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.

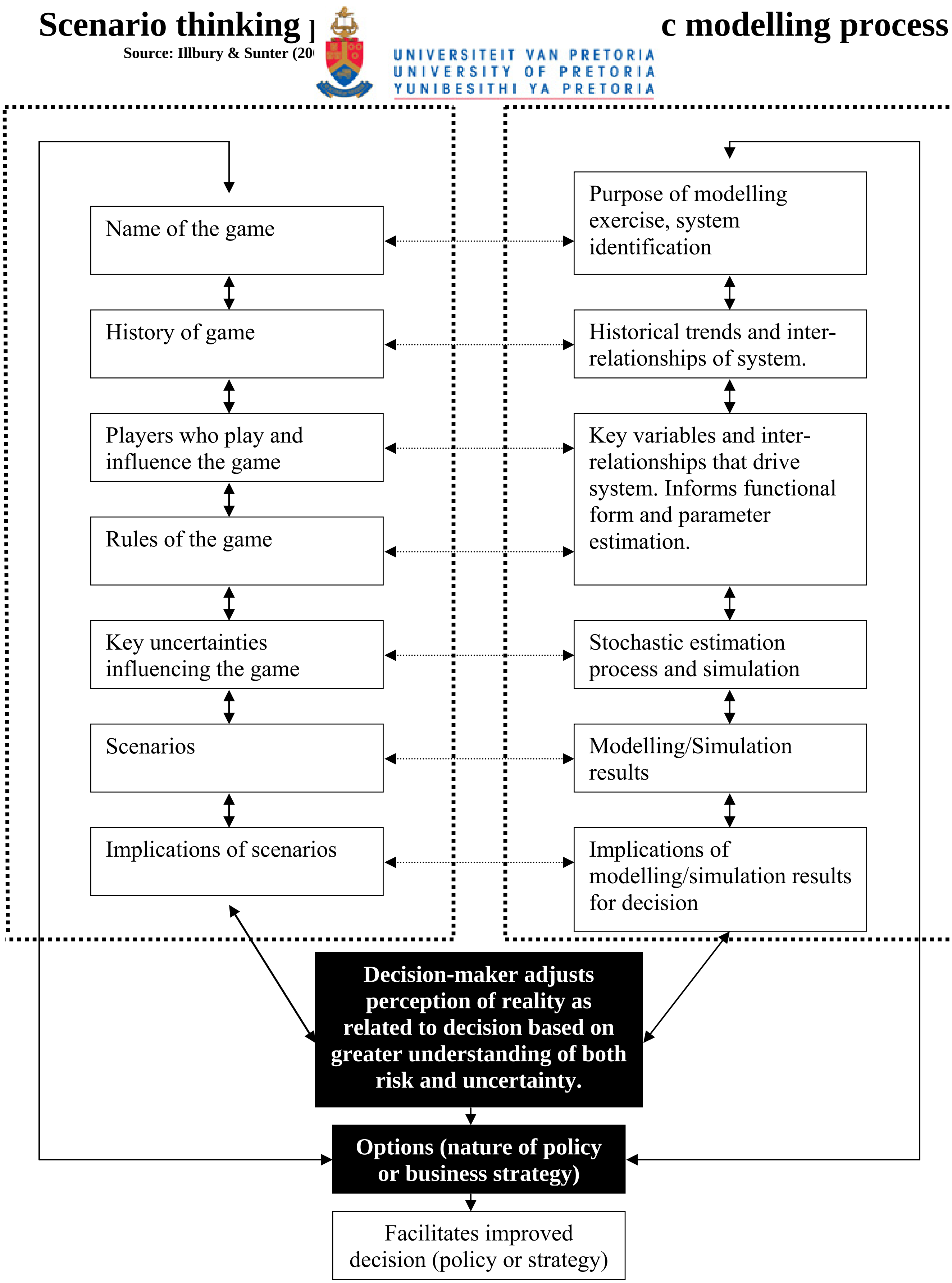

Figure 4.1: The proposed framework for addressing risk and uncertainty

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 5th 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).

