DECISION SUPPORT SYSTEM TO MANAGE INVESTMENT RISK OF GRAIN FARMERS IN SOUTH AFRICA

by

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Soli Deo Gloria!

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Summary

The Agricultural Products Marketing Act of 1996 caused a revolution in the marketing of South African crops. The abrupt transition to a totally deregulated marketing environment shifted the marketing responsibility from the various boards to the producers. Around the same time came new marketing instruments that producers can use to protect themselves against price risk.

Producers can choose how to manage price risks. Each choice has its own combination of costs and benefits. The study assumes that producers select a combination of marketing alternatives that optimize expected returns, subject to the degree of risk they are willing to accept. The large number of possible marketing alternatives can be grouped into three categories: spot market strategies, the use of forward contracts and derivative contracts. Thus, the task of defining a menu of realistic marketing choices and specifying their benefits and costs is complex.

Learning from mistakes can be an effective educational tool. But learning from marketing mistakes may be too expensive. Provided they are applied with

sufficient realism, decision support systems can help producers to explore marketing management matters without having to pay too much for possible mistakes. The question posed in this study is whether a marketing decision support system (MDSS) can be developed to manage the investment risk faced by grain producers.

From the study, the following conclusions can be drawn:

- An MDSS has been successfully developed for producers to apply to manage marketing risk and minimise investment risk.

- An MDSS was successfully developed for any size producer, from small producers to large producers, for white maize, yellow maize, sunflower seed and wheat.

- No MDSS could be developed for soybean crops, which are not actively traded on the South African Futures Exchange.

- The MDSS developed in this study incorporated all the different marketing tools available to South African grain producers to manage investment risk. It is the first model developed in South Africa that implements more than one or two strategies at a time.

- The MDSS developed in this study has added value to agricultural risk management in South Africa.

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CHAPTER 1

SCOPE OF THE STUDY

'Thriving markets and human security go hand in hand; without one, we will not have the other'

- Kofi Annan, UN Secretary General

1.1   INTRODUCTION

Agriculture is a dynamic industry, constantly affected in various ways by changes in climate, technology, marketing and government policy. Consequently, little in agriculture remains the same for long. Therefore, most economic decisions are made under uncertainty because individual decision-makers are not aware of the complete set of alternative actions available to them or the possible outcomes associated with each action. This is especially true for the decisions faced by crop producers.

Until recently, South African markets for maize, wheat, sorghum and oilseeds were stringently controlled in single channel systems, with both producer and consumer prices set by government. Producers could only sell to government control boards, and consumers procured grains and oilseeds by simply placing an order with the relevant boards. There were no price risks and there was no need for traders.

The Agricultural Products Marketing Act No 47 of 1996 caused a revolution in the marketing of South African grain. The abrupt transition to a totally **deregulated** environment obviously necessitated vast adjustments. Because the marketing boards had handled marketing in the past, producers and consumers had gained little experience in the 'art' of grain marketing. After the reform, producers and consumers had to realize that prices can and do fluctuate from day to day, and

had to learn to cope with such risks. Consumers had to adjust to the fact that their opposition could now buy grain more cheaply than they did. A first generation of domestic agricultural traders had to emerge, and a proper trading infrastructure had to be created. Alternative structures to aid producers in the marketing of their crop had to be developed to perform market functions previously performed by the boards. The structures created include forward marketing, futures contracts and options on futures contracts. With these new structures, producers can market their crops during three different time intervals:

- pre-harvest;
- during the harvest; and
- after the harvest.

Producers have always been exposed to some risk of loss because future crop yield is uncertain and prices cannot be predicted with certainty. After the abolition of various control boards, price risk in the agricultural sector increased. Producers now have to establish their own prices and with that, price risk increases, which could have a negative effect on farm returns. Since expected yield times the expected price(s) generates an estimate of future gross revenues, investment risk is also linked to yield and price risks. With the aid of risk management instruments listed above, producers have to manage investment risk optimally to ensure farming in the future.

An ideal risk management instrument would cost little, reduce the chances of low net returns, and not sacrifice upside price potential. However, tradeoffs have to be made between these characteristics. Some instruments cost very little, but offer little downside protection, or they limit upside gains. Alternatively, they may cost a lot. A question faced by producers is how producers can determine which instrument is best suited for their individual farm operation.

Against this background, the question posed in this study is not how producers market their crop. The real question is whether a marketing decision support

system can be developed to manage investment risk faced by grain producers who have to market their crop.

1.2   JUSTIFICATION OF THIS STUDY

In agriculture, risk is unavoidable. Stochastic environmental factors strongly influence agricultural production processes, thereby creating uncertain financial outcomes. One group of environmental factors, namely climatological factors and biological factors (for example, infectious diseases), cause variability in the physical production process. The second source of uncertainty is market price variability, composed of variability in the prices of inputs and product prices. The factors which cause the uncertainty are fairly unpredictable and cannot be controlled by producers. Thus, producers have to try to anticipate and respond to these risky circumstances.

Successful marketing is one of the most important aspects of a modern crop farm business. Consequently, it has become important for producers to change their view on marketing. Gone are the days when a producer could simply deliver a product to the co-operative (which acted as an agent for a marketing board) without showing any further interest in the sale of the product. Farm planning starts at the market, while marketing planning and marketing management should form an integral part of overall farm management.

South African maize production can fluctuate considerably, mostly due to low and variable rainfall. The coefficient of variation in production levels during the past ten years is 32%, compared to 19% in the USA's production of maize. Moreover, compared to other maize producing countries, the South African maize crop in some years is in surplus of domestic consumption, while in other years it is in deficit, which increases the scope for domestic price fluctuations over and above the fluctuating world market prices tremendously.

This variability has vexed South African governments since early this century. Various schemes failed, and the single channel marketing system was eventually instituted in 1944/45 when wartime transportation problems and extortionate local hoarding compounded the problem. The single channel marketing system was maintained until April 1995, although statutory retail and wholesale price regulations on maize products were abolished in the 1960's and 1970's respectively. In 1987 the system of fixed prices to producers had already been replaced by a pooled system of initial and supplementary payments in order to limit the Maize Board's losses due to the narrow margins set by government.

The single channel marketing system, which had induced the establishment of large, centralized processing plants, was increasingly attacked. Initially, the criticism came from academics, because the system conflicted with the theory of profit margins. Then large consumers (processors), who wrongfully ascribed their decreasing markets to the system instead of the escalation in transport costs, joined the attack. Eventually the criticism became widespread as the government's setting of the board's domestic selling price became increasingly politicized. In 1994, the government announced that the single channel system would be abolished and invited all sectors of the maize industry to get together to devise a system which would allow the market to determine prices, whilst still giving producers some protection against abnormally low prices. A further condition was that the system had to be self-funding, which meant that a government-funded type of strategic reserve programme was not an option.

After long negotiations, a floor price system was devised in which the Maize Board set a levy on domestic consumption in order to subsidize exports, so that domestic prices to producers could be supported at pre-set minimum levels. Producers could either sell to domestic consumers or deliver to export pools, and the consumers were responsible for raising the levies. The system was instituted on 1 May 1995 for the 1995/96 marketing year. For the 1996/97

marketing year, the system was altered in some ways, but in October 1996 the Minister of Agriculture finally announced that the system would be terminated on 30 April 1997 and that all government interventions would be abolished from 1 May 1997 onwards. Producers are now faced with the responsibility of marketing their own crops. The Wheat Board and Oilseed Board were also abolished and the marketing responsibility now lies with the producer.

1.3   LITERATURE REVIEW

In agriculture, it is especially ideas and practices derived from decision analysis and the expected utility model that are used to analyse producers' decisions under risk. Overviews are given of the application of decision analysis in agriculture as presented by experts in the field of risky decision-making in agriculture, both at the theoretical and empirical level. Research topics that have been reviewed are listed below.

Operations research models are used to analyse, supply and demand structures (Hanf & Mueller, 1979; Hazell, 1992). To determine optimum farm cropping plans (Hazell, 1978; Mapp et al., 1979; El-Nazer & McCarl, 1986) or to derive them theoretically (Collender & Silberman, 1985; Collins & Barry, 1986). Also, optimum hedging ratios are either derived theoretically (Bond & Thompson, 1985; Nelson, 1985) or are obtained by simulation (Baily & Richardson, 1985; Brandt, 1985; Lambert, 1984).

Some empirical studies examining the attitudes of farmers towards income risk are those of Randall (1986), Francisco and Anderson (1972), Dillon and Scandizzo (1978) and Binswanger (1980). The studies of Lovemore (1986), Lin, Dean and Moore (1974), Brink and McCarl (1978) and Scott and Baker (1972) focused on the choice of farm cropping plans as a decision under risk.

Decisions concerning the optimum level of pesticides are analysed in studies such as those of Charlson (1970), Webster (1977) and Thorton (1985). The use of fertilizer is examined in Moscardi and De Janvry (1977) and the amount of future reserve by Officer and Halter (1968). The adoption and utilisation of modern seed technology in the Phillippines is studied by Huijsman (1986), who analyses the hypothesis that the slow adoption of new technologies by poor farmers is caused by farmers' risk aversion. Specific attention is paid to risky decision-making by small subsistence farmers in underdeveloped countries by Roumasset, Boussard and Singh (1979) and Young, Landon and Mahama (1984).

Previous research conducted in South Africa on the topic of marketing decision support systems is very limited. Lombard (1993) did research based on a stochastic decision-making model for the evaluation of agricultural property transactions. De Waal (1991) conducted research on agricultural project management and Fraser (1991) investigated marketing systems in agriculture in the Ciskei region. The only research on decision support systems was done by Bestbier (1990), who developed a decision-making support system for the production and distribution scheduling of KWV distilleries. Moolman (1989) developed a computer-assisted management planning and decision support system, while Breen (1996) did research on the management of South African Estuaries. Lambrechts (1994) looked at the conceptualization and implementation of a marketing information and decision support system. Research based on risk management was done by Meiring (1994). He looked at the development and application of a decision-making support system for the economic evaluation of risk management at farm level. In addition, his study implemented a system to evaluate alternative risk management strategies for irrigation farmers in the region around the PK le Roux Dam.

Two aspects are striking in this literature. Firstly, literature on decision-making for producers, where risk is incorporated in the decision-making process, is

predominantly devoted either to total farm planning, especially crop production planning, or to specific production decisions such as fertilizer input decisions and pest management. Surprisingly little literature exists on producers' market-related decisions under risk. When marketing decisions were studied, so far, the studies were primarily concerned with the futures market. One such study is that of Allen, Heifner and Douglas (1985), who studied the impact of the futures market on marketing risk management. It is not very surprising that attention is directed to the futures market when producers' marketing behaviour is studied, since the futures market was developed as an aid to reducing price risks.

The second observation is the fact that no research has been conducted on the South African agricultural marketing environment since the dismantling of the various control boards. The only study, done during 1991, that focused on marketing systems in South Africa was done on the Ciskei region before the dismantling of the control Boards.

1.4   RESEARCH OBJECTIVES

Various marketing techniques have come into being since deregulation. They include grain pools, forward contracts, futures contracts, options on futures contracts, and cash markets. Producers must decide which marketing instruments to use. This decision is, of course, influenced by:

- the producer's marketing skills;
- the producer's risk profile;
- the producer's knowledge of the market;
- supply and demand; and
- the prices that can be realised by using the various marketing instruments.

Producers can now market their grain over a period of approximately twelve months. This means that producers retain ownership of their products over a

longer term than in the past. This entails additional costs for producers, but it also gives them an opportunity to ensure that they get the best possible price in the free market. The implications of the longer term for grain marketing include the risk that outstanding production credit may not necessarily be redeemed after the harvest as it was in the past. This affects the cash flow position of the producer and eventually influences the producer's capital investment abilities. Investment risk management is therefore now more important than ever before.

Strategies for coping with risk have been developed in a number of areas of agricultural decision-making. The development of these strategies in decision theory has opened the door to a more sophisticated treatment of producer decision behaviour under risk and uncertainty. Because of the complicated nature of uncertainty, researchers have chosen to implement only one or two risk strategies in their models at a time. However, at a time when producers are vulnerable to such serious risks as production, price and cost uncertainties, it is imperative to explore further methods of reducing such insecurity. Thus, the time is ripe for a closer examination of risk management instruments available in the marketing of crops. Producers now need to manage both production and price uncertainty.

The objectives of this study are:
- to develop a decision support system that producers can apply to assist them in minimize investment risk;
- to test whether this decision support system is applicable to the management of white maize, yellow maize, sunflower seed, soybeans and wheat; and
- to test whether any size farmer (from big producers to small producers) can apply this decision support system.

In the agricultural sector, risk management in the future will consist of an unlimited array of domestic and off-shore exchange contracts, on- and off-exchange traded derivatives and unconventional risk management instruments.

This study aims to serve South African agriculture by providing greater customisation and matching customer needs with the appropriate instruments. When uncontrollable risks are managed, businesses can focus on areas that provide the greatest return not only to business, but also to society.

1.5 LIMITATIONS OF THE STUDY

The research objectives presented in Section 1.4 must be interpreted within the following limitations of this investigation:

- The principal limitation of this investigation is the lack of available historical data. The South African Futures Exchange agricultural division only started trading in 1996. During the initial period, producers used the market as a guaranteed forward market and not as a price risk management instrument. The model should be tested in times of over- and under-supply.
- Only a few producers used in the investigation were actively using the futures market as a price risk management instrument. Therefore, the better results obtained by the model may be unjustifiable compared to the results obtained by the producers.
- In an investigation of this nature, is it impossible to compare one model (such as the one developed here) with a supposedly superior model. The primary reason for that is there is no such model for South African producers as yet.
- The tax implications of regular trading for any of these marketing instruments were not considered. The tax implications are, however, relevant when the trading rules are compared with a storage or a storage hedge strategy. Since this aspect was not taken into account, it must be considered to be one of the limitations of this investigation.
- Using the model on a crop like soybeans, which are not traded on SAFEX, does not prove that the decision support system provides better results than the individual soybean producer does. The main reason for this is the fact

that South Africa is a net importer of soybeans and that the South African price follows the international price. The prices obtained by producers in South Africa are normally close to the import parity price of soybeans. The pricing alternatives available to soybean producers are limited.

1.6 OUTLINE OF THIS STUDY

In order to accomplish the overall aim as described in Section 1.4, the following approach, which also serves as an outline of the study, is adopted:

- Chapter 2 provides a critical overview of grain production in South Africa. It establishes what the principal crops are and looks at the history of marketing in South Africa. This chapter therefore serves as a theoretical justification for the crops chosen for the application of the decision support system.

- Chapter 3 discusses risk management in agriculture with particular reference to risk management practices in South Africa. The chapter also analyses risk management instruments available to producers to manage investment risk.

- Chapter 4 investigates the history and development of futures markets and futures contracts.

- Chapter 5 discusses the development and application of options on futures contracts as a viable risk management instrument.

- Chapter 6 provides the theoretical description and development of a proposed decision support system to aid producers in managing their production risk. It also describes and empirically justifies the methodologies employed in determining the selection of farms to be simulated in the proposed model.

- Chapter 7 discusses the results of this investigation.

- Chapter 8 presents a summary of the study and identifies areas of further research.

1.7 CONCLUSION

Although the real contribution of agricultural crops to the gross domestic product (GDP) has declined since 1990, grain production remains of strategic importance to South Africa. The strategic importance of the South African grain industry lies in its forward and backward integration with the rest of the economy, the establishment and maintenance of food security, the creation of wealth in rural areas and its contribution to a healthy balance of payments.

South African producers face their most daunting challenge ever: to compete at the international level in a new free-market environment. Several factors will determine the continued viability of grain production in South Africa, including the capacity of producers to adapt to changing circumstances, correct interpretations of international and local market information, the transparency of various role players in the grain industry and successful use of marketing instruments.

Several risk management instruments are available to producers who wish to manage their investment risk. Producers need to understand how to use the various pricing instruments to manage market risks and how to select the most appropriate pricing instrument to accomplish their objectives. Some instruments manage only one of the primary market risks, while others may manage several sources of risk. Knowing how to use the various alternatives involves understanding the mechanics of such aspects as opening a trading account with SAFEX, placing orders with the broker and meeting margin requirements. It also

includes understanding obligations and responsibilities for delivery, and conditions under which contracts can be cancelled or modified.

The subsequent chapters explain the new agricultural environment, the risks it poses and risk management instruments available to producers to manage their investment risks.

CHAPTER 2

GRAIN PRODUCTION IN SOUTH AFRICA

Studying history is pointless unless one learns something from it.

- Anon.

2.1   INTRODUCTION

Variety and uncertainty characterise grain production in South Africa. Much of this variety stems from the uniqueness of each individual farm unit and its products. Location, capital structure, land, planting patterns, production methods, marketing strategies, and producer demography – all combine to make each farm a distinct unit. Given the globalisation of markets and rapidly changing requirements and technology, it is important to think and plan ahead. Peter Drucker (1995) aptly remarked about future predictions:

> 'In human affairs – political, social, economic or business – it is pointless to try and predict the future, let alone to attempt to look ahead 75 years. But it is possible and fruitful to identify major events that have already happened, irrevocably, and that will have predictable effects in the next decade or two.'

Maize, grain sorghum, wheat, barley, oats, rye, soybeans, beans and sunflower seed are the principal crops grown on commercial farms in South Africa. From these possible crops the following have been chosen as the outputs of the farm prototypes used in this study:

- maize,
- soybeans,

- wheat, and
- sunflower seed.

In South Africa many hectares are devoted to the production of these crops, which explains why these crops have been selected for this study. Furthermore, these types of crops have been chosen because, with the exception of soybeans, they were the first crops to be traded on a South African Commodity Exchange. Consequently, there are futures and option trading opportunities and forward contracting opportunities in these commodities. Although soybeans are not traded on SAFEX, they are traded on other world exchanges, for instance, the Chicago Board of Trade. The demand for the crops resulting from their processing and their ultimate consumption is also an important characteristic that distinguishes the production and marketing opportunities of each commercial grain farm. Each type of grain is discussed briefly below in terms of its importance, production quantity and economic implications for the periods before and after the reform process. The history of maize is also discussed, because of the importance of the crop to South African agriculture.

After the deregulation of the agricultural sector and especially the dismantling of the one-channel grain marketing system, it became apparent that structural changes would take place in the market. Marketing strategies changed and the timeous gathering and interpretation of information in order to function optimally became more important. This chapter focuses primarily on the development of the production of principal crops in South Africa, the marketing thereof and the challenges producers face in this new agricultural era.

2.2 SOUTH AFRICAN AGRICULTURE BEFORE THE REFORM PROCESS

The regulation, and eventual deregulation, of agricultural marketing in South Africa has to be viewed in the context of the evolution of South Africa's agricultural sector and the broader policy environment that shaped it.

2.2.1 Principal crops produced in South Africa

2.2.1.1 Maize

Maize became known to Western Civilisation for the first time after the discovery of the New World by Columbus in 1492. The most developed Indian races in the Americas from Southern Canada to Southern Chile grew maize. It was, at that stage, already known in Haiti and Cuba (Van Rensburg, 1995). An indication of the real age of maize may be obtained from fossils of pollen grains unearthed 60 metres below Mexico City. Although these fossils have been estimated to be more or less 80 000 years old, they were found to be nearly identical with the pollen of modern maize in respect of their morphological properties.

After the second voyage of Columbus in 1493, the importation of maize seed to Spain from the West Indies began. Its cultivation spread rapidly to France, Italy, the Balkan States and North Africa, where, initially, maize was grown as a pastime in home gardens (Van Rensburg, 1995). The Portuguese called maize as 'milho'. From the beginning of the 16th century, the Portuguese took maize along in their exploration of the West Coast of Africa and the Far East.

The first written record of maize in South Africa is diary entry by Jan van Riebeeck, who noted in 1655 that a consignment of maize seed had arrived from Holland (Cownie, 1986). Van Riebeeck encouraged his burghers to grow maize.

However, because maize is a summer rainfall crop, it did not thrive in the dry summers of the Cape with its Mediterranean climate. South Africa's 1820 Settlers, did, however, see the value of maize and grew it on their farms in the Eastern Cape. Not long afterwards, the families who took part in the Great Trek of 1838 began to plant maize wherever they went (Cownie, 1986).

The weather and soil conditions in spring and early summer influence the timing of planting strongly. The soil must be dry enough to allow machinery into the fields, yet wet enough to ensure seed germination. Since maize needs a substantial frost-free growing span of 80 to 160 days to mature, planting must be delayed long enough to avoid late spring cold snaps, yet early enough to minimise vulnerability to early autumn frosts. In South Africa, planting starts from September and continues until early December.

As with most crops, the weather during the growing season is one of the main determinants of output. The logistic growth and survival model was determined to be a highly accurate representation of the growth, formation and survival of the maize kernels (Kaufman, 1986). The model is written as

$$Y_i = \frac{a}{1 + brt_i + e_i}$$

Where:
- a, b, and r are non-negative constants and $0 < r < 1$;
- e_i is the disturbance term (error dependent on time t);
- t_i is the independent time variable (time series); and
- y_i is the dependent variable representing growth or survival.
- (i = 1,2,...,n)

According to Kaufman (1986), it can be assumed that the reflection point (y_i) shows a short period in which most of the rapid growth takes place. Large variances in yield can be associated with problems occurring in the point of the growth cycle prior to t_i. An especially critical time during the growing season is from January to middle February when pollination occurs. Hot weather and drought conditions at this stage of growth reduce yields because of impeded kernel set.

Grain production in South Africa fluctuates due to weather conditions and the number of hectares planted. Due to the fact that, in the past, government determined the producer prices, the prices used to vary very little, except for the normal increases. Table 2.1 shows the fluctuation in production and producer prices from 1931 to 1967.

The growth in maize production is mainly due to better farm management practices and an increase in the number of hectares planted. According to the Annual Report of the Mealie Industry Control Board (Union of South Africa, 1940a) the rapid increase in the number of hectares planted was mainly due to the fact that during the recession of the 1930's, producers needed to utilise their land on a more intensive basis than for grazing. Also, the main technical problems of production had been largely overcome and knowledge of maize production had reached the stage where producers found they could successfully grow maize in areas which had previously been regarded as marginal land. These trends continued well into the 1970's.

Table 2.1: Total production of maize and producer prices received from 1931 - 1967 (bags of 90,7 kg each)

Year	Production million bags[1]	Producer price - white maize[2] (Rand)	Producer price - yellow maize (Rand)
1931-35	17.2	R0.75	
1936-40	22.4	0.88	
1941-45	20.3	1.39	
1946-50	26.5	2.14	
1950/51	32.3	2.50	2.50
1951/52	22.4	2.85	2.85
1952/53	37.9	3.00	3.00
1953/54	43.6	3.20	3.20
1954/55	41.7	3.10	3.10
1955/56	41.7	3.00	3.00
1956/57	47.1	2.95	2.95
1957/58	40.7	2.875	2.875
1958/59	43.8	2.825	2.825
1959/60	47.3	2.92	2.92
1960/61	58.2	3.125	3.05
1961/62	66.2	3.075	3.00
1962/63	67.3	2.80	2.75
1963/64	47.1	2.87	2.87
1964/65	49.5	3.00	3.00
1965/66	55.7	3.15	3.15
1966/67	106.2	3.575	3.50

Source: Union of South Africa (1938, 1939, 1940b, 1941b, 1942, 1943, 1944, 1945) & Central Statistical Services (1969:14,64).

When one calculates the compound growth rates on the production and the prices received for white and yellow maize for the period from 1947/48 to 1966/67, it is important to note that the large fluctuation in the compound growth

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[1] The production year runs from September to May.
[2] May-April net prices for best grades

rate of production is mainly due to weather conditions. Figure 2.1 presents the compound growth rates of production volumes and prices received from 1947/48 to 1966/67.

Figure 2.1: Compound growth rates (point-to-point) on production volume and maize prices from 1947/48 to 1966/67
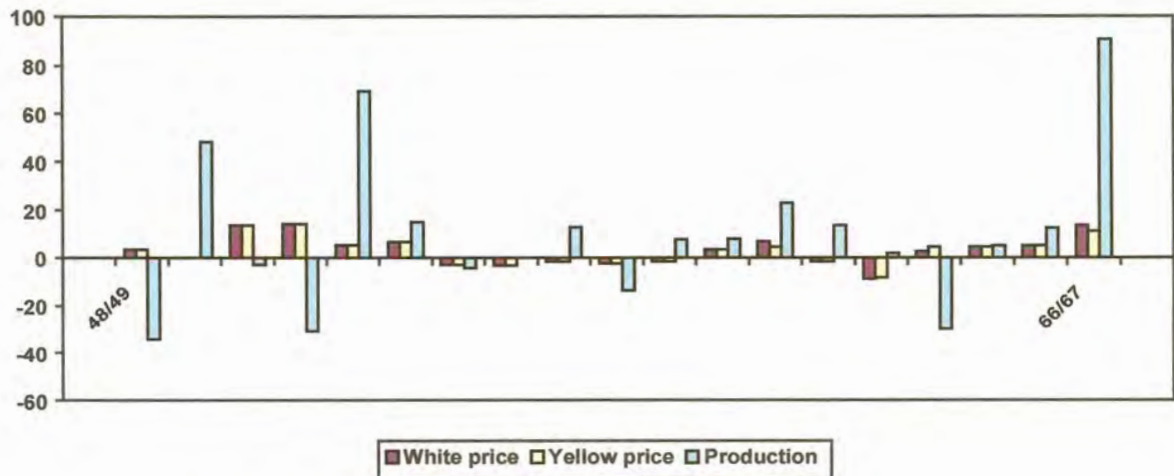
Source: Adapted Central Statistical Services (1969:14,64)

The compound growth rate for prices received shows few changes, possibly indicating that the objectives of the Marketing Act were achieved. Negative growth rates can be associated with periods of over-supply.

Figure 2.2 shows the fluctuation of South Africa's production volumes for the period from 1966/67 to 1996/97, emphasising the sensitivity of maize to weather conditions.

Figure 2.2: Maize production and area planted for the period from 1966/67 to 1996/97
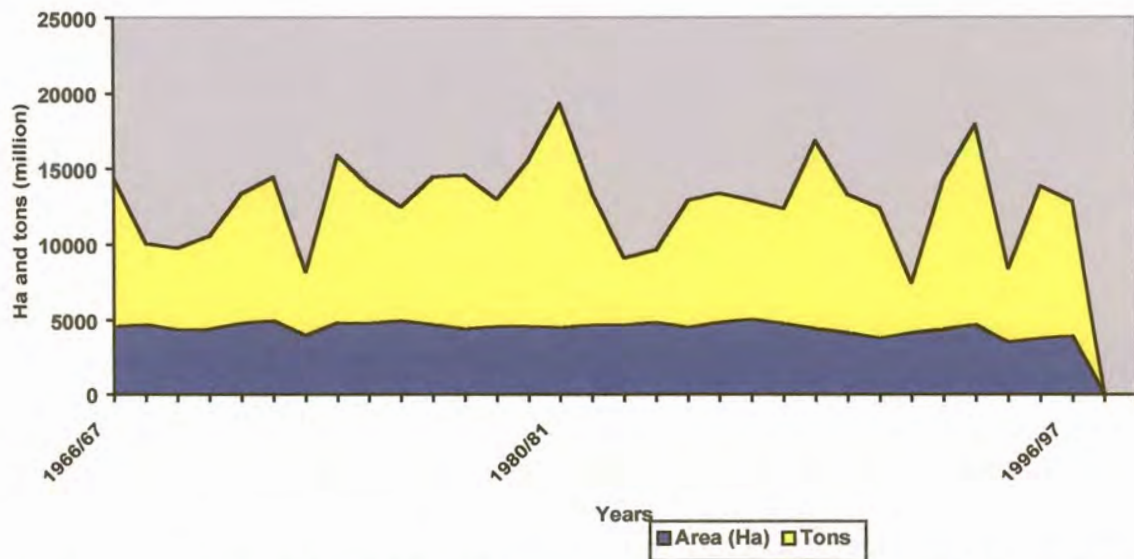
Source: Central Statistical Services (1996a) & Statistiek Suid-Afrika (1998)

Although the area planted fluctuated very little, from the smallest area (3 761 000 Ha in 1995/96 with an average yield of 2.7 tons per hectare) planted, to the largest area planted (5 063 000 Ha in 1986/87 with an average yield of 1.6 tons per hectare), the production volumes fluctuated drastically. The lowest production volume is 3 277 000 tons during the 1991/92 season, resulting in an average yield of 0.7 tons per hectare. This is due to the harsh South African weather conditions, especially during the critical kernel formation period. The marketing system that was used until 1994/95 was a single channel marketing scheme. This marketing system changed for the first time on 1 May 1995 to a surplus removal export pool.

2.2.1.2 Soybeans

The soybean *Glycine max Merill* is an upright annual legume with a wide morphological variety. Plant height varies between 50 cm and 120 cm and the growing period varies between 70 and 180 days (depending on the hybrids used and prevailing weather conditions). Due to the specific photoperiodic (hours of daylight) sensitivity of soybeans and the availability of genetic variation for this trait, it is possible to grow soybeans in a variety of climatological conditions.

