WHEN PROBABILITY DISTRIBUTIONS MISS THE POINT: USING SCENARIO THINKING AND STOCHASTIC MODELLING IN CONJUNCTION[1]

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ABSTRACT

This article argues that significant shortcomings currently exist with respect to the analysis of risk and uncertainty in agricultural commodity markets, given the possibility that uncertainty will only increase in future. Based on this argument, a framework is proposed whereby intuitive logic scenario thinking is applied in conjunction with stochastic econometric modelling in order to mitigate this weakness. A case study is presented whereby the proposed framework is applied, to show the success of applying the framework given the current turmoil experienced in the general economy as well as in agricultural commodity markets. The case study results indicate that the application of the proposed framework should lead to improved decisions with respect to policy and business strategy pertaining to agricultural commodity markets, despite increased uncertainty.

Keywords: agricultural policy, business strategy, modelling, risk, scenario thinking, stochastic uncertainty

1 INTRODUCTION

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

As a result of the experts "getting it so wrong", questions are being asked about the reliability of risk and uncertainty analysis. Even though the experts used

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highly advanced analytical techniques in analyzing the risks and uncertainties to formulate predictions and outlooks, both the "food price crisis" and the economic implosion were totally unanticipated. The same can be said of risk and uncertainty analyses in agricultural economics. With agriculture experiencing a period of fundamental change, causing significant uncertainty, the analysis of risk and uncertainty in agriculture needs to move to the next level to ensure that policies and business strategies are adequately robust.

Against this background this article has the following aims:

- **First** – to explore the very foundations of risk and uncertainty, and their analysis in agricultural economics to show a fundamental weakness in the way that uncertainty is addressed in agricultural economics.
- **Second** – to identify and discuss a technique, namely, intuitive logic scenario thinking, which is suitable to analyze uncertainty, and which can be used in conjunction with an existing technique used in agricultural economic literature, namely, stochastic econometric modelling.
- **Third** – to present a framework in which intuitive logic scenario thinking and stochastic econometric modelling can be applied in conjunction to analyze risk and uncertainty simultaneously in a technically correct manner.
- **Fourth** – to present a case study whereby the proposed framework is applied to demonstrate its success.

2 CONTRASTING RISK AND UNCERTAINTY

The concept of risk, derived from the Italian word *risicare*, which means "to dare", was not well understood until approximately 1654 when the Theory of Probability was finally grasped (Bernstein 1998, pp. 3, 8). Bernstein views the Theory of Probability as the mathematical foundation of the concept of risk (Bernstein 1998, p. 3). In contemporary literature, risk is generally defined as a situation in which probabilities (different possible outcomes) of a system or factor are known or can be calculated. Hardaker, *et al.* (2004, p. 5) argue that this definition of risk is not useful, since objective probabilities are seldom known and subjective probabilities, therefore, need to be calculated. As a result, they define risk as "uncertain consequences". Bowles (2004, p. 101) defines risk as being more finite, namely, when the outcome of an action in the individual's choice set is a set of possible outcomes to which known probabilities can be attached. Valsamakis *et al.* (1996, p. 23) argue a broader definition of risk, writing: *"In his effort to understand or minimise uncertainty, man has attempted to determine causation, unfold patterns and give meaning to unexplained events, possibly in terms of a controlling power."* Ilbury and Sunter (2003, p. 42), although not referring directly

to risk, also argue along this line of thought, and write about the rule of law (or causality) and the motivation of people to analyse and understand cause-and-effect in order to quantify it.

To understand risk and its impact and thereby make good decisions, causality between various factors, events, actions and the resulting potential outcomes need to be understood and quantified to some extent. *The fact that causality is determinable and quantifiable, leads to the possibility of calculating and assigning probabilities (either objective or subjective) to the occurrence of events.* Based on the ability to quantify the probability of the occurrence of events, a decision maker can begin to calculate the magnitude of potential consequences, should a specific event occur. The insight gained by the decision maker through this process, leads to the understanding of the risks faced, and hence partially assists the decision maker in making a good and informed decision.