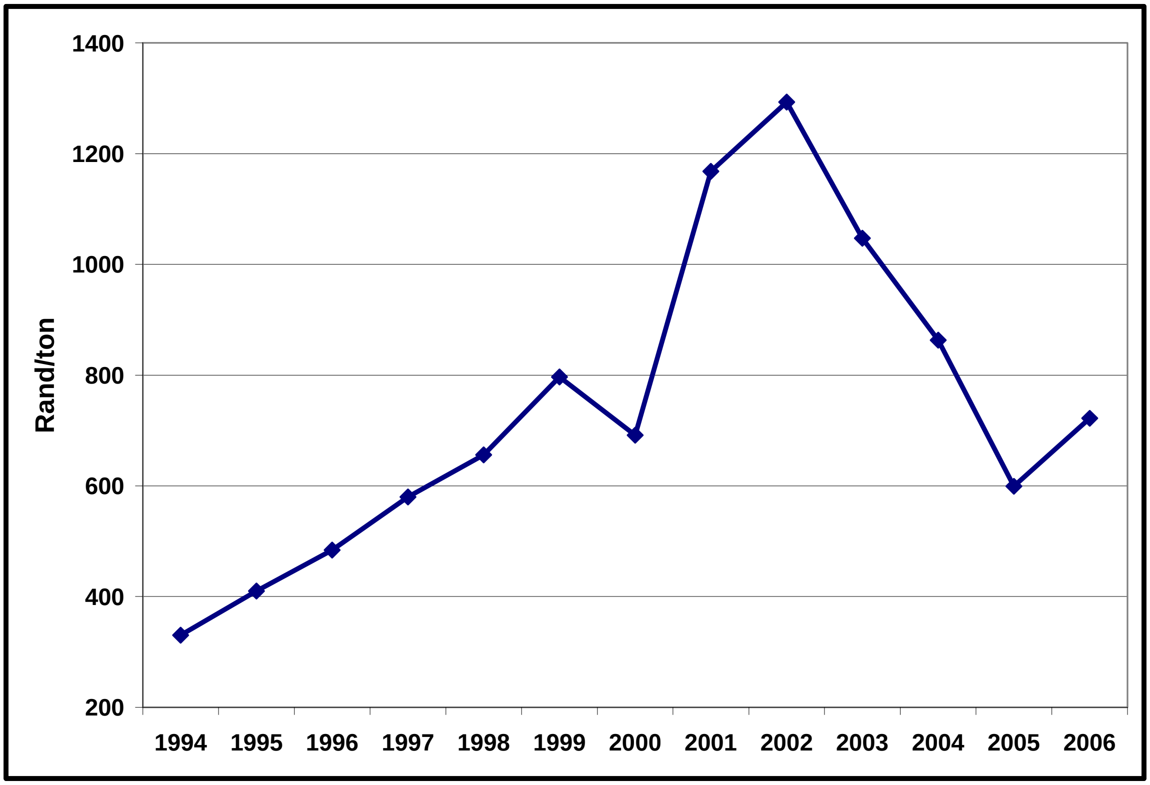

Figure 5.1: Nominal yellow maize producer price (Source: BFAP, 2005a)

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.

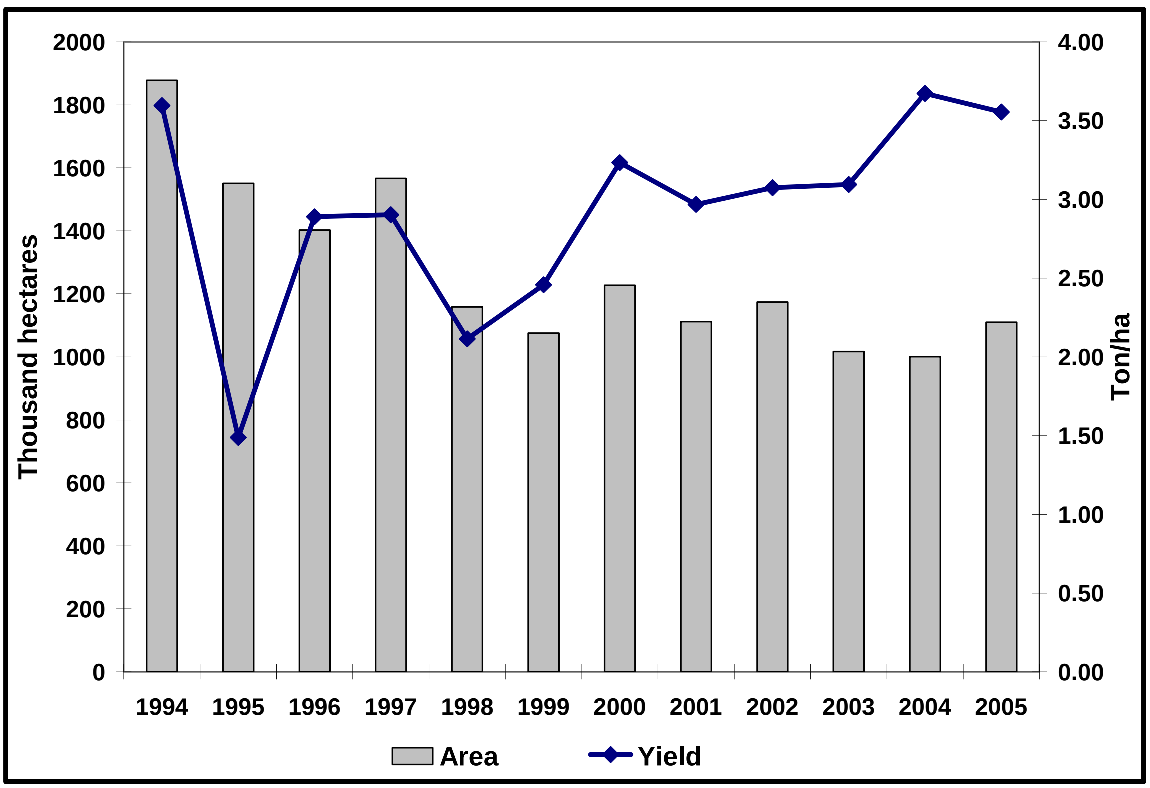

Figure 5.2: Yellow maize yield and area harvested (Source: BFAP, 2008)