Like most cash crops, soybeans thrive in deep, well-drained soil with a high fertility status. In South Africa, the planting of soybeans has mostly been restricted to heavier soils due to a potential nematode risk in lighter sandy soils and the fact that soybeans, compared to maize, performed better on heavy turf soils. Soybeans can be planted in areas with a rainfall in excess of 450 mm, or where special moisture conservation practices or irrigation is applied. Soybean production cannot be considered on soils where atrazine or related herbicides have been applied during the previous season (Smit, 1987). Depending on land management practices and soil types, producers can substitute maize for soybeans and *vice versa*.

Figure 2.3 indicates the fluctuation and overall increase in area planted and production volumes for soybeans for the period from 1970/71 to 1996/97.

Figure 2.3: Soybean production and area planted for the period from 1970/71 to 1996/97
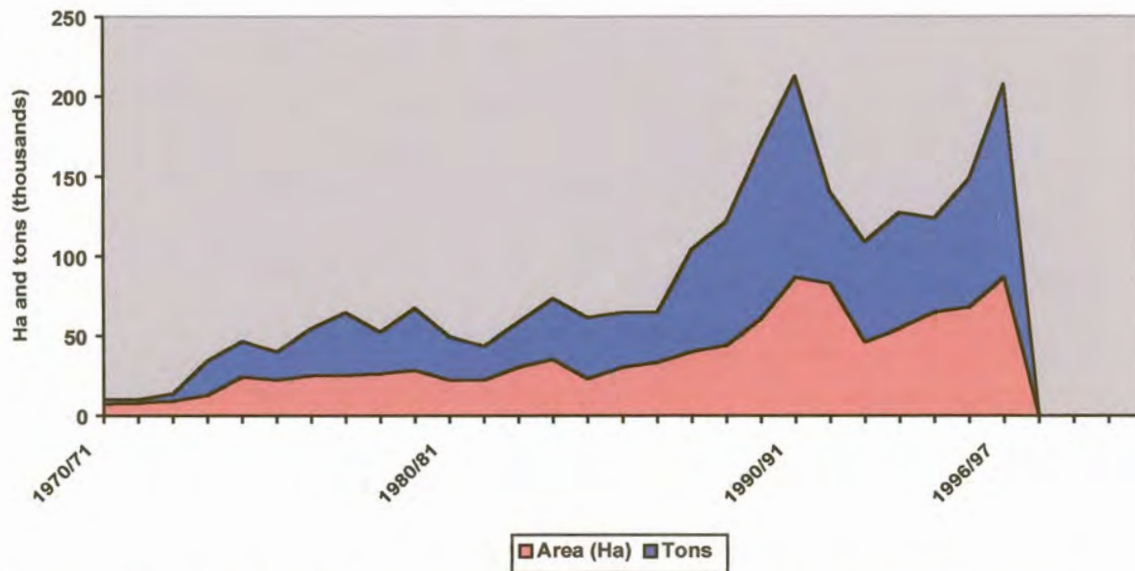
Source: Central Statistical Services (1996a) & Statistiek Suid-Afrika (1998).

The initial increase in volume in the 1980's is due to the fact that more producers were willing to plant soybeans, that hybrid quality and variety had improved, and that a more scientific approach towards the production of soybeans had been adopted. The decline in soybean area planted in the 1991/92 season can probably be attributed to a shortage of irrigation water and more favourable price levels for rival products such as ground nuts and sunflower seed. The sharp increase in area planted after 1995 suggests that producers had realised the potential of soybeans as an alternative crop.

2.2.1.3   Sunflower seed

The sunflower, *helianthus annuus,* is distinguished from other cultivated crops by its single stem and conspicuous, large inflorescence. Sunflowers are very tolerant to different temperatures, with an average growth period of 70 to 114

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days, and perform well in most temperature zones. Sunflowers are a highly cross-pollinated crop. Pollination occurs primarily by insects and only to a limited degree by wind. Sunflowers grow well in soils ranging in texture from sand to clay. They do not require soils as highly fertile as do crops such as maize, wheat or potatoes to produce satisfactory yields.

Figure 2.4 details the area planted and production volume of sunflower seed for the period from 1957/58 to 1996/97

Figure 2.4: Sunflower seed production and area planted for the period from 1957/58 to 1996/97
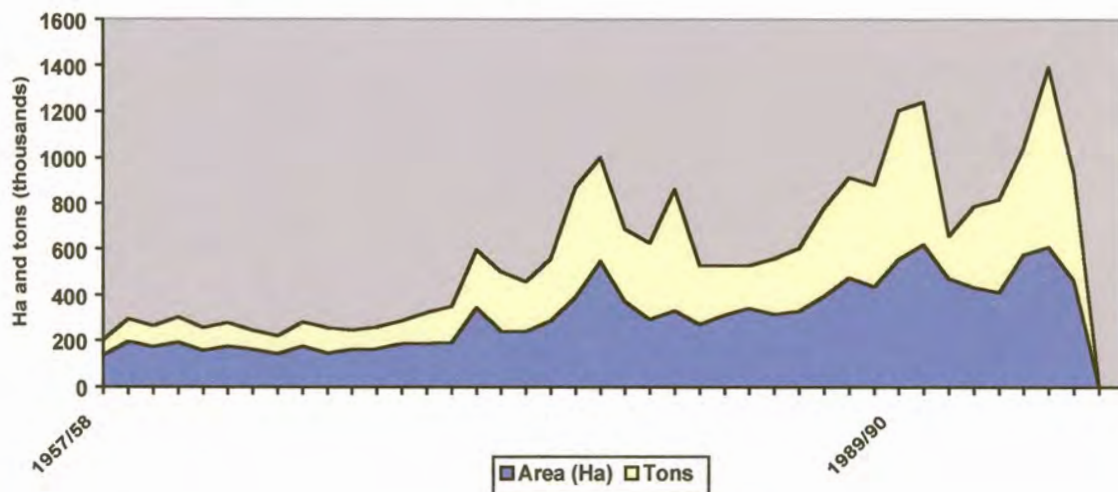
Source: Central Statistical Services (1996a) & Statistiek Suid-Afrika (1998)

The increase in the area planted can be attributed to better management practices, herbicide improvement and greater hybrid variety.

Sunflowers rank second to soybean among annual field crops grown throughout the world for the production of edible oil. Sunflowers are not highly drought-tolerant, but often produce satisfactorily when other crops are seriously damaged. Sunflowers possess several agronomic characteristics which support

an expansion of their production. They are deep-rooted and use soil moisture efficiently, and thus are better adapted to growing in drier regions than most crops. Sunflowers also have one of the shortest growing seasons of all economic crops in the world. This, together with the fact that less tillage is needed for many other crops, makes sunflowers a very good choice for producers.

2.2.1.4   Wheat

The approximately 28 wheat species that are cultivated throughout in the world at present are characterised by their annual life cycle. Ontogenetically, this cycle can be divided into two phases, the vegetative and reproductive phases. The transition from a vegetative to a reproductive growth phase is controlled by specific environmental stimuli. Temperature and day length are probably the most important, and there is evidence that some wheat cultivars have more specific requirements in this regard than others. Winter wheat species require cold for flower initiation, whereas spring wheat is able to form ears without cold. Apart from the fact that a critical day length is necessary for some types of wheat, some plant cultivars are greatly influenced by longer photoperiods; for example, the number of spikelets depends on day length, and longer days increase the rate of spikelet initiation (Department of Agriculture, 1996).

The ideal climate for wheat is a cool, moist season for planting, growing and production, followed by a hot, dry season for harvesting. This type of climate occurs especially in the winter rainfall area, the south-western Cape. Other areas where wheat is grown include the eastern and north-eastern, central and north-western Free State Province, eastern Mpumalanga and the Springbok Flats.

Figure 2.5 indicates the area planted and production volume of wheat for the period from 1960 to 1997.

Figure 2.5:   Wheat production and area planted for the period from 1960 to 1997
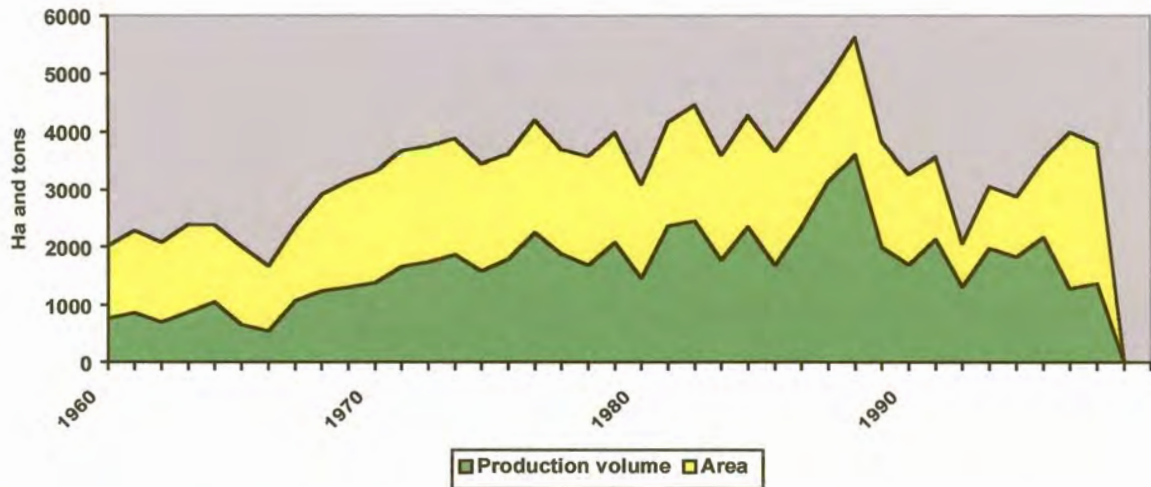
Source: Central Statistical Services (1996a) & Statistiek Suid-Afrika (1998).

The area planted increased slowly from 1967 to 1990, whereafter it slowly began to decrease. The lowest production level was experienced in 1966, with 548 000 tons of wheat produced, resulting in an average yield of 0.5 tons per hectare. The highest production level was during 1988 with 3 620 000 tons of wheat produced, resulting in an average yield of 1.8 tons per hectare.   Wheat production seems less sensitive to weather conditions than maize production, possibly because a large area of wheat is planted in the winter rainfall area.

Until 1995, the Wheat Board was the only buyer of wheat in the Republic of South Africa.   It bought wheat through its agents, who operated throughout the country. In most cases, the agents were ordinary farming co-operatives. Their main functions were to purchase and distribute these cereals (wheat, barley, oats and rye); to fix prices for the cereals and certain cereal products; to

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supervise the maintenance of prices and to rationalise the wheat milling and baking industries.

2.2.2 Crop economics

2.2.2.1 *Contribution of agricultural crops*

Although the real contribution of agricultural crops to the gross domestic product (GDP) has declined since 1990, grain production is still of strategic importance to South Africa. The strategic importance of the South African grain industry lies in its forward and backward integration with the rest of the economy, the establishment and maintenance of food security, the creation of wealth in rural areas and its contribution to a healthy balance of payments. The decline in the contribution of grain crops to the gross value of agriculture is probably due to the huge increase in horticultural produce since the early 1990's (http://www.sbic.co.za, 1999).

The contribution of agriculture to the total economy fluctuates significantly from quarter to quarter. These changes can primarily be attributed to two factors. Firstly, agriculture is dependent on climatic factors such as rainfall and temperature, which determine the yield of the various crops to a large extent. Secondly, most agricultural crops, and especially grain crops, are traditionally harvested and traded during only one or sometimes two quarters of the year. These are the causes of the cyclical nature of agriculture's contribution to the country's economy.

Figure 2.6 reflects the seasonal variation in agriculture's total contribution to the country's economy on a quarterly basis.

Figure 2.6:   Percentage contribution of agriculture to the National GDP at factor cost (1995=100)
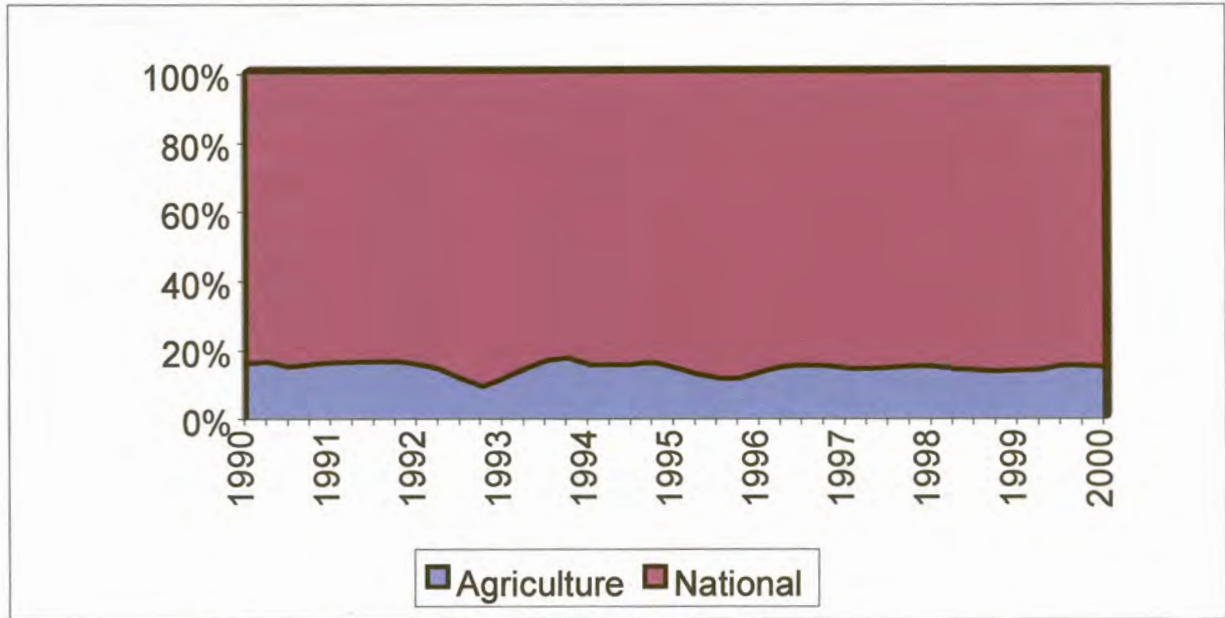
Source: Reserve Bank (1994, 1998, 2000)

Poor agricultural years such as the El Niño years of 1992 and 1995 are evident from the graph, lower peaks in the third quarter (36,4% decline from the previous year) and fourth quarter (51,7% decline from the previous year) of 1992 and a decrease of 26,9% in the third quarter of 1995 and a decrease of 31,3% in the fourth quarter of 1995. Note, however, that since 1996 the agricultural contribution to the national gross domestic product (GDP) of South Africa shows less variation. This phenomenon may be attributed to various reasons, *inter alia* that the production of most grain products has declined since the good harvest of 1996. Furthermore, the deregulation of the marketing boards has resulted in producers' marketing their grain over longer periods than was previously the case in order to meet the continuous demand of processors, and earn income dispersed throughout the year. From this it can be deduced that, since the deregulation of the market, producers have started marketing over a longer period than in the past (less seasonality).

2.2.2.2   *Exchange rate fluctuations and production cost of maize and wheat*

Maize and wheat are severely affected by any cost-price squeeze. Fluctuating climatic conditions, prices and increases in production costs will play an even more decisive role in the competitiveness of maize and wheat producers in future. Fluctuations in the value of the Rand have a direct impact on input costs. The effect will, however, differ from one region to the next, since both input costs and the composition of input costs differ from one region to the next.

Tables 2.2 and 2.3 illustrate that if the domestic prices of maize and wheat remain the same and the effective exchange rate ($/R) declines, the competitive positions of South African maize and wheat products weaken. Within a liberalised agricultural environment, there is no guarantee that product prices will change to such an extent that this can counteract the effect of fluctuations in the exchange rate.

Table 2.2: Effect of fluctuation in the value of the Rand on the production cost of maize in various regions

Region	% Change in value of Rand			
	-10%	-20%	-30%	-40%
North West	3.21	6.43	9.64	12.86
Northern Province	3.23	6.45	9.68	12.91
Mpumalanga	3.20	6.41	9.61	12.81
Gauteng	3.25	6.51	9.76	13.02
KwaZulu-Natal	3.08	6.16	9.24	12.41
Eastern Free State	3.35	6.7	10.06	13.41
North-west Free State	3.47	6.94	10.42	13.89
Average	3.25	6.51	9.77	13.03

Source: http://www.sbic.co.za (1999)

Table 2.3: Effect of fluctuations in the value of the Rand on the production cost of wheat in various regions

Region	% Change in value of the Rand			
	-10%	-20%	-30%	-40%
Central Eastern Free State	3.59	7.17	10.76	14.35
Eastern Free State - Cape	3.45	6.89	10.34	13.78
Free State	3.31	6.62	9.93	13.24
Western Cape	3.33	6.66	9.99	13.32
Western Free State	3.88	7.77	11.65	15.53
Average	3.51	7.02	10.53	14.04

Source: http://www.sbic.co.za (1999)

If the value of the Rand declines in relation to the US dollar, the cost of the import of maize and wheat increases proportionally. This increase is equal to the depreciation of the Rand, which in a deregulated market exerts upward pressure

on domestic prices. Tables 2.2 and 2.3 also show that a depreciation of 10% in the Rand to the US dollar results in an increase of 3,25% and 3,51% respectively in the average production cost of maize and wheat. In this case, maize in the north-western Free State and wheat in the western Free State show the highest increases in terms of production costs.

Foreign exchange rates play an important role in production costs. With the deregulation of marketing, it is essential that producers take full cognisance of the influence of the Rand on product prices as well as on production costs. Producers should also note that these influences are not the same in both cases.

A mere six countries (the USA, China, Brazil, Mexico, France, Argentina) produce 75% of the world's maize supply. The USA alone produces 39% of the total (http://www.iastate.edu, 1999). Due to the USA's market share in the world's production, the USA is regarded as the world price leader. The US yellow maize price therefore serves as a barometer of international maize prices. When the relation between the US yellow maize price and variables such as production, consumption and closing maize stocks is examined, one finds that yellow maize world prices are determined mainly by the level of closing stocks of yellow maize in the USA (http://www.sbic.co.za, 1999). If the stock levels in the USA and the world are high, the price of yellow maize declines and *vice versa*. Production and consumption have an indirect effect on this price, in that production and consumption determine stock levels.

In a deregulated market environment and against the background of international trade liberalisation, the prices of grain in the local market are influenced to a large extent by international prices and the Rand-dollar exchange rate. It is clear that local producers will in future have to pay attention to production, consumption and closing stocks of grains on the world market, because these factors eventually determine the prices that producers receive in South Africa.

2.2.2.3   Growth rate comparisons

The volatility in the price of grain or the amount of price risk exposure can be analysed using the standard deviation and the coefficient of variation. The standard deviation is a measure of the dispersion of data around the average or mean. The coefficient of variation is the standard deviation expressed as a percentage of the mean (Brigham, Gapenski & Daves, 1999). Thus, it is possible to compare the dispersion of two or more sets of data that are expressed in different units. That is, it would be difficult to compare the amount of volatility in the maize and soybean markets using just the standard deviations of each, because soybean prices are higher than maize prices and thus one would expect the standard deviation for soybeans to be greater than for maize. Using the coefficient of variation (a percentage measure) allows for the comparison of volatility or risk between the two markets even though the two sets of data are not identical. Table 2.4 indicates the standard deviations and coefficient of variation of the point-to-point price growth rates of maize, wheat, sunflower seed, and soybeans for the period from 1970/71 to 1994/95.

Table 2.4: Standard deviation and coefficient of variation of price growth rates for the period from 1970/71 to 1994/95

	White maize	Yellow maize	Wheat	Sunflower Seed	Soybeans
Average growth rate	12.6%	12.9%	10.8%	11.4%	11.2%
Standard deviation	15.2	15.0	11.4	8.2	7.4
Coefficient of variation	1.2	1.2	1.1	0.7	0.7

Based on the standard deviations, the volatility of the yearly price growth rates of white and yellow maize range between -2.6% and 27.8% around the mean 68% of the time. Based on the standard deviations, the risk associated with maize price growth rates is more than double the risk associated with soybean price growth rates. If one compares the coefficient of variation, the risk associated with maize and wheat is more than the risk associated with sunflower seed and soybeans (the higher the coefficient of variation, the higher the risk).

2.2.2.4   *Correlation between the crops*

The degree to which prices and yields are related is usually measured by the correlation coefficient. Correlation is a statistic that measures the relationship between the movement in prices, or yields or area planted, of one crop and that of another. The prices, yields or area planted of crops can be either

- positively correlated, if the series moves in the same direction;
- negatively correlated, if the series moves in opposite directions; or
- uncorrelated, if there is no relationship between the movement of one crop and another.

A correlation coefficient of -1.0 means that if yield turns out to be lower than expected, prices will always be higher than expected. Conversely, a correlation coefficient of nil means that if yields are greater than expected, then there is a 50% chance that prices will be higher than expected and a 50% chance that prices will be lower than expected. That is, there is no relationship between yields and prices (Ferris, 1998). As long as commodities are not perfectly positively correlated, diversification between the crops can reduce the risk (either the price or the yield risk).

A strongly negative yield-price relationship is beneficial to producers because it tends to lower their income risk. Prices that are higher than expected tend to offset yields that are lower than expected, and prices lower than expected are typically offset by high yields. A strongly negative relationship between prices and yields is also important because it makes forward sales a risky proposition. Suppose, for example, that a producer forward contracts 100% of the expected production and then suffers a yield shortfall. Not only will the producer have to buy grain to meet contractual commitments, but he/she can be almost certain that the grain he/she has to buy is expensive. Table 2.5 indicates the different correlation coefficients of the various crops for the period from 1970/71 to 1994/95.

Table 2.5: **Correlation coefficients of price, yield and areas planted of various crops for the period from 1970/71 to 1994/95**

Correlation coefficient	White Maize	Yellow maize	Wheat	Sunflower seed	Soybeans
Price : yield	-0.556	-0.556	0.127	0.4710	0.683
Yield : area planted	0.071[1]	0.071	0.246	0.763	0.867
Price : area planted (same year)	-0.147	-0.132	-0.830	0.727	0.841
Price : area planted (previous year price)	-0.483	-0.455	-0.821	0.727	0.653

[1] Yield represents the total production quantity of maize

It is clear from Table 2.5 that forward pricing for maize is risky, due to the relatively strong negative price-yield correlation. However, the risk associated with forward pricing for soybeans is more strongly positive. The yield-area planted correlation indicates the sensitivity of the crops to climate. It is clear that maize is very sensitive to weather conditions, whereas sunflowers and soybeans are less sensitive. Diversification between maize, wheat, sunflower seed and

soybeans is then a possibility producers can use to manage their price and yield risks.

By drawing the correlation matrixes of production volumes and price, one can determine whether these crops can be used to manage risk. Tables 2.6 and 2.7 represent the correlation matrix of production and price for the period from 1970/71 to 1994/95.

Table 2.6:   Production correlation matrix for maize, wheat, sunflower seed and soybeans for the period from 1970/71 to 1994/95

	Maize	Wheat	Sunflower seed	Soybeans
Maize	x	0.014	0.396	0.114
Wheat	0.014	x	0.176	0.263
Sunflower	0.396	0.176	x	0.733
Soybean	0.114	0.263	0.733	x

From Table 2.6 it is clear that wheat and soybeans can be used as a possible strategy to diversify a farm that plants mainly maize. The production correlation between sunflower seed and soybeans indicates that there is a strong possibility of a good sunflower and soybean yield in the same year.

Table 2.7: Price correlation matrix for white and yellow maize, wheat, sunflower seed and soybeans.

	White maize	Yellow maize	Wheat	Sunflower Seed	Soybeans
White maize	x	0.992	0.968	0.971	0.969
Yellow maize	0.992	x	0.962	0.966	0.961
Wheat	0.968	0.962	x	0.972	0.983
Sunflower seed	0.971	0.966	0.972	x	0.986
Soybean	0.969	0.961	0.983	0.986	x

It would not help to use different crops to manage price risk because there is a strong price correlation between all the crops. This was mainly due to the fact that all the prices before 1995 were controlled by the various marketing boards. With the reform process came the dismantling of the marketing boards, resulting in price risk. It is therefore necessary to investigate different marketing instruments available to producers to manage their marketing risk. In Chapter 3, Chapter 4 and Chapter 5, the different marketing instruments available to producers are discussed.

2.3.1 THE REFORM PROCESS

2.3.2 The Marketing Act

By the early 1860's, agricultural production in the area that is today South Africa was sufficient to meet the consumption requirements of its population. Farming in much of the interior could be characterised as subsistence-based. Commercially-oriented agricultural production was largely limited to the coastal

areas. The main exception was wool farming, which extended into the country's southern interior. Wheat, fruit, butter, beef and maize were produced for internal consumption, whilst wool, wine, hides and ostrich feathers were produced for export.

The discovery of diamonds and gold in the interior in 1867 and 1886 respectively led to a dramatic change in the economic landscape. The level of urban settlement grew rapidly, the demand for agricultural commodities expanded, and prices rose accordingly. Although there was a supply response, local production had to be supplemented by imports that were transported by the growing rail network. By 1899, South Africa was importing large quantities of wheat, maize, meat, eggs, milk and butter (Van Rensburg, 1995).

From 1910 until the early 1920's, the average annual production of maize in the Union of South Africa amounted to approximately 12 000 000 bags (the bag size was 200 lb or 90.7kg). During this period, the production of grain was adjusted to the demand while export surpluses were small and posed no serious problem for the industry. During the 1920's the maize producers generally received relatively high prices for maize products. Since 1924 the production of maize showed a steady increase, but without a corresponding increase in the demand. As a result, one third of the marketable crop had to be sold on overseas markets. A great spirit of optimism reigned, not only on the agricultural front, but throughout the whole economy. Despite the good crops during the 1927/28 and 1928/29 seasons and the good crop expected for the 1929/30 season, the average domestic price in 1929 for grade two maize ex silo was, for instance, a satisfactory R12,90/t (15/1d a bag) (Nampo, 1993).

From 1929 onwards, the prices of agricultural products began to fall dramatically. Not only in the Union of South Africa and the USA, but throughout the whole world, maize prices dropped. For instance, the price of maize in the United

Kingdom fell from R16,64/t in 1929 to R10,80/t in 1930. The domestic average producer price for 1930/31 reached the low figure of R7,44/t or 10/2d a bag (Nampo, 1993). World prices for maize receded to such low levels that the position of maize producers in the Union of South Africa became desperate. In an endeavour to alleviate the situation, the Mealie Control Act No 39 of 1931 was passed in Parliament. Subsequent to this Act, the state sought to influence the marketing of maize and other agricultural products indirectly. The new Act marked the advent of a new policy of direct state intervention in the marketing of maize, with the specific object of artificially raising local producers' prices above the depressed world levels that prevailed after 1931. The purpose was to ensure a higher average return to the maize grower in the Union.

When, under conditions of free marketing, an export surplus of maize was produced in the Union, the internal demand-supply relationship was overshadowed by the world relationship of supply and demand, because, if export were to be allowed, it would be the function of market forces to establish an internal price level that would be equal to the net realisation on the world market (that is, to export parity price). Export parity would become the basic price-determining factor and local prices would fluctuate only in conformity with the movement of world prices. When the Mealie Control Act sought to establish a producers' price on the internal market higher than export parity, conditions had to be created under which maize would be relatively more scarce for the consumer in the Union than overseas (Union of South Africa, 1938-1939, 1940b, 1941b, 1942-1946). This Act compelled local purchasers to buy and export a portion of the exportable surpluses.

In 1935 the Mealie Industry Control Board was established under the Mealie Control Act to act as an advisory body. In 1937 the Marketing Act No 26 of 1937 was placed on the Statute Books, and soon schemes under this Act took the place of the Mealie Control Act of 1931. The position of maize producers had

not changed materially in the intervening years and controlling producer prices were still low.

The legal framework of controlled marketing in South Africa is already set out in the Marketing Act of 1937. The main objectives of the Marketing Act of 1941 were:

- to promote stability in the prices of agricultural products;
- to narrow the gap between the producer price and the consumer price by means of rationalisation; and
- to increase the productive efficiency of farming.

The 1941 Act with its subsequent amendments was replaced in 1968 by the Marketing Act of 1968 (Act 59 of 1968). The intention of the 1941 and 1968 acts was to increase the productivity of the farming industry and the efficiency of allied marketing, processing and distributive industries to the general benefit of the producing and consuming communities. To achieve these objectives, the Marketing Act of 1968 provided for marketing schemes specifically tailored to the needs of the various products. These schemes cover domestic and export marketing arrangements, market promotion and all aspects of marketing research.

The Marketing Act of 1968 provides for five main types of marketing schemes. These include (World Bank, 1994):

- Single-channel fixed price schemes – producers were legally obliged to market their products through the board or its appointed agents, and prices were fixed for each season. Major domestic crops such as maize, winter grains (wheat, barley and oats), industrial milk and cream fell into this category.

- Single-channel pool schemes – producers marketed their products through a pool conducted by the various agricultural boards who paid advance payments upon receipt of the product. Deferred payments were made when the final realisation of the pool, after deduction of pool expenses, was known. Crops facing a relatively elastic demand, for example, export crops such as oilseeds, leaf tobacco, chicory, buckwheat, lucerne seed, deciduous fruit, citrus, rooibos tea, wool and mohair fell into this category.