However, a dilemma arises from these arguments on the definition and analysis of risk. The problem emerges when causality or the rule of law breaks down, whether determined objectively or subjectively. In such situations it becomes difficult to form a perspective on the cause-and-effect relationships in a system and, therefore, on objective or subjective probabilities of the occurrence of potential events. Frank Knight discussed this dilemma in his seminal work *Risk, Uncertainty and Profit* (1921, p. 224). He 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 similar in every way, apart from really indeterminate factors. These kinds of probabilities are typically mathematical probabilities, for example, the flipping of a coin, where the only indeterminate factors are whether the coin is "loaded" or 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 Knight refers to the situation where probabilities (objective or subjective) can be calculated based on observed data or empirical classification of instances.
c) The third probability situation Knight calls *estimates*. 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 be attached to an outcome in such a situation, and hence he defines it as "*true uncertainty*". Knight argues that in such a case it is fundamentally not possible to assign even 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.

Based on Knight's original arguments and his distinction between risk and uncertainty, subsequent authors such as Bowles (2004, p. 101) define uncertainty as a situation where no probabilities, whether objective or subjective, can be assigned to an outcome. Bernstein (1998, p. 133) also argues along similar lines, and defines uncertainty as unknown probabilities. 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 are not available to estimate "new" correlations. The second problem stems from the fact that, as a result of structural changes in a system, different factors come into play that drive and shape the system. The implication is that a "new" rule of law (Ilbury & Sunter 2003) appears. In many instances these "new" factors are difficult to either understand or quantify. Thus, the "new" factors influencing the system, along with the difficulty of either understanding or quantifying these factors, make it very difficult to calculate probabilities accurately, and so to quantify and understand risk and uncertainty.

Pierre Wack (1985, p. 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.*" Grossmann (2007, p. 878) follows his argument, and writes that discontinuities can be organised into three categories:

a) *A temporary or permanent break within one condition or field*.
b) *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*.
c) *A significant change due to a gradual, long-term process of change*.

Volume two of *Ecosystems and Human Wellbeing* (Millennium Ecosystem Assessment 2005, p. 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 owing 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 influences the system.

3 RISK AND UNCERTAINTY ANALYSIS IN AGRICULTURAL ECONOMICS

Formal risk and uncertainty analysis techniques have been invented and adopted by agricultural economists to study the problems, challenges and consequences created by risk and uncertainty or, as stated by Hardaker *et al.* (2004, p. 23), *"to try to rationalise and assist choice in an uncertain world.*" These techniques mostly include probabilities, whether objective or subjective, in the analysis in order to capture and communicate the potential effect and outcome of risk and uncertainty. Examples in the literature where these techniques have been applied include the work of Butt and McCarl (2005, p. 434), Binfield *et al.* (2002), and Westhoff *et al.* (2005)[4]. These studies do indicate the importance of taking risk or probabilities into account when analysing decision-making factors – whether it is a policy, production or any other kind of decision. However, discontinuities in endogenous and exogenous variables included in the modelling framework might cause the probabilities presented (or assumed) in these studies to be either over- or underestimated. Therefore, the main shortcoming with regard to these research results is that uncertainty (as per definition it includes possible discontinuities) is not explicitly accounted for. This point is confirmed as follows in the writing of Binfield *et al.* (2002, p. 7): "*By no means, however, have all possible sources of variability been captured. It would be a mistake to conclude that the extreme values achieved in this analysis represent the absolute extremes that are possible in the future.*"

In this area, therefore, lies the major weakness of these techniques and models: they are based on the hypothesis that ***the future is likely to be like the past and present***. Based on the arguments on the definition of uncertainty, it becomes clear that it is not possible and, logically, does not make sense to assign probabilities in the presence of uncertainty. Interestingly, Knight (1921, p. 231) pointed out this exact same 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).