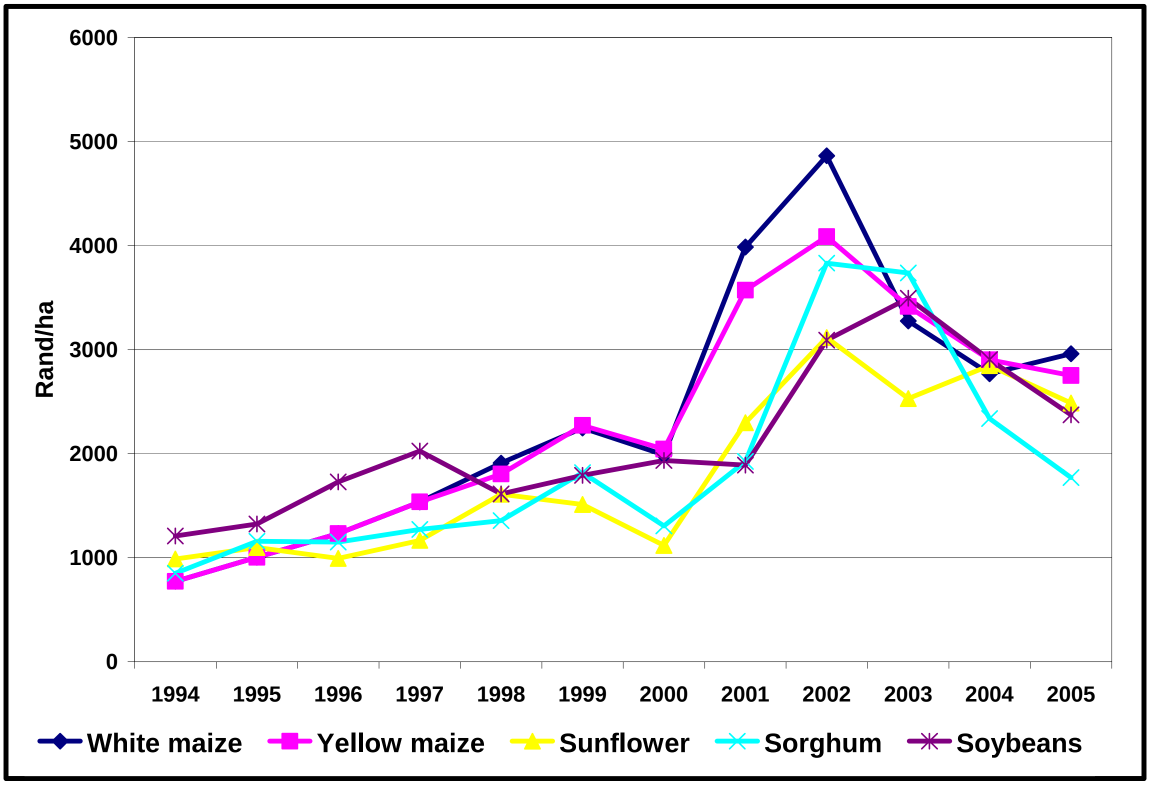

Figure 5.3: Expected gross market returns of summer crops (Source: BFAP, 2008)

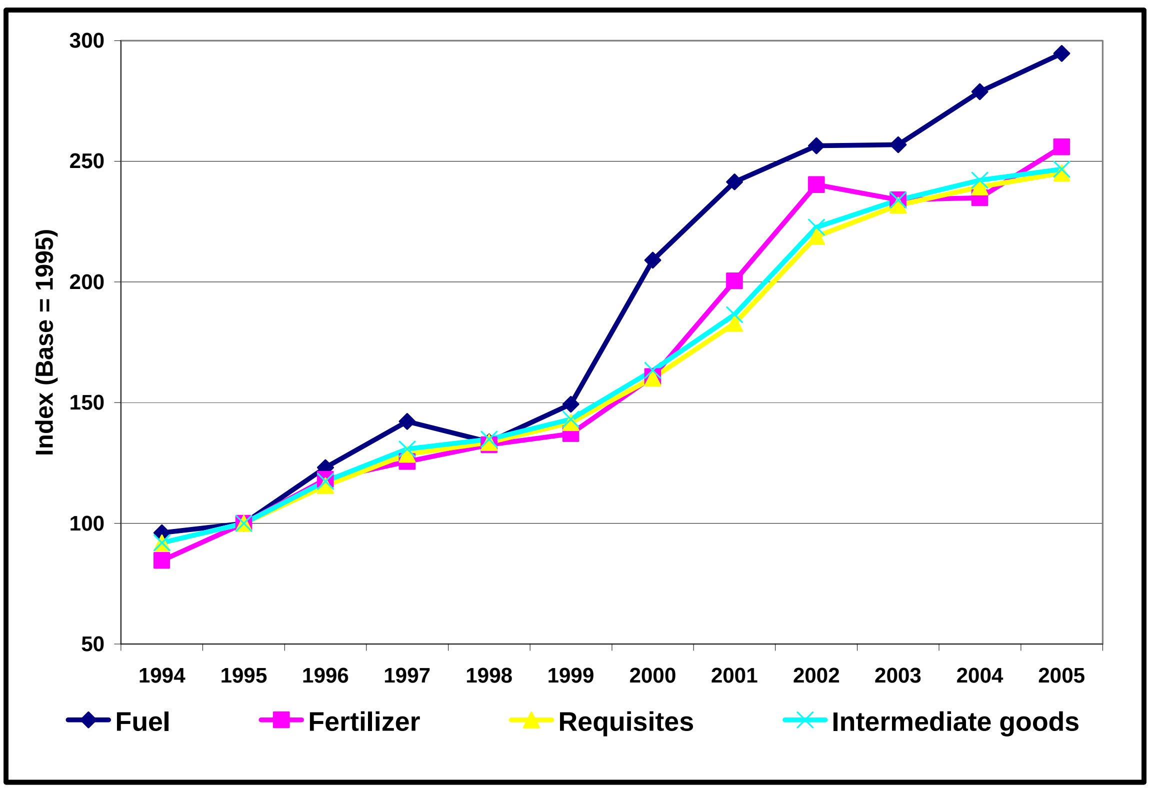

Figure 5.4: Input cost indices for grain crops (Source: BFAP, 2008)

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.

