Scenario thinking and stochastic modelling for strategic and policy decisions in agriculture

by

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DECLARATION

I declare that the thesis which I hereby submit for the degree PhD Agricultural Economics at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE: ……………………………..   DATE: **17 September 2009**

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ABSTRACT

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In 1985, Pierre Wack, arguably the father of modern scenario thinking, wrote the following: *"Forecasts often work because the world does not always change. But sooner or later forecasts will fail when they are needed most: in anticipating major shifts…"* (Wack, 1985: 73). The truth of this statement have again become apparent, first as the "food price crisis" played out during 2007 and 2008, and secondly as the current financial and economic crisis are playing out. Respected market commentators and analysts, both internationally and within South Africa, made all sorts of "informed predictions" on topics ranging from oil prices, interest rates, and economic growth rates to input costs and food prices. The problem is that none of these "respected views" and "informed predictions and estimates" became true within the period that was assigned to these predictions. In fact, just the opposite occurred: the unexpected implosion of the global economy and hence commodity markets.

The result of the experts "getting it so wrong", is that questions are being asked about the reliability of risk and uncertainty analysis. Even though the experts used highly advanced analytical techniques in analyzing the risks and uncertainties in order to formulate

predictions and outlooks, both the "food price crisis" and the economic implosion were totally unanticipated. The same questions need to be asked in terms of risk and uncertainty analyses in agricultural economics. With agriculture experiencing a period of fundamental changes causing significant uncertainty, risk and uncertainty analyses in agriculture will need to move to the next level in order to ensure that policies and business strategies are robust enough to withstand these newly arising uncertainties.

The proposed solution to this problem and therefore the hypothesis offered and tested by this thesis is to work with two techniques in conjunction without combining it when developing a view of the future. The two techniques used, namely intuitive scenario thinking and stochastic modelling are based on two fundamentally different hypotheses namely: the future is like the past and present (stochastic modelling), and the future is not like the past and present but is a result of combining current and unexpectedly new forces or factors (intuitive scenario thinking). The idea behind this stems from the philosophy of Socrates, whereby he postulated that the truth can never be fully known and therefore, when working with the truth, one needs to work with multi-hypotheses about the truth until all but one hypothesis can be discarded. This will then bring one closer to the truth, but never lead you to know the truth in full, since the truth can't be known in full.

Applying this idea means conjunctively using two techniques which are based on the two hypotheses about the future. From a literature review it was realised that two such techniques existed, namely, stochastic modelling and scenario thinking. Stochastic modelling, by its very nature, is based on the assumption that the future is like the past and present since historical data, historical inter-relationships, experience, and modelling techniques are used to develop the model, apply it, and to interpret its results. Scenario thinking on the other hand, and specifically intuitive logics scenario thinking, is based on the notion that the future is not like the past or present, but is rather a combination of existing and new and unknown factors and forces.

At first the perceived problem with this idea was thought to exist in the problem of using both techniques in combination, since the two techniques are fundamentally different because of the fundamentally different assumptions on which they are based. The question and challenge was therefore whether these two techniques could be used in combination, and how? However, the solution to this problem was more elementary than what was initially thought. As the two techniques are fundamentally different, it implies that the two techniques can't be combined because the two underlying assumptions can't be combined. However, what is possible is to use it in conjunction without adjusting either technique. Rather, one would allow each technique to run its course, which at the same time leads to cross-pollination in terms of ideas and perspectives, where possible and applicable. The cross-pollination of ideas and perspectives will then create a process whereby ideas regarding the two basic assumptions on the future are crystallised and refined through a learning process, hence resulting in clearer perspectives on both hypotheses about whether the future will be like the past and present, or whether the future will be a combination of existing and new but unknown factors and forces. These clearer perspectives provide a framework to the decision-maker whereby the two basic hypotheses on the future can be applied simultaneously to develop strategies and policies that are likely robust enough to be successful in both instances. It also provides a framework whereby reality can be interpreted as it unfolds, which signals to the decision-maker which of the two hypotheses is playing out. This will assist the decision-maker in better perceiving what is in fact happening, hence what the newly perceived truth is in terms of the future, and therefore what needs to be done in order to survive and grow within this newly developing future, reality, or truth.

The presentation of three case studies assists in testing the hypothesis of this thesis as presented in chapter one, and concludes that the hypothesis can't be rejected. Hence, through the presentation of the case studies it is found that using scenario thinking in conjunction with stochastic modelling does indeed facilitate a more complete understanding of the risks and uncertainties pertaining to policy and strategic business decisions in agricultural commodity markets, through fostering a more complete learning experience. It therefore does facilitate better decision-making in an increasingly turbulent and uncertain environment.

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CHAPTER 1: Introduction

1.1 Background

Literature indicates that although the direct contribution of agriculture to the economy is often relatively small, especially in the case of developed and some developing economies such as South Africa, the indirect contribution to the Gross Domestic Product (GDP) is often significant because of indirect links with other sectors in the economy. Apart from the direct and indirect contribution to the GDP of a country, the agricultural sector is often an important sector with regards to employment, rural stability, and also in supplying food at relatively low and stable prices to sustain and enhance economic and social development (Eicher & Staatz, 1998: 8 – 38; Fényes & Meyer, 2003: 21 – 45; Vink & Kirsten, 2003).

The significance of agriculture in terms of its economic and social contribution was highlighted with the significant increase in food prices during 2007 and 2008, widely termed the "food crisis." The unanticipated and significant increase in food prices caused unexpected inflationary pressure, which eventually led to major social unrest in various parts of the world, as well as economic instability. Much was written about the potential reasons for the soaring food prices, but at the end of the day it was ascribed to the following factors: rapid economic growth in emerging economies such as China and India led to an increase in the demand for food and commodities; in general, urbanisation that resulted in changing consumer preferences in terms of dietary composition, notably in respect to protein and starch; adverse weather conditions caused a decline in production of grain and grain stocks such as wheat, in various parts of the world. Other contributing factors were: the increased demand for maize and oilseeds for biofuel production; increases in production costs mainly due to an increasing oil price, and lastly, speculation in commodities to use as a hedge against a weakening US Dollar (International Food Policy Research Institute, 2007; United States Department of Agriculture, 2008).

Two questions arise as a result of the occurrence of the food crisis: first, were the dramatic increases in food prices and the resulting turbulence in food markets during 2007 and 2008 a once-off event, or could similar unanticipated events frequently occur in future? Secondly, if this is not a once-off unanticipated event, and is in fact a potential signal of an increasingly volatile and uncertain future food environment, what approach or combination of approaches should be followed in terms of agricultural commodity markets to facilitate good decision-making (strategic and policy decisions) to ensure the continued contribution of agriculture to the general economy and therefore society?

To find an answer to the first question, one needs to consider some developments during the past few decades that shed light on some present day trends and events, and the resulting volatility. The demand and supply of food is driven by changes in various spheres: namely, the economy, society, technology, the natural environment, institutions, and politics. During the past twenty to thirty years, it appears that the general rate of change in each of these various spheres is increasing rapidly, as is their level of inter-connectedness. The result is that a change in one sphere could potentially cause significant and unexpected shifts in some (or all) of the other spheres, causing further unestimable volatility.

Several examples exist to support this point. Thirty years ago, a computer was the size of a room, yet it had the computational power of a present day pocket calculator. Today, although smaller, their computational power is infinitely greater. Modern computers mean instant communication and information sharing through various communication channels, which have significant implications for politics, economics, and society in general (Rosenberg, 2004; Wellman, Salaff, Dimitrova, Garton, Gulia & Haythornthwaite, 1996). On the political front, dramatic global changes took place during the middle and late 80s when communism collapsed in the former Soviet Union. As a result, political, economic, and social changes are still taking place in several countries and regions around the world, such as China, the Middle East, South Africa, and South America (Zakaria, 2003). With regards to global economics, the rise of economic superpowers is rapidly occurring. For example, China and India's economies have been growing at a minimum rate of 8% per annum during the past five to ten years. These high economic growth rates cause significant increases in per capita income levels, resulting in increases in the demand for minerals, energy, and food (International Monetary Fund, 2008). This of course places a large burden on environmental sustainability, as well as social and political stability. In conjunction with the increasing pressures created by economic growth, are signs that the natural environment appears to be changing dramatically. Scientific evidence indicates that the natural environment thirty years from now will be significantly different. This has important implications for stable and affordable food production as well as economic, political and social stability (Millenium Ecosystem Assesment, 2005). On the social front, consumer preferences are changing rapidly too because of changes in living standards and styles as a result of changes in income and culture, due to this economic growth and urbanisation (International Food Policy Research Institute, 2007).

As indicated, the above mentioned changes and accelerated rate of change in the macro spheres, has an impact on the demand and supply of food. A number of examples exist to illustrate this, such as: the rapid growth in the demand for organically grown food and health food; the significant advances in the cultivation of genetically modified foodstuffs, and the rapid changes in food trade patterns resulting from multilateral and bilateral trade negotiations (Dimitri & Greene, 2002; International Food Policy Research Institute, 2007; Rippin, 2008; Kern, 2002). Other examples are changes in policy and legislation due to political changes, such as the change in agricultural marketing that took place in South Africa during the 1990s (Van Schalkwyk, Groenewald, Jooste, 2003).

Geographically, the production and consumption of food has changed dramatically during the past couple of years, and witnessed the rise of several global players such as Brazil, Argentina and China. A more recent example of dramatic changes in the global agricultural sector is the large scale movement towards producing fuel from food and fibre, especially in the USA. This movement has changed the economic structure of the international agricultural sector significantly, and permanently (International Food Policy Research Institute, 2007; United States Department of Agriculture, 2008). Combined with all these changes to the various spheres (both external and internal to the agricultural sector), two other trends have emerged. They are global population growth and a decline in land availability for food production. This has resulted in an agricultural sector that is very unstable in terms of supplying affordable food at stable quantities (International Food Policy Research Institute, 2007; United States Department of Agriculture, 2008).

Just (2001) expresses a similar view to what is set out in the previous paragraphs when he writes that agriculture in the twenty-first century is likely to face greater variability in the range and magnitude of events, especially in terms of the changes in the internal structure of agriculture. To support his point, he quotes Andrew Barkley's presidential address to the Western Agricultural Economics Association in 2001, where Barkley said: *"The agricultural economy of the United States is in a state of massive and rapid transition. Recent advances in information technology, biotechnology, and the organization of agribusiness firms have resulted in unprecedented change in the food and fibre industry."*

Based on the before mentioned arguments, one can therefore conclude that the rate of change, and therefore the level of risk and uncertainty of the agricultural sector's external and internal environments, appears to be increasing, hence the point that similar unanticipated events such as the food crisis of 2007/08 could occur in future, at a higher frequency. The implication of this point is that humans, and therefore governments and firms, will have to survive and thrive in such an increasingly volatile and uncertain environment. In order to do this, ways in which decisions are made on business strategy and policy will have to improve in order to ensure that good decisions can be made, which will ultimately lead to desired outcomes despite volatility and uncertainty. The problem is, however, that the fast-changing environment poses significant challenges to decision-makers in making correct policy and strategic business decisions, especially in terms of agricultural commodity markets. This is because change, and the accelerated rate of change, creates risks and uncertainties. This makes good policy and strategic decision-making in agricultural commodity markets a significant challenge.

1.2 Problem statement

Understanding and managing change, as indicated in the previous section, is a key challenge to survival and growth - for individuals, communities, societies, governments, and firms. Change creates such a key challenge, because through change, different spheres and levels of human existence are influenced and altered. In order to manage change, humans either react individually or devise institutions (Bowles, 2004). However, the exogenous environment as well as the underlying social interactions that give rise to institutions, also change as a result of changes in the shaping factors (Bowles, 2004: 49). Since economics is essentially the study of choice in order to understand allocation and distribution of resources, the study of change has always formed a key part of economics. Change influences choice and therefore allocation and distribution of resources. Bowles (2004: 6) writes: *"Contrary to its conservative reputation, economics has always been about changing the way the world works."*

The process of change in a system is driven by a factor, or combinations of factors, endogenous and exogenous to the system. Depending on the relative magnitude, direction, form, and combinations of the individual shaping factors, the process of change can be either sudden, or gradual and almost insignificant. Understanding the process of change by identifying and understanding the shaping factors, and also perceiving their impacts, is extremely difficult since it depends on the scale and scope of the analysis of the shaping factors. For example, when analysing global forces shaping global politics, economics, technology, social relationships, the natural environment, and therefore the human future, it is possible to identify an almost infinite list of forces. During 2002, Shell International made an attempt to do this and published a booklet on global scenarios for 2020 which indicates that globalisation, development of new technology, and liberalisation of markets appear to be the primary factors that shape the human future (Shell International, 2002:12).

Wack (1985b:150) writes that during steady times, changes in the aggregate environment and potential impacts are relatively easy to perceive since causality, and therefore risk, is fairly well understood. However, in times of turbulence and rapid change, decision-makers often fail to keep up with changes in reality, since the causes of turbulence are not well understood and quantified. Hence, the level of uncertainty increases. As a result, a decision-maker's framework of perceptions fail to reflect reality with accuracy, which could lead to bad decisions. The problem is that decision-makers never know when to expect a stable environment and when to expect a turbulent one, and therefore operate in an uncertain environment. Bernstein (1998: 151) states it slightly differently: *"The answers to all these questions depend on the ability to distinguish between normal and abnormal."* Based on the arguments of Wack and Bernstein, one could argue that normality and risk are similar concepts, while abnormality and uncertainty are similar concepts. In the case of normality or risk, causality is well understood, while in the case of abnormality or uncertainty, causality is not well understood, hence creating significant additional difficulties when making decisions.

In order to make decisions, in either normal or abnormal conditions, decision-makers make use of tools in an effort to make a good decision. Which approaches or tools to use is a difficult question, as circumstances change. What should be used when: events are normal or just a short-term deviation from the normal; when events are abnormal and could lead to permanent deviations from what was deemed to be normal before?

In agricultural economics, normality and abnormality, or risk and uncertainty, arising from external and internal change have been researched rather extensively. However, in light of a potentially faster-changing aggregate market environment, as explained in ection 1.1, three questions arise:

1) What methods and approaches are presently used to analyse risk and uncertainty (from an aggregate market perspective) in order to inform agricultural policy and strategic business decisions?
2) Are these methods still sufficient to capture the risks and uncertainties arising in an increasing volatile and uncertain agricultural sector, in order to facilitate informed decision-making?
3) If these methods are not sufficient, what alternative method(s) is available, and how can it be combined with existing methods and approaches?

A review of literature on policy and business strategy in agricultural economics, indicates that in the assumed presence of risk and uncertainty, formal decision analysis as termed by Hardaker, Huirne, Anderson and Lien (2004), is mostly used to inform decision-makers about the risks associated with making policy and strategic business decisions. In the economic and agricultural economic literature, decision analysis is predominantly developed by calculating objective probabilities for the various outcomes, and then attempting to maximise expected utility (Taylor, 2002: 254; Bowles, 2004: 101 – 102). This provides the decision-maker with an indication as to what decision to make in order to maximise expected utility. In the case of uncertainty, analysis is developed by replacing the objective probabilities with subjectively estimated probabilities, and then maximising expected utility. It is then assumed that these subjective probabilities are adjusted over time, using a process termed Bayesian updating, which was 'invented' by Reverend Thomas Bayes, an early writer on Probability Theory (Bowles, 2004; Hardaker *et al.*, 2004: 55 – 61; Taylor, 2002: 254).

Hardaker *et al.* (2004: 18) argue that formal analysis of risk and uncertainty has costs, especially the cost of the time that it takes to formally analyse each risk as well as potential options on how to manage and mitigate the effect of this risk. Hence, they state that not many decisions carry enough merit to make formal risk analysis worthwhile. However, Hardaker *et al.* argue that there are two situations in which formal analysis might be worthwhile. The first is where repeated risky decisions of the same nature need to be made on a continual basis. This necessitates setting up a formal strategy (achieved through formal analysis) which can be continuously consulted. The second instance is where the positive and negative outcome of a decision differs significantly from each other, and where the negative outcome could lead to the termination of the organisation. In such a situation, formal analysis could be beneficial.

Analysing the various options ensures that negative consequences are managed and mitigated, to such an extent that the survival and growth of the organisation is secured. However, in some situations, making an agricultural decision can be very complex. Using formal methods to analyse these situations is not always possible. Hardaker *et al.* indicate some characteristics of such complex decision situations, namely:

1. The available information about the problem is incomplete.

2. The problem involves multiple and conflicting objectives.

3. More than one person may be involved in the choice or may be affected by the consequences.

4. Several complex decision problems might be linked.

5. The environment in which the decision problem arises may be dynamic and turbulent.

6. The resolution of the problem might involve costly commitments that may be wholly or largely irreversible.

In situations of accelerated change, such as the present conditions experienced by the agriculture industry, the six characteristics, or at least a combination of some of the characteristics, are often present. This results in an extremely complex decision-making environment. Formal decision analysis techniques are therefore not always relevant and fail to guide the decision-maker as to which decision and action needs to be taken. Hence, in rapidly changing environments, it is insufficient to solely align with risk and uncertainty analysis currently used in agricultural economic literature.

From the definitions of risk and uncertainty (which are explained in detail in chapters two and three), it is possible to argue that, since researchers mainly focus on either objective or subjective probabilities to analyse and communicate risk and uncertainty, researchers in actual fact don't take full cognisance of uncertainty. The possibility exists that the probabilities - whether objective or subjective - might be either over- or underestimated, since discontinuities might occur in respect of the key assumptions, inter-relationships, or factors used in the framework of analysis. Hence, in the situation where the rate of change increases, as discussed in the background, the possibility of the probability distributions being over- or underestimated increases significantly. This could well lead to spurious analysis, which could lead to incorrect decisions. Hence the need to identify the failings of the current decision-making methods used in agricultural economics to analyse risk and uncertainty.

To support this point, a number of literary examples are included. The paper by Butt & McCarl (2005: 434) serves as a first example, and illustrates how risks are both of an exogenous and endogenous kind. In their paper, they develop a framework for projecting the effects of policy, and technological and environmental change on the prevalence of undernourishment in a country. The researchers do this by integrating a methodology developed by the Food and Agricultural Organisation (FAO) for estimating undernourishment in a specific country into a stochastic economic mathematical agricultural sector modelling framework. Changes in factors that can be simulated in this modelling framework are: climate, resources and resource limitations, demographics, market dynamics, adoption of improved cultivars, and crop land expansion. The researchers apply this modelling framework to Mali, a country in Sub-Saharan Africa, to explore alternative options for reducing undernourishment.

To project future levels of undernourishment, the researchers project future food consumption against production. In the modelling framework, future food consumption is mainly determined by population growth and trends in per capita food consumption; the latter is determined in turn by increase in income over time. Food production in turn is determined by area, and crop and range land productivity. The authors indicate that the latter factor is showing a declining trend due to increased cropping intensity and low levels of fertiliser use. Furthermore, high grazing and stress from periodic dry conditions leads to further decreases in range land productivity. In order to take account of variability in climate, which has an impact on crop and livestock production, the researchers include variability in crop yields based on the period 1985 to 1996, which implies twelve observations. A trend yield is included to take account of cultivar technology adoption. The researchers use the framework along with the crop yield variability to simulate different probability distributions, under various situations that they define as scenarios. The results of each 'scenario' then indicates different probabilities of undernourishment.

Referring to the definition of uncertainty and the cause of uncertainty (namely discontinuities), as well as looking at the modelling framework and the technique that is used in this paper, the first point is that the researchers make use of stochastic modelling, and therefore probabilities, to take account of risk. Looking at the results of the paper, one can conclude that - given the climate risks faced by Mali, the various situations or 'scenarios,' along with the probability distributions presented in Fig 2 (p443) of the paper - they give a good indication to decision-makers of the probabilities of undernourishment.

However, given the fact that per capita consumption and climate are two of the key driving variables in the modelling framework, discontinuities in either or both of these factors might cause the probabilities and probability distributions to be either over- or underestimated.

Brand & Chamie (2007) indicate that the rate of urbanisation, especially in Africa, is likely to increase significantly during the period 2000 to 2030. In Africa, they argue that the urban population might double during the next 30 years as opposed to current figures. If this is true, the urban population could change significantly in Mali during the period for which Butt & McCarl are doing projections. Urbanisation might cause significant discontinuities with respect to per capita income, since beliefs, preferences and constraints of people that move to urban areas might change significantly. Looking from a micro-economic perspective, this in turn will influence per capita consumption and therefore total consumption, which could have a dramatic effect on the probability of undernourishment. The same goes with climate change. Scientists are publishing more and more literature on the possible effects of climate change and changes in rainfall patterns and temperatures. In the case of Mali, Butt & McCarl indicate that pressure on crop land and range land is increasing due to changing production practices. Should climate change occur the way climate scientists are thinking, dramatic discontinuities might occur in production patterns and practices. This again could have significant consequences for the realism of the probability distributions presented by Butt & McCarl.

Several other examples of research papers exist where stochastic modelling or probabilities are used to inform and guide decisions in the face of risk and uncertainty. Examples of such research include Binfield, Adams, Westhoff and Young (2002), Rasmussen (2003), and Westhoff, Brown & Hart (2005). These studies do indicate the importance of taking risk or probabilities into account when analysing decision-making factors – whether it's a policy, production or another type of decision. However, discontinuities in endogenous and exogenous variables included in the modelling framework might cause the probabilities presented (or assumed) in these studies to be either over- or underestimated. Therefore, the main shortcoming with regards to these research results is that uncertainty (as per definition it includes possible discontinuities) is not explicitly accounted for. This point is confirmed in the writing of Binfield *et al.* (p7): "*By no means, however, have all possible sources of variability been captured. It would be a mistake to conclude that the extreme values achieved in this analysis represent the absolute extremes that are possible in the future.*" Or otherwise, as stated by Knight (1921:231): "*…since at best statistics give but a probability as to what the true probability is."* Westhoff *et al.* (2005) also concludes that stochastic analysis is not perfect in terms of indicating possible variability in outcomes.

Just (2001) and Taylor (2002) argue along similar lines and attempt to show that methods, especially system modelling methods in agricultural economics, tend to ignore the fundamental difference between risk and uncertainty, and therefore lead to results that mostly exclude uncertainty. Again, this leads to problems or shortcoming in terms of making informed policy decisions. A similar argument could be made in the case of strategic business decisions. This strengthens the argument that formal decision analysis, without due inclusion of uncertainty through the inclusion of possible discontinuities, might lead to spurious conclusions and therefore incorrect decisions with regards to agricultural policy and business strategy.

The insufficiency of the presently used methods does not imply that these methods should be discarded, since they remain useful for specific purposes. Wack (1985a: 73) argues this point when stating that modelling, and therefore decision analysis, mostly gives relatively correct answers compared to reality since "*…the world of tomorrow often remains unchanged relative to today.*" However, the danger with modelling is firstly that the models are simplified representations of reality, or parts of reality, and secondly, models are based on historical structures and relationships between various factors in the system. The problem with modelling, as argued by Wack, arises from three aspects. A discontinuity might occur in a variable included in the model. Secondly, a discontinuity might occur in a factor that historically did not influence the system but due to the event, suddenly does influence the system being modelled. Lastly, relationships and therefore correlations change as a result of a discontinuity and could significantly influence probability distributions. Therefore, when only modelling and probabilities are used to analyse a decision and communicate risk and uncertainty, the occurrence of a discontinuity or discontinuities that will make a strategy or policy obsolete, is much higher.

Two implications with regards to policy and strategic business decisions arise from this argument. Firstly, firms and governments should take risk into account when making policy or strategic business decisions. They should use modelling and probabilities since modelling often works when change and the rate of change is well understood. Secondly, they must also have the ability to anticipate major discontinuities, and design strategies and policies that ensure their strategies and policies don't become obsolete should these discontinuities occur. In other words, businesses and government should also take uncertainty, along with risk, into account when making policy and strategic business decisions. The question is how?

Although Just (2001) and Taylor (2002) argued along similar lines, as presented in this section and the previous section, and although Just did present some potential solutions on how to mitigate this problem, neither of the two authors offered tried-and-tested solutions. This is clear from Just's remark: *"For the remainder of this article, I attempt to suggest some marginal possibilities…. Although these suggestions are easy to criticise, I encourage them with the apparent reality of the propositions of this article."*

The aim of this thesis is to build on the ideas of Just (2001) and Taylor (2002). It proposes and tests an approach to policy and business strategy decision-making in agricultural commodity markets. It sets out to prove itself more effective in capturing both risk and uncertainty as opposed to current individual decision analysis techniques being applied in agricultural economics. By using this proposed approach, policy and business strategy decision-making will hopefully improve in the face of greater risk and uncertainty.

1.3 Hypothesis

It is hypothesised that the simultaneous use of two methods, namely, scenario thinking and stochastic modelling, facilitates a more complete understanding of the risks and uncertainties pertaining to policy and strategic business decisions in agricultural commodity markets. This is likely to facilitate better decision-making in an increasingly turbulent and uncertain environment.

The hypothesis is based on two arguments. Firstly, the environment faced by the decision-maker essentially consists of both risk and uncertainty. Risk is defined as the situation wherein a probability can be attached to the occurrence and outcome of an event; uncertainty is defined as a situation in which no probability can be assigned to the occurrence or outcome of an event due to possible discontinuities and, therefore, changes in the cause-and-effect relationships in a system. The existence of both risk and uncertainty emphasise the importance of making use of techniques in the decision-making process to assist the decision-maker in understanding both risk and uncertainty. The second argument fuelling the hypothesis is that the underlying cognitive development processes of the two techniques are fundamentally different.

The importance of these two arguments in the development of the hypothesis is two-fold. Firstly, the underlying processes involved in scenario thinking and stochastic modelling are fundamentally different, since stochastic modelling informs risk through either objective or subjective probabilities, while scenario thinking informs uncertainty through the analysis of discontinuities. Secondly, based on the theories of cognitive development proposed by Vygotsky and Piaget (discussed in chapter 4), the cognitive developmental processes underlying modelling and scenario thinking are, to an extent, different. Based on these two points, one can argue that although scenario thinking and stochastic modelling are fundamentally different, the processes and results of the two techniques are actually complimentary. Using both techniques simultaneously leads to a more complete understanding of risk and uncertainty, thereby leading to a more complete learning experience. Using the two methods in conjunction will therefore ensure that the mental model, or perceptions, of the decision-maker 1) reflect actual risk and uncertainty, and 2) are enabled, by following two different learning processes, to accurately assess reality and change in accordance with the changes in the agricultural environment. By adjusting the decision-maker's mental model to reflect reality more accurately, his or her understanding and insight into the decision-making environment improves. This is likely to lead to better decisions, despite an increasingly turbulent environment. This makes the conjunctive application of both approaches essential in the decision-making process.

1.4 Research objective, methods, and contribution

1.4.1 Objective

The objective is to test whether stochastic modelling used in agricultural economics, or the conjunctive use of scenario thinking and stochastic modelling as proposed in chapter four of this thesis, is more effective in capturing the relevant risks and uncertainties of an increasingly turbulent environment to the extent that good policy and strategic business decisions can be made. This will be achieved by means of comparing results from the two different approaches to an actual market outcome in three case studies. The results will be used to demonstrate which approach captured risk and uncertainty most effectively given the actual market outcome, and therefore which approach led to better decisions.

The testing procedure consists of three steps:

1) Compare an actual agricultural commodity market outcome to the simulation results of an existing stochastic multi-market model of the same agricultural commodity market, in order to determine whether the simulation process and results sufficiently captured the risks and uncertainties that eventually led to the actual market outcome;
2) Compare the same actual agricultural commodity market outcome to analysis results where the proposed framework of this thesis as presented in chapter four has been applied. This is an attempt to determine whether the conjunctive use of the two techniques captured the risks and uncertainties sufficiently, which ultimately led to the actual market outcome.
3) Compare the results of step one and two, to determine which approach captured the risks and uncertainties more sufficiently and therefore led to better decisions given the actual market outcome in each of the three situations.

Thus, by comparing the results as described above in point three it would be possible to determine which of the two approaches, stochastic modelling on its own or the proposed framework of this thesis as presented in chapter four, captured risk and uncertainty more effectively and therefore led to better decisions given the actual outcome of the market.

As indicated, the general objective is attained by presenting three case studies. The three case studies that are used to test the hypothesis are taken from work done by the author in cooperation with colleagues at the Bureau for Food and Agricultural Policy (BFAP)[1] for three respective agribusinesses at different points in the past four years. The first case study involves a firm in the pork supply chain who had to make decisions on hedging of yellow maize for the 2005/06 maize season in attempting to manage feed costs and pig prices. The second case study involves a farmer co-operative who had to make financing decisions for the 2005/06 maize production season. The third case study involves a commercial bank that makes financing decisions in terms of agricultural commodity market conditions during the 2007/08 and 2008/09 maize production seasons.

1.4.2 Methods

The general objective will be attained by means of the following steps:

1) Select a suitable stochastic agricultural market model through a comprehensive review of the literature on risk analysis in the field of agricultural economics. The selected model will be used to test whether it captured risk and uncertainty sufficiently, and compared to an actual market outcome.
2) Select a suitable scenario thinking technique through a comprehensive review of the literature on scenario thinking and futures thinking. The selected technique will be applied in conjunction with the selected stochastic model in point 1 as proposed through the framework presented in chapter four of this thesis, to test whether conjunctively using the two techniques captures risk and uncertainty more effectively than using only the selected stochastic model.
3) Apply the stochastic model as selected in point 1, in order to simulate the South African yellow maize price for the 2005/06 season. The simulated results are compared to the actual yellow maize price for the 2005/06 season to determine whether the application of the selected model sufficiently captured the risks and

1 For more information on BFAP and its activities, visit www.bfap.co.za

uncertainties faced by decision-makers during the 2005/06 season, which led to the eventual actual yellow maize price of 2005/06. In addition, an actual case study of a private company that conjunctively applied both the selected stochastic model and scenario thinking technique, as proposed through the framework of this thesis as presented in chapter four, during the 2005/06 yellow maize season, is reviewed. The case study compares the yellow maize price and the actual outcome of the yellow maize price for the 2005/06 season, and examines whether the conjunctive use of the two techniques captured the risks and uncertainties sufficiently in order to lead to good and better decisions compared to a situation where only stochastic modelling is used to guide decision making.

4) The discussion of the second and third case studies follows a similar vein to the first case study. Firstly, the selected stochastic model was applied on its own and then compared to the actual outcome. Secondly, the case study results were reviewed in terms of which conjunctively applied both techniques, and compared to the actual outcome. This indicates whether the stochastic model on its own or the conjunctive use of the two techniques captured risk and uncertainty more sufficiently, and hence which approach led to the best decisions given the actual market outcome with respect to what the decisions were made.

1.4.3 Contribution of study

The increasing rate of change experienced in agricultural commodity markets increases both risk and uncertainty pertaining to making a decision in the market. Through the testing and acceptance of the proposed hypothesis, it will be shown that in an increasingly turbulent environment, with increasing risk and uncertainty, it is essential to conjunctively use scenario thinking and stochastic modelling to facilitate decision-making. Furthermore, it will be shown that an alternative to subjective probability assignment does exist to analyse uncertainty in agricultural economics.

1.5 Outline of chapters

The study consists of seven chapters. Chapter one provides the introduction and background. Chapter two reviews the body of literature on risk in agriculture in order to define risk and review different risk analysis techniques so that a suitable existing stochastic model can be selected to test the hypothesis. Chapter three reviews literature on uncertainty in order to define uncertainty, and describes the link between uncertainty and scenario thinking. It also reviews literature on scenario thinking in order to select a suitable scenario thinking technique to test the hypothesis. Chapter four initially presents the framework proposed by this thesis on how the two selected techniques can and should be used in conjunction. Secondly, it theoretically demonstrates how the combined use of the two techniques through the proposed framework of this thesis should sufficiently capture risk and uncertainty, and thirdly argues why the combined use of the two techniques should facilitate improved strategic and policy decisions in agricultural commodity markets. Chapter five presents two case studies (as explained in ections 1.4.1 and 1.4.2 of this chapter), and tests which approach captures risk and uncertainty most effectively and is best for making good policy and strategic business decisions in an increasingly turbulent environment. Chapter six presents the third case study. This case study is presented separately because it is work in progress, and hence the resulting scenarios that were developed are still playing out. Therefore, chapter six aims to apply the proposed framework of this study - in a past and future context. It will hopefully show the usefulness of the proposed framework of this thesis in the current volatile economic and agricultural economic markets. Chapter seven concludes the study and identifies potential areas for future research with respect to the combined use of scenario thinking and stochastic modelling.

CHAPTER 2: Risk and Stochastic Modelling

We are not certain, we are never certain. If we were, we could reach some conclusions, and we could, at last, make others take us seriously.

Albert Camus, 1956

(In Valsamakis, Vivian & Du Toit, 1996: 22)

2.1 Introduction

Risk is a key ingredient of the agricultural environment. For example, rainfall and temperature vary from season to season, causing crop yields and disease prevalence to fluctuate. This influences production, and as a result, stock levels and prices. An excellent example of where rainfall variability had a significant impact on stock levels and prices, is the case of Australia's drought during 2006 and 2007. This drought caused world wheat stocks to significantly decrease, and also resulted in dramatic increases of wheat prices (United States Department of Agriculture, 2008: 21). Other examples of factors that cause fluctuations, and therefore risk, in agricultural commodity markets are: the variability in economic factors such as oil prices; exchange rates; fertiliser prices and changes in internal structures and relationships within the sector, such as institutional changes or changes in the interaction between industry role players. Fluctuations of these factors cause variability in supply, demand, and prices, which ultimately influence the profitability and risk of agricultural production and food processing.

The challenge is that, despite the inherent and continued risk faced in agricultural commodity markets, decision-makers have to make ongoing policy and business strategy decisions that will impact on the future growth and survival of the institutions and the sector. Hence, present decisions and actions will create future conditions, which are often irreversible. The problem is that these decisions and resulting actions might become either obsolete or have unintentional negative consequences in future, given the occurrence of risky events. To combat this challenge, decision-makers need to take potential risks into account when making decisions, and ensure that unintentional negative consequences do not result from their decisions and actions. In order to do this, a sufficient understanding of the definition of risk is needed, as well as an understanding as to what tools are available to analyse risk.

The purpose of this chapter is therefore to define risk; identify and discuss the sources of risk in agriculture; discuss agricultural risk management, and lastly to review literature on different methods of risk analysis from an aggregate market perspective in agricultural economics. The chapter will conclude by selecting an appropriate risk analysis technique that will be used to test the hypothesis.

2.2 Definition and sources of risk

The concept of risk is derived from the Italian word *risicare,* which means "to dare," and was not well understood until approximately 1654 when the Theory of Probability was finally grasped (Bernstein, 1998: 3, 8). Bernstein writes that this occurred when Chevalier de Méré and Blaise Pascal solved a puzzle that was posed two hundred years earlier by the monk Luca Paccioli. This led to a prolonged process of formulating the Theory of Probability, during which concepts such as normal distribution, standard deviation, and regression to the mean were discovered (Bernstein, 1998: 5, 6). The formulation of the Probability Theory culminated in 1952 when Harry Markowitz mathematically proved that diversification is an excellent risk mitigation strategy (Bernstein, 1998: 6).

Bernstein views the Theory of Probability as the mathematical foundation of the concept of risk (Bernstein, 1998: 3). In contemporary literature, risk is generally defined as a situation in which probabilities (different possible outcomes) of a system or factor are known and can be calculated. Hardaker *et al.* (2004: 5) argue that this definition of risk is not useful, since objective probabilities are seldom known, and subjective probabilities therefore need to be calculated. As a result, they define risk as "uncertain consequences." Bowles (2004: 101) defines risk as being more finite - when the outcome of an action in the individual's choice set is a set of possible outcomes to which known probabilities can be attached.

Valsamakis, Vivian and Du Toit (1996: 23) argue wider on the definition of risk, and write: *"In his effort to understand or minimise uncertainty, man has attempted to determine causation, unfold patterns and give meaning to unexplained events, possibly in terms of a controlling power."* Ilbury & Sunter (2003: 42), although not referring directly to risk, also argue along this line of thought, and write about the 'rule of law' (or causality) and the motivation of people to analyse and understand cause-and-effect in order to quantify it.

The implication of these arguments is therefore to understand and define risk, causality between various factors, events, actions and resulting outcomes need to be understood and quantified. *The fact that causality is determined and quantifiable, leads to the possibility of calculating and assigning probabilities (either objective or subjective), to the occurrence of events.* Therefore, based on the ability to quantify the probability of the occurrence of events, a decision-maker can begin to think about the potential consequences, should a specific event occur. The insight gained by the decision-maker through this process, leads to the understanding of the risks faced, and hence partially assists the decision-maker in making a good and informed decision.

The literature on risk indicates that the sources of risk can be grouped into two major groups, namely, exogenous and endogenous sources of risk. Exogenous risk stems from factors *outside* of the system, and the effect of the risks basically feed *into* the system, thereby affecting the system. Examples include: climate changes that impact on farm-level; the international maize price that could affect the domestic maize price in the case of a small and open economy, specifically pertaining to maize; changing exchange rates that influence price levels etc. Endogenous sources of risks are risks that stem from within the system under study. From a micro-economic perspective, an example is changes in behaviour because of changes in beliefs and preferences (Bowles, 2004: 93 – 126).

Hardaker *et al.* (2004: 6) describe various categories of risk encountered in agriculture, namely: production risk; price or market risk; institutional risk; personal or human risk, and financial risk. All risks (excluding financial risk) are aggregated into what Hardaker *et al.* term 'business risk.' They define business risk as being comprised of all the risks that affect the profitability of the firm, excluding the risks that originate from the way the firm is financed. Hence, finance risk is defined as a set of risks that stem from the way the firm is financed. Therefore, the more debt used to finance the firm, the higher the leverage and therefore the higher the potential return or loss on the owner's equity.

2.3 Risk management

The understanding of risk alone does not assist a decision-maker in taking decisions. In order to take decisions that will most probably have positive consequences, or at least mitigate the majority of negative consequences, a process needs to be followed in order to take a decision. This process is described as risk management in the literature.

Dickson in Valsamakis *et al.* (1996: 13) defines risk management as the: *"identification, analysis and economic control of those risks which threaten the assets or earning capacity of an organisation."* Hardaker *et al.* (2004: 13) argue along the same lines, and describe risk management as the: *"systematic application of management policies, procedures and practises to the tasks of identifying, analysing, assessing, treating and monitoring risk."* Risk management can therefore be defined as a function falling under general management functions, with its focus being to mitigate negative consequences resulting from specific events, in order to enable the firm or institution to reach its desired goals (Head, 1982 in Valsamakis, 1996:15). In 1916 Fayol argued, according to Valsamakis *et al.* (1996: 13), that management entails various functions, one of which is 'security.' He argued that it is the responsibility of management to secure the well-being of revenue-generating assets. This implies that a systematic approach to risk management is critical.

According to Valsamakis *et al.* (1996: 15) a systematic approach to risk management mainly consists of four stages, namely:

1) *risk identification;*
2) *risk quantification;*
3) *risk control directed at loss elimination, or more usually, loss reduction;*
4) *risk financing, via transfer.*

Hence, risk management is a process whereby causality is determined in order to quantify the probability of occurrence, as well as the potential consequences. This assists the decision-maker in developing options on how to mitigate the potential negative consequences - by means of loss elimination or loss reduction mechanisms such as insurance or hedging.

Hardaker et al. (2004: 14 – 18) present a more detailed approach to risk management. Essentially, the approach consists of seven steps, each connected to the previous step but also indirectly to the other steps. Figure 2.1 presents the outline as explained by Hardaker *et al.*

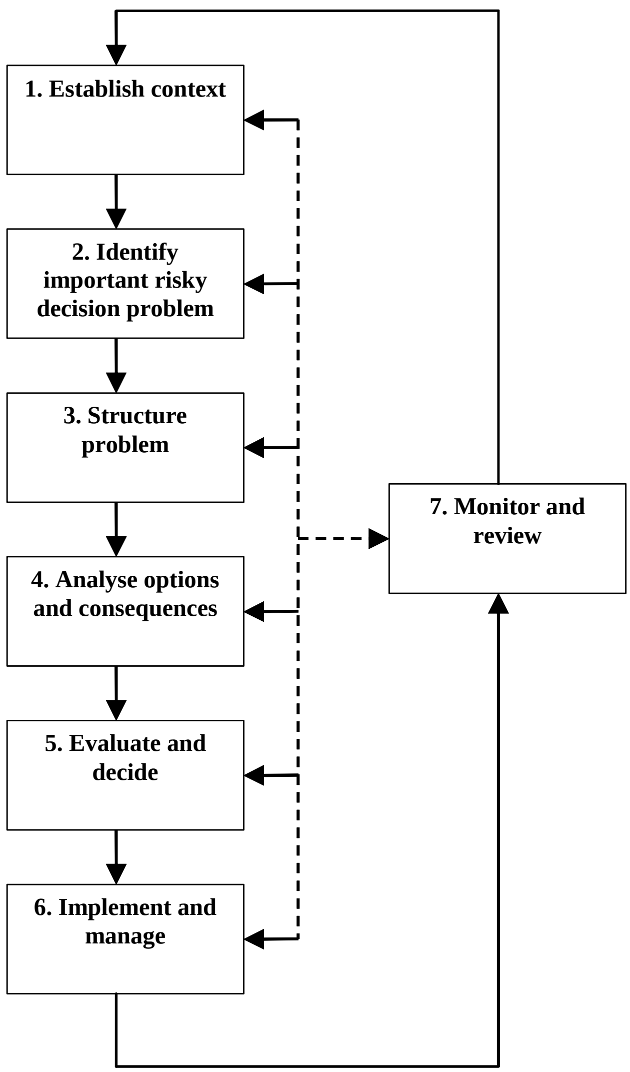

Figure 2.1: An outline of an approach to risk management (Hardaker *et al.*, 2004)

The first step of establishing context, consists of establishing the general milieu and parameters within which a specific risk or set of risks will be considered. This could be done by considering three different aspects of the organisation, namely: the strategic milieu, organisational milieu, and risk management milieu.

Considering the strategic milieu entails defining the inter-relationship between the organisation and its external environment. This includes considering the strengths, weaknesses, opportunities and threats of the organisation. When considering the strategic milieu, one should focus on identifying the key factors that determine the organisation's position relative to its environment, and which could significantly influence the ability (positively or negatively) of the organisation to fulfil the needs of its stakeholders.

The evaluation of the organisational milieu essentially deals with understanding the objective setting within the organisation, and the allocation of responsibilities, in order to reach the objectives. Hence, the consideration of the organisational milieu focuses on the question of whether the organisational structure and allocation of responsibilities are adequate enough to reach the set objectives.

The risk management milieu needs to be evaluated in order to understand how risk management procedures are structured within the organisation, and to determine whether protocols are sufficient enough to identify and manage the relevant risks as identified in the strategic and organisational milieus.

The second step in the risk management process entails the identification of the key risks faced by the organisation, hence, implying the prioritisation of the various risks faced by the organisation. This is done by listing the various risks in terms of importance or potential effect on the organisation.

Step three entails attempting to understand the underlying nature of the risk or risks as identified in step two. Various questions need to be answered during this stage according to Hardaker *et al.* For example: "Who faces the risk?"; "Who suffers if things go wrong?"; "What are the basic and proximate causes of the risk?"; "How is the risk currently managed?"; "What other options are available to manage the risk?" and "Who decides what to do?"

Following step three, options are analysed in terms of how to mitigate or act in the presence of adverse consequences, or in case the risky event should actually occur. The objective of this step is to separate the low-probability or low-impact events from the higher probability or higher impact events, which need additional and more formal analysis.

The fifth step entails evaluation and decisions. Decision-makers consider the risky consequences of the available decision options in order to reach a final decision or option that is likely to be the best, or most acceptable, in terms of mitigating the consequences of the risk or set of risks. This implies that the level of risk aversion of the organisation plays a key role in this step of determining which option should be taken.

Step six entails the implementation and management of the option that was picked in step five, while step seven revolves around continuous monitoring and review. The purpose of step seven is to establish whether the risk management plan is working, and to identify additional aspects that need consideration to ensure that the risk management plan remains relevant.

Comparing the risk management approaches presented by Valsamakis *et al.* and Hardaker *et al.*, it is clear that the general logic behind the two approaches is fundamentally similar. Essentially, both approaches contain three phases, namely: observation and identification; prioritisation and analysis, and implementation, which includes management and control. Since the specific problem of this study essentially deals with the analysis of risk pertaining to agriculture in a fast-changing environment, the remainder of this chapter reviews the body of literature on risk analysis in agricultural economics. The purpose of the review will be to firstly develop an understanding of the various methods that can be used to test the hypothesis, and based on the gained understanding, select a suitable method.

2.4 Risk analysis in agricultural economics

Formal risk analysis has been a key area in the field of agricultural economics for many years. Since the age of industrialisation and therefore specialisation, the need to produce greater quantities of food at affordable prices has increased dramatically. During the 1930s, the whole economic system came under severe pressure, resulting in the Great Depression, which forced governments to relook their views towards the production of affordable food for the masses. This introduced significant food production policy interventions in agriculture to ensure stability and affordability. However, policy interventions influenced the profit and risk profile of food production and processing in such a way that incentives were often skewed so as to cause unintentional consequences (Van Schalkwyk *et al.*, 2003: 119 - 127). This partly motivated agricultural economists to study risk and the impact it has on the stability and affordability of food production. The result was that a number of formal risk analysis techniques were invented and adopted by agricultural economists in order to study the problems, challenges, and consequences risk creates, or as stated by Hardaker *et al.* (2004:23): *"to try to rationalise and assist choice in an uncertain world.*" The purpose of this section is to give a broad overview of the main risk analysis techniques in agricultural economic literature.

2.4.1 Basic assumptions

In order to analyse and understand the impact of each of these risks, various assumptions or axioms are made in the agricultural economic literature which underly the analyses, namely (Hardaker *et al.*, 2004: 35):

- *Ordering: faced with two risky prospects, a_1 and a_2, a decision maker either prefers one to the other or is indifferent between them.*
- *Transitivity: given three risky prospects, a_1, a_2, and a_3, such that the decision maker prefers a_1 to a_2 (or is indifferent between them) and also prefers a_2 to a_3 (or is indifferent between them), then the decision maker will prefer a_1 to a_3 (or be indifferent between them).*

- *Continuity: if a decision maker prefers a_1 to a_2 and a_2 to a_3, then there exists a subjective probability $P(a_1)$, not zero or one, that makes the decision maker indifferent to a_2 and a lottery yielding a_1 with probability $P(a_1)$ and a_3 with probability $1-P(a_1)$.*
- *Independence: if the decision-maker prefers a_1 to a_2 and a_3 is any other risky prospect, the decision maker will prefer a lottery yielding a_1 and a_3 as outcomes to a lottery yielding a_2 and a_3 when $P(a_1) = P(a_2)$."*

Based on these axioms, Daniel Bernoulli proposed a principle called the Subjective Expected Utility Hypothesis (Hardaker *et al.*, 2004: 35). The principle states that for a decision-maker for whom these axioms hold, a utility function U exists which has the following characteristics:

a) *If a_1 is preferred to a_2, then $U(a_1) > U(a_2)$ and vice versa.* The implication is that risky options faced by the decision-maker can be ordered according to the preferences of the decision-maker.

b) The expected utility of a risky option is its utility, hence $U(a_k) = E[U(a_k)]$ where $U(a_k) = \sum_j U(a_k | S_j)P(S_j)$ for a discrete distribution of outcomes. For a continuous outcome distribution function it is expressed as follows: $U(a_k) = \int U(a_k | S_j)P(S_j)$. The implication of these two utility equations is that higher order moments such as variance are not introduced into the choice between risky options, which implies that the choice between risky options hinges on the expected outcome and not the potential variability underlying the choice (Hardaker *et al.*, 2004).

c) The utility function, U, is defined as a positive linear transformation. The implication of this point is that it limits the way in which utilities can be interpreted and compared, since the origin and scale of the function is arbitrary (Hardaker *et al.*, 2004).

Based on the above description of the axioms and the resulting properties of the utility function, Hardaker *et al.* argue that it implies a unified theory of preferences and beliefs - preference is quantified by means of utility, and belief is quantified by means of probabilities, whether objective or subjective. Through this unified theory, it is possible to guide or prescribe to a decision-maker which option to choose when risk is present, by means of combining the decision-maker's beliefs and preferences. This is an important point, as nobody knows what the future holds and therefore cannot claim to be making the correct choice; the only thing that can be done is to make a good choice. A good choice is defined by Hardaker *et al.* (2004: 25) as a choice that is consistent with the decision-maker's beliefs about the risk faced when making the decision, and also with the decision-maker's preferences in terms of different consequences as a result of the choice being made. This approach to decision analysis, where the beliefs and preferences of the decision-maker are used to guide the decision-making process, is termed the prescriptive approach towards decision analysis (Hardaker *et al.*, 2004:36).

2.4.2 Probabilities and correlation

A key component of the prescriptive approach towards decision analysis or risk analysis, is probabilities. Probabilities are used to communicate or include the impact of risk on a decision by means of using it to understand the potential consequences should a specific choice be made. Probabilities can either be objective or subjective. According to Hardaker *et al.* (2004:38, 39), objective probabilities are founded in the view that probabilities should be based on a relative frequency ratio that stems from a large body of data on that specific variable. Hence, by using the data set, it is possible to calculate the potential occurrence of a specific value of the relevant variable. However, underlying structures and inter-relationships change, causing these frequencies to change over time. Hence, using the same body of data to calculate relative frequencies might not be accurate any more, due to underlying changes in the system. In such a case, Hardaker *et al.* argue that one should rather use subjective probabilities, which is defined and set up by making use of the subjective beliefs of the decision-maker about the potential occurrence of a specific event. This implies that the probabilities are based on the decision-maker's perceptions about underlying causalities and trends, and how these forces will play out in leading to the eventual outcome.

Several methods exist to elicit subjective probabilities from a decision-maker in order to incorporate it into the decision problem. A general approach called visual impact methods include probability trees, allocation of counters, and a reference lottery. The triangular distribution method can be used in the case where the decision-maker has clear beliefs about the lowest, highest and most likely value for a specific variable. In the case where data is available and the decision-maker is confident that the data does represent the current and future environment relatively well, statistical techniques can be used to calculate probability distributions. These can be used by the decision-maker to form an opinion on the probabilities faced. Along with statistical analyses, expert opinion can be used as an input for the decision-maker to form an idea on the potential probabilities faced in taking the decision. All of these probabilities can be updated by means of using Bayes' Theorem, which assists decision-makers in updating these subjective probabilities based on newly obtained information.

To run stochastic simulations with the various types of models as described in ection 2.4.3, two different sampling methods can be used, namely, Monte Carlo sampling and Latin hypercube sampling. These sampling methods are used to generate values based on pre-specified input distributions (Hardaker *et al.*, 2004:158). The mechanics of a stochastic simulation model are specified, based on a set of equations and inter-relationships. Each time the model is solved, a different set of values is generated by means of the sampling method underlying the model. This set of values is generated based on a specified structure in terms of the inter-relationships between the different variables. For example, when a high oil price is generated by means of the sampling method, a high fuel price also needs to be selected, since both these variables are directly and positively correlated. The same holds for above-normal rainfall and above-normal yields, except when rainfall is excessive and the crops actually begin to drown. Hence, as a result of drawing a different set of input variables, different outcomes to the model are simulated. This results in probability distributions being simulated for the respective key output variables. These probability distributions can be used by the decision-maker to form an idea of the underlying probabilities of various events, as well as the probability of the occurrence of potential consequences, especially negative consequences. Based on this information, the decision-maker can make a much more informed decision on what action to take.

Mathematically, there is a difference between the Monte Carlo sampling technique and the Latin hypercube technique. One of the most frequently used outputs of a sampling technique is a Cumulative Distribution Function (CDF). The CDF indicates what the probability of P is, so that the variable X will be less than or equal to x. Mathematically, it is expressed as follows:

$$F(x) = P\ (X \leq x) \qquad (1.1)$$

Where: F(x) ranges from zero to one

The Monte Carlo technique firstly calculates the inverse of function 1.1, and secondly uses the inverse function to draw a specific probability from a sample. The drawn probability is then fed into the inverse function to calculate the matching x value. Mathematically, the inverse function is expressed as follows:

$$x = G(F(x)) \qquad (1.2)$$

In the case where a large sample is taken in terms of probabilities, a large sample of x values will be calculated. These should represent the original distribution quite accurately. Because this sample is generated by picking uniformly distributed values F(x) between zero and one, it means that every value of F(x) between zero and one has an equal probability of being picked. The problem with this is that it leads to samples of x being drawn from the more dense part of the distribution, implying that only with a very large sample is one likely to recreate the original distribution accurately. This implies that in the case where only a small sample can be drawn, Monte Carlo simulation is not likely to generate an accurate distribution of the original distribution, leading to inaccurate results and potentially bad decisions. This led to the development of the Latin hypercube sampling technique.

The Latin hypercube sampling technique works on the same principle as Monte Carlo in terms of taking the inverse of the function and then drawing x values accordingly. The difference between Monte Carlo and Latin hypercube is that Latin hypercube divides the CDF into *n* intervals, which have equal probability to be drawn. Secondly, sampling without replacement takes place. This implies that each observation can only be drawn once. The result of using Latin hypercube is that the original distribution can be recreated fairly accurately with only a small sample being drawn. In the case of a very skew original distribution, Latin hypercube does not recreate an even more skewed distribution, but rather an accurate representation of the original. This implies that Latin hypercube can recreate the original distribution more efficiently than Monte Carlo sampling (Hardaker *et al.*, 2004: 167).

The most important advantage of using Latin hypercube is that it regenerates the tails of distributions more accurately, implying that outlying events with low probabilities of occurrence are still included in the regenerated distributions. This is important because events that are outliers (with low probabilities of occurrence) are normally the events that wreak havoc in the business and policy environment. Examples include a hundred-year drought or flood, or, an oil price of $200/barrel. Events such as these are extremely important to take cognisance of during the planning process, since their occurrence can lead to the policy or business strategy becoming obsolete, causing the firm or sector to experience disastrous times. By using Monte Carlo, events such as these tend to disappear from the 'radar,' implying that if it is not included in the decision-making process, significant risks are unknowingly taken by the decision-maker.

Another key challenge in stochastic simulations is how to take account of inter-relationships between risk factors. To explain this point, rainfall is often a key risk variable since it influences crop yields. In the case where above-average rainfall occurs (without detrimental affect on crops), the sampling technique needs to draw an above-average yield too, in order to represent reality as accurately as possible. Several techniques exist which offers this function, namely, the hierarchy of variables approach, use of historical data and lookup table, using a correlation matrix, and using copulas. Since a correlation matrix is most often used to represent the underlying inter-relationships between key variables in a system, it will be discussed. The other three methods are less commonly used at this point in time.

Correlation measures the stochastic dependency between two or more variables. This is done by means of analysing the dependency between the first-order co-moments of two or more variables, namely, the covariance (Hardaker *et al.*, 2004: 170). This can be done by analysing the inter-relationships (assuming it is linear) between two or more variables by means of linear correlation, or analysing the inter-relationships (assuming it is non-linear) by means of rank order correlation. Linear correlation seldom works as inter-relationships are more frequently non-linear than linear; secondly, mathematically, it is not possible to draw linear relationships when the respective functions of the different variables are non-linear. In such a case, rank order correlation is used.

Rank order correlation analyses the relationship between two or more variables by looking at the rank of the values of each variable within their different distributions. Hence, rank correlation does not use values to calculate correlations, as is the case of linear correlation, but rather looks at ranking of values. The implication is that stochastic dependency might not always be reflected correctly by rank correlation, as ranks are used, which infers that some information in the data (in terms of dependency) gets lost.

Another method to analyse stochastic dependency is to use copulas. A copula unites two or more marginal distributions, and through that analysis, the stochastic dependency between two or more variables in a more complete manner. It does not just look at covariance or ranks, but also includes more levels of stochastic dependency (Hardaker *et al.*, 2004:172).

2.4.3 Risk analysis methods

A review of literature indicates that risk analysis in agricultural economics can be divided into two main literary bodies, namely: the analysis of risk in terms of its impact on aggregate supply, demand and prices, and the analysis of risk impact in terms of decision-making on individual firm level, based on risk preference assumptions. Since this thesis focusses on risk analysis of agricultural commodity markets, only the body of literature applicable to this perspective will be reviewed[2].

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[2] A large body of South African literature on risk in agricultural economics exists. However, not all focus on the analysis of the impact of risk on aggregate markets, nor utilise a specific risk analysis

The body of literature on risk analysis from an aggregate perspective can be divided in three sub-areas, namely: regression modelling, time series econometrics, and mathematical programming. The remainder of this section will review literature on each of these sub-approaches with the aim of selecting an approach and within that approach select a specific model which exists at the point in time of writing this thesis that can be used to test the hypothesis.

2.4.3.1 Regression modelling

Just (2001) describes alternative levels of econometric model specifications that include some form of risk, and which have been used to model and therefore simulate aggregate economic systems and the impact of risk on the aggregate system in terms of demand, supply and price impacts. He defines these different model specifications as static specifications. With static, he implies model specifications that do not adjust over the sample or prediction period, based on actual underlying structural changes that occur or which could potentially occur (Just, 2001: 1131 – 1138).

a) Static models with static parameters

Static models with static parameters are described as models of the form $y_t = f(x_t, \varepsilon_t|\theta)$, where:

> y_t is a vector of observed endogenous variables at time *t;*
>
> x_t is an observed vector of exogenous variables at time *t;*
>
> θ is a fixed vector of unknown parameters which implies f has a fixed form throughout the sample and prediction period; and
>
> ε_t is a vector of unobserved random disturbances with a static distribution determined by parameters also in θ. Thus, ε_t incorporates risk in the modelling framework.