As indicated in the opening paragraph of this article, during some stages, systems change rapidly and unexpectedly, rendering any analysis useless if based on the assumption that the future will be like the past and present. This is because a system experiences rapid and unexpected change due to discontinuity. This results in a new form of causality, which implies that it is pointless using correlations and probabilities that are calculated on the basis of the historical structure of the system. Hence, during such periods, current models and techniques in terms of

analysing and communicating risk and uncertainty become worthless, and to apply them might even result in spurious decision making. This implies that during such times, it is important to have an alternative approach to decision making that works with an alternative hypothesis: namely, ***the hypothesis that the future is NOT like the past OR present.***

4 INTUITIVE LOGIC SCENARIO THINKING

One technique that offers the ability to work with the hypothesis that the future is NOT like the past or present, is intuitive logic scenario thinking. In agricultural economic literature, the word "scenario" is often used to describe a projection about the future. This, however, constitutes a misunderstanding and, in actual fact, an abuse of the concept of a scenario. The aim of this section is to introduce intuitive scenario thinking, hopefully, to prevent the misuse and abuse of scenarios in agricultural economics in future; to indicate how scenarios should be structured and set up under the intuitive scenario thinking methodology, and what value scenarios offer in terms of working with the hypothesis that the future is not like the past or present; and, lastly, to show the fundamental difference between intuitive scenario thinking and stochastic modelling. These arguments will point out why the two techniques cannot be combined, but can only be used in conjunction, as proposed by the framework presented in this article. The use of scenarios originated in military planning in the USA (Bradfield *et al.* 2005, Segal 2007). After World War II, facing various *uncertainties*, the US Department of Defence had to make decisions on which weapons development programmes to fund. To make these decisions, they developed various techniques, including scenario thinking. Herman Kahn at the RAND Corporation used scenarios based on their initial work 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. Following Kahn's initial work, mainly three different approaches to scenario thinking emerged, namely, intuitive logic scenario thinking, a probabilistic modified trends approach, and La Prospective thinking. The weakness of the latter two approaches was that they included probabilities in terms of setting up and presenting the scenarios, which in actual fact constituted analyzing risk instead of uncertainty. As a result, intuitive scenario thinking became the "gold standard" of scenario thinking techniques, and is used extensively today in both business strategy and policy development. The two best-known examples where the intuitive logic scenario thinking approach has been used are the "Mont Fleur" scenarios, developed and used for the transition period in South Africa, as well as the "High Road, Low Road" scenarios also developed in South Africa by Anglo American in cooperation with Pierre Wack, and presented by Clem Sunter during the late 1980s.

Under the intuitive logic scenario thinking approach, various definitions of a scenario exist. Ilbury and Sunter (2003, p. 87) describe a scenario as being not 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 neither a view based on consensus nor a prediction or forecast. Rather, it conveys a potential milieu and how that could change. Glen (2006, p. 2) 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 one 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, for instance, different exchange rate projections or different oil price projections, hence "more of the same". Wack defines these types of scenarios as "first generation" scenarios, and describes them 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, p. 76). Therefore, it does not provide the decision maker with any sound basis on which to exercise his or her judgement.

The improvement on first generation scenarios offered by Wack is decision scenarios. These are scenarios that are structured around predetermined and uncertain factors (Wack 1985b, p. 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 these predetermined elements along with key uncertainties, and through that process develops an understanding of the impossible and, therefore, the possible. Wack (1985a, p. 74) describes the process of scenario development as follows: "*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. 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, which are often unrelated and contradicting, in order to sort the possible from the impossible, and the controllable from the uncontrollable (Ilbury & Sunter 2003, pp. 21, 23, 29, 31).

Wack (1985b, p. 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 & Sunter 2003, p. 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, p. 74). It is important to note that the incorporation of the intuitive logic scenario thinking technique does not involve the mere plugging in of a range of values, for example, 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. Scenarios 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 judgement in making a decision (Davis-Floyd 1998). This is neatly stated by Wack (1985b, p. 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, p. 146), decision scenarios also serve the purpose of assisting decision makers in anticipating and understanding risk, as well as discovering entrepreneurial opportunities.

Ilbury and Sunter have published two works (2003 & 2005) describing a scenario development technique. These two publications culminated in their most recent work, published in 2007. Their tried-and-tested approach is mostly based on Socratic methodology. 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, p. 150). Other approaches to developing scenarios by means of the intuitive logic scenario thinking approach are those of Wack (1985), Van der Heijden (1996), Schwartz (1991) and Shell (2003).