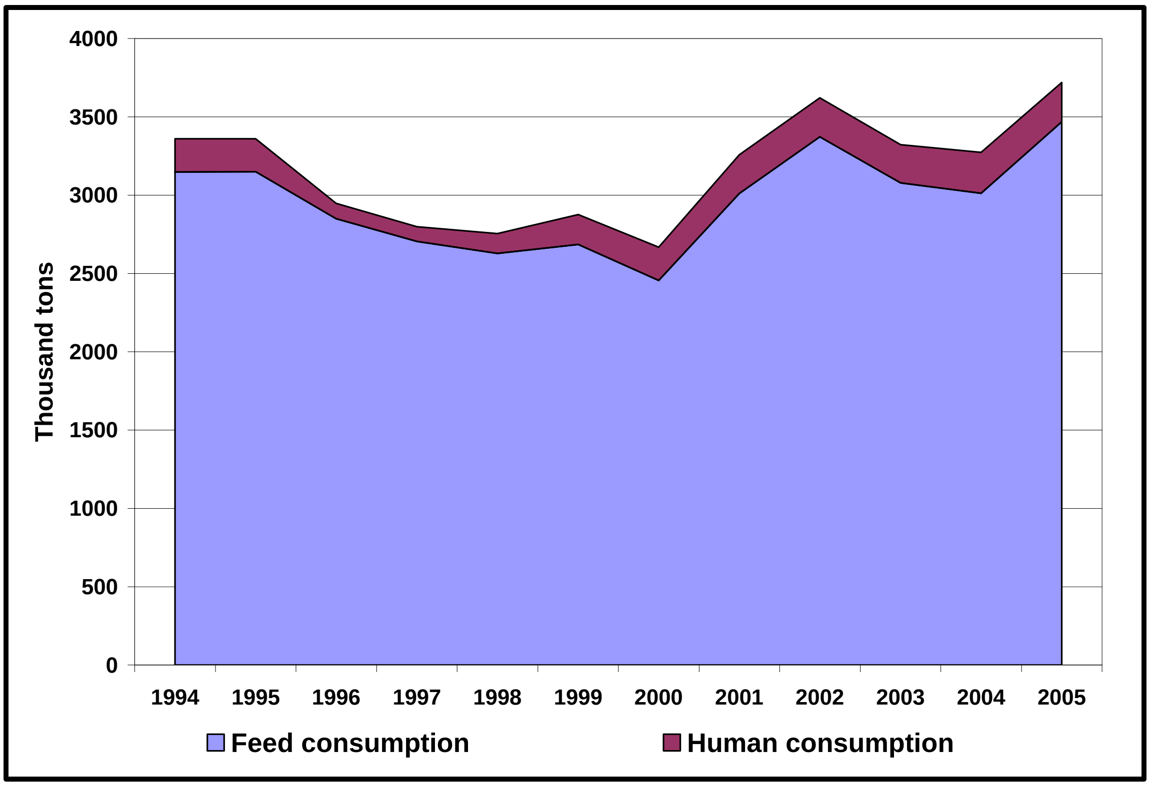

Figure 5.5: Yellow maize domestic consumption (Source: BFAP, 2008)

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.

