STOCHASTIC EFFICIENCY ANALYSIS OF ALTERNATIVE BASIC MAIZE MARKETING STRATEGIES

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ABSTRACT

The use of modern marketing strategies to minimize risk exposure is not a widely adopted practice under maize producers. The producers tend to use high risk strategies which include the selling of the crop on the cash market after harvested; while the current market requires innovative strategies including the use of Futures and Options as traded on SAFEX. However, due to a lack of interest and knowledge of producers understanding of modern, complicated strategies the study illustrates by using a SERF and CDF that the use of three basic strategies namely a Put-, Twelve-segment-, Three-segment- can be more rewarding. These strategies can be adopted by farmers without an in-depth understanding of the market and market-signals. The results obtained from the study illustrates that producers who tend to be more risk neutral would prefer using the Twelve-segment- or Spot-strategy while a risk averse producer would prefer the Three-segment-, or Put-strategy. It also indicates that no strategy can be labelled as the all-time best and that the choice between strategies depends on risk adverse characteristics of the producer. The purpose of the study is to prove that the adoption of a basic strategy is better than adopting no strategy at all and to convince producers to reconsider the adoption of modern marketing strategies.

Keywords: Marketing strategies, futures, options, SERF

1. INTRODUCTION

Profit is the reward for risk-taking, therefore any profit seekers in the farming business, or in any other business, must be prepared to bear some risk (Varangis, Donald and Anderson, 2002). Because of risk and uncertainty components, high fluctuations in yields and prices have occurred in agricultural products as proven by Jordaan *et al.* (2007); which lead to high income fluctuations in agriculture.

Price risk is a major source of risk to producers both locally and internationally (Woodburn,1993; Coble and Barnett,1999). Price risk is important mainly due to the fact that high variability in profits is a direct result of variability in prices. Prior to the deregulation of markets in 1996 grain prices were determined by the Maize Board and set fixed. This period of regulation ended with the employment of the Marketing of Agricultural Products Act of 1996 ordering the demise of most of these control boards. Groenewald *et al.* (2003) argue that the variability of prices has increased since deregulation. Jordaan *et al.* (2007) confirmed the increase of variability by means of determining the price volatility of field crops that are traded on the South African Futures Exchange (SAFEX). The increase in price variability has exposed South African producers' price risk management abilities.

Risk management strategies are developed to provide some protection in situations in which the consequences of a decision are not known when the decision is made. Risk strategies are defined as the methods applied to remove or reduce partly the effects of factors creating risk in agriculture (Akcoaz and Ozkan, 2005). The selection of good risk strategies depends on the farm operator, the financial institution and risk attitude of the producer (Akcoa and Ozkan, 2005). Most commodity trading theorists have visualized the hedger as a dealer in the actual commodity who desires insurance against the price risks he faces (Johnson, 1960). There are numerous ways in which risk can be managed; the use of the derivative market is just one. Other methods amongst others is the use of insurance, price-pooling where farmers have the opportunity to reduce price risks through marketing arrangements and lastly management of available debt and savings. However, forward contracting of produce is a much more effective and relatively widely used form of risk management for farmers, the most common being a contract for the sale of a crop (Varangis, Donald and Anderson, 2002).

In financial markets, the term derivatives are used to refer to a group of instruments that derive their value from some underlying commodity in the market. Forwards, futures, swaps and options are all types of derivative instruments and are widely used for hedging or speculative purposes (JSE, 2010). The markets are highly dynamic and continuously changing. It requires an in-depth understanding of global markets and knowledge of present and future trends with regards to the agricultural sector.

Agricultural economists have devoted much effort on attempts to analyze futures markets systematically and to show how risk-averse producers 'should' use such markets. However, reality is that rather few farmers actually use futures hedging. Most probably the reason is because of a lack of knowledge on how the market works (Varangis, Donald and Anderson, 2002). Jordaan and Grové (2007) also found that only 44% of their sample of respondents used forward pricing strategies. None of these respondents used option strategies. These researchers indicated that respondents perceive the market as ineffective and that the producers have a lack of human capital to apply more complicated marketing strategies. Various international authors including O'Brien (2000), Zulauf, Larson, Alexander and Irwin (2001), Bates (2003), and local authors such as Grönum and van Schalkwyk (2000)

Scheepers (2005) and Cass (2009) evaluated marketing strategies consisting of futures and options. In many instances these strategies are to complicated for farmers to apply.

Price risk management is hampered in the presence of highly sophisticated marketing strategies that are not likely going to be adopted by producers that are not highly skilled in the application of these strategies. The question remains to what extent less complicated marketing strategies such as routine marketing strategies will aid farmers in price risk management. O'Brien (2000) defined routine strategies as "Those in which grain is marketed each year during the same time period using the same marketing tools regardless of market conditions".

The main objective of this paper is to determine the benefit of routine marketing strategies compared to a baseline where only the spot market is used for decision-makers with varying degrees of risk aversion. A constant absolute risk aversion utility function is employed to calculate the benefit of routine marketing strategies. A secondary objective is to determine to what extent routine marketing strategies will increase the probability that a producer will be able to cover his direct allocable costs of production. The analyses are done for four major maize production regions in South Africa.