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technique as reviewed in this thesis. Hence, the research will not be included in the review. This includes the work of Mac Nicol, Ortmann, and Ferrer (2008); Jordaan and Grové (2008); Geyser and Cutts (2007); Grové (2006); Gakpo, Tsephe, Nwonwu, Viljoen (2005), and Viljoen, Dudley and Gakpo (2000).

According to Just, this model specification implicitly represents simultaneous equation models where $y_t = f(x_{t,}\ \varepsilon_t|\theta)$ is the reduced form. This type of modelling specification is often used in agricultural economic literature to study economic systems from an aggregate perspective, and to model the impact of risk in terms of supply, demand, and prices.

b) Dynamic models with static parameters

The typical modelling specification of dynamic models, according to Just (2001), are: $y_t = f(y_{t-1},\ x_{t,,}\ \varepsilon_t|\theta)$. The specification implies that although y_t is a function of y_{t-1} and is therefore dynamic, the parameters in terms of θ remain static, implying that the model structure does not change as changes occur in the market system environment. The error term ε_t again captures the stochastic nature of the system.

c) Dynamic models with unobserved static variation

According to Just (2001), these types of models are specified as $y_t = f(y_{t-1},\ x_{t,,}\ \varepsilon_t|\theta_t)$ where $\theta_t = g(z_{t,,}\ \delta_t\ |\ \omega)$.

z_t is an observed vector of exogenous or predetermined variables;

δ_t is a vector of unobserved random disturbances with a static distribution determined by ω;

ω is a fixed vector of unknown parameters implying that g has a fixed form throughout the sample and the prediction period.

Thus, as written by Just, θ_t implies varying parameters which represent both unknown parameters and also unobserved exogenous variables.

Just (2001:1138) indicates that models of this specification typically include random parameter models (which are less common according to him), and switch regression models. Switching regression models are typically regime switching models that simulate an economic system based on fixed specifications of the switching process, and fixed specifications of the alternative regimes.

d) Dynamic models with unobserved stochastic evolution

Just indicates that models of this specification have the form $y_t = f(y_{t-1}, x_{t,}, \varepsilon_t | \theta_t)$ where $\theta_t = g(\theta_{t-1}, z_{t,}, \delta_t \mid \omega)$. This implies that the parameters evolve over time, and therefore, such models could simulate some form of evolution in an aggregate market.

e) Dynamic models with unobserved exogenous change

Models with this specification include some stable and potentially dynamic relationships where an unknown parameter(s) or unobserved exogenous variable(s) can change so that it cannot be described by estimable specifications or stochastic processes.

Various examples of the types of models in especially categories *a*, *b* and *c* are found in the South African agricultural economic literature, as well as international literature. In recent South African literature, regression modelling that includes some form of risk have been used by Breitenbach & Meyer (2000); Meyer & Kirsten (2005) and Meyer, Westhoff, Binfield & Kirsten (2006)[3].

Breitenbach & Meyer (2000) developed a partial-equilibrium model in order to model fertiliser use in the grain and oilseed production sectors of South Africa. The model was used to analyse the potential impact of changes in the physical and economic environment on production of grains and oilseeds, and the resulting impact on fertiliser use. Different 'scenarios' were modelled, and results indicated that the total area under cultivation decreased and appears to have moved closer to the expected optimum production pattern. This results in lower production levels and also lower exports. As a result of the decrease in the area under cultivation, fertiliser use also decreases. The modelling framework includes supply, demand, and a link between demand and supply in order to simulate market equilibrium, as well as risk, by means of including gross income

[3] Another recent example of econometric modelling based research in South African literature is the work of Sparrow, Ortmann & Darroch (2008). Their paper is however not discussed since it does not analyse an agricultural commodity market from an aggregate perspective.

variations. Gross income variations were deflated and used as a measure of risk, and risk was assumed to be an additional cost, which means the supply curve shifted to the left. Shortcomings of the study indicated by the authors are that modelling results were only as reliable as the input data, and stepped demand functions were not used. This could have resulted in different equilibrium results. Also, the model was validated by comparing actual modelling results with current market situations, implying that the assumption was made that future market situations will be structurally similar to current situations, hence making the model accurate in terms of simulating the future market conditions. This, however, is not correct, since future market structures are not necessarily a direct function of past or present market structures, as argued in the introduction of this thesis.

Meyer & Kirsten (2005) present a partial-equilibrium model of the South African wheat sector, and use the model to create a baseline projection in terms of the supply and use of wheat in South Africa for the period 2004 to 2008. The model is also used to analyse the impacts of different policy alternatives on the wheat sector for the same period. The result of the study indicates that the areas cultivated in both the summer and winter rainfall areas, are likely to decrease over time as a result of higher prices of substitute products such as sunflower. This results in farmers more readily planting alternate crops (such as sunflower) than wheat. Other results of the study indicate that, should the import tariff on wheat be eliminated, domestic prices will decrease as a result of cheaper wheat imports; this will therefore lead to a further decrease in the cultivated wheat area in both the summer and winter rainfall regions. Shortcomings of the specific study are that not all cross-commodity interactions are taken into account, and the future projections are based on a limited set of assumptions. These assumptions include factors that will influence the future wheat price, such as: the exchange rate, the international wheat and sunflower prices, the gross domestic product deflater, and population. Should any of these assumptions change as a result of a significant structural change, the baseline would be incorrect, and hence an incorrect deduction (in terms of the impact of changes in policy) might be made, leading to incorrect decisions.

Meyer *et al.* (2006) developed an econometric regime-switching model within a partial equilibrium framework for the South African agricultural sector. The model includes 18 agricultural commodities and consists of 126 behavioural equations, along with a number of identities. The model has the ability to distinguish between different equilibrium conditions within the same market, depending on the domestic demand and supply situation, as well as the external economic and agricultural economic environment relative to the South African agricultural sector.

The three market equilibrium conditions that are simulated by the model are called the import parity regime, near-autarky regime, and the export parity regime. The import parity regime represents a situation where the difference between the import parity price and the domestic price is greater than the transfer costs. This makes arbitrage possible, and hence imports of the specific commodity possible. The implication of the import parity regime is that the domestic price is largely influenced by world prices, the exchange rate, transport costs and all other costs involved in importing the product. Therefore, the domestic price is driven largely by the external macro-economic and agricultural market environment. The export parity regime represents just the opposite situation, wherein the difference between the domestic price and the export parity price exceeds the transfer costs, making it possible (and profitable) for export to take place. This regime again implies that the domestic price is largely driven by external macro-economic and agricultural market conditions. The near-autarky regime represents the situation wherein the domestic price falls between import and export parity prices, and hence prevents significant levels of trade. The near-autarky regime implies that the domestic price is largely driven by the domestic demand and supply situation, and to a very small extent by external macro-economic and agricultural market conditions.

The regime-switching model is used to analyse the impact of a 10% increase in world prices of white maize, yellow maize and wheat, by means of comparing it to a baseline that was simulated by the same model. Results indicate that the level of market integration between the domestic market and the international market do indeed increase in the case of the import or export parity regime, when compared to the near-autarky regime. This supports the argument that different equilibrium conditions exist within the same market, given the domestic demand and supply situation as well as the external macro-economic and agricultural market situation. The authors conclude by stating that this model has already been used by various South African agri-businesses during past production seasons to do market analyses.

Although not highlighted by the authors, a shortcoming of the model and therefore modelling results, is that the baseline projections and 'scenario' projections are based on projections of exogenous factors such as the exchange rate, oil price and world prices. Should the projections on the exogenous factors be incorrect, the results and therefore deductions based on these results might be incorrect, leading to incorrect decisions that are based solely on the modelling results. A major strength of the model presented in the paper is that it accurately simulates different market conditions, and hence does take some form of risk into account, aside from the standard procedure of including risk by means of the error term. Therefore, the model of Meyer *et al.* (2006) is an excellent example of the type of model that Just (2001) refers to as a dynamic model with unobserved static variation. This makes the model of Meyer *et al.* (2006) more advanced - from a risk analysis perspective - than the models presented by Breitenbach & Meyer (2000) and Meyer & Kirsten (2005).

In international literature, several recent examples are cited where some form of regression modelling (that includes risk) has been used to analyse an aggregate market system. Examples in the literature include the work of Binfield *et al.* (2002); Barrett & Li (2002); Westhoff *et al.* (2005); Koizumi & Ohga (2006); Cutts, Reynolds, Meyer & Vink (2007); Tokgoz, Elobeid, Fabiosa, Hayes, Babcock, Yu, Dong, Hart & Beghin (2007); Elobeid, Tokgoz, Hayes, Babcock & Hart (2007) and Baker, Hayes & Babcock (2008).

The review of both the South African and international literature - where regression modelling has been used with some form of risk included in order to analyse agricultural commodity markets - reveals the following strengths and weaknesses. Firstly, most of the analyses are based on projections of exogenous factors that influence the specific market that is being analysed. The fact that the actual outcome of the exogenous factors could differ significantly from the projections used in the analyses, increases the risk of making inaccurate deductions based on the modelling results, which could lead to incorrect decisions. Regression models do pose the possibility of drawing erroneous conclusions that might lead to incorrect decisions. A strength, however, of the regression models reviewed is that it is fairly accurate in terms of representing actual inter-relationships and trends based on historical data. This makes these models highly applicable in terms of understanding the underlying causality structures and inter-relationships that could cause variation in the market and therefore the economic system. Hence, this type of model does add significant value in analysing the impact of different types of risk on a market system. The fact that the model structure is based on historical data, implies that the regression model might not accurately simulate the same market system in the case of a significant structural change, hence creating a dilemma for the modeller and decision-maker in determining how to use the model. However, since most of these models are built in a fairly 'free' form by means of statistical relationships and coefficients, it is easy to adjust the structure of the model as needed, based on perceived structural changes, thereby improving the model through time to more accurately reflect reality. This, however, creates statistical theoretical problems since correct estimation procedures are not followed in the case where the structure of the model is adjusted 'by hand' and based on expert opinion.

2.4.3.2 Time series econometric modelling

Another general approach found in the agricultural economics literature that deals with risk analysis from an aggregate perspective, is the use of time series econometric modelling. Several sub-approaches to time series econometric modelling exist, namely: autoregressive integrated moving average (ARIMA); vector autoregression (VAR) models (Gujarati, 1995); Bayesian VAR, and flexible combination models (Colino, Irwin & Garcia, 2008).

Time series econometric modelling originated out of the need to understand and simulate aggregate economic systems, given that changes in underlying structures such as policy frameworks do take place. Hence, econometric regression modelling was found wanting due to changing structures underlying the aggregate economic systems that were modelled, and hence modellers adopted time series approaches to analyse these systems (Gujarati, 1995: 735).

Time series econometric techniques aim to analyse the stochastic component of an economic time series without imposing any significant economic theory. Hence, it is assumed that the outcome of the economic series analysed is a function of its own past behaviour, as well as a stochastic component (Gujarati, 1995: 735). Otherwise, as stated by Jordaan, Grové, Jooste and Alemu (2007: 306), analysis of such an economic series to determine volatility and therefore risk, needs to take into account both the predictable and the unpredictable components that cause the eventual economic outcome under study.

Examples of South African agricultural economic literature that use time series econometric techniques to analyse risk of a specific economic time series, include the works of: Jordaan *et al.* (2007), Jooste, Alemu, Botha and Van Schalkwyk (2003) and Ghebrechristos (2003). Jordaan *et al.* (2007) used the GARCH approach to analyse the price risk related to different crops traded on the South African Futures Exchange (SAFEX), namely, yellow maize, white maize, wheat, sunflower seed and soybeans. The reason for using the GARCH approach is that the researchers found that volatility of the stochastic component varied over time, implying that heteroskedasticity is present. The researchers found that the price volatility of white maize was the greatest, followed by yellow maize, sunflower seed, soybeans, and wheat. The researchers concluded that risk averse farmers would be better off farming wheat, sunflower and soybeans based on price risk, since the risk is much lower when compared to white and yellow maize. The researchers therefore recommend that farmers who farm white and yellow maize should use price risk management tools such as forward pricing or options in order to mitigate the price risk. They argue that the volatility in maize prices is difficult to predict and therefore the possibility of losing money if price risk management does not take place, is quite significant. Since the aim of the study was simply to quantify and compare the volatility of the respective crop prices, the cause of the variance in volatility levels over time is not analysed. The study concludes that further research needs to be done, since the underlying causalities of the economic system or series under study needs to be understood in order to support and facilitate policy and investment decision-making. (No indications are given by the authors on how and when such research will be conducted.)

In the international agricultural economic literature, time series econometric techniques have been used to analyse risk of an aggregate economic system by means of analysing an economic time series. Examples include the work of Colino *et al.* (2008), Ramírez and Fadiga (2003), Haigh & Bryant (2000), and Kroner, Kneafsey, Claessens (1993).

Colino *et al.* (2008) compare the accuracy of hog price forecasts released by Iowa State University with alternative market and time series forecast techniques such as univariate time series representation, VAR, Bayesian VAR, as well as other specifications designed to allow for instabilities in market relationships. Their findings indicate that VAR and Bayesian VAR do outperform the Iowa outlook estimates, but they indicate that forecasting success remains limited due to volatile markets. Ramírez & Fadiga (2003) compare the performance of an asymmetric-error GARCH model to that of normal-error and Student-t-GARCH model by applying the different models to forecast US soybean, sorghum, and wheat prices. Their findings indicate that the asymmetric-error GARCH and t-GARCH models perform better with the error term than GARCH, which appears as non-normal. Their findings indicate that although the t-GARCH and a-GARCH models do provide more reliable results, problems still occur in terms of capturing non-normality sufficiently, which could lead to incorrect forecasts.

Haigh & Bryant (2000) use a multivariate GARCH-M model to determine the impact of volatility in barge and ocean freight prices on international grain market prices. Their findings indicate that volatility in ocean freight prices influence volatility in international grain prices to a lesser extent than barge freight prices. The authors conclude by speculating that the possible reason for these findings is that no futures contracts exist for barge rates, while futures contracts do exist for ocean freight rates. Important to note is that through their research, some conclusions can be drawn on the impact of risk, but no underlying causality structures could be determined. The researchers could only speculate on what the underlying causes could be for the observed risk impacts. Kroner, Kneafsey, Claessens (1993) propose a combined approach to derive probability distributions for forecasting agricultural commodity prices, and advocate combining market expectations with options prices and time series modelling. Their findings indicate that some forecasting improvement does occur when their proposed combined approach is used.

From the overview of the literature, two major shortcomings were identified. The first is that the model structures specify that future variance is a function of the weighted long-run average variance; the variance predicted for the current period of estimation and new information that is captured by the most recent squared residual (Engle, 2001), implies that the outcome of the model should mostly be a function of past and present data. This is confirmed by Engle (2001: 160) who states that with a long-run forecast, a GARCH model is mean reverting, conditionally heteroskedastic, and has a constant unconditional variance. The problem with this is that in a fast-changing and turbulent environment, a structural shift often occurs in the long-run, implying that the long-run average up till present is not applicable any more in terms of the newly formed future environment. This is endorsed by Nwogugu (2006: 1736). The author argues that these types of models are based on the assumption of conditionality that stipulates that all conditions and causal factors that existed in period *t* are present in period *t+1*, which is often not the case. In addition, even when the same conditions and causal factors do exist, the intensity, duration, impact and correlation is likely to differ from period *t* to period *t+1*. Thus, a model that reverts to the mean is likely to give an incorrect result in terms of future trends, and since heteroskedasticity is assumed to be constant, the forecasted volatility of the model is also likely to be incorrect when compared to reality. Colino *et al.* (2008) also confirms this point when indicating that published research on price forecasting has decreased significantly during the period 1993 to 2008, due to the fact that the agricultural environment has become much more turbulent and the magnitude and frequency of changes has increased significantly. They argue that this makes accurate forecasting much more challenging as underlying structural changes occur.

The second major shortfall identified in using time series econometrics is that the underlying factors that cause the observed volatility in the economic series are difficult to deduce from the modelling results. This is also confirmed in the writing of Nwogugu (2006: 1740) when the author argues that, due to the under-specification of these types of models, and therefore the limited use of a number of parameters, the error terms cannot be decomposed into causal elements. Hence, the analyst and decision-maker are able to understand the past and present volatility and therefore risk of the analysed economic series, but are often not in a position to understand and deduce the underlying causality structures causing the observed trends and volatility. This point is further confirmed, although indirectly, by Jordaan *et al.* (2007: 321) in the concluding paragraph when addressing potential sources of the observed price volatility, namely: supply and demand; weather conditions; changes in trade volumes; terms of trade shocks, and exchange rates with respect to the commodity prices analysed in their article (done without supplying quantified evidence from the modelling results).

Time series econometrics offer valuable approaches when quantifying risk (in terms of magnitude of economic time series from an aggregate perspective) but is limiting in that it does not inform the analyst and decision-maker about the underlying causality structures that cause the observed risk. Good decision-making not only depends on understanding the magnitude of the risk faced, but also the underlying causality structures that cause the risk. Correctly understanding the potential impact of the risk of a decision, requires more than just time series econometrics.

2.4.3.3 Mathematical programming

Mathematical programming consists of various methods that can be used to solve optimisation problems. An optimisation problem is normally described as a problem wherein an objective function has to be optimised, dependent on a set of constraints. Mathematical programming is often used to analyse on-farm or whole-farm optimisation problems, but also to simulate aggregate market systems in terms of supply, demand, and prices. In such cases, an objective function is described, and then, using the constraints faced by the farm or market such as land availability, soil potential, water availability, labour availability and capital availability, an optimal solution for the system is found.

The problem with finding an optimal solution is often that one does not take risk into account and therefore one might, in actual fact, not have the optimal solution, given that external conditions can change and variability in the constraints can occur. To solve this problem, mathematical programming techniques have been developed to include the impact of risk. Hardaker *et al.* describe two main approaches to include risk in the optimisation problem, namely, risk programming and stochastic programming. Risk programming techniques are used to include non-embedded risk, while stochastic programming is used to include embedded risk (Hardaker *et al.*, 2004: 187). Non-embedded risk is defined by Hardaker *et al.* as arising when a decision is not dependent on previous decisions and resulting uncertain events; embedded risk is opposingly defined i.e. when a decision does depend on both previous decisions as well as outcomes of uncertain events. Hence, to decide which main approach to follow, one has to decide on the nature of the risk faced by the entity, and how it impacts on decisions.

Various methods exist within each of the two main approaches described in the preceding paragraph. Methods included in risk programming are: linear risk programming; quadratic risk programming; MOTAD programming; Target MOTAD programming, and Mean-Gini Programming. Stochastic risk programming includes the technique of discrete risk programming (DSP). Discrete risk programming is used when a decision depends on previous decisions as well as outcomes of uncertain events. To solve a problem such as this, the decision problem is set up in stages that are similar to those of a decision tree, after which each stage is solved in order to get to an optimum. The problem with DSP, as described in Hardaker *et al.*(2004: 203) by Raiffa, is that the problem tends to evolve into too many stages, causing the problem to become too complicated and therefore creating confusion as to what the optimal solution is, given the risks faced.

In terms of risk programming techniques, linear programming is most often used in optimisation problems, and can take cognisance of non-embedded risk quite successfully. The limitation, as indicated by Hardaker *et al.*, is that linear programming does not take account of the situation where the decision-maker is not risk neutral. To mitigate this problem, quadratic risk programming (QRP) has been developed to include the risk aversion coefficient, which represents the decision-maker's attitude towards the risks faced. To solve models such as these, different types of programming software can be used to solve the non-linear relationships. Examples of such software are the General Algebraic Modelling System (GAMS), and Lingo. The assumptions underlying QRP, according to Hardaker *et al.*, is that the decision-maker's utility function is quadratic, or the distribution of total net revenue is normal. As argued by Hardaker *et al.*, these assumptions do not always hold, since total net revenue is seldom distributed normally, and quadratic utility functions are not increasing at all points. In addition, using it implies absolute risk aversion is increasing. This is not always the case.

A number of examples exist in the South African agricultural economics literature where mathematical programming that includes risk, has been used to analyse an aggregate market system. This includes the work of Ortmann (1988), Van Zyl, Vink, Townsend and Kirsten (1998) and Esterhuizen, Van Zyl, and Kirsten (1999).

Ortmann (1988) developed a linear programming model that included negative-sloping demand functions for crops, and positive-sloping supply functions for labour and production risk, by means of using variance-covariance matrices. The model was developed for the South African sugar industry, and regions included the Eastern Transvaal/KaNgwane (now Mpumalanga province), Pongola/Jozini/Makatini, Zululand, and Natal (now Kwazulu-Natal province). In the model, the regional demand curves for tomatoes, cucumbers, green beans, gem squash, hubbard squash, bananas, pawpaws, mangos, litchis, guavas, dry beans, and cotton were estimated. Regional labour supply curves were also estimated. Risk was included by using the mean absolute deviation method. This was done by relating enterprise price elasticity and yield variability to income variability, and including that in the objective function under the assumption that distributions are normally distributed, and that the objective function is linear. Modelling results were compared to actual cropping patterns, actual land rentals, and actual crop prices to validate the model. Results indicated that the model accurately simulated all three of the above-mentioned aspects in the comparison.

Van Zyl *et al.* (1998) also developed a linear programming model based on the model structure used by Ortmann (1988), in order to estimate the effect of market liberalisation on production, employment, price, and welfare impacts in the agricultural sector of the Western Cape province of South Africa. Risk was included in the model by using Minimisation of Total Absolute Deviations (MOTAD), which is similar to the technique used by Ortmann. Six years of historical data, namely, 1983 to 1988 were used as a basis for deriving probability distributions for prices and yields in order to simulate production risk. The model was validated by comparing production levels of crops (in terms of hectares or livestock numbers), with simulation results from the model. It was found that the modelling results compare relatively accurately with actual numbers for the year 1988, which is the base year for the model. The year 1988 was selected as the base year because the researchers argued that it was a fairly 'normal' year. (No reasons are given by the authors as to why they thought it was a 'normal' year.) Results indicated that market liberalisation could have a significant impact on prices, especially where extensive market intervention takes place, namely, with grain and livestock. In the case of vegetables and fruit, it was found that market liberalisation does not have such a significant impact, since these industries were not influenced by market intervention to the same extent as grain and livestock. Hence, the vegetable and fruit industries were perceived as being much more globally competitive in agricultural markets.

The model developed by Esterhuizen *et al.* (1999) was used to analyse the operation of the most important stockfeed proteins in South Africa, with regards to demand and supply. This included products such as maize, wheat, sorghum, oilseeds and fishmeal. The model developed and used by the researchers was similar to that developed by Ortmann (1988) and Van Zyl *et al.* (1998), and also made use of MOTAD to include risk in the modelling exercise. The model covered the nine provinces of South Africa, and the assumed base year for the model was the 1995/96 production year. Time series data for the period 1990/91 to 1995/96 was used to set up the risk distribution functions, while cross-sectional data was used to set up the structure of the model. Validation of the model was done by means of comparing modelling results to actual data for specified variables such as production and prices. The model was used to simulate different outcomes of various selected factors such as: a drought; a general increase in production costs; an increase in transport costs; a change in the yield and production costs of yellow maize, and an increase in the yield and price of soybeans. Each of these situations that were analysed was called a 'scenario.' Results indicated that the model is quite useful in understanding the impacts of exogenous variables on the aggregate system being studied.

In international literature, various examples exist where mathematical programming models have been used to analyse an aggregate market system. Examples include the work of Butt & Mccarl (2005), which has already been reviewed and discussed in chapter one of this thesis, and Olubode-Awosola, Van Schalkwyk, and Jooste (2008). Olubode-Awosola *et al.* use an extended version of the standard Positive Mathematical Programming (PMP) model calibration approach to analyse the potential impact of land redistribution on the production of crops and animal products. The study uses the Free State province of South Africa as a case study. The data and model is validated by means of using expert opinion, as well as comparing model results with actual data on specified variables. The researchers found that the model simulates the actual economic system accurately. Findings indicate that as the number of large farm units decrease, the number of small farm units increase, as a result of the assumed land redistribution policy modelled. This resulted in a general decline in total production levels of crops and livestock products - the decline in production due to the decline in large farm units overshadowed the increase in production attributed to the increased small farm units. This effect is especially apparent in the case of capital-intensive production activities such as soybeans, wheat, sorghum, sunflower seed, broiler operations and layer operations. The researchers conclude that the South African government needs to balance equity with efficiency in a free market economy when designing a land redistribution policy.

The overview of the different mathematical programming models show that mathematical programming is useful in analysing the impact of demand, supply and prices on an aggregate market. Mathematical programming models tend to have extensive range in terms of the number of inter-relationships and equations that can be included. This makes mathematical programming very useful in the sense that underlying causality structures can be captured accurately and with a lot of detail, making it an ideal technique to study the impact of risk on aggregate market systems (Van Zyl *et al.*,1998:83). However, this means that mathematical programming models can be very demanding – many data inputs are needed to estimate the various parameter values. Also, in many instances, assumptions need to be made on causality structures simply due to a lack of accurate or timely data. This causes the modelling exercise to be highly reliant on expert opinion and other sources to ensure that modelling results accurately reflect reality (Van Zyl *et al.*, 1998: 83; Olubode-Awosola *et al.*, 2008: 847 - 848).

2.5 Conclusion

The discussion of the various methods of formal risk analyses clearly highlights, in broad terms, the various advantages and disadvantages of each method. As clearly illustrated in chapter one, the environment into which the agricultural sector is moving, is one of increasing volatility and therefore risk. However, given the potential increase in volatility, underlying structures and inter-relationships between factors are likely to change over time and possibly at irregular intervals. This implies that the method or combination of methods used to analyse risk needs to be flexible and adaptable in order to keep up with these structural changes.

Decision-makers need tools that can map changes in inter-relationships and structures as they happen. From the description of the various decision analysis techniques, it is clear that regression modelling offers this capability. It provides flexible and mathematically and economically rigorous analysis, that is virtually independent of intuition. However, it is not as structured as mathematical programming in the sense that it relies on very specific assumptions about functional form, and linearity or non-linearity in inter-relationships, which makes it a bit more flexible (but less rigorous) than mathematical programming. Regression is also more structured with regards to revealing the underlying causality structures compared to time series econometric analysis, making it more useful when analysing risk. Therefore, regression modelling, and specifically the model of Meyer *et al.* (2006) will be used in the remainder of this thesis to test the hypothesis. Other reasons for selecting the model of Meyer *et al.* (2006) is because it simulates the South African yellow maize price from a national perspective which is needed for presenting the case studies in chapters five and six, and also includes interaction with other grain crops, livestock sectors, the macro-economy, the policy environment and the natural environment. It has also been shown that the model of Meyer *et al.* is based on the model typology presented by Just (2001) and is significantly advanced in relation to other regression models in South African literature. Hence it is quite suitable to do risk analysis in the South African agricultural commodity market.

A major shortcoming, however, as indicated throughout this chapter, is that all types of models used in agricultural economic risk analysis, use historical data to derive underlying causality structures or to understand risk. Risk is also included by means of objective or subjective probabilities, as explained. In the case where subjective probabilities are used, agricultural economists tend to argue that both risk and uncertainty are included in the analysis. This links up to the argument made by Valsamakis *et al.* (1996: 24) which proposes that when considering the definitions of risk and uncertainty, one should rather focus on the similarities between the two concepts. Valsamakis further argues that the interpretation of risk and uncertainty should rather be based on a situation in which certainty is absent.

This argument is, however, flawed, since a fundamental part of decision-making lies in correctly identifying and analysing risk AND uncertainty. In order to identify and analyse both risk and uncertainty effectively, one needs to use the correct approaches or tools. However, using the correct tool depends on whether one is working with risk or uncertainty. A clear distinction should be made between risk and uncertainty, and it should be based on whether causality can be determined and is still relevant or not, and therefore whether probabilities (subjective or objective) can be assigned to different outcomes. In the case where probabilities can't be assigned, and causality can't be determined nor understood, uncertainty per definition does exist. Consequently, different tools need to be used to understand and manage uncertainty. The following chapter defines and discusses uncertainty, and presents a tool that can be used to analyse uncertainty in a fundamentally more correct and comprehensive fashion than by just assigning subjective probabilities.

CHAPTER 3: Uncertainty and Scenario Thinking

"Nature has established patterns originating in the return of events, but only for the most part…"

Gottfried von Leibniz, 1703

(In Bernstein, 1998: 4)

3.1 Introduction

Business managers and policy makers often have to make decisions that could potentially have significant long-term consequences. The challenge in making most of these decisions is that the decision-maker does not know what the future holds. Any change in the environment that is either unknown or out of the decision-maker's control, can make decisions and actions worthless, and could even result in unintentional consequences. To deal with this challenge, decision-makers therefore need to make use of tools to assist them in understanding the risk and uncertainty faced, as well as potential consequences arising from unexpected events. Decision-makers use tools to envisage various situations, and draw up plans to mitigate potential negative effects flowing from decisions, or capitalise on unanticipated opportunities.

Various approaches to analysing risk and uncertainty exist, which help the decision-maker to better understand the consequences of risk and uncertainty, and hence make better decisions. The previous chapter defined risk and described how it is managed and analysed, specifically in agricultural economics. It was however argued in the first two chapters of this thesis that a fundamental shortcoming exists with regards to the way in which risk and uncertainty is analysed in agricultural economics, as uncertainty is not captured to the extent that it should be.

The purpose of this chapter is to initially define uncertainty in order to show the fundamental differences between risk and uncertainty; secondly, it explains the link between uncertainty and scenario thinking, and thirdly, reviews the literature on scenario thinking in order to identify and select a suitable scenario thinking technique to test the hypothesis.

3.2 Defining uncertainty

The definition and description of risk as used in agricultural economic analyses and as discussed in chapter two of this thesis, however, creates a dilemma for analysts and decision-makers. The dilemma arises when causality or the 'rule of law' breaks down and it becomes difficult to form a perspective on the cause-and-effect relationships in a system, and therefore on objective or subjective probabilities of events. Frank Knight, in his seminal work 'Risk, Uncertainty and Profit,' discussed this dilemma and concluded that a clear distinction does exist between risk and uncertainty (Knight, 1921: 224). Knight indicated that a scheme can be set up for classifying three different 'probability' situations, detailed below:

a) *A priori* probability: these are probability situations that can be calculated using homogenous classification of instances that are completely similar except for really indeterminate factors. These types of probabilities are typically mathematical probabilities. An example of such a probability is the flipping of a coin, wherein the only indeterminate factor is whether the coin is “loaded” and whether the person follows exactly the same action each time the coin is flipped.
b) The second type of probability situation is called *statistical probability*. Here he refers to the situation wherein probabilities (objective or subjective) can be calculated based on observed data or empirical classification of instances.
c) The third probability situation is called *estimates* by Knight. This he defines as the situation wherein *no valid basis exists of any kind for classifying instances*. The implication is that no probability (objective or subjective), can hence be attached to an outcome in such a situation, and hence he defines it as “*true uncertainty.*” Knight argues that this type of probability situation typically occurs in the practical day-to-day decision-making environment where a totally unique decision has to be made, and where no historical reference points exist to indicate some sort of success or failure probability. Knight uses an example of a manufacturer having to decide whether to expand production facilities. No data or any other information exists to guide the decision-maker on what the probability of success will be, and hence the decision-maker has to make an estimate on the possibility

of success, and based on this estimate, make the final decision. Ultimately, the decision-maker does attach an intuitive subjective probability to the potential success of the decision, but that subjective probability is fraught with risk since a real probability exists that the subjective probability could be incorrect. Knight argues that in such a case it is fundamentally not possible to even assign a probability of making an error in judgement, hence rendering it meaningless to assign a probability, since the decision-maker does not have the slightest idea whether the decision would be correct or not. Thus, to speak about probability assignment in this type of probability situation, is actually irrelevant.

Therefore, based on Knight's original arguments and distinction between risk and uncertainty, subsequent authors such as Bowles (2004: 101) define uncertainty as being when no objective or subjective probabilities can be assigned to an outcome. Bernstein (1998: 133) also argues along similar lines, and defines uncertainty as unknown probabilities. Based on these authors' arguments, a clear distinction does exist between risk and uncertainty, pointing to the incomplete manner in which uncertainty is accounted for in the analysis of risk and uncertainty, especially in agricultural economics. Interestingly enough, Knight (1921: 231) pointed out this shortcoming as far back as 1921 when he stated that: *"It is this third type of probability or uncertainty which has been neglected in economic theory, and which we propose to put in its rightful place."* Sadly, it appears that this type of probability situation, namely uncertainty, has not been put in its rightful place by subsequent agricultural economics researchers in the field of risk and uncertainty, as evidenced by the arguments of Just (2001) and Taylor (2002).

Uncertainty stems from two underlying problems. The first problem is the task of calculating accurate and realistic probabilities in order to quantify risk, which is difficult to do because correlations between factors change. Correlations between factors change as a result of a change in the cause-and-effect relationship between factors. Since the accurate calculation of probabilities is dependent on correlations between factors, probability distributions are due to change should correlations between factors change. However, in many instances, knowledge or data is not available to estimate 'new' correlations. Correlations are based on the changes in the relationships between factors, which naturally makes it difficult to accurately estimate correlations in real-time. The second problem stems from the fact that, as a result of the structural change in the system, different factors come into play that drive and shape the system. The implication is that a 'new' rule of law (Ilbury and Sunter, 2003) appears. In many instances these 'new' factors are either difficult to understand or to quantify. Thus, the 'new' factors influencing the system, along with the difficulty to either understand or quantify these factors, make it very difficult to accurately calculate probabilities and so quantify and understand risk. It becomes clear that decision-makers have to consider risk as well as some element of uncertainty with regards to relationships between factors, and also the 'path' of the factor itself when making policy and strategic business decisions.

Pierre Wack (1985a: 73) writes about the dilemma that arises when events result in a breakdown of causality. He describes such "causality-breaking" events as discontinuities. He defines discontinuities as "*...major shifts in the business environment that make whole strategies obsolete.*" Wack's definition and ideas spring from his experience in a business environment, having worked for the Royal Dutch Shell Company for years. Therefore, his definition of discontinuities only refer to changes in the business environment. However, given that policy decisions also need to be made in a risky and uncertain environment, the definition of discontinuities could be useful in referring to changes in the business environment, and also to changes in a more general environment that affect both policies and business strategies.

Grossmann (2007: 878) writes that discontinuities can be organised into three categories:

α) A temporary or permanent break within one condition or field.

β) A significant change occurring without a break in any particular condition through the combined influence of several trends in different fields – all of which may be unspectacular by themselves.

χ) A significant change due to a gradual, long-term process of change.

Volume two of Ecosystems and Human Wellbeing (Millenium Ecosystem Assesment, 2005: 39), attributes the source of discontinuities to indeterminacy, which is caused by ignorance, surprise, and volition. Ignorance refers to limited knowledge, resulting in a lack of knowledge about systems and causality within these systems. A change in the causality of the system can therefore lead to unexpected outcomes due to a lack of knowledge. Surprise is defined as uncertainty arising from the inherent indeterminism of complex systems, while volition is defined as uncertainty that arises from human actions embedded in the system that extensively influence the system.

Based on the different sources of discontinuities, one can argue that discontinuities occur in an environment much wider than just the business environment, and can cause major shifts that not only make business strategies obsolete, but also policies. The implication of discontinuities for agricultural policy and strategic business decisions is that not only must risk be analysed through probability analysis, but uncertainty must be analysed too. There is the possibility of discontinuities occurring that could cause probability distributions to change significantly from what is probable, given historical relationships between factors.

3.3 The link between uncertainty and scenario thinking

The word scenario is often used when people speak about the future, especially in the case of modelling projections in economics and agricultural economics. This can be attributed to the fact that many people, including modellers, think that any situation or idea or projection of the future, is a scenario. Studying the scenario and futures literature, it is clear that little consensus exists in terms of what a scenario is, how to set up a scenario, and how to use a scenario. This point is emphasised by Bradfield, Wright, Burt, Cairns, and Van Der Heijden (2005). To provide some clarity on these issues, we look to the origins of scenarios and to the background pertaining to why they were useful. We then discuss the different techniques and hence definitions. The remainder of this section focuses on the origins, while the following section discuss the different techniques and resulting definitions.

Bradfield *et al.* (2005) writes that the concept and use of scenarios has been widely known and implemented by humans, and can be traced back as far as Plato's publication, *Republic,* wherein Plato describes his idea of an ideal republic. Later in history, writers such as George Orwell and Thomas More also made use of scenarios to present a potential future state of the world (Bradfield *et al.* 2005). These examples, however, indicate where scenarios were used as normative tools to communicate a specific message around a specific issue. Interestingly, scenarios only came into serious use as a planning tool after World War II, although the first signs of scenarios being used in war simulation games can be dated as far back as the nineteenth century. Evidence to this effect is found in the writings of von Clausewitz and von Moltke (Bradfield *et al.*, 2005). According to Bradfield *et al.*, the use of scenarios for planning occurred after World War II in two different geographical centres, namely the USA and France.

The use of scenarios in the USA originated in military planning (Bradfield *et al.*, 2005, Segal, 2007). After World War II, the US Department of Defence had to make decisions on which weapons development programmes to fund. To make these decisions, they were however faced by various *uncertainties.* Was developing these weapons worthwhile, especially in light of 1) the time taken to do so; 2) the political uncertainty resulting as tensions increased between Russia and the West, and 3) whether the weapons had longevity as other nations concurrently may have been developing better weapons that would make the US weapons obsolete. The result was that two approaches were developed to capture these uncertainties during the planning process, namely: the development of consensus on key issues through the use of a large number of experts (which eventually led to the development of the Delphi method); secondly, the development of simulation models that allow one to simulate alternative policies and so get an idea of what the potential consequences could be.

These developments provided the platform for Herman Kahn at the RAND Corporation, a research group that evolved out of a joint project between the US Airforce and the Douglas Aircraft company. They used scenarios to inform decisions in considering a large scale early warning missile system. Afterwards, Kahn started the Hudson Institute, where he continued to use scenarios for social projections as well as to inform public policy. During this period, Kahn published various works containing scenarios that informed decisions. Kahn influenced other businesses to realise the potential value of using scenarios in strategic planning, given the rise in uncertainties faced by businesses (Bradfield *et al.*, 2005; Segal, 2007).

3.4 Scenario thinking techniques

Based on Kahn's work, different scenario thinking techniques developed. As a result of the different techniques, different definitions for scenarios were developed by the different schools with respect to each type of technique. In the available literature, three articles have been published in which the different scenario development techniques are organised. The papers are by Bradfield *et al.* (2005), Van Notten, Rotmans, Van Asselt, and Rothman (2003) and Bishop, Hines, Collins (2007). Some scholars attach probabilities to the scenarios, and others don't. Another major difference lies in the use of intuition in developing the set of scenarios, versus using modelling to develop the sets of scenarios. In order to provide more clarity on this, each technique (along with the definition of scenarios that accompany the technique) is discussed in this section, as well as the classification offered by Bradfield *et al.* (2005). Although the classification offered by Bishop *et al.* offers a greater variety of scenario development techniques, their classification is essentially captured by Bradfield *et al.* and Bradfield's classification offers a view of scenario development techniques at a much higher level. The ultimate purpose of this section is to identify a suitable scenario thinking technique to use to test the hypothesis.

3.4.1 The Intuitive Logics approach to scenario thinking

One company that adopted scenario thinking based on Kahn's work was the Royal Dutch Shell Company. Pierre Wack, a French economist and employee at Shell, was instrumental in getting scenario planning adopted at Shell. Shell adopted this technique because it needed to make decisions about long-term investments in production capacity, shipping capabilities, pipelines and refineries. The problem was that environmental uncertainties made formal forecasting techniques unhelpful, in that they could not analyse the impacts of these uncertainties and therefore develop strategies on how to manage these potential impacts (Segal, 2007). As a result, Wack and his team adopted the scenario technique developed by Herman Kahn, and adjusted the technique over time to make it more practical in assisting Shell with its long-term investment decisions. Wack and his team developed a unique scenario development technique that was later termed "Intuitive Logics" (Bradfield *et al.*, 2005). Through time, and based on the work done by Wack and his team, various sub-approaches to the Intuitive Logics methodology have been developed and published, including that by Scwartz (1991),Van Der Heijden (1996), Ilbury and Sunter (2003, 2005, 2007) and Shell (2003).

3.4.1.1 Definitions of scenarios under Intuitive Logics approach

Various definitions regarding scenarios exist, which is in line with the Intuitive Logics approach to scenario thinking. The South African Pocket Oxford dictionary (2002: 802) defines a scenario as follows: "*1) A written outline of a film, novel, or stage work. 2) A possible sequence of future events*." Ilbury and Sunter (2003: 87) describe a scenario as not being a single forecast but rather a plausible story or pathway into an unknown future. Shell (2003) describes a scenario as being a story that portrays a potential future. The story normally consists of a combination of momentous events, players who influence the story through their motivations, as well as an underlying assumption about the functioning of the world within the story. The scenario is not a view based on consensus; neither is it a prediction or forecast. It rather conveys a potential milieu and how it could change. Glen (2006) defines a scenario as follows: "*A scenario is a story with plausible cause and effect links that connect a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative."* In Davis-Floyd (1998), Betty Sue Flowers, the editor of the 1992 and 1995 Shell scenarios, describes a scenario as a coherent story that leads you to understand relationships and therefore causation.

Wack (1985a) defines two different types of scenarios, namely "*first generation*" scenarios and *"second generation*" scenarios, or "*decision scenarios."* He writes that in many instances people think scenarios merely quantify alternative outcomes of obvious uncertainties e.g. different exchange rate projections or different oil price projections hence "more of the same." Wack defines this type of scenario as a "first generation" scenario and describes it as being simple combinations of obvious uncertainties. He argues that first generation scenarios are needed in the planning process, since they tend to improve the understanding of reality, and therefore lead one to question perceptions and search for the true underlying forces and interactions that drive a system. However, first generation scenarios do not help much with actual decision-making since they tend to lead the decision-maker to fairly straightforward and often conflicting strategic solutions (Wack, 1985a: 76). Therefore, it does not provide the decision-maker with any sound basis on which to exercise his or her judgement.

Wack argues that for scenarios to really assist in decision-making, they need to challenge the decision-maker's assumptions and judgements about how the environment works, and therefore require them to change their views in such a way that they more closely reflect reality. Scenarios that do exactly this he defined as *decision scenarios* or "second-generation" scenarios. Decision scenarios, according to him, differ from "first generation scenarios" in the sense that they incorporate the "unthinkable." Hence, through the development of first generation scenarios, a process is started whereby the underlying forces and interactions are analysed, which leads to a deeper level of understanding. Wack defines decision scenarios as scenarios that deal with two worlds: *"…the world of facts and the world of perceptions"* (Wack, 1985b:140). Decision scenarios therefore gather facts from the 'outside world' and structure them in such a way that they link to the 'inner world' or perceptions of the decision-maker. This forces the decision-maker to reconsider previously held perceptions, and leads to adjustments in perceptions so that they reflect reality more accurately. By doing that, decision-makers have a sounder basis on which to make decisions, and the chances of making good decisions in uncertain and turbulent situations increases.

3.4.1.2 Application of scenarios under Intuitive Logics approach

Decision scenarios are structured around predetermined and uncertain factors (Wack, 1985b: 140). Wack defines predetermined elements as being events already in the pipeline or that are certain to occur, of which the consequences have yet to unfold. According to him, predetermined elements can be viewed as interdependencies within the system, breaks in trends, or the "impossible." The foundation of decision scenarios lies in exploring and expanding the predetermined elements, along with key uncertainties, and through that process developing an understanding for the impossible and therefore the possible. Wack (1985a: 74) describes the process of scenario development: "*by carefully* *studying some uncertainties, we gain a deeper understanding of their interplay, which, paradoxically, leads us to learn what was certain and inevitable and what was not."* He describes the process of sorting out which factors or elements are predetermined and which are key uncertainties. He states that first generation scenarios are useful in the sense of gaining better understanding of what the predetermined factors really are, and what is really uncertain. This then leads to second-generation scenarios or decision scenarios. Wack (1985a: 77) further states that first generation scenarios are essential since it is almost impossible to immediately jump to second generation scenarios. The key uncertainties are the factors or events that are plausible but to which *no probability* can be attached. Therefore, the scenario thinking process can be described as a process that entails thinking about the unthinkable. Or, as a process entailing pursuing ends, often unrelated and contradicting, in order to sort possible from the impossible, and controllable from the uncontrollable (Ilbury and Sunter, 2003: 21, 23, 29, 31).

Wack states that a decision scenario must be possible, plausible and internally consistent (1985a: 77). Hence, as stated by Wack: *"Decision scenarios rule out impossible developments; they deny much more than they affirm"* (Wack, 1985b: 140). Decision scenarios provide the decision-maker with situations that challenge his or her perceptions. A scenario that is not possible or plausible will be seen as a story without substance, and therefore won't be seriously considered when making decisions. Wack emphasises this important point by comparing scenarios that are not possible, plausible and internally consistent to a tree without roots. Both will not develop and grow.

3.4.1.3 Purpose of scenarios under intuitive logics approach

Wack (1985b: 140) describes the purpose of scenarios and the intuitive scenario thinking process as follows: *"Scenarios must help decision makers develop their own feel for the nature of the system, the forces at work within it, the uncertainties that underlie the alternative scenarios, and the concepts useful for interpreting key data."* By sifting and separating the probable and plausible, one develops a better understanding of the unthinkable or the known unknowns and unknown unknowns (Ilbury and Sunter, 2003: 83). Furthermore, scenarios serve the purpose of signalling changes in predetermined factors and key uncertainties, in order to facilitate better understanding of the possible occurrence and the impact of discontinuities (Wack, 1985a: 74). Important to note is that the incorporation of the intuitive logics scenario thinking technique does not involve the mere plugging in of a range of values e.g. inputting different exchange rates into a model, as often happens in agricultural economic literature. Instead, it implies that the possible occurrence of discontinuities, and therefore uncertainty, is also taken into consideration in the decision problem. Scenario should not simply consist of quantified alternative outcomes because the decision-maker needs to be able to deduce from the scenario why a specific event or chain of events could potentially occur, and based on that, exercise their judgement in making a decision (Davis-Floyd, 1998). This is neatly stated by Wack (1985b:149) when he touches on Roberta Wohlstetter's reference to the Pearl Harbour attack, in which early warning radio signals did appear but weren't correctly interpreted. He writes: *"To discriminate significant sounds against this background of noise, one has to be listening for something or for one of several things… one needs not only an ear but a variety of hypotheses that guide observation."* Therefore, according to Wack (1985b:146), decision scenarios also serves the purpose of assisting decision-makers in anticipating and understanding risk, as well as discovering entrepreneurial opportunities.

Davis-Floyd (1998) writes that the purpose of the Shell scenarios is to provide its managers with a set of stories that can be used to interpret weak signals and events in their decision environment. Through interpreting the weak signals and events, their understanding of the underlying causality is improved, as well as the potential occurrences and consequences that could ensue. This puts them in a better position to make quick and accurate decisions since their perception of reality, and how these events and unfolding uncertainties link up with their decisions and actions, is better developed and more complete. Wack also spoke about this and is quoted in Davis-Floyd (1998) as follows: *"It is extremely difficult for managers to break out of their worldview while operating within it. When they are committed to a certain way of framing an issue, it is difficult for them to see solutions that lie outside this framework. By presenting another way of seeing the world, decision scenarios allow managers to break out of a one-eyed view. Scenarios give managers something very precious: the ability to re-perceive reality…"*

The underlying value of re-perceiving reality and being able to interpret weak signals and events is stated by Betty Sue Flowers (the editor of various Shell scenarios), in Davis-Floyd (1998):*"Then it gets even more mysterious, because then you begin to see that the future is what you use to create the present, and that the present that you then create will create the future that you want. I mean, it's chicken-egg…."* In other words, as stated by Davis-Floyd: "*…it becomes a very strong cognitive feedback loop."* This implies that learning takes place.

Since scenarios need to encapsulate uncertainty, a scenario is never used on its own, but always forms part of a set of scenarios used to capture key uncertainties and the potentially different milieus. This then provides a decision-maker with a set of alternative "wind tunnels" or hypotheses in the form of scenarios, which can be used to test and compare options and outcomes. According to Wack (1985b: 146) the amount of scenarios in a scenario set should not be more than four since it becomes increasingly difficult for decision-makers to simultaneously consider more than four different situations. He indicates that three is a good combination, since one scenario can represent the current view of decision-makers, while the other two can show totally opposing worlds. The two alternatives can then be used to show the weaknesses in the current view, and thereby coerce decision-makers to reconsider their perceptions. What is important when using three scenarios, is that they should not operate along the same dimensions, since decision-makers might view one of the scenarios as a baseline, and this would lead them to focus on the baseline and not all three scenarios. Focussing just on the baseline puts them into a "forecasting" frame of mind, which leads them to ignore uncertainty. Using a set of only two scenarios can be dangerous as well, according to Wack, since one scenario is normally an optimistic view and the other is a pessimistic view. This encourages decision-makers to think that the truth (and therefore the future) might lie somewhere in the middle, which again puts them in a "forecasting" frame of mind, again implying that uncertainty is ignored.

3.4.1.4 Intuitive logics scenario development techniques

Ilbury and Sunter have published two works (Ilbury and Sunter, 2003 & 2005) describing a scenario development technique. These two publications culminated in their most recent work, published in 2007 (Ilbury and Sunter, 2007). Their tried-and-tested approach is mostly based on the Socratic methodology, developed and tested by Socrates himself. It essentially entails asking critical questions in order to eliminate hypotheses. This leads to re-thinking previously held beliefs, which eventually leads to a better understanding of reality and how uncertainty impacts decisions and actions. Decision-makers therefore know which decisions and resulting actions are most likely to lead to desired outcomes. The approach they present consists of ten questions, each structured in such a way that it connects to all the other questions and leads to a process of "re-perceiving reality," as coined by Wack (1985b:150).

Ilbury and Sunter use the concept of a game as an analogy to the business or decision-making environment. They believe that games and business are both governed by a set of rules, involve competing teams with an eventual winner, contain risks and uncertainties, and have definitive outcomes. As such, their set of ten questions used to develop decision scenarios and make decisions, contain 'game' elements. The ten questions are as follows (Ilbury & Sunter, 2007: 33, 34):

1. *Context: how has the game in your industry changed, where is it heading and how have you fared as a player?*
2. *Scope: what is your playing field today, and how do you want to expand (or contract) it in light of the developing context and the resources at your disposal?*
3. *Players: who are the players that can most advance or retard your strategy, and how should you handle them in future?*
4. *Rules: what are the rules of the game that are likely to govern your strategy under all scenarios?*
5. *Uncertainties: what are the key uncertainties that could have a significant impact on the game and divert your course either positively or negatively?*
6. *Scenarios: on your gameboard, what are the possible scenarios and where would you position yourself in relation to them now?*
7. *SWOT: what are your strengths and weaknesses as a player; and what are the opportunities and threats offered by the game?*

8. *Options: within your span of control, what options do you have to improve your current performance and long-term prospects in the game?*
9. *Decisions: which options do you want to turn into decisions right now, and what is the initial action associated with each decision?*
10. *Outcomes: what is your meaning of winning the game in five years' time, expressed as a set of measurable outcomes?*

The 'rules of the game' (as termed by Ilbury & Sunter) are defined by Wack (1985a) as predetermined factors. Comparing the approach and arguments of Wack to the approach presented by Ilbury and Sunter, it is clear that both suggest that the scenarios should be structured around predetermined elements and key uncertainties. Ilbury and Sunter, however, have gone one step further by proposing steps on how to link these scenarios to the inner thoughts or perceptions of the decision-makers. This is done by means of eliciting answers from the decision-makers for questions 1 and 2, and for 7 to 10. Questions 3 to 6 are aimed at structuring the scenarios as decision scenarios and not simply as first generation scenarios. Hence, it can be concluded that the approach presented by Ilbury and Sunter is closely related to that argued by Wack.

Another approach presented in the literature is that of Shell (2003). Shell indicates that scenarios are an iterative process that turns around key questions, potential branches, and scenario outlines. Setting the key questions initially starts with the setting of research priorities - by getting some general ideas from the scenario building team, as well as from outside experts from various fields. The next step is to conduct interviews with people from the organisation who are going to use the scenarios to assist them in making decisions. After setting research priorities and conducting interviews, central themes begin to emerge as well as the commonly held perceptions about reality. Then central themes and central questions are developed to serve as a basis for scenario construction. These central themes interact with each other and through this interaction, potentially different realities, branches, or worlds are created. Naturally, the next step is for the scenario building team to debate these potentially different realities and how they could come about. By following this step, the outlines of the various scenarios are formed and expanded.

According to Shell, the development of these storylines or scenario outlines can either be deductive, inductive, or normative. A deductive scenario is a scenario that is developed around two critical uncertainties or themes, and configured in the form of a matrix that has four quadrants. Each quadrant represents a potential scenario. This closely resembles the gameboard presented by Ilbury and Sunter (2003). A combination of predetermined factors, along with the key uncertainties set out in the matrix, are then used to develop the four different storylines represented by the four quadrants in the matrix. Inductive scenarios are constructed by combining a number of different chains of events, in various combinations, to construct different plausible and possible storylines. From these storylines, a scenario structure is induced that could lead to potentially different scenarios. Lastly, a normative scenario is constructed by starting at the very end of the story, and working backwards to develop a storyline that logically and realistically could lead to the envisaged outcome.

After the storyline has been completed and the dynamics within each scenario have been clarified, the scenarios are presented to an objective audience for comment and feedback so that they can be refined and improved. Then onto the final phase - presenting the scenario to the decision-makers. The purpose of this phase is to ensure that the scenarios truly connect to the inner thoughts and perceptions of the decision-makers. Pre-presentation questioning is used, and scenarios are often vividly illustrated by using sketches, films, or simply excellent story-telling. During the presentation, care is taken to draw the decision-maker's attention to the various implications of each scenario, as well as the potential signals that will indicate which scenario or combination of scenarios is beginning to play out.

3.4.2 Probabilistic modified trends approaches

Along with the Intuitive Logics approach, another approach developed in the USA is the "Probabilistic modified trends school," as termed by Bradfield *et al.* (2005) This approach basically incorporates two different methods, namely Trend Impact Analysis (TIA) and Cross-Impact Analysis (CIA). Both these methods advocate that future probabilities of events will be different to historical occurrences, therefore trends need to either be changed, or correlations between various factors need to be adjusted.

The main difference between the Intuitive Logics approach to scenario thinking and the Probabilistic Modified Trends approach to scenario thinking is the use of probabilities. As explained, in the Intuitive Logics approach, probabilities are not used in defining, setting up, or presenting scenarios. With the Probabilistic Modified Trends approach, probabilities do form a fundamental part of setting up and presenting the scenarios (Bradfield *et al.,* 2005). The problem is that, by assigning probabilities, uncertainty is assumed to be out of the equation, and risk is introduced into the equation. Hence, the Probabilistic Modified Trends approach moves away from the fundamental logic of using scenarios to analyse uncertainty, and rather analyses and communicates risk.

3.4.3 The prospective thinking approach

While all these developments took place in the USA, similar developments took place in France. Gaston Berger founded the Centre d'Etudes Prospectives, where he developed a scenario planning technique called Prospective Thinking or *La Prospective* (Bradfield *et al.*, 2005). Berger, a French philosopher, studied the long-term social and political future of France, and wanted to show that the future was not simply a function of the past and present, but that the future could be changed and adapted for the better. The available forecast techniques did not offer this capability to Berger - since forecasting essentially assumes that the future is mostly a function of the past and present – and Berger had to develop an alternative technique to study the long-term future. This led to the *La Prospective* scenario thinking technique. What Berger started, was developed further by Michel Godet, who transformed the process into a more mathematical and probabilistic approach to scenario development.

Subsequent to the development of the various techniques, Bradfield *et al.*(2005) argue that there are three main categories of scenario development techniques, namely: the *La Prospective*; the Intuitive Logics approach, and the Probabilistic Modified Trends (PMT) methodology, which comprises the TIA and CIA approaches. The key difference between the Intuitive Logics approach and the *La Prospective* approach is that the former is more elaborate, complex and mathematical, and relies heavily on computers to simulate these scenarios. Of the three approaches, the Intuitive Logics approach appears to be used most frequently, while the *La Prospective* methodology is used least often. The reason for this, as indicated by various authors, is that its usefulness and implementation is not easy as it is complex and requires effort to master.

As addressed, the *La Prospective* methodology is similar to the Probabilistic Modified Trends approach, and introduces probabilities in terms of defining, setting up, and communicating the scenarios. This results in the introduction of risk rather than uncertainty, and hence leads to a fundamental difference between *La Prospective* and the Intuitive Logics approach.

3.5 Selecting a scenario thinking technique

From the discussion in this chapter, one basic point becomes very clear: the various scenario development techniques all originated out of a need to have a better understanding of uncertainty and how it impacts decisions and actions. Whether considering weapons development, politics, economics, the natural environment, or society, all scenario thinking techniques were borne out of the need to better capture the impact of uncertainty on decisions and resulting actions. Given the fundamental difference between risk and uncertainty, as explained in ection 3.2, and given the potential that agricultural commodity markets will become more volatile in future, it is important to select the correct scenario thinking technique to use in conjunction with stochastic modelling. This way decision-makers will be better equipped to understand the risks and uncertainties of agricultural commodity markets.

Since scenario thinking developed out of the need to capture the link between uncertainty and decisions, it is imperative that the scenario development technique chosen should have the ability to capture uncertainty and not assign probabilities to key uncertainties. Bradfield *et al.* (2005) indicate that when scenarios are developed by means of the La Prospective (or the PMT methodologies), probabilities tend to be assigned to the various scenarios. Namely, a base case scenario plus upper and lower case scenarios based on probabilities calculated through the hugely complicated system of models. On the other hand, the Intuitive Logics approach does not rely on probability assignment to scenarios, and hence all the scenarios generated through the process are treated as having equal probability of occurring. Thus, when it comes to capturing uncertainty correctly, the Intuitive Logics approach appears to be the more suitable methodology.