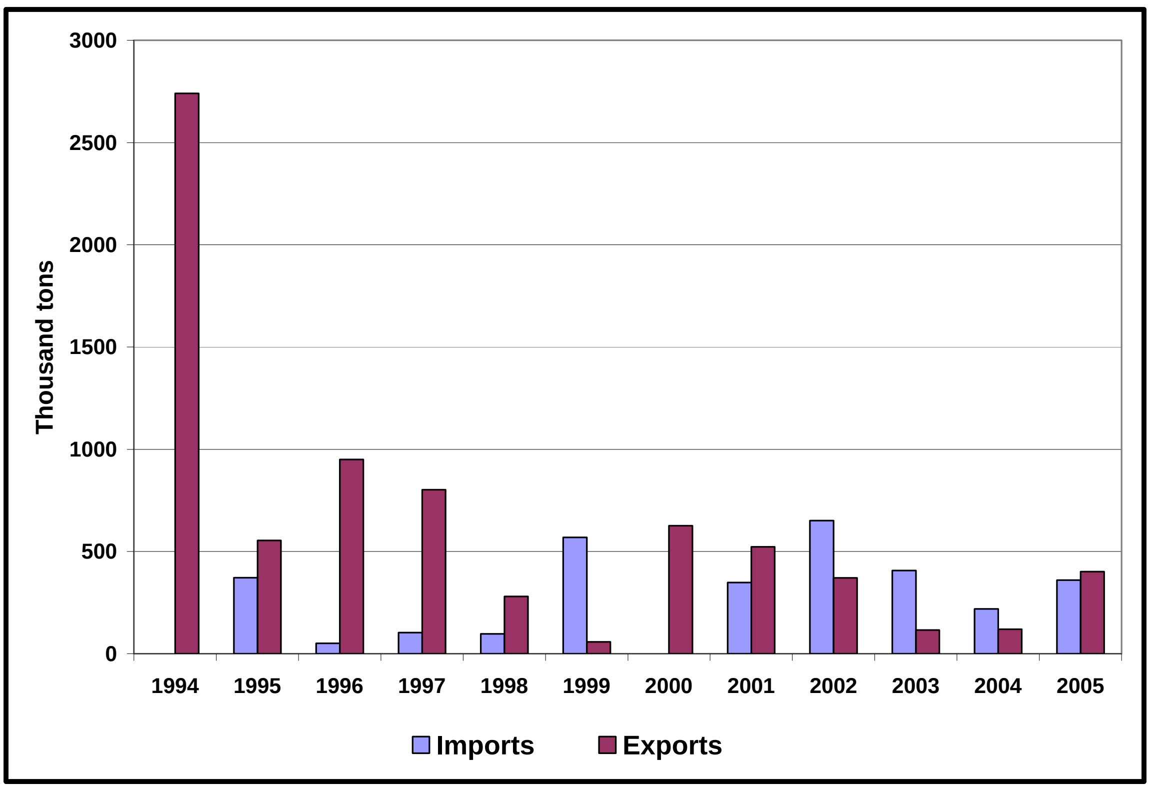

Figure 5.6: Yellow maize imports and exports (Source: BFAP, 2008)

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.

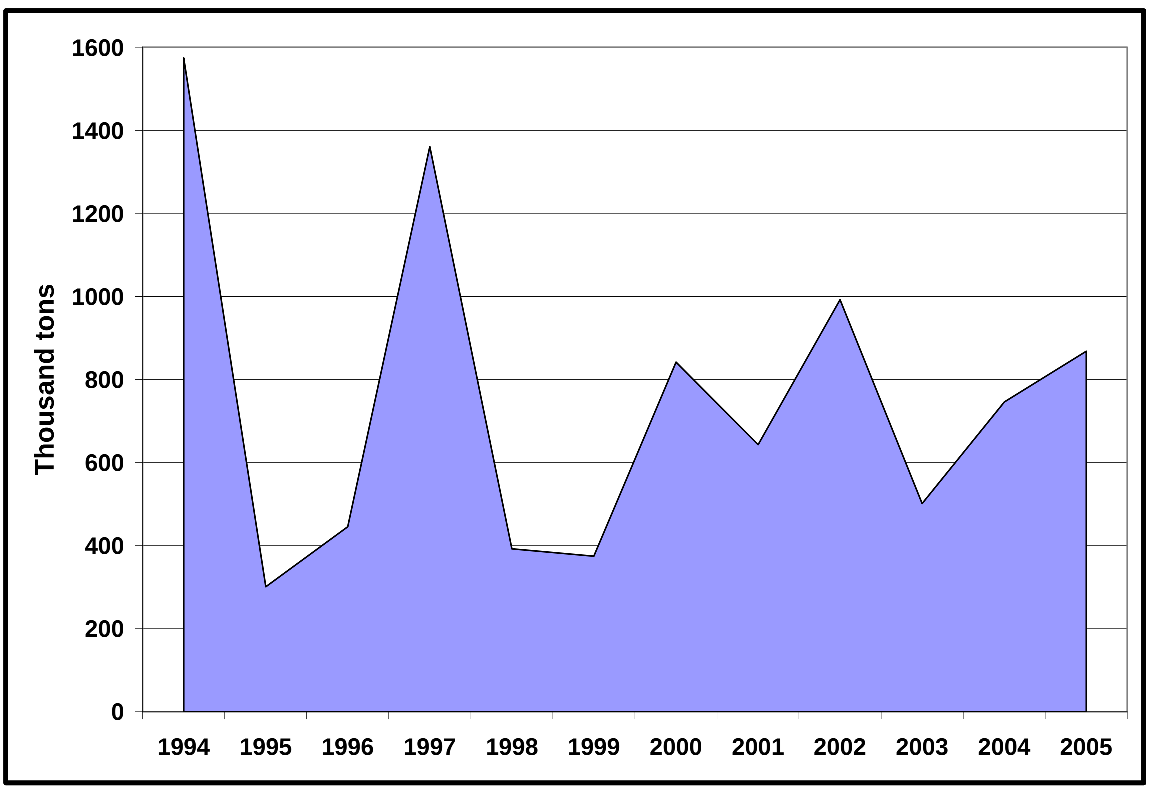

Figure 5.7: Yellow maize ending stocks (Source: BFAP, 2005a)

