of output should remain constant. Equation 3.13 explains this condition:

Equation 3.13: $$MP_1(x_1^*, x_2^*)dx_1 + MP_2(x_1^*, x_2^*)dx_2 = 0$$

Thus, if a change takes place in the amount of x_1 being used, the amount of x_2 should change in the opposite direction as that of x_1. This will ensure that the level of output remains constant. When the firm is producing at the point where costs are minimized, it can be represented as follows:

Equation 3.14: $$w_1 dx_1 + w_2 dx_2 \geq 0$$

If the change of $(-dx_1, -dx_2)$ is considered, the result will also be the point where output is constant and costs at a minimum. Equation 3.15 represents this.

Equation 3.15: $$-w_1 dx_1 - w_2 dx_2 \geq 0$$

Combining Equations 3.14 and 3.15 results in Equation 3.16:

Equation 3.16: $$w_1 dx_1 + w_2 dx_2 = 0$$

Thus, solving Equations 3.13 and 3.16 for $\frac{dx_2}{dx_1}$ results in Equation 3.17:

Equation 3.17: $$-\frac{MP_1(x_1^*, x_2^*)}{MP_2(x_1^*, x_2^*)} = TRS(x_1^*, x_2^*) = -\frac{w_1}{w_2}$$

Equation 3.17 explains that the point of production where the combination of inputs produces a specified level of output and at the same time minimizes costs is the point where the technical rate of substitution is equal to the factor price ratio.

3.3 FINANCIAL STATEMENTS

Within the framework of constraints due to technological reasons the firm makes choices with regards to production. Hence the firm makes profit maximization and cost minimization choices. The question, however, is what the results of these choices are, and more specifically what the financial results are. Hence, the method of presenting the financial results of these choices in the form of financial statements is used.

The set of financial statements of an enterprise consists of a balance sheet, income statement and cash flow statement. The purpose of this framework of financial statements is to present the financial results of economic activities for a specific period. Each component of the set of financial statements presents a different perspective on the economic activities' financial results. By analysing the three components together, the final results of analysis should give an indication of the financial position of a firm that is as close to reality as possible.

The balance sheet has the purpose of stating the financial position of the business enterprise. It reports on the major classes and amounts of assets, liabilities and stockholders' equity and their interrelationships at specific points in time (White, Sondhi & Fried, 1998: 16). Assets reported on the balance sheet are either purchased or generated through economic activities. Creditors and/or stockholders of the firm finance the purchase or generation of assets. The financing of the assets can be directly or indirectly. Based on the interrelationships between the three components of the balance sheet, a fundamental accounting relationship developed. This relationship was codified by Luca Paccioli, an Italian priest (Bernstein, 1996: 42). The fundamental accounting relationship can be expressed as follows:

Assets = liabilities + stockholders' equity.

Assets are defined in Statement of Financial Accounting Concepts 6 (SFAC 6) as "probable future economic benefits that are obtained or controlled by a particular entity as a result of past transactions or events" (Financial Accounting Standards Board, 1998). White et al, however, point out that the weakness of the above definition is the fact that it doesn't refer to risk and specifically the risks of ownership. Thus, an entity that retains the risks of ownership is influenced by the asset, and therefore "owns" it although it doesn't control it nor possesses it.

Liabilities are defined by the Statement of Financial Accounting Concepts 6 (SFAC 6) as "probable future sacrifices of economic benefits arising from present obligations of a particular entity to transfer assets or provide services to other entities in the future as a result of past transactions or events" (Financial Accounting Standards Board, 1998). The weakness of the definition of liabilities according to White is the fact that it doesn't include contractual obligations.

Based on the above definitions, stockholder' equity is therefore defined as the value or interest in the net assets of an entity. The net assets are calculated by subtracting the total liabilities from the total assets.

The second component of the set of financial statements is the income statement. The purpose of the income statement is to report on the financial performance of the entity resulting from economic activities incurred. It thus attempts to explain changes in assets, liabilities and stockholders' equity between two consecutive balance sheet dates. The action of linking two consecutive balance sheets by means of an income statement implies interrelatedness between the balance sheet and the income statement.

The income statement is designed according to the basic principle of matching flows or actions. This implies that performance can be measured realistically if revenues and costs are accounted for, which are incurred during the same period. Thus, expenses incurred to generate revenues must be for the same period.

The income statement consists of two basic elements namely revenues and expenses. Statement of Financial Accounting Concepts 6 (SFAC 6) defines revenues as "inflows of an entity from delivering or producing goods, rendering services, or other activities that constitute the entity's ongoing major or central operations". Expenses are defined as "outflows from delivering or producing goods, rendering services, or carrying out other activities that constitute the entity's ongoing major or central operations"

(Financial Accounting Standards Board, 1998). According to White et al. these definitions purposefully exclude gains and losses due to the fact that gains and losses can be defined as a decrease or an increase in net assets from peripheral or incidental transactions. Gains and losses are therefore not linked to operating events, and should not be taken into account in the income statement.

The third component of the set of financial statements is the cash flow statement. The purpose of the cash flow statement is to report cash receipts and payments in the period of occurrence. These payments and receipts can be classified according to three activities namely operating activities, investing activities and financing activities. The cash flow statement also serves the purpose of explaining changes in two consecutive balance sheets, and thus serves as an additional explanatory tool to the income statement. The Statement of Financial Accounting Standards 95 (SFAS 95) defines investing cash flows as the acquisition or sale of property, plant and equipment (Financial Accounting Standards Board, 1998). The acquisition or sale of a subsidiary or segment as well as the purchase or sale of investments in other firms is also defined as investing cash flows. Financing cash flows is defined as issuance or retirement of debt and equity securities as well as dividends paid to stockholders. Operating cash flows is defined as the cash effects that don't meet the definition of investing or financing cash flows. Operating cash flows are therefore cash flows resulting from the operating activities or revenue-producing activities of the entity.

The three components of the financial statements namely the balance sheet, income statement and cash flow statement serve the purpose of presenting financial results of economic activities undertaken by the firm. The different statements each shed a different perspective on the financial results, but are interlinked and therefore depend on each other. This implies that it is a dynamic system in which change in one component affects the other two components as well as the component in which the change took place due to a feedback effect.

The shortcoming of the set of financial statements is that the results of economic activities are presented in numeric format, but the results are not interpreted for decision-making. Hence, the method of ratio analysis developed in order to generate interpretable results that can be used for decision-making.

3.4 RATIO ANALYSIS

Investors, creditors and other stakeholders need to make decisions with regards to investment, credit and the management of a firm. This implies that decisions with regards to risk and return of a firm have to be made. In order to compare the risk and returns of different firms for the purpose of aiding investment, credit and management decisions, the method of financial ratio analysis was developed. Financial ratio analysis uses the set of financial statements as the basis of analysis. Financial ratios serve the purpose of profiling the firm in terms of economic characteristics, competitive strategies and its unique operating, financial, and investment characteristics (White et al., 1998: 141).

Ratio analysis consists of four categories of measures (White et al., 1998). The four categories are:

- Activity analysis. Revenue and output as generated by the entity's assets are analysed.
- Liquidity analysis. The entity's cash resources are measured to determine if the firm will be able to meet near-term cash obligations.
- Long-term debt and solvency analysis. The capital structure of the firm is analysed in terms of the composition of different financing resources and the ability of the firm to meet long-term debt and investment obligations.
- Profitability analysis. The income of the firm is measured relative to the revenues and invested capital.

The different categories of ratios each provide a different perspective on the risk and return relationship of the firm or entity. *Gitman (2000) writes that liquidity, activity and debt ratios primarily measure risk, while profitability ratios measure return. Since the different categories of ratios are interrelated due to the interrelatedness of the set of financial statements, all the categories of ratios need to be taken into account when a decision has to be made especially on the financial viability of the business enterprise*. However, when the decision is more focused on either the risk aspect of the firm, as is the case of credit decisions, a more stringent focus has to be applied to the applicable ratios. In the case of an investment decision, the focus of ratio analysis will be more on the return ratios, while also considering the risk ratios.

According to White et al. (1998: 140), the informational needs and appropriate analytical techniques used for the ratio analysis in order to take investment or credit decisions, depends on the decision-maker's time horizon. Short-term bank and trade creditors are primarily interested in the immediate liquidity of the firm. Louw (1979: 30) writes that a distinction should be made between firm liquidity and operational liquidity. According to Louw firm liquidity is a static measure of the farm business's liquidity at a specific time and is measured by the ratio of short-term assets to short-term liabilities. Operational liquidity, according to Louw, is the measure of liquidity of a farm business within a specific period of time and is therefore measured by the ratio of cash inflows and cash outflows. Louw indicates that operational liquidity is a more dynamic measure of a farm business's liquidity, and is therefore a more acceptable measure of liquidity in the case of farm businesses. Long-term creditors are interested in long-term solvency, therefore whether the firm will be able to meet interest and principle obligations in the long term. Equity investors are interested in the long-term earning potential of the firm. The risk-return relationship is therefore analysed in order to determine if the return will be commensurate with the risk.

The method of ratio analysis uses the financial statements of the firm as the basis of analysis. The utilisation of the financial statements for the purpose of ratio analysis has shortcomings as pointed out by White et al. (1998: 142). The shortcomings are due to the underlying assumptions of ratio analysis, which often are not applicable to a specific analysis. The underlying assumptions of ratio analysis concern economic assumptions, benchmarks, timing and misrepresentation, different accounting methods and negative numbers.

Ratio analysis is designed for comparing different firms in order to make an investment, credit or management decision. However, based on the economic theory of scale, the cost structure of different sized firms are likely to differ due to different levels of fixed and variable costs. This implies that specific types of ratios, especially activity analysis ratios, are likely to differ based on the different economies of scale of the different firms. The assumption that appropriate benchmarks are available to compare ratios of different firms is also not always applicable. Since ratio analysis depends on the perspective from which the analysis is done, the available benchmark is not necessarily the correct benchmark, since the question that needs to be answered from the analysis may differ. For example, for a credit decision high liquidity is important, but for an investment decision high solvability is more important and in the short term liquidity can be low in order to ensure long-term solvability. Thus, in such a case ratio analysis will not be an objective method of analysing the financial position and potential of the firm. Ratio analysis can also be misleading depending on the timing of the release of the financial statements. In the case of a farm, before harvest time debt ratio is likely to be much higher than after harvest time. The division of one negative number by another yields the same result as when a positive number is divided by another positive number. The answer might thus be misleading. Lastly, different accounting methods will lead to different values being reported, thus causing different sets of ratios when the data are actually for the same time period of the same firm. A clear description should therefore exist on which accounting method or approach is followed, before ratio analysis is done.

3.5 CONCLUSION

In this chapter a brief overview of firm theory in terms of technology and choices is given. The theory of financial statements and ratio analysis is also discussed. The motivation for studying firm, financial statement and ratio analysis theory is to attempt to understand the underlying principles and driving forces that determine and influence the farm system that is studied. Hence, it is attempted to understand the system under study as well as the questions that need to be answered from studying the system. The knowledge of the system under study, together with the type of model and approach to modelling and simulation being used in this study will ultimately influence the structure of the farm-level model in terms of inputs, calculations and outputs of the model. Thus, the study of firm theory, financial statements and ratio analysis will serve as background to the literature study of similar types of positivistic farm-level models in Chapter 4 as well as the development of the farm-level model structure in Chapter 5. Lastly, from the theory on ratio analysis it is concluded that in order to study the financial position of the business enterprise, the ratios concerned with activity, liquidity, solvency and profitability need to be analysed. This study will focus on operational liquidity and solvency of the farm business.

CHAPTER 4
POSITIVISTIC FARM SIMULATION MODELS

4.1 INTRODUCTION

In Chapter Two general background on the system approach, the general system theory, and different types of systems in agriculture was provided. The impact of the general system theory on the definition, philosophy and methodology of modelling and simulation was reviewed in terms of the two types of models namely deterministic and stochastic models as well as the two different approaches, namely normative and positive, due to the difference in the purpose of studying and analysing the system. The different methods of modelling that resulted due to the two different approaches of normative and positive as well as the advantages and disadvantages of each of these methods were discussed.

Based on the background knowledge of the system approach and the types of models and approaches to modelling, the type of farm-level simulation model required for accomplishing the objectives of this study was determined. The model and simulation results will be applied in terms of answering questions regarding "what if" scenarios, therefore the models should be more orientated towards behavioural variability.

From this it is concluded that a deterministic type of model will be built, and a positivistic approach will be followed that is based on actual behavioural trends as estimated from actual farm-level data. Since the focus of the farm-level model is on the financial viability and hence financial outputs of the farm business, a budgeting type of model consisting of statistical relationships as well as accounting identities should be constructed.

In the literature, five models were identified that exhibit a combination of the characteristics as listed in the previous paragraph. Three of the models, namely FLIPSIM, TIPI-CAL and FES are international models, while the model developed by André Louw was specifically constructed for South African farms.

The purpose of this chapter is to provide a general discussion on each of these models, and where information is available, supply a specific discussion on issues like asset replacement, debt amortization and cash flow and how it is calculated in that specific model.

4.2 THE FARM LEVEL INCOME AND POLICY SIMULATION MODEL (FLIPSIM)

James Richardson and Clair Nixon developed the Farm Level Income and Policy Simulation Model at Texas A&M University with input from various other people. The first version was released in 1981, but numerous changes have been made to the original version to make it more powerful.

FLIPSIM is a stochastic as well as a deterministic simulation model, depending on the choice of the user of the model. The model is used to simulate individual as well as representative farms over a multiple-year planning horizon. The 1 600 plus output variables are summarised in terms of probabilities, such as the probability of remaining solvent, the probability of an economic success, and the probability of losing more than a specified percentage of real net worth. The model is capable of simulating livestock and dairy farms, mixed farms (grain and livestock), grain farms, different farm programmes, risk management strategies, technologies and income tax provisions.

FLIPSIM is a Fortran recursive model that consists of various identities, accounting equations and probability distributions. Richardson (2004), however, indicates that FLIPSIM has been converted to Excel format. The model uses producer information obtained from panel groups in different states of the USA. The panel members provide the following information:

- Size of operation (acres, head, etc.)
- Tenure and asset values
- Enterprises and production costs related to each enterprise
- Fixed costs
- Yield history

- Farm programme participation
- Machinery and replacement strategy

The panel consists of producers and other roll players that know the specific area and farming practice of that area very well. Local grant personnel identify the panel members. Usually, two farms are built for a specific area, in order to attempt to capture different sizes of enterprises.

FLIPSIM has been used quit extensively to simulate and analyse policies, changes in technology, risk management strategies, tax provisions, baseline projections, insurance options, farm management, marketing and finance of a farm.

4.3 TECHNOLOGY IMPACT AND POLICY IMPACT CALCULATIONS (TIPI-CAL)

TIPI-CAL is a further development of FLIPSIM in Europe and was developed by the Federal Agricultural Research Centre (FAL). It is used to simulate a typical farm in different regions of Europe. It can simulate dairy farms, arable farms, beef and hog farms. Output results are summarised to indicate farm profit, development of equity, cost of production (competitiveness), and survivability (cash flow, change in equity). It is a deterministic recursive production and accounting model that simulates in Excel.

TIPI-CAL is used to simulate and analyse farm management strategies, policies, technology, production cost and cost components.

4.4 FINANCIAL-ECONOMIC SIMULATION MODEL (FES)

The development of the FES model started in 1990 in the Netherlands by the Landbou Economisch Instituut (LEI), Wageningen University. Dutch banks, farmer organisations and the Dutch government are all users of the FES model. The main purpose of the model is to answer questions regarding future financial economic development of different sizes and types of farms in different agricultural sectors in the Netherlands.

The FES model is part of the group of discrete-event simulation models and is a stochastic micro-simulation model. The framework of the FES model is based on the accounting of the firm, and thus mainly consists of accounting identities. The accounting basis implies that the historical as well as possible future developments of the firm can be studied and analysed.

Simulation is used to update and analyse effects of changes within the firm as well as in the environment it operates in. The effects of these annual changes are reflected in the accounts or financial statements of the firm, which are used to analyse and predict, by means of different ratios, what the financial expectations of the firm are over a specified future time period. The model can be run in both deterministic and stochastic mode.

4.5 ANDRé LOUW – MODEL

André Louw (1979) developed a farm simulation model for the purpose of simulating the effect of different growth strategies on the growth of a farm business in dynamic conditions that include risk and uncertainty. Louw writes that the model is based on simulation models developed by Eisgruber in 1965 as well as later developments of the Eisgruber model by Patrick (Patrick & Eisgruber, 1968) and Harshbarger (1969). Louw, however, made a few adjustments to the Harshbarger and Patrick models for the purpose of his study. The adjustments made concerned labour decisions, buying of livestock, inflation, land classification, rent of assets, production functions, system of evaluating budgeted results, exclusion of production and price cycles, tax calculations, management capabilities and assumptions on the initial financial position of the farm under study. The model was verified and validated by means of data obtained from farmers in the Wes-Transvaal (at present North West province). The data from the farmers were used to construct a representative farm that was used in the simulation process. The model consists of grain and livestock enterprises, equations on grain and fodder buying and sales, machinery and fixed improvement needs, depreciation on machinery and fixed assets, debt repayment, tax, a financial summary and stochastic calculations on yield and price. The model has the ability to simulate in both deterministic and stochastic mode, and is written in a format readable by Fortran IV.