A comparison of the flexibility of the three methods again shows that the Intuitive Logics approach is better. To support this point, Bradfield *et al.* (2005) identify four areas of purpose when using scenarios namely:

- *making sense of a particularly puzzling situation;*
- *developing strategy;*
- *anticipation; and*
- *adaptive organisational learning.*

They argue that the Intuitive Logics approach has been practically proven as useful in all four areas indicated above. Although PMT and La Prosepective should also be theoretically useful in all four areas, practice and literature have shown that its most useful application is in regard to the first two areas. This is because the main aim of both techniques tends to be to determine the most probable evolutionary development of a particular event. As a result, PMT and La Prospective predominantly lend themselves to improving the efficiency of policy and strategy development.

The Intuitive Logics approach captures and links uncertainty to decisions and actions, and is flexible, achieving all four purposes of scenario thinking. As such, the Intuitive Logics approach has become the “gold standard” of corporate scenario generation (S Millet in Bradfield *et al.*, 2005). Therefore, in this thesis, the Intuitive Logics approach to scenario development - as originated by Wack - will be used as the scenario development method to test the hypothesis. An extensive body of literature exists on the Intuitive Logics approach to scenario thinking, including work by Wack himself (1985a & 1985b), Ilbury and Sunter (2003, 2005, 2007), Van Der Heijden (1996), and Scwartz (1991).

3.6 Conclusion and summary

The aim of this chapter was to define uncertainty, describe the link between uncertainty and scenario thinking, and review the different definitions of scenarios and resulting scenario thinking techniques. Consequently, the Intuitive Logics approach to scenario thinking as originally developed by Pierre Wack was selected as the technique to test the hypothesis. Aside from attempting to identify a scenario thinking technique, the chapter described what a scenario is - from the point of view of the Intuitive Logics approach, how it should be set up, and how it should be used. The objective was to resolve the current ambiguity regarding the finite meaning of 'scenario thinking' within agricultural economics. This will hopefully lead to less abuse of the word and concept of scenarios in agricultural economics literature, and and also lead to a clearer distinction between the often confused concepts of impact analysis, sensitivity analysis, parametric analysis, projections and simulations.

Why and how could the conjunctive use of scenario thinking and stochastic modelling assist decision-makers in an increasingly risky and uncertain climate? This question will be answered in the next chapter, chapter four.

CHAPTER 4: Conceptual Framework: Using Scenario Thinking in Conjunction with Stochastic Modelling

"Those who live only by the numbers… have simply replaced the oracles to whom people resorted in ancient times for guidance…. At the same time, we must avoid rejecting numbers when they show more promise of accuracy than intuition and hunch…."
Bernstein, 1998: 336

4.1 Introduction

The environment is ever-changing, and it appears as if the rate of change is increasing. This situation also applies to the food and agricultural sector. Ultimately, more and more decisions have to be made in order to keep up with these changes. As explained in the introductory chapter, the problem is that, due to a faster-changing environment, it becomes increasingly difficult to make successful decisions that will be robust enough in light of increasing levels of risk and uncertainty. The proposed solution to this problem is to follow a decision-making process that has a framework within which both risk and uncertainty are sufficiently captured. In using such a framework, it enables the decision-maker to make decisions that could stand up to these risks and unexpected events.

As indicated in the introductory chapter of this study, the conjunctive application of scenario thinking and stochastic modelling could potentially provide the decision-maker with a process and framework that captures risk and uncertainty more efficiently than just applying stochastic modelling, as is presently done in agricultural economics. Effectively capturing risk and uncertainty should lead to more robust decisions in policy and business strategy, ultimately improving the survival and potential success of policies or business strategies.

The aim of this chapter is to present and discuss the conceptual framework as proposed by this thesis of applying scenario thinking in conjunction with stochastic modelling. The first part of the chapter presents and explains the proposed conceptual framework, and argues how the two fundamentally different techniques could be used in conjunction. The second part of the chapter argues in favour of applying this proposed framework, and shows how its adoption should lead to more robust, better decisions in an increasingly turbulent environment that is fraught with risk and uncertainty. The uniqueness and contribution of the proposed framework presented in this chapter will be highlighted and explained in chapters five and seven.

It should be noted that the uniqueness and hence contribution of this study is not founded in the development of a new Scenario Thinking approach or Stochastic Modelling approach. The contribution is rather founded in proposing and applying a framework within which both techniques (although they fundamentally differ – see chapter two and three) are conjunctively applied without adjusting either of the techniques. This leads to a process whereby the respective strengths of the two techniques, namely, the focus on risk (stochastic modelling) and the focus on uncertainty (scenario thinking), are used to mitigate the weaknesses of each technique, namely the focus on risk (stochastic modelling) and uncertainty (scenario thinking). Understanding this point is critical in understanding the contribution of this study... a decision-maker never knows what to expect - a risky event or an unexpected event. By applying the proposed framework of this study, which combines two complimentary techniques, a much more robust decision-making process and framework is created, especially in light of the potential occurrence of either risky and/or unexpected events. This point is explained in greater detail in ection 4.3.1 of this chapter, and again in chapter 7.

4.2 The proposed conceptual framework

The conceptual framework proposed in this thesis proposes that the intuitive scenario thinking process is simultaneously applied with the stochastic model development and application process. The proposed framework is presented in Figure 4.1 on the next page.

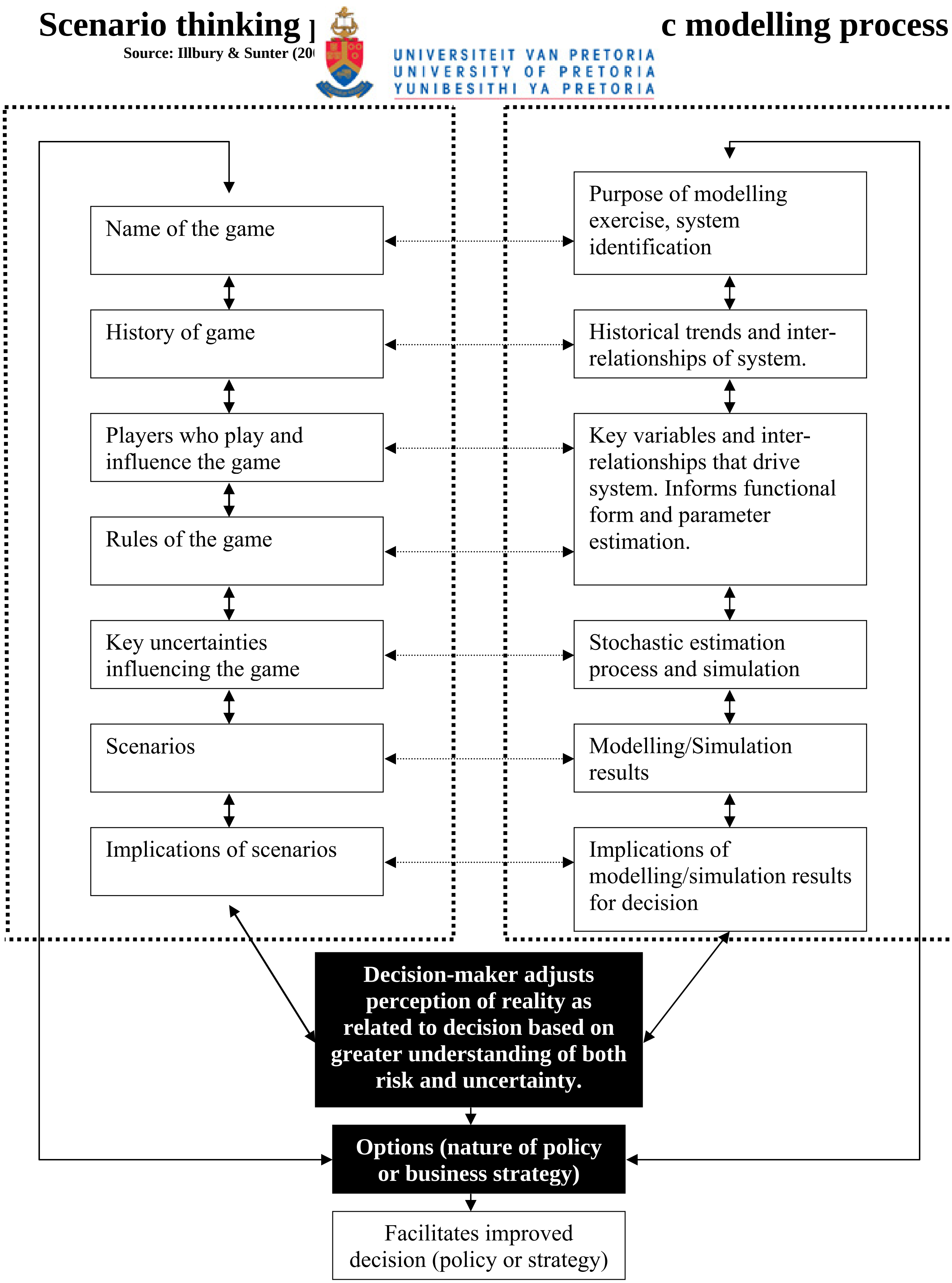

Figure 4.1: The proposed framework for addressing risk and uncertainty

In essence, the proposed framework stipulates that the steps that make up the respective two techniques (intuitive scenario thinking and stochastic model development) are to be applied separately. This ensures that the two fundamentally different techniques are not adjusted or combined, but rather applied separately and technically, in the most correct way. This ensures that the strengths of both techniques are kept part of the decision process, namely, that both risk and uncertainty is analysed and included in a technically correct manner. The result of this is that the implications of both the occurrence of risky events and unexpected events will be contemplated, and hence included in the eventual decision that will be made. This will lead to more robust decisions that are more likely to lead to favourable results in terms of either the policy or business strategy.

The framework thus stipulates that nine different steps are followed in setting up a group of scenarios and applying it, namely: contemplating the name of the game as well as the history of the game; identifying players who play and influence the game; figuring out the rules of the game; identifying key uncertainties that influence the game; setting up the scenarios; deducing implications of scenarios; generating options in terms of either policy or business strategy, and making a decision with respect to which policy or business strategy to implement. Each of these steps was explained in detail in chapter three. Concurrently, while setting up the scenarios, one should set up and apply a stochastic model. This entails the following steps: describing the purpose of the modelling exercise and thereby identifying the system that will be modelled; identifying historical trends and inter-relationships that influence and drive the system; analysing and quantifying key variables and inter-relationships that will drive systems in future; based on the analysis, setting up the mathematical[4] functional forms to use in the model structure; setting up the stochastic simulation process to be followed; running the model; analysing the modelling results and deducing implications from the results; generating options based on implications in terms of policy or business strategy, and lastly, making a decision with respect to which policy or business strategy to implement.

[4] With “mathematical,” both econometric functional forms and mathematical functional forms (in the sense of mathematical economics) are included. The reason for this is that both are essentially mathematical equations that are set up by different techniques, namely, empirical estimation through econometric techniques or mathematical techniques.

Although Figure 4.1 makes use of the scenario thinking process specifically developed by Ilbury and Sunter (2007), it does not imply that only their scenario thinking process can be used in this framework. The reason is that almost all Intuitive Logics scenario thinking processes evolved out of the same process developed by Wack (1985), and therefore essentially consist of the same steps. Hence, the scenario thinking process proposed by Van Der Heijden (1996), Scwartz (1991), and Shell (2003) would also be able to fit into this framework, and be used concurrently with the model development and application process that is presented in this framework.

While following the separate steps as part of each technique, the different steps are linked informally by means of a thinking and communication process that is exercised while executing each step. To elaborate... the scenario thinking process entails a communication process between people that are essentially responsible for taking the final decision on either the policy or business strategy. Hence, an interactive communication process takes place between the people involved in the scenario thinking exercise; whilst communication takes place, the various people also think as a result of the steps that scenario thinking entails. Simultaneously, setting up the model and applying it, also involves a communicative process in the sense that the modeller(s) communicate with the same group of decision makers involved in the scenario thinking exercise in order to better understand the system that is being modelled. During the process of communicating with the decision makers and setting up and applying the model, a thinking process also takes place in the mind of both the modeller(s) and the decision makers. By conjunctively applying scenario thinking and stochastic modelling, two separate communicative and thinking processes take place because of the fundamental difference and focuses of the two techniques. However, these two communicative and thinking processes are linked, as they are applied by the same people. This therefore leads to interaction and hence cross-pollination between the two communicative and thinking processes.

To illustrate the interaction of communication and thinking that takes place when both techniques are conjunctively applied, each of the steps of the respective techniques will now be explained in detail:

To begin, contemplating the name of the game entails thinking and discussing: what the game is all about; what it means to win the game; why the specific institution is part of the game; what the ultimate goal is in terms of the involvement in the game; what the short history of the game is, and what role the institution played in the history of the game. While the name of the game is pondered, the purpose of the modelling exercise as well as the system that will be modelled is also contemplated. This entails thinking and discussing: the purpose of the modelling exercise, and hence what the key output variables and results of the modelling exercise should be; what basic factors need to be included in order to get answers to the key output variables, and hence what factors and inter-relationship limits should be included. This leads to greater clarity and focus in terms of *what* is to be analysed by the model and *why* it needs to be analysed. The same clarity and focus is gained with respect to the scenario thinking exercise by pondering the name of the game. However, the scenario thinking exercise looks at the situation from an individual and strategic perspective with regards to interaction (an almost game theoretic perspective); modelling looks at it from a more objective perspective. Each technique brings a different perspective and thus factors to the table in terms of the 'name of the game' and 'purpose of modelling exercise' step. The different perspectives lead to cross-pollination in the sense that factors that would not have been necessarily pondered during the 'name of the game,' would be pondered in the 'purpose of modelling exercise' step, and vice versa.

The same holds true for the second step i.e. in-depth pondering of the history of the game whilst pondering and analysing the historical trends and inter-relationships relevant to the system that will be modelled. While conversing about the history of the game, the modeller will be able to develop a better understanding of what the key factors and inter-relationships are that have driven the system in the past. Hence, it would indicate to the modeller what data will be needed (and on which factors) in order to model the system.

The opposite is also true in the sense that, by analysing historical data on factors that are believed to have driven the system under study, greater clarity will be obtained about the history of the game and which factors played a part in creating that history.

The third and fourth steps of the scenario thinking process can occur simultaneously with the third step of the stochastic modelling process. This implies that the players in the game (as well as the rules of the game), are contemplated simultaneously, while key variables and inter-relationships are analysed and quantified in order to construct the functional forms of the various equations that will make up the model. One also considers inter-relationships through parameter estimates, and therefore functional forms, and cross-pollination takes place. In this case, cross-pollination means that while pondering the rules of the game (how they work and affect the game), a thinking process is facilitated on how the different equations in the model need to be set up and linked, and how the model could be closed in order to create a simultaneous modelling system. The opposite is of course also true in the sense that the functional form and linking of the equations will facilitate the thinking process on: what the rules of the game are; how they work, and how they govern the way the game is played. Along with the rules of the game, the thinking about the players of the game will assist in understanding how each player's behaviour could or would influence the game, therefore it provides guidance to the modeller on how to set up the equations in order to capture the various players' behaviour and the impact this has on the system being modelled. This therefore assists the modeller to not only capture abstract factors in the model, but also the behaviour of economic agents. Hence, the model is likely to represent the system more realistically and capture the salient features of the real world, which in turn improves the accuracy and reliability of the model. This makes the model more valuable in terms of using it to conduct analysis of the system.

After thinking about the players and rules of the game, one thinks about the key uncertainties that could significantly and unexpectedly influence the outcome of the game. During this step in the scenario development process, the focus is not on what is probable, but rather on what is possible and plausible. The line of thinking therefore moves away from probabilities, and rather focusses on understanding what is possible and plausible. This therefore leads to the identification of unexpected potential events, and helps the decision-maker to think about the "unthinkable" rather than the "probable." The decision-maker can therefore better understand the uncertainties in the system. Concurrent to this step, is the step of setting up the stochastic process that will be followed in the model. In this step, the focus is on what is probable, and thinking revolves around probabilities, not possibilities or plausible events. By focusing on probabilities, the decision-maker develops a better understanding of risk.

In following these two steps, namely "key uncertainties" and "setting up stochastic process," a clear distinction takes place within the framework. On the one hand uncertainty is contemplated and analysed, and on the other, risk. By simultaneously following two fundamentally different steps, the decision-maker develops a clearer picture on what is probable (i.e. risk) and what is possible and plausible but not necessarily probable (i.e. uncertainty.) The cross-pollination that takes place during this step, is therefore not a convergence of thinking in terms of structuring the scenarios and setting up the model. Rather it is one of divergent thinking, resulting in multi-hypotheses that take into account both risk and uncertainty simultaneously in a technically sound manner. The divergence in thinking is the crux of using this proposed framework, since it provides a decision-making process that facilitates simultaneous and technically correct thinking on the issues of both risk and uncertainty. It therefore offers a solution to mitigating the weaknesses of the two individual techniques by applying the strengths of each technique simultaneously. By mitigating the weaknesses, the robustness of the decision-making process is improved, and hence the diminished possibility of making a decision that will not be robust enough to withstand the onslaught of either a risky or unexpected event. The conjunctive application of these two steps therefore coerces the decision-maker into thinking about events that might be both expected and unexpected, and hence leads the decision-maker to develop options that can deal with both situations. The importance of this point will be explained in greater detail in the next section.

After identifying and describing the key uncertainties, as well as setting up the stochastic process, the actual set of scenarios is set up and the model is used to simulate the system. From the set of scenarios that do not include any form of probabilities, but do include unexpected events and hence uncertainty - and from the modelling results that do include probabilities and therefore risk - the decision-maker can now separately infer things and compare both sets of results. This provides a platform for the decision-maker to compare implications based on uncertainty (and hence the possible occurrence of unexpected events) with implications based on risk and hence expected events. By doing this, the decision-maker develops a better idea and perception of what is possible, what is probable, and what uncertainties and risks exist. Again, it provides the decision-maker with alternative and divergent outcomes based on fundamentally different assumptions, namely, when uncertainty is present and when risk is present.

Following the generation and comparison of implications, a considered policy or business strategy can be drawn up that is better aligned to achieving its goals. At this point one knows what the goal of the policy or business strategy is, and what the potential implications of risk and uncertainty are. The question is: what will be the right thing to do to reach that goal? By following this proposed framework, the implications of both the occurrence of risky and unexpected events will be understood much better. This facilitates a process whereby options, in terms of either policy or business strategy, are generated that do include the implications of both risk and uncertainty. This implies that the options that are generated will be robust, since options will be generated with the ability to handle both uncertainty and risk. Hence, the possibility of generating options that will lead to negative results in the case of either expected or unexpected events will be lessened, since the options will include thinking on both unexpected and expected events and implications.

An option that appears to be robust enough to handle both risky and unexpected events can now be selected, and hence a decision can be made on what to do. This therefore leads the decision-maker to make a much more robust decision on either policy or business strategy, and furthers the possibility of being successful, regardless of whether expected or unexpected events occur.

Hence, in the framework, each of these processes is followed separately, and therefore should provide implications in line with the underlying thinking, assumptions, and logic of each of the two techniques. However, when generating policy, business strategy ideals and making an eventual decision, only one process is followed. This means that the implications flowing from the two separate techniques are included simultaneously, but only the most robust and favourable option in terms of either policy or business strategy is eventually selected and implemented.

The proposed framework of this study does indicate that although the two techniques are fundamentally different in their logic and application, conjunctively using the two techniques should simultaneously inform the decision-maker about the risk and uncertainty in a given decision situation. Better insight about current and potential future realities should lead to the generation of more robust options in the presence of both risk and uncertainty, and therefore lead to more robust decisions and a better chance of reaching the enterprise's goals.

4.3 Why will this framework lead to better decisions?

4.3.1 Normality (risk) and abnormality (uncertainty)

Distinguishing between normal and abnormal events is a problem that people have grappled with ever since they began thinking in terms of risk and uncertainty. Decision-making must take these concepts into account. This is vividly discussed by Bernstein (1998) and various other authors such as Valsamakis *et al.,* Hardaker *et al.*, Ilbury & Sunter, Wack, and Khan.

When reviewing the literature on risk and uncertainty, especially the history of risk analysis, it is clear that since the 1700s people knew that the better one could understand causality and patterns, the easier it would be to forecast potential future events. Now, a clear distinction can be made between what is known and what is not known about the future, and the decision-maker can form a picture of potential occurrences of events and hence potential consequences. Also, by understanding what is normal, or what is known, a better understanding can be developed about the abnormal or unknown. Through better understanding of both the normal and the abnormal, better decisions can be made.

'Normal,' by virtue of being 'normal,' implies statistical dominance. This is of course the foundation of the normal distribution and regression to the mean. Hence, by using this assumption, it becomes easier to base decisions on the 'normal' rather than the 'abnormal,' since the norm is statistically more likely to play out. This leads to greater reliance on methods that analyse and present the norm in such a way that decisions can be based on the results. Greater reliance on such methods tend to work quite well, since the future is often like the past and present, and hence the probability that normal conditions will reign is rather good. This point is reiterated by Wack (1985a: 73) when he writes that forecasts (or simulation) often work because they are based on the assumption that the future is like the past and present. Simply, it works because the world doesn't change that often.

However, during some periods in time, for example the 1930s, the 1970s, and again while writing this thesis, the environment does go through rapid and unexpected changes caused by discontinuities, such as those described in chapter three. The result is that normality ceases, and abnormality becomes the norm until systems have established a new balance through newly formed inter-relationships.

The challenge for a decision-maker in such a situation is then to have the ability to distinguish between normal events, once-off deviations from normality, and abnormal events due to permanent breaks from the historical norm. This can only be achieved by using the correct combination of methods. The decision-maker's perceptions of 'normal' and 'abnormal' should be guided by using methods that are strong but flexible. The methods must distinguish risk and uncertainty and their respective implications, given the decision situation. The framework presented in the previous section provides such an approach and tool to decision-makers involved in the agricultural sector.

The argument supporting this idea is that, by using stochastic simulation in conjunction with scenario thinking, it becomes possible to simultaneously distinguish between normal and abnormal, or risk and uncertainty. Stochastic simulation is based on the assumption that the future is like the past and present. Hence, in situations where events are normal or once-off deviations from the norm, the technique of stochastic simulation, if used correctly, should guide the decision-maker in determining whether events are normal or once-off. This is because stochastic simulation clearly analyses the underlying causalities and driving forces.

In the situation where abnormal events begin to occur, scenario thinking offers the framework for the decision-maker to interpret these abnormal events. By using the set of scenarios that result from the scenario thinking process, the decision-maker starts to understand that events are deviating from what was previously deemed normal. Hence, the decision-maker is in a position to proactively analyse and understand: what the causes of abnormal events are; where these abnormal events are leading to, and what the potential consequences could be in terms of a 'new' normality. This is done by means of structuring a scenario, and by using a set of scenarios that is coherent and logical - without assigning any probabilities to the occurrence of each of the scenarios. By using the set of scenarios that clearly stipulate different plausible causality structures, the decision-maker is in a position to test reality against the different plausible causality structures. The decision-maker can then deduce which causality structure (or combination of causality structures) is forming or playing out during abnormal events. Hence, the decision-maker can compare the historic causality structure - using data from personal experience and from the stochastic model - with the causality structure that is being formed. This will help in understanding what the abnormal changes really are, as well as what the level of risk and uncertainty is in this newly formed causality structure. This then helps the decision-maker to understand potential future occurrences of events, potential consequences of the respective events, and therefore which decision will be the most robust, and most likely to yield wanted outcomes, regardless of whether expected or unexpected events occur.

By using both techniques, one can simultaneously analyse and understand both normal and abnormal, or risk and uncertainty. This is done by working with two hypotheses, namely, that the future is like the past and present, and that the future is NOT like the past or the present. Thus, multi-hypotheses are used in the decision-making process, and through time and by following a critical thinking process such as that developed by Socrates, a decision-maker can eventually discard one of the hypotheses that does not appear relevant.

4.3.2 A more complete cognitive developmental process

Apart from the above argument on why conjunctively using the two techniques should lead to better decisions, there is another valid argument - the use of the two different techniques implies the simultaneous use of two different cognitive processes. Following two different cognitive developmental processes should lead to a more complete learning process as well as a better understanding of both the normal and the abnormal, or risk and uncertainty, and how it links up with the decision.

Shell (2003) argues that when individuals or organisations make decisions, it is done using mental maps. A mental map visually represents a person or organisation’s perception of reality within its relevant context. A mental map therefore includes perceptions on inter-relationships between elements, and therefore causality. The moment a mental map is compared to reality, people often realise that parts of their mental map are either incomplete, or that perceptions about inter-relationships and causality are incorrect. This then leads to adjusting the mental map so that it better represents reality. This leads to a learning process, which in turn leads to further adjustment, in terms of how to react to changes in the environment. Adjusting to changes in the environment improves the chances of an individual or organisation's likelihood to survive and grow. This is also applicable to both policy development and business decisions.

The understanding of the cognitive developmental process that take place when developing a set of scenarios is tied to understanding the technicalities of second generation scenarios, as termed by Wack. The technicalities of second generation scenarios derives from the philosophy that the scenarios deal with the perceptions and judgement of the decision-maker (Wack, 1985b: 140). Wack indicates that the process of scenario thinking, by definition, deals with trends and events outside the microcosm of the decision-maker e.g. supply, demand, prices etc. However, according to Wack, this is only part of the scenario thinking process as these scenarios have to come alive in the microcosm of the decision-maker in order to have any influence on his or her mental model or perception of reality. Wack believes that the world of scenarios must deal with both the world of fact and the world of perception if they are to have any positive impact on decision-making.

Van Der Heijden (1996) along with Ilbury *et al.* (2003) build on Wack's argument about how scenarios and scenario thinking deal with the world of perception, and instead argue that scenarios and the process of scenario building, specifically the Intuitive Logics approach, serves as a foundation of learning or cognitive development. Wack (1985a: 74) states that the development of scenarios is not mechanistic but organic, therefore, whatever is learnt from the previous step in the organic process takes one to the next step, which keeps the learning process going. They argue that underlying the process of developing scenarios, is a learning or cognitive developmental process that effectively changes the mental model of the decision-maker (Wack, 1985). The mental model of a decision-maker is defined as the way in which a decision-maker perceives reality. Thus, based on their arguments, the purpose of scenarios is to be a learning or cognitive developmental tool that assists decision-makers in re-perceiving reality.

Van Der Heijden (1997) specifically refers to the theory of cognitive development proposed by Vygotsky as the learning process underpinning scenario thinking. Researchers other than Vygotsky, namely Piaget and Brenner, also put forward theories on cognitive development or learning. Vygotsky argued that cognitive development takes place through formal instruction via language (Nelson, 1996: 227). Piaget’s theory, on the other hand, proposed that cognitive development takes place through an organic process whereby a person learns by building on previous ideas and concepts (Inhelder & Piaget, 1958: 272-281). Piaget's theory links up to Wack's argument, which explains that the process and purpose of scenario thinking is organic (Wack, 1985a: 74). Since the

Intuitive Logics approach to scenario development, as explained in the literature, consists of mainly intuition, logic, and creativity, one can argue that scenario development and thinking depends to a lesser extent on instruction and to a greater extent on an organic process of cognitive development. Although scenario thinking is based on both an organic and instructional cognitive developmental process, the underlying process is organic to a larger extent than an instructional process.

The same argument can be raised regarding cognitive development with stochastic simulation modelling. Judge, Day, Johnson, Rausser & Martin (1977: 166, 167) argue that models are used to describe, explain, predict, and assist with decisions pertaining to a specific situation. They argue that by using models to describe and explain a system or environment, understanding is gained about how the system works as well as the causality directions and magnitudes that exist within the system. One can therefore argue that modelling also has a learning or cognitive developmental process that assists decision- makers in perceiving reality, in changing their mental models and ultimately improving their decision-making capabilities. It can be assumed that the underlying cognitive developmental process of modelling is closer to the theory postulated by Vygotsky. Modelling essentially entails analysis of data and combining of different factors in modelling techniques that are guided by 'instructions' from modelling and statistical theory. Thus, it can be argued that modelling - although comprising both organic and instructional cognitive developmental processes - is based on an instructional process to a larger extent than on an organic process, as proposed by Piaget.

Therefore, by using the two techniques in conjunction by means of the proposed framework, two fundamentally different cognitive developmental processes are followed, implying that this total cognitive developmental process is more complete. This implies a more complete learning process, which implies a more complete and realistic mental model, which is likely to lead to better decisions in the face of increasing risk and uncertainty.

4.4 Conclusion and summary

This chapter presents and explains the conceptual framework in terms of how scenario thinking and stochastic modelling can be conjunctively used in order to improve policy and strategic decision-making in an increasingly turbulent environment. In essence, the proposed framework stipulates that the application of the two techniques (intuitive scenario thinking and stochastic model development) is followed separately from each other in terms of each of the steps that make up the respective techniques. This ensures that the two fundamentally different techniques are not adjusted or combined, but rather applied separately, to ensure that the strengths of both techniques are kept part of the decision process. In other words, both risk and uncertainty is analysed and included in a technically correct manner. The implications is therefore that both the occurrence of risky events and unexpected events will be pondered simultaneously, and therefore included in the eventual decision, leading to more robust, beneficial policy or business strategy decisions. Hence, risk and uncertainty will be contemplated in conjunction when developing policy or business strategy.

The chapter then explains why using stochastic simulation in conjunction with scenario thinking could assist good decision-making, even in an increasingly turbulent agricultural environment, fraught with increasing levels of risk and uncertainty. The motivation is based on two arguments.

The first argument states that by combining and using both techniques, it provides the decision-maker with the tools to distinguish between normal events and abnormal events, or between risk and uncertainty. Hence, it is argued that by using both methods in conjunction, risk and uncertainty (or the normal versus the abnormal), is captured more completely than by just using each technique on its own. It therefore implies that the decision-maker has a more complete understanding of the realities, potential events, and potential consequences faced. A more complete understanding leads to a more accurate perception of reality, and hence should lead to improved decision-making.

The second argument states that two fundamentally different cognitive developmental processes are followed by using stochastic simulation and scenario thinking. The total cognitive developmental process is therefore more complete, and therefore leads the decision-maker to a more complete understanding of risk and uncertainty, or normality versus abnormality. A more complete understanding of this aspect leads to perceptions that more accurately reflect reality, and ultimately, to better decisions.

The next two chapters aim to illustrate the practical application of the framework proposed in this study, and test whether the application of the framework does indeed lead to better decisions in the face of risk and uncertainty, compared to just using stochastic modelling.

CHAPTER 5: Illustrating past application of the proposed framework with two case studies

5.1 Introduction

With reference to chapter one (which presents the hypothesis of this thesis), the objective is to test whether stochastic modelling versus conjunctively using scenario thinking and stochastic modelling, as proposed through the framework presented in chapter four, more sufficiently captures the relevant risks and uncertainties in an increasingly turbulent environment. To be able to test for sufficiency in order to lead to either a rejection or non-rejection of the hypothesis, the test needs to consist of two steps to shed light on two key issues: **firstly**, the test results need to show whether the application of the framework did indeed lead to **good decisions,** given the context within which the decisions were made and given the eventual market outcome; **secondly,** the test needs to indicate whether the **decisions** made based on the application of the proposed framework of this thesis, were in fact **better** compared to decisions made using only a stochastic modelling exercise to guide the decision-making.

In order to administer the first step of the test, three case studies are presented — two in this chapter and one in the next chapter. In each case study, the framework as proposed in chapter four, was applied in co-operation with the specific agribusiness to which the case study was relevant, in order to assist the business in making a strategic decision. The purpose of presenting the three case studies is to show how using the proposed framework assisted each of the three agribusinesses in understanding the prevailing risks and uncertainties at the time of making their decisions. This will indicate whether the application of the framework helped them to make **good decisions** given their respective external contexts, internal situations, as well as the eventual market outcome. Important to note is that administering the test by presenting the case studies, does not entail an exercise to attempt to prove the success of the proposed framework "in hindsight." It rather provides proof, through factual support gathered from reports written at the time the work was done for the different agribusinesses[5], that shows the application of the proposed framework did result in good decisions in real-time.

Executing the second step is a bit more complicated and tricky in terms of testing whether the application of the proposed framework did in fact lead to **better decisions** compared to a situation in which only a stochastic modelling exercise would have been used to guide decision-makers. To execute this step, ideally, the decisions that resulted from applying the framework should be compared to decisions that resulted from using only stochastic modelling to guide the decisions that had to be made. The problem, however, is that no stochastic modelling exercise was done on its own without also having conjunctively applied scenario thinking, since the agribusinesses were more interested in getting answers to make critical decisions as quickly as possible, than in an academic exercise testing a framework and comparing it's success with another technique. Hence, no decisions based only on stochastic modelling exist to compare with the decisions that were in fact made based on the application of the proposed framework.

As a result, to administer the comparison of whether the application of the framework or whether a stochastic modelling exercise on its own would have led to better decisions, a "back-in-time" exercise is done in order to "reconstruct" the decision context at the time when the three agribusinesses had to make their decisions. This reconstruction process is based on information gathered from the reports presented in the appendices in order to ensure it is objective and factually correct. Using this reconstructed context, a stochastic modelling exercise is done for each of the agribusinesses by following the correct process in terms of conducting a stochastic modelling exercise. Based on the stochastic modelling exercise, it is deduced what the decisions would likely have been given the stochastic modelling results and decision context. By taking these deduced decisions and comparing it to the decisions that were made based on the application of the framework, it is possible to obtain an answer for which approach would have resulted in better decisions – the proposed framework or stochastic modelling on its own.

[5] The reports are available in the appendices

Presenting the results of the three case studies in order to reach the objective of this thesis, therefore poses several significant challenges. Firstly, the reader can argue that it is an "in hindsight" exercise, because the presentation of the case studies is based on reports written for the agribusinesses at the time of applying the framework. However, using the reports serves to show that the application of the framework did in fact alter decisions in real-time and led to good decisions in real-time. Secondly, to present the results in an accurate but concise and understandable format, the "stories" of each case study need to be told as realistically as possible. This implies that the "human" factor is included in terms of perceptions and emotions on the side of the respective decision-makers, as these factors influence the eventual decisions that are made by the various agribusinesses. However, to prevent the stories from becoming a "one-sided" affair, the reports that were written for the three agribusinesses as a result of using the framework proposed in this thesis, are used as the basis from which the stories are told. The reports are available in the appendices.

Apart from the dimension of preventing the story-telling from becoming an "in hindsight" and "one-sided affair," several other dimensions exist regarding the presentation of the three case studies, especially the fact that each case study occurred at a different point in time. Firstly, in terms of applying the framework, lessons were learnt from previous experience with each case study and hence led to slight changes in the way the framework was applied after each case study. These changes were made in order to add more value to the next agribusinesses in terms of the decisions they had to make. This implies that the focus was different in each case study with regards to different elements of the framework, which impacted on the results. The reason for the change in focus with respect to the different elements of the framework, is because it was realised that as a result of decision-makers' unique business situation and perceptions with respect to risk and uncertainty, they tended to put more weight on some elements of the framework and hence spent more time discussing those specific elements and in greater detail. This led to different results, even though the external market situation was the same as with case studies one and two.

A second dimension related to applying the framework that is quite evident from the case studies, is the learning process and resulting change in perceptions that takes place in the minds of the decision-makers due to the different cognitive developmental processes followed during the application of the framework. The changes in perceptions are manifested in each case study by the realisation that the eventual market outcome could be significantly different from what the decision-makers initially expected it to be, due to the potential interaction and occurrence of both risky and unexpected events. These cognitive developmental processes were already explained in chapter four, specifically section 4.3.2.

Taking account and including the different cognitive developmental processes is important because it provides the foundation of the argument of this thesis, by linking scenario thinking to stochastic modelling. Since the two techniques are fundamentally different both in terms of logic and the underlying cognitive developmental process followed by each, the only way to link the two techniques is by using the two different cognitive developmental processes of each technique in a synergistic way, thereby assisting the decision-maker in understanding reality both in terms of risk and uncertainty. Hence, the synergistic platform provided by the two cognitive developmental processes, provides the opportunity to link the two fundamentally different techniques in an informal way, without combining the two techniques. Due to this argument, it therefore implies that the two techniques can’t be combined, as they are fundamentally different in terms of logic, mechanics, and results. The major contribution of this thesis is found in this implication. Current thinking both within scenario thinking and stochastic modelling either argues that the two techniques should be combined, or that the two techniques can’t be used at the same time at all! This thesis argues and proposes a framework that shows that the two techniques can’t be combined, but can be used simultaneously and in a synergistic way, based on the synergies that exist between the different cognitive developmental processes underlying the two techniques. Hence, understanding the different cognitive developmental processes and why it needs to be followed as proposed in the framework, therefore explains why scenario thinking and stochastic modelling can't be combined, but can only be followed in conjunction and hence linked in an informal manner.

To summarize: The purpose of this chapter and the next is to present three case studies of companies which applied the proposed framework as presented in chapter four. The objective of presenting these case studies is to test, through comparison, whether the application of only the multi-market stochastic model versus the application of the proposed framework (as presented in chapter four), captures risk and uncertainty more sufficiently. This is done to determine if the application of the framework does in fact facilitate good and better decisions as opposed to when only applying a stochastic model.

5.2 How the framework came about

As indicated in the introduction of this chapter, one of the dimensions that the reader needs to take cognisance of when reading this chapter is the fact that the proposed framework (as applied in this chapter) was not developed in one day. In order to create a better understanding on why and how the initial development and consequent improvement of the framework with respect to its application occurred, the following historical perspective is provided. Apart from providing a better understanding with respect to how the framework presented in chapter four came about, it will also assist the reader in understanding one of the dimensions in terms of the case studies which ultimately caused a difference in the results between the case studies, namely, the dimension of learning how to apply the framework.

In 1998 it was realised that, given the structural changes that occurred at that stage in the South African agricultural marketing environment, the agricultural sector's exposure to international markets would increase significantly. As a result, a need was identified with respect to policy decisions, whereby a tool or set of tools would be needed in order to analyse the impact of changes in international and domestic markets and policies on local agricultural industries and firms, as they are significantly exposed to the variability and uncertainty of international markets. Consequently, contact was made with the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri, and in 2002 a researcher at the University of Pretoria, Ferdinand Meyer, visited FAPRI for a period of six months, during which time he developed a partial equilibrium model for the South African wheat sector based on the methodology of FAPRI.

In 2003, the selection of models was expanded, improved, and regularly applied, especially with respect to the analysis of commodity markets for private sector institutions. However, through time and through using these models, it was realised that the models did not capture the risks and uncertainties sufficiently enough pertaining to the international and domestic market situation, given the specific needs of the private sector institutions. As a result, the idea emanated of incorporating scenario thinking into the framework of analysing markets and communicating risk and uncertainty to decision-makers. Hence, the basic framework of what is now presented in chapter four was born.

Consequently, the framework was developed and improved, and during 2005 two opportunities came about in terms of applying the framework. As a result, work was done for the pork company (case study one) and the farmer co-operative (case study two). The work for the pork company was done during April and October 2005, while the work for the farmer co-operative was done in September 2005. After conducting the analysis and applying the framework for these two companies, it was realised that several shortcomings existed with respect to knowledge regarding scenario thinking and stochastic modelling, and as a result, an intensive process followed to obtain better training and understanding of each of the two techniques. Consequently, the focus and depth of analysis and discussion with respect to each of the steps of scenario thinking and stochastic modelling, changed compared to what was done with the pork company and the farmer co-operative. Consequently, the work for the commercial bank (case study three) was conducted in February and April of 2008.

Therefore, although the framework did remain the same since 2005, the focus and depth in terms of each of the elements changed and improved over time, as experience was gained on the conjunctive application of scenario thinking and stochastic modelling proposed by this thesis. Hence, when reading the case studies presented in this chapter, the reader will become aware that the structure, depth and breadth of the eventual scenario and stochastic modelling results changed over time when comparing the three case studies. This is important to note, since it implies that there is a learning process involved in terms of the person applying the framework. This learning process will lead to different results over time as people get to understand the two different techniques and the framework better, and hence begin to understand how to conjunctively apply them more accurately in order to obtain better results in terms of understanding risk and uncertainty and therefore make better decisions.

5.3 A troubled pork company: Case study one

5.3.1 Background

Case study one is about a company involved in the pork supply chain in the South African market. The company processes pork meat, and procures the meat by means of contractual agreements with selected pig producers. These contractual agreements are renegotiated on an annual basis or as needed, should market conditions change dramatically. The contractual agreement between the company and the producer stipulates the quantity, quality, time, and price at which the company will buy the pigs from the pig producer one year in advance. Interestingly, the pig producers have shares in the company, which creates incentives for the pig producers to ensure that the company is profitable and sustainable, by means of providing pork meat at a competitive price to the company. This can only be done if the pigs are produced as cheaply as possible, ensuring that the pigs are bought by the company from the producers at the lowest possible price.

Since feed costs make up an estimated 65% of pig production costs (BFAP, 2005b), it is one of the key factors to manage to ensure that pigs are produced as cheaply as possible. Yellow maize is the key ingredient in pig feed, therefore, to manage feed costs it is critical to manage the costs at which yellow maize is bought. However, since the pork company and the pig producers operate their businesses independently, it is not possible for the company to play a direct role in managing feed costs in terms of the producers' businesses. Therefore, the only way for the company to "manage" increasing feed costs, is by hedging against rising yellow maize prices independently of the pig producers. This will ensure that the pork company can offset increasing pig prices due to increasing feed costs, by means of profits made through hedging against increasing yellow maize prices.

5.3.2 Application of the framework

As discussed in the introduction of this chapter, testing the hypothesis entails two steps, the first of which is to test whether the application of the proposed framework of this thesis led the pork company to make good decisions with respect to hedging against an increase in the yellow maize price. Hence, the aim of this section is to present the process, eventual results and decisions whereby the proposed framework was applied in collaboration with the pork company. The aim of presenting this is to show that the application of the framework did indeed assist the pork company in making good decisions with respect to hedging the yellow maize price one year ahead, specifically with respect to the 2005/06 maize season. Writings in this section are based on two reports, available in Appendix A, which were written at the time the maize hedging decision had to be made.

Two meetings were held with the pork company at their headquarters in South Africa. The first meeting was held on the 18th of April 2005, while the second meeting was held on the 27th and 28th of October 2005. During the first meeting, the initial perceptions of the CEO were tested in terms of his expectations regarding the expected market outcome, and hence the decision that needed to be made with respect to hedging yellow maize for the 2005/06 season. After this discussion, the framework was applied and basic results were compiled and presented to the CEO of the pork company. During the second meeting in October 2005, the process and results of the April 2005 meeting were revisited, updated and improved, after which final results were presented to the CEO of the pork company. Following the presentation, the CEO realised that, although his initial expectations as well as general expectations in the market were that maize prices would stay low for another season, the results from the application of the framework indicated that the possibility did indeed exist for yellow maize prices to increase unexpectedly and significantly within the season lying ahead. After examining these results from the application of the framework and based on the insights gained from applying the framework, the CEO decided to hedge yellow maize on SAFEX against a possible significant increase in yellow maize prices.

The practical process of applying the framework in collaboration with the CEO of the pork company follows (as presented in Figure 4.1, chapter four). During the morning of the first meeting on April 18th, the initial perceptions of the CEO were tested in order to gather what his initial expectations were in terms of the potential market outcome. Following this conversation, a discussion was started with the purpose of identifying the name of the game (step 1 of the scenario thinking process) and understanding the history of the game (step 2 of the scenario thinking process) from the CEO's perspective. During this conversation, the CEO first explained the company's business model, in the sense that it procures pork from specific pork producers via procurement contracts, but at the same time the pork producers are shareholders in the pork company. He also explained the dilemma of having to negotiate a future pork price with the pork producers, without being able to actively manage feed costs in order to mitigate the risk of increasing pork prices due to increasing feed costs. He explained too that if it were possible to actively hedge against rising feed costs, it would be possible for the pork company to be more competitive at retail level, since the company could use the profits of the hedging exercise to pay a competitive price to its pork producers without having to immediately increase its pork prices at retail level. This would provide the company a competitive edge. Hence, in summary, he indicated that the "name of the game" (in terms of the purpose of playing it) was all about understanding the relationship between maize and pork prices, and actively managing this relationship in order to profit from relative movements between the two products. Finishing the discussion on the name of the game, he continued to explain, based on his experience, the history of the game in terms of linking pork prices and feed costs, and as a result, the link between the maize and pork price both at farm level and retail level. He was, however, not able to quantify this relationship in terms of correlations or any other quantitative measure.

Here it is important to note that the conversations on the name and history of the game provided the modelling exercise with enough background and insight in terms of what exactly the goals and needs of the company were, and therefore what the variables and inter-relationships were in terms of the maize-pork market system that the CEO wanted to have analysed and debated in order to make a good hedging decision.

Following the discussion on the name of the game and history of the game, the question was posed to him as to who the players in the game were and how could they potentially influence the game. Answering the question, he explained the various competitors' market share of the pork industry, their business models, and therefore their resulting strengths and weaknesses. Based on this information, he then explained how each of these players could potentially influence the outcome of the game under different market conditions, given their respective strategies. According to the CEO, the poultry and beef industries were also seen as major players in the pork market. Due to the substitutability of pork, poultry and beef, and hence the competition between these products, he highlighted the relationship between pork, beef, and poultry at retail level, based on his own experience. He was, however, not able to express the relationships in terms of elasticities or any other quantitative measures. He highlighted that policy makers are key players in terms of their formulation of policies — specifically with regards to the production of ethanol from maize. He was concerned about policy makers as players, because if policies were designed in such a way that significant amounts of maize would be used to produce ethanol, it would mean increased competition for maize with regard to demand, which would result in higher maize prices and therefore higher pork prices. Exporters of South African maize were also seen as key players by the CEO, since above-average exports could possibly lead to a decrease in stocks and therefore an increase in maize prices. Other players that he highlighted were big producers, especially as they can hold maize stocks for long periods, which could also influence maize prices if all of them dumped their maize stocks at the same time in the market.

After discussing the players of the game, and hence gaining a better understanding of who could shift the market outcome in what way, the rules of the game were discussed. During this part of the discussion two key rules were discussed: firstly, the importance of rainfall during planting time as well as during the pollination stage of maize, as it influences the maize area planted as well as maize yield; secondly, the relationship between the exchange rate and domestic maize prices as a result of export, imports, and the domestic supply and demand situation. As stated earlier, the South African maize industry is relatively small and is open to the global maize market, which essentially implies that the South African maize market is integrated with the global maize market to varying degrees, depending on the local supply and demand situation. Given the second rule, the following rules thought to influence the exchange rate, were discussed in detail, namely: the interest rate differential between South Africa and other countries, the US$ and € exchange rate relationship, the price of gold, as well as investor perceptions of South Africa (specifically with respect to political stability). Another key rule of the game highlighted during this discussion was the beef import/export relationship between South Africa, Botswana and Namibia, which in turn influenced domestic beef prices, and hence pork prices due to the substitutability between the two products. Again, it is important to note here that during the discussion on the rules of the game, it was not possible for the CEO to express these relationships in any quantitative measure.

Based on the discussions of the name of the game, the history of the game, players of the game, as well as the rules of the game, the 5^{th} step of the scenario thinking process was executed. This entailed identifying and discussing the key uncertainties as identified through the previous discussions as part of the previous steps. Five factors were identified as key uncertainties that could potentially and unexpectedly influence the yellow maize industry, and therefore price, to such an extent that a totally different market outcome could be realised as opposed to what was generally expected at that stage in the market and by the CEO himself. These five factors were: unexpected variability in the exchange rate due to unexpected macro-economic and political events; lower beef prices due to higher imports which could influence pork and poultry prices and hence the demand for yellow maize for feed; unexpected changes in ending stocks as a result of unexpected high levels of yellow maize exports to other African countries; a dramatic change in area planted with yellow maize due to rainfall variability during planting time, and the introduction of ethanol production from maize that could result in significant additional demand for maize and hence an increase in maize prices.

After debating each of these key uncertainties in depth, and relating them back to the step of where it fits into the scenario thinking process and how it links to the other steps of the scenario process, variability in area planted was viewed as the key uncertainty in terms of the 2005/06 season. Hence, the focus turned to developing scenarios around this factor in terms of its implications for the outcome of the market. It was felt that variability in rainfall during planting time could result in significant variations in areas planted, resulting in different production levels, and therefore different possible yellow maize prices. As a result, three scenarios were developed whereby macro-economic assumptions were kept similar, but the area planted with yellow and white maize was adjusted. The three scenarios were as follows:

Scenario 1: "Import parity"
In this scenario it was postulated that only 500 000 ha of white maize and 500 000 ha of yellow maize are planted. This assumption was made on the basis of below-normal rainfall during planting time with respect to the 2005/06 maize season.

Scenario 2: "Autarky"
With this scenario, a situation was sketched whereby 1.21 million ha of white maize and 895 000 ha of yellow maize are planted, based on a situation whereby rainfall during planting time was assumed to be close to long-term average levels.

Scenario 3: "Export parity"
This scenario presented a situation whereby 1.8 million ha of white maize and 1.2 million ha of yellow maize are planted due to above-average rainfall during planting time.

Having the set of scenarios describing the potential different market milieus that can be faced with respect to yellow maize, the model of Meyer *et al.* (2006) was used to quantify the three scenarios but without including any probabilities (to ensure uncertainty is included in a technically correct manner). Each scenario was simulated separately by assuming the levels for the various variables included in the model as stipulated through the three scenarios. Hence, the scenarios were quantified, and the result was that a deterministic yellow maize price was obtained for each scenario.

Following the scenario thinking process, the stochastic modelling process was followed as stipulated by the framework and as presented in Figure 4.1 of chapter four. The model of Meyer *et al.* (2006) was applied, with the aim of simulating a probability distribution of the yellow maize price for the 2005/06 maize season so as to compare these results to the scenario thinking results in terms of the deterministic yellow maize prices for each scenario. In the first step, the system that needed to be simulated was identified based on the insights gained from the conversation of the "name of the game" that formed part of the scenario thinking process. Hence, the discussion on the name of the game informed and facilitated the process of initially identifying the variables and system that needed to be simulated by means of the stochastic model.

In the second step, through understanding the factors and system that needed to be modelled, it was fairly easy to identify which variables needed to be included in the modelling exercise, and therefore which historical trends of which variables needed to be scrutinized in order to understand the historical trends and inter-relationships of the system that had to be modelled. This assisted in terms of beginning to develop some idea of the quantified history of the game. Hence, although the CEO was able to supply some perspective on the history of the game, he was not able to express this history in terms of numbers. Therefore, by means of applying the "history of the game" step as part of the scenario thinking process, but also looking at data indicating historical trends and inter-relationships, it was possible to gather both a quantitative and qualitative view on the history of the game in terms of trends and inter-relationships.

Following the improved insight of the history of the game, it was possible to identify, analyse and quantify the key variables and inter-relationships that would drive the system that had to be modelled. Insights gained from identifying and understanding the players of the game as well as rules of the game, were part of the scenario thinking exercise, and was used to identify, analyse, quantify, and interpret the key variables in terms of trends and inter-relationships forming part of modelling the system. At the same time, by quantifying these trends and inter-relationships, it resulted in a better understanding of the players of the game and the rules of the game in terms of their quantified effect on the potential outcome of the game. This was especially important, since it was not possible for the CEO to provide quantified measures of the effect the rules and players of the game would have on the outcome of the game, highlighted during the scenario thinking exercise. By providing this information in a quantified format, it assisted the CEO in forming a more objective understanding of the effect that some players and rules of the game have on the potential outcome of the game.

The next step in the modelling process was to assign probabilities to the variables that were deemed to pose some form of risk in terms of the outcome of the system, specifically with respect to the yellow maize price. Once again, the scenario thinking process, through the step of identifying key uncertainties, informed the modelling exercise in terms of which variables were seen as risky. However, some of the variables identified as key uncertainties, could not be expressed in terms of a probability distribution, since either no data existed in order to assign probabilities (objective or subjective probabilities), or it was felt that structural changes have occurred, meaning that historical data or experience could not be used in calculating or assigning probabilities as it might incorrectly reflect the future situation. These variables included: beef prices due to the outbreak of "foot-and-mouth" disease in Botswana; ending stock levels as a result of the actions of players influencing imports, exports and ending stocks, and the introduction of ethanol production from maize which could influence maize prices. Consequently, probability distributions were assigned to only rainfall and the exchange rate, while specific values were assumed for the factors deemed to be "uncertain." The outcome of the modelling exercise was a probability distribution indicating the yellow maize price for the 2005/06 season in terms of a minimum, mean, and maximum price.

Hence, by the end of the afternoon of the first meeting, the following results were on the table: discussion results from the various steps of the scenario thinking process as well as quantified results from the steps of the modelling process; three plausible scenarios describing the potential milieus that might be faced; the three scenarios quantified by means of the model without including probabilities, and lastly, a probability distribution indicating the minimum, expected, and maximum yellow maize price based on applying the stochastic model. The set of results were presented to the CEO the following morning, and the implications were discussed in detail in terms of the potential for an unexpected market outcome. After this, the meeting was ended, and therefore no decisions were yet made on whether to hedge yellow maize or not.

During the second meeting in October 2005, the process and results obtained from the first meeting were reviewed in the same order as at the first meeting. In other words, each step was followed in the same order as described for the first meeting (and as presented in Figure 4.1 in chapter four). The results were reviewed to verify whether any changes needed to be made based on new information obtained and new insights. As a result of the review process, it was decided that the international maize price, particularly the US No. 2 yellow maize price, needed to be added as a key uncertainty as well as a risk factor. The result was that the three scenarios were again simulated by means of the model of Meyer *et al.* (2006) without including probabilities, thereby ensuring that uncertainty is incorporated correctly. It also meant that the stochastic model was re-simulated in order to obtain a probability distribution based on the inclusion of a probability distribution for the US No. 2 yellow maize price.

The scenario results indicated that a yellow maize price of R1 174/ton (Import parity scenario), or R908/ton (Autarky scenario), or R571/ton (Export parity scenario) was possible and plausible, while the stochastic simulation results indicated that prices would probably be R858/ton or lower. The CEO initially expected prices to also remain low. Market expectations were that the price would remain between R700/ton and R800/ton for the 2005/06 season.

The eventual outcome of the process was therefore three different scenarios, indicating three different possible and plausible outcomes for the yellow maize market, and also a probability distribution for yellow maize based on the stochastic modelling exercise.

Hence, the CEO of the pork company, the decision-maker on what to do in terms of hedging, realised that, although the probability distribution indicated that the probability of maize prices rising significantly during the 2005/06 season was extremely small, the import parity scenario indicated that the possibility indeed existed for maize prices to increase significantly and unexpectedly. This realisation was totally against all beliefs and opinions currently in the public domain and in the market, as well as against the initial expectations of the CEO. Based on this realisation, the CEO went ahead and took out hedging positions during November 2005. In this way, the company was positioned correctly should a dramatic increase in the yellow maize price occur as stipulated by the "Import parity" scenario.

During December 2005 and the early months of 2006, it became apparent that less maize had indeed been planted due to unfavourable rainfall during planting time, as well as expected low profitability of producing maize. The result was that maize prices increased drastically and unexpectedly to levels of around R1 400/ton. The eventual average SAFEX price for yellow maize during 2006 was R1 414/ton. As a result, when the eventual market outcome unfolded, the pork company was indeed positioned correctly through its hedging positions, and did make significant profits based on its hedging positions. These profits were used to offset unexpectedly and significantly higher feed costs and therefore pig prices, and as a result the company was much more competitive in the retail market as it could sell pork for below-market prices and still make significant profits. The fact that the pork company was close to bankruptcy in October 2005, meant that the profits gained from taking the hedging positions led the company to make a significant profit during 2006. This profit (along with good management) contributed to the turnaround of the financial position of the company, and at the time of writing this thesis, the company was once again one of the main players in the pork market in South Africa.

5.3.3 Context of application of the framework

Based on the application of the framework, to determine whether the hedging decision taken by the pork company's CEO was indeed a good decision, one firstly needs to determine whether using the proposed framework did sensitise the CEO sufficiently regarding the risks and uncertainties faced in making the final hedging decision. And secondly, given the final market outcome and the decision taken through applying the proposed framework, did the decision lead the pork company to reach its goal in terms of hedging successfully, given the final outcome of the 2005/06 maize market? In order to determine these two aspects, it is necessary to describe the context within which the decision was made in order to enlighten the reader about the risks and uncertainties faced at the time the decision had to be made and how these risks and uncertainties were pointed out by applying the proposed framework. Then we look to the final market outcome and the gains that were made from the hedging decision. Therefore, a description is presented of market conditions and expectations during the period before the decision was made.

The period in time during which the company was considering the decision, namely April to November 2005, was an extremely volatile and uncertain period. Hence, the company was faced with immense market risks and uncertainties that could potentially make the hedging decision become obsolete, leading feed costs and therefore pig prices to get out of control. The market at that stage was oversupplied with yellow maize due to an excellent 2004/2005 production season, and expectations were that yellow maize ending stocks would be at near record levels of around 1,35 million tons at the end of the 2004/05 marketing season (BFAP, 2005a). This resulted in an extremely low yellow maize price of around R599/ton during October 2005 as well as expectations of a yellow maize price of around R722/ton for the 2005/2006 season (BFAP, 2005a). These yellow maize prices were extremely low in both nominal and real terms compared to historical yellow maize prices (Figure 5.1).