The rest of the paper is structured as follows. Alternative marketing strategies are discussed in Section 2 followed by a short description of the data and procedures used to quantify marketing risk. The procedures that were used to conduct the stochastic efficiency analysis are discussed in Section 4. Next the results are presented and discussed in Section 5. The paper is concluded with a section on the conclusions and recommendations.

2. ALTERNATIVE MARKETING STRATEGIES

There are multiple marketing strategies that can be used to manage risks in marketing. The complexity of maize marketing strategies may vary significantly between alternatives. Examples of more complex strategies are amongst others buying a synthetic put or call option, using bull spreads or the Butterfly option strategy. For the purposes of this research easy to use routine strategies are identified and evaluated mainly due to the fact that producers do not implement complex strategies.

2.1. Strategy Spot: Sell the crop in the cash market after harvesting

Strategy spot is used as the baseline strategy and signifies a situation where no active marketing is done. More specifically it is assumed that the decision maker sells his produce in the spot market during July. In cases where the market moves upwards since planting time, this strategy will ensure best results but provides no price risk management against a declining market. The strategy is not amended with regards to price risk management and is only used to make comparisons.

2.2. Strategy Put: Buy a put-option after commodity is planted

Options are derivative instruments that can be used for price risk management (hedging) or as a means of speculation. The holder of an option has the right, but not the obligation to buy or sell and underlying instrument at a predetermined price during a specific period or at a specific time. Buyers hold the rights, but no obligations while sellers assume obligations to buy or sell an underlying futures contract if the option is exercised by the buyer (JSE, 2010). A producer, who has just planted, and is concerned that the market may decline sharply in the near future, will by a put. The producer buys the right to sell at a minimum price to manage the price risk. Thus, at the expiring date the producer will have the right to sell his crop at a minimum price which was agreed on at planting time. When a producer exercises this option, he developed protection against falling prices and has the opportunity to benefit from increasing prices. The put strategy has the negative effect of a premium that must be paid for the put strategy.

Data used for this strategy is SAFEX-prices on the 1st of December $_t$[5] this is also the strike price. The option cost is calculated by using the Black Scholes Model originally developed by Black and Scholes (1973), given the SAFEX-price (at the money) while historic volatilities are obtained from SAFEX. The expiry date for the option is July $_{t+1}$ and the July spot price is the alternative price when the option is not exercised (Spot price -premium).

2.3. Strategy 3x: Sell production in three segments on the futures market

A futures contract is a contract requiring commitment to take or make delivery of a specific commodity according to a specific quantity and quality as stated in the contract at a specific

[5] Year of planting

location on a specific timeframe in the future. Futures are mainly exchanged in the process of price discovery and price risk management. In the case of grain marketing using futures a farmer will sell his crop in a future market at a specific price at a specific point in time prior to harvesting time. When the futures contract expires, the producer is obligated to deliver the exact amount and quality grain in exchange for the agreed price at the agreed location. The futures contract can also create a new risk for the producer named yield risks. If the producer did not achieve his expected yield he/she have a shortage of production on the contract, which means that the producer must buy grain to fill his contract quantities which can be negative or positive.

When a producer is concerned that the price of the commodity will decline with the maturing of the season, the producer has the choice to sell his crop in the future market in which the producer commits to sell a specific quantity and quality of his crop at a specific time and place. The strategy states that the production is sold in three segments of equal quantities, the first is sold when the crop is planted (December), the second at pollination phase (February) and the third segment at harvesting (July) this is three important timeframes within the industry. To lock the producer's price level at the beginning of the season, the producer obtain a short position in futures. The producer is protected against declining prices but cannot benefit from an increase in commodity prices. A short future position locks the same price level regardless of the direction of the market.

2.4. Strategy 12x: Sell crop in twelve segments

Using the same concept as the previous strategy, the producers sells the crop in twelve segments starting at planting time and ending at harvesting time in a three-week interval. The producer still locks the price, but on twelve different time-frames at twelve different prices this strategy will spread the producer's risk and obtain an average price for the season. Prices are fixed every three weeks starting from December up to the end of July. The exposure to risk will be greater than the previous example but in cases where the market may move upwards, the producer has a higher chance in benefitting from an ascending market.

3. RISK QUANTIFICATION

A non-parametric approach is adopted in this study to quantify cumulative distribution functions (CDF) of maize prices and gross margins for the alternative marketing strategies. According to Goodwin and Mahul (2004) a non-parametric approach is the preferred method of analysis in cases where few data points are available such as is the case in this study.

Eight years of historical volatilities, spot and futures contract prices for white maize were obtained from the Agricultural Products Division, better known as SAFEX (SAFEX, 2010) and used to quantify the price risk associated with each of the marketing strategies. Resulting marketing prices were expressed in 2008 rand values before constructing the CDF assuming each year has an equal chance of occurring.