- Surplus-removal schemes – producers sold their produce on an open market. The relevant board intervened when prices dropped below a fixed minimum price by purchasing surplus for distribution and resale at a later date. Crops such as grain sorghum, dry beans, potatoes, slaughtered stock and dairy produce fell into this category.

- Supervisory schemes – the relevant board acted in a supervisory capacity and as a mediator in arranging price and purchase contracts between producers and buyers. Producers could only sell to firms at a price in accordance with the grade of the product. Products included canning fruit and cotton.

- Sales promotion schemes – this was confined to karakul pelts. The scheme for karakul pelts was aimed at enabling the board to promote the sales of pelts locally and abroad by means of publicity.

Based on Rand values, until the early 1980's, about 80% of agricultural production was marketed in terms of the schemes mentioned above. Of the remaining 20%, about one half fell under other legislation, for example, quotas, and the other half was uncontrolled and consisted mainly of fresh vegetables.

Under the Marketing Act, the following control measures were enforced (RSA, 1970):

- For maize, the Republic was divided into three areas, namely Areas A and B and the exempted area. In Area A, the Maize Board was the sole buyer of maize; in Area B, producers could sell maize only to registered traders, such as co-operatives, who bought for their own account. In the exempted area, producers were at liberty to sell their maize to any person at the best prices obtainable in that area.

- For winter cereals, such as wheat, barley, oats and rye, the Wheat Control Board undertook marketing. The Board was the sole buyer and seller of these cereals, which were produced in or imported to the Republic.

- In respect of oilseeds, a scheme for regulating the marketing of groundnuts, sunflower seed, and soybeans under the Marketing Act was published in March 1968 (to include the marketing of soybeans) to replace the Oilseeds Control Scheme that had been in operation since July 1961.

With the 1968 Act, came certain limitations. The production area of maize comprised the then Transvaal and Orange Free State provinces and the magisterial districts of Bellville, Dannhauser, Dundee, Escourt, Glencoe, Gordonia, Hartswater, Hay, Herbert, Hopetown, Kenhardt, Kimberley, Kliprivier, Newcastle, Paulpietersburg, Phillipstown, Prieska, Utrecht, Vryburg, Vryheid and Warrenton. Producers in the production area were prohibited from selling their maize to anyone other than the Maize Board. Since the bulk of South African maize is produced in the production area, the Maize Board had virtually full control over the producer price and disposal of all maize marketed in the country. Under the Act the Winter Cereal Scheme prohibited any trading in winter cereals (that is wheat, barley, and oats) except through or with the permission of the

Wheat Board. The Oil Seed Board determined the producer prices of oil seeds and marketed these oilseeds. Although the boards marketed the crop on behalf of the producers, all price negotiations were taken away from the producers.

2.3.2   Historical perspectives on grain marketing in South Africa

2.3.2.1   The period from 1937 to the 1980's

According to De Swardt (1983), the period from 1929 to 1936 represented a watershed in South African agriculture and marked the end of pioneer farming and the beginning of commercial farming. This can be seen clearly in the production of and areas planted with maize, wheat, sunflowers and soybeans, as discussed in Section 2.2.1.

According to Frankel (1988) the Marketing Act of 1968 created a more stable market environment. It also allowed technological and economic development, created opportunities to develop infrastructure and structures whereby certain earlier shortcomings in the marketplace could be addressed. Some areas that changed were storage, refrigeration, processing, transportation, export, market information and trading systems and facilities. In general, the aim of the marketing system was to raise domestic producer and consumer prices to levels comparative to those on world markets.

2.3.2.2   The 1980's

The 1980's were characterised by declining profitability in agriculture in general and a weakening in primary producers' terms of trade. The Co-ordinating Committee of Agricultural Marketing Boards (RSA, 1987) estimates the nominal

protection coefficient for yellow maize at between 1.2 and 2.8 during the period from 1986 to 1987. The resulting rise in production was overshadowed by the welfare losses for consumers.

Maize is produced primarily for the domestic market. White maize is an important staple diet in South Africa, and is not generally available for export to elsewhere in the world. Before 1987, the producer price was frequently set above export parity, generating exportable surpluses that had to be sold at a loss.

The marketing system was reformed in early May 1987. From 1932 until 1986, the Minister of Agriculture had set the producer prices of maize. The new marketing arrangements meant that the Maize Board was itself responsible for determining maize prices (Maize Board, 1988). In practice, pre-planting maize prices were made known to the producer. Three basic processes could be distinguished in determining prices for a specific marketing season (Maize Board, 1988):

- **Price scenario** referred to a price indication based on current market conditions made known to maize producers before planting time. The most important market factors influencing the processes of price determination included the crop size, international market conditions, exchange rates, domestic demand, marketing costs, operational financing and government aid, if any.
- **Delivery price** was determined on the same basis as the price scenario, based on current market conditions that applied in March and April (the end of every marketing year). The delivery price was paid over to producers upon delivery of maize to agents of the Maize Board during the following marketing season.

- **The final price** was the result of the actual course taken by the market factors during a marketing season. Surpluses were paid out as a supplementary payment to producers.

A unitary pricing system was still followed, but the Maize Board no longer had the power to carry over surpluses or losses arising from exports. The Board could not use loans to finance a particular marketing year. From 1987, the producer price was essentially operated as a pooled price based on actual performance.

A policy document of the South African Agricultural Union (SAAU) (1988), stated: 'Various reasons, including inadequate exposure to direct marketing forces, have contributed to some of the problems experienced in agriculture.' To reverse this trend, the SAAU proposed the following: 'Agriculture and producers will in future (have to) be exposed even more fully to market forces as modified and supported by the implementation of mechanisms available in terms of the Marketing Act and other relevant agricultural legislation.'

2.3.2.3   The 1990's

With the widening of the price gap between the Maize Board's buying and selling prices, the single-channel marketing system came under pressure. As it stood, the system provided an incentive to use maize on-farm as a feedstock rather than to sell it to the Board and to incur the levies. Likewise, the price gap provided an incentive for those who used large amounts of yellow maize as feedstock to invest in maize production[3].

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[3] It is reported that the largest commercial producer of maize is the leading poultry producer.

On 25 June 1992, the Minister of Agriculture appointed the Committee of Inquiry into the Marketing Act (CIMA) under the chairmanship of Professor WE Kassier, to 'conduct an in depth inquiry into and to report to the Minister of Agriculture on the marketing of agricultural products under the abbreviated heading "Marketing Act 59 of 1968, quo vadis?"' (RSA, 1992).

The first question that the Committee needed to answer was whether the Marketing Act had achieved the goals that were originally set. According to Groenewalt (1992), the answer was that it did not. The goal of efficient production had not been achieved, as productivity indices showed only a slight increase over the preceding three decades. The stabilisation of producer prices had been achieved in some industries, but this had not been accompanied by income stabilisation. Fair and equal access to as many producers as possible was thwarted by discriminatory legislation with a bias in favour of large-scale farming. The promotion of demand and consumption had not been achieved either.

In the executive summary of the CIMA report (RSA, 1992), the following findings were noted:

- CIMA argued that the Marketing Act had not achieved its intended goals and objectives.

- Different types of statutory levies could be imposed on controlled and uncontrolled products under the Marketing Act. The Committee was of the opinion that a case could possibly be made for the imposition of a statutory levy on all products to finance research and to generate information. The Committee was, however, not in favour of statutory levies to finance the SAAU and its affiliates.

- The Committee believed that the responsibility for quantitative import/export controls and the imposition of tariffs should rest with an independent statutory body acting in consultation with the responsible Minister(s).

- The Marketing Act had merit, provided that some of the powers that vested in the Act were not devolved to such an extent that vested interests may dominate society's welfare. To this end it would seem sensible to retain the Act as well as a national marketing body, albeit with a different composition.

To implement its findings, the Committee recommended (RSA, 1992):

- that mechanisms be established to ensure a legitimate and transparent process of reform;

- that transitional arrangements be made to correct some major flaws in the current system; and

- that policies and structures within which new role players can operate should be put in place.

As a result of the investigation and recommendations by the Committee, a new maize marketing scheme that replaced the fixed one-channel grain marketing scheme became operative on 1 May 1995. The basic characteristics of the new maize marketing system implied that in future the Maize Board (as well as the Wheat and Oilseeds Boards) would no longer operate actively on the domestic market, other than as buyers to remove surpluses on a pooled basis. Formerly controlled markets were deregulated. At the end of 1996, the Marketing of Agricultural Products Act (Act No 47 of 1996) was passed, providing for certain limited interventions such as registration and information collection.

The 1968 Act and the 1996 Act were designed to be enabling. As such they both implied the deregulation of statutory power from Parliament to the Minister to take certain decisions with the force of law, without further input from Parliament. They specified a process, including advice from a statutory council, through which all ministerial decisions should go, and specified the type and extent of market interventions that would be allowed. The Agricultural Products Act is based on the view that state intervention in agricultural markets should be the exception rather than the rule. During 1996 the functions of the Maize Board were terminated. Producers are now responsible for the marketing of their own maize. The 1996/97 season was also the last season when the price of wheat was fixed.

By early 1998, all control boards dealing with maize, sorghum, oilseeds, wool, meat, wheat, cotton, mohair, lucerne, citrus, deciduous fruit, dried fruit, milk and canned fruit had ceased to operate (except for residual legal and technical functions). Price controls were removed and single-channel markets disappeared with the abolition of control boards.

As the marketing arrangements for various commodities become less regulated, there is a danger that the potential benefits of deregulation may be counteracted by market concentrations that were nurtured by the control board system. The government will have to monitor the impact of market concentration on the efficient performance of deregulated agricultural markets. Where problems are identified, the government will have the option of utilising competition legislation operating in terms of the Department of Trade and Industry, or taking sector-specific initiatives.

The implementation of the 1996 Act has resulted in several developments:

- The representatives of commercial farmers have lost their most important vehicle for influencing net producer prices. Producer representatives have been forced to seek out new ways of affecting prices.

- The termination of levies for the funding of the SAAU's activities, together with the establishment of trusts for the receipt of control board assets, has shifted the balance of power between the SAAU and its commodity affiliates. The affiliates are now in a better position than the SAAU to argue for the allocation of trust monies to fund their activities.

- Since South Africa became a signatory to the World Trade Organisation's Agreement on Agriculture, the parameters within which South African agricultural commodity prices are set have been influenced more and more by world prices, exchange rates and the level of import protection. As the powers of control boards decreased, so the representatives of farmers and processors have increasingly tried to prevail upon government to use the tariff regime to protect them.

2.4 AFTER THE REFORM PROCESS

Different commodities have been deregulated at different times and at different rates. As a result, the impact of deregulation has been become clearer for some commodities than for others. Furthermore, deregulation has taken place in conjunction with a broader series of reforms to the agricultural sector and the wider economy. It is therefore difficult to isolate the effect of domestic market deregulation from other developments, such as the relaxation of exchange controls, international trade liberalisation, movements in world prices, and

fluctuating production conditions. One must therefore exercise caution when one tries to draw conclusions on the impact of market deregulation *per se*. Nevertheless, the response to reforms to date by farmers and the private sector has been impressive. Some of the most important developments across the broad spectrum of agriculture can be summarised as follows (Baily, 1999):

- A large number of organisations have emerged to compete with Outspan and Unifruco in the exportation of citrus and deciduous fruit.

- There has been an acceleration in the establishment of new enterprises in the food and agricultural sector.

- The real value of South Africa's agricultural trade, exports in particular, has grown significantly.

- Real retail food prices have not increased since 1992, in spite of the Rand's depreciation in real terms against the US dollar between 1994 and 1998.

- There has been a shift in production patterns in response to changes in the relative risks and prices with which producers are confronted.

- Real land prices continued to fall in the mid 1990's.

It is important that government ensures that the response of the agricultural sector and related industries to deregulation is monitored and evaluated on an ongoing basis. This will make it easier for government to assess properly whether further initiatives are necessary to improve the efficiency of South Africa's deregulated markets. Furthermore, it will make an objective evaluation of the likely costs and benefits of any future statutory interventions much easier.

The following lessons can be drawn from the South African experience since the mid-1990's:

- In order to achieve the best results possible based on the liberalisation of domestic and international agricultural markets, a stable macro-economic environment and a basic level of infrastructure (transport, storage and communications) must be in place.

- In particular, where there is the potential for the price of a commodity to swing between export and import parity-related prices, it is crucial that producers, processors and traders should have access to as wide a range of price risk management mechanisms as possible.

- The success of the reform process so far, and the fact that it has operated relatively smoothly to date, is due to the fact that there was strong political backing for the reform process. Furthermore, by the 1990's most of the South African control boards worked extensively through their agents. Most did not own the marketing infrastructure, or handle, store, process, or finance agricultural production or marketing activities themselves. As a result, the closure of the control board system did not create a significant vacuum in the marketing chain.

A crucial aspect of the existing business and investment environment in the agricultural sector relates to the consistency and predictability of government decision-making around agricultural marketing. The government has been clear in its view regarding the division of responsibilities between government and the private sector.

The deregulation of South Africa's agricultural marketing and trade, particularly in the context of a shift towards the freer trade of agricultural commodities within

the South African Developing Countries (SADC) region means that there may be greater opportunities for countries such as Zimbabwe and Zambia to expand their agricultural exports to South Africa. Furthermore, they could benefit from access to South Africa's sophisticated price risk management mechanisms. However, such benefits are, to a significant extent, dependent on there being a domestic policy environment in these countries conducive to such trade, and a move away from *ad hoc* market interventions and restrictions over exports.

South Africa's deregulation has already had an impact on other members of the Southern African Customs Union (SACU) (Botswana, Lesotho, Namibia and Swaziland). Since independence, policy in these countries has been designed to encourage agricultural self-sufficiency (particularly in respect of staple grains) by means of the inflation of producer prices. Notwithstanding their membership of a customs union, the main policy instrument has been restrictive issuing of import permits for agricultural commodities. In spite of their self-sufficiency policies, all four members of SACU are, to a greater or lesser extent, structural net importers of maize, wheat and most other agricultural commodities, mainly via South Africa.

The implementation of restrictions on agricultural imports from South Africa was facilitated by the existence of the South African control boards. For example, the Maize Board would only issue export permits for maize destined for SACU countries if the applicant could produce a corresponding import permit from the government of the destination country. This is not to say that informal trade did not take place. However, it is clear that South Africa's deregulation of its controlled marketing system has made it much more difficult for SACU member countries to implement import restrictions which have welfare benefit implications for the majority of their citizens.

2.4.1 Producer prices

The biggest change in the agricultural market in future can be expected in producer price levels. Producers now have to establish their own selling prices, whereas previously the various agricultural boards had performed this task. There was no price volatility. Since the reform process, the level of volatility has changed dramatically. Figures 2.7 and 2.8 indicate how the volatility of maize prices has changed since the period before the reform process and thereafter.

Figure 2.7:   Prices before the reform process
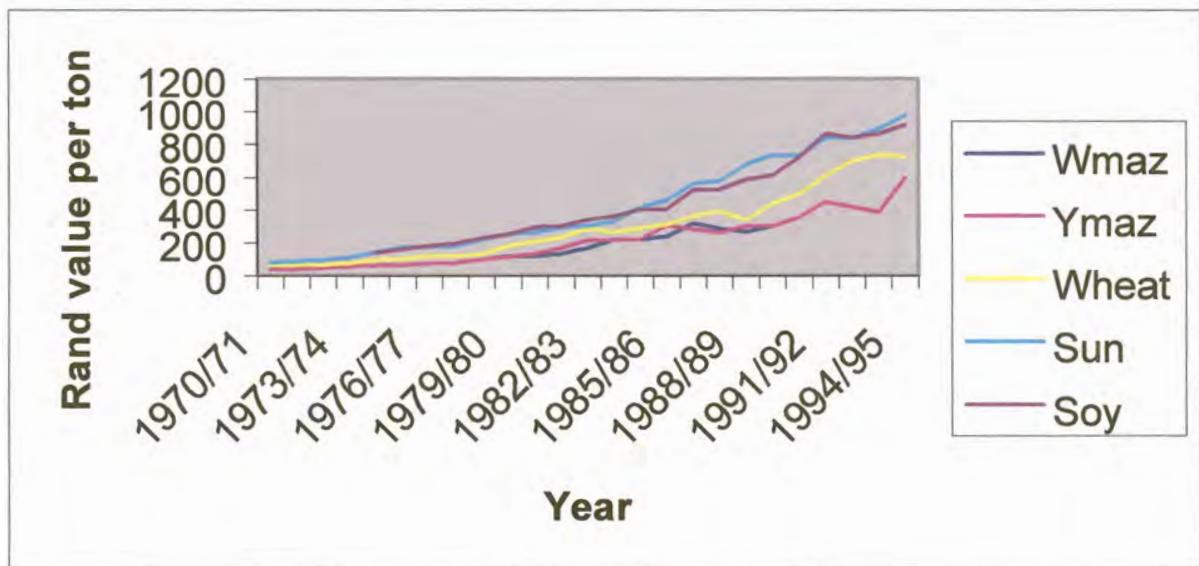
Source: Central Statistical Services (1996:7,10,18,20)

This figure clearly indicates that there was a steady rise in prices received for these commodities from 1970/71 to 1995/96. A very important aspect is that the prices were fixed throughout the marketing year and that the producers and processors knew exactly what the price of a commodity would be for the rest of the marketing season. Although the prices changed yearly, the prices were constant throughout a given marketing season.

Figure 2.8: Closing prices of white and yellow maize (July contract) from 26 February 1996 to 12 April 2000
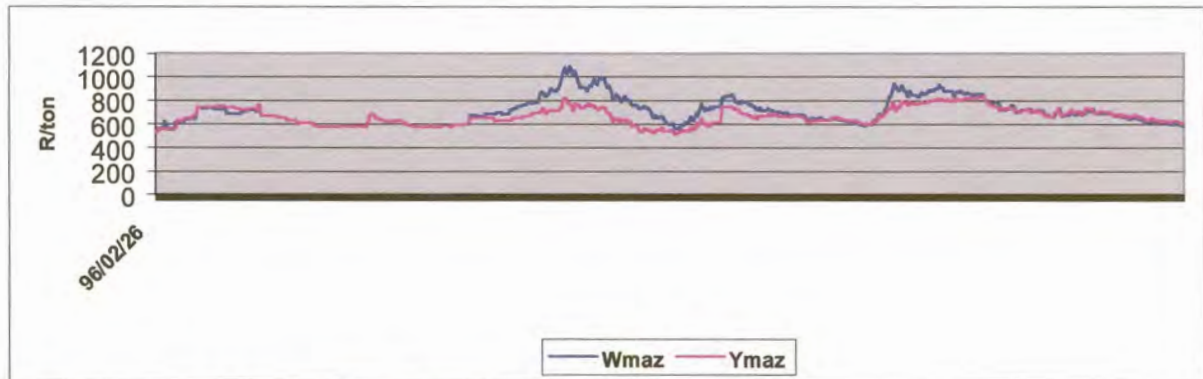
Source: SAFEX (1999, 2000)

It is clear from the figure that white and yellow maize experienced frequent price movements, resulting in high price variability. The higher the price changes, the greater the price risk for both producer and processor. The producer now has to use basic fundamental analysis, supported by basic technical analysis, to try to determine the general price movement. The same variability occurs with other agricultural commodities. Figure 2.9 indicates the daily price movements of white maize and yellow maize.

Figure 2.9: Daily price movement of white and yellow maize (July contract) for the period from 26 February 1996 to 12 April 2000
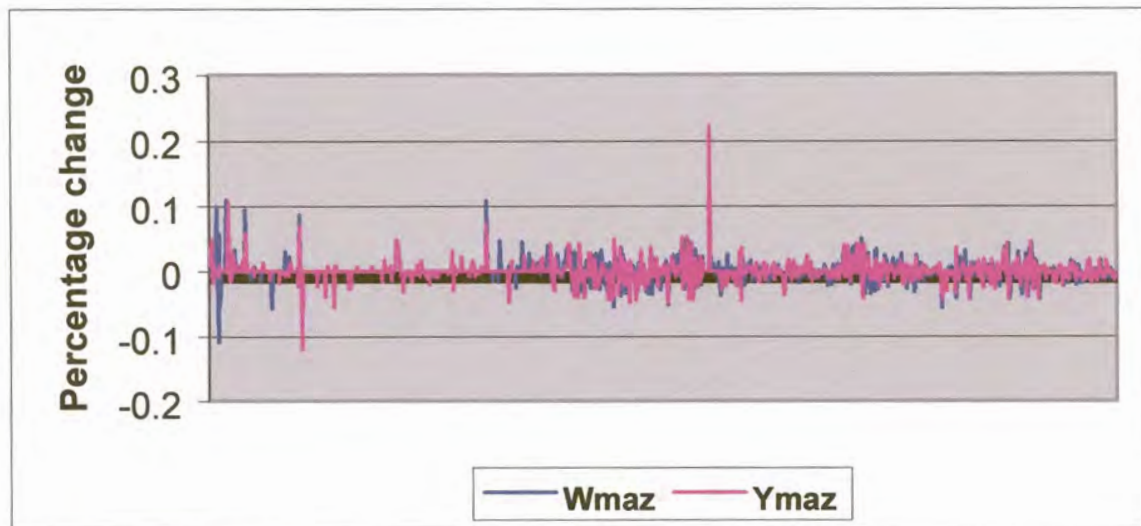
Source: SAFEX (2000)

It is clear from the figure that both white maize and yellow maize experienced a nearly daily price movement, resulting in high price variability. The same nearly daily price movement was present with sunflower seed prices and wheat prices. Soybeans tended to be less sensitive to price movements. The primary reason for this is that soybeans are not traded on a futures market, but are traded locally. Heavy price movements for soybeans only occur near the end of the marketing season, when there are normally low stock levels.

2.4.2 Production patterns

Producers have started to adjust their planting patterns. These changes are a response to changes in the relative risks (production risk and price risk) and relative prices with which producers are confronted. Figure 2.10 and Table 2.8 show how the areas planted with different crops have changed, compared to the early 1990's.

Figure 2.10: Average commercial area (Ha) planted to different crops in the
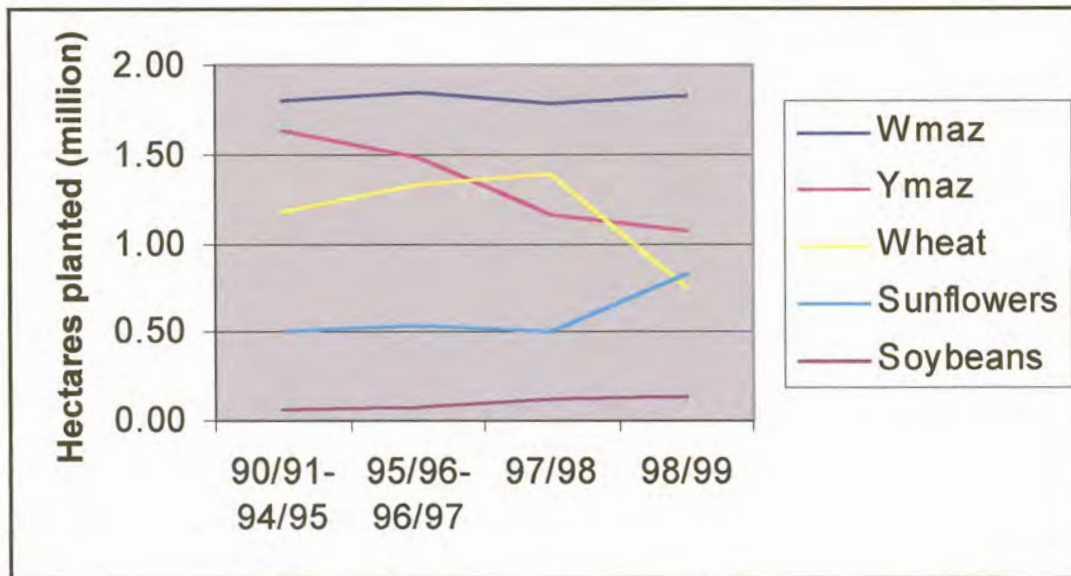
1990's

Source: Central Statistical Services (1996) & National Crop Estimating Committee (NCEC) (1999a, 1999b)

With the dismantling of the system of guaranteed markets and guaranteed seasonal prices and the reduction of import protection, it is to be expected that there will be changes in cropping patterns. There has been a shift to oilseeds (sunflower seed and soybeans) from maize and wheat in the northern production areas and from wheat to canola and grazing in the Western Cape. This shift can be partly attributed to the fact that there are no longer guaranteed seasonal prices and to the opening of export opportunities for higher value commodities. The first indication of changing cropping patterns can be found in the maize industry. Although the total area planted with maize has decreased in the last few years, this change was mainly in terms of area planted with yellow maize. As is shown in Figure 2.10, producers have planted more white maize relative to yellow maize since 1996, whereas there was previously only a small difference in the areas planted. That was because of the small difference between the net prices received for white and yellow maize. Data show that the process of

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market deregulation has shifted producer and trader sentiment in favour of white maize.

Table 2.8: Average commercial area (Ha) planted/intention to plant for winter crops in selected areas

Crop	Average area 90/91 – 94/95	Average area 95/96 – 96/97	Average area 97/98	Average area 98/99	Intention to plant 99/00
Wheat (W/ Cape)	362 572	401 900	400 000	300 000	280 500
Wheat (Free State)	664 643	760 500	790 000	350 000	243 000
Wheat (national)	1 174 000	1 328 475	1 382 300	748 000	613 500
Canola	–	–	13 000	17 000	21 200
Lupins	–	–	1 889	16 300	25 000

Source: Central Statistical Services (1996) & National Crop Estimating Committee (NCEC) (1999a, 1999b).

The Western Cape first experienced an increase in the area planted with wheat from 1990/91 to 1994/95 and in the 1995/96 to 1996/97 seasons. In the next marketing season, the area planted with wheat stayed nearly constant, followed by a sharp decline in the 1999/00 season for both the Western Cape and the Free State Province. From Table 2.8 it is clear that producers have moved away from wheat to substitute crops, especially lupins.

Table 2.9 indicates the correlation coefficient of area planted before the 1995 marketing season and thereafter.

Table 2.9: Correlation matrix of area (Ha) planted before and after the reform process

	Maize		Wheat		Sunflower		Soybeans	
	Before	After	Before	After	Before	After	Before	After
Maize	x	x	0.45	0.51	-0.72	-0.51	-0.55	-1.00
Wheat	0.45	0.51	x	x	-0.51	-1.00	-0.55	-0.51
Sunflower	-0.72	-0.51	-0.51	-1.00	x	x	0.83	0.52
Soybeans	-0.55	-1.00	-0.55	-0.52	0.83	0.52	x	x

There is a strong negative correlation between maize and soybeans and between wheat and sunflower seed. This is an indication that more producers have discovered all the positive effects of soybean production above those of maize (*cf.* Figure 2.10). This correlation matrix confirms the shift in the planting patterns of producers after the 1995 marketing season. Producers now realise that the previously 'safe' crops are not that 'safe' any longer.

2.4.3 Balance of trade

It is foolish to read too much into year to year changes in South Africa's trade statistics, due to rainfall variations and world price movements (as in 1996). Nevertheless, Table 2.10 demonstrates that even in years affected by drought, as was the case in 1992 and 1995, South Africa is a net exporter of agricultural commodities.

Table 2.10: Free-on-board values of agricultural imports and exports (1990 to 1998)

Year	Agricultural exports (%) of total exports	Agricultural imports (%) of total imports
1990	8.6	4.9
1991	8.9	5.5
1992	7.8	8.5
1993	6.8	6.4
1994	8.8	6.1
1995	7.9	6.9
1996	9.2	6.7
1997	8.5	6.6
1998	N/A	N/A
Annual rate of change in agriculture	%	%
1990-1998	12.9	21.7
1994-1998	15.3	21.1
1997-1998	5.3	11.7

Source: RSA (1999)

The liberalisation of agricultural trade, taken together with a gradual move away from exchange controls, has not, to date, had a negative impact on South Africa's balance of agricultural trade and has not had a destabilising impact at the macro-economic level.

2.5 A NEW AGRICULTURAL WORLD ORDER

The General Agreement on Tariffs and Trade (GATT) has been the principal instrument regulating world trade in the period since World War II. One of the objectives of GATT has been to liberalise world trade by reducing or removing both tariff and non-tariff barriers. For this purpose, GATT has organised several rounds of trade negotiations. The last in this series of trade negotiations was the Uruguay Round which was launched in Punta del Este, a city in Uruguay, in September 1986.

One of the most important ways in which the Uruguay Round of Trade Negotiations was different from all previous rounds was that, whereas the previous rounds had been primarily geared to reducing barriers to trade transactions imposed at the border, the Uruguay Round sought to regulate economic activities inside the sovereign territory of GATT member states. Thus the Uruguay Round went beyond trans-border trade and intruded into the sovereign economic space of the negotiating partners. This was achieved by bringing within the scope of the negotiations trade in services, the regulation of investment measures and the inclusion of provisions for higher levels of protection for intellectual property rights.

During the Uruguay Round, most of the non-tariff barriers to trade were eliminated and replaced with tariff equivalents. In South Africa the greater openness to imports could lead to lower floor prices over the short term as tariffs are reduced over time and subsidised international producers are able to access the South African market. This could also lead to a decline in total agricultural production, due to the negative effect of imports. Government should consider carefully the impact that different tariff levels may have on key agricultural products and the effect on total production that contributes to the overall availability of food in South Africa (http//www.sbic.co.za, 1999).