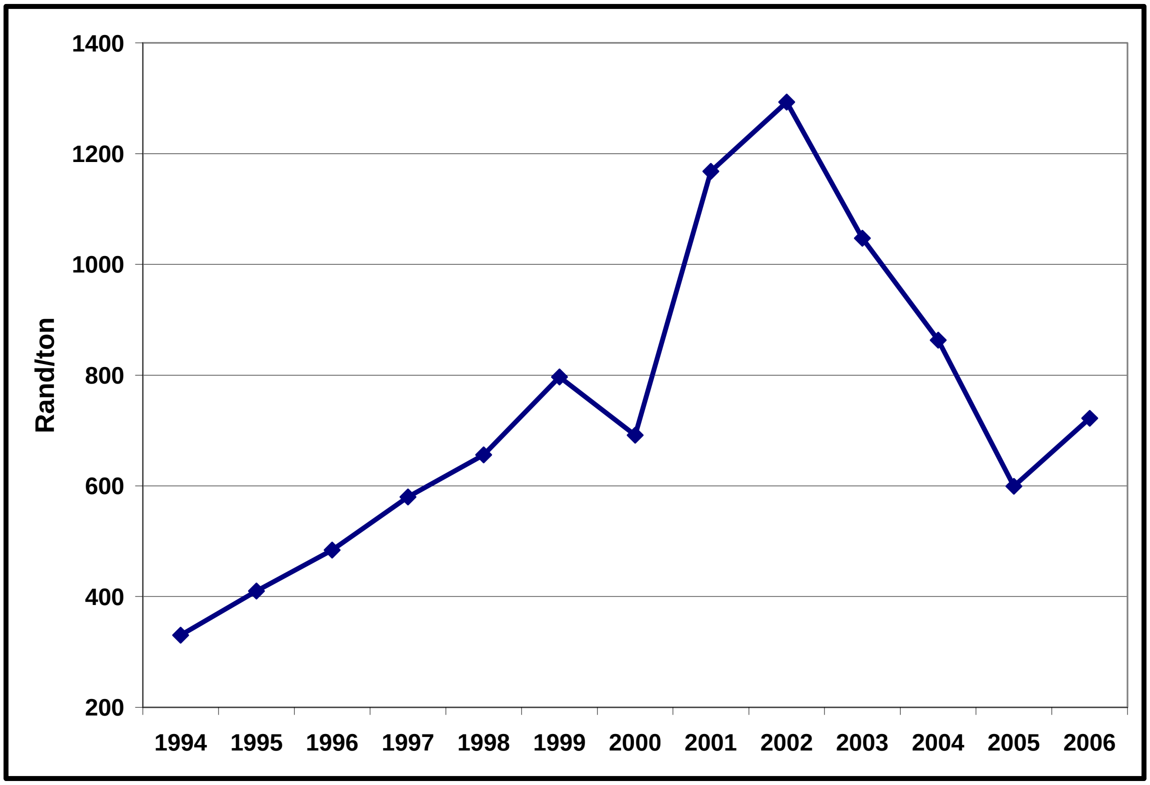

Figure 5.1: Nominal yellow maize producer price (Source: BFAP, 2005a)

Note: The price for 2006 was the expected price at that stage for the 2005/06 season

In conjunction with the large maize stocks in the market, the exports of maize to African countries and other overseas markets was perceived to be hampered due to a relatively strong Rand against other currencies, as well as infrastructural constraints that limited the movement of large amounts of maize to export harbours. Total exports were expected to be a mere 192 000 tons for 2005 and 266 000 tons for 2006 (BFAP, 2005a). On top of this, the previous rainfall season was above normal, thus causing above-average yields in conjunction with improved yellow maize cultivars (BFAP, 2005a). This resulted in expectations that, should another good rainfall year occur, yields could again be above long-term average levels, resulting in further increases in yellow maize stock levels. An additional increase in yellow maize stock levels would have led to a further glut in the market, resulting in another year of record low yellow maize prices.

Uncertainty existed on the “stock-holding” ability of stakeholders in the yellow maize industry, and hence the ability to handle an additional increase in stock levels should another above-average production season occur during 2005/06. This created additional uncertainty with respect to a potential glut in the yellow maize market and hence the potential of continued low prices. Lastly, international maize markets were experiencing high variability due to the outbreak of bird flu in China and other parts of the world, which resulted in uncertainty with respect to the demand for poultry and hence the demand for maize. Consequently, world maize prices experienced large fluctuations, dependant on the news of the day about bird flu outbreaks around the world. Fears also existed in South Africa that a potential domestic outbreak of bird flu could occur, which would have led to a significant dampening in the demand for poultry and hence yellow maize demand domestically (BFAP, 2005a). In such an event, yellow maize prices would have remained at low levels.

Concurrent with the domestic and global maize market situation, oil prices were fluctuating significantly. However, oil prices were also increasing gradually due to uncertainty regarding the political situation in the Middle East and hence the risks of oil supply problems in the region. This resulted in investor uncertainty, specifically with respect to emerging markets, including South Africa. It also resulted in the US Dollar gradually weakening against other major currencies such as the Euro. The result was volatility in the exchange rate as well as volatility with respect to input costs, specifically fertiliser, which is a main input in maize production. The Zimbabwean crisis was also deepening, resulting in investor uncertainty with respect to the Southern African region. This caused additional variability in the exchange rate relative to other major currencies such as the Euro and US Dollar.

The combined effect of all these factors meant significant levels of risk and uncertainty in the market regarding the issue of whether the price of yellow maize would increase or stay low in a twelve month period. Answering this question was critical to the pork company, as an unexpected and dramatic increase in maize prices without hedging correctly would have led to dramatic increases in feed costs and pig prices, hence a loss of competitiveness in terms of the pork price at retail level. This would have led to a serious dent in the company’s market share. On the other hand, too much covering in terms of hedging, without a maize price increase, would have led to excessive amounts of money being spent on hedging without getting any value out of it, which would have been detrimental in terms of costs to the company and would have put pressure on profits. Since the company was experiencing significant financial problems during the time of having to make this decision, it was imperative to make a decision that would provide optimum hedging coverage but at the same time minimise hedging costs. The questions were therefore: to hedge yellow maize prices or not, how much yellow maize should be hedged, and at what cost?

The eventual outcome of the market was one where prices did increase significantly due to a combination of factors, from a level of R599 during October 2005 to an average level of R1 414.60/ton for the 2005/06 season. The first was a depreciation in the Rand from a level of 595 cents/US$ to an eventual average for 2006 of 639 cents/US$. The exchange rate depreciation improved the competitiveness of maize exports, and hence led to an increase in exports and therefore a decrease in stocks. The second factor was a dramatic decrease in plantings during November and December of 2005. Reasons for decreased planting include: the unanticipated low rainfall; risk averse banks not financing maize farmers due to excessively low maize prices; and farmers just not being willing to risk planting maize when they expected excessively low prices and the risk of making a loss during the 2005/06 season. Plantings of yellow maize for the 2005/06 season decreased from an initial expected level of 1,019 million hectares to an eventual 567 thousand hectares. On top of this, world maize prices for 2006 increased from an expected level of $108/ton to an unexpected level of $159.44/ton, specifically for US No. 2 (FOB Gulf) yellow maize. The increase in the world yellow maize price was due to: a slight increase in crude oil prices from levels of around $50/barrel to levels of $60/barrel for Brent Crude oil; an increase in the demand for soft commodities in countries such as China and India and hence a resulting decline in stock levels; and the introduction of biofuel plants in the USA to produce ethanol from maize resulted in an increased demand for maize but also a decrease in maize stock levels (BFAP, 2008, FAO, 2008, FAPRI, 2008).

Since the South African maize market is small and open to the world maize market, an increase in the global maize prices can result in a local maize price increase, depending on whether the local market is oversupplied, undersupplied, or in autarky (Meyer *et al.*, 2006). Because the South African maize market was oversupplied during the 2004/2005 season and eventually undersupplied during the 2005/06 season due to low production, it meant that movements in world maize prices had a very direct effect on domestic maize prices during the 2005/06 season. Thus, as a result of an increase in world maize prices, the domestic maize price also increased.

The purpose of this section is to test whether the application of the framework did lead to a good hedging decision by the pork company's CEO. Hence, did the applied framework sensitise the CEO with regards to the risks and uncertainties that were faced in making the hedging decision, and what was the gains from the hedging decision following the eventual market outcome? Since the yellow maize price increase was mainly caused by significantly lower plantings due to unfavourable rainfall during the end of 2005, and since one of the main results of applying the framework was to show the CEO that variability in area planted due to low rainfall was one of the key risks and uncertainties to keep an eye on, it means that applying the framework did indeed sensitise the CEO towards one of the major uncertainties that eventually did cause the yellow maize market to swing in an unexpected direction. As a result, the CEO did decide to put hedging positions in place in case the yellow maize price increased unexpectedly, which meant the pork company was positioned correctly to mitigate the eventual increase in yellow maize prices. Furthermore, the CEO was also sensitised with respect to the other risky and uncertain factors that also eventually contributed to the eventual increase in the yellow maize price. Hence, due to the hedging positions taken, the pork company did make significant profits from the hedging positions, which resulted in the turnaround of the financial position of the company. Therefore, it can safely be concluded that the application of the proposed framework did guide the CEO of the pork company to make a good hedging decision.

5.3.4 Application of the stochastic model

The purpose of the previous section was to apply the first part of the test, namely, to test whether the application of the framework did result in good decisions. In this section, the second part of the test is applied, namely, whether the application of the framework would have led to better decisions compared to a situation whereby the CEO of the pork company would have only used a stochastic model as a guide in making the hedging decision. Hence, in this section, the "back-in-time" exercise discussed in the introduction of this chapter is executed so as to logically deduce what decisions the CEO would likely have made if he had only used a stochastic model instead of applying the framework proposed in this thesis. By comparing these deduced decisions which used only the stochastic model, to the decisions made by applying the framework of this thesis, one will get an indication of which decisions would have been better. Hence, this serves the purpose of testing whether only applying the stochastic model or applying the proposed framework would have led to better decisions with respect to hedging yellow maize for the 2005/06 season.

The model of Meyer *et al.* (2006) is used to administer the above-mentioned test as it is the most suitable model. The model developed by Meyer *et al.* (2006) is an annual multi-market econometric stochastic model. This means that the outputs of the model reflect the interaction between various industries in the market; the outputs are annual averages over a multi-year period of ten years; the model does include the effect of different risks on price via supply and demand effects, and the model does incorporate changes in parameters in the form of regime switches. It is a closed system model that includes the major grain and livestock industries in the South African agricultural sector. It therefore includes crops such as white maize, yellow maize, wheat, sorghum, barley, soybeans, sunflower, and canola. Also included are beef, mutton, wool, dairy, pork, broilers and layers. Hence, should a shock to either demand or supply occur in one of the grain industries, for example maize, the impact can immediately be seen on all the livestock industries dependent on maize for feed, such as poultry, pork and beef. Additional to the range and interaction between industries in the model, the model does include macro-economic variables such as the crude oil price, the exchange rate, interest rates, economic growth, population, and climate. Over and above this, the model includes world grain and livestock prices, including maize prices. Hence, global or domestic market or policy changes can be simulated by the model to test what the impact is on demand, supply, and therefore prices of all the major domestic grain and livestock industries (Meyer *et al.* (2006)). The model is therefore ideal for simulating the market situation faced by the pork company.

As indicated in chapter four, the process of setting up and applying a model essentially entails the following steps: describing the purpose of the modelling exercise and thereby identifying the system that will be modelled; identifying historical trends and inter-relationships that influence and drive the system; analysing and quantifying key variables and inter-relationships that will drive the system in future, and based on the analysis, setting up the mathematical functional forms that will be used in the model structure; setting up the stochastic simulation process to be followed in the model; running the model; analysing the modelling results and deducing implications from the results; generating options based on implications, and lastly, making a decision. Hence, in order to ensure that the correct process is followed to test whether the stochastic model would have captured the risks and uncertainties sufficiently, the process as set out in this paragraph is followed.

Step 1 - Purpose of modelling exercise:

Model the yellow maize industry in order to obtain simulation results on the expected yellow maize prices for the season 2005/2006. The system that is modelled is therefore the grain and livestock system, with the focus being on yellow maize prices. The reason for including the livestock sector is because the yellow maize industry, and hence the yellow maize price, is dependent and influenced by demand for yellow maize in the livestock sector for feed purposes.

Steps 2 and 3 – Key trends and inter-relationships driving the system:

Steps two and three of the stochastic modelling process entail identification and analysis of the trends of key factors as well as inter-relationships thought to influence the system that will be modelled, namely, the yellow maize industry. Through discussions with industry stakeholders as well as the CEO of the pork company, the following factors and inter-relationships were found to be key to modelling the yellow maize industry: yield; area harvested; expected gross returns of yellow maize compared to other summer grain crops versus input cost trends; domestic consumption of yellow maize; yellow maize imports and exports; yellow maize ending stocks; crude oil price; exchange rate; rainfall in total maize production area; trade policies in the form of tariffs, and premium of South African yellow maize on world markets.

Important to note is that the marketing year for yellow maize starts on 1 May of every year, and therefore ends on 30 April of the following year. The implication is that during October 2005, when the decision had to be made by the pork company, some variables in terms of levels or values were already known for the 2004/05 harvest, for example, yield, area harvested, gross returns, input costs, and rainfall. The other variables for 2004/05, such as consumption, imports and exports, ending stocks, international maize price, oil price and exchange rate were still playing out. Hence, in the respective figures in the following paragraphs on steps 2 and 3, some figures have actual values for 2005 (which refers to the 2004/05 season), while other figures only contain expected values for 2005 (as they were still expected during October 2005).

In Figure 5.2, the trends of yellow maize yield and area harvested are presented. It is clear that although area showed a declining trend throughout the period of 1994 to 2005, yield showed a strong growth trend. This implied that although area was declining gradually, total production of yellow maize was increasing due to strong growth in yield levels.

To better understand the reason for the decline in yellow maize area, especially from 2002 to 2005, one needs to study Figures 5.3 and 5.4. In Figure 5.3 the expected gross returns on the various summer grain crops are presented. Expected gross returns are calculated by multiplying the yield per hectare by the price per ton of the specific product. Figure 5.3 clearly indicates that expected gross returns showed a significant decline for all crops from 2002 to 2005. Comparing the trends in Figure 5.3, to the input cost trends in Figure 5.4, it is clear that although gross returns did decline, input costs such as fuel, fertiliser, seed, chemicals and other production inputs in fact kept increasing. This implies that net returns of grain farmers experienced severe pressure from 2002 to 2005, implying that farmers would have experienced pressure on profits, most probably cash flow pressure, and hence have struggled to finance the planting of crops. Based on the explanation above, expectations for the 2005/06 season were therefore that farmers would plant a smaller area compared to previous years due to profit and cash flow pressure. Since the model solves area planted endogenously, no assumption would be made on a specific area within the model, and hence the model will be allowed to solve the area based on assumptions on exogenous variables such as exchange rate, oil price, rainfall, international grain and meat prices, trade policies, and the premium of South African yellow maize on international markets.

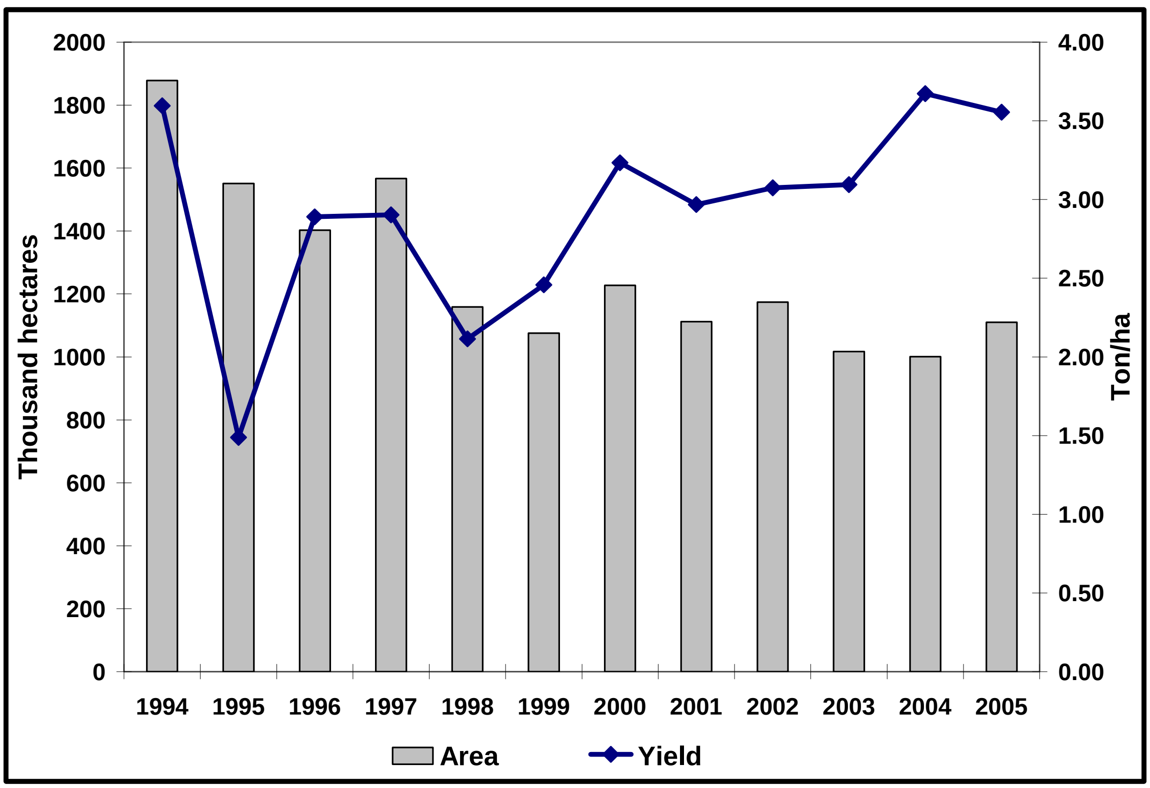

Figure 5.2: Yellow maize yield and area harvested (Source: BFAP, 2008)

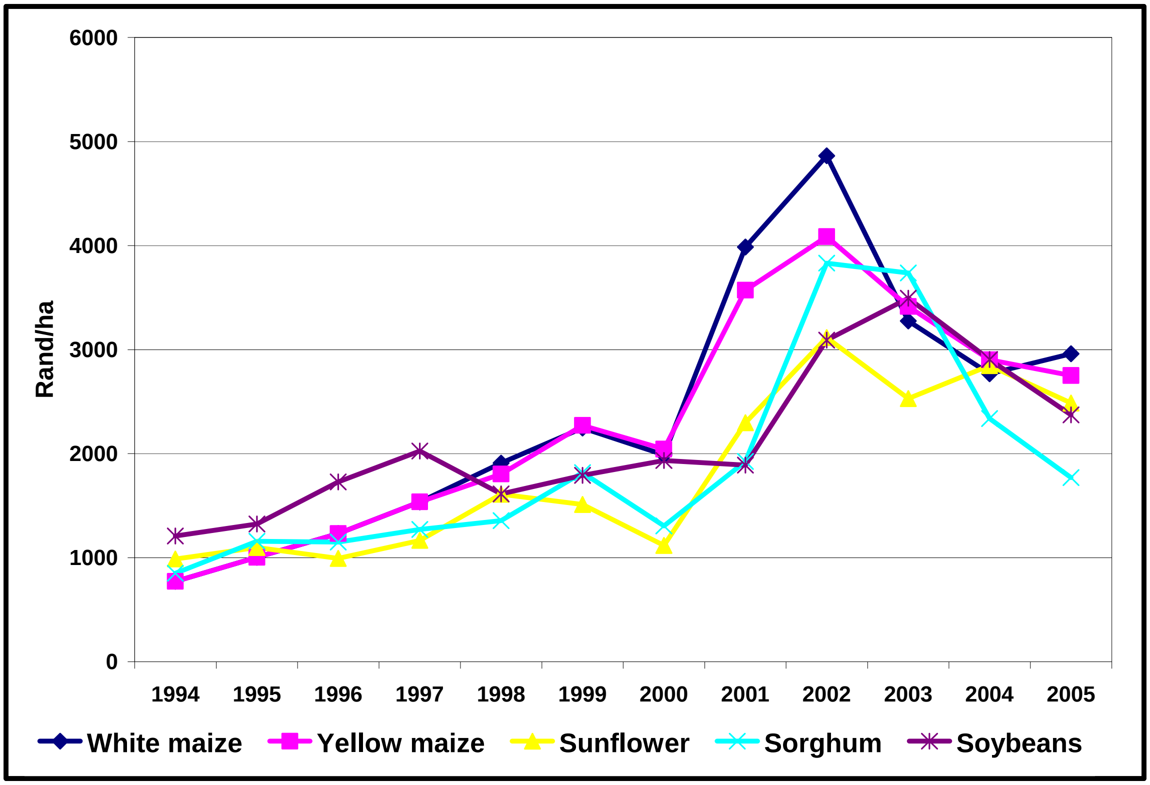

Figure 5.3: Expected gross market returns of summer crops (Source: BFAP, 2008)

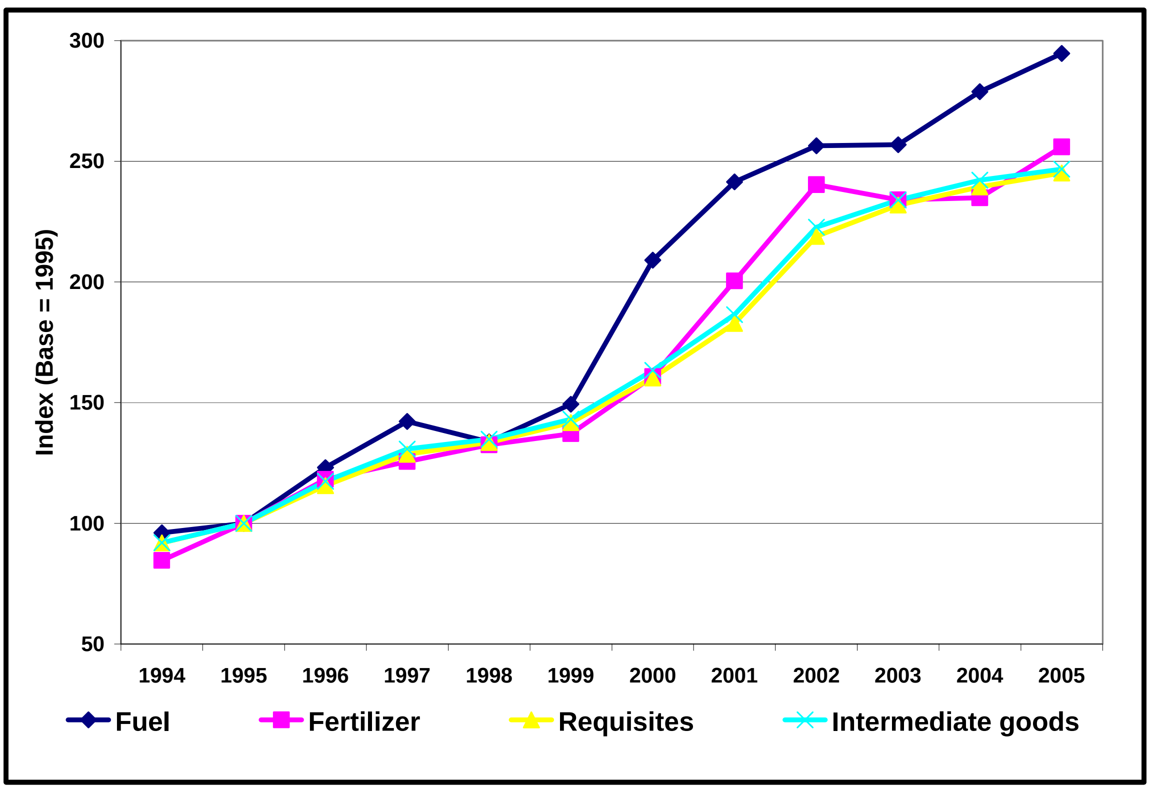

Figure 5.4: Input cost indices for grain crops (Source: BFAP, 2008)

In terms of domestic consumption of yellow maize, animal feed consumption increased from 2000 to 2003, after which it declined during 2004 (Figure 5.5). Expectations during October 2005 were that animal feed consumption of yellow maize would significantly increase again compared to 2004 levels. Human consumption contributed a very small percentage to total domestic consumption of yellow maize and remained fairly flat from 2000 to 2004. Expectations were that it would remain flat for 2005. Hence, the most important factor in terms of understanding yellow maize consumption was the demand for yellow maize for animal feed.

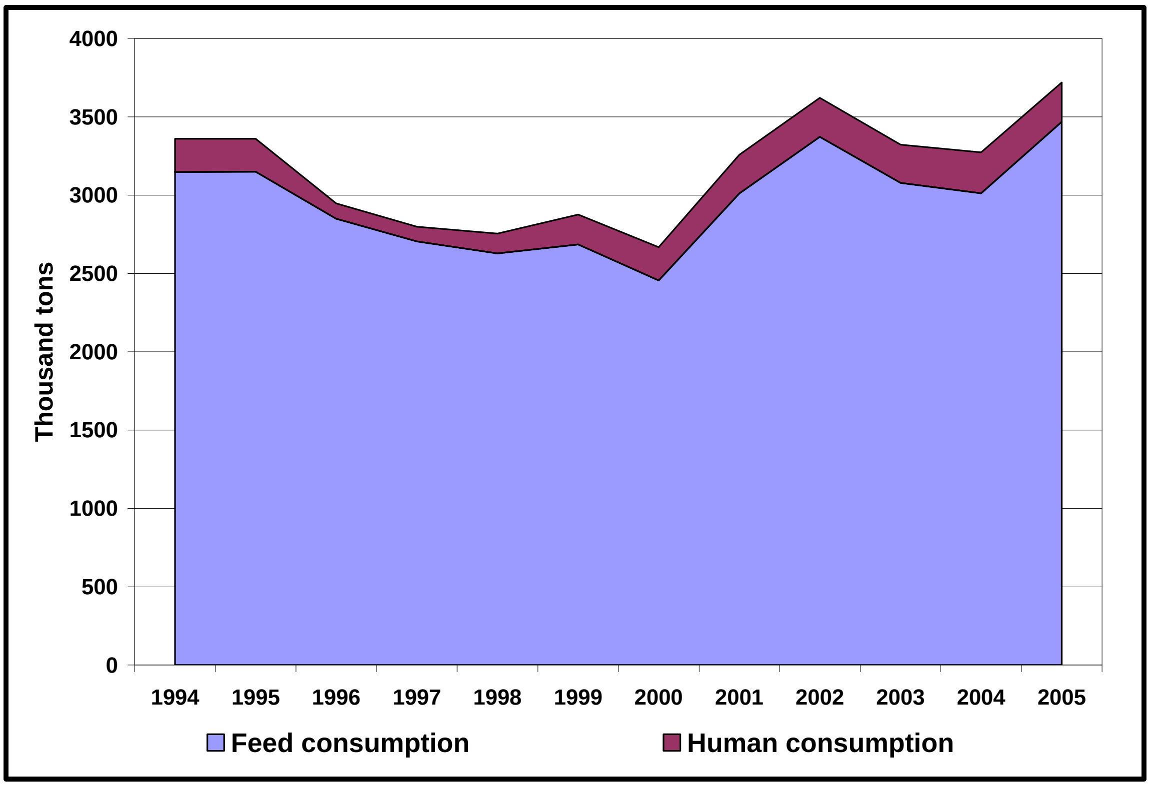

Figure 5.5: Yellow maize domestic consumption (Source: BFAP, 2008)

Note: values for 2005 were expected values during October 2005

The main users of yellow maize in animal feed are poultry, pork, beef, and dairy cattle (BFAP, 2008c). The reason for the increase in the demand for yellow maize for animal feed during the period 2000 to 2005 is ascribed to an increase in the demand for meat, especially poultry. The reason for the increase in the demand for meat was due to strong economic growth in South Africa, government policies in terms of welfare grants and Black Economic Empowerment, and population growth. The combination of these four forces led to the creation of a bigger middle class who had much stronger spending power compared to the 90s (BFAP, 2008c). Hence, due to stronger spending power, consumers demanded more meat, which meant that demand for animal feed increased in order to keep up with the demand for meat. Expectations were therefore that demand for yellow maize would keep increasing due to expected increased demand for meat in 2006. However, since the model solves demand endogenously, based on assumptions on exogenous variables such as economic growth, the exchange rate, oil price, interest rates etc., no direct assumptions are made on demand for the modelling exercise. The assumptions made on the exogenous variables for the modelling exercise are presented and explained in step 4 of this section.

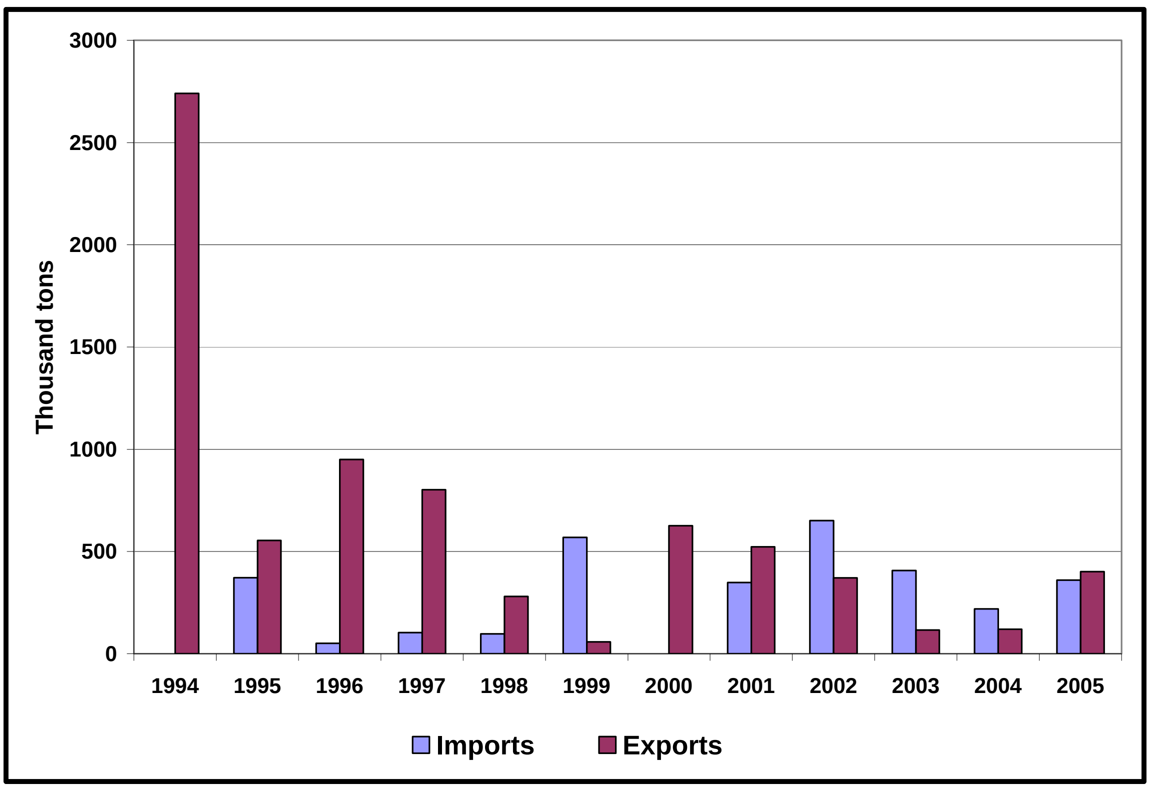

Figure 5.6: Yellow maize imports and exports (Source: BFAP, 2008)

Note: values for 2005 were expected values during October 2005

Analysing imports and exports of yellow maize as presented in Figure 5.6, it is clear that both showed a declining trend from 2002 to 2004. During 2005, imports were expected to keep decreasing while exports were expected to increase slightly. Looking at Figure 5.7 on ending stocks, it becomes clear why imports kept decreasing while exports were expected to increase slightly during 2005. Except for 2003, ending stocks remained above or very close to the ten-year average stock-to-use ratio of 23%, and ended at 746 000 tons during 2004, implying a stock-to-use ratio of 21% for 2004. This meant that ample stocks were available for domestic consumption, which would have kept imports low for 2005 and have resulted in an increase in exports. Due to low expected imports, but also low expected exports because of perceived infrastructural and transport constraints existing during October 2005, expectations were that ending stocks would increase to a level of 1,35 million tons for 2005. This would have meant a stock-to-use ratio of 35%. This would have been way above the 10-year average level of 23%. Again, since ending stocks, imports and exports are solved endogenously in the model, assumptions are only made on exogenous variables that drive these factors in order to allow the model to solve for these factors. These assumptions are presented and explained in step 4 of this section.

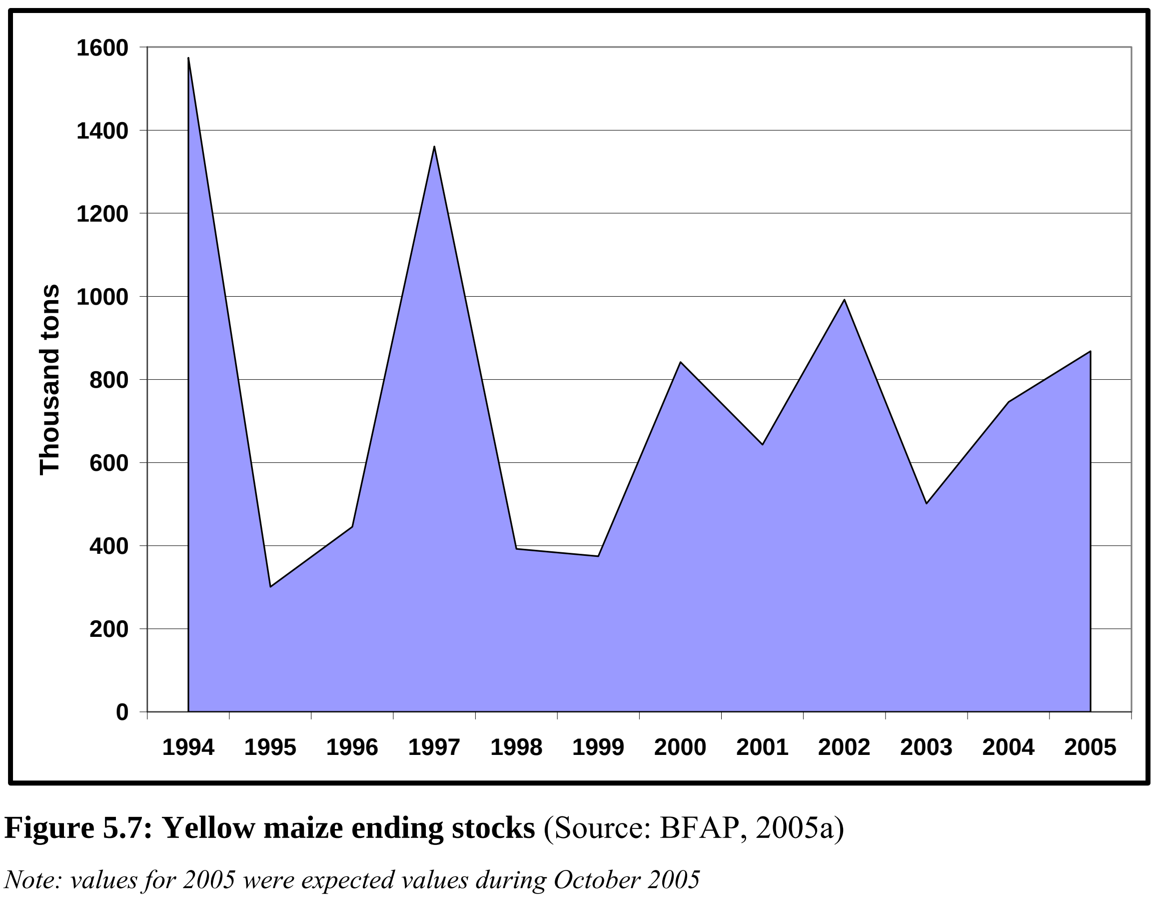

Figure 5.7: Yellow maize ending stocks (Source: BFAP, 2005a)

Note: values for 2005 were expected values during October 2005

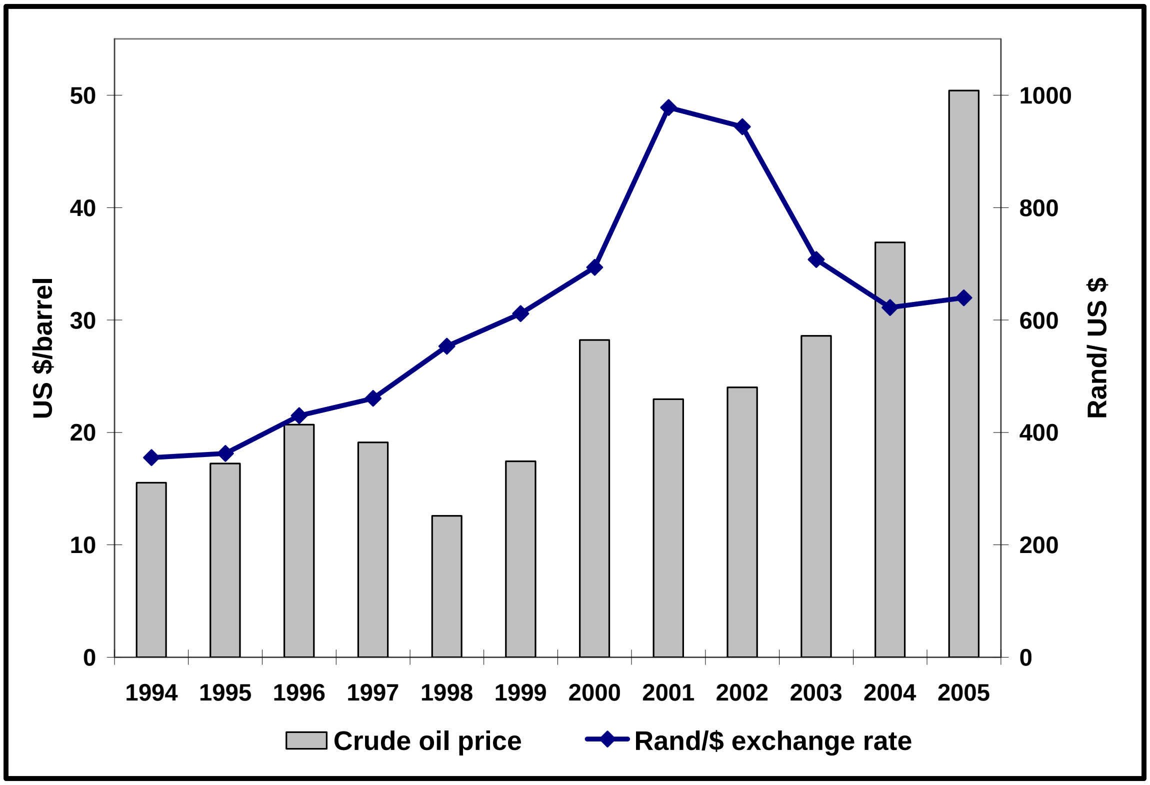

Figure 5.8: Brent Crude oil price and exchange rate (Source: BFAP, 2008)

Note: values for 2005 were expected values during October 2005

The Brent Crude oil price showed an increasing trend, especially from 2001 onwards, and expectations during October 2005 were that it would end at around $50/barrel on average for 2005 (Figure 5.8). The Rand/$ exchange rate showed an appreciating trend from 2001 to 2004, but expectations were that its 2005 annual average would slightly depreciate from its 2004 annual average. Since Brent Crude and the exchange rate are not solved endogenously in the model, specific assumptions need to be made for the 2005/06 season. These assumptions are stated and explained in step 4 of this section.

From a South African perspective, the most important international maize price at that stage was the US No. 2 yellow maize price. This maize price showed a declining trend from 1995 onwards, and expectations for 2005 were that it would keep following the declining trend (Figure 5.9). The international maize price is not solved endogenously in the model, and hence a specific assumption needs to be made on this variable in terms of the 2005/06 season. The assumption is stated and explained in step 4 of this section.

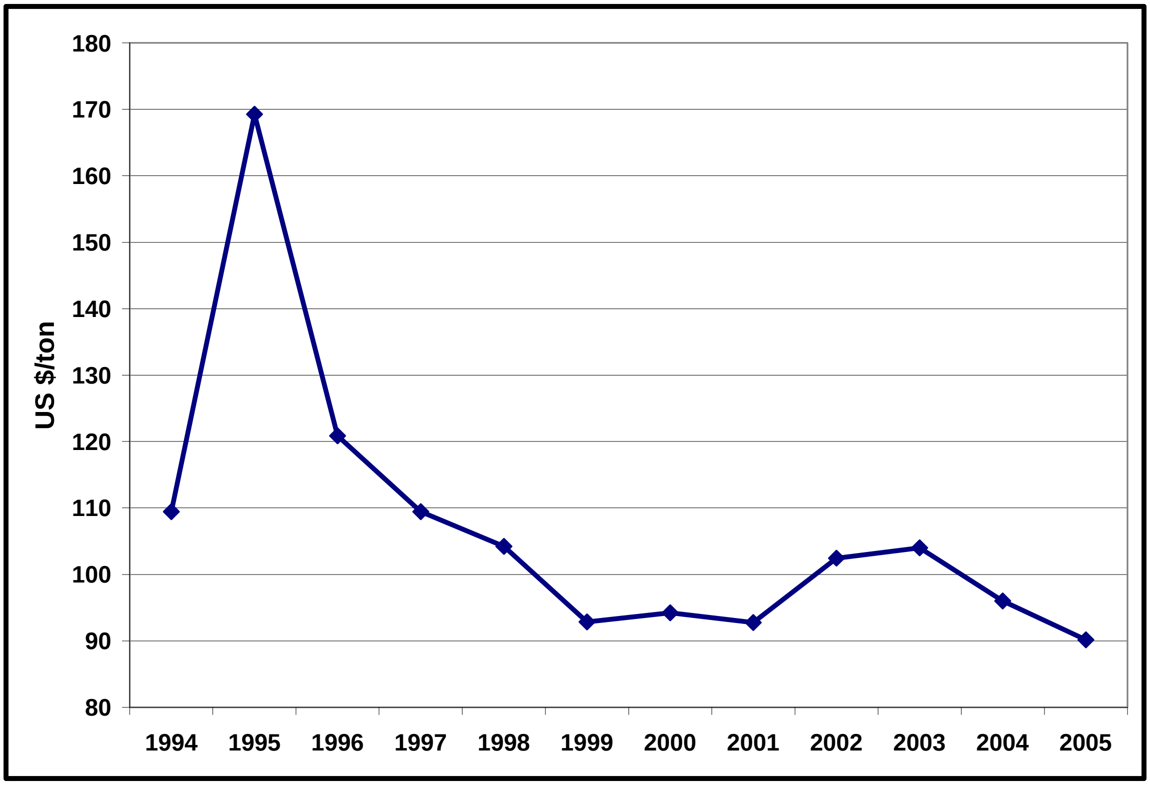

Figure 5.9: US No. 2 (FOB Gulf) Yellow maize price trend (Source: BFAP, 2008)

Note: values for 2005 were expected values during October 2005

In terms of import tariffs on yellow maize into South Africa, expectations were that the tariff formula, where $110 for US No. 2 served as a reference price, would be kept in place for 2005 and onwards. Since the US No. 2 price was expected to keep decreasing to levels well below $110/ton for 2005, expectations were therefore that the yellow maize import tariff would increase to levels of around R45/ton (Figure 5.10). Expectations were that the historical price premium that South African yellow maize did obtain on international markets for quality reasons, would remain at fairly the same levels as had been seen up to 2004. Hence, it was expected that a premium of around $5/ton would be obtained should yellow maize be exported. The tariff is solved endogenously in the model, and hence no assumption was made on its level for the 2005/06 season. The premium, however, is exogenous, and hence a specific assumption is made and explained in step 4 of this section.

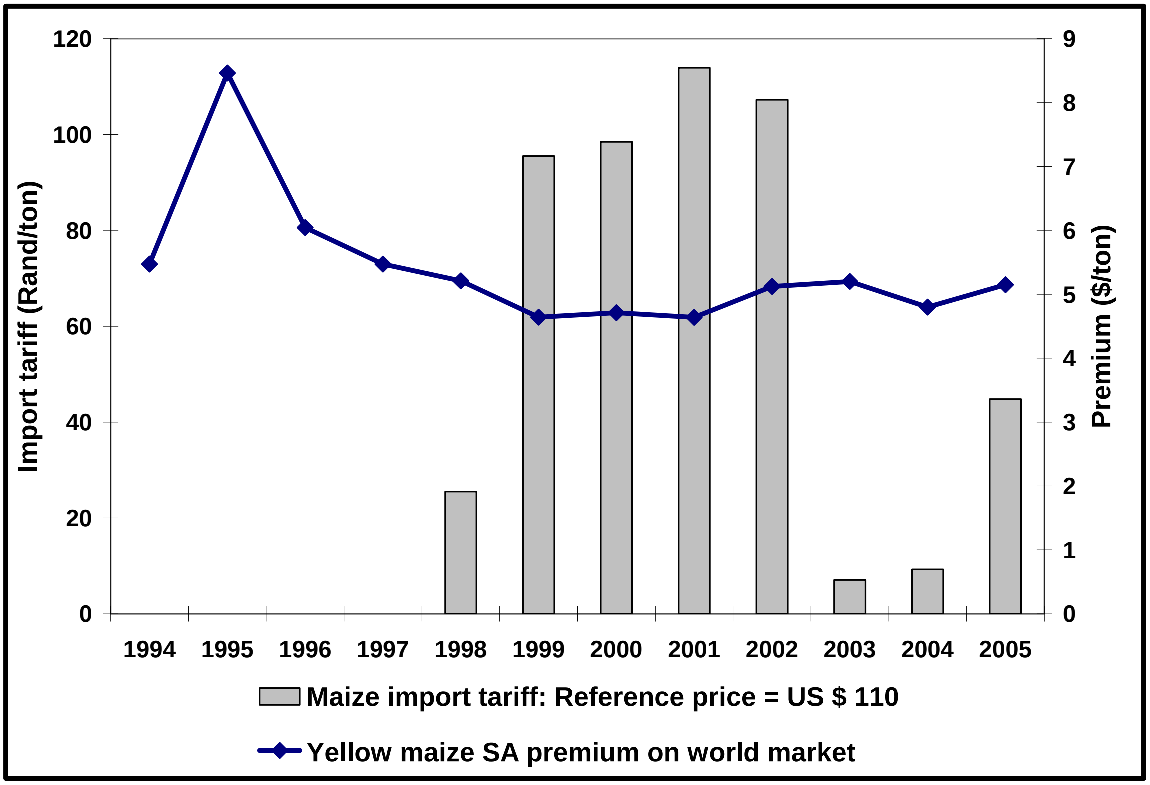

Figure 5.10: Yellow maize import tariff and premium on world markets (Source: BFAP, 2008)

Note: values for 2005 were expected values during October 2005

Average annual rainfall in the maize producing area for South Africa showed a slight declining trend from 1996 to 2005. Since this meant that rainfall during this period had been moving slightly below the long-term average, it was expected during October 2005 that rainfall for the 2005/06 maize season could be above average. Since rainfall is exogenous to the model, a specific assumption is made and explained in step 4 of this section as to the assumed level of this variable for the 2005/06 season.

Since the model of Meyer *et al*. (2006) already exists, and all functional forms and parameters are already in the model and estimated on the basis of the before-mentioned trends and inter-relationships presented in this step, it is assumed that this remains as it is. Therefore, no new functional forms or parameters are estimated for the sake of this modelling exercise.

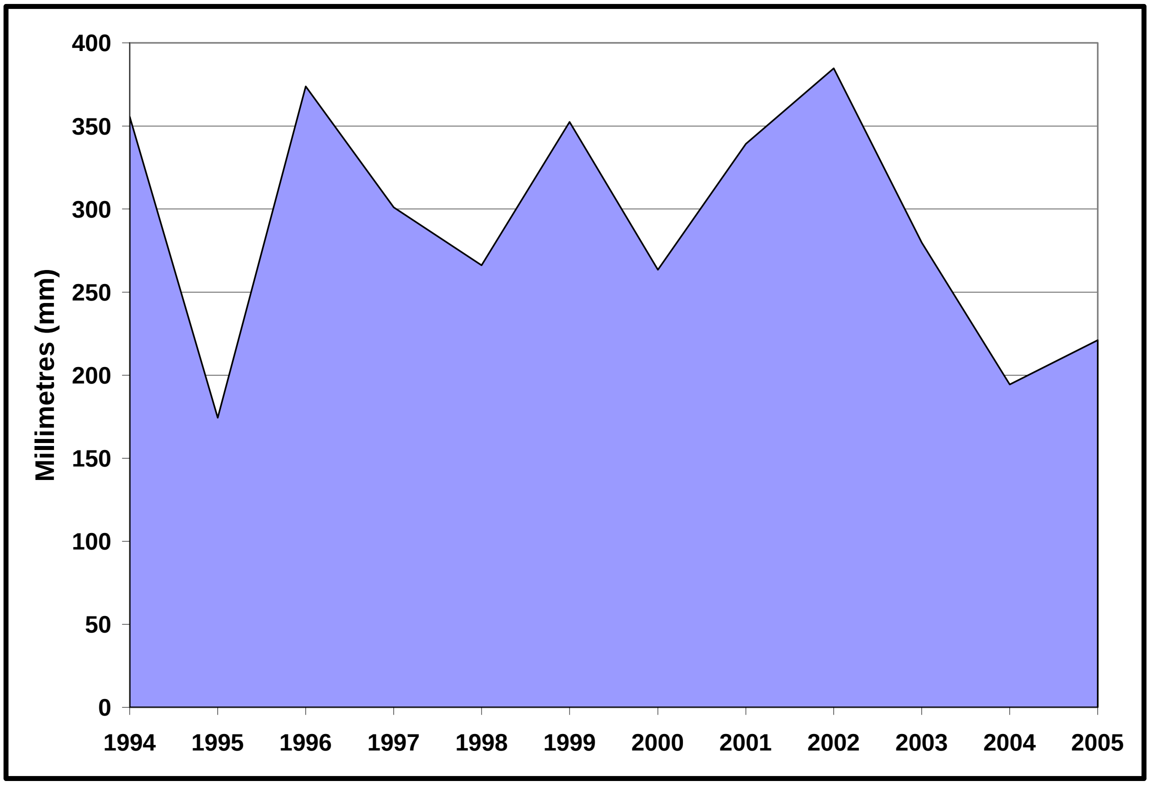

Figure 5.11: Total rainfall trend, maize planting area of South Africa (Source: BFAP, 2008)

Step 4 – Exogenous variable assumptions and the resulting stochastic process:

Based on the analysis of the yellow maize industry presented in steps 2 and 3 as well as through discussions with the CEO of the pork company in April 2005 and October 2005, the factors that were deemed as major risk factors with a view on the 2005/06 yellow maize season, and which needed to be included in the model were: international grain and livestock prices; exchange rate; oil price, and domestic rainfall, which influences the amount of hectares planted. Since, yellow maize yield, yellow maize area planted, consumption of yellow maize, imports and exports, and yellow maize ending stocks are endogenously solved in the model, based on assumptions made on the before-mentioned factors, no trends or risk distributions are assigned or assumed for these specific variables. Hence, trend assumptions and probability distributions are estimated and assumed for the exogenous variables and based on solving the model, probability distributions are generated for the key output variables. In this case study the key output variables were yellow maize yield, area harvested, ending stocks, consumption, imports and exports, and the resulting annual average yellow maize price for the 2005/06 season.

The risk that each of these exogenous factors hold in terms of the outcome of the system, are included by following a stochastic process as proposed by Richardson (2003), and using the method of Latin Hypercube to generate the eventual probability distributions of the key output variables. The process entails: assigning correlated probability distributions to the respective key input or exogenous variables by means of de-trending historical data of the key input variables; setting up a correlation matrix based on the absolute deviation of the variable around its trend; then simulating the key output variables by means of a correlated empirical distribution for each of the respective key input variables, and by running 500 model iterations in order to obtain stable probability distributions for the key output variables. The correlation matrix that is used in this case to correlate the key input variables is presented in Appendix B. The resulting trends and probability distributions estimated and assumed for the different key input or exogenous variables for the 2005/06 season are also presented in Appendix B.

Step 5 - Model results:

As a result of the process followed in steps two to four, the modelling results are presented in Table 5.1. It depicts the probability distribution of the yellow maize price and other key output variables pertaining to yellow maize for the season 2005/2006. The simulation results are compared to the eventual actual market outcome for the 2005/06 season (last column).

Table 5.1: Simulated probability distribution results for yellow maize for 2005/06 season versus the eventual actual market outcome for the 2005/06 season

Variable	**Mean**	**Min**	**Max**	**Std dev**	**CV**	***Actual market outcome***
Production (1000 tons)	3243	2717	4067	309	9.52	***2315***
Ending stocks (1000 tons)	856	602	1189	120	14.11	***440***
Human consumption (1000 tons)	266	237	285	7.45	2.79	***290***
Feed consumption (1000 tons)	3166	2771	3599	135	4.28	***3260***
Exports (1000 tons)	241	169	617	24.32	10.06	***117***
Imports (1000 tons)	228	0	583	64.35	28.17	***930***
Yellow maize producer price (R/ton)	858	491	1427	143.55	16.72	***1414.6***

From Table 5.1, the indication is that the expected yellow maize price based on the estimated probability distributions and trends of the exogenous variables for the season 2005/2006, would have been R858/ton. The estimated standard deviation would have been R143/ton, while the minimum and maximum values would respectively have been R491/ton and R1427/ton. Hence, based on the simulation results, which include the key trends and inter-relationships as well as the interaction between risky variables, a maize price of R858/ton should have been expected, while with 95% statistical significance, it would have been expected that the yellow maize price would have moved between R715/ton and R1001/ton. Based on the simulation results, the probability of obtaining a price of R1414 or higher, which was the eventual actual market price, was less than 0.02% (Figure 5.12). Thus, the stochastic model would have indicated to the decision-maker that the eventual market outcome was extremely improbable.

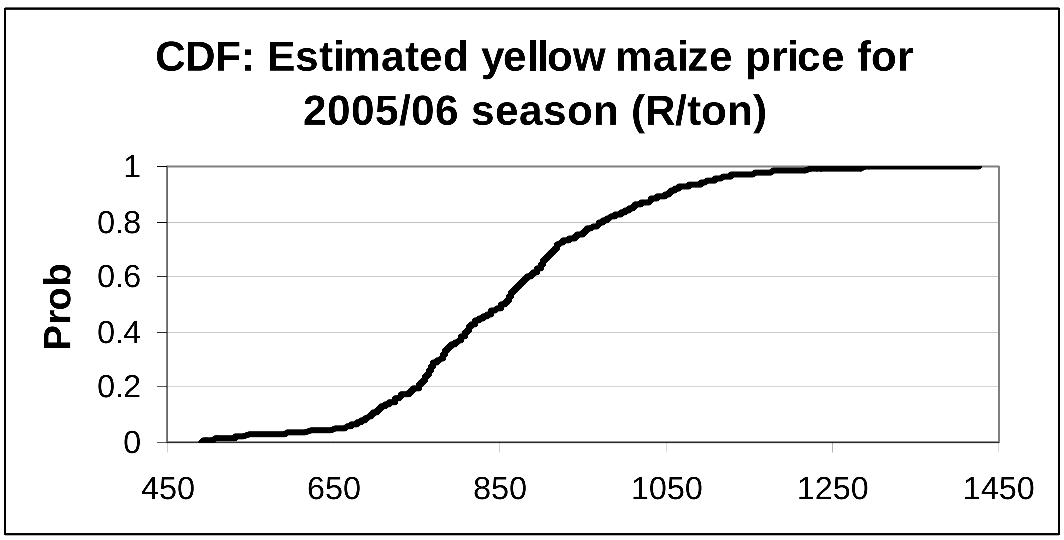

Figure 5.12: Cumulative distribution function of estimated yellow maize price for 2005/06 season

In addition to the low probability assigned to the eventual market outcome, the generated probability density function would have indicated to the decision-maker that the probability of a maize price occurring that is lower than the simulated mean of R858/ton was 57% (Figure 5.13). Hence, the probability density function is skewed to the left, indicating that based on the estimated probability distributions, trends, levels and interactions between the various factors driving the system that is modelled, the yellow maize price for 2005/06 would have been likely to remain below the estimated expected price of R858/ton.

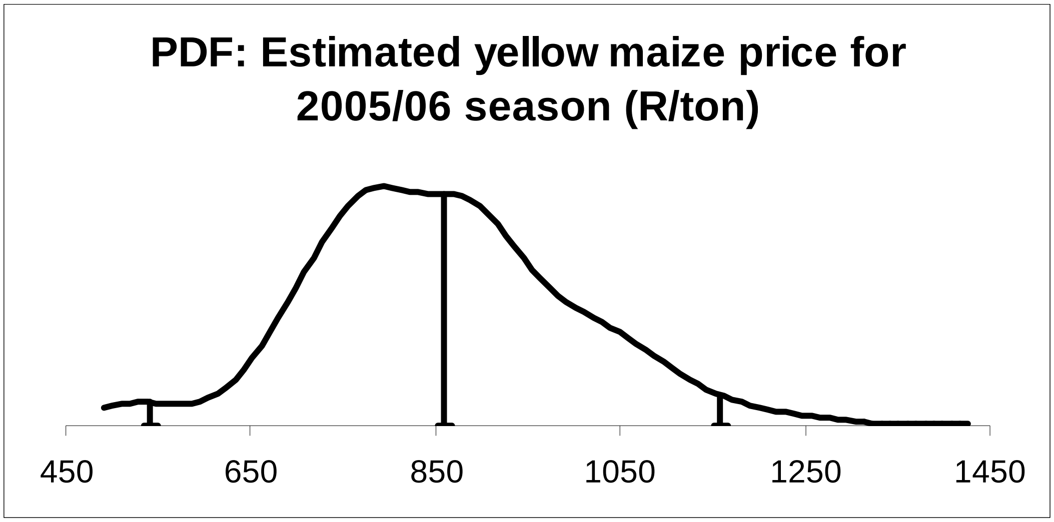

Figure 5.13: Probability density function of estimated yellow maize price for 2005/06 season

5.3.5 Stochastic model versus framework

Based on the simulation results after applying only the stochastic model, the argument can be made that the model **would not** have captured and communicated the risks and unexpected events sufficiently enough. Although the model is extremely detailed, and would have included the majority of variables and inter-relationships that do drive the yellow maize system that was modelled, it still would not have captured and communicated the possibility of the eventual market outcome accurately for the decision-maker. This is because most of the simulated levels of the key exogenous variables did not correctly reflect what eventually occurred in the market. This therefore would have led to a simulated probability distribution for the yellow maize industry for the 2005/06 season that would have included the eventual outcome, but assigned an extremely small probability to the eventual outcome. Furthermore, the estimated probability function would have indicated that the probability of the yellow maize price remaining below the estimated mean would have been much bigger than for the yellow maize price increasing above the estimated mean.