5 A PROPOSED FRAMEWORK FOR ADDRESSING RISK AND UNCERTAINTY IN AGRICULTURAL DECISION MAKING WITH RESPECT TO BUSINESS STRATEGY AND POLICY

The problem is that a decision maker never knows when to work with which hypotheses: Will the future be LIKE the past and present, or will the future be UNLIKE the past and present? This implies that for the alternative approach to add value in terms of analyzing risk and uncertainty, the approach should include both hypotheses simultaneously. This offers the decision maker a process whereby both hypotheses are included when formulating policy or a business strategy. Such an approach will offer the decision maker the possibility of discarding one of the hypotheses at a stage when enough information has been gathered and sufficient events have occurred for one to know whether the future is like the past and present, or NOT like the past and present. The framework proposed by this article, in which both hypotheses are captured and tested simultaneously during the decision-making process, is presented in Figure 1.

In essence, the proposed framework stipulates that the steps that make up the respective two techniques (intuitive scenario thinking and stochastic modelling) are applied separately but in conjunction. This ensures cross-pollination in the sense that ideas are shared between the two techniques and hence learning takes place, but that the two fundamentally different techniques are not adjusted or combined but, rather, applied separately and technically in the most appropriate way. This ensures that the strengths of both techniques remain part of the decision process, namely, that both risk and uncertainty are analysed and included in a technically correct manner. This also implies that the weaknesses of one technique are covered by the strengths of the opposite technique. The result is that the implications of both the occurrence of risky events and unexpected events will be contemplated and, therefore, 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 set of scenarios and applying them, 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. Concurrently, while setting up the scenarios, one sets up and applies a stochastic econometric 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[5] 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.

6 ARGUMENTS UNDERLYING THE PROPOSED FRAMEWORK

The first argument on why this proposed framework should lead to an improvement in terms of risk and uncertainty analysis in agricultural economics, is based on the following point: In following the two steps of identifying "key uncertainties" during the scenario setup process as well as the "setting up stochastic process" as part of the model, a clear distinction takes place within the framework. On one hand uncertainty is contemplated and analysed (scenario thinking), and on the other, the focus is risk (stochastic modelling). By simultaneously following two fundamentally different steps, the decision maker develops a clearer picture of what is probable (i.e. risk) and what is possible and plausible but not necessarily probable (i.e. uncertainty). The value that is added in terms of the decision-making process when following these two steps in conjunction is, therefore, not a convergence of thinking in terms of structuring the scenarios and setting up the model. Rather, it is a divergence of 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 way to mitigate 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