The agricultural trade agreement was designed to achieve more open and fair trading in agricultural commodities by reducing export subsidies, tariffs and non-tariff barriers and domestic support structures. The agreement did result in a significant reform of the rules for agricultural trade, with some of the most important changes being tariffication (the conversion of non-tariff barriers to bound tariffs), the binding of all tariffs (commitments to the maximum tariff that can be applied at the border), bans on new export subsidies, and bindings on existing export subsidies (Ingco, 1995). The agreement has established a long-term trend toward much freer markets, including agricultural markets, around the world.

2.6 CONCLUSION

Over the years, there has been much direct and indirect intervention in the agricultural sector in the Republic of South Africa. The situation and mode of thinking in the 1930's, namely that a small body of responsible and well-informed individuals could perform better than a market consisting of a large number of poorly organised and financially weak producers with conflicting interests, has given way to a view that a more liberated economy with more exposure to market forces is needed.

An analysis of the Marketing Act of 1968 shows that it makes allowance for an extraordinarily wide spectrum of activities with extensive powers vested in boards and the Minister. However, over the years, the functioning of the schemes and the respective control boards which were instituted under the umbrella of the Act revolved mostly around only a few of the provisions of the Act. This involved the imposition of levies and special levies, surplus removal schemes, single-channel schemes and the manipulation of prices. Quantitative

import and export control was maintained via Section 87 of the Act. Apart from these rather stringent provisions, most of the boards have been engaged in various deregulation exercises in the last few years. The boards are no longer involved. The only import 'control' that still exists is that when the price of maize in America decreases below a certain level, the Government can institute an import levy to protect South African prices to a certain extent.

In the past, with annual prices fixed by the boards, the procurement and marketing of grain in South Africa was relatively simple. There was no competition between suppliers and buyers on the basis of price, as the boards bought from every seller and also sold to every buyer at a fixed price. The domestic market was also insulated against the volatility of international prices and the supply and demand factors that influenced these prices.

Theory suggests that one of the basic building blocks of a free market is 'perfect information'. This implies that adequate, standardised, up-to-date and reliable information is available to all role players in the market and that all role players must have equal access to this information. 'Perfect information' also implies that agricultural role players must be able to make meaningful deductions about the market from the information available in order to ensure strategic, sustainable growth and involvement in agriculture over the long term.

During the 1990's things have changed dramatically for South African producers. The boards were dismantled and producers are now responsible for their own marketing. In response to these changes, the Agricultural Futures and Options market has become active. In the following chapters, the origin of futures markets world-wide as well as in South Africa is discussed, as well as risk management strategies available to producers to manage their business risk better.

CHAPTER 3

FARM RISK MANAGEMENT

He is no wise man that will quit a certainty for an uncertainty.

Samuel Johnson (1709 – 1784)

3.1   INTRODUCTION

Elements of risk pervade every phase of economic activity. Most economic decisions are made on the basis of imperfect knowledge about the future, because individual decision-makers are not aware of the complete set of alternative actions available to them or all the possible outcomes associated with each action. This is especially true for the decisions faced by grain producers. The natural and economic environments within which these producers operate interact to complicate decision-making. Weather, insects and weeds make planting, fertiliser, herbicide and insecticide decisions extremely difficult and cause yields to fluctuate enormously. The competitive environment within which producers operate subjects them to wide fluctuations in price.

As little as a decade ago, South African agriculture was characterised by subsidies and other concessions, which supported producers, not only in difficult times, but also in prosperous times. During the 1990's the last agricultural control boards were abolished and the agricultural sector was deregulated. Both the playing field and the rules of the crop marketing game in the South African agricultural sector changed in a short space of time. Therefore, South African producers had to reposition themselves to adapt to these changes. To be a successful producer, a producer needs to look at a deliberate, considered and

knowledgeable approach to risk management as a vital part of the planning process.

Risk management involves choosing between alternatives to reduce the effects of the various types of risk. It typically requires an evaluation of trade-offs between changes in risk, changes in expected returns, and entrepreneurial freedom, as well as other variables. This chapter highlights the types of risks faced by producers in the agricultural environment in South Africa and focuses on different risk management strategies (excluding those available through the South African Futures Exchange) available to producers.

3.2 FARM RISK

3.2.1 Quantifying risk

The defined goals of financial management are generally seen as surviving, avoiding financial distress and bankruptcy, beating the competition, maximising sales or market share, minimising costs and maintaining a steady growth in profits. Ross *et al.* (1996) simply define the goal of financial management as maximising shareholders' wealth, in other words, maximising the wealth of the owners of the business. For crop producers, this can be defined as the maximisation of sustainable net worth (assets minus liabilities). For crop producers to succeed in today's economic climate and global markets, they should plan their farms so that they maximise their net worth over a sustained period within the prevailing market and economic conditions. All the financial alternatives must be carefully weighed and the most profitable alternative must be selected.

Risk refers to a situation where the outcome is unknown, but the probability of alternative outcomes is known. Risk affects an individual's welfare, and is often

associated with adversity and loss (Bodie & Merton, 1998). Risk is uncertainty that 'matters' and may involve the probability of losing money, possible harm to human health, repercussions that affect resources (irrigation, credit), and other types of events that affect a person's welfare. By contrast, uncertainty is a situation where the probabilities of different outcomes are unknown. Uncertainty is necessary for risk to occur, but uncertainty needs not lead to a risky situation. A common example of uncertainty is the price changes in agricultural markets. A producer has no real basis for assigning a probability to the occurrence of any price at some point in the future. Price outcomes are uncertain and influenced by conditions in world markets, government policy, monopolies, politics and other factors. The degree of uncertainty surrounding the event determines the extent of risk. In many cases, the distinction between a risky situation and an uncertain situation is blurred. This phenomenon is represented in Figure 3.1 as a continuum.

Figure 3.1: Risk and uncertainty as a continuum of possible situations

Certainty	Risk & uncertainty	Uncertainty
Probabilities known	Some knowledge of probabilities	Probabilities unknown
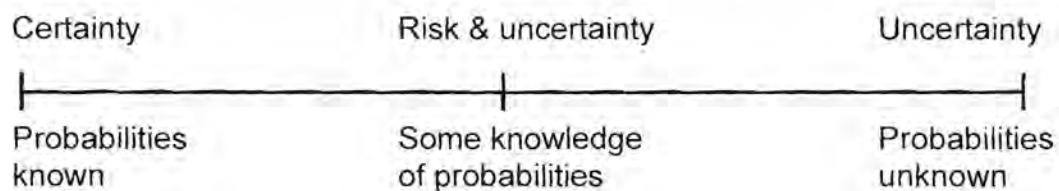
Risk is presented on the continuum by the middle area where some information is known about the probability of certain outcomes.

For an individual producer, risk management involves finding the preferred combination of activities with uncertain outcomes and varying levels of expected return. One might say that risk management involves choosing between alternatives to reduce the effects of investment risk on a farm, and in so doing, to affect the farm's welfare position. Some risk management strategies (such as

diversification) reduce risk within the farm's operation, others (such as production contracting) transfer risk to beyond the farm, and still others (such as maintaining liquid assets) build the farm's capacity to bear risk. Risk management typically requires the evaluation of trade-offs between changes in risk, expected returns, entrepreneurial freedom, and other variables.

3.2.2 Types of risk

Some risks are unique to agriculture, such as the risk of adverse weather, which can significantly reduce production levels within a given year. Other risks, such as the price or institutional risk discussed below, are common to all businesses, and, for producers, they reflect an added economic cost. If the producer's cost-benefit trade-off favours minimisation, then the crop producer can attempt to lower the possibility of adverse effects. These risks include the following (Hardaker, Huirine & Anderson, 1997; Boehlje & Trede, 1977; Baquet, Hambleton & Jose, 1997; Fleischer, 1990):

- **Yield risk** occurs because agriculture is affected by many uncontrollable events. These events are often related to weather, including excessive or insufficient rainfall, extreme temperatures, hail, insect plagues and diseases. Technology plays a key role in reducing production risk in farming. The rapid introduction of new crop varieties and production techniques offers the potential for improved efficiency, but may at times yield poor results, particularly in the short term. On the other hand, there is always the threat of the obsolescence of certain practices (for example, if one uses machinery for which parts became unavailable), which creates another, and different, kind of risk.

- **Price risk** refers to risks associated with changes in the price of outputs or inputs that may occur after production has begun. In agriculture, production

is generally a lengthy process. Livestock production, for example, typically requires ongoing investments in feed and equipment that may not produce returns for several months or years. Because markets are generally complex and involve both domestic and international considerations, producer returns may be dramatically affected by events in far-off regions of the world.

- **Institutional risk** results from changes in policies and regulations that affect agriculture. This type of risk generally manifests itself as unanticipated production constraints or price changes for inputs or for outputs. For example, changes in government legislation regarding the use of pesticides (for crops) or drugs (for livestock) may alter the cost of production, or a foreign country's decision to limit imports of a certain crop may reduce that crop's price. Other institutional risks may arise from changes in policies affecting restrictions in conservation practices or land use, or changes in income tax policy or credit policy. The dismantling of the control boards in South Africa serves as an example of how institutional risk can alter marketing policies and influence the producers' responsibility in farm management.

- Producers are also subject to the **personal risks** that are common to all businesses. Disruptive changes may result from events such as death, divorce, injury, or the poor health of a principal on the farm. In addition, the changing objectives of individuals involved in the farming business may have significant effects on the long-term performance of the operation.

- **Exchange rate risk** is the danger of an unexpected change in the exchange rate between the dollar and the Rand, thus affecting the import and export parity prices of South African commodities. As the Rand weakens against the dollar, import parity prices increase and *vice versa*. A weaker Rand therefore implies a higher local price for commodities. The South African

market is strongly influenced by the exchange rate and this makes it difficult to manage all the risks faced by producers.

- **Financial risk** differs from the risks previously described in that it results from the way the farm's capital is obtained and financed. A producer may be subject to fluctuations in interest rates on borrowed capital, or face cash flow difficulties if there are insufficient funds to repay creditors. The use of borrowed funds means that a portion of the returns from the farm must be allocated to meeting debt payments. Even when the farm is financed fully by the owner, the owner's capital is still exposed to the probability of any lowering of equity or net worth. Financial risk has three basic components:
  - the cost and availability of debt capital;
  - the ability to meet cash flow needs in a timely manner; and
  - the ability to maintain and increase equity.

Of the three basic components, the ability to meet cash flow needs in a timely manner is especially important because of a variety of ongoing farm obligations, such as cash input costs, cash lease payments, tax payments, debt repayment and family living expenses.

Production, marketing and financial risks on most farms are interrelated. The ability to repay debt obligations depends on production levels and prices received for the products. Financing the production and storage of commodities depends on borrowing ability if a producer is using a production loan. Therefore, all three types of risk must be considered together. Producers differ greatly in terms of their willingness to take financial risks and their ability to survive unfavourable outcomes.

The basic tool for identifying and measuring a producer's exposure to financial risk is the risk-return profile. The risk-return profile is a graph showing the

relationship between changes in the price and changes in the value of a farm (Ross *et al.*, 1996). This is illustrated in Figure 3.2.

Figure 3.2:   **Risk profile**

Change in Rand value

Risk-return profile

Change in commodity price
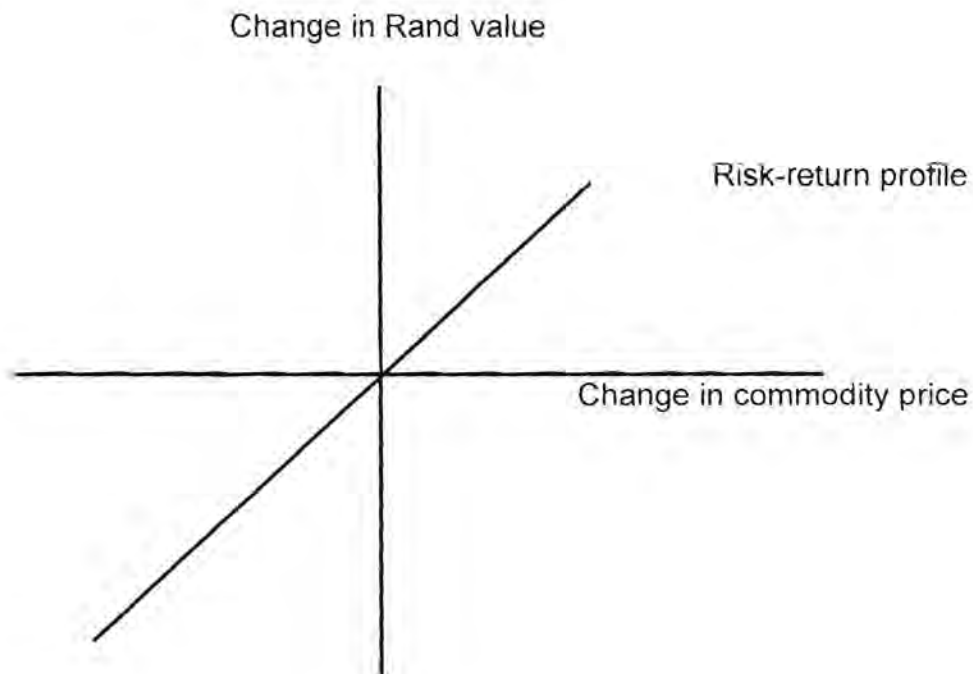
From Figure 3.2, the following two conclusions can be reached.

- Increases in commodity prices increase the value of the farm (upward sloping line). Due to the slope (influenced by the sensitivity of the crop price to price changes), the exposure to price fluctuations increases and a producer may wish to take steps to reduce that exposure.

- Risk management optimises rather than maximises returns. In *The Wall Street Journal* of 26 April 1994, Tim Ferguson described risk management as a principle 'to spread risk and reward so that uncertainty does not inhibit commerce'. In both financial and agricultural businesses, risk management strategies are often utilised in the expectation of outperforming the market.

It is important to specify a generally acceptable level of risk. The three basic risk preference behaviours are depicted in Figure 3.3.

Figure 3.3: **Crop producer risk preferences**
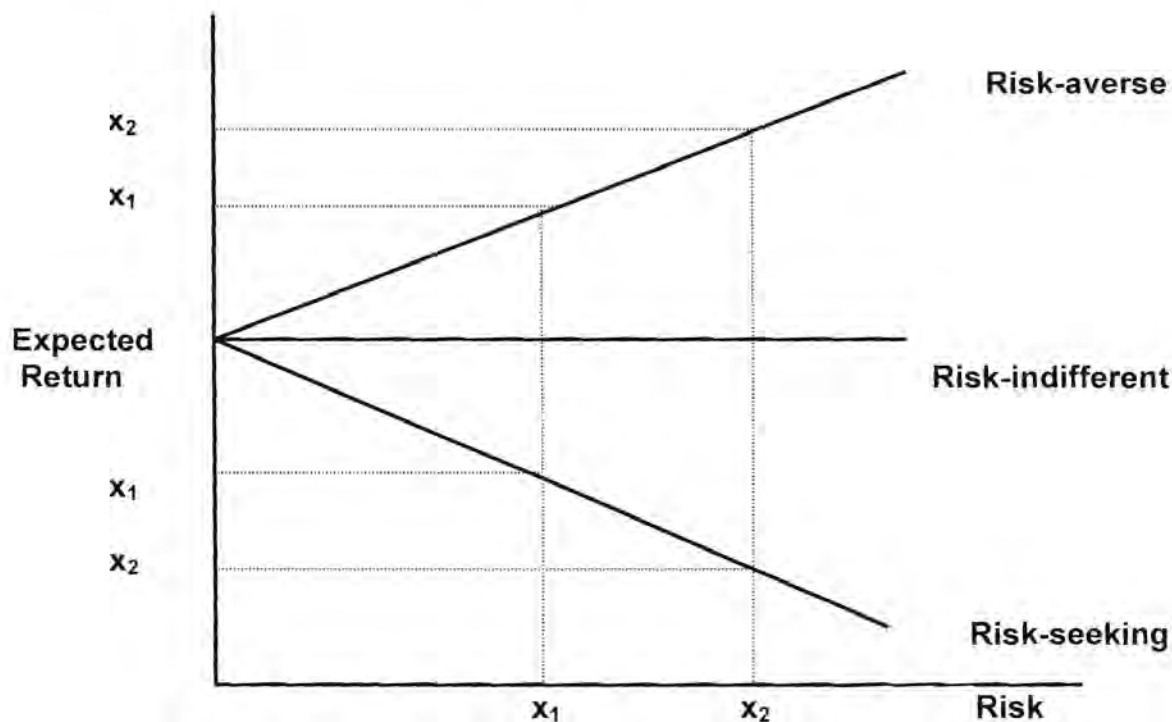
As risk goes from x_1 to x_2, the expected return for a risk-indifferent producer does not change. A risk-seeking producer has an attitude towards risk which means he/she will accept a decreased return for increased risk. In the case of a risk-averse producer, the expected return must increase for an increase in risk. The risk disposition of each producer can be measured and producers tend to accept only those risks with which they feel comfortable. In this study, risk-averse producers are assumed to be producers who generally tend to be conservative

rather than aggressive when accepting risk. This implies that such producers require a higher return (from x_1 to x_2) as the risk increases from x_1 to x_2.

3.2.3 Risk management strategies

Producers face several alternatives when they want to minimise risk. Where the risk situation prevails and probabilities for economic loss can be determined, insurance may be available. If the risk situation involves only subjective estimates of probabilities, financial management strategies (the use of risk-adjusted interest rates) should be considered. As indicated above, uncertainty describes those situations in which there is no certainty of the probabilities of certain outcomes. In such cases, decision-makers cannot buy insurance to guarantee an outcome or compensate for a loss if the situation has various opportunities but is fraught with problems of uncertainty. Other strategies must be pursued in order to manage variables in uncertain situations effectively. An important aspect that could increase farm risk is a change in market prices and/or the marketing environment in which producers operate. Changes in market prices result in price risk. Crop producers can divide their marketing activities into three broad time frames to manage price risk effectively. These are:

- pre-harvest;
- harvest; and
- post-harvest.

Due to production risks, it is rarely an informed decision to price 100% of the expected production before harvest. Instead, it is advantageous to consider various pricing strategies that can be used for a portion of the crop(s). In Sections 3.2.3.1 to 3.2.3.8, different strategies available to producers are

discussed. The roles of futures contracts and option contracts are extensively discussed in Chapters 4 and 5.

3.2.3.1 Forward contracts

A forward contract is an agreement between a producer and a buyer to deliver a given amount of a commodity in exchange for payment at a later date (Helmberger & Chavas, 1996). A properly written forward contract is a legal obligation enforceable in court requiring delivery of a commodity of specific quantity and quality to a given location during a predetermined time period. Since crop production is subject to uncertainty, producers are rarely advised to sell forward contracts on their entire expected crop. The characteristics of forward contracts, in contrast with those of standardised futures contracts, reflects the needs and characteristics of both sellers and buyers. In Figure 3.4, the payoff from selling a forward contract is superimposed on the original risk-return profile of a crop producer (cf. Figure 3.2).

Figure 3.4:   **Forward contract payoff profile**

Change in Rand value

Risk-return profile

Change in price

Forward contract
pay-off profile
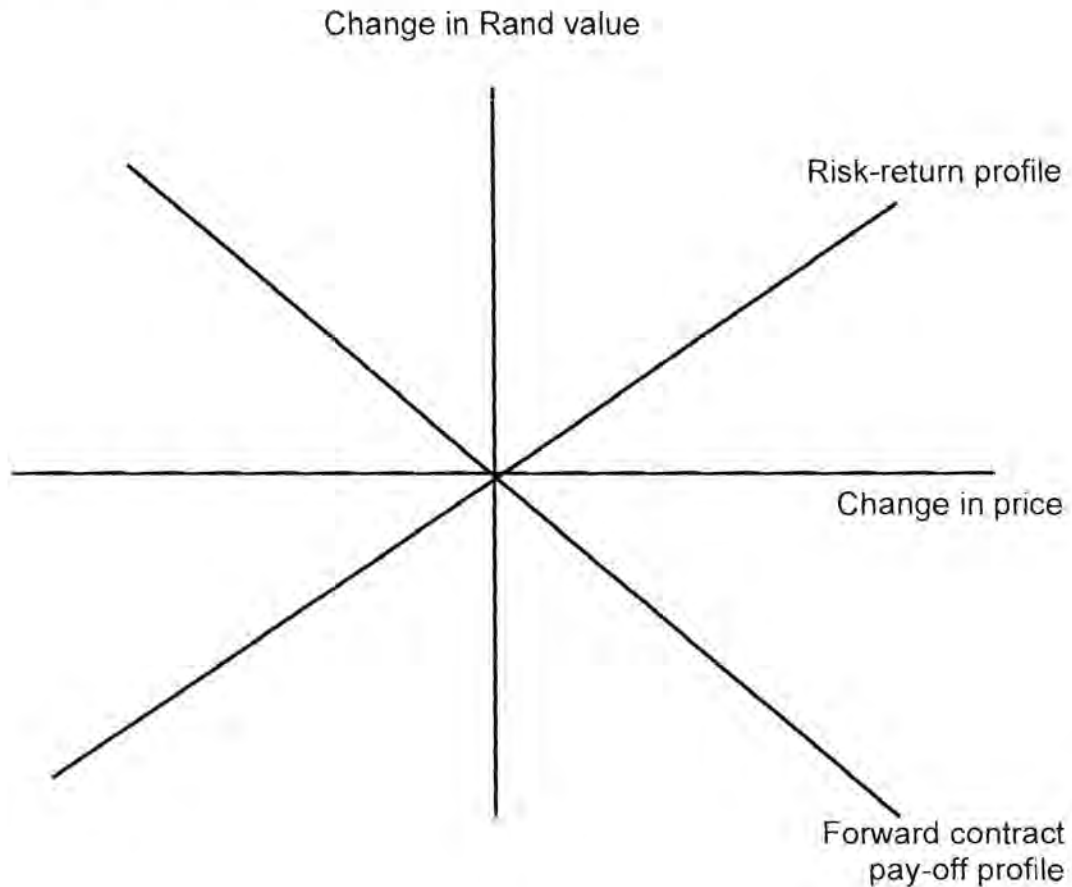
If the actual price of the crop is higher than the expected price, the producer (seller) loses because less than the market price is received, leading to a decline in the value to the producer. However, this decline in value is offset by the profit on the forward contract. Thus, the forward contract provides a perfect hedge (to take a position that offsets an existing position in order to reduce the price risk in the open position).

Since maintenance margins are not required, one disadvantage of forward contracts is the possibility of default. There is no exchange to guarantee the execution of a contract, as is the case with futures (see Chapter 4). Another feature is that the value of the forward contract is conveyed only at the contract's

maturity. No payment is made either at the origination and signing of the contract, or during the term of the contract.

The use of a cash forward contract effectively locks in a price that the producer will receive for a specific quantity of output. A cash forward contract has the advantage of ensuring that the producer gets a guaranteed minimum price, but it normally also eliminates the possibility of receiving higher prices if market conditions change in the producer's favour. There are four principal types of forward contracts. They are (Nelson, 1985; Fleisher, 1990):

- **Fixed price contracting.** At the time the contract is signed, the price is determined. This price is often based on the futures price quotation for a contract whose expiration follows the delivery time closely. The quantity, quality, and time and place of delivery are also often decided when the contract is initiated.

- **Deferred price contracting.** A deferred pricing forward contract is a binding contract to deliver a specific quantity or a specific number of hectares' output and quality of product to the purchaser at a time specified in the agreement. The buyer and seller agree to some price quotation upon which the price to be paid will be based. The futures contract price, minus some adjustment for the risk assumed by the purchaser, and posted elevator prices on a pre-selected day are commonly used price indexes. Postponement in setting the price distinguishes the deferred price contract from other contractual arrangements. The seller is usually given the option of deciding when to establish the price.

- **Minimum price forward contracting.** This refers to a binding contract to deliver a specific quantity or a specified number of hectares' output and quality of product to the purchaser at a time specified in the agreement. A

guaranteed minimum price is set, but the contract provides for a higher price if the market price increases.

- **Pooled sales.** Upon delivery of a crop to a marketing agent, the seller is given a cash advance. After the marketing agent has concluded all sales, the producer is given an additional payment that depends on the success of the marketing agent in selling the crops of all members of the pool. The producer receives an average price determined by the average price the pooled sales generated. Co-operatives and their members are the primary users of such contracts.

Forward contracting, and the closely related practices of minimum price forward contracting and deferred pricing forward contracting, are the forms of forward contracting most commonly used by agricultural producers. Deferred pricing and minimum price forward contracting are often used in situations where producers want to ensure markets for specialized or perishable commodities or buyers want to ensure sufficient supplies. This is commonly the case when fruit and vegetables are grown for processing at a local plant. Processors with a substantial investment in plant and equipment in one location are often willing to pay prices that reflect local market conditions to ensure supplies at that time and in future years, even though the price paid to producers is above the minimum price established in the contract for that year.

Minimum price forward contracting guarantees a minimum price. In contrast to cash forward contracting, minimum price forward contracting allows for a higher price to be paid if the market price increases. The likelihood of receiving a higher price depends on where the initial price is set relative to market prospects. However, producers are expected to pay some premium for the privilege of a guaranteed minimum price.

Deferred pricing contracts carry the same delivery requirements as other types of forward contracts. However, pricing is accomplished via an agreement on some future standard price quotation upon which the final price is based. Deferred pricing contracts can pose specific problems for producers who have agreed to use the elevator's posted price (for South Africa, that normally represents the Randfontein spot price, because delivery of all futures contracts is based on ex-silo Randfontein prices). A buyer with many outstanding delayed pricing contracts and relatively few other buying opportunities may be tempted to accept lower-than-competitive prices during the time in which the outstanding contracts are fixed.

Participants in a pooled sales scheme deliver their crops to the pool system and receive an advance payment price for the crops delivered. This price is derived from a conservative estimate and the expected total amount of crops received by the pool system. The marketer of the pool system is responsible for selling the crops. After all marketing expenses, storage and other expenses have been met, the net amounts are paid to the participating producers.

A pool sales scheme is normally a good alternative if the producer expects the price of the crop to increase during the marketing season. If the producer seeks protection against price declines, it is the producer's responsibility to determine whether the pool system is protected from negative price movements. There are a number of advantages and disadvantages associated with pool marketing. These are listed below:

- Advantages:
    - easy choice for producer;
    - any volume of crop can be delivered to the pool scheme;
    - it is a proved marketing mechanism;
    - price risk is lowered due to a relatively long marketing time; and
    - producers combine strengths to gain a stronger influence on market

prices.

- Disadvantages:
  - producers carry the price risk if the pool scheme is unprotected from negative price movements; and
  - final payment can take longer than a year.

When hedging with futures (see Chapter 4), producers must pay commissions and forgo higher earning potential on money placed in margin accounts. Producers who use cash forward contracts may incur such costs indirectly, to the degree that local buyers lower prices paid to cover their hedging costs. Moreover, the prices obtained by hedgers may differ from the price expected at delivery by the amount that speculators require as compensation for standing by to take hedgers' trades and/or for bearing risks.

3.2.3.2 Spot market

Some buyers are willing to purchase crops at a specific price from producers on the day of delivery. This price is referred to as the spot (cash) price. It fluctuates from day to day and reflects local and world market conditions. A spot sale represents the least flexible but least risky pricing tool. The producer receives the price of the day, and payment is immediate. The producer makes no precommitment to the buyer about price, quantity, or to whom delivery will be made (Branson & Norvell, 1983). Pricing occurs when delivery is complete. According to Bodie, Kane & Markus (1998), there are several advantages and disadvantages to spot marketing:

- Advantages:
  - easy to implement;
  - price risk limited to growing period; and

- price and yield risk separated in decision-making.
- Disadvantages:
    - limited flexibility (tax planning, cash flows);
    - price often at seasonal low; and
    - selling decisions made during busy time (harvest time).

Since the amount of crops produced in South Africa is not known with certainty until harvest time, producers usually refrain from pricing all their anticipated production prior to harvest, leaving some portion of the crop(s) to be marketed during or after the harvest.

3.2.3.3   Production contracts

Price uncertainty can be reduced through various forms of contracting. The problems of basis risk (see Chapter 4), variation margin deposits, the timing of the contracts, and the existence of transaction costs are undoubtedly contributing factors to the relatively greater popularity of forward and production contracts. In a production contract, the timing of delivery can usually be set to meet the buyer and/or seller's needs. The forward price is locked in just as with futures contracts, but no margin deposit is required. Production contracts typically give the buyer of the commodity considerable control over the production process (Perry, 1989). These contracts usually specify in detail the production inputs supplied by the contractor, the quality and quantity of a particular commodity that is to be delivered, and the compensation that is to be paid to the producer.

Firms commonly enter into production contracts with producers to ensure timeliness and quality of commodity deliveries, and to gain control over the methods used in the production process. Production contracting is favoured

when specialised inputs and complex production technologies are used, and the end product must meet rigid quality levels and possess uniform characteristics.