The fact that an extremely low probability was assigned to the eventual market outcome, and given the skewness of the estimated probability density function, implies that the CEO would have been led to believe that it was not probable that the maize prices would increase dramatically. This implies that the CEO's initial expectation of prices staying low, would have been strengthened by the stochastic modelling results. Based on this belief, and given the goals of optimising hedging coverage but minimising hedging costs, the CEO would have made hedging decisions based on the view (as held by the decision-maker and supported by the simulated probability distribution) that the maize price would probably remain in the region of between R715/ton and R1001/ton for the 2005/06 season, and probably below the estimated mean of R858/ton. This would have resulted in taking hedging positions that would have hedged a smaller percentage of the total amount of maize that would have been needed to offset increasing feed costs and therefore pig prices. Hence, non-optimal hedging coverage would have been obtained since the chances of a significant price increase would have been seen as low. In other words, the decision-maker would have argued: “Why spend a lot of money on hedging the total amount of maize needed for feed when the price is likely to stay low?” Given that 65% of pork input production costs are made up by the cost of yellow maize in the feed, the fact that the price eventually did increase to R1414/ton would have resulted in dramatic profit pressure if the correct hedging positions were not in place.

Comparing the stochastic modelling results to the results of the application of the framework presented in sections 5.3.1 and 5.3.2 of this chapter, it is clear that the framework results indicated that it is indeed possible and plausible for the yellow maize price to more than double. Although the stochastic model on its own (as presented in section 5.3.4) indicated that it is not probable, the scenario results did indicate that it was indeed possible and plausible. At the time of simulating the scenarios and presenting the results to the pork company, the maize price was at a level of R599/ton, and hence the price of R1414.60 which eventually crystallised in the market was deemed to be highly improbable and therefore almost “impossible.” What the scenario results actually indicated was that it was indeed possible and plausible. Hence, the framework did in fact capture the risks and uncertainties that led to the eventual market more sufficiently, and hence did signal to the decision-makers in the company that, due to the potential occurrence of risky and/or unexpected events, a highly improbable outcome was in fact possible and plausible. Using the framework therefore resulted in the CEO questioning his own assumptions and expectations with regards to the potential market outcome. This led to the CEO going through a learning process with respect to understanding and re-perceiving both the risks and uncertainties that were faced in making the hedging decision. This re-perception process resulted in the CEO changing his hedging decision, which eventually proved to be a good decision.

Therefore, following the results of the two tests presented in sections 5.3.2 and 5.3.4, it is clear that applying the stochastic model on its own would not have captured the risks and uncertainties which eventual led to the actual market outcome sufficiently enough, and would likely have misled the decision-maker into thinking that the potential for an increase in the yellow maize price was much lower than what it actually was. The application of the framework did signal that the eventual market outcome was in fact possible and plausible. This led the decision-makers of the company to set up hedging positions which did optimise hedging coverage and minimised hedging costs in the face of the market situation that eventually crystallised, and hence the company was in a position to offset an increase in feed costs (and therefore pig prices) by means of profits made from hedging against increasing yellow maize prices.

Hence, in this specific case study, it can be concluded that applying the framework as proposed in chapter four of this thesis, did capture the risks and uncertainties more sufficiently compared to applying only the stochastic model. Doing so improved the decision-maker's understanding of the realities faced pertaining to the decision's associated risk and uncertainty. Using the framework led the decision-maker to make hedging decisions that were robust enough to withstand the occurrence of both risky and unexpected events, and hence led to positive results in terms of the hedging strategies that were followed. Thus, applying the **framework did lead to good and better decisions** compared to using only the stochastic model; therefore, applying the proposed framework assisted the company to succeed and reach its goals with regards to the hedging exercise.

5.4 A farmer co-operative: Case study two

5.4.1 Background

The second case study is on a farmer co-operative that operates in the eastern part of South Africa. Most information presented in the second case study is based on a report that was written for the co-operative at the time the proposed framework of this thesis was applied in collaboration with the co-operative in order to assist them in making decisions with respect to production finance, hedging, and moveable asset finance. The report is available in Appendix C.

The co-operative's members mainly produce summer grain crops such as yellow maize, sunflower and soybeans, but also produce wheat as a winter crop. Of these crops, yellow maize and wheat are the main contributors to the turnover of the co-operative in terms of selling the production inputs to the farmers but also selling the grain, and hence are key crops to the co-operative. The co-operative also offers finance services to its members, including input cost finance, moveable asset finance (for example financing the purchase of a tractor), and also finance for running capital by means of monthly and production accounts. Other services include trading of grain on the South African Futures Exchange (SAFEX) on behalf of members, and also buying grain from members and selling it in the market to grain millers and other users of the different grains produced in the area.

Since the co-operative is involved with input cost finance and grain trading, it was critical to them to understand what the potential yellow maize price could be for the 2005/06 maize season. Understanding what the maize price could be, would have helped them in formulating credit policies for financing potential yellow maize plantings in their area, but also would have assisted with negotiating off take agreements with potential buyers of yellow maize. If yellow maize prices would have remained low for the 2005/06 season, it was important for the co-operative to finance only the farmers whose production costs were below a specified level and who could supply enough of their own capital or collateral for the co-operative not to take excessive risks by financing the crop. Also, if the maize price had the potential to increase, it would be important for the co-operative to negotiate off take contracts to such an extent that some advantage could be gained in case yellow maize prices did increase. Concurrently, since the co-operative traded grain on SAFEX on behalf of its members, it was important for the co-operative to understand what could happen with the yellow maize price, thereby ensuring it took the correct hedging positions in the market on behalf of its members.

Decisions therefore had to be made regarding: how much yellow maize production to finance in order to balance risk versus turnover; which farmers to finance given the potential profit and risks that were faced in financing yellow maize for the 2005/06 season; what hedging position to take in terms of futures contracts, calls and puts, and what contract specifications should be negotiated with potential yellow maize buyers, especially in the situation where yellow maize prices could potentially increase.

Since the decisions had to be made during September 2005 for the season of 2005/06, the market context was very similar to that of the pork company in case study one. The difference between the case studies is, however, in that the pork company wanted to hedge against rising prices, while the co-operative's wanted to be able to hedge in such a way to mitigate the risk of lower prices but at the same time be able to make use of opportunities should maize prices increase. They also didn't want to take excessive risks in terms of financing yellow maize production should maize prices remain low or even decrease further, since that would increase the probability of defaults on production loans, and hence could potentially have led to serious income problems for the co-operative. However, as the co-operative was dependent on maize production for income through selling inputs to farmers and also selling the final product, they also didn't want to finance too little yellow maize production.

The eventual market outcome that the co-operative did eventually experience was exactly the same as in case study one, since the time period during which both case studies occurred is the same. Hence, the reader is referred to the section of case study one for more details on market context during decision time and the eventual market outcome.

5.4.2 Application of the framework

As indicated in the introduction of this chapter, in order to test the hypothesis, one first needs to determine whether applying the proposed framework led the decision-makers in the co-operative to make good decisions. Making a good decision firstly depends on how well the facts and perceptions were considered at the time the decision had to be made, and hence how well the decision-makers understood the risks and uncertainties they were faced with. Secondly, given the decision that was made and the ultimate outcome of the market, did these decisions lead the co-operative to reach its intended goals? Hence, how robust was the decision in terms of attaining goals, given the way the market finally played out? To answer these questions and therefore execute the first part of testing the hypothesis, this section aims to present the facts in terms of how the co-operative applied the proposed framework of this thesis. The focus will be on the process of how the framework was applied; what the results were; what the decisions made based on the results were; what the actual eventual market outcome was, and therefore how well the decisions did in terms of assisting the co-operative to attain its goals, given the way the market eventually played out.

The framework proposed by this study was applied in co-operation with the farmer co-operative during a session that was held on the 9th of September 2005 at the head office of the co-operative. Five members of the co-operative were present during the session and took part in the discussions, namely, the head of finance; manager: input cost finance; manager: mechanisation; manager: grain trading, and manager: farm support services. Before applying the framework, an initial conversation was held with the attendees to determine their initial perceptions and expectations regarding the potential market outcome they were faced with, and hence their initial ideas on the decisions they had to make with respect to finance etc. After this conversation, the framework was applied, which entailed following the exact steps set out in chapter four and presented in Figure 4.1 on the proposed framework in terms of setting up the scenarios but also setting up and applying the stochastic model. This implies that a similar process was followed in terms of following the scenario thinking process and then the stochastic modelling process that was described in the first case study.

What this process entailed was firstly discussing the "name of the game" with the decision-makers. This meant that the decision-makers explained their business objectives, the relationships between these objectives and the external environment, specifically with respect to the yellow maize price. The result of the discussion was a clear understanding in terms of what variables or factors the decision-makers wanted to look at in order to make their respective decisions. Following the discussion of the name of the game, the history of the game was discussed in terms of historic trends of maize production in the co-operative's region versus substitute products such as soybeans and sunflower, as well as farmers' behaviour under different conditions. The co-operative's historic dependence on maize for income was also discussed.

Completing the discussion on the history of the game, the players of the game were identified and discussed in detail with respect to how they could influence the outcome of the game. During the discussion, the farmers' behaviour was again scrutinised to understand how they would or could react to different market conditions given their financial position, risk appetite, and ability to obtain finance to plant maize. Commercial banks' financing behaviour in terms of risk appetite and credit policy was also discussed in order to understand how financing activities would change given different market conditions. Traders on the futures market were also identified and discussed in terms of the impact they could potentially have on the market by means of the different hedging and speculative positions they would take under different market situations. Other players who were identified and discussed were importers and exporters of maize (whose actions would be affected by different potential exchange rate situations) and farmers (who have the ability to hold back stock given the low market prices that were prevailing at that stage in the market).

The discussion on the rules of the game indicated that the effect of variability in rainfall during planting time and during pollination of maize would be one of the key rules in terms of determining the area planted with maize, as well as the yield. Another rule identified was that commercial banks would be very reluctant to finance farmers should the price outlook for maize remain negative, in the sense that low prices would prevail.

This in turn would have forced farmers to plant less, since their risk appetite would also be much less should a market outlook of low prices prevail. Hence, a key rule was that the willingness to finance, and the ability to obtain finance, would be critical in determining the area planted with maize. The exchange rate was highlighted as a key rule in terms of influencing imports and exports of maize, and hence stock levels. This in turn was seen as a key input in terms of influencing grain buyers in terms of the positions they would take on the futures market, and how that would influence prices.

Following the discussion of the various steps that form part of the scenario thinking process, the decision-makers of the co-operative identified and realised that the following factors (and players) are key uncertainties that could lead to an unexpected outcome in terms of the yellow maize price for 2005/06, should these factor play out in a specific way. These factors were: farmers having weak financial positions that force them to plant significantly less hectares of yellow maize; an unwillingness of commercial financiers to risk financing yellow maize production due to excessively low profits and high risk; significant variability in rainfall patterns either during planting time or during late summer, which forces farmers to unexpectedly change yellow maize area plantings or causes lower than expected yields; unexpected opportunities arising in the African market that cause exports of yellow maize to be much higher than expected and hence result in much lower ending stocks than anticipated; and lastly, large buyers of yellow maize in the South African market who could change their hedging positions unexpectedly, thereby leading to unexpected changes in yellow maize prices on the futures market and eventually the spot market. After considering each of these uncertainties, it was decided that variability in rainfall was the key uncertainty, and as a result, three scenarios were developed around this key uncertainty. The resulting three scenarios were named and described as follows:

Scenario 1: “Hope”

The Rand/Dollar exchange rate moves between R6/$ and R7/$ for the remainder of 2005 and 2006. The majority of farmers experience cash flow pressure during 2005 due to excessively low grain prices, especially maize prices, which limits their ability to plant maize and grain for the 2005/06 season. Financiers are conservative with regards to financing production costs of (especially) maize for the 2005/06 season due to farmers' deteriorating financial positions. Along with financing problems and deteriorating financial positions of farmers, a dry early summer is experienced, which leads to additional declines in area planted with maize due to unfavourable planting conditions. The total decline in area planted is 40%, of which three quarters are caused by financing problems and deteriorating financial positions, while the reminder is caused by unfavourable planting conditions. The mid and late summer is again normal with respect to rainfall, leading to above-average yields of summer grains, especially that of maize. The world maize price increases by 10% during 2006 relative to 2005, crude oil decreases from \$55/barrel in 2005 to \$40/barrel in 2006, and the Rand/\$ exchange rate is R6,70/\$ in 2006.

Scenario 2: "Ballbreaker"

This scenario is similar to scenario "Hope" in the sense that macro-economic variables are assumed to be similar in terms of the levels and order in which they play out; that financiers' behaviour in terms of not taking risks on financing maize production has a similar impact on maize plantings, and farmers' deteriorating financial position forces them to also plant less maize. The main difference between "Hope" and "Ballbreaker" is that, in this scenario, the middle and late summer is assumed to receive less than normal rainfall, and hence yields are assumed to be as follows: white maize 2.1t/ha; yellow maize 2.2t/ha; sunflower 10% below average; soybeans 10% below average, and wheat also 10% below average.

Scenario 3: "Disaster"

"Disaster" is similar to the previous two scenarios with respect to macro-economic variables in terms of order of occurrence and the levels of variables. However, in "Disaster" the early summer is assumed to receive above-average rainfall, creating extremely favourable conditions for farmers to plant. The mid and late summer is assumed to be dryer than normal, leading to lower yields compared to the long-term average. Yields are assumed to be: white maize 2.5t/ha; yellow maize 2.6t/ha; sunflower and soybeans 10% lower than average, and wheat also 10% lower than average.

The outcome of the process was that the three scenarios were documented. The three scenarios were also modelled by the model of Meyer *et al.* (2006), without including probabilities and through adjusting functional forms, parameter values, and the model structure was based on descriptions provided through the respective scenarios. The results for the three scenarios, with respect to the key output variables in terms of yellow maize price, are presented and compared to the eventual actual outcome in Table 5.2.

Table 5.2: Case study two: Framework results versus actual market outcome for 2005/06 season

	Framework application results			***Eventual actual market outcome***
Variable	**“Hope”**	**“Ballbreaker”**	**“Disaster”**	
Production (1000 tons)	2711	1430	2254	*2315*
Ending stocks (1000 tons)	639	247	465	*440*
Human consumption (1000 tons)	253	249	245	*290*
Feed consumption (1000 tons)	2856	2908	2724	*3260*
Exports (1000 tons)	238	82	213	*117*
Imports (1000 tons)	238	1021	363	*930*
Producer price (R/ton)	1106	1198	1264	*1414.6*

From table 5.2, it is clear that the scenario results indicated a significant possibility of an increase in the yellow maize price due to the occurrence of unexpected events such as changes in rainfall. Hence, by providing these results to the five decision-makers of the co-operative that took part in the exercise, it was firstly possible to show them that, although improbable and unexpected by both them and the general market, a significant and almost doubling yellow maize price was plausible and possible. This was against their initial expectations in the sense that they expected prices to remain low during the 2005/06 season.

After concluding the scenario thinking exercise, the stochastic modelling exercise was conducted, as stipulated in the proposed framework. During the stochastic modelling process, the insights gained from the scenario thinking exercise were used to inform which variables and inter-relationships to focus on. The modelling exercise in return provided some objective quantitative measures to express the impact of the players and rules of the game on the potential outcome of the game. Hence it facilitated a process whereby the decision-makers were able to develop a more objective view of these factors as opposed to what they expressed during the scenario thinking exercise. Identifying the key uncertainties also facilitated the stochastic process to determine which factors to assign a probability distribution to, and to which factors no probabilities (objective or subjective) could be assigned to. This therefore indicated to the decision-makers what the uncertainties were and what the risk factors were. Consequently, the model was used to simulate a probability distribution for yellow maize for the 2005/06 season, which indicated that the yellow maize price was likely to stay at around R800/ton and most probably fall even lower.

After completing the application of the framework, two sets of results were on the table: firstly, the three quantified scenarios each indicating a deterministic yellow maize price given the scenario structure, and secondly, a probability distribution simulated by the stochastic model, indicating a minimum, mean, and maximum yellow maize price along with the probabilities of each occurring. The results were presented to the decision-makers, and comparisons were made between the scenario results and the probability distribution. As a result, they realised that although the probability distribution indicated that the probability of a maize price increase was small, the possibility did indeed exist for the maize price to actually increase dramatically and unexpectedly. This made them realise that the financing of maize plantings should be done in a less conservative manner than what they initially thought, as farmers had a better possibility of making profits than what was initially thought. From the scenario results, they realised just how critical rainfall was in terms of influencing the market outcome, and hence decided to only finance those farmers who had prepared their fields technically correctly, and who had used the correct planting practises and cultivars. They reasoned that only farmers' whose fields were prepared correctly, and had correctly planted crops, would produce crops robust enough to survive variability in rainfall. Apart from finance, the co-operative realised that, should prices increase dramatically, replacement machinery would be at a much higher level in the aftermath of the 2005/06 harvest as farms would be very profitable. As a result, the co-operative made the decision to position themselves in such a way that they can deliver greater quantities of equipment to farmers, should these farmers decide to replace more machinery due to good profits from maize. The grain trading manager also decided to take hedging positions in such a way as to be positioned correctly should a dramatic increase in the maize price occur. Whether the co-operative did negotiate differently with potential buyers based on the information supplied through the scenario and stochastic model is not clear, since all negotiations were confidential and the researcher was not able to gather information on that.

Therefore, comparing their initial expectations to the final decisions and expectations after the decision-makers went through the process of applying the framework and hence through the learning and re-perception process, it is quite evident that applying the framework did alter their perceptions with respect to risk and uncertainty and hence altered their decisions. Given the eventual outcome of the market in terms of the 2005/06 season, the altered decisions due to altered perceptions as a result of using the framework, did assist the co-operative in making good decisions regarding financing maize production, taking hedging positions, and ensuring that more machinery was available for farmers to buy due to improved profitability at the end of the 2005/06 season. As a result of these decisions, the co-operative made good profits and provided their members with good advice on hedging.

5.4.3 Application of the stochastic model

The second part of testing the hypothesis of this thesis entails testing whether the application of the framework or the application of the stochastic model would have led to better decisions, given the farmer co-operative's business context and given the way the market eventually played out. Hence, the purpose of this section is to do the "back-in-time" exercise explained in the introduction of this chapter, in order to deduce what decisions would have been made if only a stochastic model was used by the decision-makers of the co-operative. These deduced decisions will again be compared to the decisions that were made based on using the framework of this thesis, and through the comparison it will be determined which of the two (namely stochastic modelling on its own or the proposed framework of this thesis) would have led to better decisions.

The exact same modelling process and assumptions are followed as in case study one, since both case studies apply to the exact same situation, although the types of decisions pertaining to the situation were different. Hence, the exact same results and conclusion can be reached in terms of whether the stochastic model did sufficiently capture the risks and uncertainties which led to the actual market outcome. The conclusion is therefore again that, although the probability distribution of the yellow maize price would have included the eventual actual market price of R1414.60/ton, the probability distribution by the stochastic model would have indicated that the most likely price would have been much lower, namely R858/ton. Also, the probability of the yellow maize price remaining below the estimated expected price of R858/ton was much higher than it increasing above R858/ton. Hence, the order and occurrence of events that eventually led to the actual market outcome would not have been captured sufficiently by the model, and hence using only the model in facilitating the relevant decisions would likely have led to less robust decisions, possibly causing the co-operative to make a loss.

Since the initial expectations of the co-operative decision-makers were that maize prices were likely to stay low for the 2005/06 season, the stochastic modelling results would only have strengthened their initial expectations and would not have led them to question their assumptions (on which their expectations were based). It can therefore be argued that in a case where decision-makers would only have used the stochastic model to guide making decisions regarding financing maize, hedging, and supplying equipment to farmers with a view to the 2005/06 season, they would most likely have been much more conservative in financing maize, taking hedging positions, and supplying equipment. This would have resulted in the co-operative missing opportunities that were only later realised as the market started playing out and maize prices started to increase significantly and unexpectedly. Hence, using the stochastic modelling results would have resulted in the co-operative not reaching their initial goals of selling adequate quantities of inputs, procuring adequate quantities of maize to sell to off takers, selling adequate quantities of machinery and lastly, advising and taking correct hedging positions for both the members and the co-operative so as to profit from increasing maize prices.

5.4.4 Stochastic model versus framework

A similar conclusion to that of case study one can be reached when comparing the stochastic modelling results and the application of the framework, particularly with regards to capturing the risks and uncertainties that eventually led to the actual market outcome. Although the stochastic model results would have indicated that such an outcome is indeed possible, the indication would have been that it is highly improbable. Using just the stochastic modelling results, the co-operative would likely have reached the conclusion that the yellow maize price is to remain low and probably below the estimated expected value. This would have led to incorrect decisions with respect to financing of maize, hedging positions, as well as provision of equipment to farmers during the 2005/06 season.

Applying the framework resulted in the decision-makers adjusting their perceptions and expectations due to the learning process they experienced, whence they did indeed realise that a doubling in the yellow maize price is indeed possible and plausible. This resulted in them altering their initial thoughts about what decisions to take, and therefore resulted in decisions that better positioned the co-operative with regards to the eventual market outcome. Hence, by applying the framework, risk and uncertainty was captured and communicated much more sufficiently than by using only the stochastic model. Therefore it can be concluded that in case study two, applying the framework led to more robust and better decisions in the face of risk and uncertainty compared with only using the stochastic model to guide decisions.

5.5 Conclusion and Summary

The aim of this chapter was to present two case studies where the proposed framework of this thesis was applied in order to assist the two companies to make robust decisions in the face of risk and uncertainty. The objective of presenting these case studies was to test (through comparison) whether applying a stochastic model or applying the proposed framework presented in chapter four of this thesis, would have captured risk and uncertainty more sufficiently given the specific decision context faced by the decision-makers. Hence, testing was conducted to determine whether applying the proposed framework would have led to good and better decisions than using only stochastic modelling.

In both case studies it was concluded that applying the proposed framework did in fact lead to good, better or more robust decisions than only applying the stochastic model, given the eventual actual outcome of the market as a result of the occurrence of risky and unexpected events. The advantage of the framework was that it included a simultaneous thought process on both risk and uncertainty, while applying only the stochastic model focused only on risk. Hence, applying only the stochastic model assumed that normality will reign; while applying the framework provided the decision-makers with two hypotheses, namely, that normality will reign but also that abnormality could occur. In both case studies, abnormal events and hence unexpected events occurred, which resulted in a totally unexpected market outcome. However, since both companies had applied the framework, they were in a position to perceive the possibility of this unexpected market outcome, and hence both companies were able to position themselves to survive and even take advantage of this unexpected market outcome. Should normality have reigned, in that the future was like the past and present, they would still have been positioned correctly as risk, and hence the assumption of normality, was also part of the thinking and learning process associated with using the framework.

CHAPTER 6: Illustrating a current application of the proposed framework: the case of a commercial bank

6.1 Introduction

The third case study is of a South African commercial bank that has applied and is currently still applying the proposed framework of this study in order to make strategic financing decisions with respect to maize for the 2008/09 and 2009/10 seasons. This case study serves the purpose of showing how the framework was applied for a two-year period starting in the beginning of 2008, in order to develop views on risks and uncertainties that could potentially influence the market situation. Hence, the scenarios and modelling results that were developed in the beginning of 2008 still apply to the current situation, and therefore this case study can be seen as a "live" example of the application of the proposed framework.

Two different sessions were held in 2008 with the commercial bank's decision-makers. The first was on the 6th of February 2008 and the second was in April 2008, during which session the proposed framework was applied. Bank personnel who were present during the sessions were the risk manager, the acting head of the agricultural department, and a market analyst. Most of the information presented in this chapter is from the two reports that were compiled based on the discussions and simulations done during the two sessions. The two reports are available in Appendix D.

6.2 Background

The commercial bank to which this case study applies, is one of the major providers of credit to commercial and emerging farmers in South Africa. The credit is provided in three main forms, namely, production credit, moveable asset finance, and finance of land. The commercial bank needed to develop a strategy on how to provide and manage credit exposure with respect to the 2008/09 season and the 2009/10 season. Thus, it was important for the bank to develop views on risks and uncertainties that could significantly influence the outcome of the maize market over a two-year period, starting in 2008.

Based on these views, the bank had to develop robust strategies in terms of credit provision and management that could withstand these risks and uncertainties thereby ensuring that credit write-offs are minimised.

At the time of applying the proposed framework of this thesis in co-operation with the commercial bank, namely February and April 2008, no expectations whatsoever existed in the minds of the bankers involved in the sessions as to the possibility of the financial meltdown that eventually started playing out from July 2008 and onwards. As a result of the financial and economic meltdown, oil prices have decreased from $147/barrel in July 2008 to around $45/barrel in December 2008; international and domestic soft commodity prices have dropped significantly; the Rand/$ exchange rate has depreciated from around R6.50/$ in July 2008 to R10.5/$ in December 2008; inflation has decreased; most major economies went into recession, and international trade grinded to a halt.

Since the situation is still playing out, no eventual "actual" market situation exists in order to compare whether the application of the proposed framework of this study led the decision-makers of the commercial bank to make good decisions. Therefore, the results of the framework application as well as the stochastic model are compared to how the market situation has played out from May 2008 to December 2008 to test whether the risks and uncertainties that led to the current market situation (which accounts for the 2008/09 season) were sufficiently captured. Based on these comparative test results, one can argue which approach better captured the risks and uncertainties more sufficiently given the way the market played out from May 2008 to the time of writing this thesis, namely December 2008. In other words, the test results will be used to show which approach would potentially have assisted the decision-makers most in developing robust strategies to withstand the unfolding market situation which is currently resulting due to specific risky and unexpected events occurring.

In order to test whether applying the stochastic model or the proposed framework would best help decision-makers to develop robust strategies for the 2009/10 season, the results of both procedures are compared with current expectations of futures prices for the

2009/10 season. These prices are obtained from the South African Futures Exchange (SAFEX). After comparing the results with current expectations, a conclusion will be presented on which approach is most likely to facilitate robust decisions in the face of currently perceived risks and uncertainties with respect to the 2009/10 season.

6.3 Application of the framework

Two sessions were held with the bank's decision-makers, the first in February 2008 and the second in April 2008. During these two sessions the proposed framework of this thesis was applied, as stipulated in chapter four. First of all, the name of the game as well as the history of the game was discussed. From this discussion, it firstly became clear what the goals of the bank were, namely, minimising the risk of loan defaults while maintaining market share. Hence, it was important for the bank to finance maize production, but at the same time mitigate the risk of loan defaults. This would be done by following the correct strategy in terms of identifying and analysing potential clients and also structuring clients' debt correctly by means of using different combinations of finance products. Structuring debt correctly would mean minimising the risk of loan defaults as positive cash flow would be improved.

The discussion of the history of the game mainly focused on the maize industry, and historical trends and inter-relationships within the maize industry. The reason we only discussed the history of maize was because the bank was reluctant to provide detail on its exposure to the maize industry, particularly with regard to the amount of finance provided as well as past approaches toward financing maize production, as that would have meant disclosing confidential information. From the discussion, it became clear how important the macro-economic situation was in terms of its influence on maize prices, especially due to the growing link between fossil fuels and maize as a result of biofuel production.

Moving on to the next step, the players influencing the game were discussed in detail. Players identified that could significantly influence the macro-economy and therefore the maize industry were: global investors; the presidential race in the US (Obama potentially becoming president); the reaction and measures taken by the Fed should economic conditions turn bad; OPEC and its reaction towards an economic crisis; the ability of Eskom to correct power problems within South Africa and thereby positively influence investor perceptions; and lastly, the outcome of the power struggle between the ANC and the government and how that would influence investor perceptions.

Following the discussion on players of the game, the rules of the game were debated. Two key rules were identified that would, to a large extent, determine the "playing field" on which the game would be played. The first was the rule that investors generally are risk averse. Therefore, should economic problems arise, these investors would flee to safe havens in whatever form these safe havens might present themselves. It might be commodities, a specific geographic market, or an investment instrument. However, what was important was that this rule would influence exchange rates, trade patterns, commodity prices and general macro-economic variables such as inflation and interest rates. The second rule was that the US was still the dominant economic power in the world, and therefore if the US picked up severe economic problems, it would mean global economic problems. Some uncertainty, however, existed in terms of the impact of US economic problems on China, India and the EU. Most market commentators at that stage argued and predicted that these three economic powers would have enough internal economic momentum to sustain economic growth paths regardless of what happened in the US.

Following the discussion on the history of the game, players of the game, and rules of the game, the key uncertainties were identified and discussed in detail. These were the following factors and players: the US economy going into a recession or not, and the impact of this on China, India and the EU.

As a result, three different scenarios were developed and simulated by means of the model of Meyer *et al.* (2006) through adjustment of functional forms and parameters based on each of the described scenarios, and also **without** including probabilities to ensure that uncertainty is technically captured in the correct manner. The scenarios were set up and described as follows (directly taken from the second report written for the commercial bank, BFAP, April 2008)[6]:

"SCENARIOS FOR 2008/09

In order to draw plausible macroeconomic scenarios, the rules of the game, players of the game, key uncertainties and wild cards need to be identified and explored.

Rules of the game:

- ***Investors are generally risk averse****: the implication of this driver is that investors will seek havens where the level of risk is in line with the level of potential profit. Hence, in a situation where the world economy is unstable, investors will in general opt for the less risky and stable investment environment.*
- ***In general, the US economy has a significant impact on the rest of the world's economy:*** *the implication is that if the US sneezes, the rest of the world gets a cold. Except maybe for China and India?*

Key uncertainties:

- ***Will the US economy go into a recession?*** *At this stage nobody is sure of the answer to this question. Some give it a 50% probability, others say it's a given.*
- ***Should a US recession occur, what will be the macroeconomic impacts specifically on the EU, China and India?*** *In case the EU, China and India have enough internal momentum to keep their economies growing independently of a US recession, investors will see these economies as a haven. This implies international funds could flow towards these three economies, depending on general risk of the investment environment and the interest rate differentials, leaving the rest of the world economies high and dry. If the EU, China, and India do not have enough internal momentum, implying that a US recession also leads their economies into a recession, investors have very few safe havens left and low risk investments will become an attractive option e.g. gold, money market etc.*

Wild Cards and players of the game:

- ***If Obama becomes president of the US****, will it have a significant impact on the morale of US citizens leading to optimism and hence influencing investment in the US positively? Also, what will be the impact on the "war against terror" and hence how will it influence key diplomatic relationships e.g. the Middle East, Europe and China. Also, if the stance against the "war on terror" changes significantly, it could have a significant impact on Chinese economic growth since Chinese policies are geared towards an open, free and stable world economy.*
- *It is unknown if the* **drastic monetary policy measures taken recently by the Fed** *will swing the US back unto a growth path, and if so, how soon. Hence, will the US economy first go into a shallow recession, or will it stabilize at a very low growth level and then take off again?*

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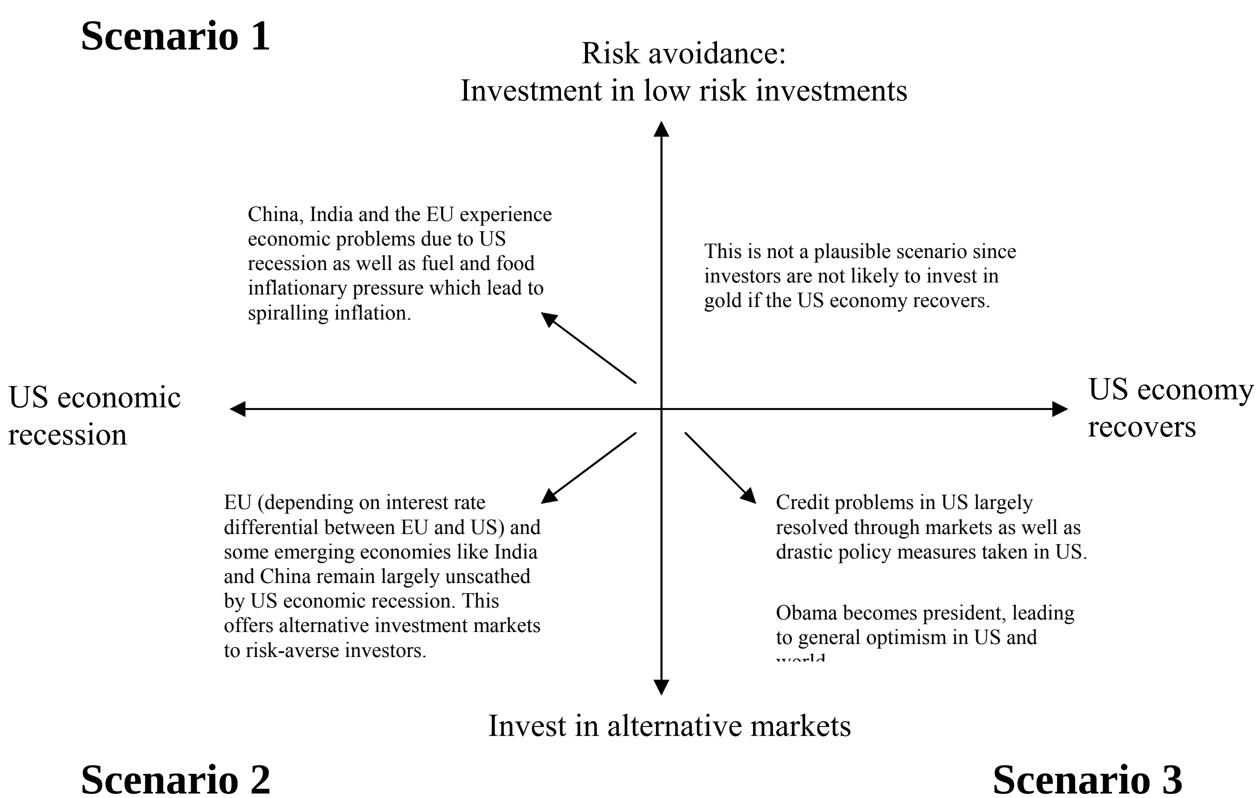
[6] The exact report is presented in order to indicate to the reader the true nature of the report that was presented to the decision-makers as early as April 2008. This serves to show exactly how the framework was applied and what the results were.

- *If a US recession does occur, what will be the* **reaction of OPEC** *be in terms of changing production policies? If they increase production or keep it stable to lower oil prices and, therefore, decrease energy costs to jump-start the world economy, the recession might be shorter and shallower than expected. If oil prices remain high and stable, the recession might last long as much fear. This could have a significant negative impact on Chinese economic growth.*
- *Will* **Eskom** *be able to manage power crisis successfully and assure investors that South Africa is a good long-term investment destination?*
- *Will the* **power struggle between the present government and the newly elected ANC executive committee** *have a crippling effect on the perception of South Africa as a potentially stable and prosperous investment haven or will the ANC and the present government manage to collaborate on key issues and hence create a perception of a stable and prosperous country.*
- ***Will Jacob Zuma become the next president of South Africa?*** *If he does, will he continue on the current policy paths, or will he drastically change policies in order to create a more social-democratic state driven by more socialist types of policies?*
- ***Will the Zimbabwe situation be solved in such a manner that the perceptions of international investors will become much more positive in terms of Southern Africa as a stable and profitable investment area?***

Scenarios



Note: The key uncertainties form the two axes of the game board.

Implications of scenarios

Scenario 1:

- *Rand weakens significantly against the US$ and the €.*
- *SA inflation generally high due to high world inflation, but follows a declining trend as world economy weakens and global inflation pressure weakens.*
- *Interest rate, therefore, remains high but also follows a sharper declining trend than expected due to SARB being careful of adjusting interest rates because of frail economy.*
- *Oil price at first decrease significantly and then moves mostly sideways on the back of slowing demand, and unwillingness from OPEC to adjust production and production capacity.*

Scenario 2:

- *Oil price remains high since economies in emerging countries continue to grow. US economic problems have less of an impact on these countries' economies.*
- *Rand weakens against other currencies including US$, because risk averse investors rather invest in more stable and growing economies.*
- *Inflation remains high because of stable and high oil price, high international agricultural commodity prices, a depreciating Rand, as well as the inflationary whiplash of services inflation. Food inflation is a strong driver in this scenario, but the impact does however lessen over time since emerging economies keep growing and hence consumers can afford and get used to higher prices.*
- *Interest rate, therefore, remains stable but high. SARB does not increase interest rates in fear of seriously damaging already frail economy.*

Scenario 3:

- *Dollar strengthens against all currencies due to new optimism amongst investors. This causes the Rand to weaken significantly, especially due to political uncertainties in Southern Africa leading to investors becoming risk averse towards SADC investments.*
- *Oil price increase significantly due to renewed global economic growth. Is $200/barrel of oil possible in this scenario as forecasted by an international institution during the week of 4 May 2008?*
- *Rand weakness and increasing oil prices lead to significant inflationary pressure in SA.*
- *Interest rate remains high."*

The purpose of presenting the actual report directly, is to show exactly how the scenarios were developed, written, and how the implications of each scenario was presented to the bank's decision-makers. Based on the scenario results, scenario one was deemed to be the most important scenario as it was deemed to hold the greatest threat to the bank at the time the decision had to be made, namely April 2008. As a result, the model of Meyer *et al.* (2006) was used to simulate scenario one, **without** including probability distributions in order to include uncertainty in a technically correct way. Functional forms and parameters were adjusted based on the description of the scenario so as to correctly reflect the scenario story by means of the model. Based on the model simulations, the assumptions and results were as follows (taken directly from the second report, BFAP, 2008)[7]:

"The scenario presented below indicates a global economy, which is severely affected by a recession in the US economy as well as overheating due to excessive high fuel and food prices. The assumption is, therefore, that the BRIC countries (Brazil, Russia, India, and China) do not have enough internal momentum to keep their economies growing at rates seen during the past few years, and also that inflationary pressure (due to excessive fuel and food prices) forces the economic growth in these countries to slow down in order to avoid excessive overheating. The macroeconomic assumption underlying this scenario is presented in Table 8[8].

Table 8: Scenario Projections: Economic indicators

		2008	2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	105.00	80.00	79.47	78.39
Population	Millions	47.63	47.79	47.96	48.13
Exchange Rate	SA c/US$	780.00	900.00	945.00	992.25
South African Real GDP	%	3.00	3.00	4.00	3.50
South African Real per capita GDP	R/capita	18,017	18,557	19,300	19,975
Interest Rate (Prime)	%	15.00	14.00	12.00	10.00

Due to a change in the interest rate differential between the EU and the US, the Dollar strengthens, which forces oil prices down. On the back of this, the pressure on the demand for oil slightly weakens since trade and consumption of general goods and commodities slow down. The result is that oil prices drop unexpectedly to levels of around $80 per barrel[9].

The impact on the South African economy is a slowdown in economic growth, and a slowdown in inflation, which forces the Reserve bank to decrease interest rates more than expected in an attempt to get the economy back on the targeted growth path. This, however, does not happen and economic growth is generally below the 4% level except in 2010.

[7] The writings in the report are again taken directly from the report to show the reader exactly how the results and implications were presented to the decision-makers at the time they had to take a decision, namely April 2008.

[8] Table numbers are as was included in report.

[9] This sentence was written at a time when market forecasts of highly reputable institutions indicated a crude oil price of around $150 to $200 by the end of 2008. As a result, $80/barrel was seen as a totally crazy idea! Who would have thought an oil price of $44/barrel on 5/12/2008 was possible?

Table 9: Scenario projections - World commodity prices:

		2008	2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	227.95	190.25	160.90	156.51
Wheat US No2 HRW fob (ord) Gulf	US$/t	243.67	203.38	172.00	167.30
Sorghum, US No.2, fob, Gulf	US$/t	223.07	171.42	149.43	144.82
Sunflower Seed, EU CIF Lower Rhine	US$/t	723.74	578.12	553.79	556.24
Sunflower cake(pell 37/38%) , Arg CIF Rott	US$/t	316.97	246.11	221.02	213.55
Sunflower oil, EU FOB NW Europe	US$/t	1860.00	1417.14	1407.75	1388.62
Soya Beans seed: Arg. CIF Rott	US$/t	490.98	451.00	404.67	408.62
Soya Bean Cake(pell 44/45%): Arg CIF Rott	US$/t	422.36	359.20	304.29	289.16
Soya Bean Oil: Arg. FOB	US$/t	1423.85	1084.84	1077.65	1063.01

Source: BFAP, 2008

Table 10: Scenario projections - SA commodity price projections:

		2008	2009	2010	2011
White maize (SAFEX)	R/ton	1976.2	1870.0	1746.8	1877.8
Yellow maize (SAFEX)	R/ton	1966.8	1885.4	1644.3	1709.7
Sorghum	R/ton	1692.1	1486.5	1361.3	1417.8
Wheat (SAFEX)	R/ton	3871.2	3350.0	3487.0	3636.9
Canola	R/ton	4091.6	3794.6	4277.3	4638.2
Sunflower (SAFEX)	R/ton	4652.7	4213.9	4216.9	4607.6
Soybeans (SAFEX)	R/ton	3818.4	4002.8	3783.0	3994.0

Source: BFAP Sector Model

The main trends in the scenario projections can be summarized as follows:

- *Due to the general slow down in the economy, world commodity prices decrease rapidly in 2009 and 2010. This does, however, not imply that prices pull back to historical levels. Commodity prices still remain relatively high.*
- *Commodity prices in the local market are expected to decrease in 2009 and 2010. As a result, farmers will respond to the lower commodity prices by reducing the area planted to field crops, especially on the back of high input costs, which are in general sticky and therefore do not decrease at the same rate as commodity prices. This causes pressure on profit margins and also increases the risk of production significantly. The decrease in area (and supply), causes prices to rise again by 2010."*

From the scenario structures and results presented above, it is clear that the financial market meltdown as well as the economic meltdown that is currently being experienced, were captured in the decision process as early as February and April 2008. Although the simulated price levels based on the scenario structure are still higher compared to what is happening in the market at the moment, the occurrence of risky and unexpected events, the order of event occurrence, and the resulting implications in terms of decreasing prices, were captured and communicated to the decision-makers via the reports fairly correctly.

Following the scenario thinking process, the various steps of executing the stochastic modelling process were followed, as stipulated by the framework presented in chapter four. During each of these steps, the information and insights gained from the opposing step in the scenario thinking process were used to guide the process on how to set up the model and simulate the maize prices. Concurrently, by going through the modelling steps in terms of quantifying the trends and inter-relationships, some objective and quantitative information was added to the thinking process. This in turn assisted the bank's decision-makers to form more objective perceptions on some of the variables and players thought to influence the market situation. As a result of following the stochastic modelling process, a probability distribution were calculated indicating that maize prices (both white and yellow), were likely to stay above R2000/ton for the 2008/09 season as well as for the 2009/10 season. This concurred with the initial expectations of the bank's decision-makers.

However, by comparing the scenario results with the stochastic modelling results generated by applying the framework correctly, it was possible for the bank's decision-makers to understand that a situation wherein the global economy could almost implode was quite possible, although highly improbable. From the scenario results it was also gathered that, should the economy implode, an unexpected decrease in agricultural commodity prices was quite possible and plausible. At the point of developing these scenarios, the possibility for scenario one to play out was deemed "unthinkable" as all opinions, views, forecasts, and technical reports pointed to a situation in which the market would and "could" only increase from the levels of April 2008. Hence, a meltdown was thought to be a totally crazy idea.

The application of the proposed framework of this study, however, clearly pointed to such a "crazy" possibility, and in fact quite accurately captured most of the dynamics that eventually caused the meltdown. Hence, as a result of presenting the scenario results, the decision-makers within the commercial bank realised that such a crazy and unthinkable event was quite possible and plausible. This resulted in them starting to question their initial assumptions and therefore expectations, and hence forced them to change their perceptions as to the potential outcome of the market. As a result, the bank's decision-makers were in a position to realise that such an event is possible and plausible, and hence re-perceived reality in terms of the actual risks and uncertainties faced at the stage of taking a decision. Consequently, the bank decided to adjust their credit provision and management strategy, which ultimately enabled them to withstand the onslaught of the eventual risks and unexpected events that led to the current market turmoil. This means that they adjusted their approach towards analysing and financing clients, specifically with respect to the criteria used to analyse a business as well as the type of product used to finance the business[10].

Based on the adjusted credit provision and management strategy, the bank thus far appears to be riding out the storm quite successfully. Hence, through making these decisions based on the results of applying the framework proposed by this thesis, they have been able to limit debt write-offs as a result of the current financial and economic conditions. This shows that the decisions made in April 2008 regarding the situation that is playing out now, were good decisions. Therefore, one can conclude that by using the proposed framework of this thesis, the commercial bank was able to learn and accurately perceive the true nature of the risks and uncertainties they were faced with in the beginning of 2008, and as a result, they were able to make good decisions in terms of credit provision.

6.4 Application of the stochastic model

In order to test whether the application of the framework would have led to better decisions compared to only using stochastic modelling, it is important to again do a "back-in-time" exercise in the sense of doing only a stochastic modelling exercise, then deducing what the decisions would have been based on the modelling results, and then

[10] Due to the confidential nature of credit provision policy and credit provision strategies, no details can be supplied in terms of the exact nature of the changes that occurred with respect to credit provision and management as this might convey, knowingly or unknowingly, sensitive information to competitors in the market.

comparing it to the decisions that were made by applying the proposed framework of this thesis.

Therefore, in this section, the stochastic model is applied on its own to test whether it would have sufficiently captured risks and uncertainties which would have led to the market situation that appears to be playing out at the time of writing this thesis. Hence, the model is applied from the perspective that the bank's decision-makers would have used the model in April 2008 to run a stochastic simulation on white and yellow maize in order to develop a view of the risks and uncertainties that could potentially result in different outcomes for the maize market for the 2008/09 and 2009/10 maize production seasons. Based on these gained insights from the modelling exercise on risk and uncertainty, it is assumed that the decision-makers would have developed specific strategies to provide and manage credit and simultaneously minimise the chance of write-offs based on the possibility of farmers making losses. Hence, the question is: given the view on risk and uncertainty that could have been developed through applying the stochastic model, would the eventual strategies have been robust enough to withstand the risks and uncertainties that are currently causing the turmoil in the financial markets and the global and domestic economy?

To apply the model, the key trends and inter-relationships for the period before 2008 are analysed and assumptions are made on the exogenous variables, in terms of trends and probability distributions for 2008 and 2009. This ensures that a logical and scientific view is taken on the potential market outcome for the 2008/09 and 2009/10 maize seasons. The trends for the period 1998 to 2007 are presented in Tables 6.1 to 6.4 to serve as background on how the assumptions are developed with regard to the values of the different exogenous variables for 2008 and 2009. Also, since the model of Meyer *et al.* (2006) is used, and since it already exists and is based on the historical trends and inter-relationships presented in tables 6.1 to 6.4, no new model or new functions are estimated for the sake of this modelling exercise. The correlation matrix used in the simulations to correlate the different exogenous variables are presented in Appendix E, as well as the resulting probability distributions of the exogenous variables and hence assumed values for 2008 and 2009.

In terms of domestic maize market trends, it is clear from Tables 6.1 and 6.2 that price increases occurred from 2006 onwards. The reason for these increases was mainly attributed to increasing world maize, grain and livestock prices (as presented in Table 6.3), an increase in crude oil prices due to a tightening supply and demand situation for crude oil, a decrease in maize plantings in 2005/06 season, as well as dry weather conditions during the 2006/07 season which led to below-average maize yields. Apart from these factors, bio-ethanol production from maize was introduced in the USA in 2006 on a major scale, while biodiesel production from oilseeds was also introduced in the EU and other parts of the world in 2006. The introduction of biofuels was mostly in response to significantly increasing crude oil prices and uncertainty with respect to future supply of crude oil due to the perceived unsustainable exploitation of crude oil reserves in the world. The US$ was also depreciating against other major currencies, and since most commodities are quoted in US$, it led investors to invest in commodities to serve as a natural hedge against a weakening US$. The result was significant increases in global commodity prices, including maize prices (IFPRI, 2007, USDA, 2008).

Table 6.1: White maize trends

Variable	2000	2001	2002	2003	2004	2005	2006	2007
Area harvested (1000 ha)	2003	1596	1842	2083	1842	1700	1033	1625
Yield (t/ha)	3.22	2.9	2.99	3.06	3.15	3.59	4.25	2.66
Production (1000 tons)	6440	4636	5576	6366	5805	6108	4392	4315
Feed consumption (1000 tons)	783	446	105	641	733	543	787	1100
Human consumption (1000 tons)	3473	3858	3643	3687	3766	3731	3718	3715
Ending stocks (1000 tons)	1273	559	1718	2123	2402	2301	1630	690
Imports (1000 tons)	0	47	274	33	0	0	0	50
Exports (1000 tons)	861	812	817	1069	712	1844	480	370
Producer price (R/t)	672	1303	1539	1004	823	854	1422	1798

Source: BFAP, 2008

Table 6.2: Yellow maize trends

Variable	2000	2001	2002	2003	2004	2005	2006	2007
Area harvested (1000 ha)	1227	1111	1174	1017	1001	1110	567	927
Yield (t/ha)	3.23	2.97	3.07	3.1	3.67	3.56	4.08	3.03
Production (1000 tons)	3969	3300	3734	3026	3677	3947	2315	2810
Feed consumption (1000 tons)	2456	3011	3373	3078	3012	3468	3260	3280
Human consumption (1000 tons)	212	247	249	245	262	251	290	260
Ending stocks (1000 tons)	842	643	992	501	746	868	440	369
Imports (1000 tons)	0	348	651	408	219	360	930	1100
Exports (1000 tons)	627	523	371	116	120	402	117	106
Producer price (R/t)	691	1168	1293	1047	863	794	1414	1852

Source: BFAP, 2008

As explained, the South African economy and maize industry is small and open in comparison to other major global economies and maize producing countries. Because of this, a change in the world price can have a very direct impact on domestic maize prices, depending in the domestic supply and demand situation. Should there be a domestic shortage or oversupply of maize, the South African maize market is directly integrated with world markets, and hence global price variations are transmitted directly into the domestic maize market (Meyer *et al.*, 2006). The result is that domestic maize prices will be closely linked to world market price movements. Since South Africa was in an oversupply situation in terms of maize during the 2004/05 season, and suddenly in an undersupply situation in the 2005/06 season, it meant that the increase in global commodity prices since 2006 (Table 6.3) had a very direct impact on domestic prices. As a result, domestic maize prices increased to historically high levels, and remained there during 2006 and 2007.

Table 6.3: World grain and livestock price trends

Variable		2001	2002	2003	2004	2005	2006	2007
Yellow maize, Argentinean Rosario	US$/t	89	102	109	89	84	148	152
Yellow maize, US No. 2	US$/t	92	102	104	96	90	159	164
Wheat US No. 2 HRW	US$/t	125	162	151	152	160	208	215
Sorghum US No. 2	US$/t	92	102	111	94	93	164	162
Sunflower seed, EU, CIF, Lower Rhine	US$/t	287	300	285	275	281	326	401
Sunflower cake (pell 37/38%), Argentinean CIF Rotterdam	US$/t	110	110	166	105	113	128	178
Sunflower oil, EU NW Europe	US$/t	587	650	660	675	637	693	846
Soybean seed, Arg. CIF Rotterdam	US$/t	203	240	312	233	247	287	335

Variable		2001	2002	2003	2004	2005	2006	2007
Soybean cake, (pell 44/45%), Arg CIF Rotterdam	US$/t	174	183	275	195	197	224	276
Soybean oil Arg. FOB	US$/t	412	585	630	530	555	645	684
Nebraska, direct steer fed	US$/t	1294	1169	1867	1868	1924	1882	2024
Chicken, US 12-city wholesale	US$/t	1303	1225	1366	1634	1561	1419	1684
Hogs, US 51 – 52%	US$/t	954	714	869	1157	1103	1041	1038

Source: FAPRI, 2008

As oil prices increased further during the early part of 2008 (Table 6.4), at the time the commercial bank had to make the decision in terms of financing provision and management, market expectations were that commodity prices would only increase in the future. Hence, it was expected that domestic maize prices would remain high during the 2008/09 maize season as well as in the 2009/10 season. In addition to this, expectations were that international and therefore domestic commodity prices would remain high for a much longer period than just two years, since global stock levels were low, economic growth was strong, and hence demand for commodities was growing significantly (IFPRI, 2007, USDA, 2008, FAPRI, 2008, FAO, 2008).

Table 6.4: Macro-economic trends

Variable	Unit	2001	2002	2003	2004	2005	2006	2007
Oil price	$/barrel	22	24	28	36	50	60	68
SA population	Millions	44.5	45.4	46.4	46.5	46.8	47.3	47.45
Exchange rate	SA cents/$	977	943	707	622	639	676	709
Real GDP per capita	Rands	14321	14772	14996	15499	16069	16653	17492
Disposable income of households	R million	645521	727116	791972	874566	964520	1075127	1064765
Disposable income of household per capita	Rands	14500	16016	17068	18808	20609	22730	22441
GDP deflator	Index ‘95	157	174	182	193	202	216	235
CPI food	Index ‘95	147	170	184	188	193	206	224
Average annual prime interest rate	%	13.77	15.75	14.95	11.29	10.62	11.16	12.5
PPI agricultural goods	Index ‘95	139	180	192	184	169	200	218
Freight rate (Arg to SA)	US$/ton	24	22.24	24.14	43.85	45.3	53	95
Discharge costs	R/ton	66	66.56	92	104	110	117	127
Maize transport costs (harbour to Randfontein)	R/ton	118	130	139	168	172	185	201
Fuel	Index ‘95	241	256	256	278	294	363	395

Variable	Unit	2001	2002	2003	2004	2005	2006	2007
Fertiliser	Index '95	200	240	234	234	255	270	294
Requisites	Index '95	182	218	231	239	245	256	278
Intermediate goods	Index '95	186	222	233	242	246	261	283

Sources: FAPRI, Absa Bank, Actuarial Association, Prof. F Smit, 2008

Based on the historical trends and inter-relationships presented in Tables 6.1 to 6.4, a correlation matrix and probability distributions were estimated and set up to generate assumed values for 2008/09 and 2009/10 seasons for key exogenous variables to be used in the model of Meyer *et al.*(2006). The correlation matrix and estimated probability distributions are presented in Appendix E. Based on the correlation matrix and probability distributions of the key exogenous variables, the following probability distributions for white and yellow maize prices for the 2008/09 and 2009/10 seasons were generated by means of the Latin Hypercube stochastic process, as well as through running 500 iterations in the model in order to obtain stable probability distributions for the key output variables. The resulting probability distributions are compared to price levels and expectations in the market at the time of writing this thesis, namely, December 2008, to test to what extent the current market situation and expectations have been captured in the modelling results (Table 6.5):

Table 6.5: Maize price simulated probability distributions

Variable	**Stochastic model simulation results**						**Average Price levels on 5/12/2008 for 2008/09**	**Spot Price on 5/12/2008**	**Futures Price levels on 5/12/2008**
	Unit	**Mean**	**Min**	**Max**	**Std Dev**	**CV**	*****		******
White maize price 2008/09	R/ton	2082	1257	3969	429	20.61	1856	1561	
White maize price 2009/10	R/ton	2042	1472	3617	300	14.7			1655
Yellow maize price 2008/09	R/ton	1935	1291	3627	307	15.88	1855	1530	
Yellow maize price 2009/10	R/ton	2076	1416	3665	336	16.21			1670

** These are the average SAFEX prices for 2008/09 season from 1/5/2008 to 5/12/2008*

*** These are the SAFEX futures prices for July 2009 contracts on both white and yellow maize*

From the simulation results, it is abundantly clear that the market situation currently playing out in terms of price levels, would have been captured in the probability distributions as simulated by the stochastic model. Calculations based on the simulated probability distributions would have indicated that the probability for an average white maize price for the 2007/08 season of R1856/ton or lower to occur was 34%, while for yellow maize priced at R1855/ton or lower, the probability was 43%. Hence, the probability distributions would have indicated that the probability was fairly high for prices to decrease.

However, given the expected prices simulated by the model, namely R2082/ton for white maize and R1935/ton for yellow maize, and comparing these simulated expected prices with current spot prices and futures prices, it is clear that the average price for 2008/09 is expected to decrease to levels much lower than what was simulated by the model and what the average price for the 2008/09 is at the moment. Given the simulated probability distributions, the probability for the annual average white maize price to move to an average level of R1561/ton or lower for 2008 would have been indicated as 8%, while the probability for the average annual yellow maize price to move to levels of R1530/ton or lower for 2008 would have been indicated as 6% (Figure 6.1).

These probabilities imply that should the decision-makers have used only the probability distributions to inform them of potential risks and uncertainties and hence the potential market situation that could play out, the possibility of prices moving to the current levels and expected levels, would have been deemed highly improbable. This point is based on the argument that the probability distributions would have indicated that the market prices would have remained at much higher levels with a high probability. This would have led decision-makers to believe that the probability of farmers incurring a loss on crops due to decreasing commodity prices is very small, and therefore that finance could be provided to farmers at a fairly low risk of loan default.