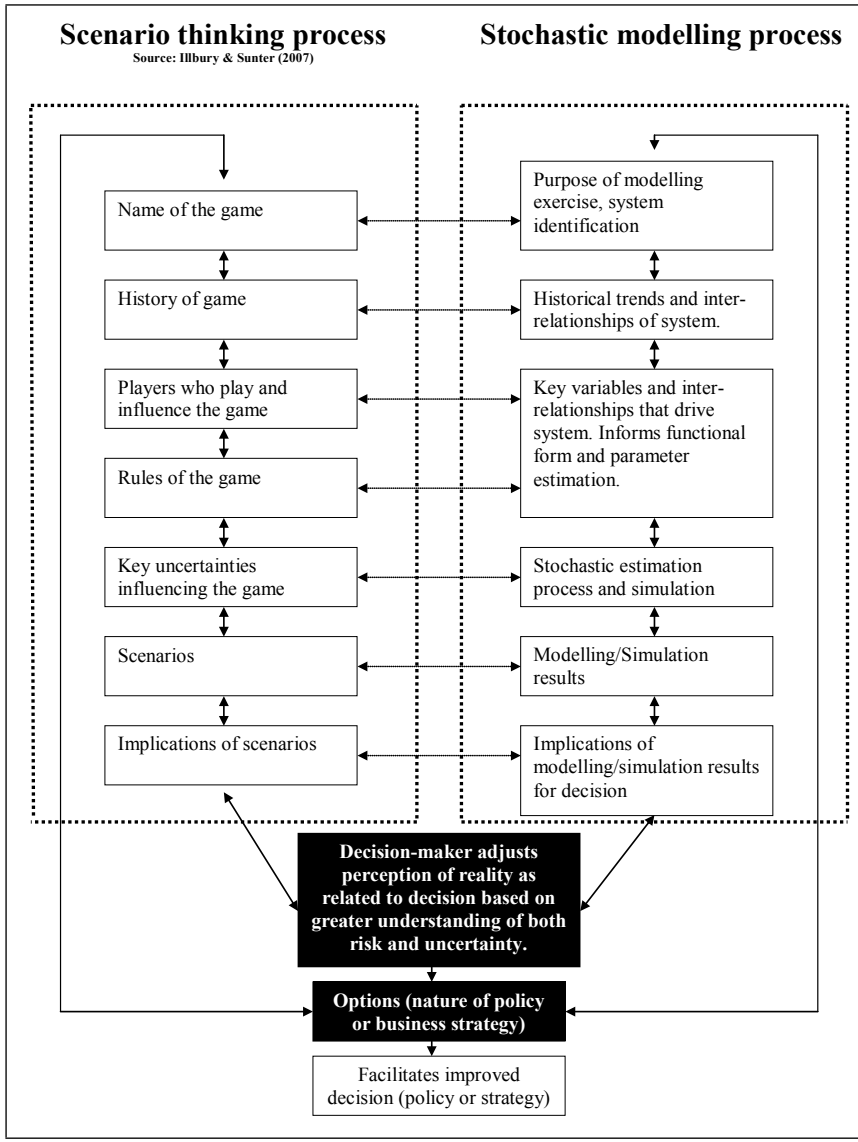

Figure 1: Proposed framework for addressing risk and uncertainty

improved, and hence there is 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.

Apart from the opportunity that it offers the decision maker to work simultaneously with two hypotheses during the decision-making process, the other major uniqueness and contribution of this proposed framework toward risk and uncertainty analysis in agricultural economics is as follows: Since the two techniques are fundamentally different both in terms of logic and the underlying cognitive developmental process followed by each one, the only way to link the two techniques is by using the two different cognitive developmental processes of each technique in a synergetic way to help the decision maker understand reality in terms of both risk and uncertainty. Scenario thinking essentially follows an internal organic cognitive developmental process (Wack 1985b, p. 140), while modelling essentially follows a cognitive developmental process through "formal instruction" (modelling techniques, statistics, economic theory) as stipulated by Vygotsky (Nelson 1996, p. 227). Hence, the synergetic platform provided by the two different cognitive developmental processes provides the opportunity to link the two fundamentally different techniques in an informal way without combining them. This argument implies that the two techniques cannot be combined since they both are fundamentally different in terms of logic, mechanics and results, and can only be used in conjunction. This implication reflects the other major concern of this article, arguing and proposing a framework that shows that the two techniques cannot be combined, but can be used simultaneously, based on the synergies that exist between the different cognitive developmental processes underlying the two techniques.

7 ILLUSTRATING THE APPLICATION OF THE PROPOSED FRAMEWORK

To illustrate the usage of the proposed framework in agricultural commodity markets to analyze risk and uncertainty, a case study is presented in this section where a financial institution applied the framework in South Africa to make decisions with respect to its agricultural financing strategy for maize production in the 2008/09 season.

Two meetings were held with the institution, the first on 6 February 2008, and the second during April 2008. Present at these sessions were the risk manager, the head of the department and a market analyst. The purpose of the first meeting was firstly to determine the initial expectations of the participants with respect to maize prices for the 2008/09 season. Afterwards the framework as presented in

this article was applied, and the results were presented to the institution in the form of a report. The purpose of the second meeting, held in April, was to revisit the results presented in the previous report, and make adjustments to the results as was deemed necessary by its decision makers. The results from the second meeting were again presented in the form of a report at the end of April 2008. The strategy for agricultural lending by the institution for the 2008/09 season was based on the second report as well as the lessons that were learnt through applying the proposed framework.