Gross margin cumulative probability distributions were also constructed for North West Province, North Western Free State, Eastern Free State and Mpumalanga to determine the probability that a specific marketing strategy will cover the production cost. Deflated historical average production costs and maize yields available from Grain SA were used for the gross margin calculations (Grain SA, 2010). Significant ($p<0.05$) time trends were identified for North Western Free State and Mpumalanga which indicates that the data generating process is time-varying. As a result yields were de-trended with 2008 as the base year in order to facilitate comparisons (Goodwin and Mahul, 2004).

4. STOCHASTIC EFFICIENCY ANALYSIS

4.1. Stochastic efficiency with respect to a function (SERF)

The stochastic efficiency of alternative marketing strategies for decision-makers with varying levels of risk aversion is determined with a technique developed by Hardaker *et al.* (2004) called stochastic efficiency with respect to a function (SERF). SERF is based on the notion that ranking risky alternatives in terms of utility is the same as ranking alternatives with certainty equivalents *(CE)*. *CE* is defined as the sure sum with the same utility as the expected utility of the risky prospect (Hardaker *et al.*, 2004). Thus, the decision-maker will be indifferent to both the *CE* and the risky prospect. *CE* is calculated as the inverse of the utility function and is therefore dependent on the form of the utility function. Assuming an exponential utility function and a discrete distribution of *x, CE* is calculated as (Hardaker *et al.*, 2004:257):

$$CE\left(x, r_a(x)\right) = \ln\left\{\left(\frac{1}{n}\sum_{j}^{n} e^{-r_a(x)x_j}\right)^{\frac{-1}{r_a(x)}}\right\} \quad (1)$$

where $r_a(x)$ is the level of absolute risk aversion and n defines the size of the random sample of risky alternative x. The relationship between risk aversion and *CE* is determined by evaluating Equation (1) over a range of $r_a(x)$ values. Repeating for different risky alternatives yields the relationship for several alternatives which are best compared by means of graphing the results (Hardaker *et al.*, 2004). The alternatives are ranked based on *CE* whereby the alternative with the highest *CE* is preferred given the specific level of risk aversion. The difference between two alternatives at a specified $r_a(x)$ level yields a utility weighted risk premium[6] which is defined as the minimum sure amount that has to be paid to a decision-maker to justify a switch between a preferred and a less preferred alternative (Hardaker *et al.*, 2004).

Application of SERF requires form the analyst to quantify the risk associated with a risky alternative as a CDF and to specify the range of risk aversion levels. The analyses are conducted in Excel© using the SIMETAR add-in (Richardson *et al.*, 2004).

4.2. Choice of absolute risk aversion levels

In the absence of utility functions for decision-makers a practical alternative is to assume a specific utility function and then to use risk aversion levels utilised in other studies to represent risk aversion. Assuming an exponential utility function a measure of absolute risk aversion is required. Choice of appropriate ranges of $r_a(x)$ is difficult because although $r_a(x)$ is unaffected by an arbitrary linear transformation of the utility function, the invariance property of arbitrary linear transformation of the utility function does not apply to arbitrary rescaling of the outcome variable x (Raskin and Cochran, 1986). Due to the before mentioned; $r_a(x)$ cannot be transferred from one study to another without applying some sort of rescaling.

In our analyses the link between the risk aversion parameter used in applied MOTAD studies and the $r_a(x)$ risk aversion parameter used in mean-variance quadratic programming problem formulations is used to guide the choice of $r_a(x)$.

[6] Note that this concept is different from the risk premium defined by Pratt (1964).

Following Biosvert and McCarl (1990) the link may be developed as follows:

MOTAD

$$\text{Max} \quad CX - \alpha\,\sigma$$

$$\text{St} \quad \begin{aligned} AX &\le b \\ X &\ge 0 \end{aligned}$$

MEAN VARIANCE

$$CX - 0.5 r_a(x)\,\sigma^2$$

$$\text{St} \quad \begin{aligned} AX &\le b \\ X &\ge 0 \end{aligned}$$

The Kuhn-Tucker conditions with respect to *X* of these two models are:

MOTAD

$$C - \alpha\frac{\partial\sigma}{\partial X} - uA \le 0$$

$$\left(C - \alpha\frac{\partial\sigma}{\partial X} - uA\right)X = 0$$

$$X \ge 0$$

MEAN VARIANCE

$$C - 2\cdot 0.5 r_a(x)\sigma\frac{\partial\sigma}{\partial X} - uA \le 0$$

$$\left(C - 2\cdot 0.5 r_a(x)\sigma\frac{\partial\sigma}{\partial X} - uA\right)X = 0$$

$$X \ge 0$$

For these two models solutions to be identical [7] in terms of *X* and *u*, then

$$\alpha = 2\cdot 0.5\, r_a(x)\sigma \qquad (2)$$

$$\alpha = r_a(x)\sigma \qquad (3)$$

Equation (3) shows that the risk aversion parameter of the MOTAD model is equivalent to the $r_a(x)$ multiplied with the standard deviation of the risky prospect. Thus, for any assumed level of α, $r_a(x)$ can be calculated. McCarl and Bessler (1989) state that α=2.5 are typically reported as the maximum value in applied MOTAD studies. Recently Conradie (2002) compared the observed crop mixes of 16 different farm types to those simulated with MOTAD in the Fish-Sundays irrigation scheme in South Africa. Reported α values varied from 0.25 to 5 with only two farms having values greater than α=2.5. In our analysis a value of α=2.5 and the standard deviation of the baseline strategy are used to calculate the upper bound on $r_a(x)$.