Note: values for 2005 were expected values during October 2005

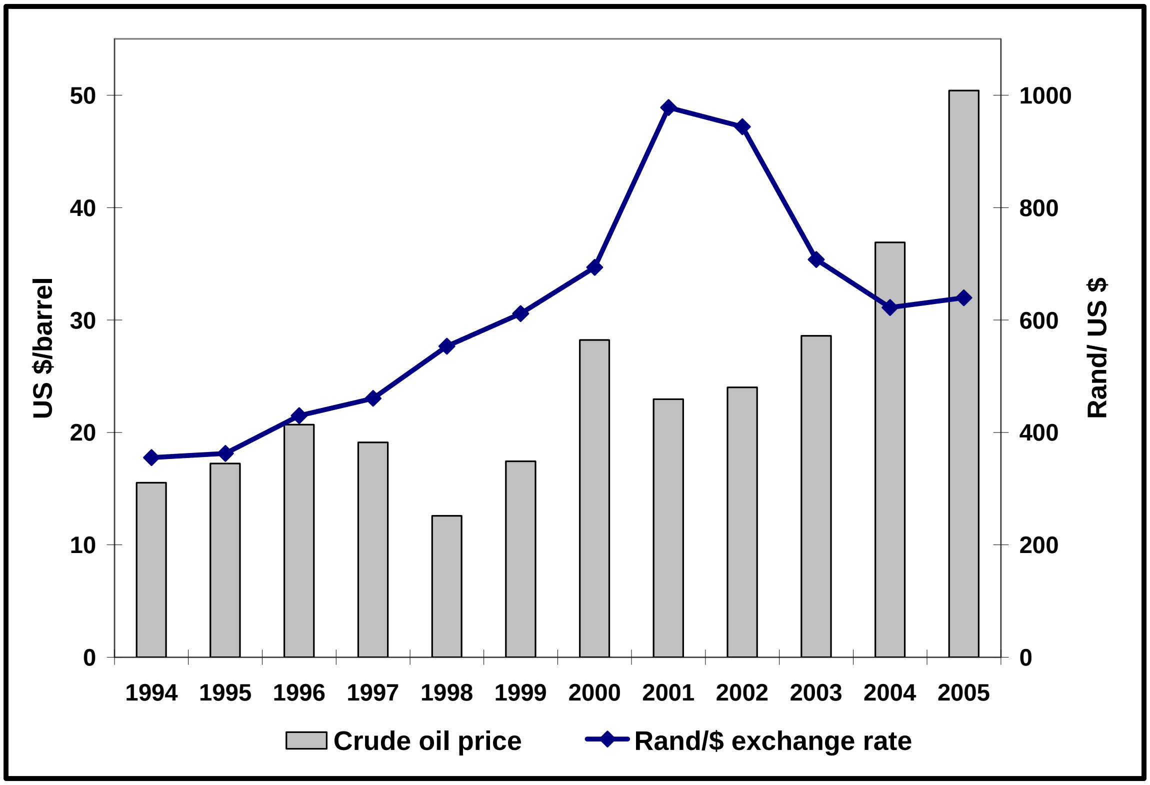

Figure 5.8: Brent Crude oil price and exchange rate (Source: BFAP, 2008)

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.

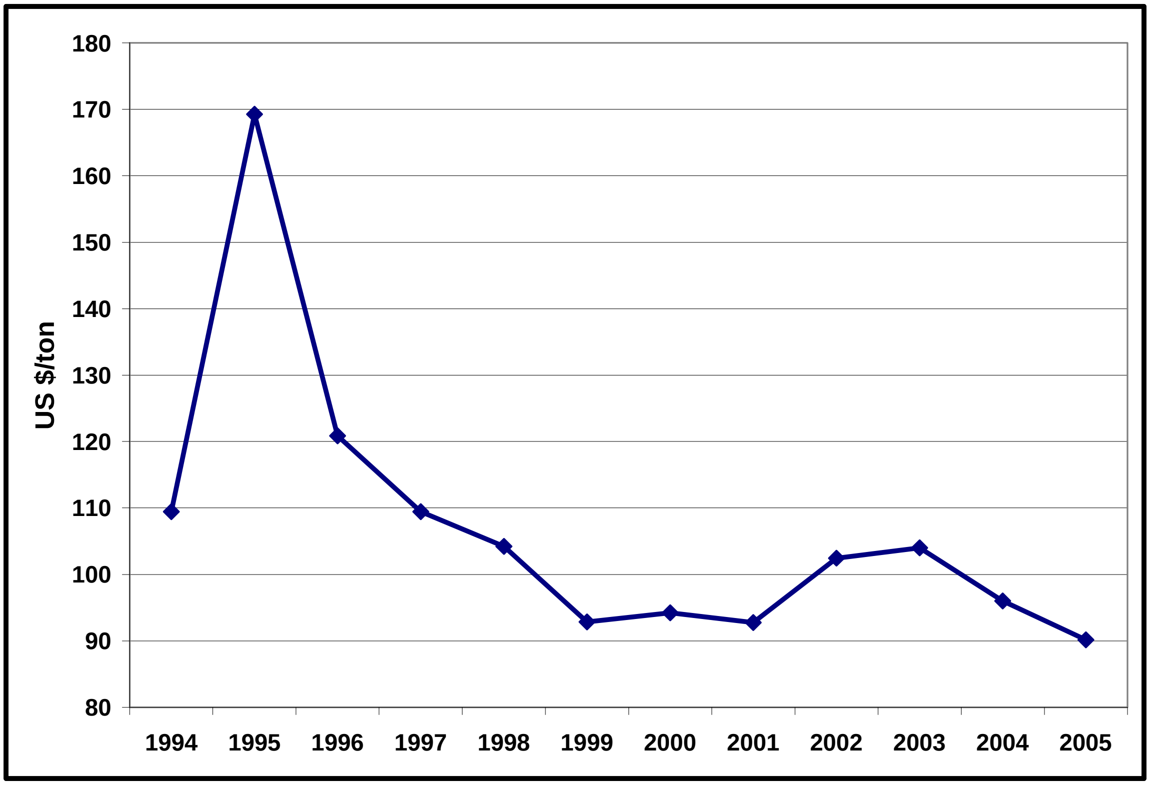

Figure 5.9: US No. 2 (FOB Gulf) Yellow maize price trend (Source: BFAP, 2008)

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.