During the first meeting, it was clear that the decision makers expected market conditions to prevail as experienced at the beginning of 2008. Hence, in line with general market expectations and reports, they expected oil prices to increase to levels of close to $200/barrel. Based on this expectation and based on the link between energy prices and agricultural commodities, which was quite strong at that time, they expected agricultural commodity prices to remain firm and even increase further along with expected increases in the price of crude oil. However, through the application of the proposed framework during the two sessions, a number of factors were identified that could potentially result in a market outcome significantly and unexpectedly different compared to their initial expectations as well as that of the general market.

First of all, the name of the game, as well as the history of the game was discussed. From this discussion, it became clear that the goals of the institution were, namely, to minimize the risk of loan defaults while maintaining its market share. Hence, it was important for the institution to finance maize production, but at the same time mitigate the risk of loan defaults. This would be done by following the correct strategy in terms of identifying and analyzing potential clients and also structuring clients' debt correctly by using different combinations of finance products. Structuring debt correctly would mean that the risk of loan defaults would be minimized, since positive cash flow would be improved.

The discussion of the history of the game focused mainly on the maize industry and historical trends and interrelationships with respect to that industry. The reason for discussing the history of maize only was that the institution was reluctant to discuss in detail its exposure to the maize industry in terms of the amount of finance provided as well as past approaches toward financing maize production, since that would have meant disclosing confidential information. From the discussion, it became clear how important the macro-economic situation became in terms of its influence on maize prices, due to the strong link between fossil fuels and maize as a result of biofuel production.

Moving to the next step, the players influencing the game were discussed in detail. Players and related activities identified that could significantly influence the macro-economy and, therefore, the maize industry were global investors, the

presidential race in the US (Obama potentially becoming president), the reaction and measures taken by the Federal Reserve Bank of the US should economic conditions turn bad, OPEC and its reaction to an economic crisis, the ability of Eskom to correct power problems within South Africa and thereby influence investor perceptions positively, and lastly the outcome of the power struggle between the ANC and the government and how that would influence investor perceptions.

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

Based on the discussions of the history of the game, players of the game and rules of the game, key uncertainties were identified and discussed in detail. These were the following factors and players: the US economy going into a recession, and the impact of this on China, India and the EU.

Following the discussions, each of the factors were divided and presented as follows in the second report to the institution[6]:

Rules of the game

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

Key uncertainties

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

Wild Cards and players of the game

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

From these factors, a set of three scenarios was written and presented to the institution's decision makers along with the potential implications of each scenario in terms of energy prices and, therefore, agricultural commodity prices. The scenarios and implications were presented as follows:

Scenarios

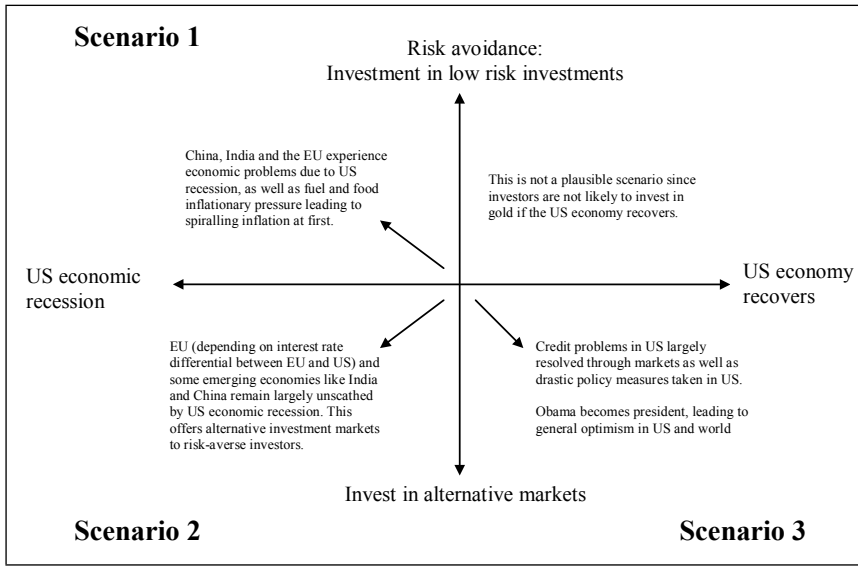

Figure 2: Implications of scenarios

Scenario 1

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

Scenario 2

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

Scenario 3

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

Based on the scenario results, the model of Meyer *et al.* (2006) was used to quantify scenario 1 in the report (without including probabilities to ensure that uncertainty is incorporated in a technically correct manner), since the decision makers thought this scenario to be the most critical in terms of developing a robust financing strategy. The modelling results that were presented to the decision makers were as follows[7]:

The scenario presented below indicates a global economy, which is severely affected by a recession in the US economy as well as overheating due to excessive high fuel and food prices. The assumption is, therefore, that the BRIC countries (Brazil, Russia, India, and China) do not have enough internal momentum to keep their economies growing at rates seen during the past few years, and also that inflationary pressure (due to excessive fuel and food prices) forces the economic growth in these countries to slow down in order to avoid excessive overheating. The macroeconomic assumption underlying this scenario is presented in Table 1.

Table 1: Scenario Projections – Economic indicators

		2009	2010	2011
Crude Oil Persian Gulf: fob	$/barrel	80.00	79.47	78.39
Exchange Rate	SA c/US$	900.00	945.00	992.25
Interest Rate (Prime)	%	14.00	12.00	10.00

Source: BFAP, 2008

Due to a change in the interest rate differential between the EU and the US, the Dollar strengthens, which forces oil prices down. On the back of this, the pressure on the demand for oil slightly weakens since trade and consumption of general goods and commodities slow down. The result is that oil prices drop unexpectedly to levels of around $80 per barrel[8].

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

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

- Due to the general slow down in the economy, world commodity prices decreased rapidly in 2009 and 2010. This does, however, not imply that prices pull back to historical levels. Commodity prices still remain relatively high (Table 2).
- Commodity prices in the local market are expected to decrease in 2009 and 2010. As a result, farmers will respond to the lower commodity prices by reducing the area planted to field crops, especially on the back of high input costs, which are in general sticky and therefore do not decrease at the same rate as commodity prices. This causes pressure on profit margins and also increases the risk of production significantly. The decrease in area (and supply), causes prices to rise again by 2010.

Table 2: Scenario projections – World commodity prices:

		2009	2010	2011
Yellow maize, US No.2, fob, Gulf	US$/t	190.25	160.90	156.51
Wheat US No2 HRW fob (ord) Gulf	US$/t	203.38	172.00	167.30
Sorghum, US No.2, fob, Gulf	US$/t	171.42	149.43	144.82

Source: BFAP, 2008

Table 3: Scenario projections – SA commodity price projections:

		2009	2010	2011
White maize (SAFEX)	R/ton	1870.0	1746.8	1877.8
Yellow maize (SAFEX)	R/ton	1885.4	1644.3	1709.7

Source: BFAP Sector Model

Following the scenario thinking process, the various steps in terms of executing the stochastic modelling process were followed as stipulated by the framework presented in Section 5. During each of these steps, the information and insights gained from the opposing step in the scenario thinking process were used to guide the process of how to set up the model and simulate the maize prices. Concurrently, by going through the modelling steps in terms of quantifying the trends and interrelationships, some objective and quantitative information was added to the thinking process, which in turn assisted the institution's decision makers to form more objective perceptions on some of the variables and players thought to influence the market situation. The result was a probability distribution, which indicated that maize prices (both white and yellow), are likely to stay above R2000/ton for the 2008/09 season (Table 4). This conformed with the initial expectations of the bank's decision makers.