4.6 SUMMARY AND CONCLUSION

In the literature review four models were identified that exhibit a specific combination of characteristics. These characteristics are deterministic, positivistic, budgeting type model consisting of statistical relationships, as well as accounting identities. The models are FLIPSIM, TIPI-CAL, FES as well as André Louw's model. The purpose of discussing these four models in some detail is to use the knowledge gained from these models to serve as background for the development of the farm-level model structure in the next chapter.

CHAPTER 5
FARM-LEVEL MODEL DEVELOPMENT

5.1 MODEL DEVELOPMENT

The approach followed towards model development in this study is based on the approach followed by Richardson (2003: 6). The "top down" approach entails that the first step of model development is the step in which the most important output variables are identified. In order to identify the most important output variables, the questions to be answered by the model or the purpose of modelling and simulating the specified system have to be defined and well understood. From the output variables, the necessary equations and parts of the models that need to calculate these output variables are determined.

The objectives as stated in Chapter One indicate that positivistic types of questions will be answered by the model and not normative types of questions. Secondly, the types of questions to be answered will be related to the likely implications of changes in markets and policies on the financial outputs concerned with liquidity and solvency of a farm business.

In order to quantify the effect of policy changes and market changes on liquidity and the solvability of a farm business, the two most important output variables are the cash surplus or deficit, as well as the debt ratio. The motivation for selecting the afore-mentioned output variables is based on the theoretical foundation of financial statements and ratio analysis provided in Chapter Three.

The model components necessary to calculate these two variables are the financial statements of the farm business, namely the income statement, the cash flow statement as well as the statement of assets and liabilities. In order to set up the financial statements, a basic production structure of production activities as well as related costs and income need to be set up. Additional to this an asset replacement function for non-fixed assets has to be set up as well as a debt repayment schedule consisting of debt as in the first year of model simulation as well as debt resulting from asset replacement during following simulation years.

5.2 MODEL OUTLAY

The farm-level simulation model consists of three basic blocks namely an input block, calculation block as well as an output block (Figure 5.1).

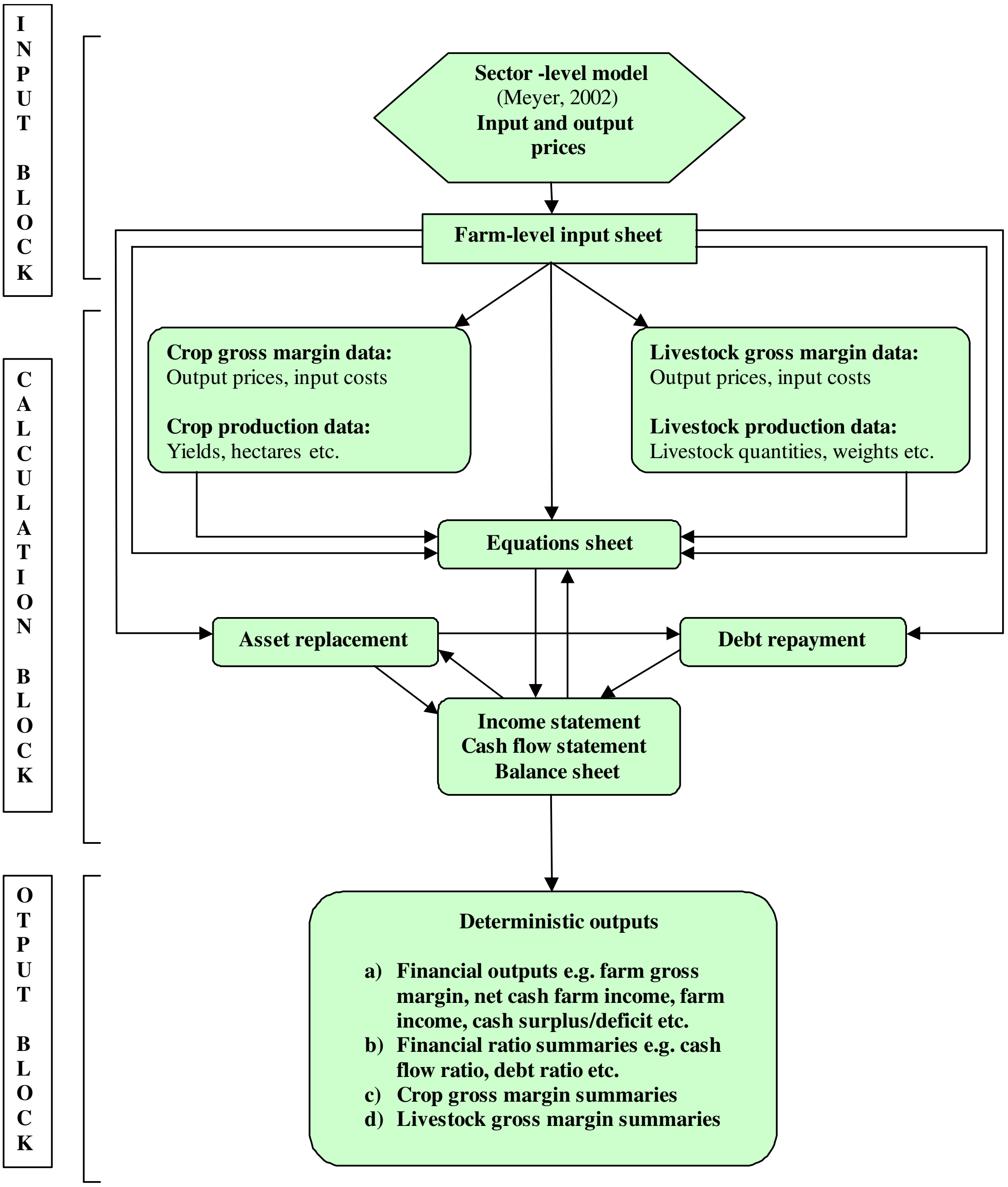

Figure 5.1: Structure of farm-level model

5.2.1 Input block

The input block consists of two sections, namely a section on management or control variables and a section on exogenous variables.

The exogenous variables section consists of eight sub-sections of outputs from the sector-level model (Meyer, 2002) as well as model outputs from various macro-economic models and experts in the field. The eight sub-sections are assumptions on:

- Depreciation rates of assets,
- Tax rates
- Interest rates
- Inflation rates
- Output prices
- Crop areas
- Crop yields
- Livestock output prices

The sub-section on inflation rates consists of inflation rates on other farm income and non-farm income, fixed costs, fixed and moveable assets and input costs of grains and livestock produced by the farm business. The sub-section on depreciation rates of assets consists of depreciation rates on vehicles, implements and machinery, equipment and tools, breeding stock in terms of cattle, sheep and pigs, and depreciation rates of office equipment and computer equipment. Farmland tax, other property tax, capital gains tax, personal income tax and farm income tax are the tax rates included in the sub-section on tax rates. The interest rates included in the section on interest rates include interest rates on savings, money market, prime rate, interest rate on an overdraft facility, production loan interest rate, medium-term loan interest rate and long-term loan interest rate.

The management or control variable section consists of six sub-sections namely:

- Details on land and fixed improvements
- Operational assumptions
- Detailed crop assumptions

- Detailed livestock assumptions
- Income statement assumptions,
- Assumptions on the statement of assets and liabilities

The details on land and fixed improvements include the different areas in terms of hectares that are allocated to dryland production, irrigation, natural pastureland, dryland cultivated pastureland, irrigated cultivated pastureland and other farmland. Each of the different area categories is divided between land owned by the farm business operator, land cash rented and land share rented. The different realistic market value for each of the land types is included in the details on the land and fixed improvements, as well as the cash rental rate per area unit in the case where a specific type of land is cash rented. The total value of houses, general farm structures as well as special-purpose farm structures are included in the details.

Operational assumptions include the following:

- Labour
- Asset replacement
- Operating loan
- Beginning bank balance
- Interest rates on cash reserves
- Carryover debt

The assumptions on labour include:

- The number of labourers involved per annum in the farm business
- The average monthly remuneration
- Annual bonus per labourer
- The value of annual rations per labourer

Asset replacement assumptions include:

- The average percentage of vehicles replaced per annum
- The average annual replacement percentage of implements and machinery per annum

Operating loan details include average percentage of operating loan used per annum as well as the interest rate on operating loan usage.

The detailed crop assumptions include assumptions on long-term average yield, amount of hectares planted with a specific type of crop in the specific year of data input. The details on the usage of the harvest in terms of percentage sold directly after harvest, percentage of harvested crop stored during the year of data input, percentage of harvest fed to animals on farm and the percentage of crop used for on-farm consumption. The beginning amount of tons of stored crop of a specific type of crop is included in the details as well as the percentage of the stored crop being sold during the year of data input. The farm price as well as the average annual selling price of the stored crop are part of the details on the input sheet. Input costs per hectare of crop planted during the year of data input are included. Input costs are seed, fertilizer, lime, herbicides, insecticide, fuel, water, irrigation electricity, seasonal labour, contract work in terms of harvesting and spraying, crop insurance, transport, drying and/or handling costs, packing material, storage costs, marketing costs, other direct allocated expenses, directly allocated repairs and maintenance and unforeseen expenses.

The input details on livestock include assumptions on livestock numbers as well as production assumptions in terms of mortalities, wean percentages, milk yields per cow per annum and replacement rates of cows. Input costs per livestock unit include feed costs, feed concentrates, veterinary and medicine costs, dips and sprays, ear tags, artificial insemination costs, labour, direct allocated repairs and maintenance, bedding, manure disposal, cleaning, catching, heating, electricity, transport, marketing, fuel contract work and other directly allocated expenses.

The assumptions on the income statement include insurance payments, non-farm income, subsidies, land rental income and other farm cash receipts. Assumptions on expenses include management salary, unemployment insurance fund payments, accident insurance for employees, provincial government levies, professional services, unallocated repairs and maintenance, unallocated fuel and lubricants, short-term insurance, farm utilities including water, electricity and telephone costs, licenses, membership fees, bank charges, auditing fees, miscellaneous, rent of moveable assets and other cash expenses.

The asset and liability assumptions include the following: asset values on vehicles, implements and machinery, other properties, co-operative member funds, other investments e.g. shares, surrender values of policies, equipment and tools, office equipment, savings account, production means, deposits, debtors, deferred payments, crop on land if it is comprehensively insured and value added tax receivable. Assumptions on liabilities include total of long-term liabilities, total annual payment on long-term liabilities, interest rate on long-term liabilities in the year of data input. The same assumptions on medium-term liabilities as that of long-term liabilities are obtained. The assumptions on short-term liabilities include outstanding balance on credit card, outstanding balance on production loan, monthly account outstanding balance, creditors, income tax overdue, tax provision and liabilities overdue.

5.2.2 Calculation block

The calculation block consists of five sections namely grain gross margins, livestock gross margins, financial statements, non-fixed asset replacement section and a debt repayment section.

The model has fifteen separate grain gross margin calculation sheets and gross margins are calculated for:

- Dryland white and yellow maize
- White and yellow maize under irrigation
- Dryland wheat (summer area)
- Dryland wheat (winter area)
- Wheat under irrigation
- Sorghum
- Sunflower
- Soybean
- Canola
- Barley

The three additional grain gross margin sheets are available in the case where more than the abovementioned grains are produced. Each of the grain gross margins sheets are based on the same outlay.

The gross margin outlay consists of four sections namely a receipt section, a production input inflation section that is linked to the exogenous variable section of the input block, an expense section that indicates the expenses of the different inputs per area unit – hectare in the case of this study. The fourth section links the hectares of the grain planted with the expense per hectare section, and thus calculates the total expense per input for the specific grain. From the different sections the gross margin per hectare, production cost as percentage of cash receipts and total gross margin are calculated. The trends in terms of hectares planted of a specific crop as well as the price received for the crop on the farm follows the same trend as that of the sector model with respect to that specific crop. The reason for simulating the on-farm hectares and price trends as explained, is to partly capture the movements in hectares and prices as simulated by the sector models, and thus to capture some of the adjustments that farmers make in response to changing conditions.

The livestock gross margins for beef, sheep and pigs are based on the same outlay and consist of ten sections namely production assumptions, livestock number calculation section, price indices section of input and output prices, breeding livestock values, marketable livestock values, receipts, expenses per livestock unit (LSU), total expenses, capital income from selling breeding stock and capital expenses from buying breeding stock. The gross margin sheet for dairy contains the same sections as that of beef except for a section on values of marketable stock. For each of the different livestock types the gross margin per livestock unit, production cost as percentage of cash receipts per livestock unit, total gross margin and total production cost as percentage of cash receipts are calculated from the different sections.

The gross margin calculation sheets on broilers, layers and free-range layers consist of five sections namely production assumptions, price indices on input and output prices, receipts and expenses per hen (in the case of layers and free-range layers) or per kilogram live weight (broilers) and total expenses. The gross margin per kilogram live-weight broiler and the gross margin per hen in the case of layers and free-range layers are calculated from the above sections. Also calculated is the production cost as percentage of receipts.

The farm-level prices for livestock products produced follow the same trend as that of the sector-level model in order to capture price movements due to change.

The outputs from the different gross margins of the grains and the livestock are linked to an equations sheet. The equations sheet consists of five different calculation sections namely total cash receipts and expenses of grains, total cash receipts and expenses from livestock, income statement calculations, statement of asset and liabilities calculations and tax calculations. The outputs from the equations sheet are linked to the sheet containing the financial statements, namely the output sheet.

The sections on the income statement and the statement of assets and liabilities in the equations sheet serve the purpose of inflating the income and assets as entered in the beginning simulation year for a future period of ten years. The rate of inflation used is the rate that is assumed in the inflation section of the input block of the model. The section on liability calculations in the equations sheet is used to calculate the average amount of usage of the overdraft facility, as well as the amount of interest being paid on the overdraft facility as well as carryover debt. The tax calculations section contains the calculation on income tax paid by the farming business. The tax calculations are based on the tax laws with regards to South African tax law in terms of farming businesses.

In order to simulate the cash surplus and debt ratio of the farm business as realistically as possible, two separate sheets for calculating asset replacement as well as debt repayment are included in the model. The reason for two sheets is that asset replacement and debt repayment affect the cash position and debt position of a farm significantly.

The asset replacement calculations are partly based on the theory of assets with consumption returns (Varian, 1999: 203) as well as articles written by Coetzee (2004) and Nel (2004). Coetzee writes that moveable assets are replaced on the basis of three factors namely funds that are available to replace assets, condition of asset necessitating replacement and technological "ageing" of asset, meaning the farmer has to improve technologically in order to remain productive and therefore competitive, thus necessitating asset replacement. Heckroodt (2004) indicates that the group of farmers being studied mostly replaced assets on the basis of funds available, thus in a year of surplus funds, assets will be replaced in order to decrease tax liability, and in years of cash deficit, replacement of assets is not likely to take place depending on the physical condition of the assets as well as the debt levels of the farm business. Additionally, Heckroodt indicates that financing of asset replacement of the group of farmers tends to be 50% own funds and 50% borrowed funds. The reason being twofold: firstly due to tax deductions based on interest and asset depreciation, farmers tend to depreciate the full value of assets within four years and thus gain the biggest tax deduction advantage by borrowing part of the replacement funds. Secondly, by using only 50% of own funds and not more to replace an asset, the cash flow position of the farmer tends to be better than in the case where more funds are used. Further research needs to be undertaken to prove this argument quantificially.

A constraint in this study was the access to specific details of asset ages and conditions as well as individual market values of the different moveable assets. In order to curb the constraint, the total value of moveable assets of an average farm as calculated from the VKB data was obtained, and a regression calculation was done in order to determine how asset values are likely to change given a change in gross farm income. This estimation was done in order to attempt to simulate the change in total moveable asset values as realistically as possible.

On the basis of asset replacement likely to take place during a year of cash surplus, and the argument that asset replacement is partly financed from own sources as well as borrowed funds, the asset replacement function was designed in such a way to incorporate different possibilities of asset replacement given the specific farmer or group of farmers' manner or motivation for replacing assets. Consequently the asset replacement function consists of two sections namely a section for replacement of vehicles and implements and the second section for the replacement of machinery with a longer lifespan.

Depending on own funds available as well as the cash surplus position of the farm, debt is likely to be incurred in the case of replacement of moveable assets. Consequently, a sheet calculating repayment of debt, as already present in the first year of simulation, was included in the model. This debt repayment sheet also contains a section for calculating payments and interest payments of debt incurred due to asset replacement. This is done in order to simulate the financial position of the farm at the end of each year as realistically as possible.