Production contracting is also favoured when there are oversupply and under-supply problems; the risk-return trade-offs are advantageous to both the producer and the contracting firm; production technologies are specific, uniform, and knowledge-based; centralised management is feasible; and the commodity is highly perishable (Kliebenstein & Lawrence, 1995; Barry, Sonka & Lajili, 1992; Farrell, 1969). In addition, crop producers may prefer to keep fixed capital assets off their balance sheets for liquidity purposes (Barry, 1984). Producers may, however, face the possibility of having to buy themselves out of a production contract if lower-than-expected yields cause production to fall below the quantity specified in the contract.

3.2.3.4   Diversification

Product diversification is a method through which producers can avoid having all their income totally dependent on one undertaking. If profit from one commodity is poor, the returns from other commodities may prevent total profit from falling below acceptable levels. The extent to which diversification can reduce income variability for a farm depends on the price and yield correlations for the selected commodities. If prices or yields for commodities tend to move up and down together, little is gained by diversification. When yields and/or prices for selected commodities move in opposite directions, income variability is reduced. The extent to which income is evenly spread depends on the corresponding proportion of income derived from each commodity. If only a small proportion of income comes from one commodity during good years, it has little effect on total income if disaster strikes to the commodity from which income is normally derived.

Many factors may contribute to a producer's decision to diversify. The underlying theory suggests that producers are more likely to diversify if they confront greater risks, are relatively risk-averse, and face small reductions in expected returns in response to diversification. Other factors may also be important. Weather is a primary factor influencing crop yields. Crops with the same growing season tend to experience the same weather, and their yields tend to have a strong positive correlation. The yield relationship between crops that have different growing seasons and are susceptible to different insects and diseases will be lower.

Depending on a farm's situation, the costs of diversifying may outweigh the benefits. A major problem with commodity diversification is the loss in efficiency and returns from specialised production (Barry, Hopkin & Baker, 1988). These losses could outweigh the value of any risk reduction from diversification. Consequently, specialisation often increases rather than decreases as farms become more commercialised to gain higher expected returns. The result is greater emphasis on other methods of risk management. Diversifying requires a broader range of management expertise and labour, good productive capacity of the land, and reasonable market potential in the surrounding area (Dodson, 1993).

As a result, producers face trade-offs when they examine diversification versus specialisation as a strategy. Specialisation can refine the expertise needed for a particular productive activity, and may also lead to the economics of scale that lower per unit production costs, increasing the profitability of the operation. A producer's decision to specialise (or diversify) may be motivated purely by expected profits, with no consideration given to reducing risk. Conversely, the benefits associated with diversifying arise through the potential offsetting

revenue interactions among enterprises, and the complementarity of equipment and activities that are used within the farming operation (Scherer, 1980).

3.2.3.5   Liquidity maintenance

Another aspect of financial risk management is the extent of liquidity. This refers to a producer's ability to generate cash quickly and efficiently in order to meet short-term financial obligations. The liquidity issue relates to cash flow. In the case of a farm, liquidity is affected by whether, when adverse events occur, a producer has assets (or other monetary sources) that can easily be converted to cash to meet financial demands. There are three fundamental types of cash demand for a farm business:

- Transactions that demand liquidity. This need arises from the normal operation of the farm enterprise.
- A precautionary demand for liquidity. This may be necessary to respond to business adversity or to meet unexpected demands for cash.
- Investment demand or speculative demand for liquidity. This demand enables the business to respond to new or unforeseen investment opportunities.

One method of determining liquidity is to use a cash flow budget. A cash flow budget lists projected cash inflows and outflows for a specific period. The cash flow budget provides a timed format for examining the financial condition of the farming enterprise, detecting potential problems and suggesting alternative approaches that could be employed to solve these problems. Cash flow requirements consist of the following expenditures:

- operating inputs (seed, fertiliser, pesticides, lime, soil tests, scouting, crop insurance, etc.);

- machinery costs (fuel, lubrication, repairs, custom hire, machine rental, down payments on new or replacement items);
- personnel costs (wages, salaries, other labour costs, family living expenses, income tax);
- miscellaneous costs (farm insurance, consultants' fees, tools, supplies, etc.); and
- debt payment (principal and interest on term loans, interest only on operating loans).

Using the cash flow budget, it is possible for producers to determine their production costs per hectare. If they know their production costs, producers can adjust their marketing by:
- providing a pricing objective by discovering break-even prices;
- determining the portion of the total crop that must be sold at a particular price to ensure that they can meet cash commitments;
- determining the portion of the crop that can be left unpriced once minimum earnings and cash flow commitments have been realised;
- understanding the earnings and cash flow implications of selling the crop at a particular price; and
- reducing emotional involvement while adding focus and discipline to the marketing decision.

The degree of marketing flexibility in a given financial situation can be estimated by means of the cash flow risk ratio. The cash flow risk ratio determines what percentage of the crop must be sold at the expected market price to meet cash obligations such as input cost, interest cost and rent cost demand. It is calculated as follows:

$$Cash\ flow\ risk\ ratio = \frac{Cash\ flow\ break - even\ price\ per\ hectare}{Expected\ market\ price\ (R/ton)}$$

Given a constant market price, the break-even price increases or decreases as yields change. If the yield declines, the percentage of the total crop (that is sold at the expected market price) required to meet cash flow needs increases. After cash flow needs have been met, the remaining production can be marketed using methods intended to gain the highest possible net price.

Producers who have low cash flow needs and substantial operating capital and borrowing capacity have more flexibility in terms of how they market their commodities. Their marketing strategy is dictated mainly by their expectations of price movements, storage costs and income tax management.

Cash flow requirements can be very different for different producers. The amount of outstanding debt serviced and whether land has been purchased or rented have the greatest impact. The following example illustrates the differences in cash flow demand and how this affects the cash flow risk ratio. Four hypothetical producers all plant 600 hectares of maize in Mpumalanga annually, using similar technology on similar land. Only their land holding and debt situations differ.

- Producer 1 holds title to all the land he farms and is debt-free.
- Producer 2 cash rents his entire land base, and has some debt because he needed to purchase machinery.
- Producer 3 has a 50 percent lease agreement on all his land, and also owes an amount of money on machinery.

- Producer 4 recently purchased 250 hectares of cropland and cash rents another 350 hectares. He has the same machinery debts as Producer 2 and Producer 3.

The cash flow requirements for one crop (maize) are set out in Table 3.1.

Table 3.1: Hypothetical cash flow requirements for maize on a 600-hectare farm

Item	1	2	3	4
Operating inputs	426 000	426 000	426 000	426 000
Machinery costs	222 000	222 000	222 000	222 000
Personnel costs	96 000	96 000	96 000	96 000
Insurance (short-term)	48 000	48 000	48 000	48 000
Land costs (rent)	0	72 000	36 000	42 000
Miscellaneous costs	48 000	48 000	48 000	48 000
Debt payments	0	50 000	50 000	50 000
Total cash flow needs	840 000	962 000	926 000	932 000
Hectares planted	600	600	600	600
Cash flow cost per hectare	1 400	1 603	1 543	1 553
Expected or actual yield (ton per Ha)	3.25	3.25	3.25	3.25
Cash cost break-even price	431	493	475	478
Expected market price (R/ton)	640	640	640	640
Cash flow risk ratio	67.3%	77.0%	74.2%	74.7%

The cash flow risk ratio indicates what percentage of the crop must be sold at the expected market price to meet all cash obligations. Once that demand has been met, the remaining production can be marketed using methods intended to gain the highest possible net price, regardless of risk. Producer 1 has 32.7% (100% - 67.3%) of his crop available for speculation. The higher the cash flow risk ratio,

the more important it is to lock in a price at or above the break-even price when it is available, and the less the producer can afford to speculate on the possibility of achieving a higher price. A cash flow risk ratio greater than 100% means that it is possible that savings and/or borrowings will have to be used to meet the cash flow needs for a given year. It is important to calculate the cash flow risk ratio for each of the major crops produced by a producer. Although the cash flow risk ratio can be used as a standard for pricing decisions, it is not necessarily a price goal. A price goal must be based on the needs of a business combined with price levels currently and potentially offered by the market. The price goal changes from year to year, or even more often, depending on changing market conditions. In some years, the market may not offer a break-even price at any time, and strategies to minimise loss are then needed.

But what about producers who diversify their crops to manage production risk? They can also use the cash flow budget to manage price risk. The following example illustrates how the cash flow budget can assist a producer in determining how much must be sold at a given price. In the example, a farmer, Dave Diversify, who is debt-free, holds the title to a 600-hectare farm in Mpumalanga. There he plants 200 hectares each of maize, sunflower seed, and sorghum. The cash flow budget of Dave Diversify is set out in Table 3.2.

Table 3.2: Cash flow requirements for a diversified farm

Item	Maize	Sunflower	Sorghum
Operating inputs	142 000	80 000	127 000
Machinery costs	74 000	70 000	74 000
Personnel costs	32 000	32 000	32 000
Insurance (short-term)	16 000	12 000	15 000
Miscellaneous costs	16 000	16 000	16 000
Total cash flow needs	**280 000**	**210 000**	**264 000**
Cash flow cost per hectare	1 400	1 050	1 320
Expected or actual yield	3.25	1.3	3.5
Cash cost break-even price	431	808	377
Expected market price[1]	600	1 050	640
Total cash receipts	**390 000**	**273 000**	**448 000**
Cash flow risk ratio	71.8%	76.9%	58.9%
Farm living expenses[2]	100 000	100 000	100 000
Contribution margin	591	413	380
Quantity available for speculation	59	-153	320
Break-even price	584.62	1 192.31	520.00
Margin of safety	2.56%	-13.55%	18.75%

Sorghum has the lowest cash flow risk and Dave Diversify has 41.1% (100% - 58.9%) of his sorghum left to speculate with. The higher the cash flow risk ratio, the more important it is to lock in a price at or above the break-even price when it is available, and the less a producer can afford to speculate on the possibility of achieving a higher price.

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[1] Market price represents the net amount after all marketing costs have been subtracted.
[2] A total of R300 000 of farm living expenses is allocated for the number of hectares planted with each crop.

An alternative method, called the **contribution margin approach**, can also be used. The contribution margin determines how much of the crop must be sold at the expected market price to cover variable cost and fixed costs. The formula for the contribution margin is the following:

Contribution margin   = Fixed cost / Contribution per ton

To determine the contribution per ton, the following formula applies:

Contribution per ton = Selling price per ton / Input costs per ton

From Table 3.2, it is clear that Dave has 59 tons of maize available for speculating. The cash flow break-even price is a reference point indicating the availability of surplus cash for potential shortfalls. In Table 3.2 the break-even price for maize is R584.62 per ton; that is the price needed to cover all costs. A price above R584.62 per ton implies a profit. The margin of safety indicates the amount that sales may decrease before a producer will suffer a loss. The margin of safety only calculates the percentage by which the net market price of the crop can decrease before a producer will suffer a loss. In the example, the market price of maize can decrease by only 2.56% before Dave Diversify will suffer a loss.

Any opportunity for any business organisation to earn a profit implies taking some risk. Although it is not generally described as a business asset, the ability and willingness to assume risk is critical. Every farm is likely to differ in its capacity to assume a given type of risk-exposure. **Ability** (or *capacity*) to assume risk differs from a **willingness** to assume risk, but either one can limit the risk exposure a firm accepts. Producers who recognise and prudently use their capacity to assume risk are likely to enhance their chances of financial success.

One way to consider a farm's capacity to assume risk is to describe it as a chain with five links:

- The first link is net earnings as a percentage of the value of the farm's crop production, which shows the farm's capacity to absorb losses resulting from reductions in yields or price.

- The second link is the working capital of the farm business. This indicates whether the business has sufficient cash flow (and current assets) to cover operating losses that occur in the first link.

- The third link is current debt repayment capacity, which refers to the farm's ability to rely on a carry-over operating loan to finance operating losses.

- The fourth link is owner's equity, which is the business's ability to sell assets to restructure its finances.

- The last link is collateral, which is the legal right to the owner's equity.

3.2.3.6   Storage

Storing grain that is not priced places the producer in a speculative position. Instead of just storing grain out of habit, the producer needs to determine whether there is an economic incentive to store. To determine this, the producer needs to know the costs associated with storing the grain (storage rates, handling charges, shrinkage, interest and opportunity cost). Next, the producer must determine whether expected cash prices might rise in the future. Lastly, the producer must determine whether the expected cash price increase is large enough to more than offset the associated storage costs. Deciding how long to store a crop depends upon a number of factors. Changes in futures prices, basis levels, delivery opportunities and interest rates all play a role. Long-term storage is profitable only if prices rise enough over the storage period to cover storage and interest costs.

Throughout this study, it is assumed that producers do not have farm storage facilities and make use of commercial storage silos. This physical storage cost ranges up to about 21 cents (SAFEX price in 1998/1999) per ton per day. A more significant cost is related to the interest rates that apply to each individual producer. For example, for a producer with outstanding debt accruing interest at 24% per year, the interest cost of storing maize, with a spot price of R650/ton, is R13/ton per month. In other words, the producer needs to make over R764/ton six months after the harvest to justify the interest cost. Another producer who has no debt may only need a R34.20/ton higher price to cover the interest cost of storing maize with a spot price of R650/ton for six months. Both producers, however, are also exposed to the risks of spoilage and theft as they store their grain.

Another important fact to consider is that holding unpriced grain in storage is a speculative venture. If prices decline instead of rising after harvest, the producer stands to lose in two ways. First, the producer loses if the price received for the grain when it is sold is lower than it was at harvest. Secondly, the producer must pay the storage cost.

Storing unpriced grain has specific advantages and disadvantages (Cramer, Jensen & Southgate, 1997) as listed below:
- Advantages:
    - storage extends the marketing season;
    - producers can take advantage of higher prices if they occur; and
    - producers can deliver when supply decreases
- Disadvantages:
    - prices may not increase enough to cover storage cost;
    - stored grain can lose quality; and
    - producers are unprotected against falling prices.

3.2.3.7   Other methods of risk management

The list of strategies and tools discussed above is by no means complete. Producers commonly use many other strategies for farm risk management. Some of these additional strategies include the following:

- **Adjusting input- and output-levels.** Producers can respond to risk by altering output levels, input use, or some combination of the two. Research indicates that a higher selling price risk for producers results in lower levels of both input use and final output (Sandmo, 1971; Ishii, 1977; Just & Pope, 1978; Robinson & Barry, 1997;). Given that risk preferences and circumstances can vary greatly across producers, the final input and output levels chosen by producers can, accordingly, vary considerably for individuals in similar situations.

- **Culture practices.** Culture practices can be used to reduce yield and income risk. One such practice involves planting short-season varieties that mature earlier in the season, protecting producers against the risk of early frost and yield loss. Supplemental irrigation due to abnormal weather is another means to protect against yield loss.

- **Excess machine capacity**. A producer may have enough machine capacity so that planting and harvesting crops can occur more rapidly than needed under normal weather conditions. By having such resources, the producer can avoid delays at either planting or harvest that may reduce yield losses.

- **Vertical integration.** Vertical integration is one of several strategies that fall under the umbrella of 'vertical co-ordination'. Vertical co-ordination includes

all the ways in which output from one stage of production and distribution is transferred to another stage. Farming has traditionally operated in an open production system, where a commodity is purchased from a producer at a market price determined at the time of purchase. The use of open production has declined, and vertical co-ordination has increased as consumers have become increasingly sophisticated and improvements in technology have allowed greater product differentiation (Allen, 1997). A vertically integrated firm, which retains ownership control of a commodity across two or more levels of activity, represents one type of vertical co-ordination.

- **Maintaining financial reserves and leveraging.** Leveraging refers to the producer's use of debt to finance the operation. Increasing the farm's leverage increases the capital available for production, allowing expansion of the business, but also entails incurring a repayment obligation and creates the risk of loan default because of the risks inherent in the farming business.

- **Leasing inputs and hiring custom work.** Producers can also manage their farming risks by either leasing inputs (including land) or only hiring workers during harvest or other peak months. Leasing refers to a capital transfer agreement that provides the lessee with control over assets owned by someone else for a given period, using a mutually agreed-upon rental arrangement (Perry, 1989). Producers can lease land, machinery, equipment, or livestock. Producers who hire custom help (who provide skilled labour and their own equipment) can lower the costs associated with committing capital to fixed inputs. With the use of custom workers (or hired or contract labour), the producer has a great deal of flexibility, potentially lowers costs, and obtains specialised labour (Perry, 1989). The use of such arrangements may, however, increase the producers' risk because they would have less control over resources than if they owned equipment outright or if workers were hired full-time.

- **Insurance.** Insurance is often used by crop producers to mitigate yield and revenue risk, and is obviously prevalent outside agriculture. Property, health, automobile and liability insurance are all forms of insurance regularly purchased by individuals to mitigate risk.

- **Off-farm employment and other types of off-farm income.** Earning off-farm is another strategy that producers may use to mitigate the effects of agricultural risk on farm and family household income. Not only can off-farm income supplement household income, it may also provide a more reliable stream of income than farm returns.

- **Flexibility.** To meet the challenge of uncertainty, the producer should plan for flexibility. Flexibility involves modifying the most profitable business plan to avoid losses or pursue new opportunities (Casavant & Infanger, 1994). Flexibility is a characteristic of a producer's attitude. The flexible producer is willing to try out new ideas, seeking new information sources, testing new techniques and experiment with new production processes. The potential for growth and profitability is the reward for a flexible attitude. Flexibility does not directly reduce risk, but it provides a means of coping with risk. One way to increase flexibility is to reduce fixed costs relative to variable costs. By doing so, producers are not hampered by expensive machinery that limits their choice of crops. They can easily change to different crops without sitting with idle expensive machinery. Short-term assets can be changed more often than long-term assets. Another way to achieve flexibility is to choose non-specific resources instead of specific resources. General-purpose buildings and machines are preferable to specialised buildings and machinery. However, with a flexible farm, the producer loses the benefits of specialisation. The higher total costs of flexibility may make this choice infeasible.

Other methods of risk management in farming are also important, and focus on other types of issues than those specific to production, marketing and finance. Legal risks and issues associated with farm liability have become increasingly important. In addition, tax concerns are a key issue in managing the income risks associated with year-to-year income flows, as are estate transfers from one generation to generation (Keller, 1998; Keller & Rigby-Adcock, 1998; Bacquet, *et al.*, 1997).

3.3 DEVELOPING A MARKETING PLAN

One of the most important steps in marketing commodities profitably is to develop a sound marketing plan. A good marketing plan allows producers to control important decisions concerning when and how to market the crop. The marketing plan is a written plan that clearly delineates what is to be done in the marketing programme.

The four basic steps in developing a marketing plan are:
- estimating a break-even price;
- determining market or price objectives;
- following through with the plan; and
- evaluating the marketing programme.

Market or price objectives vary from producer to producer. Producers need to assess their financial goals. These goals depend on capital constraints, current debt load, cash flow requirements, and the producer's risk attitude. Producers must establish price objectives that meet these goals. These objectives must be realistic for the current market as well as the expected market conditions. An acceptable market objective is to limit losses in the short run and to guarantee

long-term farming prospects. Producers must evaluate and take action on those marketing alternatives to achieve market goals and price objectives.

The most difficult part of any marketing plan is carrying it out. When markets start to move either up or down, the producers' outlook and opinions might change. It is important that producers develop a plan that they will feel comfortable carrying out, and producers must be willing to implement provisions for unexpected developments.

Once a marketing season is completed the producer must evaluate the marketing programme. It is important that any modifications and changes to the programme must be made before the new season starts and that every season must be handled in isolation. Any given specific marketing plan might not be applicable for every marketing season. A good marketing plan should be part of an integrated management approach to the farm business.

3.4   CONCLUSION

The resource limitations of producers, unpredictable weather patterns and fluctuating economic and market conditions make yearly planning difficult. Nevertheless, an understanding of the principles of financial management can help producers to maximise their net worth over a sustainable period.

Financial measures are intended to help producers analyse their farm activities from a financial standpoint and provide useful information needed to make good management decisions. By themselves, the financial measures discussed do not provide answers – they need to be reviewed in relation to each other and to other farm and non-farm activities. It is not possible to control or predict all the factors that influence the final outcome of any farm decision. Nor is it possible to

have available all of the information that would be ideal. But decision-making can be improved by using available information and by effective financial planning and analysis.

The term 'risk management' means different things to different businesses, but in agriculture it involves identifying events that could have adverse financial consequences and then taking actions to prevent and/or minimize the damage caused by these events. Due to the very nature of agriculture and the limited number of insurance contracts available to producers, the importance of price risk management instruments is so much greater. The consequences of taking business and financial risks in agriculture heighten the need for producers to develop risk managing skills. It is especially important to formulate comprehensive strategies for dealing with the multiple sources of risk. Understanding the concepts and measures of variability and correlation is also important. Risk management considers both the asset and the liability structure of farm businesses, and accounts for the sources of risk and methods of managing risk in production, marketing and financing. High-performance producers compare the costs and returns for various risk management alternatives in developing their strategies.

In the following two chapters, two more price risk management strategies that are traded on SAFEX are discussed in detail: futures contracts and options on futures contracts. These contracts are traded on a daily basis. In the following chapters, the characteristics of these risk management strategies are identified, and hedging as an alternative marketing strategy is illustrated.

CHAPTER 4

FUTURES CONTRACTS

The price of an article is charged according to difference in location, time or risk to which one is exposed in carrying it from one place to another or in causing it to be carried. Neither purchase nor sale according to this principle is unjust.

- St Thomas Aquinas

4.1   INTRODUCTION

Many factors, including unrest on farms, El Niño, volatile exchange rates, product prices, changing producer price indices and labour acts, make agri-business risky. Since the 1995 marketing season, in South Africa, marketing is the producers' own responsibility. Not only can producers now select their own marketing channels, they may also choose between alternative schemes for timing the pricing of their crops. Before crops are harvested or even planted, the agricultural products may be committed for sale using forward and derivative contracts. At harvest, crops can be sold in the spot market. As a result of storage, pricing and marketing can be delayed even further.

If the futures market is used correctly, it can contribute a great deal to a farm's net income from commodity sales. Futures contracts are based on an underlying asset. These assets can be almost anything, ranging from the physical to the more abstract – from pork offal to market indices. Unfortunately for crop producers in South Africa, the futures market system is at present functional only in the maize, wheat and sunflower seed markets. But this is no reason for the

producers of products other than wheat, maize or sunflower seed not to participate in this exciting new opportunity. Moreover, the futures market is not reserved only for big commercial producers, companies, or even major role-players. The market is open to all that can understand market conditions, negative or positive.

This chapter aims to provide a clear overview of the functioning of the futures market, the requirements of futures trading and of how futures contracts can be used to manage price risk.

4.2 HISTORY

Futures trading evolved in response to the changing needs of those who sell important commodities and to the increasing sophistication and level of civilisation of humankind. Active regulated markets in commodities existed in China, Egypt, Arabia and India twelve centuries BC. In the Western world, laws were enacted to ensure food supplies and to prevent market manipulation in the city-states of Greece, which were occasionally beset by famines. The specialisation of markets to trade in a single commodity was already accomplished in pre-Christian Rome. According to Baer and Saxon (1949),

> In the heyday of Roman dominion and power by land and sea there were in Rome nineteen ... trading markets called *fora vendalia* (sales markets), which specialised in the distribution of specific commodities, many of them brought from the far corners of the earth by caravan and galley.

During the era of the Tokugawa Shogunate (the Tokugawa dynasty of Japanese shoguns ruled Japan from 1600 until 1868), an orderly and well-disciplined futures market in rice developed. The market was officially recognised in 1730.

Some of the rules of this Oriental Exchange were, as recorded by Kaufman (1986) that:

- only trading in rice futures was permitted;
- the contract term was limited to four months and the year was divided into three four-month periods;
- all contracts in any four-month period were standardised;
- no physical delivery of rice against outstanding contracts was allowed;
- all differences in value had to be settled in cash;
- no contracts could be carried over into the new contract period and no new contracts could be made during the last three days of any trading period;
- all trades had to be cleared through a clearing house and traders were required to establish a line of credit with the clearing house of their choice; and
- any default on payments was borne by the clearing house.

Futures markets in agricultural products developed in the United States of America (USA) during the middle of the previous century. In the mid-1800's, the City of Chicago found itself rapidly becoming the grain-marketing centre of the USA. Chicago's favourable business conditions and geographical location made it an important grain terminal, because it had a large established cash market and extensive storage facilities (Kaufman, 1986).

The agricultural futures market as we know it today is a place where all buyers and sellers can meet, or be represented, in order to buy and sell futures contracts. By separating the price from the physical delivery of goods, futures markets enable buyers and sellers to remove the uncertainty associated with the price (because the price is determined in advance) (Allen, 1997). The economic function of futures markets is to allow those who are directly involved with a commodity to reduce the risk of price volatility. Producers have the opportunity

to use futures contracts, forward contracts and options to protect themselves from price risk.

The concept of hedging on international markets is not new in South Africa. During the 1960's, the South African Sugar Association, a copper dealer, and various wool companies were authorised to operate on foreign forward markets. Holcom Commodity Brokers (Pty) Limited were granted permission to act as a broker on the London Metals Exchange in 1973. Their authority was extended to include operations in other commodity markets in products such as gold, coffee, and wheat (Falkena, Kok, Luus & Raine, 1989). In South Africa, the Rand Merchant Bank took the initiative to start an informal local futures market in 1987. Initially only contracts in the All Share, Gold and Industrial indices of the JSE were traded. Later, contracts on long-dated stock, Kruger Rands and bankers' acceptances were introduced.

The South African Maize Board has operated quite successfully on the Chicago Board of Trade (CBOT) since the mid-1980's. The Maize Board started trading on the CBOT to hedge against price risk. The Board faced the risk that the producer prices paid might be more expensive than the prices received for maize in a given year.

The agricultural futures market in South Africa was established during the 1995/96 season. During the first quarter of 1996, a total of 485 maize contracts were traded. Figure 4.1 presents the numbers of maize contracts traded on SAFEX between October 1996 and July 1999 (SAFEX, 1999).

Figure 4.1: Maize contracts traded on SAFEX
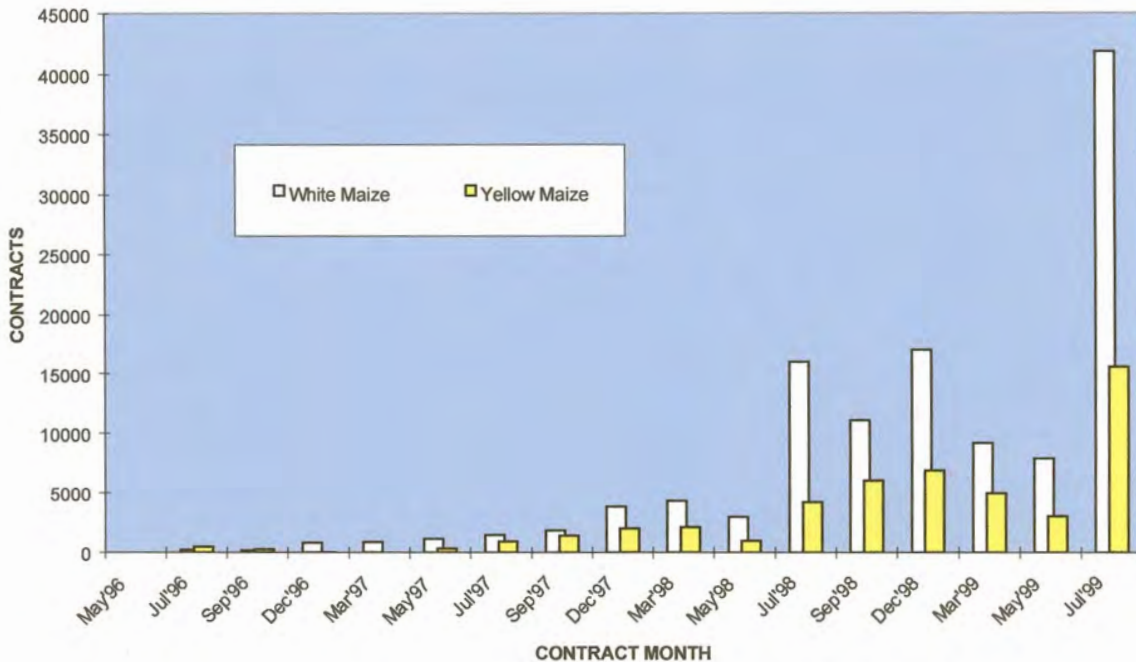
The first wheat contracts were traded on SAFEX during the fourth quarter of 1997, a total of 180 contracts. There was a drastic increase in the number of maize contracts traded from the third quarter of 1997. Until the fourth quarter of 1998, the highest number of contracts traded was 25 088 (in the third quarter of 1998), representing a 517% increase from the first quarter of 1996. In February 2000 the Agricultural Markets Division (AMD) of SAFEX set a new record with more than 39 813 contracts traded (www.safex.co.za, 2000). That is an increase of over 3 300 contracts compared to November 1999. Since July 1999, the AMD traded almost 2.2 million tons of maize each month. Figure 4.2 indicates the percentage of physical deliveries on SAFEX. The initial high percentage of physical deliveries indicates that producers used the market as a guaranteed forward market, and not as a hedging mechanism. Producers started to use the commodity market as a hedging mechanism during 1998 with only 15.86% of white maize delivered. That represents a dramatic large decrease of physical

deliveries from the 1996 and 1997-period when as much as 56.22% of white maize contracts were delivered at Randfontein.