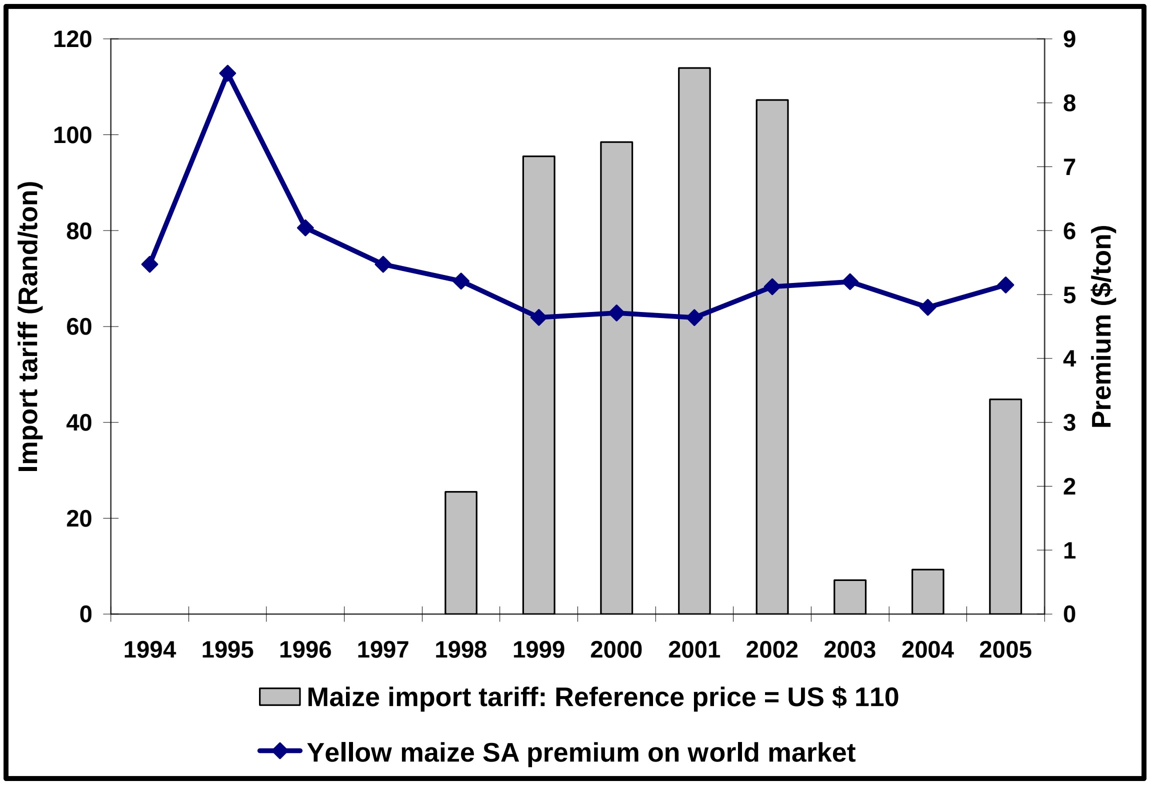

Figure 5.10: Yellow maize import tariff and premium on world markets (Source: BFAP, 2008)

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.