[7] The relationship between the risk aversion parameters of the MOTAD and EV models presented in Equation (3) is different from the relationship presented by Biosvert and McCarl (1990) because their specification treats $0.5r_a(x)$ as the E-V risk aversion parameter.

5. RESULTS

5.1. Stochastic efficiency of marketing strategies

5.1.1. Marketing risk

A number of statistical measures are used presented in Table 1 to describe the variability associated with the marketing strategies.

Table 1: Statistical moments of alternative marketing strategies.

	Put	3 X	12 X	Spot
Mean	1596	1531	1556	1464
Minimum	1006	893	810	755
Maximum	2215	2088	2288	2261
Standard deviation	430	353	418	527
Coefficient of variation	0.27	0.23	0.27	0.36

Mean price received: The mean price received from alternative grain marketing strategies is a primary indicator of their relative performance. The grain marketing strategy that returns the highest mean price compared to another will always be the best strategy given that price variability is not a concern. In this study the put strategy have the highest mean price and the spot strategy have the lowest mean price.

Minimum and Maximum: The minimum and maximum prices indicate the low/high range of the marketing strategy price outcomes over the period of 2001 up to 2009. The strategy with the highest price is the 12x strategy; the reason why this strategy has a higher price than the put is mainly when price increased rapidly from December and then decreased again in July. The market started out early December 2001 at R1 315[8] per ton inclined to a peak of R1 850 in April after which it declined to R1 630 in July 2002. The Put-strategy covered the bottom price while the twelve-segment-strategy enabled the producer to benefit from rising prices. Thus the 12x strategy benefits from the increase where the put strategy had no effect since the expiry date is July. The strategy with the lowest value is the spot strategy.

[8]Nominal values are used for interpretation purposes

Standard deviation: The standard deviation of the selling price received for a particular market strategy is used as a statistical measure of annual price variability. The higher the standard deviation of annual selling prices of a specific strategy the more variable its return is. The 12x strategy have the lowest standard deviation while, the 3x strategy have the highest standard deviation which highlights the importance of the other strategies to reduce the price variability.

Table 1 illustrates that all of the alternative marketing strategies are better than the base strategy (spot), however one cannot pin point the most efficient strategy from these statistics. To gain more insight in the distribution of prices associated with each marketing strategy the CDF of each of the strategies are portrayed in Figure 1.

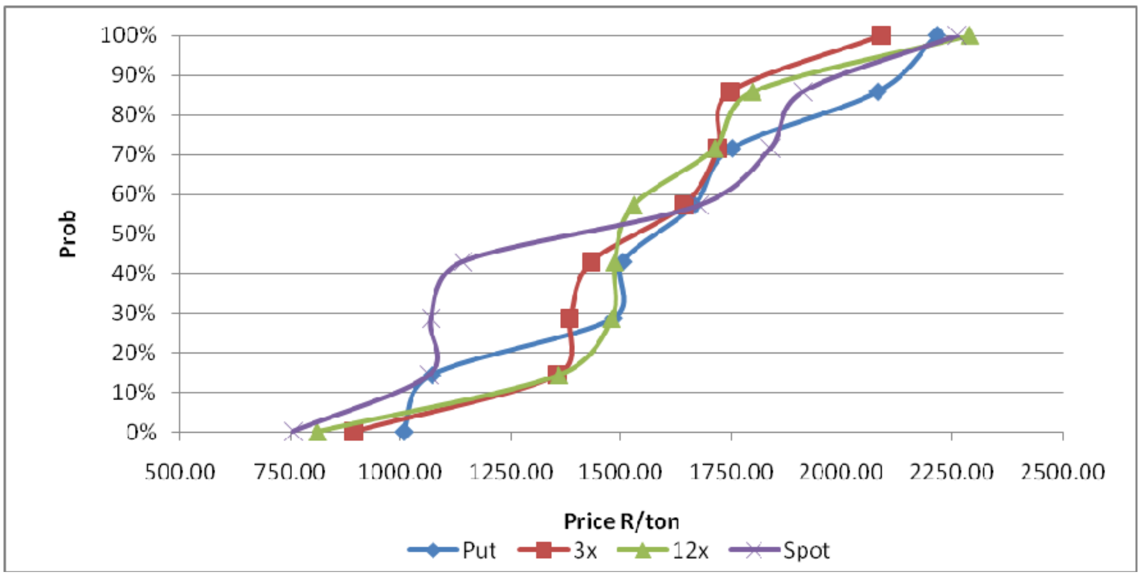

Figure 1: Cumulative Distribution Function for price for alternative marketing strategies

The CDF illustrates that if the producers decide to implement the spot strategy there is a 50% that he will receive a lower price than with the other alternative strategies. Thus, the alternative marketing strategies proof to be valuable in increasing prices at the lower probability ranges. The 3x and 12x strategies follow similar trends with the 3x strategy having a higher minimum value and a lower maximum value. The put strategy has the highest minimum price of an R1000/ton but between 5% and 25% the it is dominated by strategy 3x and 12x. The put strategy also has a 75% change of creating a higher outcome when compared to strategy 3x and 12x. Choices between the alternative marketing strategies are difficult since none of the strategies clearly dominates the others and the choice will depend on the risk preferences of decision makers. However, overwhelming evidence exist that the alternative strategies are capable of increasing minimum prices which is the main purpose of a risk management strategy.