Figure 4.2: Percentage maize delivered on SAFEX
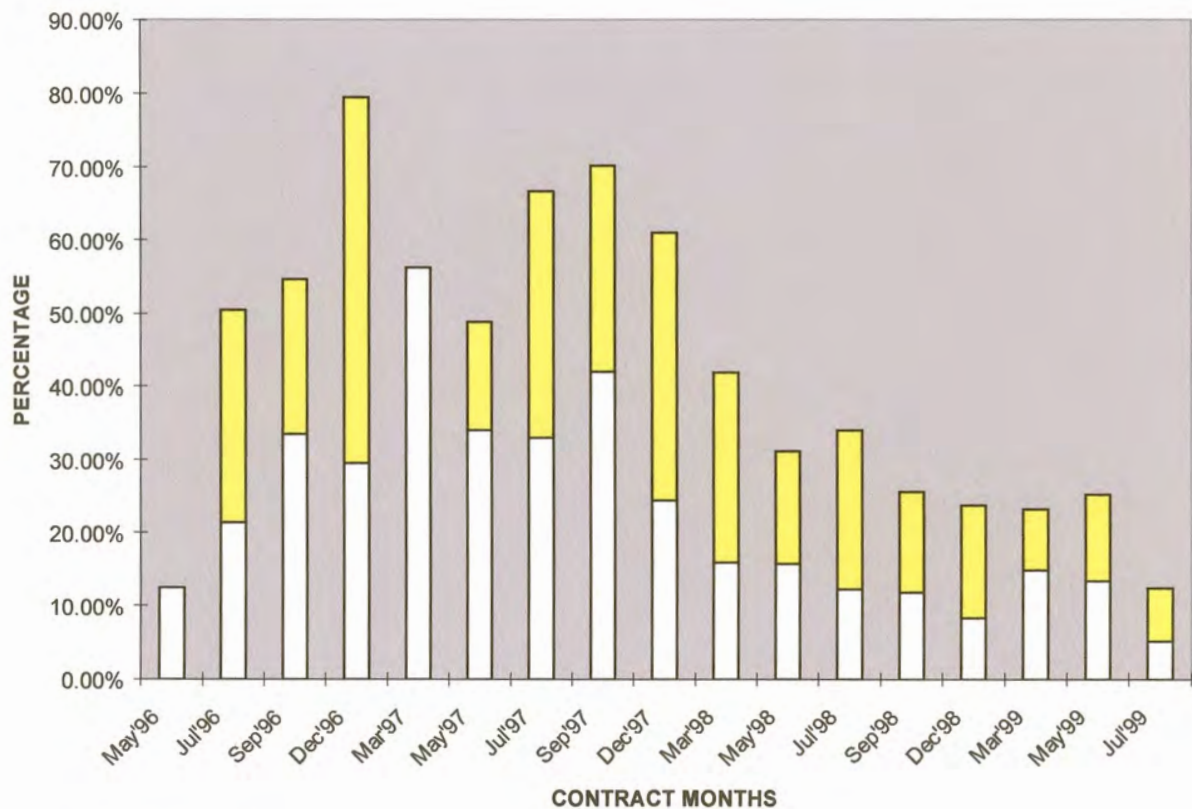
Source: SAFEX (1999)

Futures markets are not designed to determine or influence the absolute level of prices. Their pricing function determines only inter-temporal or contingent prices. An contingent price relationship is a relationship at a given time between prices applicable to different times. Inter-temporal prices should improve the conditions under which decentralised production and consumption decisions are made and should ensure that risk is taken into account more adequately. However, there seems to be some confusion in the literature when it comes to

the question of why futures markets actually exist. That is, it is not clear that their primary social and economic function is to determine inter-temporal prices. While some believe that futures markets serve as a vital tool for managing economic and financial risks (Diercks, 1978), others believe the markets are gambling casinos (Hardy, 1944). The latter notion was especially valid in the early phases of futures markets because during these stages these markets were very much unsophisticated.

Keynes (1923), who developed the theory of normal backwardation, emphasised the financial burden posed by the necessity for carrying inventories of agricultural products. He therefore suggested that futures markets can facilitate hedging. On the other hand, Working (1949) promoted the notion that the primary function of futures markets is the provision of returns for storage services.

4.3   EFFICIENCY THEORY

According to Fama (1970), an efficient market is one that accurately incorporates all known information in determining the price of an asset. Fama's original definition came to be known as the efficient market hypothesis. The efficient market hypothesis states that, at any given time, security prices fully reflect all available information. It is essentially an extension of the zero profit equilibrium of a competitive market in a certain world to a more uncertain world of price dynamics. The implications of the efficient market hypothesis are truly profound. Most individuals who buy and sell securities do so assuming that the securities they are buying are worth more than the price that they are paying, while the securities that they are selling are worth less than the selling price. However, if markets are efficient and current prices fully reflect all information, then buying and selling securities in an attempt to outperform the market will effectively be a game of chance rather than skill. In an active market which includes many well-

informed and intelligent investors, securities will be appropriately priced and reflect all available information. If a market is efficient, no information can be expected to allow a product to outperform an appropriate benchmark. For the commodities market, the efficient market hypothesis states that all past information should already be incorporated into the current futures price, and therefore it should have no effect on the future spot price.

There are three forms of the efficient market hypothesis (Bodie, Kane & Marcus, 1998):

- The weak form asserts that all past market prices and data are fully reflected in securities prices. In other words, technical analysis is of no use.
- The semi-strong form asserts that all publicly available information is fully reflected in securities prices. In other words, fundamental analysis is of no use.
- The strong form asserts that all information is fully reflected in securities prices. In other words, even insider information is of no use.

Furthermore, Fama (1970) assumes that there are no transaction costs, that information is costless, and that the implications of current information for both current price and the distribution of future prices are generally accepted by all market participants. At least two of Fama's assumptions are unrealistic. Firstly, there are transaction costs, such as brokerage fees. The existence of transaction costs must change the criteria by which market efficiency is evaluated. Secondly, information is costly to acquire and analyse (Zulauf & Irwin, 1997). These assumptions make it difficult to describe any market as efficient.

If a market is indeed efficient, that has a very important implication for market participants: all investments in an efficient market are expected to be zero net present value investments at the time the investment is made. If prices are

neither too low nor too high, then the difference between the market value of an investment and its cost is zero, therefore no value is added to the business, resulting in a zero net present value. Grossman and Stiglitz (1980) show that, if information is costly, it is impossible for prices to reflect all available information perfectly. Otherwise, those who use various resources to obtain information would earn no compensation to cover their costs to acquire and analyse the data. This insight introduces a potential avenue for profitable trading. Profit can be earned by using information and analysing it to take a position in anticipation of price changes that occur as the rest of the market becomes aware of the information. These trading returns represent a return on the costs incurred in acquiring and analysing information. It also implies an alternative statement of market efficiency: a market is efficient with respect to the information set available at a future time, provided economic returns generated by trading on this information set do not exceed transaction and information costs (Conklin, 1998).

Market efficiency implies that futures prices equals expected future spot prices plus or minus a possibly time-varying risk premium. This risk premium includes factors such as interest rates, local and international demand and weather expectations. Futures prices are unbiased forecasters of future spot prices only if markets are both efficient and have no risk premium (Mckenzie & Holt, 1998). Research done by Beck (1994) and Mckenzie and Holt (1998) indicates that maize and soybean futures markets are both efficient and unbiased in the long run. These results suggest that in the long run, risk premiums do not exist in these markets.

4.4 THEORY OF NORMAL BACKWARDATION

In 1936, John M. Keynes originated the theory of normal backwardation. In his view, futures prices are unreliable estimates of the spot price prevailing on the date of expiry of the futures contract. He believed it is 'normal' for the futures price to be a downward biased estimate of the forthcoming spot price. His theory of normal backwardation has been reinterpreted many times over since its conception. The following discussion of his theory is therefore more of a discussion of post-Keynesian interpretations of his theory. Post-Keynesian interpretations argue that futures provide a mechanism to transfer risk from the hedgers (commodity producers who have natural long positions in the commodity) to speculators. Theoretically, the market is 'normally' inefficient, because the futures price is not an unbiased estimate of the subsequent spot price. To accomplish this transfer of risk, speculators only buy commodity futures contracts if the expected rate of return for holding futures would exceed the risk-free rate (Kolb, 1999). For the expected rate of return on the futures position to exceed the risk-free rate, the futures price would have to be less than the expected spot price and rise as the contract maturity date approaches. This relation, referred to by Keynes as normal backwardation, is illustrated in Figure 4.3.

Figure 4.3: Futures prices over time with constant future price expectations
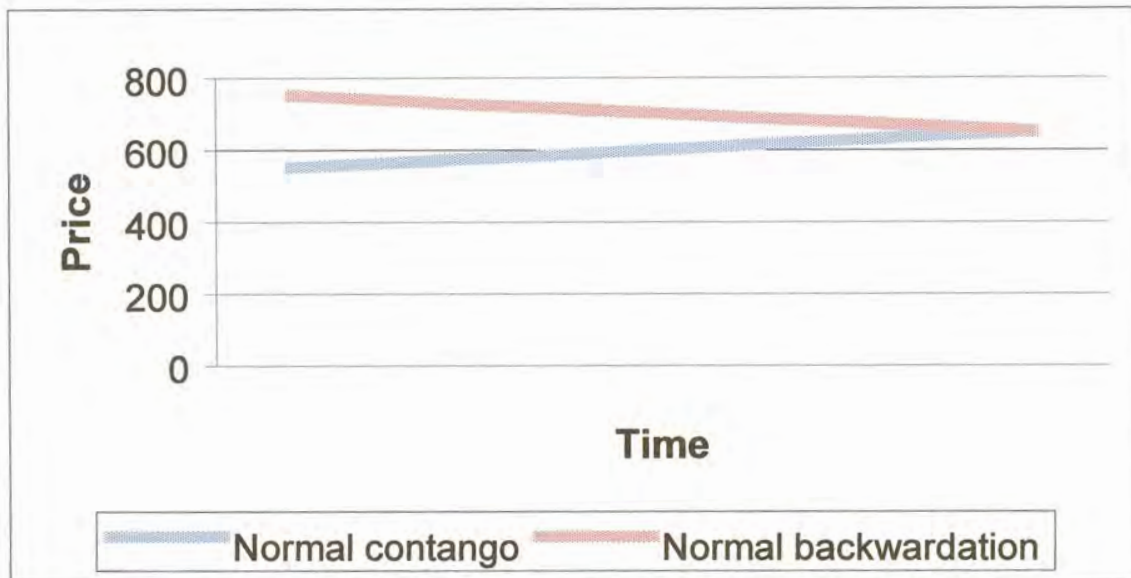
Source: Adapted from Kolb (1999)

The view that futures prices tend to rise over the contract life due to the hedgers' general desire to be net short is known as **normal backwardation**. Normal backwardation should not be confused with a market that is in backwardation. A market is in backwardation at a given moment if the cash price exceeds the futures price or if a nearby futures price exceeds a distant futures price. In normal backwardation, the expected price is lower than the realised price. If this situation exists, futures prices should increase over the course of a contract, resulting in positive trading returns to a long position. A long position implies that there is a buyer for a futures contract. Conversely, if hedgers are net long, then the futures price would lie above the expected future spot price, and the price of the futures contract would fall over its life. This pattern of falling prices is known as a **contango** (illustrated by the falling line in Figure 4.3). The expected price is higher than the realised price. Hence, a short futures position can earn positive trading returns. A short position implies that there is a seller for a futures contract.

The three crucial assumptions of the theory of normal backwardation are that speculators:

- are net long;
- are risk averse; and
- are unable to forecast prices.

Given these assumptions, the theory has two important implications. The first implication is that over time speculators can earn profits by merely holding long positions in futures markets. The second implication is that there is an upward trend in futures prices, relative to spot prices, as the contract approaches maturity. Hicks (1946) and Houthakker (1959) modified the theory of normal backwardation by assuming that speculators are able to forecast prices. This modification implies that the returns to speculators may include a payment for forecasting as well as for risk bearing. Cootner (1960) argues that Keynes's hypothesis implies that futures prices should not necessarily rise until after the peak of net short hedging has passed. That is, he interprets the theory to mean that seasonal trends in futures prices should be taken as an indication of a risk premium.

Telser (1958) and Cootner (1960) both tested their interpretations of the theory of normal backwardation and obtained conflicting results even though they used the same data. Cootner found evidence to support the theory of normal backwardation, whilst Telser's conclusions were the opposite. Telser assumed that speculators require no remuneration to play the futures market and then went on to conclude that they earn no remuneration in a competitive market.

Several other writers have also tested the validity of the theory of normal backwardation. A concise summary of their findings is given by Rockwell (1967), who describes the state of the theory as follows:

While the theory of normal backwardation may be valid for particular markets under special conditions, it is not adequate as a general explanation of the flow of profits in commodity markets...

Dusak (1973) tested for the existence of a risk premium within the context of the capital asset pricing model. Dusak argues that the risk premium required on a futures contract should depend on the extent to which the variations in prices are systematically related to variations in the return on total wealth. If the risk of a futures contract is independent of the risk of changes in the value of all assets taken together, then investors do not have to be paid for that risk since they can diversify the risk away. The Keynesian 'insurance' interpretation identifies the risk of a futures asset solely with its own price variability.

4.5   FUTURES CONTRACTS

A futures contract is a standardised agreement between two parties that commits one to sell and the other to buy a stipulated quantity and grade of a commodity, currency, security, index or other specified item at a set price on or before a given date in the future that requires the daily settlement of all gains and losses as long as the contract remains open (Purcell, 1991, Kleinman, 1997). The futures contract is not itself a purchase or sale of a commodity; it is a contract to conclude a purchase or sale in the delivery month. Ownership of the commodity does not change hands unless and until delivery is arranged after cessation of futures trading. These contracts have several key features:
- the buyer of a futures contract, the 'long', agrees to receive delivery;
- the seller of a futures contract, the 'short', agrees to deliver;

- futures contracts are market to market each day at their end-of-day settlement prices, and the resulting daily gains and losses are padded through to the margin accounts; and

- futures contracts can be terminated by an offsetting transaction (that is, an equal and opposite transaction to the one that opened the position) executed at any time prior to the contract's expiration.

A unique characteristic of futures is that the sellers are not linked with specific buyers, as would be the case in forward contracts. The intermediary between buyers and sellers is a clearing house that ensures that contracts held to delivery are fulfilled. If a producer buys a futures contract, the producer has a right to take delivery on the cash commodity at a given price in a specified future period and is defined as taking a **long** position in that contract. If a producer sells a futures contract, the producer has a right to deliver the cash commodity at a given price in a specified future period and is defined as taken a **short** position in that contract.

Standardisation is the key characteristic of futures contracts. This standardisation is evident in the contract specification for the commodities shown in Table 4.1. The homogeneity of well-specified contracts facilitates and encourages high volume trading on organised exchanges. The only non-standard item of a futures contract is the price of an underlying unit, which is determined in the trading arena.

Futures contracts are essentially guaranteed against default. The clearing house at the exchange is both a buyer to every seller and a seller to every buyer since neither party is named on the same contract.

Table 4.1:   Commodity contract specifications

FUTURES CONTRACT	WHITE MAIZE	YELLOW MAIZE	WHEAT
ATS code	WMAZ	YMAZ	WEAT
Trading Hours	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00
Underlying Commodity	White maize of African origin grade WM1	Yellow maize of African origin grade YM1	Bread Milling Wheat meeting protein, specific weight, moisture and falling number criteria with fall back positions for protein and specific weight (specified origin)
Contract Size	100 metric tons	100 metric tons	100 metric tons
Expiry Dates & Times	12:00 on eighth last business day of May, July, September, December and March; physical deliveries from first business day to last business day of expiry month	12:00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month	12:00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month
Settlement Method	Physical delivery of SAFEX silo receipts giving title to maize in bulk storage at approved silos at an agreed storage rate	Physical delivery of SAFEX silo receipts giving title to maize in bulk storage at approved silos at an agreed storage rate	Physical delivery of SAFEX silo receipts giving title to wheat in bulk storage at approved silos at an agreed storage rate
Quotations	Rands/ton	Rands/ton	Rands/ton
Minimum Price Movement	Twenty cents per ton	Twenty cents per ton	Twenty cents per ton
Initial Margin	R7000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R2250/ contract for calendar spreads. R4000/contract for white spreads	R6000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R1750/ contract for calendar spreads. R4000/contract for yellow spreads	R6000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R2000/ contract for calendar spreads. R4000/contract for Cape wheat spreads
Maximum Position Limits	None	None	None
Expiry Valuation Method	Closing futures price as determined by the clearing house	Closing futures price as determined by the clearing house	Closing futures price as determined by the clearing house
Booking Fee Charges By SAFEX	R34.20/contract	R34.20/contract	R34.20/contract

(continued overleaf)

Table 4.1: Commodity contract specifications (continued)

FUTURES CONTRACT	CAPE WHEAT	SUNFLOWER SEED
ATS code	CWHT	SUNS
Trading Hours	09:00 to 12:00	09:00 to 12:00
Underlying Commodity	Bread Milling Wheat meeting protein, specific weight, moisture and falling number criteria with fall back positions for protein and specific weight (specified origin)	FH South African Origin high oil content sunflower seeds meeting specified criteria
Contract Size	100 metric tons	50 metric tons
Expiry Dates & Times	12:00 on eighth last business day of May, July, September, December and March. Physical deliveries from first business day to last business day of expiry month	12:00 on the eight last business day of March, May, July, September and December. Physical deliveries from first business day to last business day of expiry month
Settlement Method	Physical delivery of SAFEX silo receipts giving title to wheat in bulk storage at approved silos at an agreed storage rate	Physical delivery of SAFEX silo receipts at approved silos at an agreed storage rate
Quotations	Rands/ton	Rand/ton
Minimum Price Movement	Twenty cents per ton	One Rand per ton
Initial Margin	R6000/contract up to first notice day. R10 000/contract up to expiry day. R20 000/contract up to last delivery day. R2000/contract for calendar spreads. R4000/contract for Randfontein wheat spreads	R5000/contract up to first notice day. R8000/contract up to expiry day. R16 000/contract up to last delivery day. R1600/contract for calendar spreads
Maximum position Limits	None	1000 contracts within 10 days of expiry month
Expiry Valuation Method	Closing futures price as determined by the clearing house	Closing futures price as determined by the clearing house
Booking Fee Charges By SAFEX	R34.20/contract	R17.10/contract

Source: http://www.SAFEX.co.za (1999)

Wherever there is price volatility, there is a potential need for futures contracts. Whatever the commodity underlying the futures contract, every market needs certain ingredients to flourish. These include (http://www.fiafii.org/tutorial.htm):

- Risk-shifting potential: The contract must provide the ability for those with price risk in the underlying commodity to shift that risk to a market participant willing to accept it.

- Price volatility: The price of the underlying commodity must change enough to warrant the decision to shift price risk.

- Cash market competition: The underlying commodity market must be broad enough to allow for healthy competition, which creates a need to manage price risk and decreases the likelihood of market corners, squeezes or manipulation.

- Trading liquidity: Active trading is needed so that sizeable orders can be executed rapidly and inexpensively.

The mechanics of futures trading are straightforward. Both buyers and sellers deposit funds with a brokerage firm. As indicated in Figure 4.4, if a producer goes long (buys) a futures contract and the price goes up, the producer gains by the amount of the price increase times the contract size. If the price decrease, the producer loses an amount equal to the price decrease times the number of contracts.

Figure 4.4:   Payoff diagram of a long futures position

Source: http://www.fiafii.org/tutorials/htm
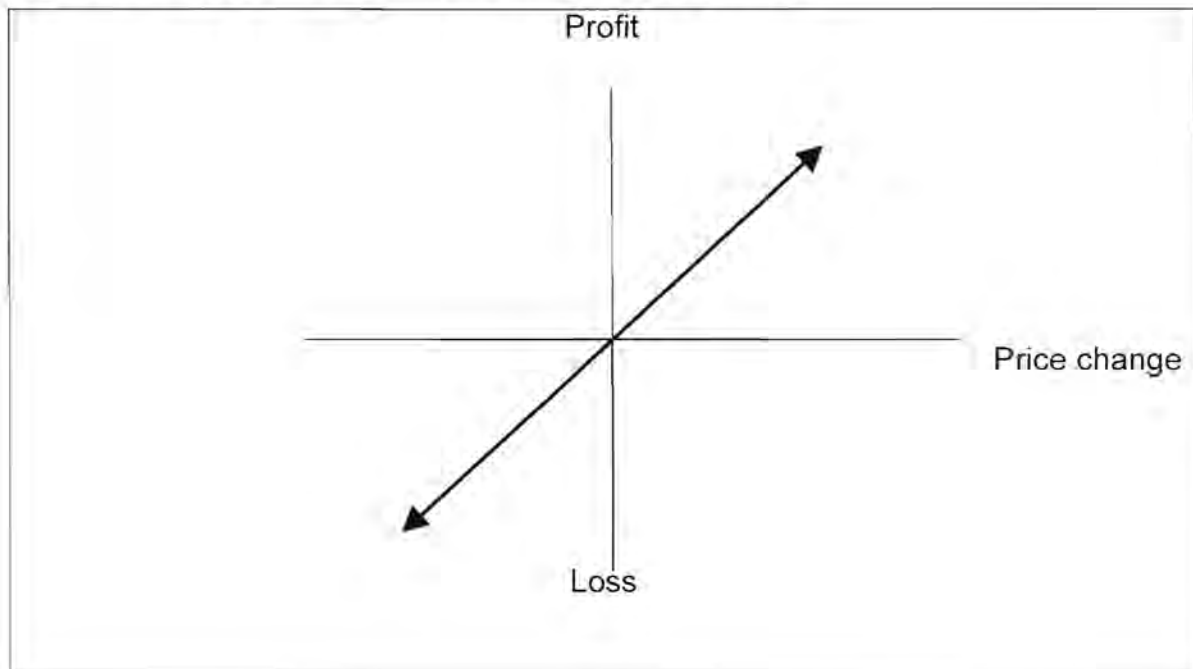
Figure 4.5 reflects the profit and loss potential of a short futures position. If a producer goes short (sells) on a futures contract and the price goes down, the producer gains by the amount of the price decrease times the contract size. If a producer sells and the price goes up, the producer loses an amount equal to the price increase times the contract size. These profits and losses are paid daily via the futures margining system.

Figure 4.5: Payoff diagram of a short futures position

Source: http://www.fiafii.org/tutorials/htm
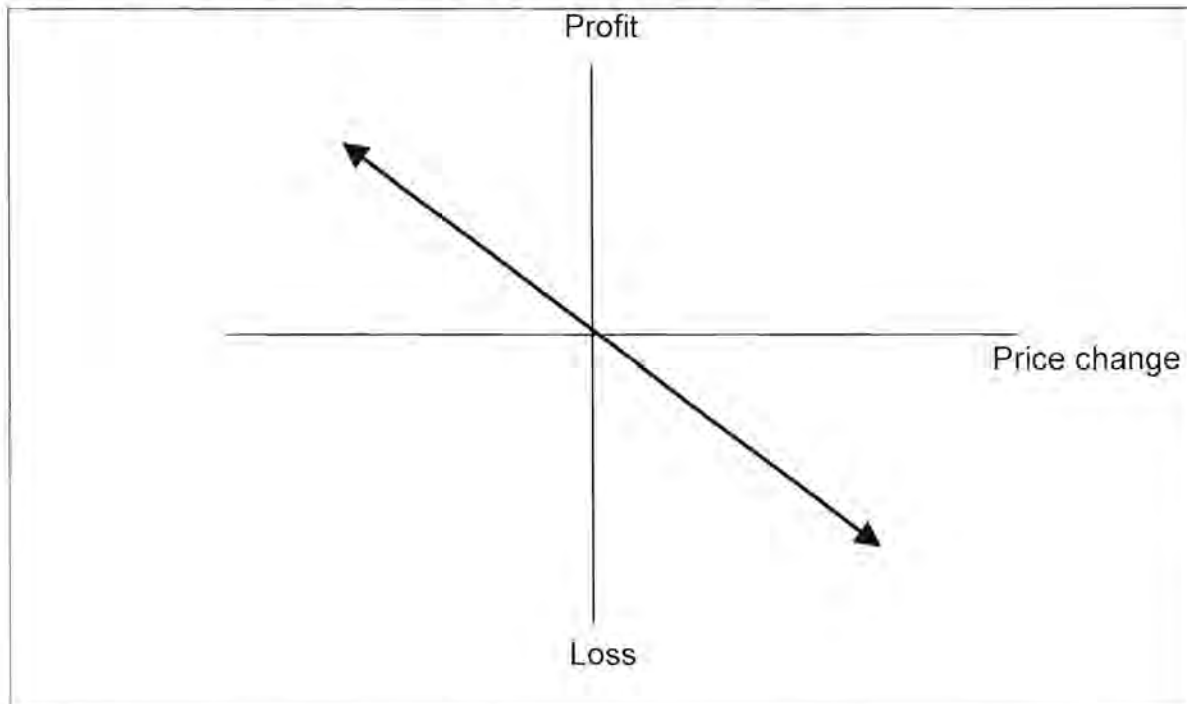
The futures price reflects the price at which buyers and sellers are prepared to buy and sell the commodity contract for a future month. The futures price therefore reflects a consensus of market opinion. It combines the opinion of a producer, for instance, who expects a smaller crop because of damage caused by wind and heavy rains, with the opinion of another producer who expects a bumper crop, with the opinion of a feed manufacturer who expects the demand for maize (for example) to be higher because of herd expansion after good rain, and the opinion of a grain trader who expects a good USA crop and changes in the statutory maize marketing scheme (Battley, 1989). The futures prices is therefore a forecast of what the spot price of the commodity will (probably) be for a given future month, based on currently available information. The futures price reflects the price of the commodity, the levy, storage and handling cost paid for delivery in the month the futures contract expires.

White and yellow maize futures contracts on the South African Futures Exchange (SAFEX) are both initially traded for five months – March, May, July, September and December. During 1999, SAFEX expanded the futures trading to the other months, January, February, April, June, August, October and November. The futures price for each successive month in the production season is usually higher (all other variables being constant) than the preceding month by the amount of storage and finance charges. Figure 4.6 indicates the hypothetical futures prices during a marketing season.

Figure 4.6: Hypothetical futures prices over time
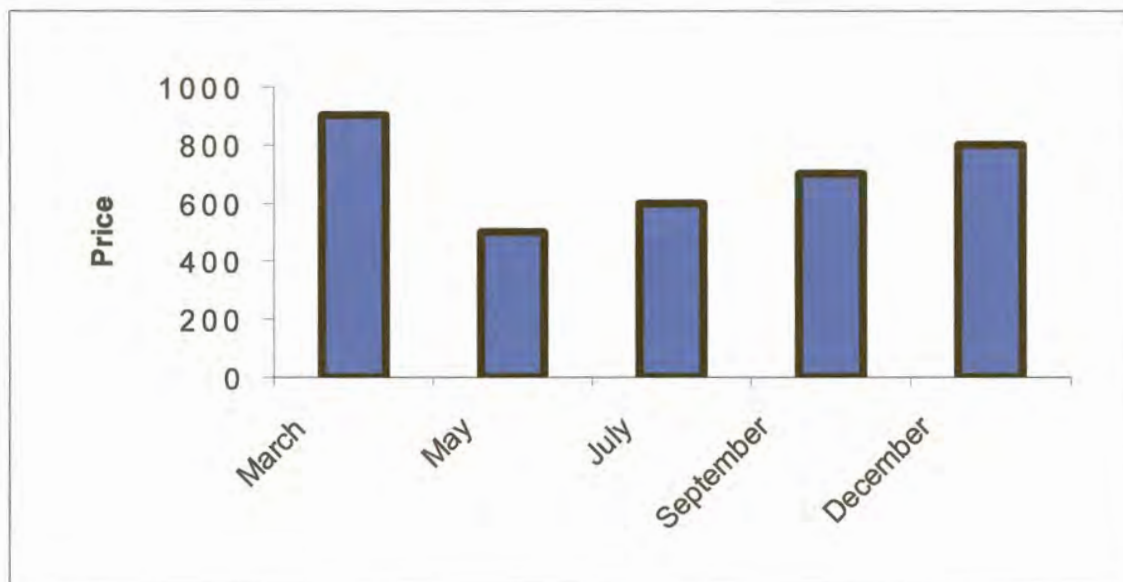
The futures price for March, the last month of the maize marketing season, may differ sharply from the price for May and July. March reflects 'old-crop' which may be in short supply, while May and July reflect the incoming 'new crop', which may be expected to have a depressing effect on maize prices.

To avoid unwarranted swings in prices, the markets establish maximum daily price fluctuations. As soon as these limits are reached, the market closes for the rest of that day. In South Africa, this is R30 per ton for the first two days, and

R45 per ton for the third day. After the third day, there is no price limit, the prices can increase or decrease by more than R45 per ton per day without interference by SAFEX. The limit refers to price changes, up or down, during a trading day relative to the closing or settlement price of the previous trading day. The rationale is to allow re-assessment of market fundamentals overnight and avoid unfounded panic on any given market day. If the market moves the limit in the same direction in the following days, the limit is removed, based on the logical assumption that the fundamentals justify the fact that the market is seeking its new level.