5.2.3 Output block

The output block consists of the income statement, cash flow statement and balance sheet. The three statements are linked by means of the net cash farm income, cash surplus or deficit, asset replacement function and debt repayment function. The income statement is presented by dividing it in two major sections, namely the farm cash income section and the farm cash expenses section. Based on these two sections the gross farm income is calculated, interest and land rent are subtracted from the gross farm income and net cash farm income is calculated. Depreciation on moveable assets is subtracted in order to calculate net farm income. Schematically the calculation of the net farm income can be presented as follows (Figure 5.2):

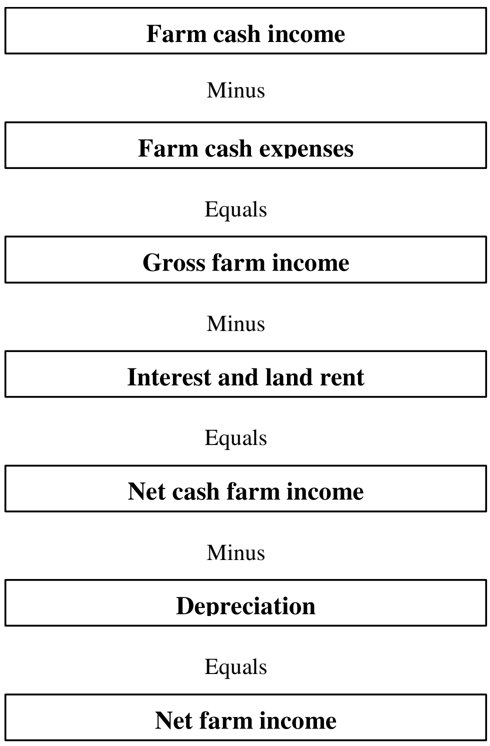

Figure 5.2: Calculation of net farm income

The net cash farm income is entered into the cash flow statement, which consists of two sections, namely cash inflow section and cash outflow section. The cash inflow section contains beginning cash reserve, net cash farm income, non-farm income, interest on cash reserves and net cash inflow from asset replacement. The cash outflow section contains net cash outflow from asset replacement, principal payments on medium and long-term debt, income tax and land tax payments as well as payment of carryover debt. The difference between cash inflows and cash outflows is calculated as the return to family living. In order to calculate the ending cash surplus or deficit, family living expenses are subtracted from return to family living (Fig. 5.3).

Cash inflow

Minus

Cash outflow

Equals

Return to family living

Minus

Family living expenses

Equals

Ending cash surplus/deficit

Figure 5.3: Calculation of ending cash surplus/deficit

The linkage between the statement of assets and liabilities and the cash flow statement is through the ending cash surplus or deficit value. In the case of a cash surplus, the cash surplus is indicated in the assets as cash, while in the case of an ending cash deficit the cash deficit is indicated as carryover debt on the liabilities side of the asset and liabilities statement. The section on assets is divided into three sections namely fixed assets, moveable assets and current assets. The liabilities section is divided into long-term liabilities, medium-term liabilities and short-term liabilities that contain details on production loans, credit card, overdraft balance, creditors and income tax overdue.

The output of the financial statements is summarised in a set of financial values and ratios. Included in the financial ratios and outputs are net cash farm income, cash flow ratio, return to family living, ending cash surplus or deficit, nominal net worth, real net worth, total debt ratio and total cost ratio of the farm business.

5.3 SUMMARY

The approach towards model development followed in this study is based on the "top-down" approach as described by Richardson. The key output variables in order to analyse and study the financial survivability of a farm business are the financial outputs with respect to liquidity and solvency. These outputs include the ending cash surplus or deficit as well as the debt to asset ratio of the farm. The model structure is set up in order to calculate the ending cash surplus or deficit and the debt to asset ratio over a ten-year period. In order to calculate the output variables, the model consists of three blocks namely an input, calculation and output block. The input block contains assumptions and input data on endogenous and exogenous variables influencing the farm financial and production system under study. The calculation block contains different sheets and formulas in order to calculate the interaction between the different endogenous and exogenous variables while the output block presents the results of the calculations in the form of financial statements. The outputs from the financial statements are summarised in the form of key output variables and financial ratios.

CHAPTER 6
VALIDATION OF THE FARM-LEVEL MODEL

6.1 INTRODUCTION

In Chapter Two the difficulties of simulation and modelling were discussed to some extent. As indicated, the purpose of the positivistic approach to modelling and simulation is the attempt to present reality as closely as possible and therefore answer questions of a positivistic kind. However, since the purpose of simulation models is to represent reality as closely as possible, outputs from simulation models have to be tested or validated against reality before it can be used to attempt to answer the questions for which it was constructed.

The purpose of this chapter is, firstly, to give a brief background on model validation and verification. Secondly, background on the Reitz district with respect to rainfall and temperatures will be presented in order to increase the understanding of the structure and data of the representative farm. Thirdly, the data as used by the sector model in the simulation exercise and the farm-level data obtained from VKB used to construct the representative farm, will be presented and discussed. The fifth section presents the simulation results and tests the output through statistical and visual tests, after which the chapter is concluded.

6.2 VALIDATION AND VERIFICATION

Model validation is the process by which the model is tested for completeness, accuracy and forecasting ability. The process of validation consists of two parts namely verification and validation (Richardson, 2003: 12). Verification is the process by which all equations are tested for accuracy in terms of answering the question of *"Is the formula calculating the exact correct answer?"* This implies testing all formulas for arithmetic accuracy as well as testing if all the linkages between the different equations are correct and in the correct order, thereby determining whether the causality is proceeding in the correct direction.

According to Richardson (2003: 13), model validation involves answering the following questions:

- Does the model accurately forecast the system being analysed?
- Do the results conform to theoretical expectations?
- Do the results conform to expectations of industry and farm experts?

6.3 BACKGROUND OF REITZ DISTRICT AND INPUT DATA

Reitz is a town situated in the eastern to north-eastern part of the Free State province, South Africa (Figure 6.1).

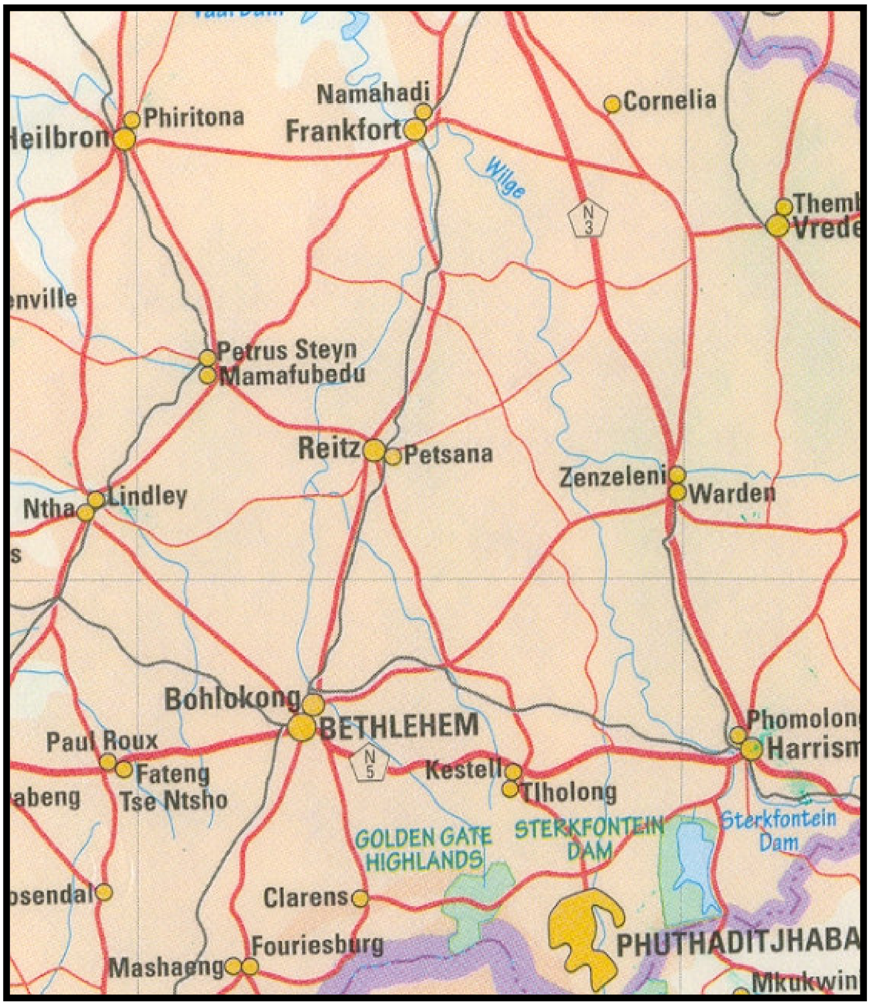

Figure 6.1: Map of the Reitz area

Source: Chief Directorate: Surveys and Mapping, 2002

One of the co-operatives active in this area is Vrystaat Koöperasie Beperk (VKB). VKB has an active economic bureau that gathers data from a number of its member farmers. This data is then processed and analysed in order to be used by VKB as well as the member farmers for decision-making purposes.

The purpose of this section is to present brief background on the area to be studied, and to present the structure of the representative farm as constructed from the data obtained from VKB for the Reitz district. The tables summarise the averages of the respective items for the period 1996 to 2003. Due to the sensitivity and confidentiality of the data, only percentages are given and not any specific monetary values.

6.3.1 Rainfall

The Reitz district has had an average rainfall of 695 millimetres per annum for the period 1970 to 2003. The lowest annual rainfall during the period 1970 to 2003 was 494 millimetres, which was recorded during 1990, and the highest recorded rainfall was 950 millimetres, during 2000 (Figure 6.2).

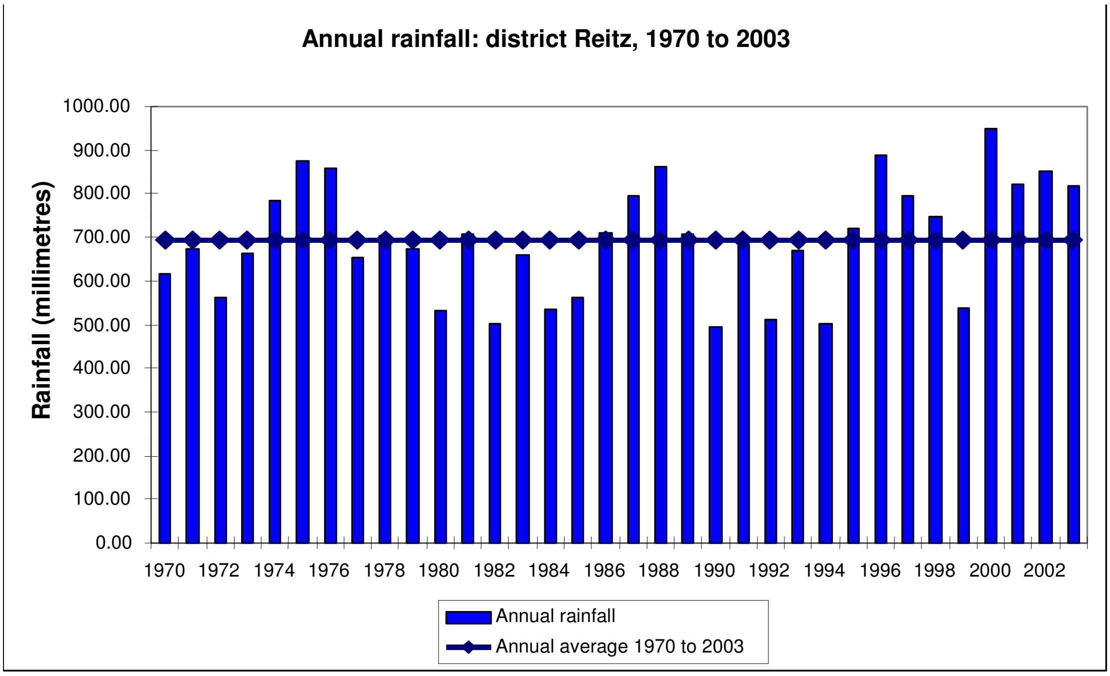

Figure 6.2: Annual rainfall for the period 1970 to 2003, district Reitz

(Source: South African Weather Bureau, 2005)

As indicated in Figure 6.2, the variation in rainfall between two consecutive years is highly variable. The cyclical trend of annual rainfall appears to be relatively stable with a peak amount of rainfall almost every ten years, which is during 1976, 1988 and

1996. On inspection of the rainfall data, the peak year of 2000 seems to be an outlier. Intermittent to these peak rainfall years, extremely low rainfall occurred during 1972, 1980, 1982, 1984, 1985, 1990, 1992, 1994 and 1999. Although the period 2000 to 2003 received above average annual rainfall, a declining trend is clearly visible.

When studying the average monthly rainfall as indicated in Figure 6.3, it is clear that the Reitz district is mainly a summer rainfall area. Some rainfall does occur during the months of May, June and July, but on average the amount of rainfall during these months is relatively low compared to the summer months. On average, from 1970 to 2003, the peak rainfall occurs in January, while the low rainfall month is July.

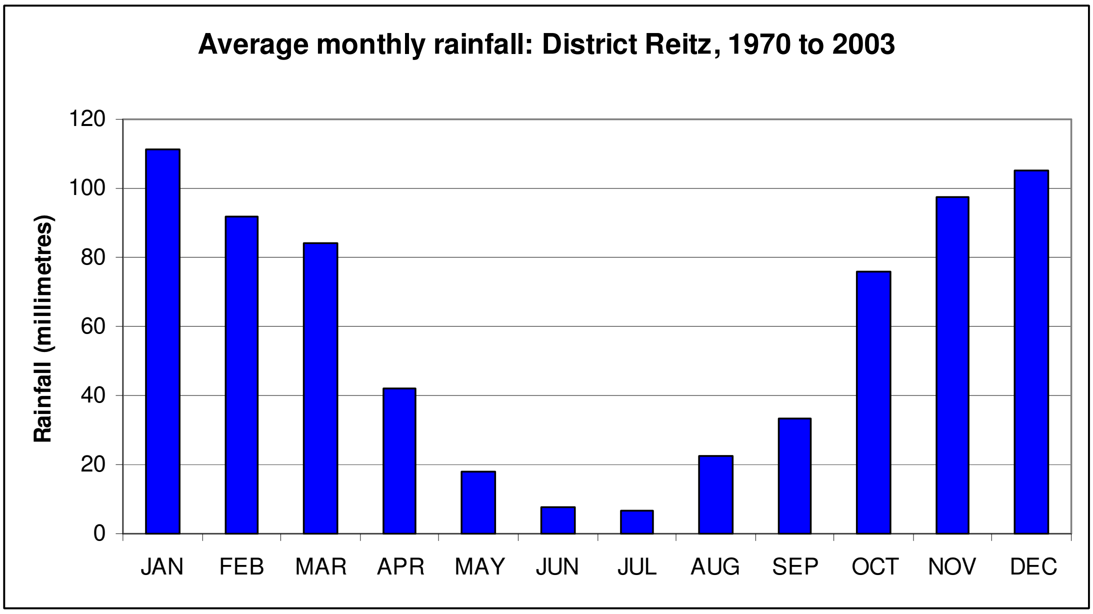

Figure 6.3: Average monthly rainfall for the period 1970 to 2003; district Reitz (Source: South African Weather Bureau, 2005)

By using the coefficient of variation to analyse the variability of the rainfall during the different months from 1970 to 2003, it is indicated that rainfall is less variable during December and January, while the most variation in rainfall is during July (Figure 6.4). The coefficient of variation is calculated by dividing the standard deviation of the rainfall for that specific month by the average rainfall for the specific month for 1970 to 2003. The coefficient of variation thus indicates the variability or stability of rainfall during a specific month.

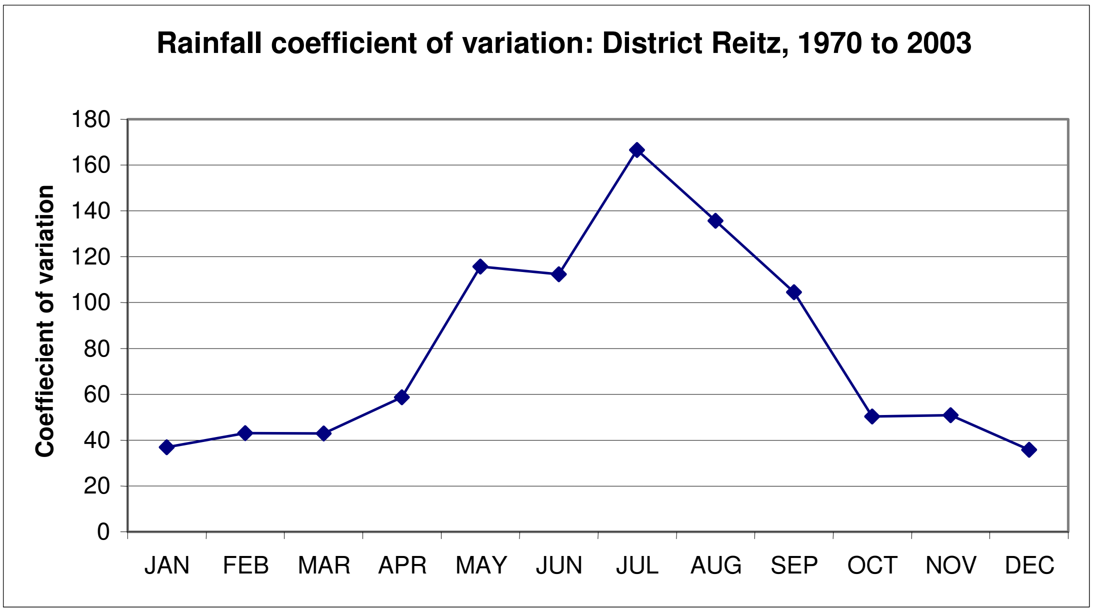

Figure 6.4: Coefficient of variation of rainfall: district Reitz, 1970 to 2003

6.3.2 Temperatures

Table 6.1 presents summarised results of temperatures in degrees Celsius (˚C) for the Reitz area.