5.1.2 Utility weighted premiums

Negative exponential utility weighted risk premiums are graphed for decision-makers with varying degrees of absolute risk aversion in Figure 2. Risk neutrality is characterised by a zero absolute risk aversion level and risk aversion increases with increasing levels of absolute risk aversion. The premium at a specific level of risk aversion indicates the difference between CE of the spot market and the alternative marketing alternative with which the spot marketing strategy is compared.

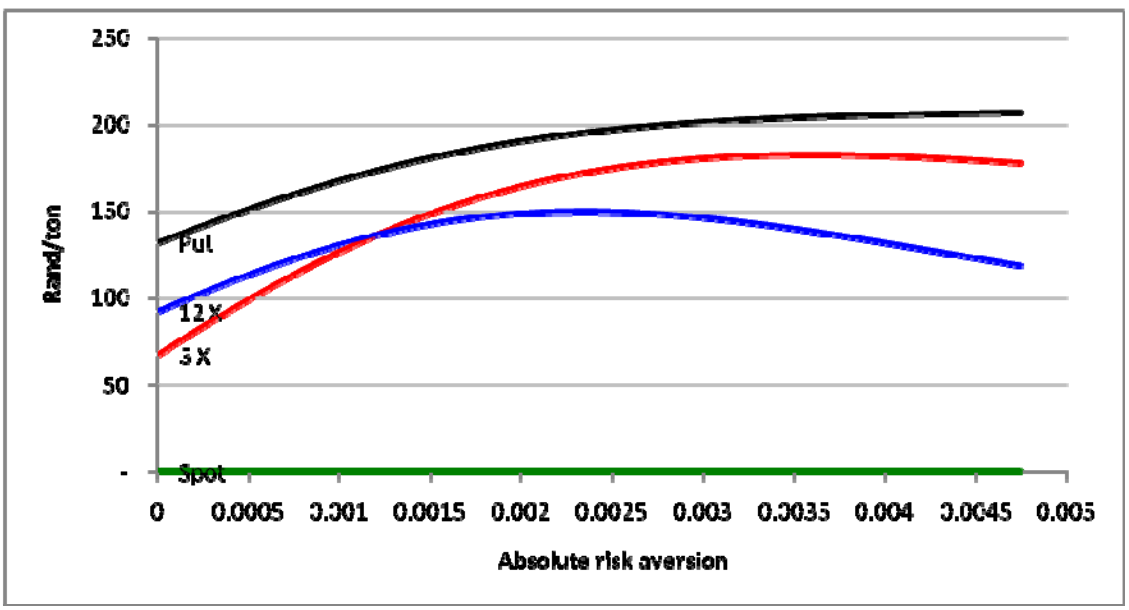

Figure 2: Negative Exponential utility weighted risk premiums relative to Harvest

Results indicate that risk averse decision-makers will benefit most from employing the put strategy. More specifically the calculated benefit for a risk neutral producer to move from the spot market strategy to the put strategy is R130 per ton. The benefit increases to over R200 per ton for a decision maker that is severely risk averse. When the 12x and 3x strategies are compared to the baseline no one strategy clearly dominates the other. The differences between these two strategies are also rather small when the range of risk absolute risk aversion levels is considered. For most of the range the absolute difference is no more than R25 per ton. At relatively lower levels of risk aversion the 12x strategy is more beneficial whereas the 3x strategy dominates at higher levels of absolute risk aversion. The trade-off between the two strategies is governed by the specific form of the CDF of the two alternatives. However, more important is the fact that both strategies are significantly more beneficial when compared to the spot market.

5.2 Risk management sensitivity for different regions

To determining what the probability of each strategy is to cover a farmer's production costs CDF'S are calculated for each region. The results of the CDF'S for the different provinces are interpreted separately starting with the North West Province.

North West Province

The gross margin probability results for North West are illustrated with a graphical presentation of the CDF in Figure 3. The CDF indicated that, when a producer decides to sell his crop in the spot market, he has an 8% chance of generating a negative gross margin in other words not covering his direct allocable costs, a 60% chance of reaching a gross margin less than R1 000 per hectare and a 100% chance of realising a gross margin less than R6 500 per hectare. However, if the producer decides to apply the spot strategy there is a 65% change that the producer will receive a gross margin that is lower than the other strategies. The 3x and 12 x strategies are almost similar however both this strategies have a 0 % change of not covering the direct allocable costs. If the producer decides to apply the put strategy he has a 0% chance of realising a gross margin lower than R330 per hectare.