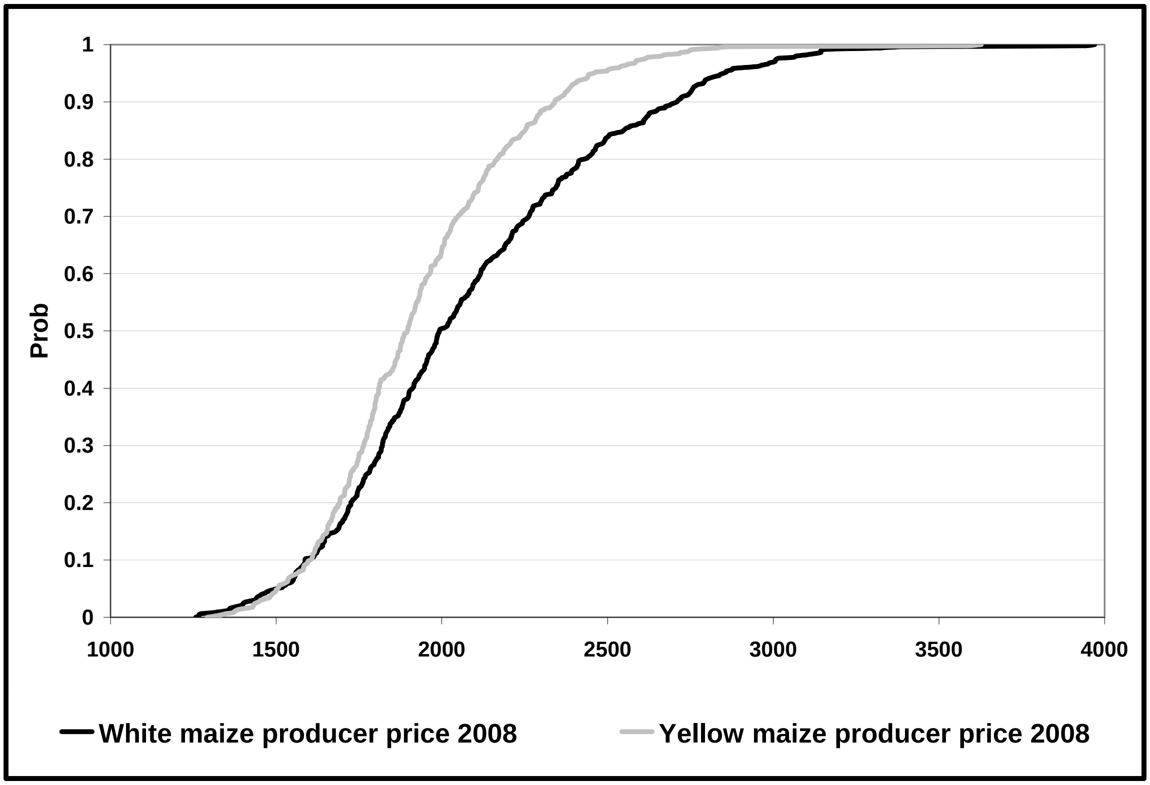


Figure 6.1: Simulated cumulative distribution functions of white and yellow maize for 2008/09 season

The reality, however, was that, as the market situation turned around and commodity prices started dropping from July 2008 and onwards, the probability of loan defaults and hence write-offs increased significantly. The problem is that once the finance has been provided to the farmer, the bank is locked in and hence has to "ride out the storm." Therefore, the argument can be made that if the bank had used the stochastic simulation outputs as a basis to develop their strategy for the 2008/09 season, they would likely have developed a strategy that would not have been robust enough to handle the risky and unexpected events that are causing the current financial, economic and grain market turmoil. This argument is based on the point that, since the simulated probably distributions would have indicated that only very small probabilities existed for the current market situation to play out, the decision-makers would most probably have used the range in which prices were expected to move to base their strategy development on. This implies that developing the strategies would not have included thinking about the risks and uncertainties that occurred, implying that the strategies would most probably not have been successful given the current market situation. Hence, the strategies would most probably not have been robust enough to lead to success.

In terms of the view for the 2009/10 season, it is evident from Table 6.5 that current futures market prices, which indicate market expectations, are much lower than the simulated, expected prices of the model. Although current futures market prices were captured in the probability distributions, the probability of current expectations playing out were assigned low probabilities. In the case of white maize, the probability of a market price of R1655/ton or lower occurring is only 6%, while for yellow maize the probability of a market price of R1670/ton or lower occurring is only 8.5% (Figure 6.2).

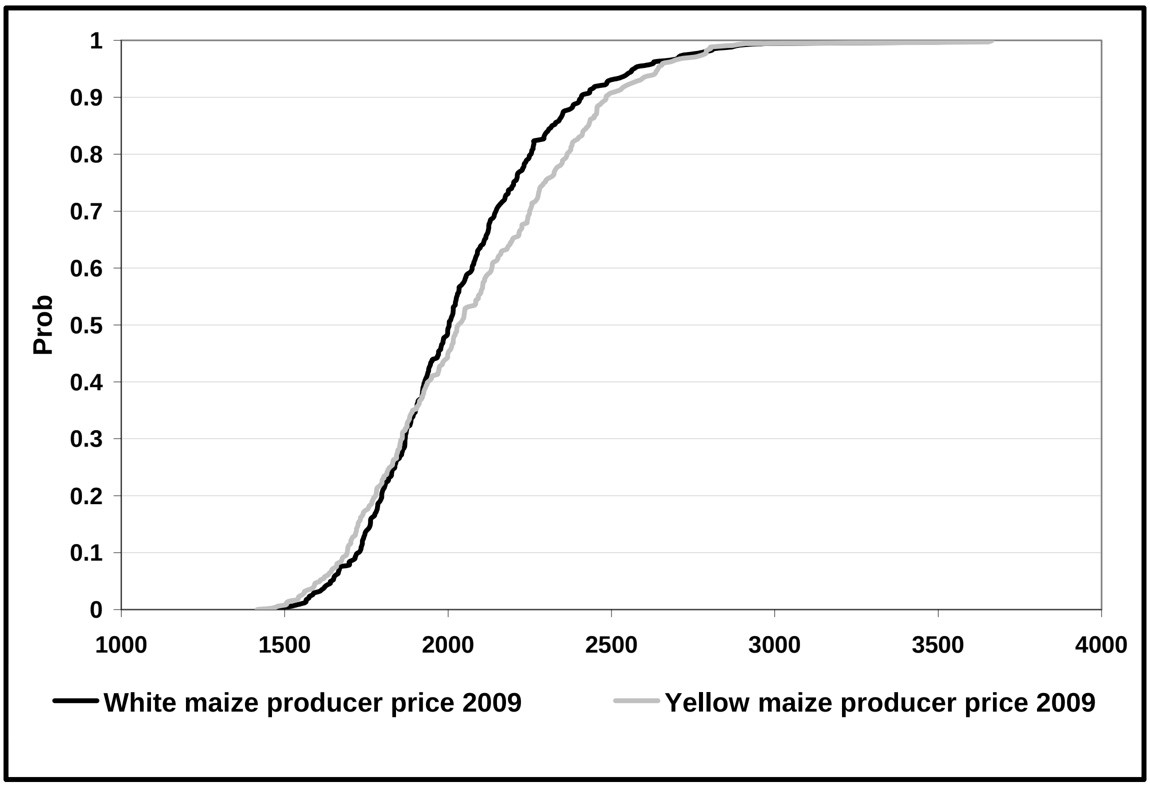


Figure 6.2: Simulated cumulative distribution functions for white and yellow maize 2009/10 season

Since finance is already provided between August and September of each year for the coming production season, it meant that finance would have been provided to farmers for the 2008/09 season when prices were still at very high levels and were expected to remain there. Hence, using only the probability distributions to develop a financing strategy for the 2008/09, would have led the decision-makers to believe that prices were likely to remain high. Hence, the bank would have been locked into a situation in which huge amounts of finance would have been provided to plant maize, while prices are dropping and are expected to drop to levels where maize production is not viable at all, given the cost of inputs at the time the inputs were bought and crops were planted.

It must be noted that the simulated prices of the model are annual averages, and that it is not entirely correct to compare the simulation results to current market expectations with respect to futures prices on the day. However, futures market expectations do give an indication of what is expected in future, and can therefore provide some indication as to what the potential annual average price could be for the 2009/10 season. As the July 2009 futures contract is the contract furthest into the future available on the futures market as on 5/12/2008, it is the only contract available to form a picture of what the expectations are in terms of the 2009/10 season. Therefore, the modelling results are only compared to the July futures prices.

Based on the model results as well as the market expectations as presented through the futures prices, it is clear that by just using the modelling results, the decision-makers would have come to the conclusion that market prices as low as either occurring or expected to occur, had a very low probability of occurring. The argument can therefore be made that the decision-makers would have made a decision based on a view that commodity prices were likely to stay higher than what is playing out and could potentially occur during the 2008/09 and 2009/10 seasons, and that the probability of loan default is therefore much lower than what it in fact is now. Hence, the strategy that would have been developed based on the view of a low probability of low prices, could likely have been unsuccessful, given the way the market appears to be playing out at present. Therefore, the conclusion can be drawn that just using the stochastic model would not have sufficiently captured the risks and uncertainties of both the 2007/08 and 2008/09 seasons, and hence that it would not have assisted the decision-maker in developing adequately robust strategies that would have led to success during both seasons.

6.5 Stochastic model versus framework

Comparing the results of using only the stochastic model versus applying the proposed framework, clearly indicates that the framework has captured risk and uncertainty much more sufficiently thus far, given the way the market is playing out and is expected to play out. It can therefore be argued that the framework is an improvement on using only a stochastic model, in the sense that it led the bank to make **better decisions** compared to what would have been decided if only the stochastic model was used. Hence, the conclusion can be drawn that, although the market situation in which this case study and using the proposed framework is still playing out, the application of the framework did result in the bank's decision-makers re-perceiving the reality of what the risks and uncertainties really were in developing the financing strategy for the 2008/09 and 2009/10 seasons. Therefore, using the framework did lead to a more robust decision based on a better and more complete understanding of both risk and uncertainty, but this also occurred because of a much more complete learning process that led the decision-makers to understand reality better. The framework thus far reflects how the market is playing out and has made a significant difference the bank's ability to develop a robust financing strategy, given the current market situation.

6.6 Summary and Conclusion

The third case study presented in this chapter, serves the purpose of providing an actual and "live" situation in which the proposed framework of this study is applied, and where the results are presently being used to make decisions on future market situations. The case study is on a commercial bank active in the South African agricultural market and which had to develop financing strategies for the 2008/09 and 2009/10 maize seasons in the beginning of 2008. Hence, the framework was applied to assist the bank to develop views on risks and uncertainties that could potentially cause a market outcome significantly and unexpectedly different from what was expected in the beginning of 2008. The result was the development of three different scenarios, one of which was identified as the most threatening and was therefore simulated by means of the model of Meyer *et al.* (2006), without including probabilities. This was done to ensure that uncertainty is captured and communicated correctly, but also to ensure that the scenario results are in a useful format for the decision-makers in terms of yields, quantities and therefore prices.

The scenario that was selected was a scenario in which the global economy moved into a deep recession, causing commodity prices, including maize prices, to decline sharply. At the time of writing and simulating this scenario, namely April 2008, a situation as described in the scenario was thought to be impossible. However, as it turned out, the impossible became the probable, which became the reality. At the time of writing this thesis, the US, EU, and Japan were already in a recession, while Chinese, Indian, Russian and Brazilian economic growth (along with South African economic growth) were declining rapidly — something unthinkable just eight months before.

Based on the scenarios developed and the modelling results, it was possible to indicate to the bank's decision-makers that such a situation was indeed possible and plausible, and hence put the bank's decision-makers in a position to re-perceive reality in terms of the actual risks and uncertainties being faced at the time of making the decision on the financing strategy. As a result, a more robust financing strategy was developed, and it appears as if the bank is riding out the storm quite successfully at the moment in terms of its agricultural finance.

This chapter also indicated that using only the stochastic model would most likely not have put the decision-makers in a position to understand the actual risks and uncertainties that were faced in April 2008, and hence might have misled them into developing less robust financing strategies. Should this have happened, it is highly likely that the financing strategy would not have been robust enough to withstand the risks and uncertainties that led to the current market situation, and hence might have resulted in the bank not being able to ride out the storm safely in terms of the 2008/09 season. With regards to the 2009/10 season, the same argument can be made. However, only time will tell whether this argument proves to be correct.

CHAPTER 7: Summary and Conclusions

"Likeness to truth is not the same as truth."

Bernstein, 1998

7.1 Introduction

Since the beginning of time, human beings have always wanted to get to know the truth, but have always struggled. The reason for struggling, is because truth has many dimensions and therefore always presents itself in many different "shapes and sizes," which often seem to contradict each other. This makes it very difficult, confusing, and almost impossible for us humans to get to know the full truth. One of the dimensions of the truth is the future. The future is often like the past and present. However, in some situations the future is not like the past or the present, as a result of change. Therefore, the problem is that in our search for the truth, and hence in attempting to understand the future, we as humans almost never know whether the future will be like the past and present, or whether it will in fact be a totally "new" future which will be unlike the past and/or present.

As a result of this problem, humans have devised methods whereby the past and present is analysed in great detail in order to understand it. Based on the understanding of the past and present, view(s) on the future are then developed. The logic behind this lies in the idea that, since we believe we understand the past and present based on our in-depth analysis, we then believe we can understand the future better as we mostly work with the assumption that the future will be similar to the past and present. The reasons for working with this assumption are because we firstly "know" the past and present and hence the "facts," and secondly, because we "know" the past and present, we already think and believe we "know" at least a part of the future and hence part of the truth. Hence, we reason that by knowing the past and present and using that to explain a view of the future, it is easier to defend that view of the future, since we can defend the view of the past and present because it is based on perceived "facts."

As a result of using the assumption that the future is like the past and present, we are often quite correct, since the future is often like the past and present. However, during some stages in human history, as is currently occurring in the world and in agriculture as argued in chapter one, changes take place at a rate and magnitude "never" witnessed before in human memory, resulting in a future that is not at all like the past or the present. Situations like these then lead to a total breakdown in views of the future, since the assumption that the future is like the past and present doesn't hold anymore. This results in all our techniques and methods based on this assumption becoming obsolete, even if it is just for a short period in time. The result is then confusion and helplessness in the face of the sudden "inexplicable unknown," which leads to bad decisions.

7.2 The proposed framework of this thesis

The proposed solution to this problem and therefore the idea offered by this thesis is to work with two hypotheses when developing a view of the future, and hence developing a view of that dimension of the truth. The two hypotheses that are used are: the future is like the past and present, and that the future is not like the past and present but is a result of combining current and unexpectedly new forces or factors. The idea behind this stems from the philosophy of Socrates, whereby he postulated that the truth can never be fully known and therefore, when working with the truth, one needs to work with multi-hypotheses about the truth until all but one hypothesis can be discarded. This will then bring one closer to the truth, but never lead you to know the truth in full, since the truth can't be known in full.

Applying this idea means conjunctively using two techniques which are based on the two hypotheses about the future. From a literature review it was realised that two such techniques existed, namely, stochastic modelling and scenario thinking. Stochastic modelling, by its very nature, is based on the assumption that the future is like the past and present since historical data, historical inter-relationships, experience, and modelling techniques are used to develop the model, apply it, and to interpret its results. Scenario thinking on the other hand, and specifically intuitive logics scenario thinking, is based on the notion that the future is not like the past or present, but is rather a combination of existing and new and unknown factors and forces.

At first the perceived problem with this idea was thought to exist in the problem of using both techniques in combination, since the two techniques are fundamentally different because of the fundamentally different assumptions on which they are based. The question and challenge was therefore whether these two techniques could be used in combination, and how? However, the solution to this problem was more elementary than what was initially thought. As the two techniques are fundamentally different, it implies that the two techniques can't be combined because the two underlying assumptions can't be combined. However, what is possible is to use it in conjunction without adjusting either technique. Rather, one would allow each technique to run its course, which at the same time leads to cross-pollination in terms of ideas and perspectives, where possible and applicable. The cross-pollination of ideas and perspectives will then create a process whereby ideas regarding the two basic assumptions on the future are crystallised and refined through a learning process, hence resulting in clearer perspectives on both hypotheses about whether the future will be like the past and present, or whether the future will be a combination of existing and new but unknown factors and forces. These clearer perspectives provide a framework to the decision-maker whereby the two basic hypotheses on the future can be applied simultaneously to develop strategies and policies that are likely robust enough to be successful in both instances. It also provides a framework whereby reality can be interpreted as it unfolds, which signals to the decision-maker which of the two hypotheses is playing out. This will assist the decision-maker in better perceiving what is in fact happening, hence what the newly perceived truth is in terms of the future, and therefore what needs to be done in order to survive and grow within this newly developing future, reality, or truth.

The presentation of the three case studies in chapter five and six provided support to the before-mentioned argument. Applying the proposed framework did indeed lead to more robust and therefore better decisions in the face of risk and uncertainty due to conjunctively using the two techniques, but also due to the cross-pollination and learning processes that took place when the framework was applied. In addition to this, as indicated through the presentation of case study three, the results of applying the framework provided a framework for the bank's decision-makers in which to interpret unfolding present events, as well as what the implications could be for the 2009/10 maize season. This provided the bank's decision-makers with a platform to interpret events, and hence develop and adjust strategies to ensure success would be obtained through the strategies. Although the future did not turn out or seem to turn out to be like the past and present in any of the three case studies, it could very well have happened and could very well still happen in case study three. Should this have happened, or still happen in case study three, the decision-makers would still have had the results of the stochastic model which would have indicated to them that the future is going to be much like the past and present. Hence, it is important to use both techniques in conjunction, since it is important to develop strategies that are robust and hence lead to success regardless of whether the future is like the past and present, or not.

The presentation of the case studies also assisted in testing the hypothesis of this thesis as presented in chapter one, and found that it can't be rejected. Hence, through the presentation of the case studies it was found that using scenario thinking in conjunction with stochastic modelling does indeed facilitate a more complete understanding of the risks and uncertainties pertaining to policy and strategic business decisions in agricultural commodity markets, through fostering a more complete learning experience. It therefore does facilitate better decision-making in an increasingly turbulent and uncertain environment. However, based on the presentation of the case studies and testing of the hypothesis of this thesis, it became clear what the strengths, weaknesses and contribution of this proposed framework are in terms of analysing risk and uncertainty in agriculture.

7.3 Strengths, weaknesses, and contribution of the proposed framework

The strengths of this proposed framework, relative to just using either stochastic modelling or scenario thinking, is that the weakness of stochastic modelling (namely the assumption that the future is like the past and present) is mitigated by using scenario thinking in conjunction. This provides an alternative hypothesis to what stochastic modelling is based on. The opposite is also true in terms of scenario thinking. Its weakness is that it is based on the assumption that the future is not like the past and present. Since the future is often like the past and present, using just scenario thinking to develop views of the future could be misleading. Therefore, the strength of this proposed framework lies in the fact that the weaknesses of each of the respective techniques are mitigated by the strength of each of the respective techniques.

The weakness of the proposed framework is that part of it relies on human intuition, knowledge, experience, and the ability to perceive reality. However, due to bounded rationality, it implies that including the human element can result in a situation in which factors are not thought of or comprehended well enough to be included when following the framework. This could lead to results that do not capture the true risks and uncertainties that are faced, given the decision context and decision that needs to be made, and hence could lead to decisions that are not robust enough to handle the eventual outcome. Using the proposed framework does facilitate more robust and therefore better decisions, but does not guarantee robust and good decisions.

The contribution of this proposed framework towards the field of agricultural economics lies in the fact that a tried-and-tested framework now exists, whereby risk and uncertainty can be captured in a technically correct manner and also in a more sufficient manner compared with just using stochastic modelling. Thus, although stochastic modelling by means of objective and/or subjective probabilities does provide some platform to understand risk and uncertainty, the proposed framework of this thesis provides a much improved and much more solid and sound framework to analyse and understand risk and uncertainty in agricultural economics. Therefore, it is believed that the correct application of this framework in agricultural economics will provide agricultural economists with a much more solid platform to study and communicate risk and uncertainty, and thereby assist decision-makers in either the private sector or the public sector to develop much more robust and therefore better business strategies and policies.

The agricultural sector is experiencing turbulent times, and the possibility that the volatility and uncertainty could only increase in future is becoming bigger and bigger by the day. This is due to the increasing inter-connectedness between the various macro and micro forces that drive agriculture in a global and domestic context. Since the agricultural sector is critical to the survival and growth of a country's economy, especially in an increasingly global society, it is imperative that robust business strategies and policies are developed to ensure the survival and growth of the agricultural sector. In this regard, agricultural economists have played and should play a key role, since agricultural economists are the link between the agricultural sector and the rest of the economy. Hence, developing and applying such a framework as proposed by this study to assist the development of business strategies and policies in the agricultural sector, is key to the continued relevance of agricultural economists in the economy and in society.

7.4 Applying the framework in practice

The aim of this thesis was to propose an approach towards decision-making in agriculture with respect to policy and business strategy, given that risk and (especially) uncertainty is likely to increase in future. Hence, the goal was to put a framework on the table that encapsulates this approach, and which can be applied in practice, as with the presented case studies, in order to facilitate better policy and strategic business decisions. Therefore, what does it take to apply the proposed framework of this thesis in practice?

Firstly, skills and knowledge are needed by the facilitator who will apply this framework in collaboration with decision-makers, which entails an in-depth knowledge and understanding of intuitive logic scenario thinking as well as stochastic modelling. If the decision-maker wants to apply the framework without having a facilitator, it is important for him/her to also have these skills and knowledge. The skills and knowledge are needed simply because, in applying the framework and the two techniques constituting the framework, one needs to understand the fundamental differences between the two techniques, and hence understand the small but important nuances attached to each technique to ensure that they are applied correctly in conjunction. Examples of nuances include: the difference in how to think about risk versus uncertainty; the difference in understanding the “players and rules of the game” and just analysing hard data on the specific industry or system; and the differences in perspectives between the history of the game from the decision-makers' perspective, and the history of the game as presented through hard data.

Secondly, the preparation process before applying the framework in collaboration with decision-makers, entails a process whereby a first meeting is held with the respective decision-makers. The aim of this meeting should be to ask exploratory questions in order to gain insight on their initial expectations and aims with respect to the decisions that have to be made. This will indicate to the person facilitating the application process how much time is available in terms of applying the framework, who needs to be part of the session, in what format the final results should be presented, by when the final results should be presented, and hence how much time would be available to digest and capture the final results before presenting it. The issue of who needs to be part of the session is essential to the success of applying the framework. The reason is that often knowledge on some of the factors or issues to be discussed are not internalised by either the facilitator or the decision-maker. This implies that it might be necessary, in order to have a meaningful discussion on that poorly understood issue, to either involve an expert on the issue during the whole of the session, or to invite an expert to do a presentation during part of the session. This will give the decision-maker and facilitator an opportunity to question the experts, and hence have a much better view on the specific issue. However, what is important is that the number of participants and experts are limited, as too many people lead to too many opinions without ever getting to any point in terms of finalising a discussion around an issue.

It was found that, in applying this framework, the optimal amount of people involved in a session, excluding the facilitator, is between three and eight. With more than eight, it becomes tricky to have a meaningful and in-depth discussion on an issue, while less than three tends to lead to a very shallow thinking process. The “mix” of people attending the session is also important in the sense that not too many similar thinkers should be in the session as this leads to “group thinking,” implying that the discussions will not be very rich or varied. Along with this, not too many of the people should be from the same field or sector e.g. academics, as it often leads to theoretical arguments on definitions, resulting in a "loss of interest" by some participants as well as delaying getting to any point in terms of the discussion. The same can be said of people from the same sector within the private sector, as they could start arguing about internal issues specifically related to the industry. Lastly, it is important to have a mix of people who are positive, critical, and "out-of-the-box" thinkers who can add value in terms of their ideas on issues but who are also willing to entertain ideas that oppose their own. By having such a group, it is possible to get excellent insights and eventually get to solutions without having to manage major conflicts between participants which ultimately threaten to derail the process totally.

The time-length for applying the framework depends on how quickly the decision-makers want answers to make decisions, and also on how deep the decision-makers want the discussions and analysis to be. Referring to case study two, the total time needed to meet the co-operative, apply the framework, present the results orally, and compile a report was a week. One day was spent on applying the framework and presenting the results orally, while another five days were spent in writing the report. Other users of the framework have used more or less time, depending on their needs. It was found that organisations representing a specific industry and who need to report to its members, especially needed a sound scientific basis. In one instance, the total exercise (of applying the framework until presenting the final results) took eight months in total. This included an initial meeting to understand expectations and goals; an intensive one day session during which the framework was applied, and which was attended by five experts along with the decision-makers and the facilitator; and a third meeting with only the decision-makers and facilitator present, during which the results were reviewed and further discussed in detail. The final results were presented in a report of roughly sixty pages, which contained scientificly based information and detailed results.

The ideal setting for running an exercise of applying the framework is a room containing either a round table or a large enough board table that avoids "ranking" sitting positions around the table. Ideally, the room should have a large board which can be written on with non-permanent markers, a flip chart, as well as a screen on which images, data, or other information from a computer can be presented. Preferably, the venue should not be at the office of the decision-maker so as to avoid distractions due to telephone calls that need to be taken etc. This will ensure a smooth and continuous conversation without any interruptions. Because of this, it is important to keep the sessions to only one day at a time, as most people in both the public or private sector can't be out of office for more than one day at a time.

Lastly, in the case of the facilitator, it is important for the person to be well prepared when walking into the session. The facilitator needs to know what the decisions are that need to be made based on the results and insights gained from applying the framework, who the people are that will be involved in the session, what their backgrounds are, skills and knowledge, and lastly, what their intentions are in terms of being involved in the session. People with hidden agendas who are not managed correctly could potentially and easily derail the whole process. Hence, it is important for the facilitator to manage such persons in such a way that they contribute positively without creating too much frustration for the other participants. Frustration is a normal emotion during the process of applying the framework, especially on the side of the decision-maker, due to "not having answers" to the questions or "not seeing eye-to-eye" on certain issues. It is important for the facilitator to manage these periods of frustration very carefully, since these periods often serve the purpose of providing an "incubator" for brilliant insights. However, it can also be the incubator for dissent and deep frustration, leading to a derailment of the process. The facilitator therefore need to realise that a fine balance exists during these periods, in terms of either getting brilliant insights from the participants or merely creating frustration amongst the participants. The only way to manage this successfully, is to understand in which direction the conversation needs to be guided (as indicated by the ultimate goals of the session in terms of the decisions that need to be made), and also by understanding each participants' intentions regarding their involvement in the process.

7.5 Additional research and concluding comments

The proposed framework of this thesis does provide an improved platform for the analysis and communication of risk and uncertainty in agriculture, and should the framework be applied correctly, it should facilitate more robust decisions in terms of business strategy and policy. The proposed framework, however, is not the "be all, end all" of risk and uncertainty analysis in agriculture, and it is certain that new techniques will be developed in future that will create a better understanding of the future, and hence a better understanding of truth in terms of the future. One area where additional research is needed in terms of risk, uncertainty and this framework, is the learning process that takes place when applying this framework. Some light has been shed on this aspect through this thesis, but much more needs to be explored about the learning that takes place, since learning is the key to understanding how to adopt to change, expected or unexpected. Another area of research based on this proposed framework that is worth developing, is how to incorporate game theory and new institutional economics into this framework, along with scenario thinking and stochastic modelling. It is believed that strong links exist between the steps of scenario thinking set out in this thesis and game theory and new institutional economics, specifically pertaining to the steps of "rule of the game" and "players of the game." Hence, by linking game theory and institutional economics to scenario thinking, a link can be created between stochastic modelling, game theory, and institutional economics.

However, given all that is written in this thesis and given future research that will take place, it is certain that there is only one Truth, and until He doesn't come, the search for understanding the truth from a human perspective will be never ending. Until then, enjoy and make the most of the adventure of searching for the truth!

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Appendix A: Reports used in case study one

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

BFAP REPORT 2005-1

by

Jeanette de Beer
Ghian du Toit
Thomas Funke
Jacky Mampane
Ferdinand Meyer
P.G. Strauss

REPORT 2005-1

May 2005

REPORT 2005-1

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

1. INTRODUCTION

This report is organized into five sections. The first section reports on the latest deterministic and stochastic baseline generated by the South African Grain, Livestock and Dairy Sector Model (developed by BFAP). In the second section the projections and scenarios, simulated during December 2004 and January 2005 are validated. Section three contains a comparison of the rainfall patterns for crop production regions over the past three years. A range of new scenarios are introduced and analysed in section four. Concluding remarks are given in section five.

2. BASELINE PROJECTIONS

2.1 Deterministic projections

The baseline projections are grounded on a series of assumptions about the general economy, agricultural policies, weather and technological change. Macro-economic assumptions are based on forecasts prepared by a number of institutions like Global Insight, the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri, ABSA bank and the Actuarial Society of South Africa (for projections on population). Table 1 and 2 present the baseline projections for key economic indicators and world commodity prices in the model.

Table 1: Economic indicators - Baseline projections:

		2005	2006	2007	2008	2009	2010
Exchange Rate	c/US$	595.98	632.34	670.91	704.46	732.64	754.61
Population	millions	47.49	47.64	47.68	47.65	47.54	47.39
PCGDP	R/capita	15657.23	16001.69	16401.73	16696.96	17114.39	17559.36
CPIF	Index	198.67	205.23	210.97	214.98	221.00	228.51
FUEL	Index	355.24	402.49	454.01	508.04	573.07	649.86
PPI: Total	index	174.63	180.40	185.45	188.97	194.26	200.87
PPI: Agric.Goods	index	180.78	186.74	191.97	195.62	201.10	207.94
Requisites	index	230.33	237.93	244.59	249.24	256.21	264.93
Repair & Maintenance	index	248.63	256.84	264.03	269.05	276.58	285.98
Irrigation equipment	index	196.53	203.01	208.70	212.66	218.62	226.05
Fertilizer	index	244.92	253.00	260.09	265.03	272.45	281.71
Machery & Implements	index	206.385	213.195	219.165	223.329	229.582	237.388

Source: Global Insight, FAPRI, Actuarial Society, ABSA

Table 2: World Commodity Prices - Baseline projections:

		2005	2006	2007	2008	2009	2010
Yellow maize, US No.2, fob, Gulf	**US$/t**	105.00	108.00	109.00	110.00	111.00	112.00
Wheat US No2 HRW fob (ord) Gulf	**US$/t**	145.72	147.33	150.31	152.33	154.99	157.25
Sorghum, US No.2, fob, Gulf	**US$/t**	104.00	103.00	104.00	105.00	106.00	106.00
Sunflower Seed, EU CIF Lower Rhine	**US$/t**	258.00	270.00	277.00	277.00	278.00	278.00
Sunflower cake(pell 37/38%) , Arg CIF Rott	**US$/t**	104.00	106.00	109.00	111.00	112.00	111.00

		2005	2006	2007	2008	2009	2010
Sunflower oil, EU FOB NW Europe	**US$/t**	623.00	643.00	657.00	659.00	661.00	663.00
Soya Beans seed: Arg. CIF Rott	**US$/t**	217.00	227.00	238.00	243.00	243.00	244.00
Soya Bean Cake(pell 44/45%): Arg CIF Rott	**US$/t**	185.00	188.00	189.00	193.00	194.00	194.00
Soya Bean Oil: Arg. FOB	**US$/t**	480.00	492.00	504.00	511.00	511.00	515.00
World fishmeal price: CIF Hamburg	**US$/t**	659.00	669.69	673.25	687.50	691.06	691.06
Nebraska, Direct fed-steer	**US$/t**	1831.00	1773.00	1742.00	1694.00	1645.00	1612.00
Nieu Zealand lamb	**US$/t**	1692.61	1794.16	1901.81	2015.92	2136.88	2265.09
Chicken, U.S. 12-city wholesale	**US$/t**	1478.00	1392.00	1360.00	1352.00	1348.00	1351.00
Hogs, U.S. 51-52% lean equivalent	**US$/t**	1058.00	874.00	906.00	983.00	1067.00	1031.00

Source: FAPRI. Outlook 2005

The deterministic baseline projections for selected commodities that were generated in the model are presented in Table 3 in the form of balance sheets. The most important assumptions and deterministic baseline results can be summarized as follows:

- *The new FAPRI's 2005 Agricultural Outlook* is used for the projections of world prices. This outlook was published in March 2005. The following significant revisions were made compared to the 2004 Outlook:
  - Sunflower seed and cake prices are significantly lower
  - Soybean seed and cake prices have also been adjusted downwards, but to a smaller extend
  - Chicken prices were increase marginally for 2005 but then adjusted downwards from 2006 onwards
  - The cycle in pork prices "bottoms out" in 2006 and starts to increase in 2007 onwards
- It is generally assumed that current agricultural policies will be continued in South Africa and other trading nations.
- The deterministic exchange rate for 2005 is 595 SA cents per US$ after which it depreciates gradually to reach a level of 754 SA cents per US$ in 2010. (The stochastic exchange rate is presented in Figure 1 and the results are discussed in section 2.2 of this report).
- Rainfall is split into the rainfall that influences the area planted and the rainfall that influences the production of each summer crop, which is included in the model. The average rainfall for the past 30 years, for specific months influencing the area planted and the production is used as the forecasted value. The formal rainfall statistics for February, March and April 2005 are not available yet, but the unpublished statistics suggest that the rainfall for the late summer production season was higher than the average of the past 30 years. Section 4 of the report sheds some more light on the impact of rainfall when the rainfall patterns of the past three seasons are compared. This analysis suggests that the early summer rainfall for the 2004/05 season was 9% higher than the previous season's rainfall. For the deterministic baseline projections the average rainfall for the summer area is increased to 8% above the 30-year average (580 mm for critical months). This brings the projected yields of summer crops also

in line with the National Crop Estimates Committee's yield estimates. The stochastic rainfall projections are included in section 2.2.

- After the exceptional yields in the 2003/04 seasons it is now more than likely that the record yields in the history of maize production in South Africa will be achieved this year. In section 3 of the report yield forecasts are discussed in more detail.
- Total white and yellow maize ending stocks have been identified as one of the key uncertainties in the sector model. These stocks levels go hand in hand with the level of exports. In section 5 of the report, scenario 5.3 illustrates the major impact of different ending stock and export levels. These critical variables are also discussed in section 3 of the report. For latest baseline projections the ending stocks have been increased to 4.6 million tons. This is 1.4 million tons higher than the projected ending stock for the previous report in January 2005.
- The first signs of increased export levels for white maize appeared in the first three weeks of April. The level of exports increased drastically to reach a level of 55 000 tons in the third week of May. Despite of this, exports are projected at approximately 900 000 tons. In 2004 white maize exports amounted to a mere 614 000 tons.

Table 3: Deterministic baseline projections for selected commodities

	2005	2006	2007	2008	2009	2010
	thousand hectares					
White maize area harvested	1835.6	1318.6	1476.3	1676.6	1592.6	1599.6
	t/ha					
White maize average yield	3.61	3.48	3.51	3.54	3.57	3.60
	thousand tons					
White maize production	6635.3	4583.7	5181.6	5939.3	5691.8	5765.7
White maize feed consumption	756.5	748.1	698.5	724.9	752.6	757.3
White maize human consumption	3839.2	3761.6	3654.8	3669.1	3685.1	3646.4
White maize domestic use	4920.6	4834.7	4678.3	4719.0	4762.6	4728.6
White maize ending stocks	3254.1	2371.4	2287.3	2648.6	2639.3	2680.7
White maize imports	0.0	139.4	45.3	30.8	5.5	10.5
White maize exports	908.2	771.1	632.7	889.8	943.9	1006.2
	R/ton					
Avg. White maize SAFEX price	575.1	694.9	981.3	977.3	921.0	975.8
	thousand hectares					
Yellow maize area harvested	1083.3	1019.0	986.2	1001.9	1037.5	993.8
	t/ha					
Yellow maize average yield	4.17	4.01	4.05	4.10	4.14	4.18
	thousand tons					
Yellow maize production	4516.27	4082.8	3997.67	4106.44	4297.9	4158.9
Yellow maize feed consumption	3719.00	3671.1	3584.90	3580.94	3635.5	3636.5
Yellow maize human cons.	247.31	248.53	261.24	254.35	247.69	245.56
Yellow maize domestic use	4148.31	4101.7	4028.13	4017.29	4065.2	4064.0
Yellow maize ending stocks	1350.28	1305.	1211.69	1223.35	1294.5	1256.1
Yellow maize exports	192.56	266.05	303.02	282.06	249.93	274.88
Yellow maize imports	147.04	292.23	366.08	359.54	411.40	408.26
	R/ton					
Avg. Yellow maize SAFEX price	599.0	722.0	944.5	980.7	958.8	1024.0

	2005	2006	2007	2008	2009	2010
	thousand hectares					
Wheat summer area harvested	527.3	691.9	592.1	521.7	519.5	534.7
Wheat winter area harvested	313.2	347.7	320.1	304.6	302.6	303.5
	t/ha					
Wheat average yield: Sum. area	2.69	2.71	2.73	2.75	2.77	2.78
Wheat average yield: Winter area	1.71	1.72	1.72	1.72	1.72	1.73
	thousand tons					
Wheat production	1955.7	2472.5	2166.8	1958.5	1959.0	2012.7
Wheat feed consumption	44.5	67.7	79.1	73.2	67.8	71.9
Wheat human consumption	2623.8	2697.9	2728.6	2707.8	2694.5	2703.3
Wheat domestic use	2693.3	2790.6	2832.7	2806.0	2787.3	2800.2
Wheat ending stocks	632.6	694.1	716.8	703.7	692.1	694.7
Wheat exports	22.9	93.7	69.7	58.4	71.6	82.9
Wheat imports	729.7	473.4	758.2	892.9	888.4	873.1
	R/ton					
Wheat average SAFEX price	1468.2	1349.1	1518.7	1645.2	1704.6	1749.2
	thousand hectares					
Sunflower area harvested	488.6	783.4	695.3	654.5	662.1	683.4
	t/ha					
Sunflower average yield	1.39	1.28	1.29	1.30	1.31	1.32
	thousand tons					
Sunflower production	681.0	999.5	895.5	850.6	867.9	903.4
Sunflower crush	643.6	736.8	751.6	752.5	755.1	760.0
Sunflower domestic use	655.56043	748.819	763.5711	764.5125	767.07	772.0342
Sunflower ending stocks	149.2	243.4	208.5	193.4	198.2	209.2
Sunflower net imports	3.5	-156.4	-166.8	-101.2	-96.1	-120.3
	R/ton					
Avg. Sunflower SAFEX price	1743.9	1646.5	1911.6	2045.2	2109.4	2138.8
	thousand tons					
Sunflower Cake Production	270.3	309.5	315.7	316.1	317.1	319.2
Sunflower Cake consumption	252.2	313.8	329.5	347.9	361.4	372.5
Sunflower Cake Change in Stocks	67.8	75.6	76.2	75.7	75.6	76.2
Sunflower Cake Net Imports	49.7	79.9	90.0	107.5	119.9	129.6
	R/ton					
Sunflower Cake Price	1330.0	1342.0	1397.3	1445.9	1495.1	1536.3
	thousand hectares					
Soybean area harvested	155.9	128.1	133.1	130.9	130.3	130.7
	t/ha					
Soybean average yield	1.82	1.76	1.79	1.81	1.83	1.85
	thousand tons					
Soybean production	283.17	225.98	237.85	236.82	238.26	241.26
Soybean crush	35.55	36.31	36.48	36.72	36.91	36.95
Soybean feed consump. (full fat)	167.04	169.30	171.44	175.92	183.72	191.42
Soybean domestic use	263.59	266.61	268.91	273.64	281.63	289.37
Soybean ending stocks	103.97	86.31	74.26	65.44	59.97	56.89
Soybean net imports	-16.11	22.98	19.02	28.00	37.89	45.04
Avg. Soybean SAFEX price (R/t)	1238.3	1951.5	2103.4	2225.7	2312.9	2396.2

	2005	2006	2007	2008	2009	2010
	thousand tons					
Soybean Cake Production	28.44	29.05	29.18	29.37	29.52	29.56
Soybean Cake consumption	593.78	600.50	611.57	618.34	637.64	662.44
Soybean Cake Imports	565.34	571.45	582.39	588.96	608.12	632.88
	R/ton					
Soybean Cake Price	1511.6	1733.0	1846.1	1974.0	2065.5	2133.7
	thousand tons					
Pork production	139.3	140.22	141.4	143.28	145.01	146.48
Pork imports	10.2	12.7	12.73	12.08	11.55	12.09
Pork Domestic Use	146.15	150.41	151.6	152.59	153.59	155.78
Pork Exports	3.35	2.51	2.53	2.77	2.97	2.79
Pork average auction price	1301.5	1463.4	1607.1	1739.3	1893.5	2032.1

2.2 Stochastic projections of selected variables

In the results presented above no risk / uncertainty is taken into account. Risk is inherent in many of the exogenous factors influencing the grain and livestock industry. In the following set of results two critical exogenous variables, exchange rate and rainfall were simulated stochastically in the model.

Figure 1 and 2 illustrate the probability distribution function (PDF) of the exchange rate (expressed as SA cent per US$) and rainfall for the critical months that influence the summer grain production.

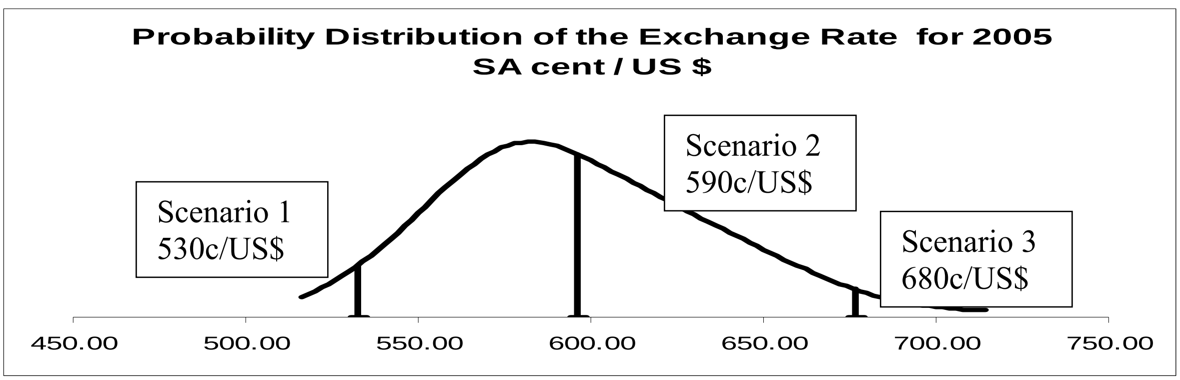

Figure 1: Probability distribution of the Exchange Rate, 2005

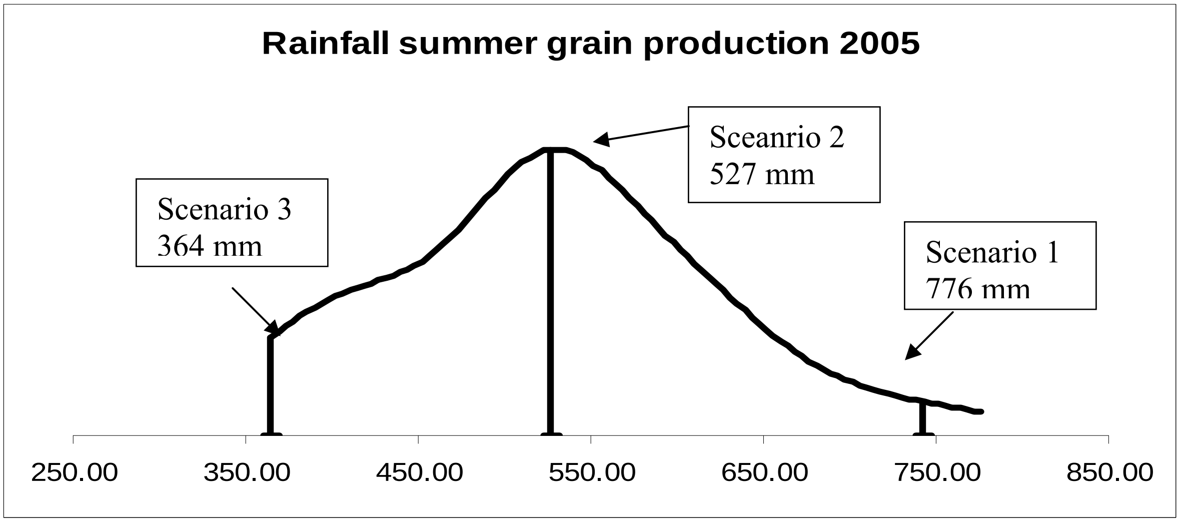

Figure 2: Probability distribution of summer rainfall for 2005

Although the rainfall distribution has not changed the total rainfall for the current production season lies to the right hand side of the figure. This implies that scenario 1 realised with above normal rainfall for the summer production season.

Figures 3 and 4 present the probability distributions for white and yellow maize for 2005. ***Note: These stochastic results are generated by making use of a stochastic exchange rate only and not a stochastic rainfall variable.*** The rainfall for the summer production region is fixed at 580 mm which results in a total maize crop of 11.1 million tons for 2004/05 season.

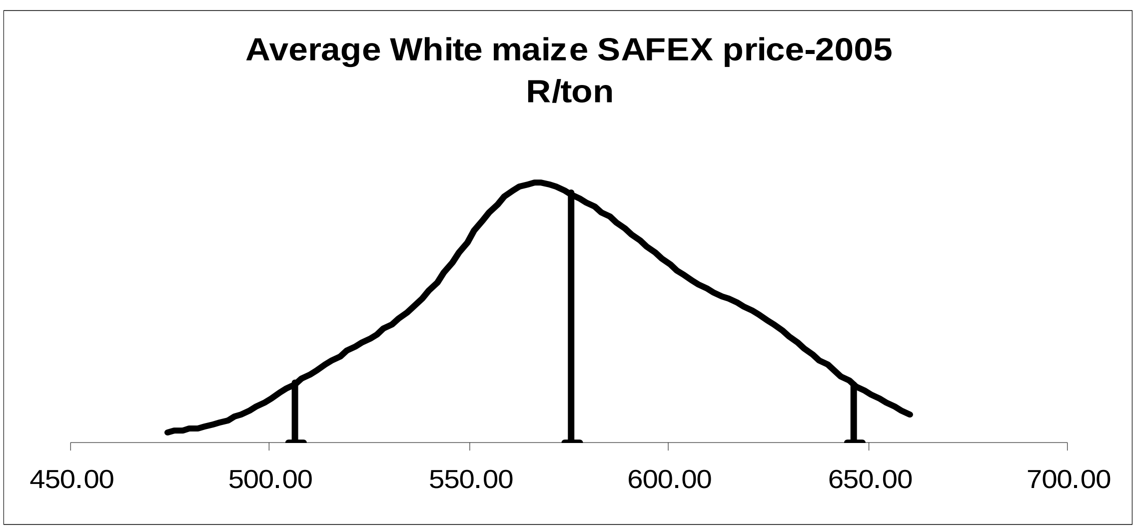

Figure 3: Probability distribution – White maize SAFEX price 2005

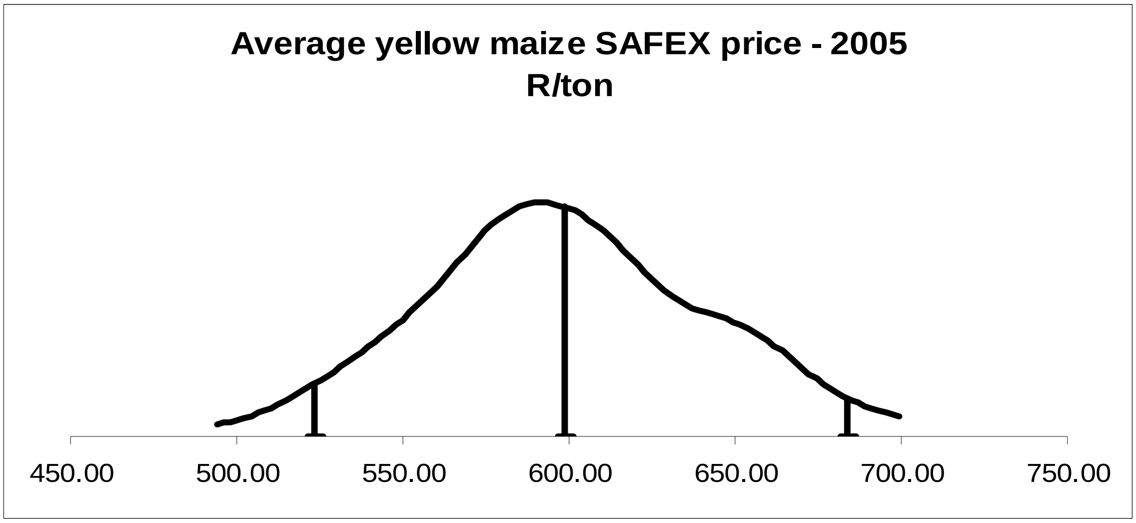

Figure 4: Probability distribution – Yellow maize SAFEX price 2005

3. VALIDATION OF PROJECTIONS AND SCENARIOS OF DECEMBER 2004 AND JANUARY 2005:

As previously mentioned baseline projections are grounded on a series of assumptions about the general economy, agricultural policies, weather and technological change. The aim is to base the projections on the best information available at the time of the forecast. Table 4 presents the deviations for the white and yellow maize sector between the three various baseline projections that were simulated in December 2004, January 2005 and the current projection of April 2005. This section compares these baseline results to the latest baseline results as presented in the first section of the result and discusses the reason for the major deviations in some of the critical variables as well as the alternative measures/improvements to the model that will be introduced to ensure more accurate scenario planning and projections.

Table 4: The major deviations of three baseline projections for 2005

		2004/05 Projections			
White Maize		**04-Dec**	**05-Jan**	**05-Apr**	**Dec Adj.**
	Production	5776.3	6180.5	6635.3	6655.7
	Domestic use	4986.3	5099.2	4920.6	5066.4
	Ending stocks	2463.2	2279	3254.1	2693.0
	Imports	0	0	0	0.0
	Exports	756.3	1205.4	908.2	1325.7
	Avg. annual SAFEX price	933.4	674.9	575.1	771.6
	Actual SAFEX monthly spot price	799.48	734.73	545	**
Yellow maize					
	Production	3731.8	3880.8	4516.3	4536.3
	Domestic use	3884.3	3992.5	4148.3	4082.9
	Ending stocks	1013.7	866.5	1350.3	1307.6
	Imports	423.6	375.4	192.6	290.3

	Exports	164.4	305	147	342.1
	Avg. annual SAFEX price	925.8	742.7	599	733.0
	Actual SAFEX monthly spot price	857.5	778.5	602	**

In December 2004 the SA weather bureau forecast a normal to below normal rainfall season for the summer production area for the remainder of the season. As a consequence the rainfall for the summer production area in the model was adjusted downwards to approximately 25% below the 30-year average. A total maize crop of 9.5 million tons was projected. Total exports were estimated at approximately 900 000 tons and ending stocks at 3.4 million tons. Deterministic white and yellow maize prices were estimated at R933/ton and R925/ton respectively. The last column in table 4, "Dec Adj.", presents the results if the production estimates of the model that was used for the December forecast are increased to the current levels of production. This implies that the total maize production is increased from 9.5 million tons (December 2004 – levels) to 11.1 million tons (April 2005-levels). No further adjustments were made to the exports or ending stocks levels, which results in total exports amounting to 1.65 million tons and ending stocks to 3 million tons. Under these market conditions white and yellow maize prices were estimated at R771/ton and R733/ton. When these results are compared to the April 2005 forecasts it becomes clear that apart from the under estimation of total production, exports and ending stock levels are the main drivers for the current low level of prices. The model overestimated exports, which led to an underestimation of ending stocks.

Rainfall forecasts will always be highly variable at best. Stochastic modelling techniques can be applied to at least obtain some indication of the band in which production might fall. Table 5 presents the stochastic price range for white and yellow maize. Already in December a minimum price of R710/ton was simulated for white maize. This price was generated at a crop of approximately 11.5 million tons. One can argue that if the correct scenarios would have been developed surrounding the level of exports and ending stocks, one could have come up with a more plausible range of prices for the current market situation.

Table 5: Stochastic projections for white and yellow maize - 2005

		Stochastic projections		
		04-Dec	**05-Jan**	**05-Apr**
Stochastic Variables				
	Rainfall	**yes**	**yes**	**No**
	Exchange rate	**yes**	**yes**	**Yes**
White Maize SAFEX Price – R/ton				
	Min	710.62	406.68	474.19
	Mean	930.57	653.70	575.22
	Max	1108.92	845.81	660.37
Yellow maize SAFEX Price – R/ton				
	Min	865.40	464.79	493.91
	Mean	944.28	722.99	598.65
	Max	1013.52	939.97	699.35

The big question is thus what drives export and ending stock levels and why did the sector model overestimate exports. A number of possible explanations can be taken into account. Firstly, although import and export parity pricing is taken into account in the import and export equations, this section of the model needs to be expanded with more relevant pricing, which includes an attempt to incorporate the import and export parity pricing of neighbouring countries. Thus, the equations in the model can be improved with more relevant variables and parameter estimates.

Secondly, since the deregulation of the commodity markets does South Africa still have the infrastructure to export large volumes of maize? This issue has been debated on many occasions. Studying the weekly SAGIS import/export data it appeared that not more than approximately 18 000 tons of maize could be exported on a weekly basis, which implies an annual figure of roughly 900 000 tons. This was proven wrong when the import/export figures, for the week 16-22 April, reported white maize exports to neighbouring countries to the amount of 32 000 tons (1.5 million per annum).

Finally, much uncertainty exists about the stock holding ability of role players in the industry. Especially in the current and previous production season big producers have demonstrated their ability to hold stock for longer periods of time than anticipated. The stock holding ability was clearly also boasted by the bumper crop of 2002, which coincided with record level prices.

Figure 5 and 6 graphically illustrate the comparison between stochastic estimates and the actual SAFEX maize prices. The current SAFEX white maize price is R160/ton below the minimum projected price in December 2004 and the current SAFEX yellow maize price is R250/ton below the minimum price projected in December 2004.

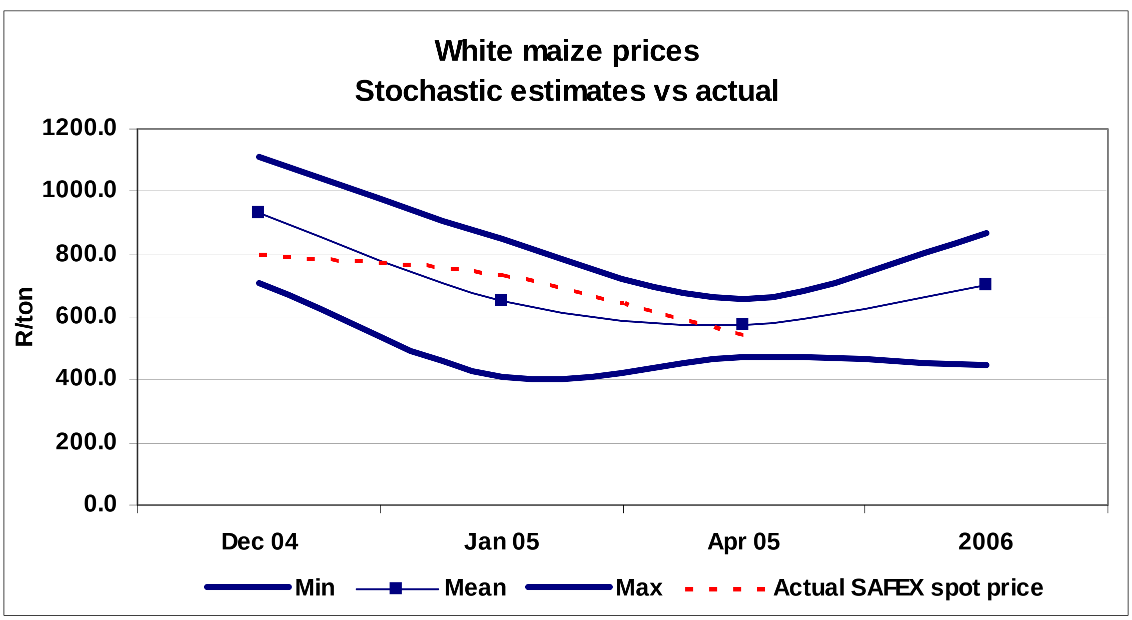

Figure 5: White maize prices – stochastic estimates versus actual spot prices

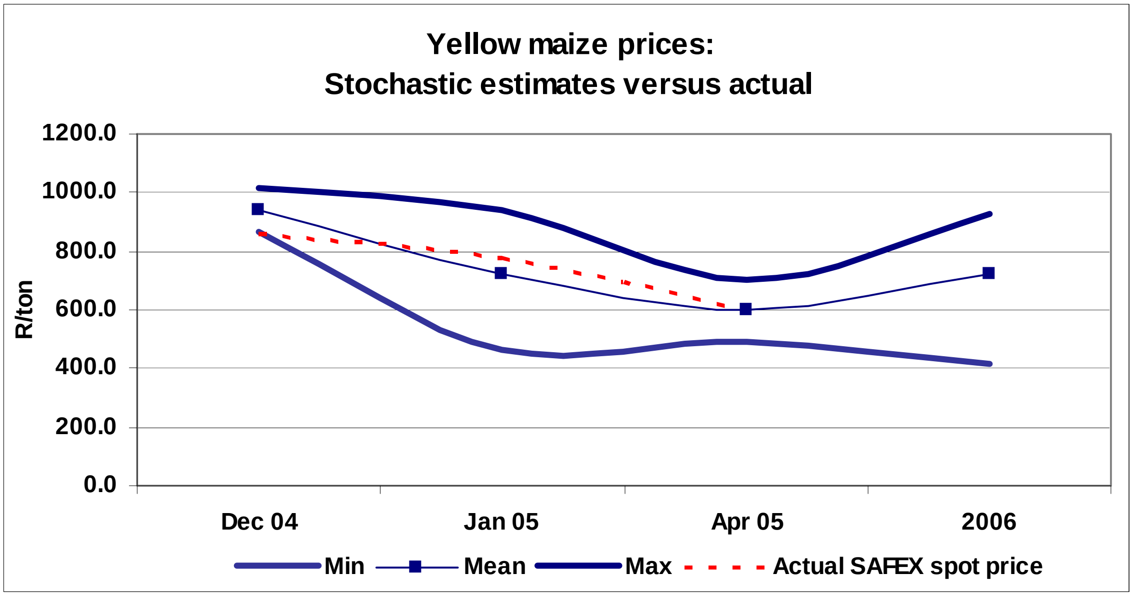

Figure 6: Yellow maize prices – stochastic estimates versus actual spot prices

To summarize, possible improvements to the model have been identified and are listed below. However, the usefulness of scenario planning cannot be underestimated and it forms a vital component of the decision making process. The process of decision-making should be based on knowledge, experience, the results of models and many other strategic planning techniques. It has to be kept in mind that the model projects annual average and despite of the fact that the stochastic ranges of maize prices have significantly narrowed down in the April projections due to a higher certainty about the size of the crop, this does not imply that prices could not move beyond these ranges in the period to come.