Table 6.1: Temperature statistics, district Reitz for the period 1961 to 1990

Month	Average daily maximum (˚C)	Average daily minimum (˚C)	Highest recorded (˚C)	Lowest recorded (˚C)
January	27	13	33	7
February	26	13	33	3
March	24	11	31	2
April	22	7	29	-3
May	19	2	27	-6
June	16	-2	22	-9
July	16	-2	24	-9
August	19	1	27	-9
September	22	5	32	-7
October	23	8	32	-2
November	25	10	33	1
December	26	12	32	1

Source: South African Weather Bureau, 2005

The temperature statistics indicate that the climate of the Reitz district is relatively moderate. During the winter months, temperatures can drop below zero degrees Celsius. Temperatures during the summer months tend to remain below 30 ˚C, which indicates that growing conditions for summer crops might not be optimal. The cool temperatures are suitable for the growth of winter crops such as wheat.

6.3.3 Sector-level data

Table 6.2 summarises the data in terms of macro-economic variables as used in the sector-level model of Meyer (2002). The effects of these variables are fed through from the sector-level model to the farm-level model.

Table 6.2: Macro-economic data

Variable	Measure	1996	1997	1998	1999	2000	2001	2002	2003
SA population	Millions	40,6	41,2	42,1	43,1	44,2	45	45,1	45,2
Exchange rate	SA cents/US $	429	460	553	611	750	860	1047	757
CPI: food	Index	106	116	123	129	139	147	170	183
CPI: total	Index	107	116	124	131	138	145	159	171
GDP deflator	Index	108	116	124	132	142	153	166	178
Interest rate (weighted)	Index	107	111	117	107	86	83	104	111
PPI: field crops	Index	104	102	108	119	122	146	161	173
PPI: total	Index	106	114	118	125	136	136	149	160
PPI: agricultural goods	Index	105	113	116	116	123	141	155	166
Fuel	Index	123	142	133	149	209	241	265	285
Requisites	Index	115	128	133	141	160	179	197	212
Intermediate goods	Index	117	130	134	143	163	184	202	218
Implements	Index	110	125	134	144	153	168	185	199
Repairs and maintenance	Index	108	120	133	146	176	194	213	229
Irrigation equipment	Index	107	119	125	138	150	153	168	181
Feed	Index	116	128	130	136	155	161	177	190
Fertilizer	Index	118	125	132	137	160	191	210	225
Machinery and implements	Index	105	117	124	137	148	161	176	190

Source: Bureau for Food and Agricultural Policy, 2005

Table 6.3 summarises the data with regards to world commodity prices as input for the farm-level simulations via the sector-level model of Meyer:

Table 6.3: World commodity prices

Variable	Measure	1996	1997	1998	1999	2000	2001	2002	2003
Yellow maize, US No 2, fob, Gulf	US$/t	120	109	104	92	94	92	102	98
Wheat US No 2 HRW fob (ord) Gulf	US$/t	184	142	118	107	126	125	162	136
Sunflower seed price, Lower Rhine	US$/t	266	309	257	214	219	287	300	285
Sunflower cake price, Rotterdam	US$/t	138	103	76	102	118	110	110	103
Sunflower oil, NW Europe	US$/t	545	730	560	413	428	587	650	636
Sorghum, US No 2, fob, Gulf	US$/t	120	109	104	92	94	92	102	98
Soya bean producer price: Rotterdam fob	US$/t	307	259	225	208	200	203	240	222
Soya bean cake price: Rotterdam fob	US$/t	278	197	150	180	188	174	183	180
Soya bean oil price: Rotterdam fob	US$/t	536	633	483	356	336	412	585	602
World fishmeal price: CIF Hamburg	US$/t	586	606	661	392	413	483	606	590
Steers, Nebraska, CIF	US$/100 lb.	65	66	61	65	69	72	67	74
Broilers, U.S. 12-city	US$/100 lb.	61	58	63	58	56	59	55	57
Cheese fob N. Europe	US$/t	2426	2425	2225	1910	1853	2171	1739	1839
Butter fob N. Europe	US$/t	1750	1723	1853	1435	1325	1335	1146	1392
SMP fob N. Europe	US$/t	1941	1739	1453	1301	1882	2012	1325	1709
WMP fob N. Europe	US$/t	1957	1828	1764	1508	1845	1972	1390	1747
Hogs, U.S. 51-52% lean	US$/100 lb.	54	51	32	31	42	43	32	36

Source: Bureau for Food and Agricultural Policy, 2005

Table 6.4 summarises the data as used in the sector level model with regards to South African commodity prices.

Table 6.4: South African commodity prices, area planted and yields

Variable	Measure	1996	1997	1998	1999	2000	2001	2002	2003
White maize price	Index	100	120	123	139	133	196	371	203
White maize yield	Index	100	90	83	79	100	90	93	93
White maize area planted	Index	100	94	94	96	105	84	97	109
Yellow maize price	Index	100	120	128	162	138	197	299	204
Yellow maize yield	Index	100	100	73	85	112	103	106	107
Yellow maize area planted	Index	100	112	83	77	87	79	84	72
Wheat price	Index	100	90	89	106	115	158	208	170
Wheat yield	Index	100	84	121	115	130	120	118	95
Wheat area planted (summer rainfall area)	Index	100	134	70	85	67	75	60	74
Sunflower price	Index	100	115	157	145	105	213	284	227

Variable	Measure	1996	1997	1998	1999	2000	2001	2002	2003
Sunflower yield	Index	100	82	85	109	107	99	106	107
Sunflower area planted	Index	100	76	84	136	65	86	110	103
Sorghum price	Index	100	109	116	154	109	160	316	284
Sorghum yield	Index	100	77	74	60	90	63	92	92
Sorghum area planted	Index	100	92	75	57	82	51	43	48
Soya price	Index	100	116	91	100	107	104	168	188
Soya yield	Index	100	92	141	118	137	139	144	145
Soya area planted	Index	100	128	184	193	138	197	183	159
Beef average auction price	Index	100	97	96	102	102	125	155	132
Chicken producer price	Index	100	103	98	101	105	120	142	145
Egg consumer price	Index	100	109	116	114	117	131	169	177
Pork producer price	Index	100	119	106	123	142	148	205	181

Source: Bureau for Food and Agricultural Policy, 2005

Table 6.5 summarises the data as used in the farm-level model on potatoes and sheep. During the time of the simulation exercises, potatoes and sheep were not included in the sector model of Meyer.

Table 6.5: Data on potatoes and sheep as used in farm-level simulation

Variable	Measure	1996	1997	1998	1999	2000	2001	2002	2003
Potatoes price*	Index	100	106	129	113	146	145	156	166
Potatoes yield**	Index	100	100	100	100	100	100	100	100
Potatoes area**	Index	100	100	100	100	100	100	100	100
Sheep price*	Index	100	97	96	102	102	125	155	132

* Source: Abstract agricultural statistics, 2004
** Own assumptions

6.3.4 Farm-level data

6.3.4.1 Area and land usage

In constructing the representative farm, on average 26 farmers' data were used for the period 1996 to 2003. Averages were used in calculating final values for the different characteristics of the representative farm, due to the lack of a modus and median in most of the data groups. VKB Economic Services did the calculations. As indicated in table 6.6, the area of the representative farm is 1 748 hectares. The composition of the farm in terms of own land and rented land is 65% own land (1 136 hectares) and 35% rented land (612 hectares).

Table 6.6: Area farmed

Area farmed		
Item	Hectares	Percentage of total land
Own land	1 136	65%
Cash rented land	612	35%
Total	1 748	100%

Source: VKB Economic Services, 2004

In terms of land usage, the farm consists of 54% dry arable land, 1% arable irrigation land, 7% cultivated grazing, 37% natural grazing and 1% other land. The composition of arable land versus grazing land and other land is therefore 55% arable land and 45% grazing and other land (Table 6.7).

Table 6.7: Land usage

Land usage		
Item	Hectares	Percentage of total land
Dryland (crops)	941	54%
Irrigation	14	1%
Cultivated grazing	115	7%
Natural grazing	652	37%
Other (yard, roads etc.)	26	1%
Total	1 748	100%

Source: VKB Economic Services, 2004

6.3.4.2 Production structure and details

Tables 6.8, 6.9 and 6.10 present the production details of the representative farm. Table 6.8 indicates that the major livestock enterprise in terms of livestock units (LSU) is beef cattle of which there are 248 livestock units on the farm. Beef is followed by dairy of which there are 71 livestock units, while the third livestock enterprise consists of sheep, of which there are 80 livestock units. The livestock units are measured in terms of large livestock units. See appendix three for details on livestock unit calculations.

Table 6.8: Livestock units

Livestock		
Item	LSUs	Percentage of total LSUs
Beef cattle	248	62%
Dairy	71	18%
Sheep	80	20%
Total	399	100%

Source: VKB Economic Services, 2004

In terms of hectares planted with cash crops (Table 6.9), wheat is the most important enterprise as on average 48% of hectares are planted with cash crops. The second most important cash crop in terms of hectares planted is maize, followed by sunflowers, potatoes and other. In total 666 hectares on average is planted with cash crops.

Table 6.9: Cash crops

Cash crops			
Crop	Hectares	Yield	Percentage of total hectares
Maize	256	3,3t/ha	38%
Wheat	317	2,4t/ha	48%
Sunflower	53	1,31t/ha	8%
Potatoes	22	1 986 bags/ha	3%
Other	18	Various	3%
Total	666		100%

Source: VKB Economic Services, 2004

As indicated in Table 6.7, cultivated grazing covers an area of 115 hectares or 7% of the representative farm's area. The most important cultivated grazing in terms of hectares planted is Eragrostis curvula and Finger grass, followed by green fodder and Lucerne (Table 6.10).

Table 6.10: Cultivated grazing

Cultivated Grazing		
Type	Hectares	Percentage of total hectares
Eragrostis curvula and finger grass	75	75%
Lucerne	4	3%
Green fodder	22	22%
Total	101	100%

Source: VKB Economic Services, 2004

6.3.4.3 Gross farm income composition

When analysing the composition of the gross farm income as presented in Table 6.11, analysis indicates that 83% of gross farm income is generated by cash crops and 17% by livestock enterprises. Wheat is the most important cash crop enterprise and on average contributes 36% to gross farm income. Wheat is followed in importance by maize, potatoes and sunflowers. Beef cattle is the most important livestock enterprise and contributes on average 8% to gross farm income, while dairy contributes 6% and sheep 3%.

Table 6.11: Gross farm income composition

Enterprise	Gross farm income composition
Maize	29%
Wheat	36%
Sunflower	3%
Potatoes	15%
Total cash crop contribution	83%
Beef cattle	8%
Dairy	6%
Sheep	3%
Total livestock contribution	17%

Source: VKB Economic Services, 2004

6.3.4.4 Cost structure

Analysis of the cost structure of the representative farm indicates that direct allocated production costs of cash crop and livestock enterprises contribute to 44% of all expenses of the farm. Cash crops contribute 40% and livestock enterprises 4%. Unallocated repairs and maintenance as well as interest and land rent both contribute 14% to total expenses, while labour contributes 7%. Unallocated fuel and lubricants, short-term insurance and farm utilities that include electricity and telephone contribute 4% to total expenses. Family living costs contributes 9% and depreciation 5% (Table 6.12).

Table 6.12: Cost structure

Item	Percentage of total expenses
Cash crops production costs	40%
Livestock production costs	4%
Labour	7%
Repairs and maintenance (unallocated)	14%
Fuel and lubricants (unallocated)	1%
Short-term insurance	2%
Farm utilities (electricity, telephone etc.)	1%
Other cash expenses	3%
Interest and land rent	14%
Depreciation	5%
Family living costs	9%
Total	100%

Source: VKB Economic Services, 2004

6.3.4.5 Asset and liability structure

Tables 6.13 and 6.14 present the asset and liability structure of the representative farm. The analysis indicates that in terms of total assets, fixed assets make up the largest share with 41% of total assets on the farm. Moveable assets contribute 32% and current assets 27% to the total asset structure of the representative farm (Table 6.13). Fixed assets mainly consist of farm land and fixed improvements, moveable assets of machinery, implements and breeding livestock while current assets mainly consist of marketable stock, production means in stock as well as savings accounts and deposits.

Table 6.13: Asset structure

Asset type	Percentage of total assets
Fixed assets	41%
Moveable assets	32%
Current assets	27%
Total	100%

Source: VKB Economic Services, 2004

In terms of liabilities, almost the opposite of the asset-side occurs. Short-term liabilities contribute 62% to all liabilities, while long-term liabilities contribute 21% and medium-term liabilities 17% (Table 6.14). Short-term liabilities mainly consist of annual production credit, bank overdraft facility usage and creditors. Medium-term liabilities are mainly finance on moveable assets, while long-term liabilities are mainly finance on buying of land.

Table 6.14: Liability structure

Liability type	Percentage of total liabilities
Long-term liabilities	21%
Medium-term liabilities	17%
Short-term liabilities	62%
Total	100%

Source: VKB Economic Services, 2004

6.4 EMPIRICAL RESULTS AND PERFORMANCE OF MODEL

6.4.1 Ending cash surplus/deficit

Important to note before comparing the actual cash surplus or deficit against the simulated cash surplus or deficit is the fact that the cash surplus as calculated by VKB is the cash surplus before principal payments and asset replacement. The simulated outputs of the model therefore had to be adjusted in order to compare the actual figures with the simulated figures by excluding principal payments and asset replacement costs. When plotting the actual cash surplus or deficit against the simulated cash surplus or deficit, it is clear that the simulation results do not have the same variability between two consecutive years as the actual figures. However, the simulation results do follow the actual figures' trend over the time period relatively accurately.

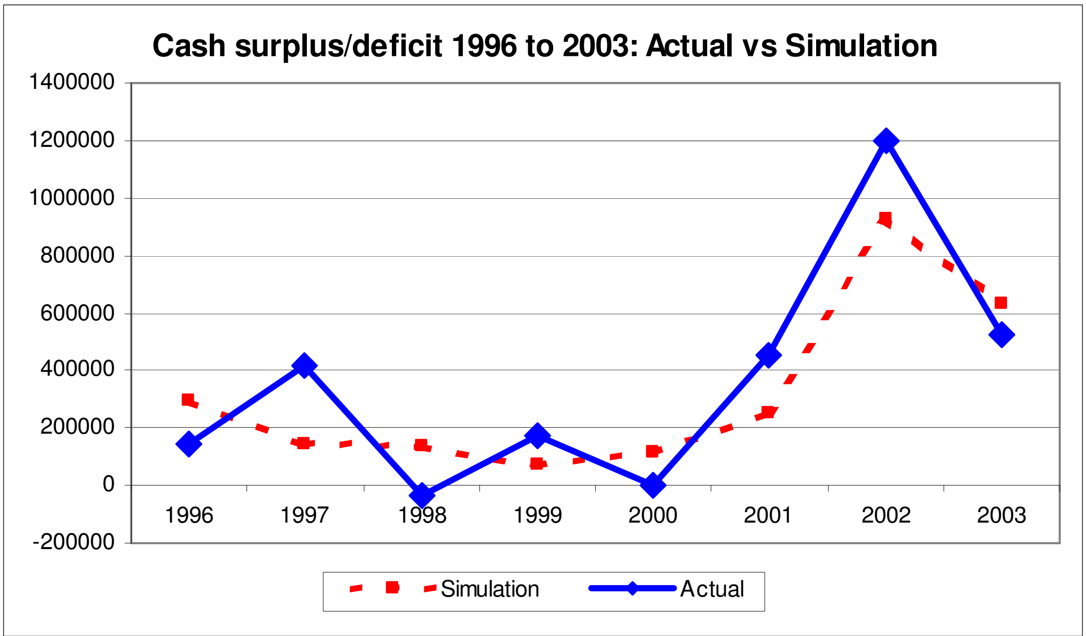

Figure 6.5: Cash surplus or deficit from 1996 to 2003

Testing the means and the variances of the actual time series against the simulated time series at a 95% confidence level, fail to reject the null hypothesis that both the mean and the variance of the simulated and actual data series are statistically different (Table 6.15).