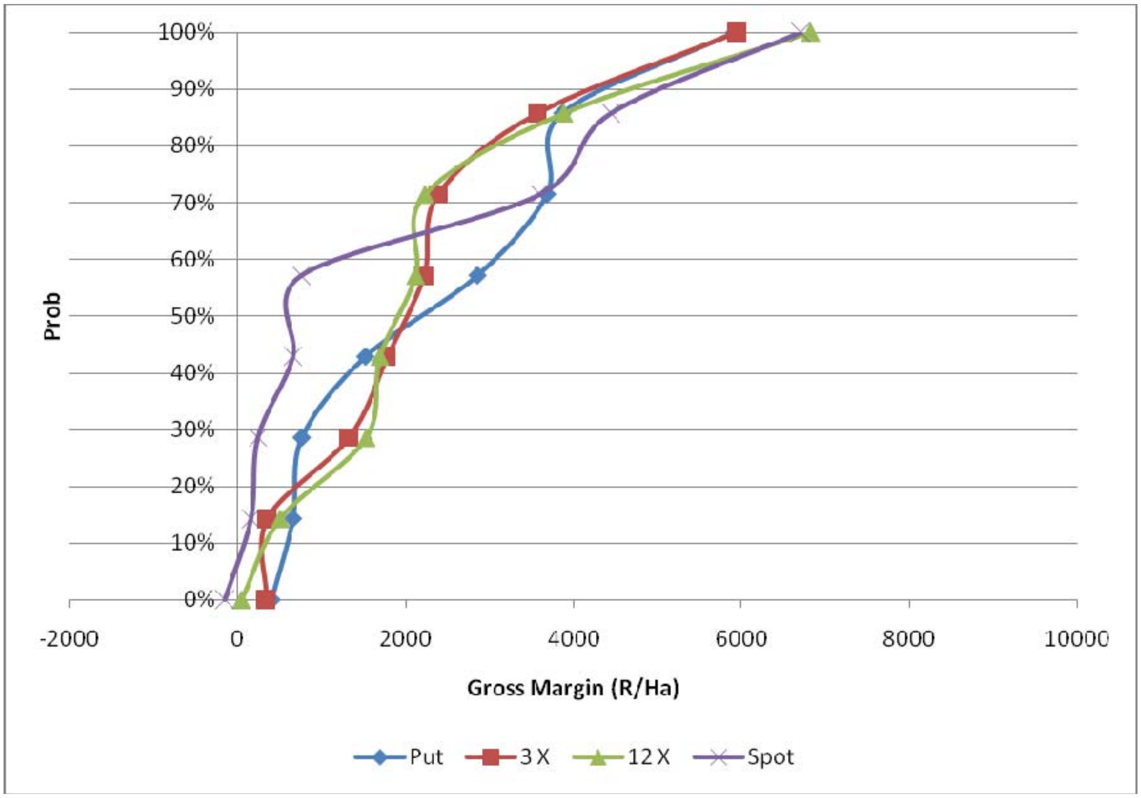

Figure 3: Cumulative Distribution Function for North West

North West Free State

The gross margin probability results for North West are illustrated with a graphical presentation of the CDF in Figure 4. The absence of negative gross margins is an interesting occurrence that can be due to the higher average yield obtained by this province. The difference between applying the base strategy and using the put strategy with a worst-case-scenario is R1 430 (R1 690-R260). With the spot strategy the producer have a 0% probability of making a gross margin lower than R260 while by using the put strategy he has a 0% chance of realising a gross margin lower than R1 690 per hectare.