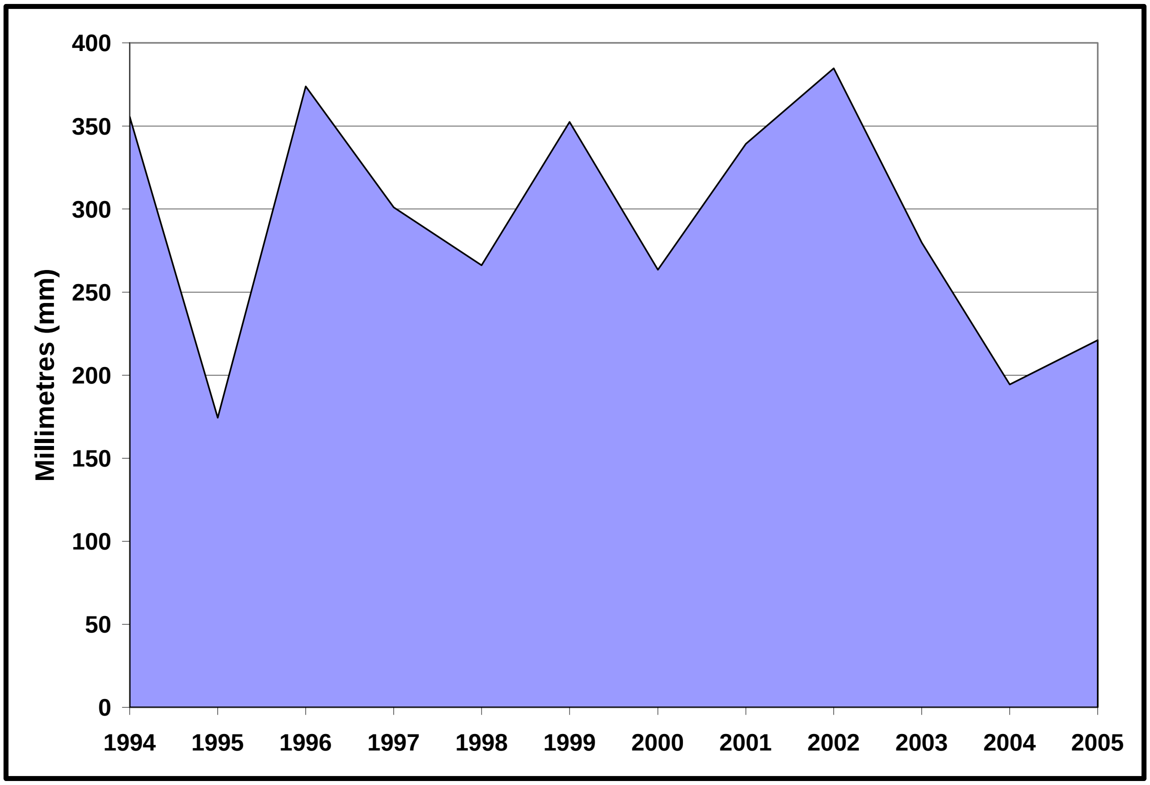

Figure 5.11: Total rainfall trend, maize planting area of South Africa (Source: BFAP, 2008)

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.

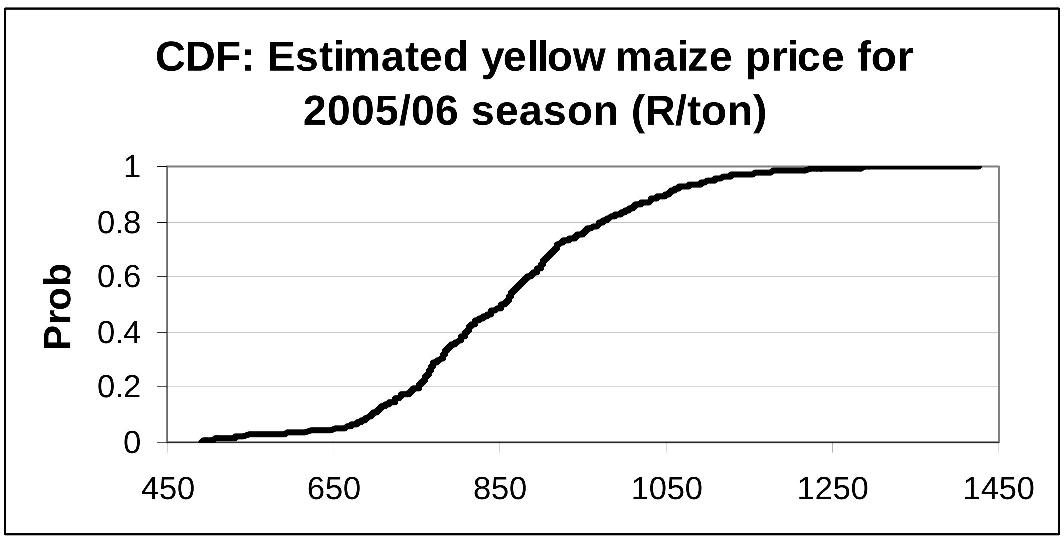

Figure 5.12: Cumulative distribution function of estimated yellow maize price for 2005/06 season

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.

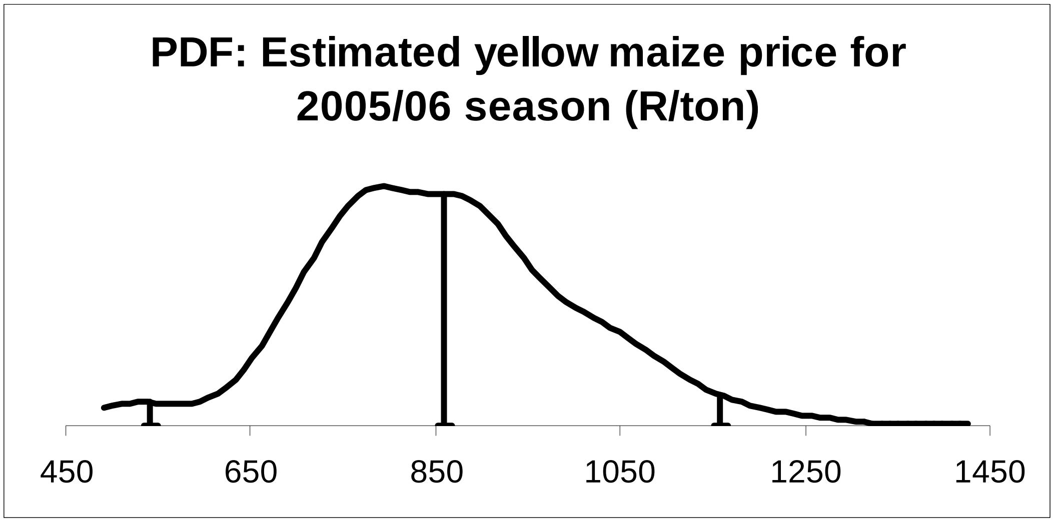

Figure 5.13: Probability density function of estimated yellow maize price for 2005/06 season

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.