Table 6.15: Distribution Comparison of simulated and actual cash surplus*

Test	Test Value	Critical Value	P-Value	Test Result
2 Sample t Test	- 0,22	2,53	0,826	Fail to reject the *Ho* that the Means are equal
F Test	1,75	3,79	0,240	Fail to reject the *Ho* that the Variances are equal

*** 95% confidence level**

6.4.2 Debt to asset ratio

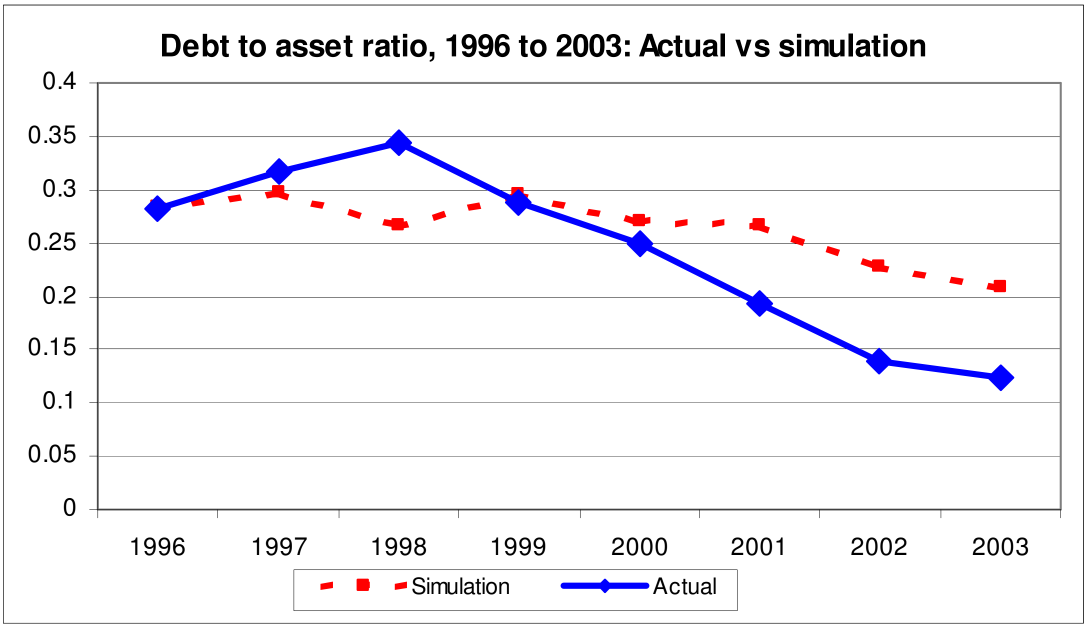

Figure 6.6: Debt to asset ratio from 1996 to 2003

Comparing the debt to asset ratio simulated by the model against the actual figures, it is clear that the simulated debt to asset ratio does follow the downward trend of the actual debt to asset ratio to a certain extent. The statistical testing results of the simulated debt to asset ratio against the actual figures at a 95% confidence level indicate that the means of the two series are statistically not different but the variances are (Table 6.16).

Table 6.16: Distribution comparison of simulated and actual debt to asset ratio*

Test	Test Value	Critical Value	P-Value	Test Result
2 Sample t Test	0,73	2,69	0,486	Fail to reject the *Ho* that the Means are equal
F Test	6,63	3,79	0,012	Reject the *Ho* that the Variances are equal

*** 95% confidence level**

Attempting to determine why deviations between the simulated results and the actual results take place, gross farm income, gross farm expenses, interest and rent, assets and liabilities are analysed in detail. This is done in order to determine which variables the model fails to simulate accurately. This will give an indication how the model could be improved by future research. However, it needs to be noted that the amount of farmers included in the group of which the data was used changed during the simulation period. Therefore the change in values can also be attributed to the change in the number of farmers taking part in the data capturing process. Hence, care need to be taken in attributing a change in a variable's value towards one single reason.

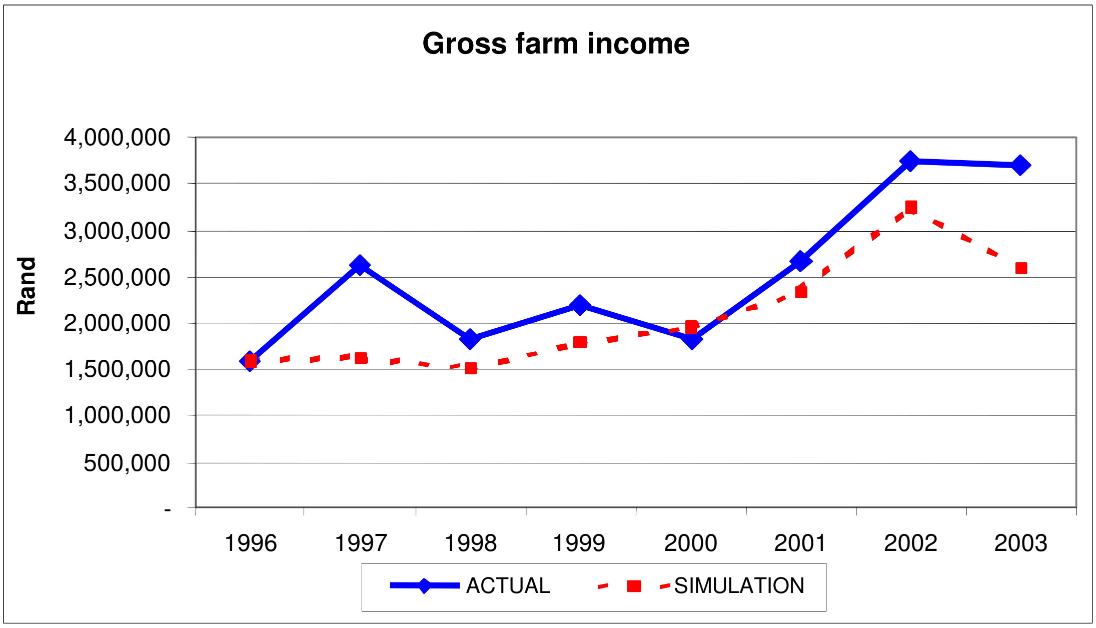

Figure 6.7: Gross farm income, actual vs simulation 1996 to 2003

In Figure 6.7 the actual versus simulated gross farm income is presented. An analysis of the gross farm income indicates that the simulation results follow the same trend as that of the actual gross farm income apart from 2003. However, the variability of the simulated gross farm income is not the same as the actual results. Deviations between actual monetary values and simulated monetary values do occur, especially during 1997 and 2003. Further analysis of Figure 6.7 indicates that the model tends to under-simulate the actual values of the gross farm income. Possible reason for the deviation of the simulated figures from the actual figures as indicated by Heckroodt (2005) are changes in the quality of crops sold and thus changes in the price received for the crop, insurance payments to the farmer due to hail damage and other types of losses, change in livestock numbers and therefore amounts of cattle sold changing between years and lastly a bonus payment to the farmer by the co-operative. The bonus that is paid out by the co-operative to the farmer is based on the turnover of the farmer's co-operative account of the previous year. Thus, in the case of above average years in terms of income (1996 & 2002), the representative farm received a bonus payment from the co-operative the following year (1997 & 2003). This possibly explains the deviation of the simulated figures from the actual figures during 1997 and 2003.

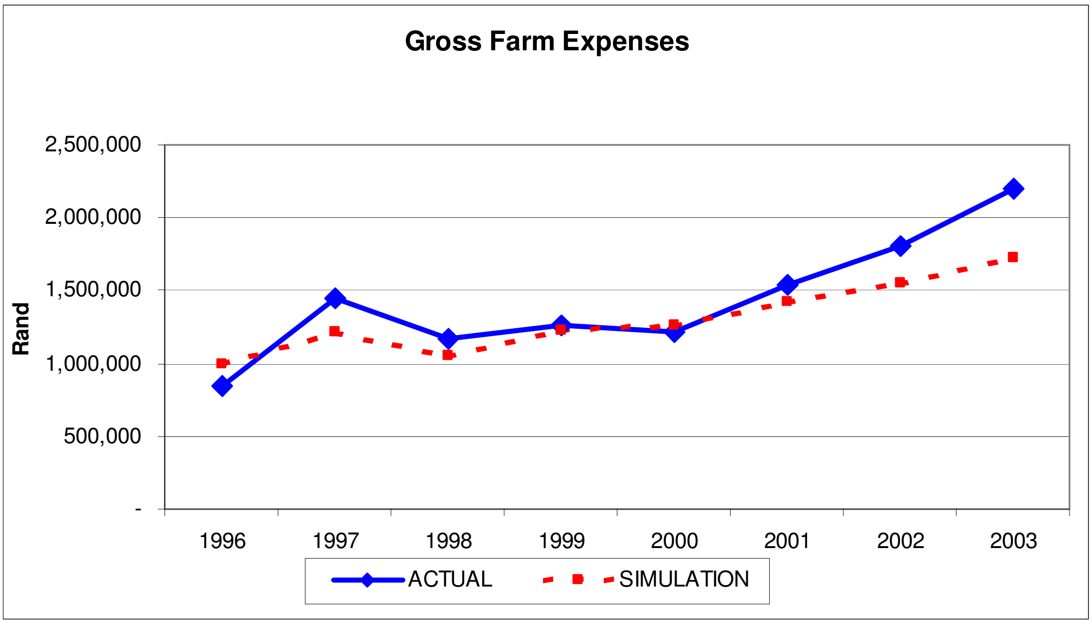

Figure 6.8: Gross farm expenses, actual vs simulation 1996 to 2003

An analysis of the gross farm expenses in Figure 6.8 indicates that the simulation results follow the actual results fairly accurately, but some deviations take place during the period 2001 to 2003. In this period the simulation tends to under-simulate the actual figures, which causes a relatively large deviation from the actual figures recorded during 2003.

An analysis of interest payments and rent indicates that the simulation results do follow the actual figures fairly accurately up to 2000 when significant deviations begin to take place.

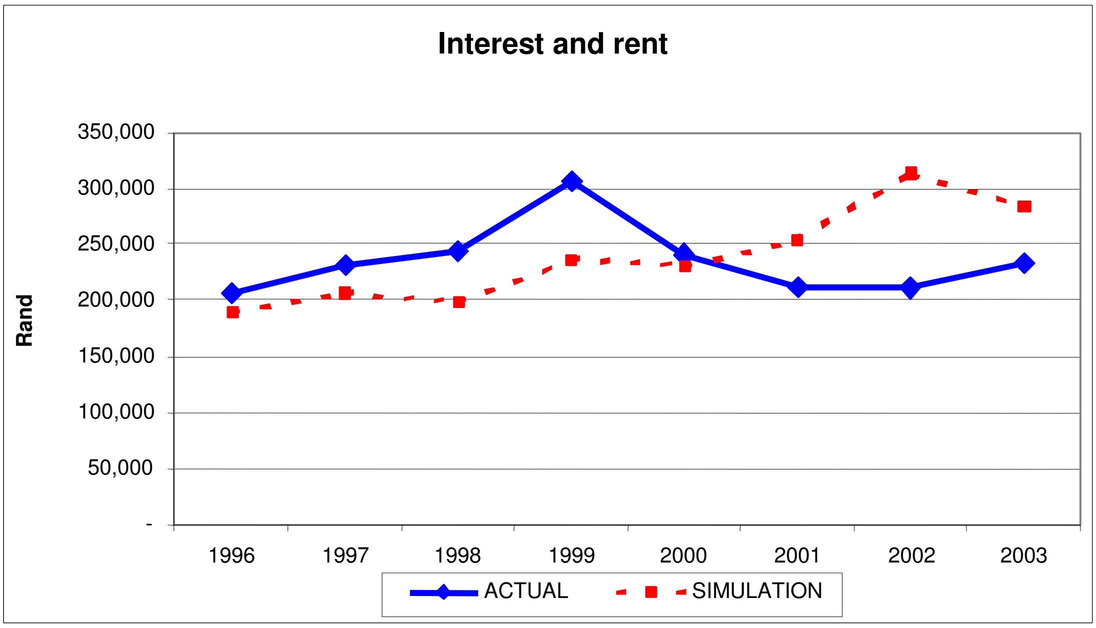

Figure 6.9: Interest and rent, 1996 to 2003: actual vs simulation

The simulated results versus the actual results in terms of medium and long-term assets are presented in Figure 6.10. Analysis of Figure 6.10 indicates that the model simulates movements in medium and long-term assets fairly accurately. The simulation results tend to follow the same trend as that of the actual figures. However, it is evident from Figure 6.10 that the model tends to under-simulate the actual figures, especially during 2003 as well as 1997 to 1999.

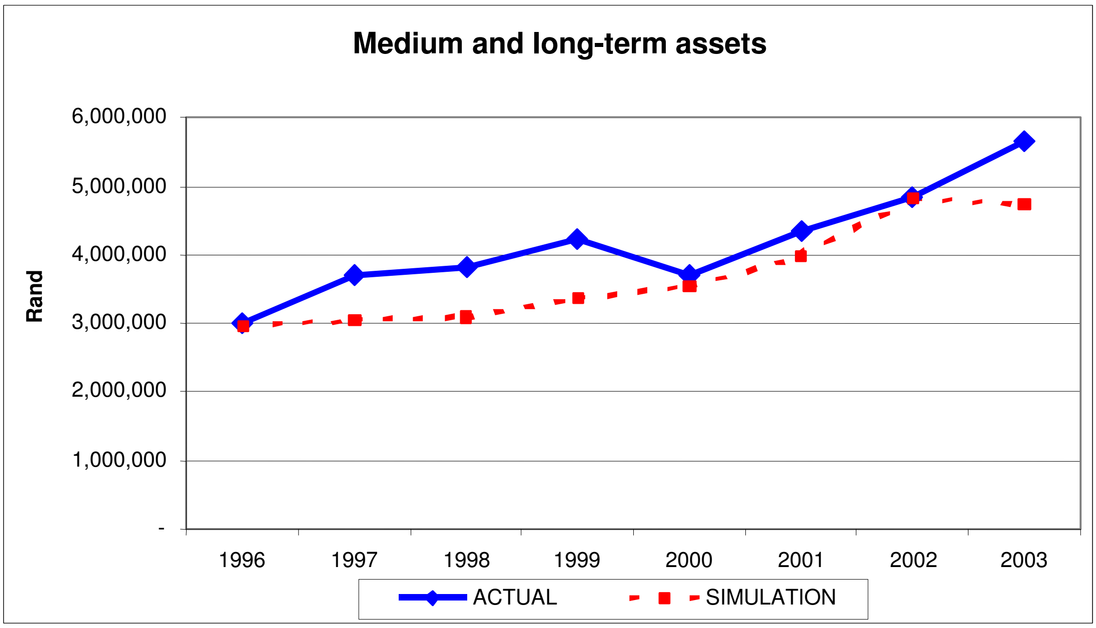

Figure 6.10: Medium and long-term assets, 1996 to 2003: actual vs simulation

Simulation results of short-term assets follow the trend of the actual figures relatively accurately, but large deviations do exist between the monetary values of the simulation and actual results (Figure 6.11).

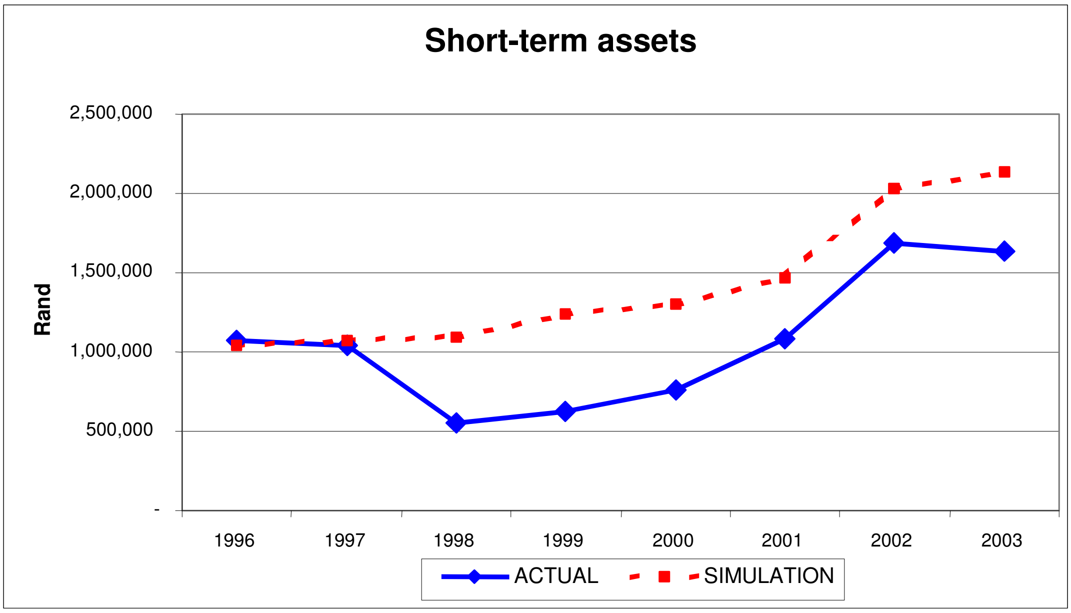

Figure 6.11: Short-term assets, 1996 to 2003: actual vs simulation

Simulation results of debt as presented by Figures 6.12 and 6.13 indicate that large deviations between simulation results and actual results exist. In Figure 6.12 it is clear that the simulation results follow almost the opposite trend than that of the actual short-term liabilities, while in the case of medium and long-term liabilities the trends are not opposite but still significantly different.