The primary difference between a futures contract and a forward contract is that the futures contract is marked to market on a daily basis (Kolb, 1999). Marked to market means that the net profit or loss on each client's open position is recalculated at the end of each trading day. Funds are withdrawn from or deposited into the clients margin account so that the balance reflects the client's net profit or loss.

There are several advantages and disadvantages associated with the use of futures contracts to hedge against price risk. According to Eales (1995), the advantages are the following:
- the contract size, underlying commodity and delivery dates are standardised;
- the market is transparent and reflects all available information;
- the market is highly liquid, which generates small bid-offer spreads;
- the market is regulated by rules laid down by the exchange; and
- it is easy to buy and sell contracts through a broker.

The disadvantages of a futures contract are the following (Eales, 1995):
- an initial and maintenance margin is required, resulting in greater cash flow needs;
- exchange trading hours may be limited;

- if maximum price movement limits are reached, futures contracts may become totally illiquid at short notice;
- there is a basis difference between spot market and futures market instruments; and
- dealing is restricted to members of the commodity exchange (dealing can only be done through a broker).

It is imperative that each producer should consider the advantages and disadvantages of every instrument before venturing into any contract. Table 4.2 compares the differences between forward contracts (cf. Chapter 3) and futures contracts.

Table 4.2:   Forward contracts versus futures contracts

	Forward contract	Future contract
Contract size	Negotiable	Standardised
Delivery date	Negotiable	Standardised
Trading locations	OTC dealer-type markets	Futures exchanges
Contract guarantee	None	By the clearing house of the commodity exchange
Price determination	Negotiated private by buyer and seller	Price determined in an auction-type market
Cash flows	Infrequently. Often at the end of delivery date	Daily, as the contract is marked to market
Security deposits	No clearing house. Depends on the credit relationship between buyer and seller	Buyers and sellers post initial margins with daily settlements. Clearing house guarantees fulfilling futures contract obligation
Frequency of delivery	Most are held to term	Some are held to maturity
Regulation	Self-regulated	Regulated

Source: Hull (1998)

4.6   MARGIN REQUIREMENTS

The mechanics of futures trading are straightforward. Both buyers and sellers deposit funds (traditionally called a margin) with a brokerage firm through whom they buy and sell the contracts. This money is not a down payment on borrowed capital, but more a kind of good faith payment that serves as an insurance to ensure contract compliance (Ferris, 1998). The price at which futures contracts are traded is guaranteed through a system of margining.

The commodity exchanges set initial and variation (or maintenance) margin levels for each contract. The initial margin is the amount required to be deposited when a position is initiated. The initial margin is based on historic price movements and is paid by both the buyer and seller of a futures contract. At the close of each trading day, the profits or losses are added or subtracted from the client's margin account. If the net amount is below the maintenance level, a margin call is issued for the amount needed to bring the total margin back to the initial level (Herbst, 1986). Figure 4.7 illustrates hypothetical margin account behaviour for a short futures position over 15 days (Eales, 1995):

Figure 4.7:   Hypothetical short futures margin account behaviour
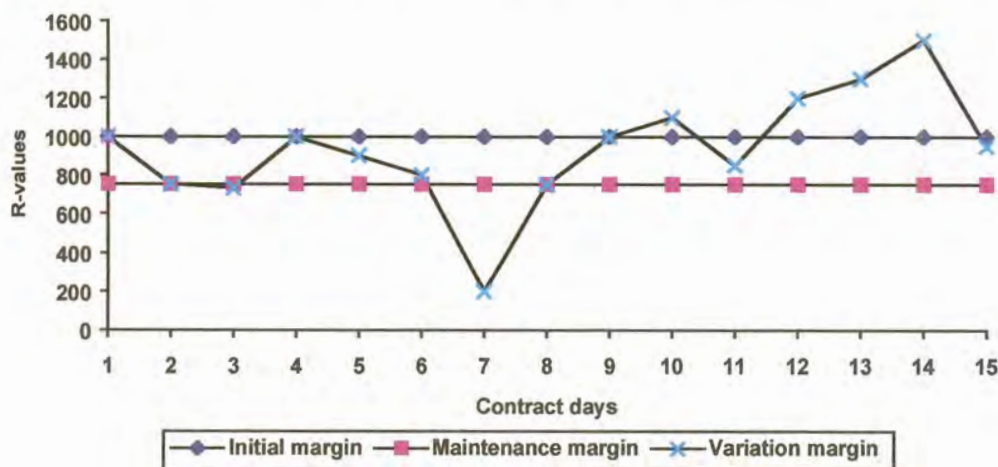
In the above figure, the maintenance margin represents 75% of the initial margin. As soon as the account moves beneath the maintenance margin, the investor should top it up, if not, the position is closed and the investor receives the difference of the margin and will no longer have a futures position. As soon as the account moves above the initial margin of R1000, in the above example, the investor can then withdraw the excess balance over the initial margin. The performance period of futures contracts is one trading day. Futures contracts are marked to market and settled at the end of every business day (the

performance period is reduced to a single day). On each trading day, gains are credited or losses debited to the customer's margin account (in cash) as the futures position increases or decreases in value.

Closing out a position involves entering into an opposite trade to the original one. For example, an investor who buys five July maize futures contracts on 6 May can close out the position on 20 June by selling five July maize futures contracts and *vice versa*. Producers successfully hedge their position against a price fall by trading futures contracts at a level which covers their production costs and locks in a return on the investment. When producers close out their positions at a price of the futures contracts which reflects the expected surplus of maize on the market at around the expiry time of the contracts traded, their margin accounts would reflect the initial margin paid by the producers plus the variation margin paid into their accounts by the long position holders. When producers decide not to close out their position but deliver on the futures contract, they receive the initial margins paid by themselves, the variation margin paid by the long position holders and the value of the maize delivered to a SAFEX approved silo determined by the closing futures price on the day prior to delivery of the SAFEX silo receipts.

According to Fraedrich (1998), the cost of initial margin and the possible risk of margin calls are potentially important. If changes in futures prices are approximately a random walk, then the income or costs associated with changes in the value of the contract are about close to zero on average. Previous studies that have included margin costs have found them to be a small component of hedging costs (Alexander, 1986; Nelson, 1985). A prudent hedger would want to establish a line of credit for the greater part of the margin risk exposure, not just for the initial margin. Margin calls on anticipatory hedges are most likely to occur as yield expectations decline (and prises rise). The appreciation in the spot price is meaningless if a producer does not have any crop to sell. Thus, a lender has

good reason for not extending credit for margin calls. In such situation, a producer may want to offset the futures position (Tomek, 1981).

4.7 BASIS

The difference between the spot prices of commodities and the prices of the related futures contract is referred to as the basis (Purcell, 1991). Every town where crops traded on SAFEX are produced has its own basis. The basis consists of two main components, namely differences in location, reflected in transport costs, and differences in time, reflected in storage costs. Figure 4.8 indicates a hypothetical spot price - futures price basis over time.

Figure 4.8: Hypothetical spot-futures basis over time
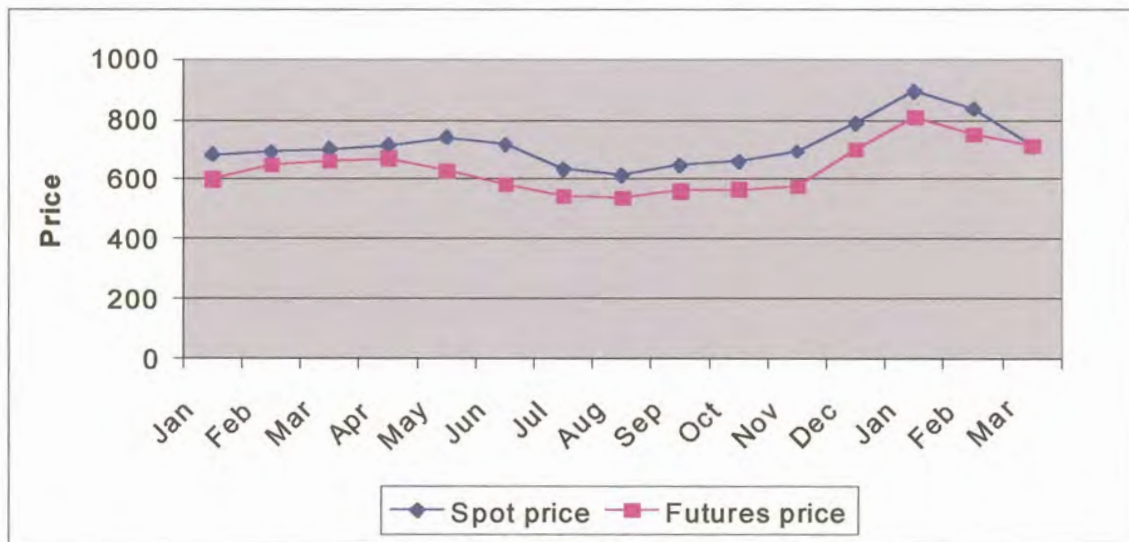
The formula to calculate basis is the following:

Basis = Spot price - Futures price

A negative basis implies that the futures price is greater than the spot price, and a positive basis implies that the futures price is less than the spot price. The hedger (the party with the long position in the commodity and the short position in the futures contract) profits if the basis gets smaller and loses if the basis gets larger. Figure 4.8 shows that, during harvest, a strong basis characteristically occurs that narrows from harvest time into the expiration of any upcoming futures contract and converges to the spot price of the underlying commodity. When the delivery period is reached, the futures price equals or is close to the spot price (Hull, 1998). The extent to which the basis narrows varies from year to year, depending on fundamental factors influencing supply and demand on the market.

The spot-futures basis is subject to a variety of influences, including seasonal factors, weather conditions, temporary gluts or scarcities of commodities, and the availability of transport facilities. Additional factors affecting the relationship between spot and futures prices are costs related to carrying such commodities and includes interest rates, storage cost and silo fees. The basis is an indication of local demand, affecting prices offered for commodities. When local users offer a price which result in a weaker than normal cash basis, local users indicate that supply is adequate. The users buy the crop, but only after deducting the full cost of storage from now until the time they can use or move the crop. Abundant supplies contribute to the wide basis at harvest time.

For maize to be harvested from June onward, the producer needs to have information on the spot futures basis using the July futures. For wheat to be harvested in November, the spot futures basis levels using the December futures are useful. From early in the year, even before the crop is planted, a maize producer can, for example, monitor the July futures to see what forward price the futures market is offering. As was stated in Chapter 3, the forward price is defined as:

Forward price = futures contract price + basis

The harvest-period basis, reflecting the July futures, is used to adjust or localise the quote coming from SAFEX. For example, at a location which normally delivers its maize to Randfontein (all futures contracts are priced at Randfontein basis, but can be delivered to any SAFEX silo), the local spot price of maize in January is likely to be below the March futures price by the cost of transporting maize to Randfontein plus the carrying charges for storing maize from January to March. Thus, if the transport cost is, for example, R41/t and the carrying charges are R20/t, the local spot price might be below the March futures price by a total of R61/t.

The hedger (the person with the long position in the commodity and the short position in the futures contract) profits if the basis gets smaller and makes a loss if the basis gets larger. The opposite is true for the speculator. The hedger has not eliminated all risk but has instead replaced price risk with basis risk. Basis risk is the risk of varying fluctuations of the spot and the futures price between the moment at which a position is opened and the moment at which it is closed (Herbst, 1986). Basis risk goes to zero if the hedge is maintained until the maturity date of the futures contract. Basis risk arises from unpredictable movements in the basis for shorter hedge holding periods. There are four primary sources of basis risk (Kruger, 1991), namely:

- changes in the convergence of the futures price to the spot price;
- changes in factors that affect the cost-of-carry;
- mismatches between the exposure being hedged and the futures contract being used as the hedge; and
- random deviations from the cost-of-carry relation.

Tracking basis information is also important for producers who market their commodities through the spot or futures market. When the basis strengthens,

the market encourages spot sales. When the basis weakens, the market discourages spot sales and encourages storage.

4.8 HEDGING WITH FUTURES CONTRACTS

In contrast to speculators, a hedger is a person who enters the futures market in order to reduce a pre-existing risk. A hedger is therefore someone who has an interest in selling or buying the actual commodity. A seller is interested in pre-pricing a product (for example, maize) that will be for sale in the future in order to avoid a price decline. A buyer is interested in pre-pricing maize needed at some time in the future in order to avoid a price increase. A speculator is someone who has no interest in the actual commodity. The speculator is interested solely in profiting from the price movement. The threat of delivery or the threat of demanding delivery prevents speculators from controlling the market and ensures that there is an orderly relationship between the spot and futures market.

A hedge is a method of decreasing the risk of holding a cash position by taking an offsetting position in the commodity or futures market (Rinehimer, 1986). According to Rinehimer (1986), there are two basic types of hedge transactions. A short hedge involves ownership or purchases of a cash commodity and the subsequent or simultaneous sale of an equivalent quantity of futures. A long hedge involves the purchase of futures to protect against a possible price increase of the actual commodity prior to its physical delivery. In futures markets hedging involves taking a futures position opposite to that of a spot market position. That is, a producer would sell maize futures against the crop. This means that the producer will sell a contract and then, before it expires, buy a contract to close the position in the market. A producer does not trade directly on the futures market, but appoints a broker to do so on the producer's behalf.

The producer will therefore have to make provision for broker's commission. The financial implications of futures market transactions are illustrated by means of the following example:

Example 1: Financial implications of futures market transactions

Mr Bright is a maize producer and wants to use the futures market to hedge against price risk. Mr Bright instructs his broker to sell ten July 2001 white maize contracts at R600/ton on 1 December 2000.

Mr Bright will initially have to pay R72 000 for the transaction, R70 000 of which can be regarded as a 'deposit' on his SAFEX account. This amount comprises the following:

Initial margin	R70 000
	(R7 000/t * 10 contracts of 100 ton)
Brokerage	R2 000
	(For example: R2/t * 10 contracts)

When Mr Bright closes his position (buys back the contract), brokerage costs have to be paid. This amount (R72 000) is the minimum that will be required. Should the price of maize rise by R1/ton, it would mean a loss of R1 000 that Mr Bright will have to pay in on his initial margin. If the price of maize decreases by R1/ton, Mr Bright will receive the R1 000 in his margin account and no margin calls will be addressed to him. The margin account bears interest on a daily basis.

Prices decrease

On 30 June 2001, a July 2001 white maize contract trades at R500/t and Mr Bright decides to close his position by buying back 10 contracts.

1/12/00	
Sell 10 WMAZ contracts @ R600/ton	
Initial margin	(R70 000)
Brokerage	(R2 000)
30/06/01	
Buy 10 WMAZ contracts @ R500/ton	
Repayment of initial margin	R70 000
Payment of profit (R600 -R500 * 10 contracts)	R100 000
Brokerage	(R2 000)
Sell maize on spot market @ R500/ton	R500 000
Profit realized	**R596 000**

Prices increase

Suppose that the July white maize price increased to R650/ton. The net effect of the hedge transaction will be as follows:

1/12/00	
Sell 10 WMAZ contracts @ R600/ton	
Initial margin	(R70 000)
Brokerage	(R2 000)
30/06/01	
Buy 10 WMAZ contracts @ R650/ton	
Repayment of initial margin	R70 000
Payment of loss (R650 -R600 * 10 contracts)	(R50 000)
Brokerage	(R2 000)
Sell maize on spot market @ R650/ton	R650 000
Profit realized	**R596 000**

The producer locked in a price to protect himself from any possible future price decreases. If the price increases, the producer cannot gain from the higher price, but is at least protected from any possible price decrease.

4.9 CONCLUSION

Changes in the marketing mechanisms of South African grains since 1995 have created considerable interest in marketing strategies based on futures and options markets to enhance the income of crop producers. These marketing contracts are important tools for managing price and income risk in the volatile environment of the new century. Successful use of such tools requires a complete understanding of how various contracts function, the kinds of risk they are designed to control, and the areas of risk that remain after the contract has been signed.

Hedging in organised futures markets has clear benefits in terms of transferring risk and assuring competitive returns identified by existing price relationships. Forward markets cannot provide above average returns for all producers. Any claim that hedging in futures can provide above-equilibrium prices is mere fiction.

The benefits of using organised markets have a cost. These costs may be relatively large for individual producers. Transaction costs, including margins, can be large. The complexity of the contracts may affect the returns from the hedge. Producers may perceive futures as complex instruments that have high costs in terms of a scarce management resource.

Today's prices in the futures market reflect the current consensus opinion of the market of what the underlying commodity will sell for at a specified time some months in the future. The participants determine the price based on their best

estimates on the balance of supply and demand for the commodity in the future. These estimates are derived from the currently available information. All new information that has any influence on these projections is reflected in the price almost instantly. The above phenomenon is referred to as the efficient market hypothesis.

The following conclusion can be reached if one accepts the efficient market hypothesis: whilst individuals can beat the market, few can consistently do so. One implication is that, with few exceptions, the crop producers who survive are those who manage price risk above production cost since efforts to improve revenue through better marketing will have limited success. Marketing strategies can assist in managing price risk and therefore add to the net crop revenue.

Theoretically, in the absence of any supply/demand imbalances, the future price of a commodity should be equal to the spot price of the commodity today, plus storage, interest, insurance and any other related expenses. The spot futures basis is extremely important to decision-makers. Looking at the behaviour of spot prices versus the nearby futures prices can provide an indication of the strength of demand in the spot market. The expected basis at harvest allows producers to monitor the forward price offered by local buyers and gives a means of comparing forward contracts with futures contracts for delivery during harvest. Storable products should be placed in storage when the projected basis improvement exceeds the cost of carrying the product.

However, futures seldom trade at the 'theoretical' price. The projected imbalance of supply and demand causes the futures price to deviate. All new information is discounted and reflected in the current price. Futures markets are very dynamic and change rapidly. The risks associated with commodities trading underscore the challenges of decision-making under uncertainty and the large number of factors that affect supply/demand imbalances. For instance, if current estimates

of supply and demand figures, locally and overseas, for three months from now show that the commodity will be in short supply, the futures price rises above the current expected price. The price differential encourages storage of the commodity. Prices in the spot market rise and the current demand is reduced through lower usage and substitution. If, on the other hand, an abundance of the commodity is projected, the futures price declines and discourages storage. Prices in the spot market decrease and attract new sources of consumption.

Producers have to consider a number of factors such as domestic production, competing foreign production, current levels of grain stocks in storage, seasonality in production, and exchange rates when they estimate the available supplies of the commodity and expected prices. Changes in weather conditions influence prices on a daily basis. The markets pay due attention to supply estimates from production. After the harvest, when the crop is stored, the focus shifts to the demand side of the equation. All forms of usage such as domestic demand, the state of the domestic economy, export demand and seasonality factors have a direct influence on prices. It is nearly impossible for producers to keep track of all this ever-changing information and the futures market is a tool to help producers manage their price risk.

Futures and option contracts support producers in managing price risk at a level above the break-even price, that is the minimum price that producers can accept to ensure that all input costs are covered by the expected market price. The next chapter explains the basics of option contracts and how option contracts can be used to manage price and investment risk for crop producers in South Africa.

CHAPTER 5

OPTIONS ON FUTURES CONTRACTS

We may never conquer the future, but we can see ways to better manage both the change and the uncertainty.

- Bill Flory

5.1 INTRODUCTION

The volatility of agricultural commodity prices makes marketing just as important as production. It is vitally important that a producer should protect himself/herself from downside price risk. A marketing strategy that allows the producer to capitalize on rising prices is beneficial as long as it enables the producer to meet price objectives and stay within the range of financial risk and cash flow ability.

Producers must continually search for new marketing instruments to help them cope with increased price variability and meet the growing need to be competitive in a global marketplace. The ability to use a diverse set of marketing instruments helps producers to optimize price and production risk while striving to achieve their financial goals and objectives. Options give the agricultural industry a flexible pricing tool to assist in price risk management. Option contracts offer a type of insurance against adverse price movements, require no margin deposits for buyers, and allow buyers to participate in favourable price moves. Commodity options can be adapted to a wide range of commodity pricing situations. For example, agricultural producers can use commodity options to establish an approximate floor price for their crops. Millers can also use commodity options to establish an approximate ceiling price. Given today's

large price fluctuations, the financial payoff of controlling price risk to protect profits can be substantial.

In the previous chapters, various marketing instruments available to producers to manage price risk have been discussed. In this chapter, options on futures contracts are explained as a price risk management instrument in agriculture. The options on futures contracts explained in this chapter refers to commodity option contracts. This chapter briefly explains the historical development of option contracts, different types of option contracts, factors affecting premium values, the pricing of options, risks associated with options, and option strategies available to producers. The chapter also briefly explains swaps and spreads as alternative marketing strategies in the agricultural sector.

5.2   HISTORICAL DEVELOPMENT

The practice of options trading in agricultural commodities is not a new phenomenon. Options were traded as 'privileges' in the late 1800's and grew into options markets in the USA. These markets were not yet regulated properly to protect buyers, and sellers and were banned in the USA during the early 1930's. This ban on options in agricultural commodities remained in place until the Futures Trading Act became law in the USA during 1982.

In South Africa, options on equities have been traded on the Johannesburg Stock Exchange since the end of the last century. Initially, only European type, non-transferable options were traded; later, fixed-interest securities were added. Since 1984, the trading activities with regard to options have escalated dramatically. The first agricultural options started trading on SAFEX during March 1998. The agricultural option market experienced excellent growth with

11 504 contracts traded in February 2000, an improvement of 369.55% from February 1999 to February 2000 (http://www.safex.co.za, 2000).

5.3   OPTIONS ON FUTURES CONTRACTS

An option contract is simply the right, but not the obligation, to buy or sell a futures contract at some predetermined price within a specified time period. Essentially, commodity options provide the 'opportunity', but not the 'obligation' to sell or buy a commodity at a certain price.   In the case of options on futures contracts, the underlying commodity is a futures contract and not the physical commodity. If the futures price changes in favour of the option holder, a profit may be realised either by exercising the option or selling the option at a price higher than originally paid.   If prices move so that exercising the option is unfavourable, then the option may be allowed to expire.   The contract specifications of put and call options traded on SAFEX are set out in Table 5.1.

Table 5.1: Contract specifications of put and call options

OPTIONS CONTRACT	WHITE MAIZE	YELLOW MAIZE	WHEAT
ATS Code			
Trading Hours	09:00 to 12:00	09:00 to 12:00	09:00 to 12:00
Underlying Instrument	1 White Maize futures contract	1 Yellow Maize futures contract	1 Wheat futures contract
Options	American type, puts and calls	American type, puts and calls	American type, puts and calls
Strike Price Intervals	R20.00 per ton	R20.00 per ton	R20.00 per ton
Quotation	In whole Rand per contract	In whole Rand per contract	In whole Rand per contract
Contract Months	March, May, July, September and December	March, May, July, September and December	March, May, July, September and December
Expiration Date and Time	12:00 on the fifth last trading day of the month preceding the expiration month of the underlying future contract	12:00 on the fifth last trading day of the month preceding the expiration month of the underlying future contract	12:00 on the fifth last trading day of the month preceding the expiration month of the underlying future contract
Exercise	Long position holders may exercise their options during market hours at any time up to and including the expiration date; provided that all in-the-money options shall be automatically exercised by the exchange at expiration	Long position holders may exercise their options during market hours at any time up to and including the expiration date; provided that all in-the-money options shall be automatically exercised by the exchange at expiration	Long position holders may exercise their options during market hours at any time up to and including the expiration date; provided that all in-the-money options shall be automatically exercised by the exchange at expiration
Expiration Price (for automatic exercise)	Mark to market price of the underlying future on expiration date	Mark to market price of the underlying future on expiration date	Mark to market price of the underlying future on expiration date
Calculation Of Mark To Market	Mark to market prices will be calculated from volatility quotes for at-the-money using the Black options pricing model	Mark to market prices will be calculated from volatility quotes for at-the-money using the Black options pricing model	Mark to market prices will be calculated from volatility quotes for at-the-money using the Black options pricing model
Volatility Scanning Range (for margining)	3.5%	3.5%	3.5%
Clearing House Fees	R17.10 per contract	R17.10 per contract	R17.10 per contract

Source: http://www.safex.co.za(1999)

The biggest difference between options and minimum price contracts (cf. Chapter 3) is, that in the case of options, the producer can decide whether the option should be exercised. This is not the case with minimum price contracts. Options provide protection against adverse price movements, while allowing option holders to gain from favourable cash price movements. In this sense, options provide protection against unfavourable events similar to the type of protection provided by insurance policies. To gain this protection, a hedger in an options contract must pay a premium, as one would pay for insurance.

There are two types of options: puts and calls. A **put** is a contract that gives the holder the right to sell a specified commodity at a specific price any time before the contract matures. A **call** is a contract that gives the holder the right to buy a specified commodity at a specified price any time prior to contract maturity (http://www.safex.co.za, 1999). The option buyer (holder) is the person who obtains the rights conveyed by the option. The option seller (grantor or writer) is the person who grants the rights contained in it. The option buyer pays a premium for the right to obtain the contract, and the option seller receives the premium paid by the option buyer for the risk taken by the seller. The option seller must maintain a margin account (a good faith deposit which serves to guarantee due performance) at the clearing house. For every purchase of a put option, there is a sale of the same put option. The put option buyer receives the right to sell a specified commodity at a specified price, and the option seller is obliged to buy the commodity at that price. For every purchase of a call option, there is a sale of a corresponding call option. The call option buyer receives the right to buy a specified commodity at a specified price before the contract matures. If the call option buyer exercises the option, the option seller is obliged to deliver the commodity and receives the price paid (strike price) by the option buyer. A put and a call are not opposite sides of the same transaction. Figure 5.1 presents this concept.

Figure 5.1: Flow diagram of put and call options

	Options on futures contracts	

Put		Call	
Buyer has right to sell futures if he/she chooses to exercise	Seller obligated to buy futures contract if option is exercised	Buyer has right to buy futures if he/she chooses to exercise	Seller obligated to buy futures contract if option is exercised
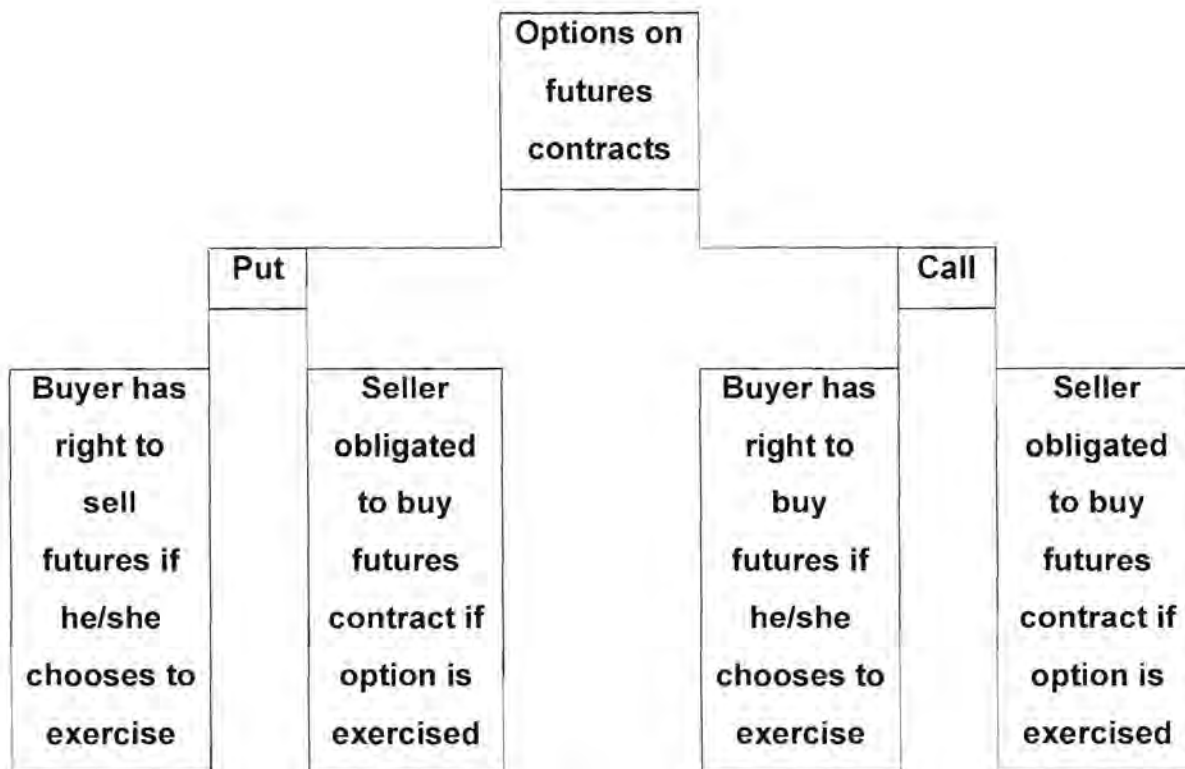
Source: Adapted from http://www.ianr.unl.edu (1999)

The specified price is called the exercise or strike price. The bidding is manifested in the option premium, which is the market value of the option. A buyer pays the premium for the right to sell or buy futures on commodities at the indicated strike price. At any time before the option expires, the option buyer can exercise the option. The expiration dates for commodity options traded on SAFEX are set out in Table 5.2.