Additional measure and Improvements

Sector model structure

- The development of a new price formation section for all commodities that includes more relevant import and export parity pricing. Currently import and export parity prices are taken into consideration in the import and export equations. However, more research is required on the impact of export parity pricing to neighbouring states. (Estimated time for completion: August 2005)
- More research is conducted on stochastic yield analysis. This involves the construction of distribution from the error terms of each yield equation. (Estimated time for completion: August 2005)
- An agreement has been reached with the SA weather bureau to supply the rainfall information as soon as the data has been processed.

Scenario planning and research

- The development of a scenario planning strategy to its fullest potential. This will ensure that a net is cast out further to capture more plausible scenarios. A distinction will be made between short-term and long-term scenarios. This initiative is already introduced in section 5 of the report.

- Improved integration of the scenario planning exercises into the technical modelling framework.
- More detailed research is currently undertaken on consumption trends of main food items in South Africa
- Training industry specialist is one of the core building blocks of the BFAP philosophy. It takes time to train people, who have a strong academic background, to become true industry specialist with a clear understanding of and feeling for the industry.

4. RAINFALL

In September 2004 forecasts were published by the *Climate Prediction Center/NCEP* in Washington, which indicated that an El Niño like pattern would most probably reveal itself. What in December was regarded as a possible drought year with low crop yields by many role players in the industry, turned out to be an outstanding year with most probably the best crop yields in the history of maize production in South Africa. This section serves as a primer/"first word" for a new initiative introduced by BFAP to research weather patterns in more detail in order to better understand long-term weather forecasts and improve stochastic estimates in the model. For this report some of the basic characteristics of the El Nino phenomenon are briefly explained after which the rainfall patterns of the past three seasons will be compared.

El Nino patterns are associated with warmer temperatures and below-average rainfalls. El Nino patterns are important in assessing future weather conditions as they account for approximately 30% of the actual weather experienced, but they cannot be viewed in isolation, as there are many other factors to take into account. The fact that SA comprises of so many unique regions makes it dangerous to make generalisations about what's going to happen with the weather, and how it could influence the agricultural scene.

Most parts of the maize producing areas received higher rainfall (between 30 mm and 100 mm) during April – August 2004 than was the case for the same period in 2003. This made excellent initial soil moisture conditions possible at planting time. (Maize Vision No 63, 21 Sept 2004, See Fig 7)

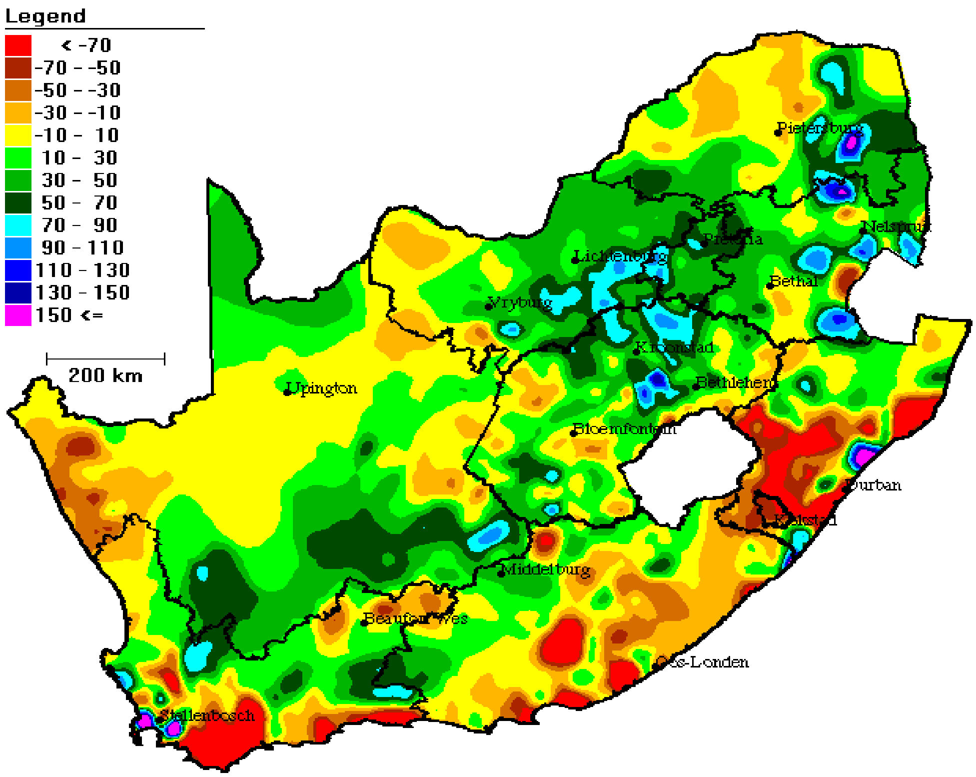

Figure 7 Differences in rainfall totals between 2003 and 2004 with positive values (green, blue and purple) indicate a higher rainfall for 2004 than 2003 and negative values (yellow, brown and red) indicate that more rain fell in 2003 than in 2004.

In 2004 *Weather SA* shed some light on the following issues with respect to El Nino and its consequences: The following range of relevant questions were quoted out of the report (Source: www.weathersa.co.za):

"Is this summer (2004) an El Niño season? Yes. The current weak El Niño conditions are expected to prevail throughout the summer into early 2005

Does El Niño cause drought in South Africa? No. Although some El Niño years have below-normal rainfall, the impact of El Niño on the agriculture is often reduced by the high level of rivers, dams, sufficient groundwater and soil moisture content carried over from the previous season.

How does El Niño influence the rainfall? The influence of El Niño on rainfall in South Africa is not straightforward. It differs from region to region and from season to season."

As previously explained in the sector model rainfall is split into the rainfall that influences the area planted and the rainfall that influences the production of each crop. A further distinction is made between the summer and winter rainfall region. The rainfall for a specific season is calculated as the simple average rainfall for the specific months that influence the area planted and the production respectively. The winter and summer regions are split up into districts, as illustrated in Figure 8 below. Rainfall data is collected by Weather SA, whereupon only the applicable regions' rainfall figures are imported into the BFAP sector level model.

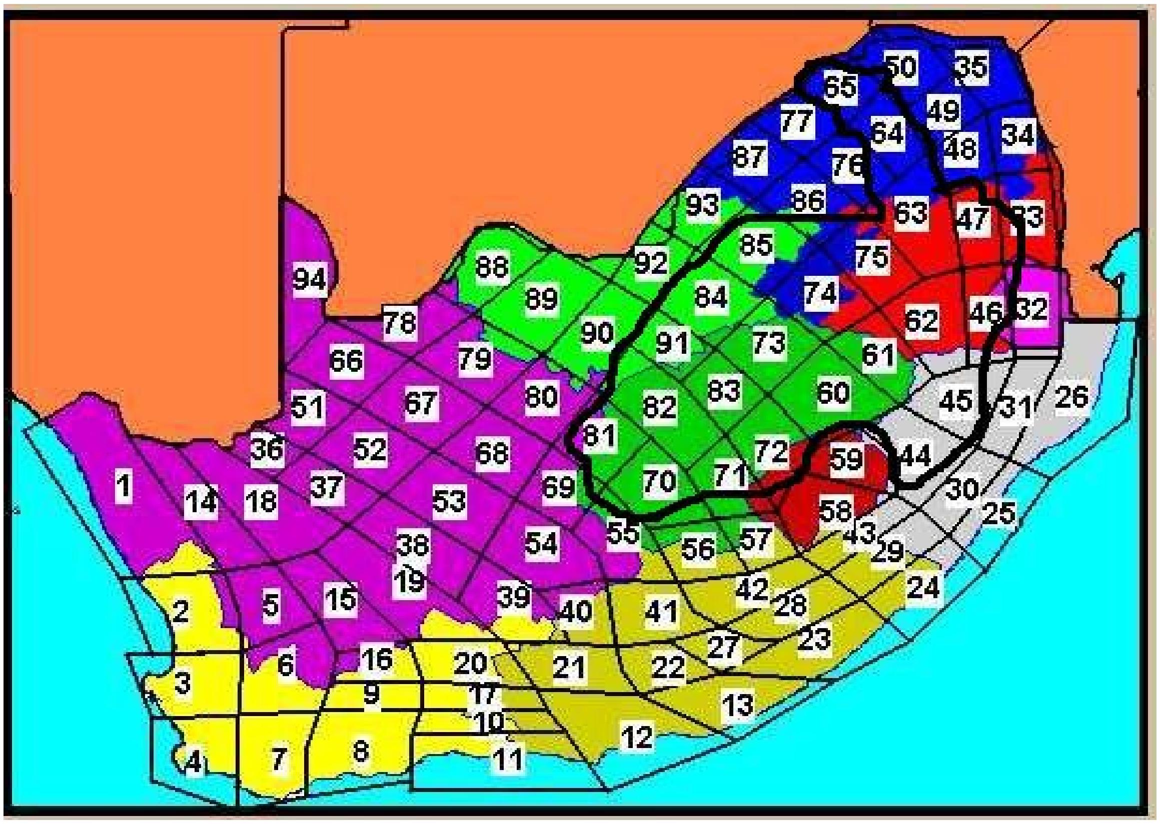

Figure 8: Rainfall district of South Africa

Table 6 below clearly depicts the specific months influencing area and production for each of the crops in the model. All the winter crops fall in the winter rainfall region category, except for the wheat summer area planted and harvested.

Table 6: Relevant rainfall months for various production seasons

	Jan	Feb	Mrt	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Summer area	■							■	■	■	■	■
Summer production	■	■	■							■	■	■
Winter area			■	■	■	■						
Winter production					■	■	■	■	■	■		
Maize area								■	■	■	■	■
Sunflower area	■										■	■
Sorghum area									■	■	■	■
Soya area											■	

Figures 9 and 10 present comparisons of rainfall statistics for the critical months over the past three production seasons. The addition of the rainfall data for February to April for each production season (2005 data for March, April and May not available yet) will add much more detail to the picture since it were exactly these months where the amount of rain was much higher than forecasted over the past two production seasons. This led to significant increases in yields.

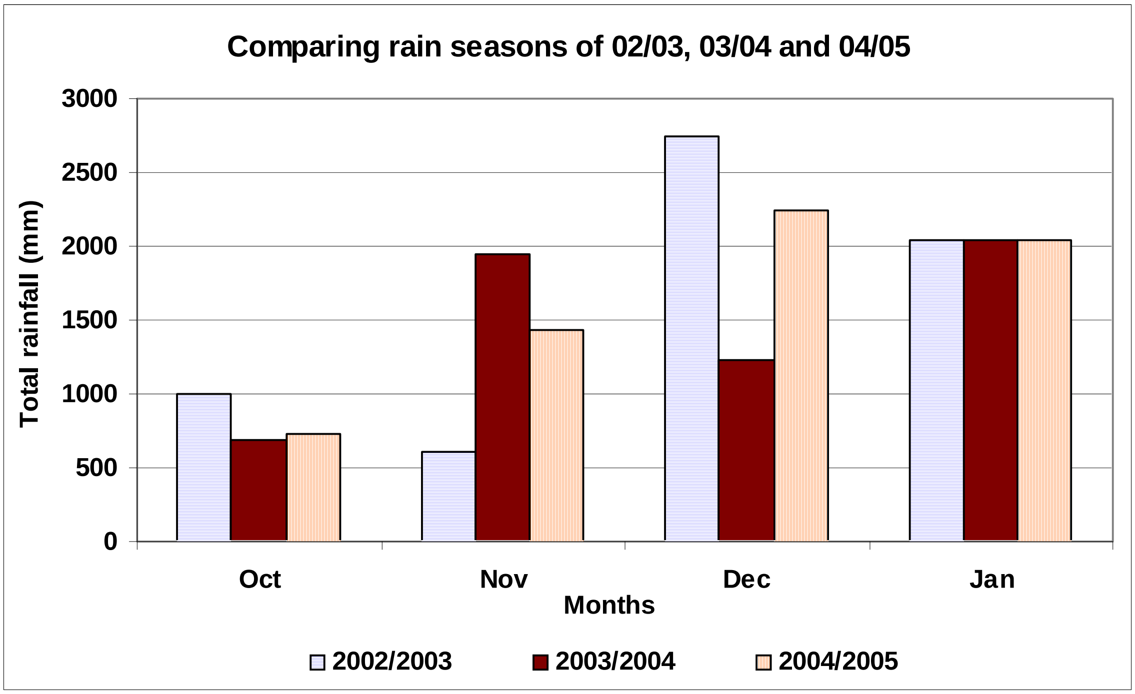

Figure 9: Rainfall district of South Africa

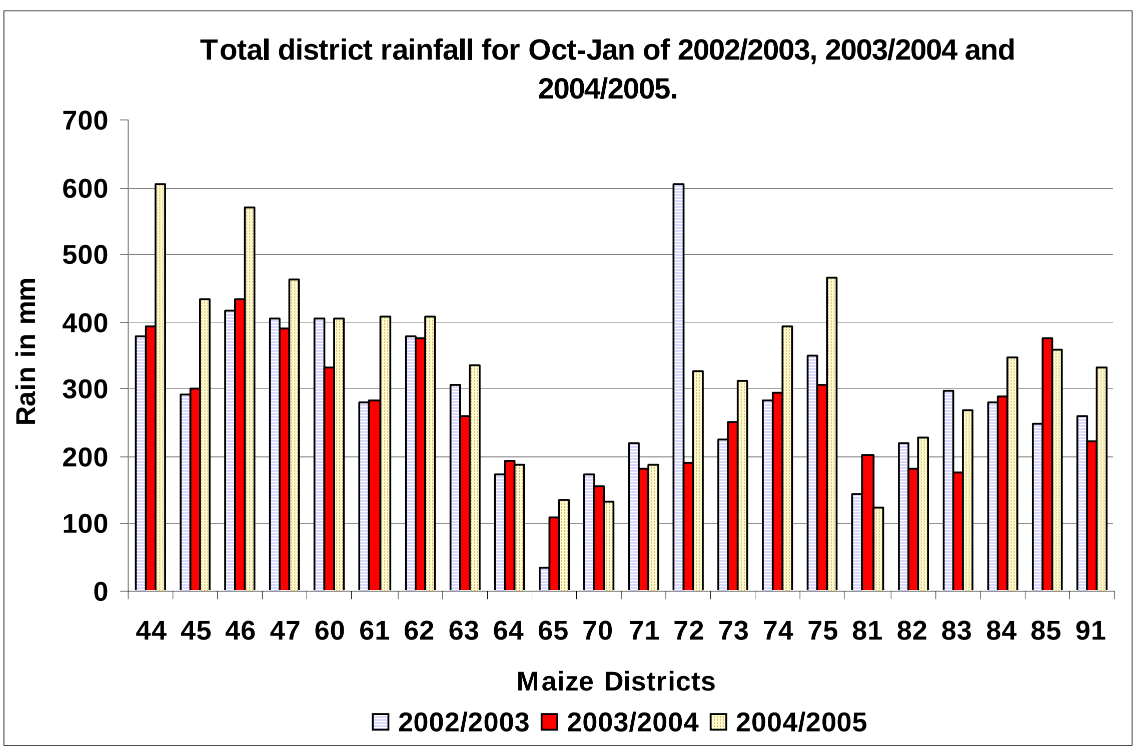

Figure 10: District rainfall for the period October – January for the past three production seasons, including 2004/05.

From Figure 10 it is evident that for most of the districts in the summer production area the 2004/05 production season recorded the highest rainfall over the past three production seasons.

5. SCENARIO ANALYSES

The purpose of this section is to introduce a range of new scenarios. These scenarios vary in nature; ranging from short term to long term. The purpose of this section is to share some thoughts on the construction and possible outcome of each scenario in order to facilitate feedback from the company as well as future scenario planning sessions for the expansion of these scenarios. The medium term and long-term scenarios follow the short-term scenarios.

5.1 Exchange Rate

Earlier this year a report came out which identified 3 drivers that influence the SA exchange rate. The three drivers were the interest rate differential between SA and other countries (particularly the US and the EU), the US/EU exchange (strength of the US$) as well as the gold price. In the last 2 months the interest rate differential has increased due to an increase in the US interest rate and a decrease in the SA interest rate. After gold sales by the IMF in an effort to lower third world debt were proposed earlier this year, experts around the world are still divided about the idea and thus gold prices are still very uncertain.

Proposed Scenario: An exchange rate of R/US$ 8.

5.2 Lower Beef Prices

This season's low maize prices have coincide with the highest beef prices in three years. This has resulted in farmers finishing weaners that can be sold in August/September this year. The higher SA prices along with Namibia and Botswana losing export contracts to the EU due to foot-and-mouth disease, have also led to higher SA beef imports from Namibia and Botswana.

These factors led to the question of the possibility of lower beef prices toward the end of the year and what the possible substitution effect could be on the pork industry. At this time these concerns are incorporated in the model through higher beef production figures. Table 7 below clearly presents the lower projected beef prices for 2005 due to an increase in beef production of approximately 28 000 tons (4.9%). Beef consumption is also projected to increase due to lower beef prices.

Table 7: Beef baseline projections

	2004	2005	2006	2007	2008	2009	2010
Beef production (1 000 t)	580.6	609.2	584.4	583.3	584.2	586.3	587.0
Beef Domestic Use (1 000t)	637.9	662.3	644.7	646.5	648.8	652.5	655.7
Beef average auction price	1326	1219	1334	1464	1540	1615	1707

5.3 Maize exports and ending stock

On April 21 I-NET Bridge reported that the Zimbabwe government needs up to 1.2 million tons of maize to make up for a shortfall. If one adds the Malawi demand for 300 000 to 500 000 tons, then SA could see 1.7 million tons of exports this year. Will SA have sufficient infrastructure to move the amount of maize if the demand exists in the neighbouring countries? As mentioned previously, in the third week of May 55 000 tons of maize were exported, which could mean an annual export level in access of 2 million tons.

It is envisaged that by the time of the next meeting with the company, the first version of a more advanced model, that incorporates a new import and export pricing section, will be ready for these analyses. In the mean time, some preliminary scenario analysis will be conducted with the current model.

5.4 Ethanol

Ethanol, also known as ethyl alcohol, alcohol, grain spirit, or neutral spirit, it is a clear, colourless, flammable oxygenated fuel (READI, 2002), which can be produced using crops such as maize and sugar. Biodiesel, in turn, refers to the monoalkyl esters of long chain fatty acids derived from plant or animal matter (Radich, 2004?). The possibility of producing ethanol in SA is currently drawing attention due to the domestic trends in maize production and its relatively low price. The feasibility of constructing small ethanol plants that uses the dry milling process (as opposed to the wet milling process) is being examined. The reasons for examining this particular option in more detail is related to the nature of agricultural production in SA as well as the characteristics of the dry milling process. The wet and dry milling methods of ethanol production have different cost structures and by-products, which in turn have different values. These differences will be examined along with countries which are currently playing an important role in the international markets for ethanol and biodiesel.

Proposed Scenario: A total of 7 ethanol plants and planned for construction. Each plant has a capacity of 370 000 tons per annum, which generates an additional maize market in South Africa of 2.6 million tons to supply 1 260 950 000 litres of ethanol. Approximately 1 million tons of DDGS (Dried distillers grain) will enter the feed market. At an exchange rate of R6/US$ - R7/US$ the breakeven price of maize for these plants is in the region of R800 – R900/ton.

What would happen if these 7 plants are brought into production?

LONG TERM

5.5 Shift in Production Maize Areas

The following scenarios are just the starting blocks for more extensive scenarios on above-mentioned issue, and therefore need to be thought through by the group, changed, expanded and enriched. After the scenarios have been completed, leading indicators need to be identified, which will indicate which scenario or mix of scenarios are playing out.

Key drivers:

- Infrastructure development
- Foreign investment
- High rainfall and fertile soils
- World trade negotiations
- World food programs
- Biotech
- South African agricultural industry survivability

Key uncertainties:

- Successful infrastructure development
- Input suppliers
- Local markets
- Export markets for biotech food
- Political unrest
- World support/finance/investment
- Commodity prices and debt levels

Countries involved:

- Angola
- Zimbabwe
- Zambia
- Mozambique
- Tanzania
- DRC
- Uganda
- Kenya

Four scenarios:

Scenario 1:
Infrastructure development does take place to an extent. However, due to world trade negotiations as well as world food programs, local markets are flooded with imported products while export markets are too competitive. Thus, commercial grain production is not viable over the long-term, and subsistence farming continues. Very little investment takes place from foreign countries including investment from South African companies. The fruit from investments flows back to investing country, and not to locals.

Scenario 2:
Infrastructure development is relatively successful. Some input suppliers invest in countries and some commercial farming does take place. However, subsistence farming is most prevalent, and infrastructure is mostly used to transport people and small amounts of farm products to local markets. Food programs still play major role. Foreigners do invest in agricultural sector, and some of the fruits of the investment flow to the locals. World trade negotiations

Scenario 3:
Infrastructure development is successful. The good infrastructure leads to investment from foreign companies. Commercial farming takes place to large extent as well as subsistence farming leading to a dualistic agricultural sector. Wealth is accumulated by a few selected locals from the foreign investments. However, the political unrest begins due to accumulated wealth leading to power struggles. This leads to periods of destabilization in the region hampering foreign investment.

Scenario 4:
Infrastructure development is successful. The good infrastructure leads to investment from foreign companies. Commercial farming takes place to large extent as well as subsistence farming leading to a dualistic agricultural sector. Wealth is accumulated by a greater part of the locals from the foreign investments. Good governance takes place, leading to political stability and more foreign investment. Commercial farmers are highly competent relative to rest of the world due to good infrastructure, supply of technology and good production knowledge. Region becomes net exporter of grain and livestock products.

6. CONCLUSION

Report 2005-2 will be completed after the next meeting. This report will consist of the latest baseline projections as well as the recommended adjustments and expansions to the range of scenario analyses. Short-run scenario analyses will include comprehensive analyses of grain markets in 2006 with respect to area planted, production and prices. Also included will be the first results of the farm-level model.

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Scenario Planning for The Company

Scenarios on maize price and maize price effect on pig producers

Constructed for The Company by BFAP

November 2005

Introduction and assumptions

During the scenario session, the company indicated that the Rand/$ exchange rate, the US maize price (US Nr 2), rainfall in the summer grain production region and the area planted with maize is likely to be the four key drivers during the South African 2005/2006 maize production season. Bird flu is seen as a key uncertainty since it can significantly influence the international feed market and therefore the South African feed market as well.

The following assumptions with regards to the probability distributions of the Rand/$ exchange rate and US Nr.2 price were made in the simulations of the various scenarios. These probability distributions are based on the views of the company.

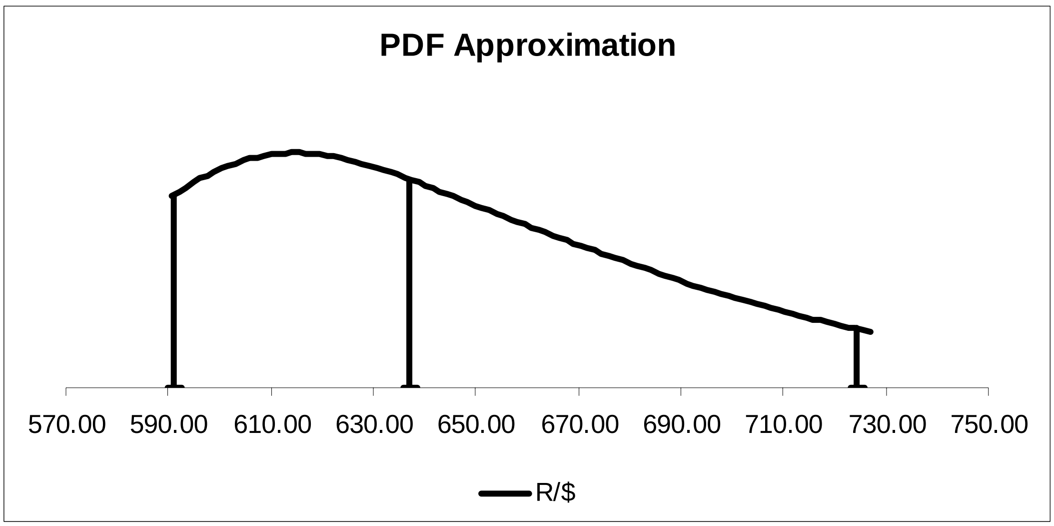

Figure 1: R/$ probability distribution

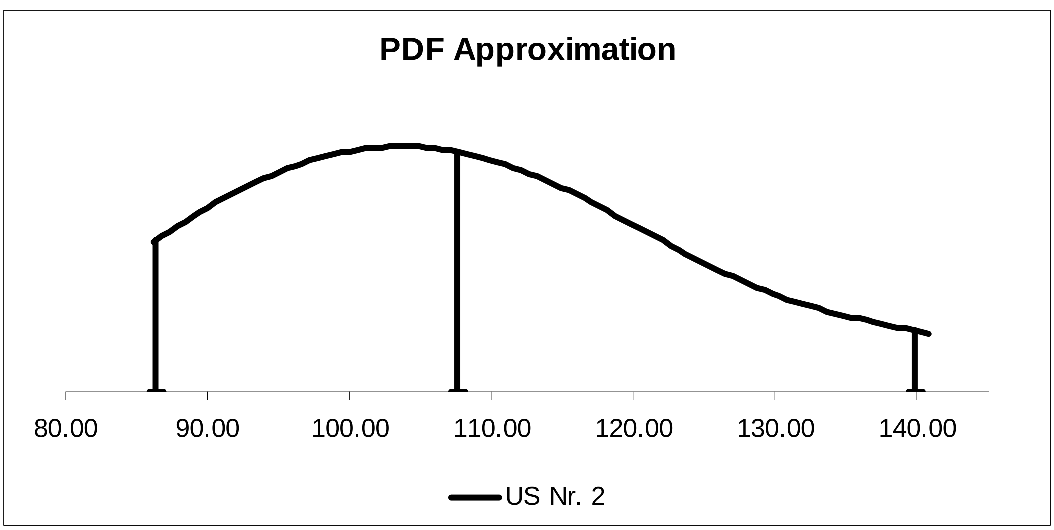

Figure 2: US Nr. 2 probability distribution

The probability density function (PDF) of the Rand/$ indicates that the average R/$ exchange rate for 2006 is likely to be R6,37/$, that the Rand is more likely to move in the area of R6,05 to R6,30 while there is a smaller probability that it might depreciate up to a level of R7,24/$ and beyond. The PDF of the US Nr. 2 price indicates an average price of $107/ton with the price more likely to move between $90/ton and $115/ton. There is a small probability of the price rising to $140/ton and beyond.

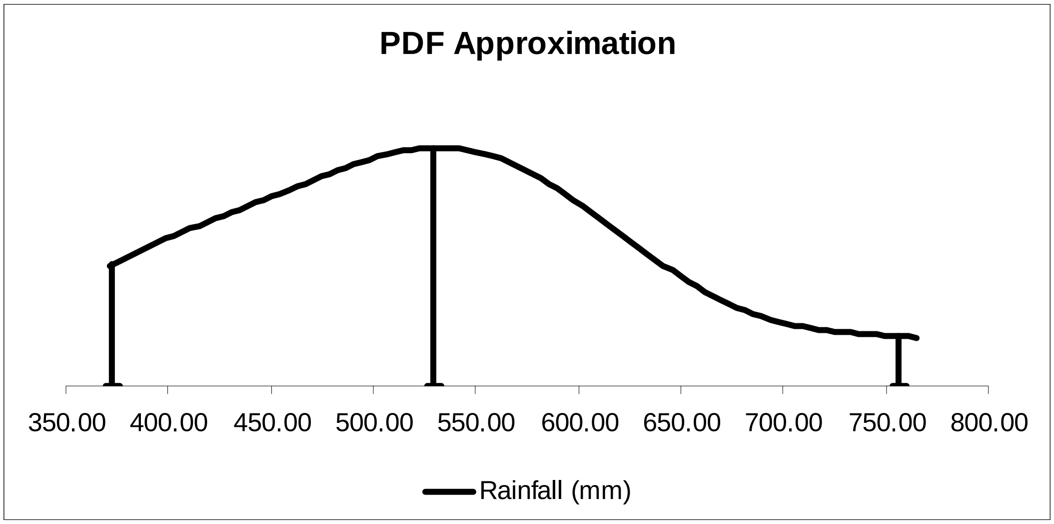

Figure 3: Rainfall (mm) during months influencing yield in summer grain area

Maize price and maize production scenarios

This section of the report presents the scenarios surrounding the area planted under maize for the 2005/06 production season along with the assumptions on the Rand/$, US Nr. 2 price and rainfall as presented in the introduction. Domestic price formation can take place at three alternative trade regimes, namely **import parity** (shortage in domestic market), **export parity** (surplus in domestic market), and **autarky** (domestic market between import and export parity). At import and export parity the cointegration between the domestic price, exchange rate and the world prices is much higher than when the market is trading at autarky. In other words, a shock in the exchange rate and the world prices has a larger impact on the domestic price if the domestic market trades at import or export parity levels. When the domestic market trades at autarky, domestic demand and supply conditions mainly determine the domestic price.

It is therefore appropriate to develop scenarios that illustrate how markets respond to exogenous shocks under the three various trade regimes. For example, the model solves for prices at import parity levels when a shortage is created in the market. Hence, by simulating three different production levels the model can solve for prices under the three various market regimes. Due to the fact that risk is inherent on most of the exogenous factors influencing the grain and livestock sectors, stochastic modelling techniques are applied to generate probability distributions for each of these exogenous factors. The level of import and export parity prices is mainly determined by the world prices and the exchange rate. Based on the stochastic simulation results of the exchange rate and world prices, probability distributions can be constructed for grain and livestock commodity prices.

The various trade regimes were simulated by shocking the area planted under white and yellow maize in 2006 as follows:

Import parity: 500 000 ha white maize, 500 000 ha yellow maize
Autarky: 1.21 million ha white maize, 895 000 ha yellow maize
Export parity: 1.8 million ha white maize, 1.2 million ha yellow maize

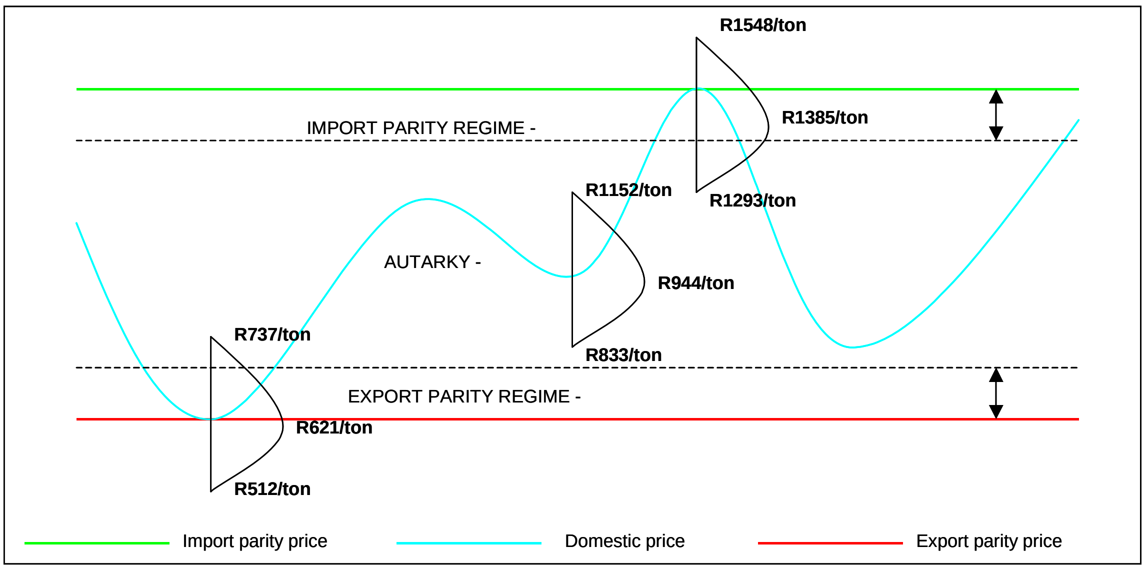

Figure 4: White maize SAFEX price distributions, 2006

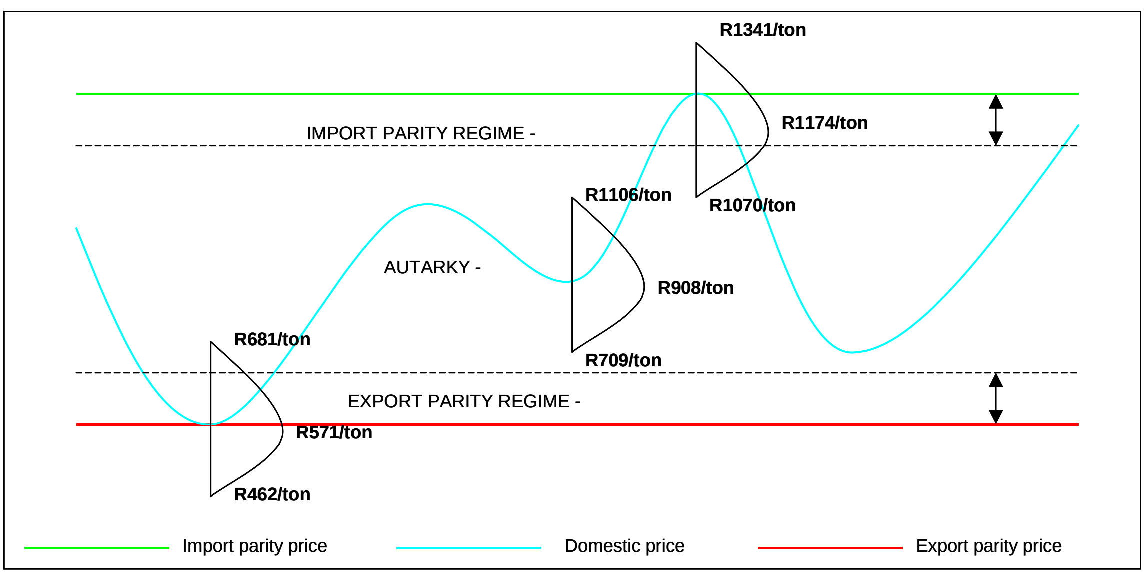

Figure 5: Yellow maize SAFEX price distributions, 2006

Given the variation in rainfall as well as the other key drivers as identified in the introduction, the PDF's of the total production of maize under the three different scenarios of import parity, autarky and export parity can be illustrated as follows:

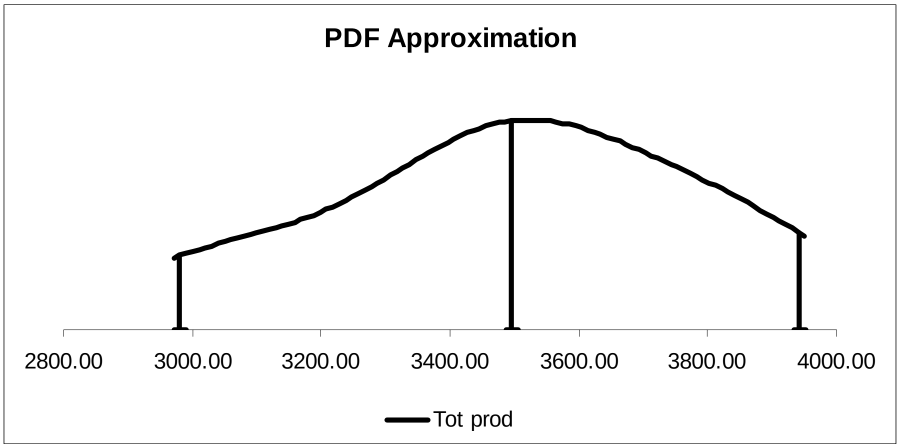

Figure 6: Total maize production (thousand tons) PDF under import parity scenario

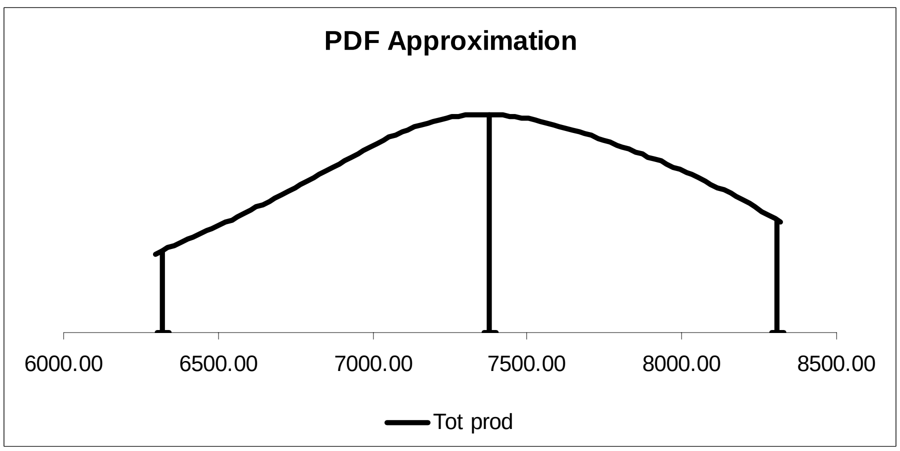

Figure 7: Total maize production (thousand tons) PDF under autarky scenario

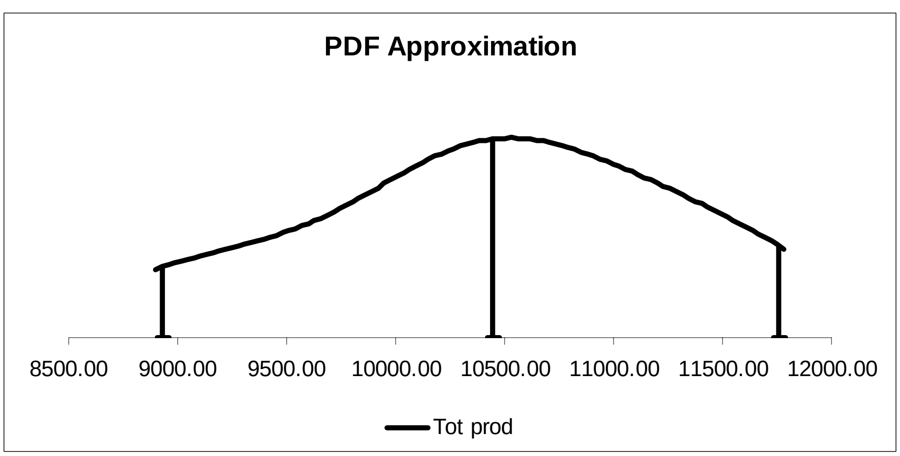

Figure 8: Total maize production (thousand tons) PDF under export parity scenario

Pork price scenarios

Based on the possible variation of the maize price in the three different scenarios, the pork price PDF's are as follows:

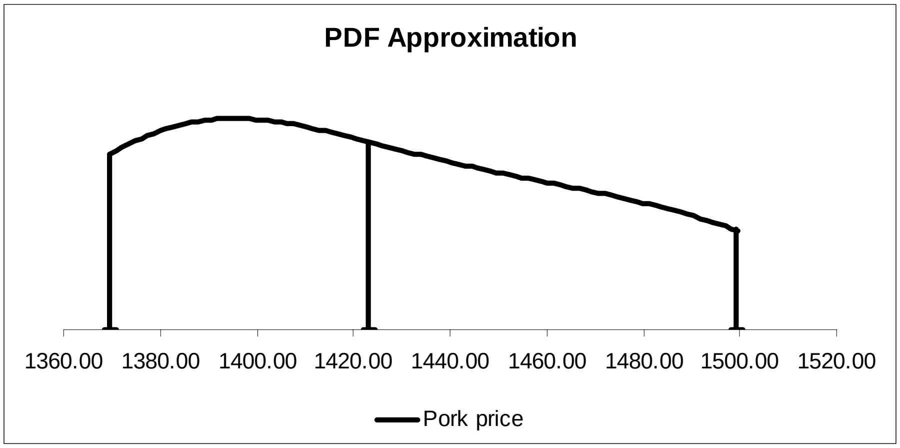

Figure 9: Pork price PDF (R/kg) under import parity scenario

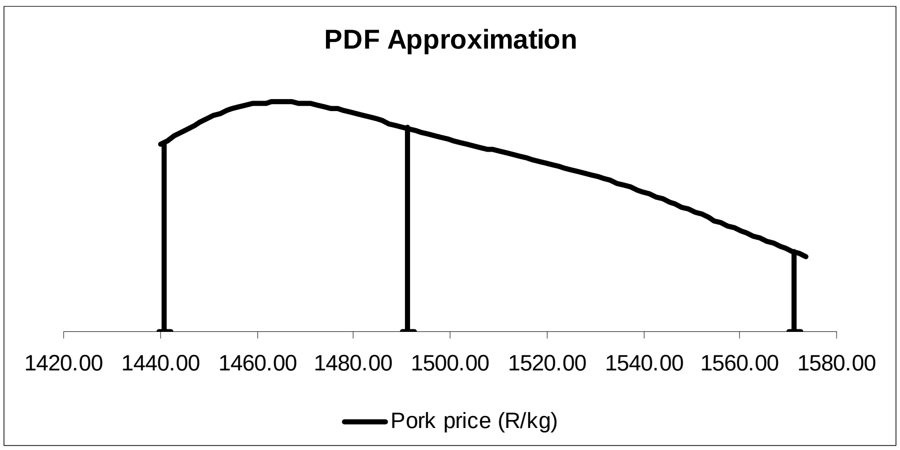

Figure 10: Pork price PDF (R/kg) under autarky scenario

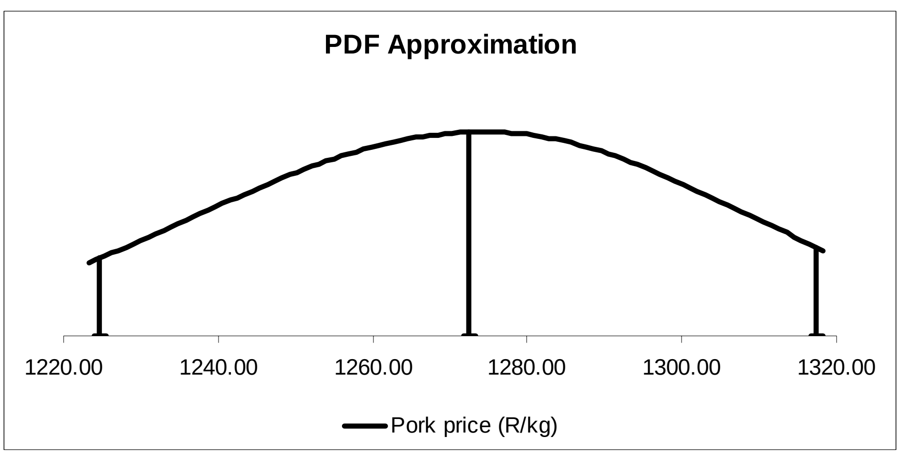

Figure 11: Pork price PDF (R/kg) under export parity scenario

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Profit before interest and tax (PBIT) scenarios

The following assumption were made in terms of the production of a kilogram of pig meat on a pig farm:

Table 1: Pig farm assumptions (2500 sow unit)

Item	**Assumption**
Production and price assumptions	
Baconer sales (amount)	46 800 pigs
Baconer weight (kg)	70 kg
Baconer price (R/kg)	R10,50/kg
Porker sales (amount)	5 200 pigs
Porker weight (kg)	55 kg
Porker price (R/kg)	R12,00/kg
Boar sales (amount)	50 pigs
Boar weight (kg)	150 kg
Boar price (R/kg)	R6,66/kg
Sow sales (amount)	1000 pigs
Sow weight (kg)	150 kg
Sow price (R/kg)	R6,66/kg
Cost of sales (Rand/sow)	
Feed	R9 500
Veterinarian	R88
Medicine	R400
Bedding	R2
Clothing	R2
Detergents	R6
Transport	R400
Repairs and maintenance	R700
Heating	R200
Breeding stock replacement cost	R1 360
Total cost of sales (R/sow)	**R12 658**
Fixed costs (R/sow)	R2 370
Total costs (R/sow)	R15 028
Total kilograms of meat sold on farm for the year	**3 719 500 kilograms**
Financial summary	
Income (R/kg)	R10,45/kg
Cost of sales (R/kg)	R8,51/kg
Fixed costs (R/kg)	R1,70/kg
Total costs (R/kg)	R10,21/kg
Profit before interest and tax (R/kg)	R0,25/kg

Given the maize price and pork price scenarios, the PDF's of the profit before interest and tax (PBIT) are illustrated as follows:

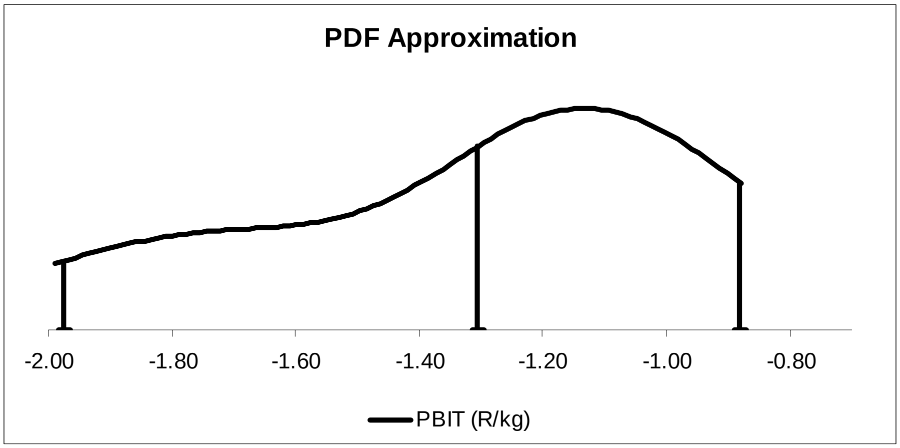

Figure 12: PBIT under import parity scenario

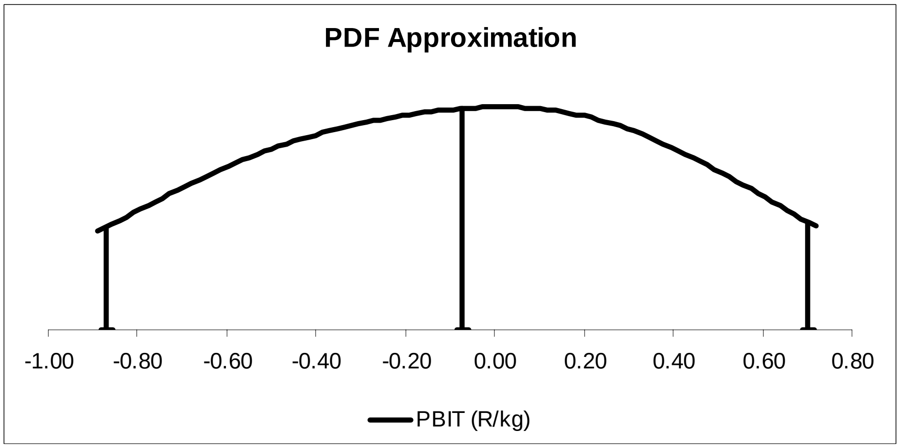

Figure 13: PBIT under autarky scenario

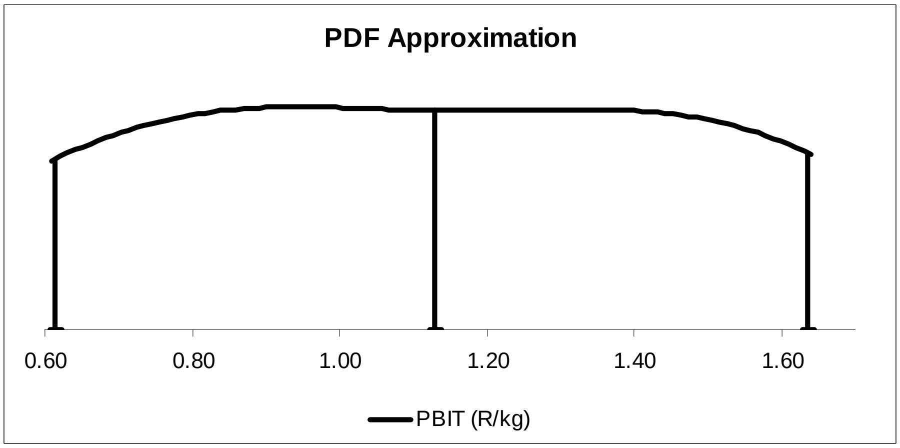

Figure 14: PBIT under export parity scenario

Appendix B: Rank correlation matrix, probability distributions used in case studies one and two

Yellow maize, Argentinean Rosario	Yellow maize, US No. 2	Wheat US No. 2 HRW	Sorghum US No. 2	Sunflower seed EU CIF Lower Rhine	Sunflower cake (pell37/38%) Arg CIF Rotterdam	Sunflower oil EU FOB NW Europe	Soybean seed Arg CIF Rotterdam	Soybean cake (pell 44/45%), Arg CIf Rotterdam	Soybean oil, Argentina	Nebraska, Direct fed steer	Chicken, US 12-city wholesale	Hogs, US 51-52% lean equivalent	Rand/$ exchange rate	US refiners acquisition price
1	0.94	0.64	0.94	0.49	0.29	0.61	0.67	0.41	0.67	-0.02	-0.06	-0.23	-0.33	-0.38
	1	0.66	0.97	0.5	0.25	0.65	0.63	0.4	0.64	-0.02	-0.03	-0.14	-0.25	-0.28
		1	0.69	0.43	0.55	0.46	0.73	0.7	0.51	0.22	0.08	0.06	-0.42	0.12
			1	0.51	0.34	0.66	0.74	0.49	0.71	0.11	0.04	-0.06	-0.33	-0.19
				1	0.3	0.85	0.58	0.25	0.81	0.01	-0.18	-0.1	-0.18	-0.24
					1	0.08	0.67	0.89	0.22	0.35	-0.03	0.18	-0.12	0.35
						1	0.61	0.2	0.89	0.05	0	-0.06	-0.31	-0.27
							1	0.82	0.77	0.24	0.16	0.21	-0.36	0.09
								1	0.33	0.39	0.18	0.31	-0.2	0.41
									1	0.05	-0.08	0.04	-0.4	-0.23
										1	0.35	0.48	-0.29	0.7
											1	0.4	-0.07	0.27
												1	-0.16	0.68
													1	0.06
														1

Table of probability distributions for key input variables for 2005/06 maize season(exogenous variables)

Variable	Yellow maize, Argentinean Rosario, FOB	Yellow maize, US No. 2	Wheat US No. 2 HRW	Sorghum US No. 2	Sunflower seed EU CIF, Lower Rhine	Sunflower cake (pell37/38%) Arg CIF Rotterdam	Sunflower oil EU FOB, NW Europe	Soybean seed Arg CIF Rotterdam	Soybean cake (pell 44/45%), Arg CIf Rotterdam	Soybean oil, Argentina	Nebraska Direct fed steer	Chicken, US 12-city wholesale	Hogs, US 51-52% lean equivalent	Rand/$ exchange rate	US refiners acquisition price	Rainfall summer area
Mean	108	107	147	103	270	106	643	227	188	492	1771	1393	875	617	56	525
Min	79	78	108	74	205	66	455	185	135	320	1354	1253	621	482	31	364
Max	160	169	206	160	314	159	822	298	268	641	2268	1636	1182	992	78	776
Std dev	16.39	16.14	24.69	16.16	32.01	18.70	86.33	30.96	32.26	84.82	282	110.64	148	137	12.22	94.22
CV	15.16	14.98	16.73	15.69	11.84	17.62	13.41	13.61	17.15	17.22	15.92	7.94	16.92	22.31	21.81	17.94

Note: these probability distributions were obtained through 500 stochastic iterations along with 3 000 internal model iterations per stochastic iteration. This implies a total of 1,5 million iterations were done in order to generate these correlated distributions. The reason for doing 3000 internal model iterations is because the model is a multi-market, simultaneous, stochastic, regime switching model as described in chapter two. Hence, for the model to obtain equilibrium in the case of one stochastic iteration it first need to run 3000 internal iterations in order to run the specific regime switch applicable to the values picked for each of the sixteen exogenous stochastic variables.

Appendix C: Reports used in case study two

BFAP / Kooperasie Scenario sessie: 09/09/2005

Drywers:
Reënval
Graan kopers
Boere finansiële posisie
Finansierders
Wisselkoers

Onsekerhede:
Finansiering van aanplantings
Suid-Amerika
Droë voorjaar
Graan teruggehou
Opbrengs – is hoer opbrengste 'n blywende tendens?
Groot kopers se posisies in graanmarkte
Afrika mark – uitvoermoontlikhede

Scenarios:

"Hoop"

Die Rand/Dollar wisselkoers bly beweeg tussen R6/$ en R7/$ vir die oorblywende gedeelte van 2005 asook vir 2006. Die meerderheid boere ervaar kontantvloeidruk gedurende 2005 weens lae graanpryse veral mieliepryse, wat hul aanplantingspotensiaal vir die 2005/2006 somergraanseisoen beperk. Finansierders is konserwatief wat betref finansiering van produksiekostes vir 2005/2006 somergraanseisoen weens boere se verswakte finansiële posisie. 'n Daling in aanplantings van mielies word ondervind a.g.v. lae mieliepryse asook minder goeie finansiële posisie. 'n Droë voorjaar word in die grootste gedeelte van die somergraanproduksiegebied ondervind, wat lei tot 'n verdere daling in aanplantings. Die totale daling in aanplantings is ongeveer 40%, waarvan 30% toegeskryf kan word aan lae pryse en minder goeie finansiële posisie en 10% aan finansieringsbeperkings. 'n Normale najaar wat reënval betref word ondervind, wat lei tot bo-gemiddelde per hektaar opbrengste wat mielies, sonneblom en sojas betref.

Opsomming van drywers:

Wisselkoers:
2005: R6.20 / VSA $
2006: R6.70 / VSA $
Wêreldpryse:
2006: 10% toename in wêreldkommoditeitspryse

Olie:
2005: $55/vat
2006: $40/vat
Mielie area
2006: 40% afname vanaf 2004/05 seisoen
Reënval:
Planttyd: Onder gemiddeld (Laer as basislyn)
Produksie periode: Normaal (Onveranderd vanaf basislyn)

Opbrengste
Mielies, sonneblom, sojas - hoër as basislyn
Koring – dieselfde as basislyn

"Balbreker"

Die Rand/Dollar wisselkoers bly beweeg tussen R6/$ en R7/$ vir die oorblywende gedeelte van 2005 asook vir 2006. Die meerderheid boere ervaar kontantvloeidruk gedurende 2005 weens lae graanpryse veral mieliepryse, wat hul aanplantingspotensiaal vir die 2005/2006 somergraanseisoen beperk. Finansierders is konserwatief wat betref finansiering van produksiekostes vir 2005/2006 somergraanseisoen weens boere se verswakte finansiële posisie. 'n Daling in aanplantings van mielies word ondervind a.g.v. lae mieliepryse asook minder goeie finansiële posisie. 'n Droë voorjaar word in die grootste gedeelte van die somergraanproduksiegebied ondervind, wat lei tot 'n verdere daling in aanplantings. Die totale daling in aanplantings is ongeveer 40%, waarvan 30% toegeskryf kan word aan lae pryse en minder goeie finansiële posisie en 10% aan finansieringsbeperkings. 'n Onder-normale najaar wat reëval betref word ondervind, wat lei tot onder-gemiddelde per hektaar opbrengste wat mielies, sonneblom en sojas betref. Die per hektaar opbrengste vir witmielies is 2,1t/ha en vir geelmielies is dit 2,2t/ha.

Opsomming van drywers:

Wisselkoers:
2005: R6.20 / VSA $
2006: R6.70 / VSA $
Wêreldpryse:
2006: 10% toename in wêreldkommoditeitspryse
Olie:
2005: $55/vat
2006: $40/vat
Mielie area
2006: 40% afname vanaf 2004/05 seisoen
Reënval:
Planttyd: Onder gemiddeld (Laer as basislyn)
Produksie periode: Onder gemiddeld (Laer as basislyn)
Opbrengste
Mielies: wit=2,1t.ha, geel=2,2t/ha (laer as basislyn)

Sonneblom, sojas = ondergemiddeld (laer as basislyn)
Koring = ondergemiddeld (laer as basislyn)

"Katarsis"

Die Rand/Dollar wisselkoers bly beweeg tussen R6/$ en R7/$ vir die oorblywende gedeelte van 2005 asook vir 2006. Die meerderheid boere ervaar kontantvloeidruk gedurende 2005 weens lae graanpryse veral mieliepryse, wat hul aanplantingspotensiaal vir die 2005/2006 somergraanseisoen beperk. Finansierders is konserwatief wat betref finansiering van produksiekostes vir 2005/2006 somergraanseisoen weens boere se verswakte finansiële posisie. 'n Daling in aanplantings van mielies word ondervind a.g.v. lae mieliepryse asook minder goeie finansiële posisie. Bo-normale reënval gedurende die voorjaar word in die grootste gedeelte van die somergraanproduksiegebied ondervind, wat lei tot 'n toename in aanplantings van wat oorspronklik verwag is. Die totale daling in aanplantings is ongeveer 20%, waarvan 10% toegeskryf kan word aan lae pryse en minder goeie finansiële posisie en 10% aan finansieringsbeperkings. 'n Onder-normale najaar wat reëval betref word ondervind, wat lei tot onder-gemiddelde per hektaar opbrengste wat mielies, sonneblom en sojas betref. Die per hektaar opbrengste vir witmielies is 2,5t/ha en vir geelmielies is dit 2,6t/ha.