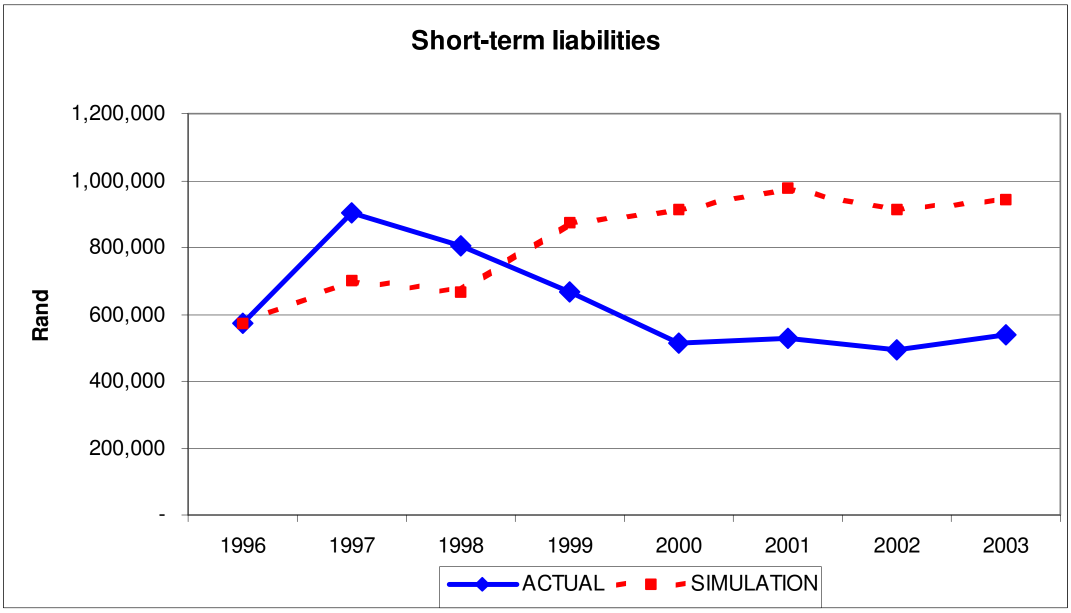

Figure 6.12: Short-term liabilities, 1996 to 2003: actual vs simulation

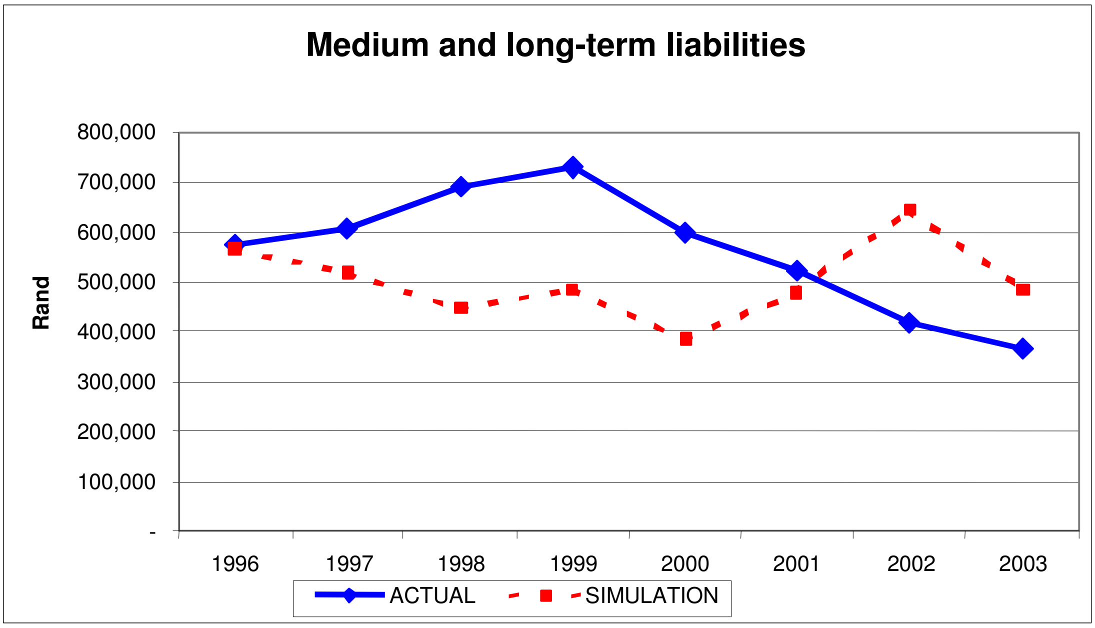

Figure 6.13: Medium and long-term liabilities, 1996 to 2003: actual vs simulation

The analyses of the above figures indicate that the simulation results differ most significantly from the actual results in the case of interest and rent, short-term assets and short, medium and long-term liabilities. In order to determine why the deviations take place in the above-mentioned variables, in-depth analysis is required. Analysis of the short-term assets indicates that large movements in the valuation of crop still in the field took place during 1998. Further analysis indicates that a large reduction in plantings of both wheat and maize took place during the 1998 season, which is the cause of the large reduction in the valuation. Although this movement in hectares planted is captured in the sector model and thus the farm-level model, the absence of a link between the crop enterprise sheets and the short-term assets in the statement of assets and liabilities causes the farm-level model not to adjust the value of the crop in the field as it takes place in reality. The result is that although the farm-level model captures the trend effect and therefore income effect on the amount of crop in the field via the change in hectares planted, the effect on value of crop in fields is not captured in the case of large deviations. This is likely to be the cause of the deviation in short-term assets as presented in Figure 6.11.

In the case of simulated liabilities not following actual liabilities in terms of movements and trends, analyses indicate that large deviations took place during 1998 and 1999 in long-term liabilities while large deviations in short-term liabilities took place during 1997 to 1999. The reason for the deviation in long-term liabilities is evident from the deviation in land and fixed improvements during 1998, which indicates the possible buying of additional land in order to increase the size of the farming operation. The buying land was most probably made possible by higher gross farm income during 1997 due to above average income from wheat. The above average income from wheat was due to increased hectares planted. The effect of increase in debt due to buying of land is not taken into account by the farm-level model, due to the difficulty of simulating a decision to buy land. The difficulty of simulating the decision to buy land is due to the fact that buying of land is not a decision that is repeated on a regular basis, and secondly that the reasons or motivation for buying land differs significantly from one farm operator to the next.

The reason for the large deviations in short-term liabilities is a large reduction in creditors during 1998. The large reduction in creditors can possibly be explained by the increase in gross farm income from wheat and maize, and therefore more cash was available for debt repayment especially repayment of short-term debt. The simulation of repayment of short-term debt above the average repayment amount is relatively difficult as in the case of buying land. Above average repayment of short-term debt due to above average gross farm income is highly unpredictable due to the many choices the farmer faces of what to do with the additional cash in the case of above average gross farm income.

Due to the large deviations taking place in the liabilities as explained, as well as the buying of land, interest and rental payments as simulated by the model deviate from the actual interest and rental payments. One possible solution to simulate interest and rental payments more accurately is to simulate repayment of short-term debt and buying of land more accurately. But, as explained, to simulate repayment of short-term debt as well as buying of land more accurately is quite difficult due to the difficulty of simulating the choices made by the farmer regarding these two variables.

6.5 SUMMARY

Chapter six served the purpose of presenting the structure of the representative grain and livestock farm in the Reitz district, as well as validating the model. Simulation results in terms of cash surplus/deficit and debt to asset ratio indicate that the model simulates reality fairly accurately, but deviations from reality do take place in both variables' simulation results. Further analyses indicate that a possible reason for the deviations is the absence of a link between change in crop hectares planted and crop in field value as indicated in the statement of assets and liabilities. Two additional reasons for the deviations are the absence of functions to simulate buying of land as well as the above average repayment of short-term debt due to above average gross farm income in a specific year. A fourth reason for the deviations might be the change in the number of farmers taking part in the VKB study group, hence the actual numbers change due to the number of farmers changing.

CHAPTER 7
BASELINE AND SCENARIOS

7.1 INTRODUCTION

The previous chapter served the purpose of validating and verifying the output results of the farm-level model. In this chapter the baseline projection for the VKB representative farm will be developed, after which three scenarios in terms of change in markets and policies will be tested. The results of each of the scenarios will be compared to the baseline results, and the implications of each of the deviations from the baseline will be discussed. The three scenarios that will be simulated are an exchange rate appreciation, the effect of an alternative wheat import tariff as proposed[1] and the effect of an ambitious world trade liberalisation scenario[2].

7.2 THE BASELINE

The purpose of the modelling and simulation action is firstly to represent the representative VKB farm as realistically as possible, secondly to attempt to understand and describe the implications of changes in markets and policies on the financial survivability of the farm business. In order to study and understand the implications, a baseline has to be generated against which the three different scenarios can be compared. This is likely to give a better understanding of the implications of change.

A baseline projection is considered as a possible market and policy outlook, and should therefore not be understood as a forecast. This implies that a baseline is developed on the basis of a set of assumptions with regards to exogenous variables and endogenous variables such as macro-economic variables, agricultural and economic policies, climatic variables, asset replacement strategies and asset values, size of farm and combination of farm activities, etc. The baseline consequently assumes that no changes will take place in these assumed variables. Furthermore, since the modelling and simulation action follows a positivistic approach, the study

[1] Competitiveness of wheat production in the Western Cape, South Africa, 2005
[2] Competitiveness of wheat production in the Western Cape, South Africa, 2005

doesn't attempt to describe what should happen to the farm, but rather what is likely to happen given the current combination of farm activities, management practises as well as financial position.

7.2.1 Assumptions

Projections for several international market and policy variables were obtained from the Food and Agricultural Policy Research Institute's (FAPRI) 2004 baseline. Projections for the South African agricultural sector were obtained from the sector-level model of Meyer (2002). South African macro-economic variable projections were obtained from Absa Economic Research unit as well as African Institute for Economic Modelling (Afrinem). Projections on population numbers were obtained from the Actuarial Association of South Africa.

Table 7.1: Macro-economic variables: baseline assumptions (base year = 1995)

Variable	Measure	2003	2004	2005	2006	2007	2008	2009	2010
SA population	Millions	46,8	47,2	47,5	47,6	47,6	47,6	47,5	47,3
Exchange rate	SA cents/US$	757	658	614	632	670	704	732	754
CPI: food	Index	183	191	198	205	210	214	221	228
CPI: total	Index	171	179	185	191	197	201	206	213
GDP deflator	Index	178	187	193	200	205	209	215	222
Interest rate (weighted)	Index	111	117	121	125	128	131	134	139
PPI: field crops	Index	173	181	188	194	199	203	209	216
PPI: total	Index	160	168	174	180	185	188	194	200
PPI: agricultural goods	Index	166	174	180	186	191	195	201	207
Fuel	Index	285	312	355	402	454	508	573	649
Requisites	Index	212	222	230	237	244	249	256	264
Intermediate goods	Index	218	228	236	244	251	256	263	272
Implements	Index	199	208	216	223	229	233	240	248
Repairs and maintenance	Index	229	240	248	256	264	269	276	285
Irrigation equipment	Index	181	189	196	203	208	212	218	226
Feed	Index	190	199	206	213	219	223	230	237
Fertiliser	Index	225	236	244	253	260	265	272	281
Machinery and implements	Index	190	199	206	213	219	223	229	237

Source: Bureau for Food and Agricultural Policy, 2005

Table 7.2: International commodity prices: baseline assumptions

Variable	Measure	2003	2004	2005	2006	2007	2008	2009	2010
Yellow maize, US No 2, fob, Gulf	US$/t	104	108	103	106	107	109	110	113
Wheat US No 2 HRW fob (ord) Gulf	US$/t	151	161	148	148	149	151	154	157
Sunflower seed price, Lower Rhine	US$/t	325	321	326	292	291	291	291	289
Sunflower cake price, Rotterdam	US$/t	166	127	117	121	122	122	122	122
Sunflower oil, NW Europe	US$/t	660	680	657	661	662	662	662	658
Sorghum, US No 2, fob, Gulf	US$/t	111	104	104	103	104	105	106	106
Soya bean production price: Rotterdam, fob	US$/t	312	261	237	243	244	244	243	242
Soya bean cake price: Rotterdam, fob	US$/t	275	210	193	199	202	204	203	202
Soya bean oil price: Rotterdam, fob	US$/t	630	547	509	507	499	493	488	485
World fishmeal price: CIF, Hamburg	US$/t	590	678	701	724	745	759	780	807
Steers, Nebraska, CIF	US$/100 lb.	70	61	66	69	68	65	62	59
Broilers, US 12-city	US$/100 lb.	62	62	59	59	59	59	60	60
Cheese, fob N. Europe	US$/t	1839	2145	2088	2068	2080	2104	2122	2145
Butter, fob N. Europe	US$/t	1392	1552	1517	1575	1615	1648	1684	1707
SMP, fob N. Europe	US$/t	1709	1809	1810	1765	1753	1769	1780	1817
WMP, fob N. Europe	US$/t	1747	1792	1781	1763	1774	1793	1813	1842
Hogs, US 51–52% lean	US$/100 lb.	39	38	41	42	40	39	40	43

Source: Bureau for Food and Agricultural Policy, 2005

Table 7.3: Domestic commodity prices: baseline assumptions

Variable	Measure	2003	2004	2005	2006	2007	2008	2009	2010
White maize price	Index	100	104	65	93	98	94	92	90
White maize yield	Index	100	105	118	119	120	121	122	123
White maize area planted	Index	100	88	88	65	79	82	83	84
Yellow maize price	Index	100	104	71	92	95	100	108	116
Yellow maize yield	Index	100	105	119	118	120	121	122	123
Yellow maize area planted	Index	100	98	108	102	104	99	95	92
Wheat price	Index	100	92	87	89	94	98	102	106
Wheat yield	Index	100	102	113	114	114	115	116	117
Wheat area planted (summer rainfall area)	Index	100	117	115	132	116	106	102	96
Sunflower price	Index	100	105	92	77	93	94	98	100
Sunflower yield	Index	100	92	92	93	93	94	95	96
Sunflower area planted	Index	100	85	91	126	96	102	101	100
Sorghum price	Index	100	53	52	55	61	65	69	73
Sorghum yield	Index	100	102	103	104	104	105	105	106
Sorghum area planted	Index	100	155	148	145	133	124	116	106
Soya price	Index	100	80	72	77	82	85	88	91
Soya yield	Index	100	144	141	142	144	146	147	148
Soya area planted	Index	100	113	121	121	119	117	116	115
Beef average auction price	Index	100	111	101	118	127	131	137	144
Chicken producer price	Index	100	89	79	88	94	97	102	106
Egg consumer price	Index	100	127	111	116	121	123	127	131
Pork producer price	Index	100	108	101	117	125	130	137	145

Source: Bureau for Food and Agricultural Policy, 2005

7.2.2 Baseline results

Detailed outputs of the baseline scenario are presented in the appendix. It needs to be noted that the ending cash surplus/deficit excludes principal payments and asset replacement cash flows for reasons as explained in chapter six, section 6.4.1.

Given the macro-economic and commodity price assumptions as presented in Tables 7.1 to 7.3, the ending cash surplus of the representative farm increases from a level of R522 881 to reach a maximum surplus level of R1 340 716 during 2007 (Fig. 7.1). However, when analysed closer, the increase in the cash surplus from 2003 to 2007 is at a decreasing rate. From 2007 onwards the cash surplus follows a declining trend and ends at a level of R1 154 542 in 2010. The reason for the decreasing trend of the ending cash surplus is due to the increase in inflation on inputs at a slightly greater rate than the increase in farm output prices, but more important is the increase in interest payments due to the increase in the debt to asset ratio up to 2007, as presented in Figure 7.2.