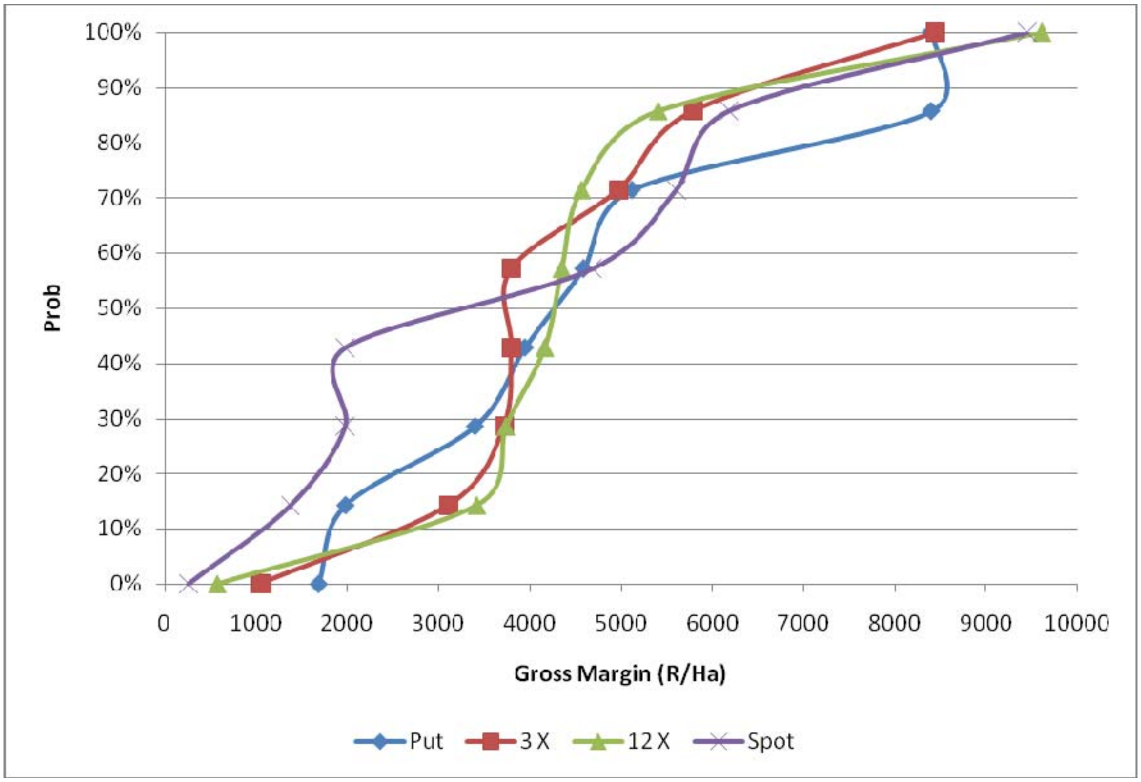

Figure 4: Cumulative Distribution Function for North West Free State

Almost the same conclusions can be made as with the North West regarding the different strategies. The 3x and the 12 x almost have similar probabilities, with the put being the dominate strategy

Eastern Free State

This is one of the provinces that produce smaller quantities and are not primarily known for their maize production. This specific region's gross margins tend to have a high variance which is a sign of a great deal of risk exposure.

Figure 5 illustrates a graphical presentation of the CDF for the Eastern Free State which differ from the previous provinces. A producer who uses the spot strategy has a 30% chance of not covering his production costs. The 12x strategy decreases this probability to 5%. The 3x strategy and the put strategy have a 1% probability of not breaking even. The spot strategy has a 64% probability of generating a lower gross margin comparing to the other strategies. The 3x and 12x are again similar with the put still the dominant strategy, however the dominance decreased. The decrease indicates that these producers are sensitive to paying put premiums.

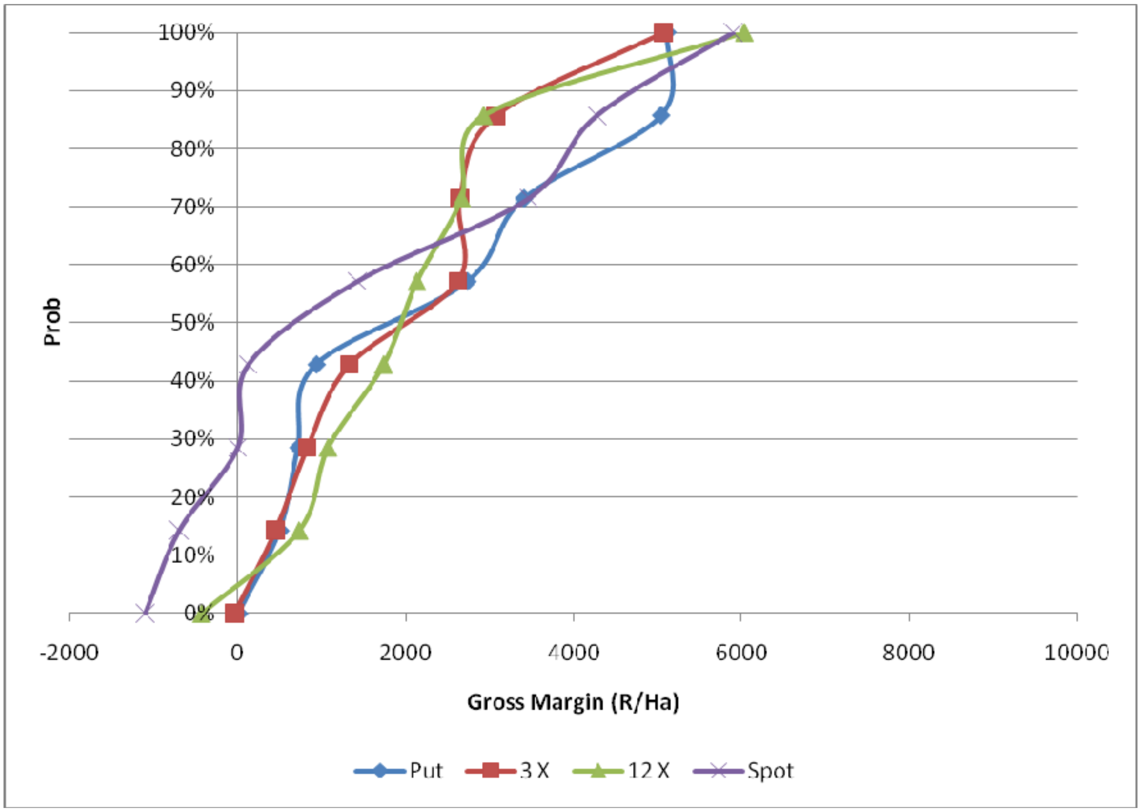

Figure 5: Cumulative Distribution Function for Eastern Free State

This region emphases' the importance of marketing strategies since this region is highly volatile to price changes.