Opsomming van drywers:

Wisselkoers:
2005: R6.20 / VSA $
2006: R6.70 / VSA $
Wêreldpryse:
2006: 10% toename in wêreldkommoditeitspryse
Olie:
2005: $55/vat
2006: $40/vat
Mielie area
2006: 20% afname vanaf 2004/05 seisoen
Reënval:
Planttyd: Bo gemiddeld (Hoër as basislyn)
Produksie periode: Onder gemiddeld (Laer as basislyn)

Opbrengste
Mielies: wit = 2,5t/ha, geel = 2,6t/ha
Sonneblom: onder gemiddeld (laer as basislyn)
Sojas: onder gemiddeld (laer as basislyn)
Koring: onder gemiddeld (laer as basislyn)

Appendix D: Reports used in case study three

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SCENARIO ANALYSIS FOR The Commercial Bank

By

THE BUREAU FOR FOOD AND AGRICULTURAL POLICY (BFAP)

February 2008

INTRODUCTION

The purpose of this report is to present the results of a scenario session held with the commercial bank on February 6th, 2008.

The report consists of three sections. Section 1 contains the baseline projections generated by the latest version of the BFAP sector model for the grain, oilseed, livestock, and potato industries in South Africa. Section 2 contains the scenario results on the various industries. Section 3 presents a discussion on table grape markets, informing decision makers on the key uncertainties and drivers likely to be faced by the table grape industry during the 2008/09 season.

BASELINE

2.1 The baseline story

The baseline is driven by several central themes currently shaping international and local markets.

Theme: "Investors on the move"[11]

From the discussions with \the commercial bank, it became evident that current beliefs are that Scenario 2 (see Appendix A for details) seems to be the one that could most likely play out with respect to the future macro-economic environment and can thus be regarded as the baseline for this report. The macro-economic assumptions are as follows:

Oil price remains high but stable since economies of Far Eastern countries and the EU continue to grow. In other words, US economic problems have less of an impact on these countries than what would otherwise be expected.
Rand weakens against other currencies including US$, because risk averse investors rather invest in more stable and growing economies such as EU, China and India.
Inflation remains high because of stable oil price and depreciating Rand.
Interest rates, therefore, remain high but stable. SARB does not increase interest rates in fear of seriously damaging already frail economy.

2.2 Deterministic projections

Table 1: Economic indicators for baseline projections:

		2008	2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	81.55	80.15	79.47	78.39
Population	Millions	47.63	47.79	47.96	48.13
Exchange Rate	SA c/US$	759.97	810.24	857.31	899.20
South African Real GDP	%	3.50	3.50	3.50	3.50
South African Real per capita GDP	R/capita	17935.7	18563.4	19213.1	19885.6
Interest Rate (Prime)	%	14.50	14.50	14.50	14.50

11 For a more detailed discussion on the macro-economic environment, see the Appendix.

Table 2: World commodity prices for baseline projections:

		2008	2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	215.00	215.05	213.76	211.68
Wheat US No2 HRW fob (ord) Gulf	US$/t	374.00	377.05	380.28	381.69
Sorghum, US No.2, fob, Gulf	US$/t	220.00	221.63	222.08	222.11
Sunflower Seed, EU CIF Lower Rhine	US$/t	745.00	740.00	718.49	706.83
Sunflower cake(pell 37/38%) , Arg CIF Rott	US$/t	410.00	403.39	393.29	390.47
Sunflower oil, EU FOB NW Europe	US$/t	1310.00	1322.54	1328.02	1334.61
Soya Beans seed: Arg. CIF Rott	US$/t	482.00	471.21	461.02	455.87
Soya Bean Cake(pell 44/45%): Arg CIF Rott	US$/t	440.00	450.38	451.19	449.65
Soya Bean Oil: Arg. FOB	US$/t	910.00	889.62	870.38	860.66

Source: BFAP

A very important picture is painted by the projections of world commodity prices, namely that most world prices are projected to remain high over the baseline period. Prices are mainly supported by high oil prices and strong growth of Asian economies. It has to be emphasised that these high commodity prices can only be sustained under the assumption of strong economic growth by major world economies. This assumption will be reviewed in the following scenario planning session with THE COMMERCIAL BANK .

The deterministic baseline projections for prices of selected commodities that are generated in the BFAP model are presented in Table 3. The detailed baseline projections are included in the Appendix B in the form of complete commodity balance sheets.

Table 3: SA commodity price projections

		2008	2009	2010	2011
White maize (SAFEX)	R/ton	1678.6	1843.9	1907.5	1951.8
Yellow maize (SAFEX)	R/ton	1666.3	1800.9	1881.1	1940.6
Sorghum	R/ton	1582.5	1652.6	1735.9	1809.5
Wheat (SAFEX)	R/ton	3619.1	3862.9	4101.1	4305.1
Canola	R/ton	3618.6	2886.6	3123.5	3267.7
Sunflower (SAFEX)	R/ton	4061.4	3725.0	3719.4	4156.0
Soybeans (SAFEX)	R/ton	3593.9	3722.5	3861.0	4012.3
Sugarcane	R/ton	207.8	211.4	231.6	240.5
Potatoes – market price fresh	R/10kg	18.09	22.77	22.37	24.57

Source: BFAP Sector Model

The main trends in the baseline projections can be summarized as follows:
In 2009 cereal prices are projected to increase while sunflower and canola prices will decrease from 2008 levels because hectares will move out of cereal production into oilseed production due to excessive favourable margins that exist in the production of oilseeds based on 2008 price levels.
Despite a sharp increase in wheat production, wheat will remain trading at import parity levels and, therefore, prices will increase over time as the exchange rate depreciates and world prices remain high.
Sugar and potato prices are projected to increase as well.

SCENARIO ANALYSES

This section analyses the possible impact on commodity markets if the global economy experience a serious stagnation in growth due to a recession in the US economy. This is in essence scenario 1, as presented in Appendix A. In short, the stagnation in world markets will cause the demand for oil to soften and, therefore, it is assumed that oil prices will decrease to levels between \$50 and \$60 per barrel. Due to biofuels, agricultural commodities are positively correlated with oil prices, which imply that lower oil prices will cause commodity prices to follow suit and decrease as well. The demand for agricultural produce will further soften by the economic stagnation. The table 4 presents the absolute and percentage deviations from baseline price projections.

The results show that an economic stagnation can have a very large effect on local commodity prices. The shock is introduced in 2008. Once the real effect of the shock starts filtering through the economy, local cereal prices can decrease by more than 35% and some local oilseed prices by as much as 42%.

Table 4: Scenario analyses 1: Absolute and percentage deviations from the baseline

		2008	2009	2010	2011
White Maize SAFEX Price		R/ton			
	Baseline	1678.58	1843.94	1907.53	1951.82
	Scenario	1574.95	1349.68	1499.04	1390.74
	Absolute Change	-103.63	-494.26	-408.49	-561.08
	% Change	-6.17%	-26.80%	-21.41%	-28.75%
Yellow Maize SAFEX Price		R/ton			
	Baseline	1666.34	1800.86	1881.13	1940.63
	Scenario	1572.41	1317.75	1448.77	1334.74
	Absolute Change	-93.93	-483.11	-432.37	-605.89
	% Change	-5.64%	-26.83%	-22.98%	-31.22%
Wheat SAFEX Price		R/ton			
	Baseline	3619.06	3862.92	4101.08	4305.13
	Scenario	3453.41	2630.50	2706.90	2784.16
	Absolute Change	-165.65	-1232.42	-1394.18	-1520.96
	% Change	-4.58%	-31.90%	-34.00%	-35.33%
Sorghum Producer Price			R/ton		
	Baseline	1582.48	1652.56	1735.92	1809.49
	Scenario	1505.95	1030.78	1145.59	1168.19
	Absolute Change	-76.53	-621.79	-590.33	-641.30
	% Change	-4.84%	-37.63%	-34.01%	-35.44%
Sunflower SAFEX Price		R/ton			
	Baseline	4061.39	3724.95	3719.45	4156.03
	Scenario	3995.86	3076.43	2121.26	2958.64
	Absolute Change	-65.53	-648.52	-1598.19	-1197.39
	% Change	-1.61	-17.41	-42.97	-28.81

Soybean SAFEX Price		R/ton			
	Baseline	3593.88	3722.46	3861.01	4012.35
	Scenario	3419.94	2278.08	2366.35	2437.48
	Absolute Change	-173.95	-1444.38	-1494.66	-1574.87
	% Change	-4.84%	-38.80%	-38.71%	-39.25%

An alternative scenario to the baseline as presented in section 2 was requested by The commercial bank. The alternative scenario uses a much higher oil price compared to the baseline. Tables 5 and 6 presents the simulation results compared to the baseline results.

Table 5: Scenario analyses 2: U.S. refiners' acquisition oil price - Absolute change from the baseline – US$/barrel

	2008	2009	2010	2011
Baseline	81.6	80.2	79.5	78.4
Scenario	110.0	111.1	112.2	113.3

Table 6: Scenario analyses 2: Absolute and percentage deviations from the baseline

		2008	2009	2010	2011
White Maize Producer Price		R/ton			
	Baseline	1678.58	1843.94	1907.53	1951.82
	Scenario	1756.55	1918.55	1912.40	1969.83
	Absolute Change	77.96	74.61	4.87	18.01
	% Change	4.64	4.05	0.26	0.92
Yellow Maize Producer Price		R/ton			
	Baseline	1666.34	1800.86	1881.13	1940.63
	Scenario	1675.64	1725.38	1902.23	1960.85
	Absolute Change	9.30	-75.48	21.09	20.22
	% Change	0.56	-4.19	1.12	1.04
Wheat Producer Price		R/ton			
	Baseline	3619.06	3862.92	4101.08	4305.13
	Scenario	3783.34	4047.92	4304.54	4528.28
	Absolute Change	164.28	185.00	203.46	223.16
	% Change	4.54	4.79	4.96	5.18
Sorghum Producer Price			R/ton		
	Baseline	1582.48	1652.56	1735.92	1809.49
	Scenario	1596.09	1659.58	1748.52	1823.00
	Absolute Change	13.61	7.02	12.59	13.51
	% Change	0.86	0.42	0.73	0.75
Sunflower Producer Price		R/ton			
	Baseline	4061.39	3724.95	3719.45	4156.03
	Scenario	4084.77	3813.75	3816.36	4221.94

		2008	2009	2010	2011
	Absolute Change	23.39	88.80	96.91	65.91
	% Change	0.58	2.38	2.61	1.59
Soybean Producer Price		R/ton			
	Baseline	3593.88	3722.46	3861.01	4012.35
	Scenario	3599.02	3729.20	3869.13	4020.48
	Absolute Change	5.13	6.73	8.11	8.13
	% Change	0.14	0.18	0.21	0.20

TABLE GRAPE INDUSTRY DISCUSSION

The current 2007/08 season for table grapes looks promising thus far. Though South African volumes appear to be closer to the lower end of the projected range of 48.3 to 54.0 million cartons, volumes from other Southern Hemisphere (SH) countries also appear to be down and prices are up from last year. Prices on the European continent responded well to the lower volumes, but in the UK prices are a bit sluggish to adjust upwards. The weaker Rand is favouring the Rand realisation price received by the farmer. On the down side, some losses may be associated with the phyto-sanitary import restrictions imposed by Thailand.

This brief summary of the first half of 2007/08 season touches on the three key drivers in the table grape industry as summarised below. These drivers and uncertainties will dictate to a large extent the setting of the 2008/09 season and beyond.

Key drivers:
Export supply from Southern Hemisphere (SH) countries: Table grape exports from SH countries increased on average by 6% per annum over the past six years. During this time the price for South African grapes showed an average decline of 8% per annum. Future export supply from South Africa and other SH countries will have a major impact on prices. Volumes may stabilise over the next two seasons, as profit margins have come under pressure the past two seasons. However, the increasing trend in total volumes is expected to resume thereafter, though probably not at the same rate of the past six years.
Maintaining and creating new markets: Maintaining market share in existing markets and creating additional demand by opening new markets are required to boost prices. Non-tariff barriers, e.g. phyto-sanitary requirements, become increasingly important in market access and trade negotiations.
The exchange rate: The exchange rate is an important determinant in the export realisation price for the producer.

Key uncertainties:
Future export supply from South America and the future demand for grapes in the US during their winter months: Approximately 76% of total SH grape exports are from South American countries, with the majority of exports destined for the United States. Will grape export supply from South American countries continue to increase and how much

of these exports will be absorbed by the US? The uncertainty of the future demand for grapes in the US is linked to the uncertain economic outlook for the US.
If volumes are down, to what extent will prices adjust upwards? Should volumes be low in our traditional export markets (UK and continental Europe), to what extent will prices adjust upwards? A number of factors come into play including the power of the supermarkets, the prominence of wholesale markets in the future, relationships among exporters and importers/supermarkets, the knowledge and ability of exporters to negotiate prices and the fragmentation or unity of the table grape industry.
What is the exchange rate going to be?

CONCLUDING REMARKS

Although expectations currently are that global and, therefore, domestic grain and oilseeds prices are to remain high at least until the end of 2008, it is clear that possible changes in a combination of factors could change this picture significantly from 2009 onwards. Probably the most important driver that will determine the profitability of the agricultural sector in the next two years is the sharp rise in input costs. In most of the industries output prices are extremely favourable, but input prices are catching up at a fast rate putting profit margins under pressure again. It can, therefore, be concluded that clear risks and uncertainties exists that can and should be monitored to ensure that proactive changes can be made in order to manage risks and potential losses.

APPENDIX A OF REPORT

BFAP MACRO-ECONOMICS

SCENARIOS FOR 2008/09

1. Introduction

During 2003 to 2007, South Africa's economy experienced one of its strongest growth periods in history. This was due to the confluence of various positive factors creating growth, namely prudent macro-economic and fiscal management, the boom in commodity prices world-wide, expansion in global and continental integration, and rapid spending of a burgeoning middle-income group. However, since the middle of 2007, the macro-economic landscape has been changing drastically due to various factors interacting such as a slowdown in world economic growth, debt problems in the US, inflation running above monetary policy limits mainly due to spiralling fuel and food costs, increasing interest rates leading to pressure on consumer expenditure, and an increase in the current account deficit of South Africa due to large amounts of goods being imported into South Africa to supply the thirst of consumer expenditure. The question is, therefore, where could the South African macro-economic landscape be moving towards over the next two years?

2. Key drivers, key uncertainties and wild cards

In order to draw plausible macro-economic scenarios, the rules of the game, players of the game, key uncertainties and wild cards need to be identified and explored.

Rules of the game:

- Investors are generally risk averse: the implication of this driver is that investors will seek haven where the level of risk is in line with the level of potential profit. Hence, in a situation where the world economy is unstable, investors will in general opt for the less risky and stable investment environment.
- In general, the US economy has a significant impact on the rest of the world's economy: the implication is that if the US sneezes, the rest of the world gets a cold. Except maybe for China and India?

Key uncertainties:

- Will the US economy go into a recession? At this stage nobody is sure of the answer to this question. Some give it a 50% probability, others say it's a given.
- Should a US recession occur, what will be the macro-economic impacts specifically on the EU, China and India? In case the EU, China and India have enough internal momentum to keep their economies growing independently of a US recession, investors will see these economies as a haven. This implies international funds will flow towards these three economies leaving the rest of the world economies high and dry. If the EU, China, and India do not have enough internal momentum, implying that a US recession also leads their economies into

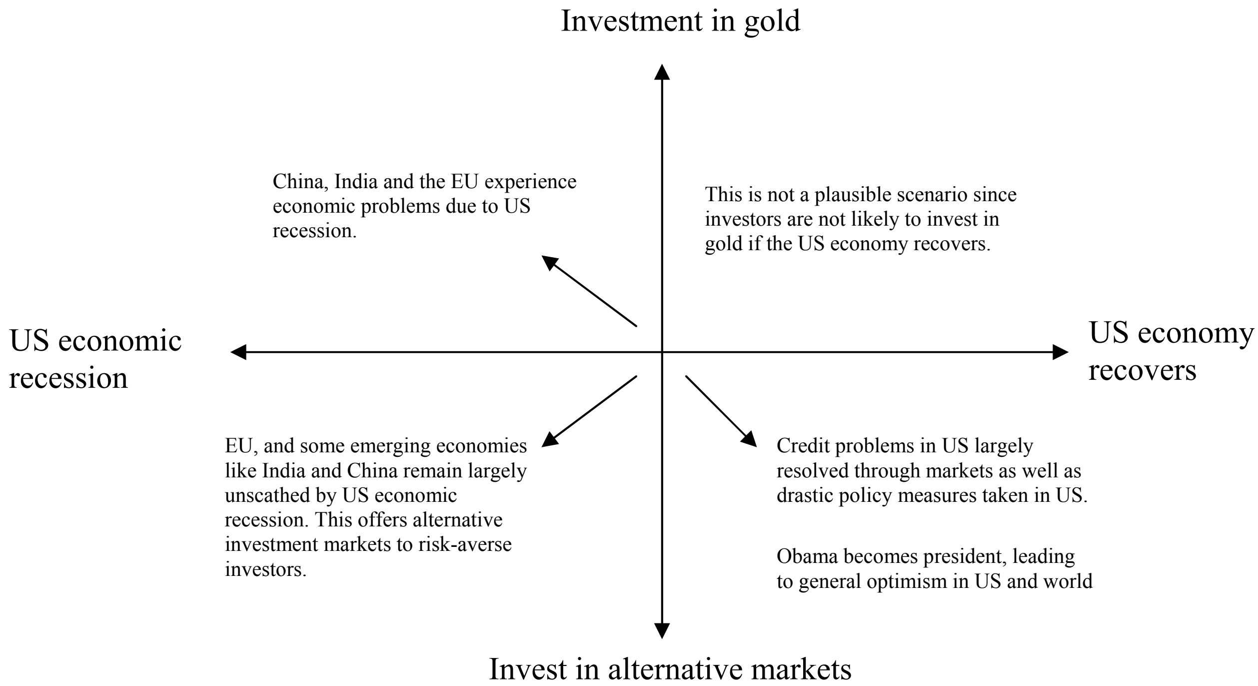
a recession, investors have very few safe havens left and gold will become an attractive option.

Wild Cards and players of the game:

- If Obama becomes president of the US, will it have a significant impact on the morale of US citizens leading to optimism and hence influencing investment in the US positively? Also, what will be the impact on the "war against terror" and hence how will it influence key diplomatic relationships e.g. the Middle East, Europe and China. Also, if the stance against the "war on terror" changes significantly, it could have a significant impact on Chinese economic growth since Chinese policies are geared towards an open, free and stable world economy.
- It is unknown if the drastic monetary policy measures taken recently by the Fed will swing the US back unto a growth path, and if so, how soon. Hence, will the US economy first go into a shallow recession, or will it stabilize at a very low growth level and then take off again?
- If a US recession does occur, what will be the reaction of OPEC be in terms of changing production policies? If they increase production or keep it stable to lower oil prices and, therefore, decrease energy costs to jump-start the world economy, the recession might be shorter and shallower than expected. If oil prices remain high and stable, the recession might last long as much fear. This could have a significant negative impact on Chinese economic growth.
- Will Eskom be able to manage power crisis successfully and assure investors that South Africa is a good long-term investment destination?
- Will the power struggle between the present government and the newly elected ANC executive committee have a crippling effect on the perception of South Africa as a potentially stable and prosperous investment haven or will the ANC and the present government manage to collaborate on key issues and hence create a perception of a stable and prosperous country.
- Will Jacob Zuma become the next president of South Africa? If he does, will he continue on the current policy paths, or will he drastically change policies in order to create a more social-democratic state driven by more socialist types of policies?

3. Scenarios

Scenario 1



Scenario 2 **Scenario 3**

Note: The key uncertainties form the two axes of the game board.

4. Implications of scenarios

Scenario 1:

- Rand on annual average stable against US$ and remains between R7 and R8 per $ since investors significantly invest in gold.
- However, Rand is highly volatile on daily basis against all currencies due to uncertainty in world markets.
- SA inflation generally high due to high world inflation, but follows a declining trend as world economy weakens and global inflation pressure weakens.
- Interest rate, therefore, remains high but also follows a slightly declining trend due to SARB being careful of adjusting interest rates because of frail economy.
- Oil price declines due to stagnating global economic growth.

Scenario 2:

- Oil price remains high since economies in Far Eastern countries and EU continue to grow. US economic problems have less of an impact on these countries' economies.
- Rand weakens against other currencies including US$, because risk averse investors rather invest in more stable and growing economies such as EU, China and India.
- Inflation remains high because of stable and high oil price and depreciating Rand.

- Interest rate, therefore, remains stable but high. SARB does not increase interest rates in fear of seriously damaging already frail economy.

Scenario 3:

- Dollar strengthens against all currencies due to new optimism amongst investors. This causes the Rand to weaken significantly, especially due to Eskom and political uncertainties in Southern Africa leading to investors becoming risk averse towards SADC investments.
- Oil price increase significantly due to renewed global economic growth.
- Rand weakness and increasing oil prices lead to significant inflationary pressure in SA.
- Interest rate remains high and stable.

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APPENDIX B OF REPORT

Commodity balance sheets for baseline projections

		2008	2009	2010	2011
White Maize					
White maize area harvested	1000ha	1654.4	1532.0	1611.23	1648.56
White maize average yield	t/ha	4.14	3.73	3.76	3.79
White maize production	1000 tons	6853.1	5720.4	6065.28	6254.47
White maize feed consumption	1000 tons	704.0	683.4	692.23	706.27
White maize human consumption	1000 tons	3883.1	3853.2	3861.10	3869.24
White maize domestic use	1000 tons	4765.0	4714.5	4731.32	4753.51
White maize ending stocks	1000 tons	1560.5	1570.6	1694.82	1825.99
White maize imports	1000 tons	0.0	0.0	0.00	0.00
White maize exports	1000 tons	1266.0	995.8	1209.76	1369.79
White maize SAFEX price	R/ton	1678.6	1843.9	1907.54	1951.82
Yellow maize area harvested	1000ha	1140.6	1014.1	1072.76	1109.98
Yellow maize average yield	t/ha	4.20	4.04	4.08	4.13
Yellow maize production	1000 tons	4789.1	4099.4	4382.03	4579.61
Yellow maize feed consumption	1000 tons	3351.8	3306.7	3290.33	3326.22
Yellow maize human consumption	1000 tons	281.8	275.8	272.54	270.39
Yellow maize ethanol use	1000 tons	0.0	0.0	0.00	0.00
Yellow maize domestic use	1000 tons	3815.6	3764.5	3744.87	3778.61
Yellow maize ending stocks	1000 tons	826.1	746.7	788.99	862.84
Yellow maize exports	1000 tons	609.3	414.3	594.83	727.15
Yellow maize imports	1000 tons	0.0	0.0	0.00	0.00
Yellow maize SAFEX price	R/ton	1666.3	1800.9	1881.13	1940.63
Wheat					
Wheat summer area harvested	1000 ha	493.7	598.1	633.65	652.24
Wheat winter area harvested	1000ha	393.8	441.6	456.88	470.12
Wheat average yield: Summer area	t/ha	2.75	2.77	2.78	2.80
Wheat average yield; Winter area	t/ha	2.50	2.51	2.51	2.51
Wheat production	1000 tons	2342.6	2761.1	2909.76	3006.76
Wheat feed consumption	1000 tons	9.2	8.9	4.10	0.99
Wheat human consumption	1000 tons	2644.7	2670.7	2684.48	2705.68
Wheat domestic use	1000 tons	2673.5	2699.3	2708.24	2726.33
Wheat ending stocks	1000 tons	292.6	219.9	181.26	163.74
Wheat exports	1000 tons	201.1	235.4	247.04	253.40
Wheat imports	1000 tons	378.5	100.9	6.93	0.00
Wheat SAFEX price	R/ton	3619.1	3862.9	4101.08	4305.13

		2008	2009	2010	2011
Canola					
Canola area harvested	1000ha	40.5	48.6	43.60	44.85
Canola average yield	t/ha	1.2	1.2	1.19	1.20
Canola production	1000 tons	47.3	57.4	51.93	53.89
Canola crush	1000 tons	40.0	40.0	40.00	40.00
Canola domestic use	1000 tons	45.1	54.1	54.24	55.48
Canola ending stocks	1000 tons	3.2	6.5	4.18	2.59
Canola net imports	1000 tons	0.00	0.00	0.00	0.00
Canola producer price	R/ton	3618.6	2886.6	3123.50	3267.65
Sorghum					
Sorghum area harvested	1000ha	94.7	105.4	106.06	106.51
Sorghum average yield	t/ha	2.96	2.97	2.98	3.00
Sorghum production	1000 tons	280.1	313.3	316.52	319.25
Sorghum feed consumption	1000 tons	9.4	14.4	13.15	12.24
Sorghum human consumption	1000 tons	165.6	164.9	163.09	161.96
Sorghum domestic use	1000 tons	185.0	189.3	186.23	184.20
Sorghum ending stocks	1000 tons	61.4	68.5	69.12	69.68
Sorghum net exports	1000 tons	59.7	116.9	129.70	134.49
Sorghum producer price	R/ton	1582.5	1652.6	1735.92	1809.49
Sunflower Seed					
Sunflower area harvested	1000ha	545.5	638.5	582.98	558.37
Sunflower average yield	t/ha	1.30	1.31	1.32	1.33
Sunflower production	1000 tons	708.9	837.0	770.57	743.95
Sunflower crush	1000 tons	559.4	593.0	637.55	670.32
Sunflower crush: Biodiesel	1000 tons	0	0	0	0
Sunflower domestic use	1000 tons	573.6	609.8	652.96	685.19
Sunflower ending stocks	1000 tons	245.9	468.2	583.96	646.36
Sunflower net imports	1000 tons	11.7	-4.9	-1.87	3.65
Sunflower SAFEX price	R/ton	4061.4	3725.0	3719.45	4156.03
Soybean Seed					
Soybean area harvested	1000ha	217.4	231.8	241.91	250.79
Soybean average yield	t/ha	1.86	1.88	1.90	1.91
Soybean production	1000 tons	405.2	436.1	459.01	479.90
Soybean crush	1000 tons	193.5	173.4	201.16	228.19
Soybean crush: Biodiesel	1000 tons	0	0	0	0
Soybean feed consumption (full fat)	1000 tons	187.7	201.1	209.65	219.03
Soybean domestic use	1000 tons	391.2	386.6	422.81	459.22

		2008	2009	2010	2011
Soybean ending stocks	1000 tons	100.3	88.8	83.37	81.15
Soybean net imports	1000 tons	-36.8	-61.0	-41.66	-22.90
Soybean SAFEX price	R/ton	3593.9	3722.5	3861.01	4012.35
Sugar					
Area in sugarcane	1000 ha	422.6	421.3	419.65	420.27
Sugarcane area harvested	1000 ha	317.4	317.0	315.91	315.52
Sugarcane average yield	t/ha	65.62	65.68	65.77	65.91
Sugarcane production	1000 tons	20828.1	20822.8	20775.91	20795.88
Sugarcane for sugar	1000 tons	20828.1	20822.8	15781.31	15821.70
Sugarcane for ethanol	1000 tons	0.0	0.0	4994.61	4974.18
Sugar extraction rate	Percent	11.8	11.8	11.76	11.76
Sugar production	1000 tons	2449.0	2448.4	1855.59	1860.34
Sugar domestic use	1000 tons	1290.6	1297.0	1303.69	1310.78
Sugar exports	1000 tons	1153.9	1146.9	547.39	545.04
Sugar statistical discrepancy	1000 tons	4.5	4.5	4.51	4.51
Sugar recoverable value	R/ton	1701.9	1732.5	1904.09	1979.78
Sugarcane average price	R/ton	207.8	211.4	231.62	240.52
Potatoes					
Total Area	1000ha	55.17	52.56	54.78	54.33
Total Production	1000 tons	2031.25	1950.37	2063.29	2080.00
Average Yield	t/ha	36.82	37.10	37.66	38.29
Potatoes Import	1000 tons	19.36	23.23	27.87	28.50
Consump: Fresh formal	1000 tons	693.85	608.76	652.00	633.91
Consump: Fresh Informal	1000 tons	570.99	588.58	619.07	642.90
Consump: Processing	1000 tons	443.89	431.74	465.05	473.50
Consump: Seed	1000 tons	232.55	217.40	229.59	226.67
Unexplained	1000 tons	0.31	0.34	0.34	0.22
Potatoes per capita consumption	kg/capita	35.88	34.09	36.20	36.37
Domestic Use	1000 tons	1941.59	1846.83	1966.05	1977.21
Potatoes Export	1000 tons	70.30	80.31	69.37	74.30
Market price – fresh	c/10kg	1809.62	2277.26	2237.83	2457.18

SCENARIO ANALYSIS FOR THE COMMERCIAL BANK

By

THE BUREAU FOR FOOD AND AGRICULTURAL POLICY (BFAP)

May 2008

INTRODUCTION

The commercial bank and BFAP met during April 2008 to review and update the baseline and scenario as presented previously in the February 08 scenario report. The purpose of this report is to present the updated baseline and scenario results.

THE COMMERCIAL BANK BASELINE

2.1 The baseline story

The macro-economic assumptions underlying the baseline as presented in this report (Table 1) represents the situation where global economic growth in general is not seriously dented by US and EU economic struggles, implying that emerging economies such as China, India, and Russia experience strong economic growth. This in turn causes oil prices to remain high, and the exchange rate to weaken moderately, relative to the Dollar and Euro. Due to high oil prices and a weakening Rand, inflation remains fairly high, supporting high interest rates. The result is that the South African economic growth slows down and only in 2011 does it reach the same growth rate it experienced during the period of 2003 to 2006/07.

2.2 Deterministic projections

Table 1: THE COMMERCIAL BANK's baseline projections - Economic indicators:

		2008	2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	105	110	115	121
Population	Millions	47.63	47.79	47.96	48.13
Exchange Rate	SA c/US$	780	830	857	899
South African Real GDP	%	3.5	4.0	5.0	5.5
South African Real per capita GDP	R/capita	18104	18828	19769	2085
Interest Rate (Prime)	%	15	15	14	13

Table 2: THE COMMERCIAL BANK's baseline projections - World commodity prices:

		2008	2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	243.67	239.27	238.06	231.56
Wheat US No2 HRW fob (ord) Gulf	US$/t	371.36	297.60	293.96	292.11
Sorghum, US No.2, fob, Gulf	US$/t	223.07	201.68	206.83	200.44
Sunflower Seed, EU CIF Lower Rhine	US$/t	723.74	642.36	647.71	650.58
Sunflower cake(pell 37/38%) , Arg CIF Rott	US$/t	316.97	273.45	258.50	249.76
Sunflower oil, EU FOB NW Europe	US$/t	1860.00	1716.65	1765.90	1817.99
Soya Beans seed: Arg. CIF Rott	US$/t	490.98	501.11	473.29	477.92
Soya Bean Cake(pell 44/45%): Arg CIF Rott	US$/t	422.36	399.12	355.89	338.19
Soya Bean Oil: Arg. FOB	US$/t	1423.85	1462.28	1566.22	1663.71

Source: BFAP

Table 3: THE COMMERCIAL BANK baseline - SA commodity price projections:

		2008	2009	2010	2011
White maize (SAFEX)	R/ton	1975.9	2062.2	2101.7	2132.3
Yellow maize (SAFEX)	R/ton	1966.9	2055.4	2085.0	2115.4
Sorghum	R/ton	1691.6	1610.2	1683.4	1724.5
Wheat (SAFEX)	R/ton	3871.2	3595.6	3720.8	3913.4
Canola	R/ton	4091.6	3994.7	4362.8	4670.9
Sunflower (SAFEX)	R/ton	4652.7	4394.3	4508.6	5094.8
Soybeans (SAFEX)	R/ton	3818.5	4107.5	4022.7	4253.0
Sugarcane	R/ton	1779.7	1942.2	2200.2	2465.2
Potatoes – market price fresh	R/10kg	2477.1	3007.6	3070.8	3360.7

Source: BFAP Sector Model

The main trends in the THE COMMERCIAL BANK baseline projections can be summarized as follows:

- Important to note is that despite the oil prices, world commodity prices are projected to decrease somewhat from the record high levels achieved in 2008. This is due to a general expansion in the global area planted to field crops, normal weather conditions and a slower growth in world demand.
- In the domestic market maize and soybean prices are projected to increase in 2009 while sunflower and canola prices will decrease from 2008 levels because some hectares will move out of maize production into oilseed production due to excessive favourable margins that exist in the production of oilseeds based on 2008 price levels.
- Wheat will also gain hectares lost to maize. However, despite a sharp increase in local wheat production wheat will continue to trade at import parity levels. Therefore, after an initial decrease in 2009 due to lower world prices, local prices will increase over time on the back of a weakening exchange rate and high and stable world prices.
- Sugar and potato prices are projected to increase as well. The reason for the increase in potato prices is a decrease in area planted due to significant increases in input costs which both decrease the potential profitability and increase the risk of potato production disproportionately to other alternatives such as maize.

SCENARIO PROJECTIONS

The scenario presented below indicates a global economy, which is severely affected by a recession in the US economy as well as overheating due to excessive high fuel and food prices. The assumption is, therefore, that the BRIC countries (Brazil, Russia, India, and China) do not have enough internal momentum to keep their economies growing at rates seen during the past few years, and also that inflationary pressure (due to excessive fuel and food prices) forces the economic growth in these countries to slow down in order to avoid excessive overheating. The macro-economic assumption underlying this scenario is presented in Table 4.

Table 4: Scenario Projections: Economic indicators

		2008	2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	105.00	80.00	79.47	78.39
Population	Millions	47.63	47.79	47.96	48.13
Exchange Rate	SA c/US$	780.00	900.00	945.00	992.25
South African Real GDP	%	3.00	3.00	4.00	3.50
South African Real per capita GDP	R/capita	18,017	18,557	19,300	19,975
Interest Rate (Prime)	%	15.00	14.00	12.00	10.00

Due to a change in the interest rate differential between the EU and the US, the Dollar strengthens, which forces oil prices down. On the back of this, the pressure on the demand for oil slightly weakens since trade and consumption of general goods and commodities slow down. The result is that oil prices drop unexpectedly to levels of around $80 per barrel.

The impact on the South African economy is a slowdown in economic growth, and a slowdown in inflation, which forces the Reserve bank to decrease interest rates more than expected in an attempt to get the economy back on the targeted growth path. This, however, does not happen and economic growth is generally below the 4% level except in 2010.

Table 2: Scenario projections - World commodity prices:

		2008	2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	227.95	190.25	160.90	156.51
Wheat US No2 HRW fob (ord) Gulf	US$/t	243.67	203.38	172.00	167.30
Sorghum, US No.2, fob, Gulf	US$/t	223.07	171.42	149.43	144.82
Sunflower Seed, EU CIF Lower Rhine	US$/t	723.74	578.12	553.79	556.24
Sunflower cake(pell 37/38%) , Arg CIF Rott	US$/t	316.97	246.11	221.02	213.55
Sunflower oil, EU FOB NW Europe	US$/t	1860.00	1417.14	1407.75	1388.62
Soya Beans seed: Arg. CIF Rott	US$/t	490.98	451.00	404.67	408.62
Soya Bean Cake(pell 44/45%): Arg CIF Rott	US$/t	422.36	359.20	304.29	289.16
Soya Bean Oil: Arg. FOB	US$/t	1423.85	1084.84	1077.65	1063.01

Source: BFAP

Table 3: Scenario projections - SA commodity price projections:

		2008	2009	2010	2011
White maize (SAFEX)	R/ton	1976.2	1870.0	1746.8	1877.8
Yellow maize (SAFEX)	R/ton	1966.8	1885.4	1644.3	1709.7
Sorghum	R/ton	1692.1	1486.5	1361.3	1417.8
Wheat (SAFEX)	R/ton	3871.2	3350.0	3487.0	3636.9
Canola	R/ton	4091.6	3794.6	4277.3	4638.2
Sunflower (SAFEX)	R/ton	4652.7	4213.9	4216.9	4607.6
Soybeans (SAFEX)	R/ton	3818.4	4002.8	3783.0	3994.0
Sugarcane	R/ton	1787.1	1961.8	2086.4	2192.1
Potatoes – market price fresh	R/10 kg	2465.6	2867.4	2891.2	3122.9

Source: BFAP Sector Model

The main trends in the scenario projections can be summarized as follows:

- Due to the general slow down in the economy, world commodity prices decrease rapidly in 2009 and 2010. This does, however, not imply that prices pull back to historical levels. Commodity prices still remain relatively high.
- Commodity prices in the local market are expected to decrease in 2009 and 2010. As a result, farmers will respond to the lower commodity prices by reducing the area planted to field crops, especially on the back of high input costs, which are in general sticky and therefore do not decrease at the same rate as commodity prices. This causes pressure on profit margins and also increases the risk of production significantly. The decrease in area (and supply), causes prices to rise again by 2010.

CONCLUDING REMARKS

From the baseline and scenario it is clear that the instability in commodity markets could potentially remain in the market place longer than expected. The world economy is moving into a situation where macro-economic and social stability is increasingly polarized and pressured; hence the uncertainties around commodity prices and input costs only increase.

It is, therefore, important that a robust framework is developed which can be used to capture and interpret various exogenous shocks and signals to understand future impacts and trends. This report provides only two possible outcomes of future scenarios.

APPENDIX A OF REPORT

BFAP MACRO-ECONOMICS

SCENARIOS FOR 2008/09

1. Rules of the game, players of the game, key uncertainties and wild cards

In order to draw plausible macro-economic scenarios, the rules of the game, players of the game, key uncertainties and wild cards need to be identified and explored.

Rules of the game:

- Investors are generally risk averse: the implication of this driver is that investors will seek havens where the level of risk is in line with the level of potential profit. Hence, in a situation where the world economy is unstable, investors will in general opt for the less risky and stable investment environment.
- In general, the US economy has a significant impact on the rest of the world's economy: the implication is that if the US sneezes, the rest of the world gets a cold. Except maybe for China and India?

Key uncertainties:

- Will the US economy go into a recession? At this stage nobody is sure of the answer to this question. Some give it a 50% probability, others say it's a given.
- Should a US recession occur, what will be the macro-economic impacts specifically on the EU, China and India? In case the EU, China and India have enough internal momentum to keep their economies growing independently of a US recession, investors will see these economies as a haven. This implies international funds could flow towards these three economies, depending on general risk of the investment environment and the interest rate differentials, leaving the rest of the world economies high and dry. If the EU, China, and India do not have enough internal momentum, implying that a US recession also leads their economies into a recession, investors have very few safe havens left and low risk invetsments will become an attractive option e.g. gold, money market etc.

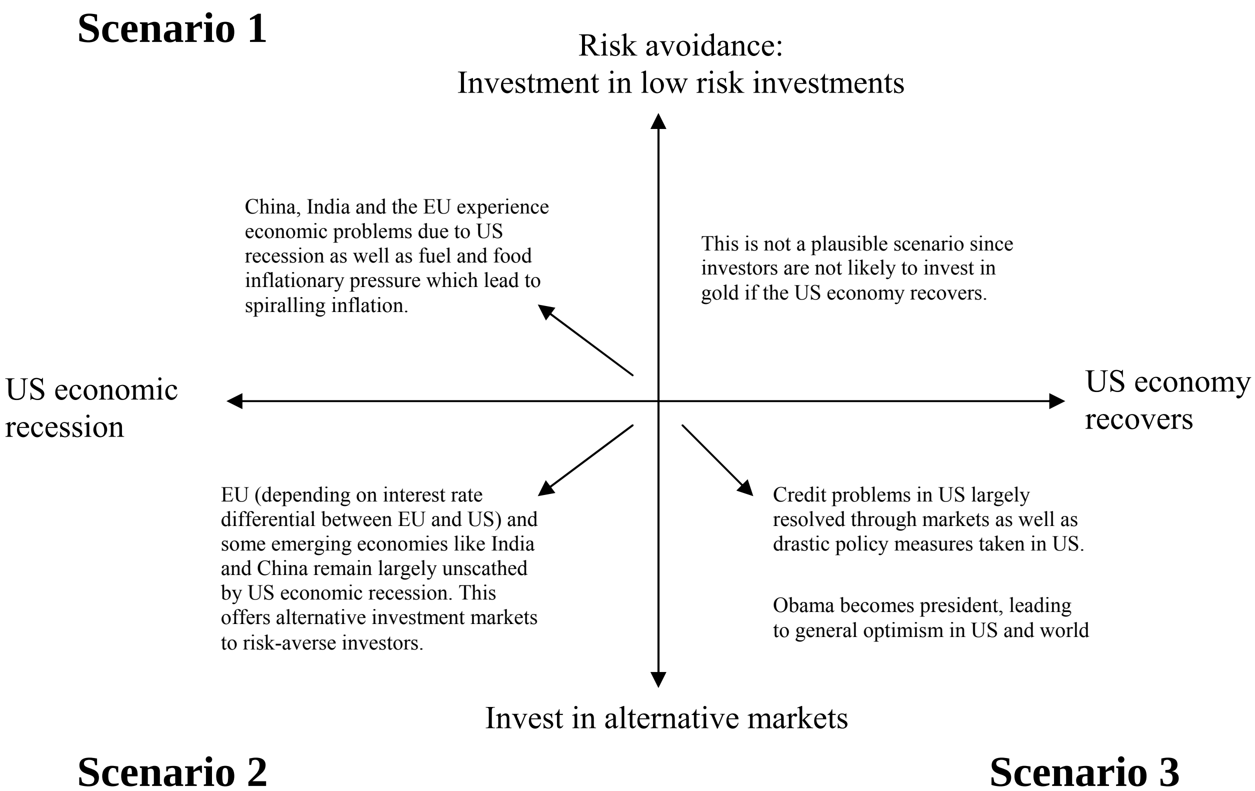
Wild Cards and players of the game:

- If Obama becomes president of the US, will it have a significant impact on the morale of US citizens leading to optimism and hence influencing investment in the US positively? Also, what will be the impact on the "war against terror" and hence how will it influence key diplomatic relationships e.g. the Middle East, Europe and China. Also, if the stance against the "war on terror" changes significantly, it could have a significant impact on Chinese economic growth since Chinese policies are geared towards an open, free and stable world economy.
- It is unknown if the drastic monetary policy measures taken recently by the Fed will swing the US back unto a growth path, and if so, how soon. Hence, will the

US economy first go into a shallow recession, or will it stabilize at a very low growth level and then take off again?

- If a US recession does occur, what will be the reaction of OPEC be in terms of changing production policies? If they increase production or keep it stable to lower oil prices and, therefore, decrease energy costs to jump-start the world economy, the recession might be shorter and shallower than expected. If oil prices remain high and stable, the recession might last long as much fear. This could have a significant negative impact on Chinese economic growth.
- Will Eskom be able to manage power crisis successfully and assure investors that South Africa is a good long-term investment destination?
- Will the power struggle between the present government and the newly elected ANC executive committee have a crippling effect on the perception of South Africa as a potentially stable and prosperous investment haven or will the ANC and the present government manage to collaborate on key issues and hence create a perception of a stable and prosperous country.
- Will Jacob Zuma become the next president of South Africa? If he does, will he continue on the current policy paths, or will he drastically change policies in order to create a more social-democratic state driven by more socialist types of policies?
- Will the Zimbabwe situation be solved in such a manner that the perceptions of international investors will become much more positive in terms of Southern Africa as a stable and profitable investment area?

3. Scenarios



Note: The key uncertainties form the two axes of the game board.

4. Implications of scenarios

Scenario 1:

- Rand weakens significantly against the US$ and the €.
- SA inflation generally high due to high world inflation, but follows a declining trend as world economy weakens and global inflation pressure weakens.
- Interest rate, therefore, remains high but also follows a sharper declining trend than expected due to SARB being careful of adjusting interest rates because of frail economy.
- Oil price at first decrease significantly and then moves mostly sideways on the back of slowing demand, and unwillingness from OPEC to adjust production and production capacity.

Scenario 2:

- Oil price remains high since economies in emerging countries continue to grow. US economic problems have less of an impact on these countries' economies.

- Rand weakens against other currencies including US$, because risk averse investors rather invest in more stable and growing economies.
- Inflation remains high because of stable and high oil price, high international agricultural commodity prices, a depreciating Rand, as well as the inflationary whiplash of services inflation. Food inflation is a strong driver in this scenario, but the impact does however lessen over time since emerging economies keep growing and hence consumers can afford and get used to higher prices.
- Interest rate, therefore, remains stable but high. SARB does not increase interest rates in fear of seriously damaging already frail economy.

Scenario 3:

- Dollar strengthens against all currencies due to new optimism amongst investors. This causes the Rand to weaken significantly, especially due to political uncertainties in Southern Africa leading to investors becoming risk averse towards SADC investments.
- Oil price increase significantly due to renewed global economic growth. Is $200/barrel of oil possible in this scenario as forecasted by an international institution during the week of 4 May 2008?
- Rand weakness and increasing oil prices lead to significant inflationary pressure in SA.
- Interest rate remains high.

APPENDIX B OF REPORT

Commodity balance sheets for baseline projections

		2008	2009	2010	2011
White Maize					
White maize area harvested	1000ha	1716.3	1590.1	1568.2	1550.7
White maize average yield	t/ha	3.84	3.73	3.76	3.79
White maize production	1000 tons	6594.9	5937.5	5903.1	5883.0
White maize feed consumption	1000 tons	698.0	690.0	690.2	704.1
White maize human consumption	1000 tons	3811.5	3735.8	3730.8	3731.1
White maize domestic use	1000 tons	4687.5	4603.7	4599.0	4613.2
White maize ending stocks	1000 tons	1466.4	1611.6	1686.0	1726.6
White maize imports	1000 tons	0.0	0.0	0.0	0.0
White maize exports	1000 tons	1204.2	1188.5	1229.7	1229.2
White maize SAFEX price	R/ton	1975.9	2062.2	2101.7	2132.3
Yellow maize					
Yellow maize area harvested	1000ha	981.7	989.2	1078.4	1102.0
Yellow maize average yield	t/ha	4.20	4.04	4.08	4.13
Yellow maize production	1000 tons	4121.9	3999.0	4405.0	4546.6
Yellow maize feed consumption	1000 tons	3259.0	3251.6	3307.8	3405.8

		2008	2009	2010	2011
Yellow maize human consumption	1000 tons	266.2	262.5	261.9	261.2
Yellow maize ethanol use	1000 tons	0.0	0.0	0.0	31.7
Yellow maize domestic use	1000 tons	3707.2	3696.1	3751.7	3880.7
Yellow maize ending stocks	1000 tons	609.8	614.8	752.5	863.5
Yellow maize imports	1000 tons	0.0	0.0	0.0	0.0
Yellow maize exports	1000 tons	336.8	297.8	515.7	554.8
Yellow maize SAFEX price	R/ton	1966.9	2055.4	2085.0	2115.4
Wheat					
Wheat summer area harvested	1000 ha	437.0	568.8	540.7	536.7
Wheat winter area harvested	1000ha	354.3	415.2	392.9	392.5
Wheat average yield: Summer area	t/ha	2.75	2.77	2.78	2.80
Wheat average yield; Winter area	t/ha	2.50	2.51	2.51	2.51
Wheat production	1000 tons	2087.7	2613.9	2490.5	2488.4
Wheat feed consumption	1000 tons	25.8	53.6	51.9	47.7
Wheat human consumption	1000 tons	2826.3	2947.8	2992.1	3028.4
Wheat domestic use	1000 tons	2871.8	3021.1	3063.7	3095.8
Wheat ending stocks	1000 tons	343.6	338.5	345.9	351.7
Wheat exports	1000 tons	153.0	176.4	156.8	153.2
Wheat imports	1000 tons	767.5	578.4	737.4	766.5
Wheat SAFEX price	R/ton	3871.2	3595.6	3720.8	3913.4
Canola					
Canola area harvested	1000ha	39.1	47.7	45.8	46.9
Canola average yield	t/ha	1.17	1.18	1.19	1.20
Canola production	1000 tons	45.7	56.3	54.6	56.4
Canola crush	1000 tons	40.0	40.0	40.0	40.0
Canola domestic use	1000 tons	35.6	38.7	36.2	36.7
Canola ending stocks	1000 tons	18.4	35.9	54.3	74.0
Canola net imports	1000 tons	0.0	0.0	0.0	0.0
Canola producer price	R/ton	4091.6	3994.7	4362.8	4670.9
Sorghum					
Sorghum area harvested	1000ha	91.8	103.6	104.1	101.0
Sorghum average yield	t/ha	2.96	2.97	2.98	3.00
Sorghum production	1000 tons	271.7	307.9	310.8	302.8
Sorghum feed consumption	1000 tons	20.2	29.2	25.3	24.8
Sorghum human consumption	1000 tons	165.2	164.8	162.3	160.1
Sorghum domestic use	1000 tons	195.4	203.9	197.6	195.0
Sorghum ending stocks	1000 tons	59.9	69.4	70.2	69.0

		2008	2009	2010	2011
Sorghum net exports	1000 tons	41.9	94.5	112.4	109.1
Sorghum producer price	R/ton	1691.6	1610.2	1683.4	1724.5
Sunflower Seed					
Sunflower area harvested	1000ha	535.1	690.7	611.6	595.0
Sunflower average yield	t/ha	1.40	1.31	1.32	1.33
Sunflower production	1000 tons	748.9	905.5	808.34	792.79
Sunflower crush	1000 tons	611.6	695.1	745.73	776.51
Sunflower crush: Biodiesel	1000 tons	.	.	.	.
Sunflower domestic use	1000 tons	626.6	713.2	761.89	792.36
Sunflower ending stocks	1000 tons	270.5	456.2	502.19	507.34
Sunflower net imports	1000 tons	12.0	-6.5	-0.50	4.71
Sunflower SAFEX price	R/ton	4652.7	4394.3	4508.61	5094.83
Soybean Seed					
Soybean area harvested	1000ha	175.5	227.8	235.16	238.70
Soybean average yield	t/ha	1.71	1.88	1.89	1.90
Soybean production	1000 tons	300.3	428.7	443.83	454.71
Soybean crush	1000 tons	179.8	270.2	279.52	289.16
Soybean crush: Biodiesel	1000 tons	.	.	.	.
Soybean feed consumption (full fat)	1000 tons	181.0	175.5	181.58	183.61
Soybean domestic use	1000 tons	370.8	457.6	473.11	484.77
Soybean ending stocks	1000 tons	98.9	87.5	87.87	87.78
Soybean net imports	1000 tons	46.8	17.5	29.63	29.97
Soybean SAFEX price	R/ton	3818.5	4107.5	4022.71	4252.98
Sugar					
Area in sugarcane	1000 ha	422.4	420.0	419.3	421.2
Sugarcane area harvested	1000 ha	317.3	316.4	315.3	315.7
Sugarcane average yield	t/ha	65.62	65.65	65.78	65.94
Sugarcane production	1000 tons	20821.6	20775.3	20737.6	20818.3
Sugarcane for sugar	1000 tons	20821.6	15726.4	11708.5	9198.9
Sugarcane for ethanol	1000 tons	0.0	5048.9	9029.1	11619.4
Sugar extraction rate	Percent	11.8	11.8	11.8	11.8
Sugar production	1000 tons	2448.2	1849.1	1376.7	1081.6
Sugar domestic use	1000 tons	1293.6	1301.2	1310.9	1322.1
Sugar exports	1000 tons	1150.2	543.5	61.3	-245.0
Sugar statistical discrepancy	1000 tons	4.5	4.5	4.5	4.5
Sugar recoverable value	R/ton	1779.7	1942.2	2200.2	2465.2
Sugarcane average price	R/ton	217.0	236.1	266.4	297.6

		2008	2009	2010	2011
Potatoes					
Total Area	1000ha	50.52	45.12	45.84	45.24
Total Production	1000 tons	1887.13	1711.20	1768.93	1775.45
Average Yield	t/ha	37.35	37.93	38.59	39.24
Potatoes Import	1000 tons	19.36	23.23	27.87	28.50
Consump: Fresh formal	1000 tons	583.33	465.00	487.12	460.03
Consump: Fresh Informal	1000 tons	578.28	581.57	604.24	627.76
Consump: Processing	1000 tons	412.12	368.20	380.51	390.36
Consump: Seed	1000 tons	223.24	204.25	211.12	208.31
Unexplained	1000 tons	0.31	0.34	0.34	0.22
Potatoes per capita consumption	kg/capita	33.04	29.60	30.69	30.71
Domestic Use	1000 tons	1797.28	1619.36	1683.33	1686.69
Potatoes Export	1000 tons	70.49	68.61	57.73	60.26
Market price – fresh	c/10kg	2486.99	3044.61	3112.42	3407.59

Appendix E: Rank correlation matrix, probability distributions used in case study three

Yellow maize, Argentinean Rosario	Yellow maize, US No. 2	Wheat US No. 2 HRW	Sorghum US No. 2	Sunflower seed EU CIF Lower Rhine	Sunflower cake (pell37/38%) Arg CIF	Sunflower oil EU FOB NW Europe	Soybean seed Arg CIF Rotterdam	Soybean cake (pell 44/45%), Arg CIF	Soybean oil, Argentina	Nebraska, Direct fed steer	Chicken, US 12-city wholesale	Hogs, US 51-52% lean equivalent	Rand/$ exchange rate	US refiners acquisition price
1	0.95	0.76	0.95	0.63	0.49	0.64	0.72	0.48	0.68	0.11	-0.02	-0.05	-0.42	0.06
	1	0.72	1	0.59	0.44	0.58	0.66	0.45	0.59	0.11	-0.01	0.03	-0.40	0.16
		1	0.73	0.51	0.61	0.46	0.7	0.66	0.52	0.28	0.00	0.16	-0.47	0.30
			1	0.60	0.49	0.57	0.68	0.47	0.59	0.12	-0.04	0.03	-0.38	0.18
				1	0.39	0.87	0.69	0.32	0.82	0.13	-0.09	0.07	-0.29	0.10
					1	0.15	0.73	0.87	0.25	0.40	0.04	0.22	-0.13	0.56
						1	0.63	0.22	0.90	0.09	0.04	-0.04	-0.27	-0.12
							1	0.83	0.74	0.39	0.18	0.23	-0.38	0.33
								1	0.34	0.58	0.33	0.43	-0.35	0.58
									1	0.11	-0.07	0.02	-0.41	-0.08
										1	0.43	0.59	-0.43	0.66
											1	0.48	-0.04	0.34
												1	-0.26	0.69
													1	-0.12
														1

Table: Estimated probability distributions for key exogenous variables used to simulate maize prices for 2007/08 season

Variable	Yellow maize, Argentinean Rosario, FOB	Yellow maize, US No. 2	Wheat US No. 2 HRW	Sorghum US No. 2	Sunflower seed EU CIF Lower Rhine	Sunflower cake (pell37/38%) Arg CIF Rotterdam	Sunflower oil EU FOB NW Europe	Soybean seed Arg CIF Rotterdam	Soybean cake (pell 44/45%), Arg CIf	Soybean oil, Argentina	Nebraska, Direct fed steer	Chicken, US 12-city wholesale	Hogs, US 51-52% lean equivalent	Rand/$ exchange rate	US refiners acquisition price	Rainfall summer area
Mean	194	211	371	207	723	317	1860	491	422	1420	2089	1689	971	793	95	525
Min	143	159	258	158	545	190	1291	380	294	898	1550	1491	670	642	45	364
Max	280	321	509	314	951	481	2356	648	579	1844	2523	1943	1222	1223	161	776
Std dev	36.04	41.45	67.58	40.61	98.62	62.64	257	74.95	75.96	244	332	141	157.96	160	29.13	94.22
CV	18.56	19.64	18.18	19.60	13.63	19.74	13.81	15.26	17.98	17.22	15.90	8.34	16.26	20.26	30.66	17.94

Table: Estimated probability distributions for key exogenous variables used to simulate maize prices for 2008/09 season

Variable	Yellow maize, Argentinean Rosario, FOB	Yellow maize, US No. 2	Wheat US No. 2 HRW	Sorghum US No. 2	Sunflower seed EU CIF Lower Rhine	Sunflower cake (pell37/38%), Arg CIF Rotterdam	Sunflower oil EU FOB NW Europe	Soybean seed Arg CIF Rotterdam	Soybean cake (pell 44/45%), Arg CIf Rotterdam	Soybean oil, Argentina	Nebraska, Direct fed steer	Chicken, US 12-city wholesale	Hogs, US 51-52% lean equivalent	Rand/$ exchange rate	US refiners acquisition price	Rainfall summer area
Mean	190	207	297	187	641	273	1717	501	399	1458	2041	1681	1044	842	89	525
Min	141	156	206	143	484	164	1191	388	277	922	1514	1484	720	682	43	364
Max	275	316	408	284	844	415	2174	662	547	1894	2464	1934	1314	1298	151	776
Std dev	35.39	40.71	54.15	36.71	87.53	54.04	237	76.50	71.78	251	324	140	169	170	27.41	94.22
CV	18.56	19.64	18.18	19.60	13.63	19.74	13.81	15.26	17.98	17.22	15.90	8.34	16.26	20.26	30.66	17.94