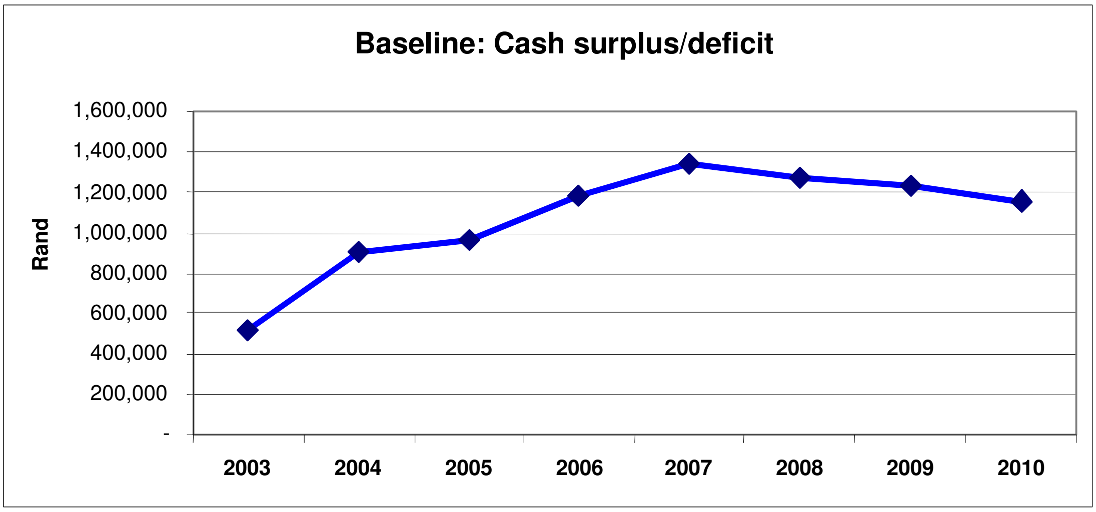

Figure 7.1: Baseline cash surplus/deficit

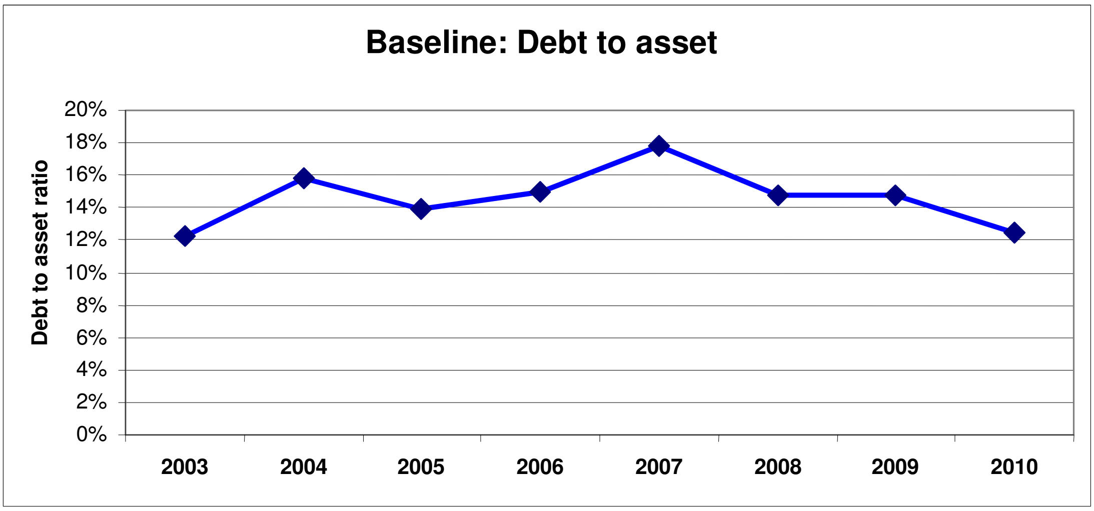

Figure 7.2: Baseline debt to asset ratio

The debt to asset ratio as presented in Figure 7.2 varies between 12% and 18% for the simulation period. During 2003 the debt to asset ratio is 12%, after which it increases to reach a maximum of 18% during 2007. From 2007 onwards the debt to asset ratio declines to return to a level of 12%. The increase in debt up to 2007 is due to a general increase in the gross farm income of the farm, hence an increase in asset replacement takes place leading to more debt incurred due to asset replacement. A reason for the decline in the debt to asset ratio is because the increase in total assets is relatively larger than the movement (increase or decrease) in total debt, which results in a decrease in the debt to asset ratio. The relative difference between the increase in total assets and the movement of total debt is evident by the increase of the real net worth as presented in the appendix.

7.3 THE SCENARIOS

7.3.1 SCENARIO ONE: THE APPRECIATION OF EXCHANGE RATE AGAINST US DOLLAR

7.3.1.1 Background and assumptions

Drastic movements in the Rand/US dollar exchange rate from 2001 to 2004 had many effects on domestic commodity prices as well as input prices. During 2002 the Rand depreciated to an average of 1 047 cents against the US dollar, and then started appreciating to an average level of 658 cents against the US dollar during 2004. In Chapter 6, Tables 6.2 and 6.4, the effects of the dramatic depreciation followed by the appreciation of the value of the rand against the US dollar are clear. From Table 6.4, Chapter 6, and Table 7.3 (Chapter 7), it is evident that an appreciation in the value of the rand has a significant impact on commodity prices in terms of causing a decrease in general commodity prices. The long-term effect of an appreciating currency on the survivability of the representative farm needs to be understood in order to develop strategic and action plans to curb the possible negative effect of an exchange rate appreciation. Therefore, a scenario where an appreciation of the rand against the US dollar does take place is simulated and analysed.

The assumption in this scenario that causes the deviation from the baseline is an appreciation of the exchange rate of the rand against the dollar in 2004 from a level of 658 cents/US dollar to 500 cents/US dollar. Thereafter a gradual depreciation of the exchange rate of the rand takes place at the same rate as that of the baseline.

7.3.1.2 Empirical results

The effect of the appreciation of the rand against the dollar during 2004 is presented in Figure 7.3. It is evident that the immediate effect of the exchange rate appreciation is zero, since the farm-level model is an annual model and simulates the financial position of the farm at the end of each period. Hence, the effect becomes visible only during 2005.

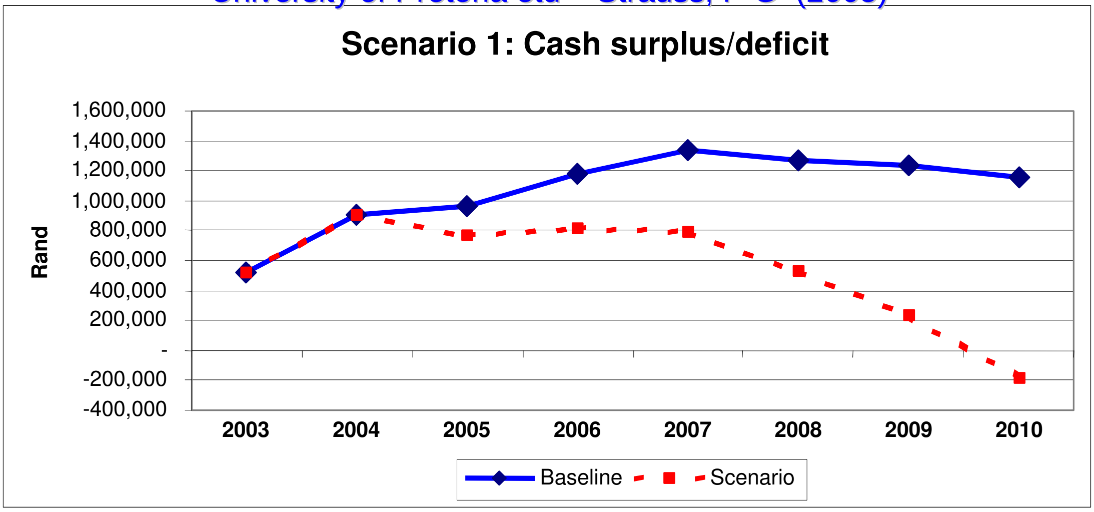

Figure 7.3: Cash surplus/deficit scenario 1

Over time, the effect increases due to debt that is incurred because of low profitability, increasing debt payments as well as interest payments (Figure 7.4). This has the effect that ending cash levels decrease at an increasing rate, until the ending cash level for 2010 becomes negative. It can therefore be concluded that the general impact of an appreciation of the rand against the dollar is likely to be negative over the long term for the financial position and hence the survivability of the representative farm. The effect of the exchange rate appreciation on input costs is, however, taken into account to a limited extent due to the fact that inflation on inputs is lower because of the appreciation but no significant decreases in input prices are simulated. The reason for this is that the sector model doesn't directly simulate the impact of exchange rate movements on input prices, but rather indirectly through adjusted inflation rates.

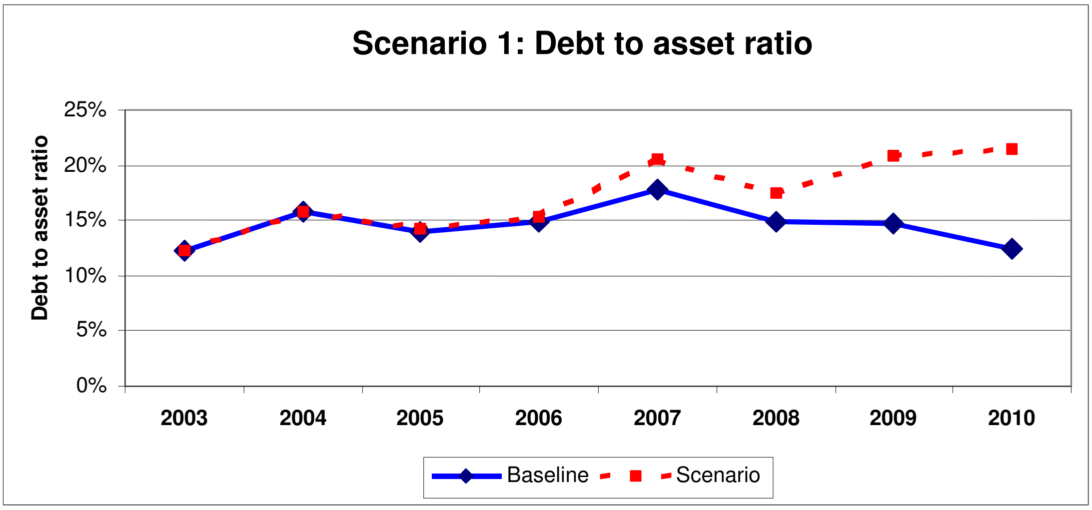

Figure 7.4: Debt to asset ratio scenario 1

7.3.2 SCENARIO TWO: ALTERNATIVE WHEAT IMPORT TARIFF

7.3.2.1 Background and assumptions

Governments, to protect domestic industries from foreign competition, traditionally use tariffs. However, over time, it became evident that tariffs have a negative impact on the general welfare of a country due to welfare losses incurred by consumers as well as the non-economic allocation of resources due to protection. Due to the welfare loss, several mechanisms were designed in order to attempt to curb the negative welfare effects. One of these mechanisms is the variable import levy, which was implemented in the case of South African imports of wheat. This mechanism, however, proved over time that it had very much the same welfare effects as traditional import tariffs.

During 2005, at the time of writing this dissertation, Meyer[3] did a study on the possibilities of an alternative wheat import tariff from the wheat import tariff used by the Department of Trade and Industry of South Africa. Meyer proposes an alternative wheat import tariff mechanism. The proposal is based on three arguments, namely the world reference price used to trigger the tariff mechanism should be a true reflection of the actual prices of imported wheat in South Africa, secondly, the tariff mechanism should be rand-based and not US-dollar based due to the extreme fluctuations in the rand/dollar exchange rate and, thirdly, the tariff has to be triggered on a frequent and transparent basis due to the high volatility in domestic wheat prices.

7.3.2.2 Empirical results

The assumption is made that the alternative tariff mechanism is introduced during 2004; hence the first effects become visible from 2005 onwards. Due to the formula by which the mechanism works, price fluctuations are curbed to a certain extent, while the average price of wheat marginally increases. The effect of the marginal increase in the mean of the wheat price has a positive impact on wheat profitability, and hence the cash position of the representative farm improves as illustrated in Figure 7.5.

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[3] Competitiveness of wheat production in the Western Cape, South Africa, 2005

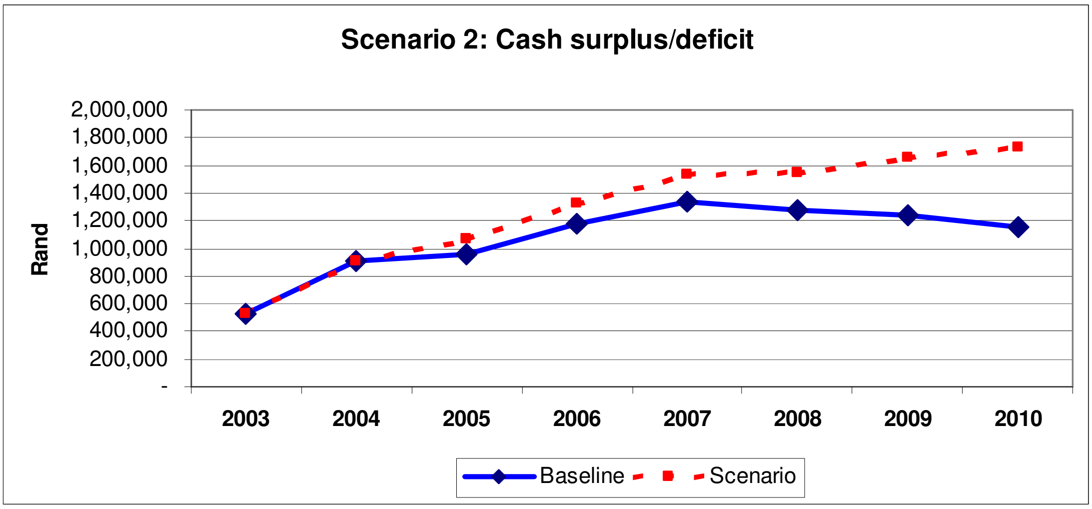

Figure 7.5: Cash surplus/deficit scenario 2

Due to the improved profitability and hence the improved cash position of the representative farm, a decrease in the debt to asset ratio is visible in Figure 7.6. The farm business therefore needs less debt to finance production activities due to better profitability. The impact of the lower debt levels is positive at an increasing rate, due to debt payments decreasing from the baseline, and therefore interest payments also decrease but at an increasing rate. The overall impact of the alternative tariff mechanism is therefore likely to be positive on the financial position, and therefore the survivability of the representative farm.

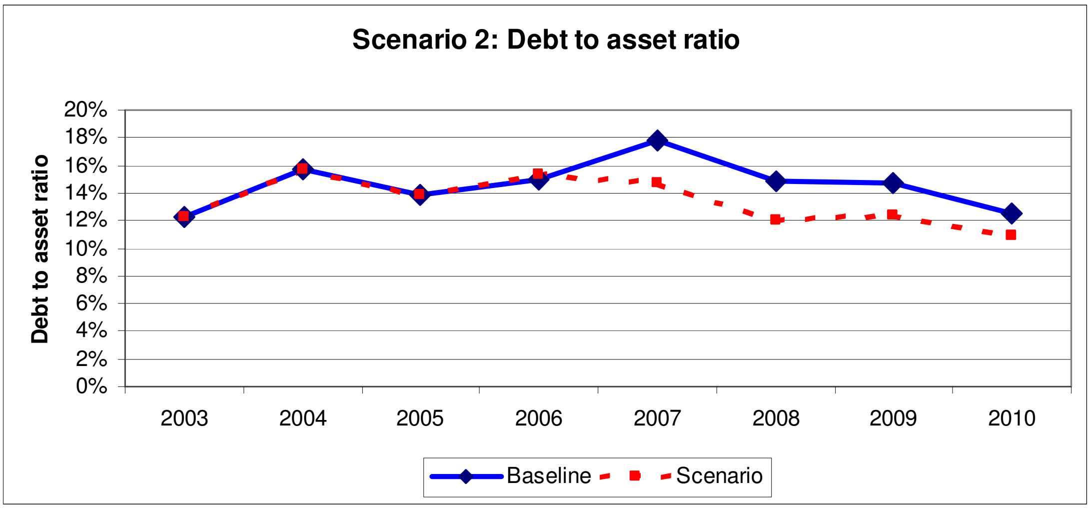

Figure 7.6: Debt to asset ratio scenario 2

7.3.3 SCENARIO THREE: WORLD TRADE LIBERALISATION

7.3.3.1 Background and assumptions

Several studies have been conducted on the effects of developed countries' agricultural policies on world markets as well as developing countries' agricultural sectors. This research includes studies on the possible effect of the abolishment of agricultural support by the developed countries on world agricultural markets and prices. The majority of the studies argue that the abolishment of agricultural support is likely to lead to a general increase in world commodity prices. A study by Elbehri and Leetmaa (2002) indicates that world wheat prices are likely to increase by 9,8% given the removal of global export subsidies, domestic support and import tariffs. A similar study undertaken by Vanzetti and Peters (2003) indicates that under an ambitious scenario of world trade liberalisation, world wheat prices are likely to increase by 14%. This scenario simulation makes use of the findings of Vanzetti and Peters under an ambitious trade liberalisation scenario to simulate the likely effect on the survivability of the representative farm.

7.3.3.2 Empirical results

The effect of world trade liberalisation under an ambitious scenario is likely to have a positive impact on the representative farm's survivability. This is evident from the improved cash position of the farm as indicated in Figure 7.7.

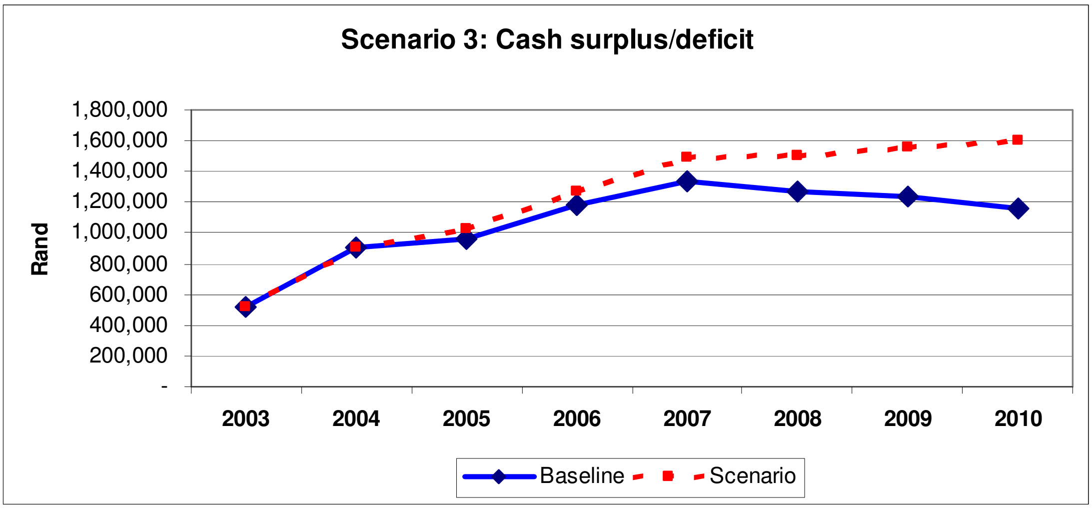

Figure 7.7: Cash surplus/deficit scenario 3

Due to a likely increase in international wheat prices, the increase is fed through to the domestic wheat market, which has a general positive impact on wheat producer prices. The profitability of wheat production therefore improves, with the result that the cash position improves over time. Interestingly, the price increase due to trade liberalisation doesn't have the same magnitude of impact on the cash position as that of the alternative tariff dispensation.