Mpumalanga

The gross margin probability results for North West are illustrated Figure 6. None of the strategy has a probability of obtaining a negative gross margin. However the lowest gross margin that can be obtained in Mpumalanga is with the spot strategy at break-even followed by the 12x at R 950, the 3x at R 1 500 and the Put-strategy with a minimum gross margin of R 1 900 per hectare. The spot strategy has a 52% probability of generating a smaller gross margin compared to the alternative strategies. The put strategy and the 12x strategy is almost the same but the put strategy is still dominant over the 3x strategy with a 60% change of generating higher gross margins.

The Eastern Free State is the most sensitive region and this region has the highest need for marketing strategies. The put option is still the dominant strategy in all of the provinces but in the Eastern Free State the dominance decreased, which indicates the sensitivity towards the put premium.

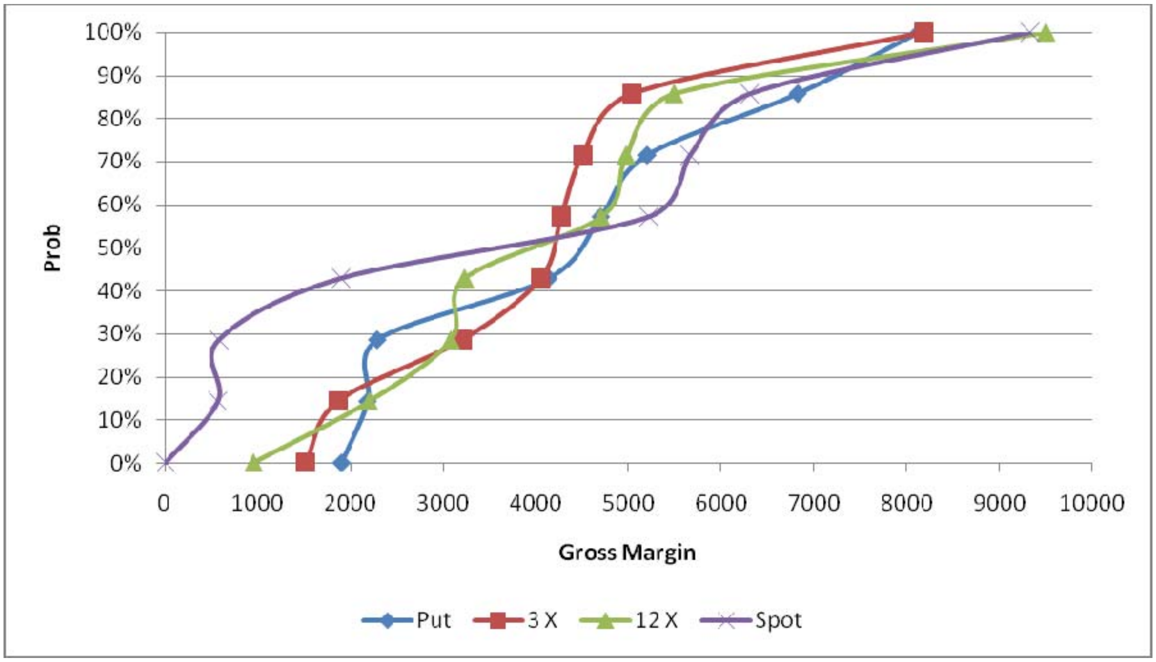

Figure 6: Cumulative Distribution Function for Mpumalanga

6. Summary and conclusions

According to Jordaan and Grové (2007) most of the producers in South Africa do not make use of pre harvesting strategies. One of the reasons for this could be that producers do not have the knowledge to apply complex strategies. Various authors such as O'Brien (2000) and Scheepers (2005) proofed that the derivative market is efficient. The main objective of this paper was to evaluate the risk efficiency of alternative routine market strategies as well as the probability that a specific strategy will increase the probability of covering your production costs. The three strategies that were compared with the spot market are selling in three segments (3x) on the futures market, selling in twelve segments on the futures market (12x) and buying a put at plant time.

Quantifying the risk of the alternative strategies clearly indicated the potential of the alternative marketing strategies to increase minimum prices. The CDFs of the alternatives marketing strategies indicated that the spot strategy has a 50% change of generating lower prices when compared to the alternative strategies. Utility weighted premiums indicated that significant benefits are possible when a put strategy is employed. Little difference exists between the 12x and 3x strategies and it is clearly dominated by the put strategy. However, these two strategies were also able to realise significantly larger prices compared to the spot marketing baseline. Thus, the conclusion is that routine marketing strategies that employ little information requirements might be of significant benefit to maize producers. Cognisance should be taken that the analyses are based on relative short time series of price information and the probabilities might not be associated with the true underlying probabilities.

In the Eastern Free State the spot strategy has a 30% probability of a negative gross margin, followed by the North West with an 8%. In all the provinces the alternative strategies has a higher probability of generating higher profits compared to the spot strategy. The put strategy is the most dominant strategy, however in the Eastern Free State the dominance decreased. This is due to the fact that the regions producing lower gross margins are more sensitive for put premiums.

7.

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