Table 4: Simulated maize price probability distributions

Variable	Stochastic model simulation results					
	Unit	Mean	Min	Max	Std Dev	CV
White maize price 2008/09	R/ton	2042	1472	3617	300	14.7
Yellow maize price 2008/09	R/ton	2076	1416	3665	336	16.21

By following scenario thinking and stochastic modelling in conjunction, and by comparing the scenario results with the stochastic modelling results, it was possible for the institution's decision makers to understand that a situation whereby the global economy could almost implode was quite possible although highly improbable. From the scenario results it was also gathered that should the economy implode, an unexpected decrease in agricultural commodity prices was quite possible and plausible. At the point of developing these scenarios, the possibility for scenario 1 to play out was deemed "unthinkable" since all opinions, views, forecasts and technical reports pointed to a situation where the market would and "could" only increase from the April 2008 levels. Hence, a meltdown was thought to be a totally crazy idea.

The application of the proposed framework, however, clearly pointed to such a "crazy" possibility, and in fact captured most of the dynamics that eventually caused the meltdown quite accurately. Hence, as a result of presenting the scenario results, the decision makers realized that such a crazy and unthinkable event was quite possible and plausible. This resulted in them starting to question their initial assumptions and therefore expectations, and hence forced them to change their perceptions as to the potential outcome of the market. As a result, the institution's decision makers were in a position to realize that such an event was possible and plausible, and hence re-perceived reality in terms of the actual risks and uncertainties that were faced at the point of taking a decision. Consequently, the institution decided to adjust their credit provision and management strategy, which ultimately enabled them to withstand the onslaught of the eventual risks and unexpected events that led to the current market turmoil. This means they adjusted their approach towards analyzing and financing clients, specifically with respect to the criteria used to analyze a business as well as the type of product used to finance the business[9].

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

Should the financing institution have used stochastic modelling only as is currently used in agricultural economic literature, only the probability distribution results as presented in Table 4 would have been available to guide decision making. This would probably have misled the decision makers to expect higher market prices, resulting in the design of a financing strategy that would most likely have been less robust in terms of withstanding the onslaught of the current market conditions.

8 SUMMARY AND CONCLUSION

This article argues that significant shortcomings currently exist with respect to the analysis of, specifically, uncertainty within agricultural economics, given the possibility that uncertainty will only increase within the sector in future. The weakness stems from the fact that probabilities (objective or subjective) are used in the analysis of both risk and uncertainty. From the literature on, and theory

and definition of uncertainty, it can be argued that probabilities cannot be used to analyze and communicate uncertainty, since logically it does not make sense to assign probabilities when uncertainty is present.

Based on this argument, a framework is proposed whereby intuitive logic scenario thinking is applied in conjunction with stochastic econometric modelling in order to mitigate this weakness. Intuitive logic scenario thinking is a technique that was specifically developed in order to analyze and understand the impact of uncertainty.

A case study was presented whereby the proposed framework was applied, to show the success of applying the framework given the current turmoil experienced in the general economy as well as in agricultural commodity markets. By means of the case study results and arguments, it was shown that the application of the proposed framework should lead to improved decisions with respect to policy and business strategy in the agricultural sector should risk and uncertainty increase in future.

Additional research that needs to be conducted on the basis of the framework that is proposed in this article is the detailed learning process that takes place when applying this framework in the mind of the decision makers who use the framework. Furthermore, research needs to be conducted in terms of incorporating game theory and new institutional economics into this framework, since the steps within the framework create the potential to incorporate these fields. This will create a much needed link between the respective fields.

NOTES

1 Credit is given to Westhoff, Brown and Hart (2005) for "inventing" part of this title.

2 Commodity manager at SABMiller, South Africa, Email: pg.strauss@za.sabmiller.com

3 Respectively Senior Lecturer and Professor at the Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, South Africa. Emails: ferdi.meyer@up.ac.za, Johann.Kirsten@up.ac.za. Physical address: University of Pretoria, Agricultural Annex Building, Room 2-21, Pretoria, South Africa.

4 Many more examples exist in both the South African and international agricultural economic literature where risk and uncertainty techniques have been applied.

5 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.

6 This part of the article is taken directly from the report written to the institution, to indicate the exact wording and format in which the results of applying the framework were presented to the institution. The report containing this information was presented to the decision makers at the end of April 2008.

7 Again this part of the article is taken directly from the report written to the institution, to indicate the exact wording and format in which the results of applying the framework were

presented to the institution. The report containing this information was presented to the decision makers at the end of April 2008.

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

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

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