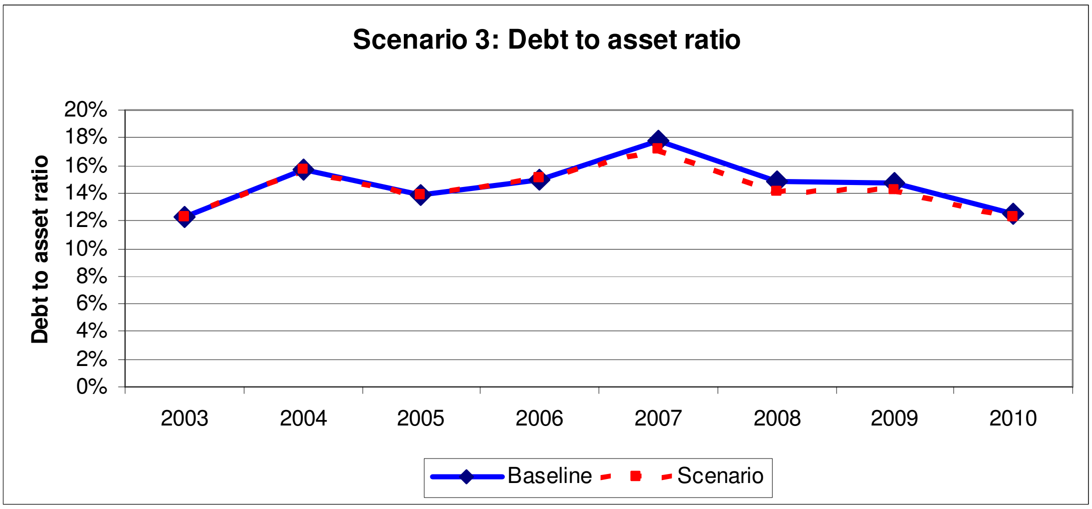

Figure 7.8: Debt to asset ratio scenario 3

The impact of the improved cash position has a slight effect on the debt to asset ratio of the representative farm as indicated in Figure 7.8. A decrease in the debt to asset ratio is visible due to improved profitability and therefore less debt is incurred to finance production activities. Debt payments as well as interest payments therefore decrease. It can be concluded that under an ambitious scenario of world trade liberalisation, the survivability of the representative farm is likely to improve due to improved profitability.

7.4 CONCLUSION

Chapter 7 served the purpose of simulating different scenarios in terms of markets and policies and their likely effects on the survivability of the representative farm. In general, the empirical results conform to theoretical expectations. Hence the conclusion can be drawn that the model has the ability to simulate the likely impact of changes in markets and policies on the survivability of the representative farm in the Reitz district, Free State province, South Africa.

CHAPTER 8
SUMMARY AND CONCLUSION

In the past decade South Africa experienced major political and economic changes. In addition to these major changes, South Africa is a highly diverse country and a country of extremes in many respects. Within this dynamic and diverse environment the agricultural sector has to survive and grow financially. In order to survive and grow, good decision-making within the agricultural sector in terms of policies and business strategies is extremely important and necessary. However, within the dynamic and extreme environment it is very difficult for decision-makers to make correct decisions since the likely impact of changes in markets and policies is difficult to quantify.

The general objective of this dissertation was to identify and construct a type of farm-level model that will have the ability to quantify the likely impact of changes in markets and policies on the financial survivability of a representative farm. The specific objective was to construct a model of a representative grain and livestock farm in the Reitz district, Free State Province, South Africa.

The first part of the dissertation outlined the basic philosophy and principles of modelling and simulation as well as the basic characteristics of the farm system under investigation. Based on the philosophy and principles of modelling and simulation as well as the type of questions that needs to be answered by this model, an approach as well as a type of farm-level model was identified. A brief literature study was conducted on the same types of farm-level models.

The approach to farm-level modelling that is followed is a positivistic approach since questions of "what is the likely impact" is asked, and not "what ought to be" questions. Apart from behavioural equations, this simulation model also consists of accounting identities. The model is of deterministic type since explanatory and descriptive type of questions needs to be answered.

Based on the approach as well as type of model, the farm-level model's structure is developed and explained. The following part validates and verifies the model, in order to determine if the model simulates reality accurately, and if not, what the reasons for deviations are.

The last part of the dissertation consists of the development of a baseline of the farm-level model that is used as basis for scenario analysis. The deviations of the scenarios from the baseline are discussed and analysed. The scenarios that were simulated were an exchange rate appreciation of the rand against the dollar, an alternative wheat import tariff as proposed, as well as an ambitious scenario of world trade liberalisation. The scenarios were selected to simulate a change in markets, a change in policies and a combination of changes in markets and policies.

The development of this farm-level model contributes to research in the field of farm-level modelling in South Africa as it has the ability to simulate the impact of changes in markets and policies on a representative farm's financial position. This is done by means of linking the farm-level model to a sector-level model developed by Meyer (2002) as well as outputs from several other institutions in terms of macro-economic variables and social variables. There are, however, several issues that became clear in this study.

Firstly, as pointed out in Chapter 2, positivistic simulation models have the disadvantage that validation and verification are difficult and time consuming due to lack of accurate and detailed data. In the case of this study, detailed accurate data were available, and therefore the model could be verified and validated to a certain extent. However, very little data existed on replacement of moveable assets that play a crucial role in the liquidity and solvability of a farm. Also, no data existed on buying of land and repayment of short-term debt, especially in the case of above average gross farm income. This resulted in the simulation results deviating from reality in the case of the debt to asset ratio. Another problem with validating and verifying the model was the fact that the number of farmers taking part in the study group changed over the period under study, hence the changes in the actual values could also be attributed to the changing number of farmers.

Furthermore, due to the nature of the positivistic approach in the sense that "what is the likely outcome" types of questions are asked, the assumption is made during the simulation process that very little adjustment in terms of the farm structure take place during the simulation process. The assumption is therefore that the farm structure remains very much the same as during the beginning year of simulation. This is not correct in most instances since farm operators attempt to adapt to changing conditions as rapidly as possible in order to ensure survival and growth. One possible solution to the problem of not being able to simulate adaptation to changing conditions is to develop a model following a normative approach. This normative model can be run on the same research problem as that on which the positivistic model is used. This will in essence render two different perspectives on the research problem that will aid the decision-maker by increased understanding of the problem.

The third problem with specifically the deterministic type of model is the fact that the model and simulation process assumes no risk. As pointed out in the first chapter, the agricultural sector is part of a highly dynamic and extreme environment, and therefore risk and uncertainty is inherently part of the system under study. By constructing a deterministic type of model, risk and uncertainty is therefore assumed not to be part of the farm system, which is not correct. Hence, the farm-level model needs to be further developed in order to incorporate risk and uncertainty.

Lastly, due to the nature of the positivistic approach to modelling, reality needs to be simulated as closely as possible. The modeller therefore needs a theoretical as well as practical knowledge and understanding of the system modelled and simulated. In many cases, the modeller does not have practical knowledge of the system, and as a result the difficulty of simulating the system realistically increases significantly. This problem can partly be curbed by actively involving industry specialists as well as people with “local” knowledge to assist in the modelling and simulation process. These people can also assist with the verification and validation of the model in the case where very little or no historical data exist with which to verify and validate the model.

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Appendix

YEAR	2003	2004	2005	2006	2007	2008	2009	2010
INCOME STATEMENT								
CASH FARM INCOME								
Crops	2,371,054	2,676,850	2,524,027	2,811,563	2,989,128	2,886,861	3,006,114	3,086,656
Livestock	738,097	756,900	721,094	822,460	882,090	922,150	981,310	1,046,792
Other	411,718	431,480	446,582	461,319	474,236	483,247	496,778	513,668
TOTAL	3,520,868	3,865,230	3,691,703	4,095,342	4,345,455	4,292,258	4,484,202	4,647,116
CASH FARM EXPENSES								
Crops	1,325,892	1,468,470	1,617,477	1,804,298	1,834,358	1,857,109	1,916,894	1,985,127
Livestock	578,213	592,542	471,689	594,141	623,417	658,451	708,102	764,716
Labour	158,028	165,613	171,410	177,066	182,024	185,483	190,676	197,159
Management salary	34,409	36,061	37,323	38,554	39,634	40,387	41,518	42,929
UIF	-	-	-	-	-	-	-	-
Accident insurance: employees	-	-	-	-	-	-	-	-
Provincial government levy	-	-	-	-	-	-	-	-
Professional services	-	-	-	-	-	-	-	-
Repairs and maintenance (unallocated)	353,488	370,455	383,421	396,074	407,164	414,900	426,518	441,019
Fuel and lubricants (unallocated)	-	-	-	-	-	-	-	-
Short-term insurance	39,580	41,480	42,932	44,348	45,590	46,456	47,757	49,381
Farm utilities (electricity, water, phone, etc.)	47,578	49,862	51,607	53,310	54,803	55,844	57,407	59,359
Licenses	28,645	30,020	31,071	32,096	32,995	33,622	34,563	35,738
Membership fees	-	-	-	-	-	-	-	-
Bank charges (admin costs)	7,819	8,194	8,481	8,761	9,006	9,177	9,434	9,755
Auditor	-	-	-	-	-	-	-	-
Land rent	86,257	90,397	93,561	96,649	99,355	101,243	104,078	107,616
Miscellaneous	-	-	-	-	-	-	-	-
Other cash expenses	13,016	13,641	14,118	14,584	14,992	15,277	15,705	16,239
TOTAL	2,672,925	2,866,735	2,923,091	3,259,882	3,343,339	3,417,949	3,552,652	3,709,040
FARM GROSS MARGIN	847,943	998,495	768,612	835,461	1,002,115	874,308	931,549	938,076
Interest Long-term debt	21,050	21,026	20,687	20,198	19,470	18,384	17,192	15,775
Interest Medium-term debt	30,376	88,337	76,846	102,479	177,858	138,627	141,268	117,855
Interest Operating loan	136,319	153,221	161,702	186,283	196,402	204,600	218,618	236,001
Interest Carryover debt	-	-	-	-	-	-	-	-
TOTAL	187,745	262,584	259,234	308,960	393,729	361,610	377,078	369,631
NET CASH FARM INCOME	660,198	735,911	509,378	526,500	608,386	512,698	554,471	568,445
Depreciation	113,993	111,143	120,289	114,274	119,358	135,424	128,653	134,395
NET FARM INCOME	546,206	624,768	389,090	412,226	489,029	377,274	425,818	434,050

YEAR	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
CASH FLOW STATEMENT								
CASH INFLOWS								
Beginning cash reserves	-	333,863	624,001	800,016	865,334	890,391	818,234	730,719
Net Cash Farm Income	660,198	735,911	509,378	526,500	608,386	512,698	554,471	568,445
Non-farm income	118,098	123,767	128,099	132,326	136,031	138,615	142,497	147,342
Interest on cash reserves	-	26,242	50,763	67,230	74,755	78,381	74,046	68,375
Cash difference asset replacement	-	-	-	-	-	-	-	-
TOTAL CASH INFLOWS	778,296	1,219,783	1,312,241	1,526,072	1,684,506	1,620,086	1,589,248	1,514,880
CASH OUTFLOWS								
Cash difference asset replacement	146,790	168,801	36,367	130,130	146,003	109,616	142,979	152,614
Principal long-term debt	6,171	6,195	6,534	7,023	7,751	8,837	10,028	11,446
Principal medium-term debt	36,057	108,219	119,710	176,343	296,571	335,802	349,857	263,960
Income taxes	40,965	87,823	117,005	106,956	96,776	95,890	96,909	92,786
Land taxes	-	-	-	-	-	-	-	-
Carryover debt	-	-	-	-	-	-	-	-
CASH OUTFLOWS (Carryover debt excl.)	229,983	371,038	279,616	420,452	547,101	550,145	599,774	520,806
RETURN TO FAMILY LIVING	548,313	848,745	1,032,625	1,105,620	1,137,405	1,069,941	989,474	994,074
Family living	214,450	224,744	232,610	240,286	247,014	251,707	258,755	267,552
TOTAL CASH OUTFLOWS	444,433	595,781	512,226	660,738	794,115	801,852	858,529	788,359
ENDING CASH SURPLUS/DEFICIT (excl cash asset repl and princ. Paym)	522,881	907,216	962,627	1,178,830	1,340,716	1,272,489	1,233,584	1,154,542
ENDING CASH SURPLUS/DEFICIT	333,863	624,001	800,016	865,334	890,391	818,234	730,719	726,522

YEAR	2003	2004	2005	2006	2007	2008	2009	2010
STATEMENT OFASSETS AND LIABILITIES								
FIXED ASSETS								
Land and fixed improvements	1,486,374	1,557,720	1,612,240	1,665,444	1,712,077	1,744,606	1,793,455	1,854,432
Other properties	46,055	48,266	49,955	51,603	53,048	54,056	55,570	57,459
Co-operative member funds	719,873	754,427	780,832	806,599	829,184	844,939	868,597	898,129
Other investments (shares etc.)	-	-	-	-	-	-	-	-
Surrender value on policies	-	-	-	-	-	-	-	-
TOTAL	2,252,302	2,360,412	2,443,027	2,523,647	2,594,309	2,643,601	2,717,622	2,810,021
MOVEABLE ASSETS								
Vehicles	2,222,855	2,405,776	2,285,487	2,387,150	2,708,486	2,573,061	2,687,903	2,687,380
Implements and machinery	-	-	-	-	-	-	-	-
Equipment and tools	-	-	-	-	-	-	-	-
Breeding stock								
Cattle	801,445	936,502	905,570	1,106,210	1,233,951	1,336,679	1,473,100	1,622,624
Dairy	181,475	292,303	346,641	492,734	612,932	723,149	852,253	991,042
Pigs	-	-	-	-	-	-	-	-
Office equipment	-	-	-	-	-	-	-	-
TOTAL	3,205,775	3,634,580	3,537,698	3,986,094	4,555,369	4,632,889	5,013,256	5,301,046
CURRENT ASSETS								
Cash surplus	333,863	624,001	800,016	865,334	890,391	818,234	730,719	726,522
Stock:								
Marketable stock:								
Cattle	19,771	21,673	19,940	23,088	24,600	25,483	26,964	28,570
Pigs	-	-	-	-	-	-	-	-
Stored crops								
Production means	114,094	119,571	123,755	127,839	131,419	133,916	137,666	142,346
Deposits	191,001	200,169	207,175	214,012	220,004	224,184	230,461	238,297
Debtors	-	-	-	-	-	-	-	-
Deferred payment	-	-	-	-	-	-	-	-
Crop on land (only if comprehensively insured)	913,536	957,386	990,894	1,023,594	1,052,254	1,072,247	1,102,270	1,139,747
VAT receivable	-	-	-	-	-	-	-	-
TOTAL	1,572,265	1,922,799	2,141,781	2,253,867	2,318,669	2,274,065	2,228,080	2,275,482
TOTAL ASSETS	7,030,342	7,917,792	8,122,505	8,763,607	9,468,346	9,550,554	9,958,958	10,386,549
LIABILITIES								
Long term liabilities	125,394	119,200	112,666	105,643	97,892	89,054	79,026	67,580
Medium term liabilities	197,602	540,172	420,462	522,746	882,282	604,518	641,629	445,468
Short term liabilities								
Cash deficit	-	-	-	-	-	-	-	-
Overdraft facility	107,562	121,230	120,236	137,648	147,464	149,098	155,830	158,394
Credit card (outstanding)	-	-	-	-	-	-	-	-
Production loans	432,121	467,730	474,119	544,306	557,772	570,886	595,721	624,055
Monthly accounts	-	-	-	-	-	-	-	-
Creditors	-	-	-	-	-	-	-	-
Income tax overdue	-	-	-	-	-	-	-	-
Tax provision	-	-	-	-	-	-	-	-

YEAR	2003	2004	2005	2006	2007	2008	2009	2010
FINANCIAL RATIOS								
NET CASH FARM INCOME	660,198	735,911	509,378	526,500	608,386	512,698	554,471	568,445
ENDING CASH SURPLUS/DEFICIT (excl cash asset repl and princ. Paym)	522,881	907,216	962,627	1,178,830	1,340,716	1,272,489	1,233,584	1,154,542
NET WORTH	6,167,662	6,669,460	6,995,022	7,453,264	7,782,937	8,136,997	8,486,751	9,091,053
REAL NET WORTH	6,167,662	6,363,989	6,448,927	6,651,882	6,756,915	6,932,581	7,033,623	7,286,706
DEBT RATIO (TOTAL DEBT/TOTAL ASSETS)	12.27%	15.77%	13.88%	14.95%	17.80%	14.80%	14.78%	12.47%
PRODUCTION COST RATIO (COSTS (excl interest): TOTAL INCOME)	75.92%	74.17%	79.18%	79.60%	76.94%	79.63%	79.23%	79.81%