Table 5.2:   Expiry dates for option contracts traded on SAFEX

Contract month	Expiry dates
July	12:00 on 5th last trading day in June
September	12:00 on 5th last trading day in August
December	12:00 on 5th last trading day in November
March	12:00 on 5th last trading day in February
May	12:00 on 5th last trading day in April

The buyer of a put option can convert an option position into a short (selling) futures position, established at the strike price, by exercising the put option. If the buyer exercises the option, the option seller is obliged to take the opposite futures position at the same strike price. The option seller receives the premium from the option buyer. Because of the seller's obligation, when the option contract is exercised, to take a commodity futures position, an option seller must post a margin to ensure due performance. Figures 5.2 and 5.3 show the payoff profiles for a call and put option (both including premiums) from both the buyer and the seller's side.

Figure 5.2: Payoff profile of a call option on a commodity futures contract
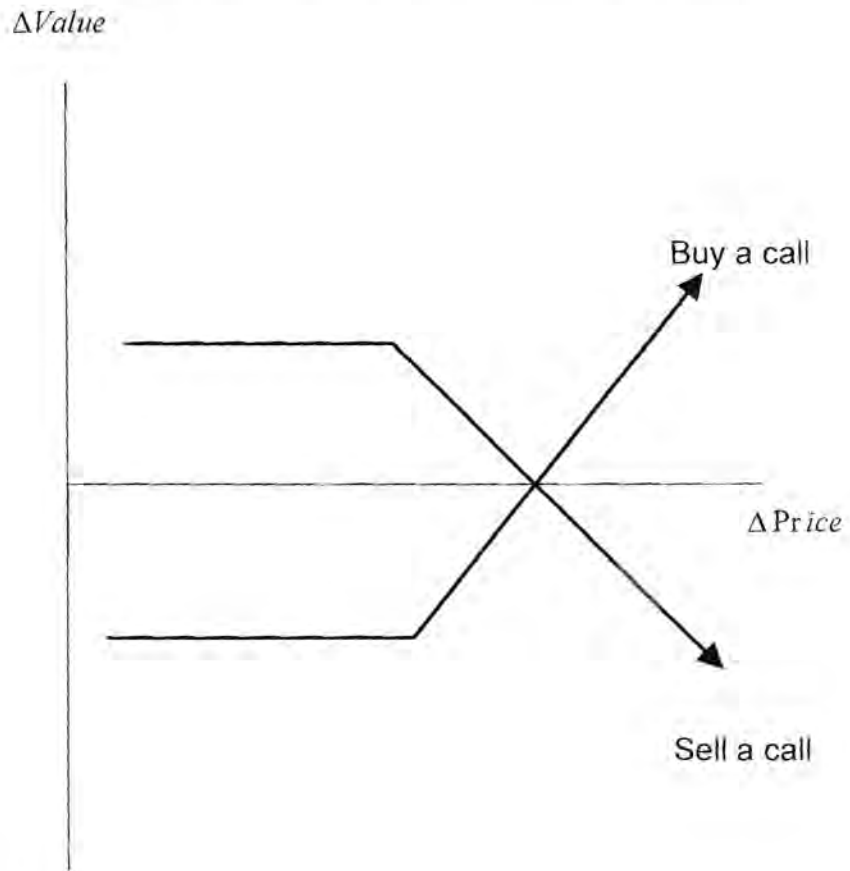
Source: Ross *et al.* (1996).

If the underlying futures price rises above the strike price, then the owner of the option will exercise it and enjoy a profit, whereas the seller of the option contract will realise a loss. If the underlying futures price decreases, the long call option contract will expire worthless and the seller of the option will profit from the premium received from the buyer (long) of the call option.

Figure 5.3:   Payoff profile of a put option on a commodity futures contract

$\Delta Value$

Sell a put

$\Delta \mathrm{Pr}ice$

Buy a put
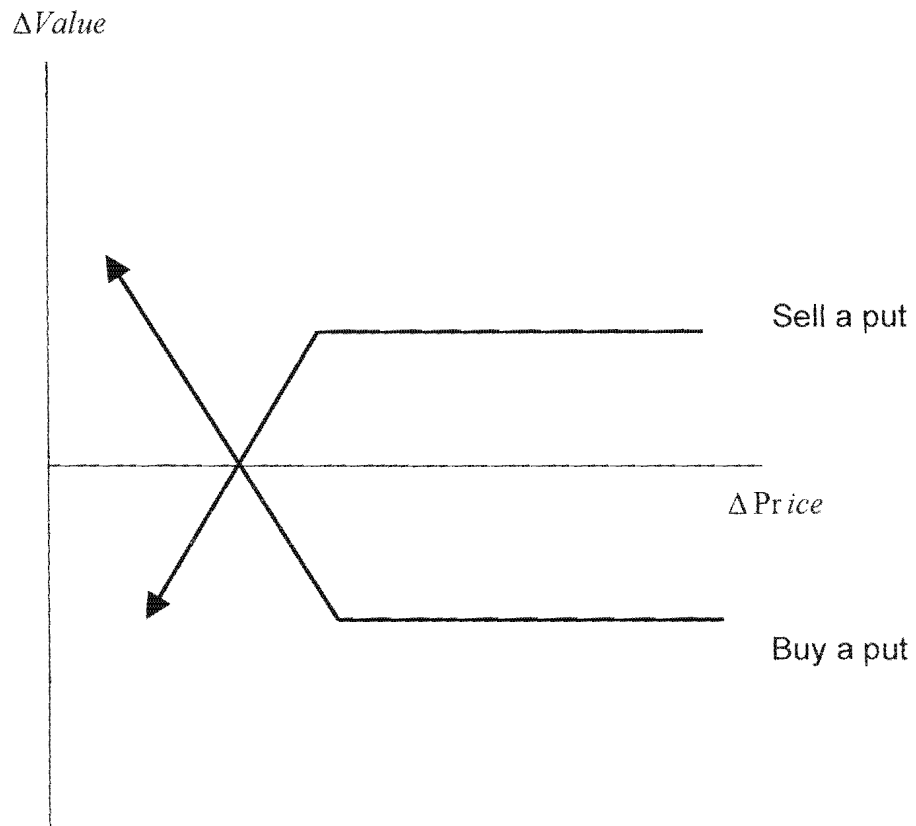
Source: Ross *et al.* (1996).

If the underlying futures price falls below the strike price, the buyer profits. The long option expires worthless with a price increase.

The intrinsic value of an option is the amount that the buyer would recover if the option is exercised immediately (Ferris, 1998). If a hedger decides to minimise price risk by hedging with options, the first question to consider is the strike price (the price at which the underlying futures contract can be bought in the case of a call, or sold in the case of a put). Options are classified into three categories, depending on the underlying relation between the exercise (strike) price and the current market price of the asset. These categories are the following (Hull, 1998; Kolb, 1997; Chance, 1989):

- In-the-money options are options that have intrinsic value, for instance, a put option with a strike price higher than the current spot price or a call option with a strike price lower than the current spot price.

- At-the-money options are those options with a strike price at the current spot price.

- Out-of-the-money options are those options that have no intrinsic value – a put option with a strike price lower than the current spot price or a call option with a strike price higher than the current spot price.

Whether an in-the-money or out-of-the-money option is purchased depends on the level of price insurance desired. An in-the-money option offers more price insurance (a higher price ceiling for a producer), but the premium paid is higher. Conversely, an out-of-the-money option offers less price insurance, and costs less.

To indicate the difference between a futures contract and an option on a futures contract, a comparison between futures and option contracts is necessary. Figure 5.4 indicates the effects of a change in price on commodity futures on the profits of long and short positions in futures.

Figure 5.4: Effects of changes in commodity futures prices on profits
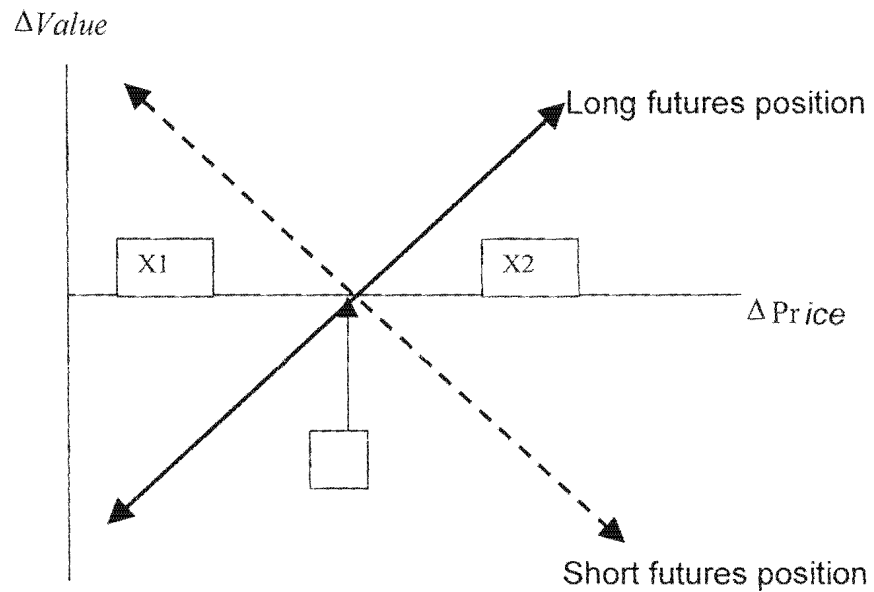
Source: Ferris (1998)

Profits on long positions (buy) are directly related to changes in futures prices, while profits on short positions (sell) are inversely related. If the futures price moves from Y to X1, the short position will realize a profit (Y - X1) and the long position will realize a loss (X1 - Y). If the futures price increases to X2, the long position will realize a profit (X2 - Y) and the short position will incur a loss (Y - X2). Figure 5.5 indicates the relationship between a change in the futures price after a position has been taken in the option market and subsequent profits at expiration.

Figure 5.5:   Effects of changes in commodity futures prices on profits in options
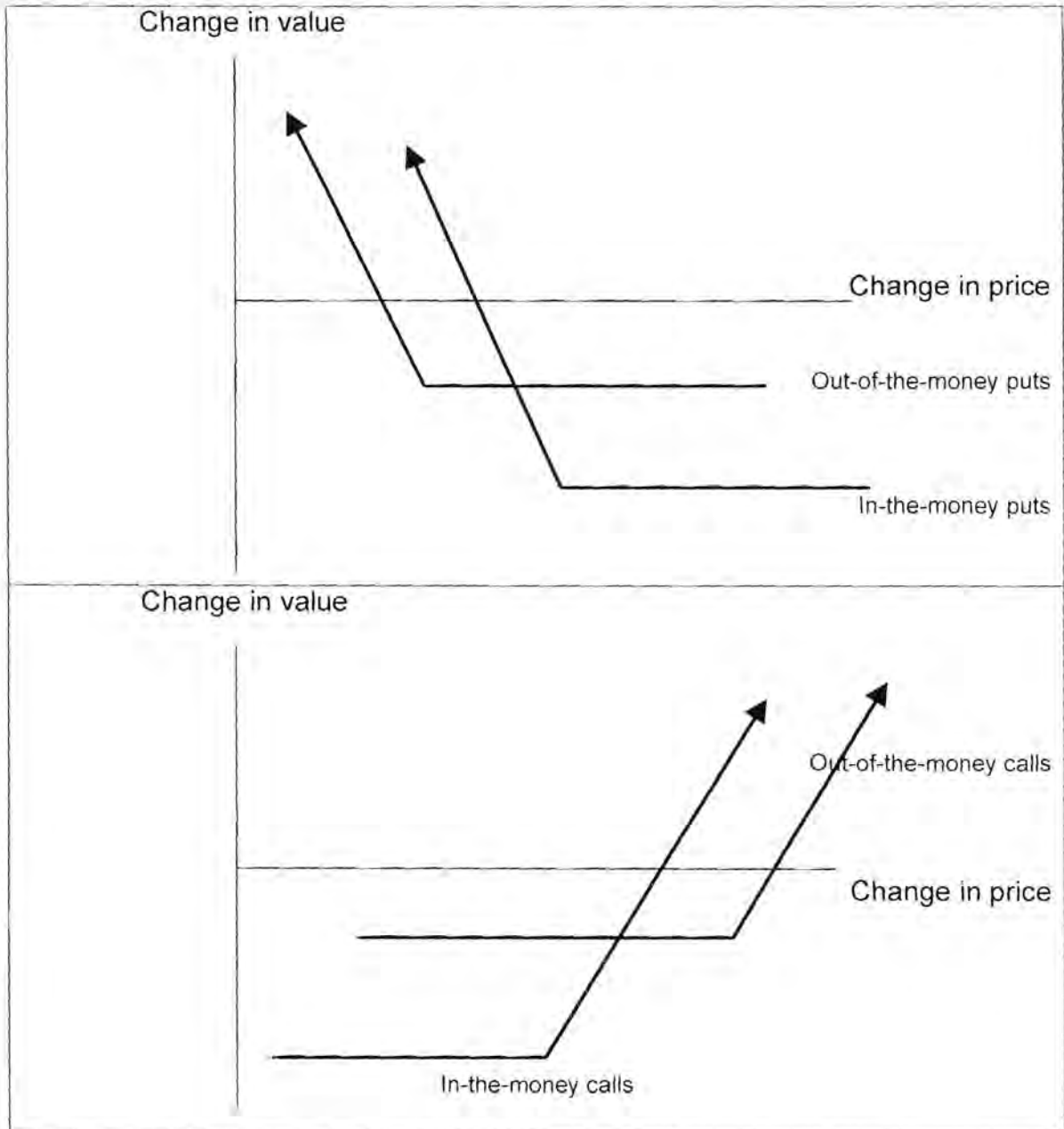
Source: Ferris (1998)

When the prices on the underlying futures decline, the right to sell at a given strike price becomes more valuable for a put option. If the additional value at expiration exceeds the premium paid by the buyer for that right (plus

commissions), a profit is realised. If the prices on the underlying futures increase, the intrinsic value of the put option declines. This establishes the maximum loss for a buyer of put options – the premium plus commissions. A buyer of puts has no upper limit on profits, but a lower limit on losses. The opposite is true for sellers of puts.

For buyers of in-the-money put options, a decline in futures immediately increases the intrinsic value. The intrinsic value is the positive difference between the strike price and the underlying futures price. For a put, the intrinsic value is the amount that the strike price exceeds the futures price. Before or at expiration, if the increase in intrinsic value exceeds the original time value, the buyer profits. When the commodity futures price rises to and above the strike price, the intrinsic value of the option becomes zero and, at expiration, the buyer of the put incurs losses equal to the original premium. Sellers of in-the-money puts incur losses if futures decline more than the time value on the option.

When the prices of futures contracts rise, the value for the buyer of a call option will increase and the call option will move in-the-money. A decline in the price of the underlying futures reduces the value of the right to buy and eventually renders it worthless as time value evaporates. The maximum loss is the original premium (plus commission paid to the trader). The seller of a call faces the opposite pattern. The futures-profit relationships on calls are essentially mirror images of those on puts.

There are three basic steps to consider in using options.
- The first is the selection of the appropriate option contract expiration month. To do this, a buyer/seller has to select the option that will expire closest to, but not before, the time when the physical commodity will be sold or purchased.

- The second step involves selecting the appropriate type of option. To insure products to be sold at a later time against price declines, the producer can buy a put option. To insure products to be bought at a later time against price increases, the producer can buy a call option.
- The third step involves determining what the option strike price offers in terms of a minimum spot selling price for put options. The calculations for the minimum selling price (MSP) can be calculated in the following manner:

	Strike price
Less:	Premium
Less:	Opportunity cost
Less:	Commissions
+/-	Basis (cf. Chapter 4)
=	MSP

A producer who has bought option contracts has three alternatives, namely:
- to let the option contract expire;
- to exercise the option contract; or
- to offset the option contract.

If the spot price increases above the strike price before the expiration date, the producer could simply let the put option contract expire. The producer is free to take advantage of the price increase and use another marketing alternative (such as futures contracts, forward contracts and spot sales). By allowing the put option contract to expire, the producer loses only the premium and brokerage fees.

If futures prices decrease, the producer could exercise the option contract. There are two alternatives to choose from when a put option contract is exercised:

- the producer can deliver his/her crop, or
- the producer can close out the futures position, profit from the lower exercise price and sell the crop on the spot market.

When a producer decides to close out the futures position to profit from the lower exercise price, the put option contract is exercised and a position in the futures market is assigned to the producer. A buyer of a put would be assigned a short position in the respective futures. A buyer of a call would be assigned a long position. At SAFEX, sellers of options are drawn at random to take the opposite position in futures to the buyer when the buyer decides to exercise. The buyer of the put option can close out the short futures position by entering into a long futures position. The profit secured by this action is the difference between the strike price of the put option contract and the price of the long futures contract. The crop can be sold on the spot market.

If prices decrease and the premium value increases, the producer may decide to offset the put option. The producer would offset the put option by selling an equal and opposite put option. The producer must sell an option identical to the one previously bought. It must have the same strike price and expiration date. By offsetting the option contract, the producer can profit on the change in value of the premium. The cost of premium and broker fees must be deducted from the final commodity sale.

5.4 FACTORS AFFECTING PREMIUMS

Premiums are affected by the intrinsic value, the underlying interest rate, the volatility of prices, and the length of time (time value) to expiration of the option. Time value reflects the risk that the option seller bears in selling the option to the buyer. For example, if a R750 December maize put sold for R50 per ton when

December maize was trading at R740, the put would have R40 per ton of time value (R50 premium - R10 intrinsic value = R40 time value). The total cost of this put option would be R5000 (R50 * 100 ton) plus a commission charge. Commission is payable to traders when an option contract is bought or sold. Of this amount, R1000 would be the intrinsic value and R4000 the time value. For options with no intrinsic value, the entire premium equals time value.

Suppose that in July a December maize put with a strike price of R800 is offered for R45 per ton. At the same time, the December maize futures price is quoted at R820. The option is R20 out-of-the-money and has no intrinsic value. Even so, the put option has a time value of R45 per ton. The R45 premium represents the risk the seller takes that the option could expire in-the-money.

The question can be asked: why would anyone pay for something that has no intrinsic value? It has value because the option still has four months before expiration in November, and during that time, the option buyer and seller know that the underlying futures price could fall below the R800 strike price. If the December maize futures price were to fall below R755 (strike price - premium), the holder of the put option would be sure of a profit. If in December the maize futures price is between R755 and R801, the put option buyer would recover all or a portion of the initial premium cost.

Time value originates from the fact that the longer the time until expiration, the more opportunity for buyers and sellers to profit – therefore, the premium reflects more than just the intrinsic value. The amount of time value depends on the time remaining until expiration. Time value decreases with the length of time until expiration. On the expiry date, the time value must be zero. However, the time value does not erode on a straight line basis. It decreases much more rapidly during the last few weeks of an option's life as the chances of a price change diminish progressively. At the beginning of a long-term option's life (three

months or longer) the effect of time erosion is usually minimal, but during the last month it becomes more severe. Therefore, as can be seen in Figure 5.6, the decay of time forms a negative exponential curve.

Figure 5.6:   Decay of option values with time
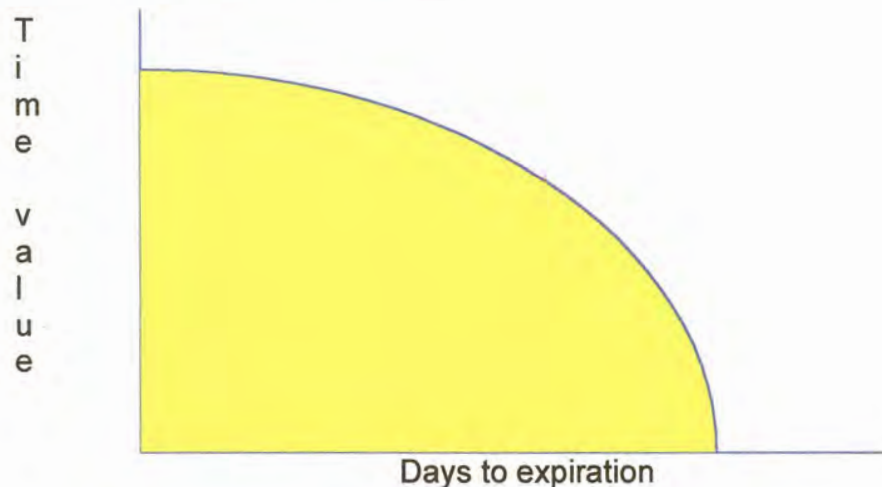
Source: Falkena *et al.* (1989)

At expiration, an option's premium consists only of intrinsic value, because the option no longer has any time value.

Consider the previous out-of-the-money maize put example. Four months before expiration, it commanded a premium of R45 a ton. The question that could be asked is the following: What are the factors that determine the option's premium? What are the factors that influence the option's time value? There are four primary factors that affect the value of premiums. They are (Ferris, 1998; Kleinman, 1997; Ross, *et al.*, 1996; Labuszewski, Sinquefield & Shculman, 1984):

a) *The relationship between the underlying futures price and the option strike price*

One indicator of this relationship is the option delta. The option delta is a measure of the amount by which an option premium will change for a corresponding change in the underlying futures price. In-the-money options have a delta near or equal to one, which means that the option and the underlying futures price move closely in tandem. Out-of-the-money options have a delta close to zero, meaning that for a given change in the price of the underlying instrument, the option price changes very little, if at all. If a producer is strongly convinced that the prices are going to increase strongly, an in-the-money option with a delta near one would be preferable.

The second indicator is gamma. The gamma of an option expresses the change in the delta as a result of a small change in the futures price. As the call option premium is positively related to the futures price, the delta increases as the option goes deeper in-the-money and decreases as the option goes deeper out-of-the-money. All things being equal, an at-the-money option has no more time value than an out-of-the-money option. The reason is that the at-the-money option has a much better chance of eventually becoming worthwhile to exercise. The figures in Table 5.3 illustrate the difference in time value. The table also shows how the cost of buying a put option to sell white maize in July 1998 at R760 per ton has increased as the price of July 1998 white maize futures contracts fell.

Table 5.3:   Increase in put option premiums for July 1998 white maize

Date of trade	Weighted price of option	Ruling futures price at close of business on day of trade
09/04/98	R32.50	R750
14/04/98	40.00	737
20/04/98	48.00	727
23/04/98	100.00	665
24/04/98	95.00	653
13/05/98	130.00	633
14/05/98	130.00	622
15/05/98	151.00	605

From the information in Table 5.3, it appears that it is cheaper to lock in a price of R760 per ton for July if the July futures price is trading at R750 than if it is trading at R650.

b) *The length of time remaining until expiration*

The longer the outstanding time of an option until expiration, the higher the premium, because the option and the underlying futures contract price have more time to fluctuate in value. The longer the time to expiration, the larger the probability that the option will, at some point, move into the money and become profitable for the buyer.

c) *The volatility of the underlying futures price*

Volatility is a measure of how quickly the underlying commodity changes in price. Option premiums are higher during periods when futures prices are volatile. Because increased price risk is associated with a volatile market, the cost of obtaining the insurance through options is also greater. An option is more likely to move in-the-money and become profitable for the buyer when prices are volatile. It is possible for an option three months from expiration to

command a higher premium in a volatile market than for an option four months from expiration in a stable market to do so. Because expected option price volatility cannot be predicted accurately, it is often approximated by the most recent historic price volatility of the underlying futures contract. The most common method of estimating volatility is to use the standard deviation of daily or weekly historical price changes over a longer period (Fitzgerald, 1987). Another method is to calculate the implied volatility. The responsiveness of the option premium to changes in the price volatility of the underlying futures contract is measured by the kappa of an option. Kappa is the points change in theoretical value for each one percentage point change in the volatility of an option.

d) *Interest rates.* According to the option pricing model is it assumed that interest rates and option premiums move in opposite directions, all else being constant. When interest rates increase, option premiums decline. The holder of an option pays the premium and commission fees upfront in order to receive a potential profit from that action at some time in the future. If interest rates increase, the current value of the expected future profit declines, while the implicit cost of the option increases.

5.5   THE PRICING OF OPTIONS

Several formulae have been developed to determine the value of options at given points in time to indicate what the premiums or prices of options should be. If the premium differs from the calculated value, arbitrage (a transaction which involves buying the asset or derivative at a lower price and selling it at a higher price) should bring the premium into line, unless traders perceive the expected volatility to differ from that measured by the formula. A breakthrough in option pricing theory was the Nobel Prize-winning work of Fischer Black and Myron

Scholes in 1973. Their model was developed to determine why options trade at their respective prices. They concluded that the fair value price (or fair premium) of an option depends upon the probability distribution of the futures price on the expiry date of the option. They noted the equivalence between options and dynamic positions (prices change continuously) in the underlying risky asset and cash.

Black and Scholes developed their formula based on the trading of options on shares. The assumptions made by Black and Scholes when they derived their option pricing formula were the following (Hull, 1998; Chance, 1989):

- the rate of return on shares follows a lognormal distribution (the logarithm of 1 plus the rate of return follows the normal, or bell-shaped curve);
- there are no commission charges or taxes;
- there are no dividends on the share during the life of the option;
- there are no riskless arbitrage opportunities;
- trading is continuous;
- investors can borrow or lend at the same risk-free rate; and
- the risk-free rate and variance of the return on the shares are constant.

There are two types of options, American and European style options. The main difference between these types is that American style options can be exercised at any time before expiration. European style options can only be exercised at expiration.

The Black-Scholes model for determining option prices on **European options** is the following (Chance, 1998):

$$CP = SN(d_1) - Xe^{-rt}N(d_2)$$

where:

CP	=	call option premium
S	=	current asset price
X	=	strike (exercise) price
t	=	time to expiration
N	=	cumulative normal distribution function
e	=	Naperian constant (e = 2,71828)

The option value does not depend on the expected rate of return on the share (when the underlying asset is a share); it is already built into the formula with inclusion of the share price, which itself depends on the share's risk and return characteristics.

The Black-Scholes equation uses six variables to calculate the fair value of an option contract:

- the asset's price;
- the option's strike price;
- annualised dividend payments;
- interest;
- volatility; and
- number of days until expiration.

The price of the option is calculated from the price of the asset and the option's strike price, and is used to determine the amount that the option is in- or out-of-the-money. The economic value of time is calculated from the interest cost of purchasing the entire position from borrowed funds, less any potential dividend payments during the period. The formula for the fair value of a futures contract is the following:

fair value = (share price*interest rate*days to expiration) - dividend payments

As the price of the underlying asset rises, so does the premium for put options and call options. Rising interest rates increase the premium for calls, but reduce the premium for puts. Dividends have the opposite effect, both on calls and puts. The Black-Scholes pricing model can be used to determine the change in the theoretical value of a put or a call if the price of the underlying futures changes, if the volatility rises or falls, if the dividend changes, or if interest rates change. Time deterioration can be determined by simply changing the number of days until expiration in the formula. Target prices, stop limits and time stops can all be formulated by forecasting price changes (Hull, 1998; Chance, 1998; Falkena, Kok, Luus & Yates, 1989; Chance, 1989).

In 1976, Black developed a variant of the option pricing model specifically to value options on futures contracts (Kolb, 1999). This model is a variation of the well-known Black-Scholes formula and is defined as follows:

$$VLCL = e^{-IT} * \{FTP*N(d_1) - STP*N(d_2)\}$$
$$VLPT = e^{-IT} * \{FTP*N(-d_1) - STP*N(-d_2)\}$$

where:

d_1 = $\{\ln(FTP/STP) + SD^2*T*0.5\}/(SD*\sqrt{T})$

d_2 = $d_1 - (SD*\sqrt{T})$

VLCL = value of call

VLPT = value of put

FTP = price of underlying futures

STP = strike price

T = time to expiration in proportion of a year

I = short-term annual interest rate on low-risk securities

SD = historical annualised standard deviation of the daily percentage change in the price of the underlying futures

This model has the virtue of not requiring a risk-free interest rate as an input to determine the value of a put option or a call option. This model is used by SAFEX (AMD) in determining the premium payable by buyers of options.

5.6 OPTION RISK

The link between probability theory and investment risk makes it possible to quantify option investment risk. In addition to strike prices, any change in the other variables (changes in the interest rate, futures prices, days to expiration, and volatility) in Black's option pricing model may bring about changes in option prices over the duration of the option cycle until expiration. Thus, these variables represent the risks of an option. These risks can be measured by 'Greeks' (Baird, 1993; Natenberg, 1994; Ferris, 1998):

5.6.1 Delta risk

The Black model provides the means to calculate a relationship called 'delta'. Delta relates the change in the option premium to the change in the price of the underlying futures contract. The delta formulas are the following:

$$
\begin{aligned}
DLTCL &= e^{-iT} * N(d_1) \\
DLTPT &= -e^{-iT} * N(d_1)
\end{aligned}
$$

where:

DLTCL = delta for a call

DLTPT = delta for a put

The delta risk of an option on a futures contract is a ratio which reflects the monetary value of change in an option price for every monetary value change in

the underlying futures price. It is a measure of the sensitivity of the calculated option value to small changes in the underlying commodity price. The formula to determine delta risk is the following:

Delta risk = Rand change in option price / Positive Rand change in futures price

These delta figures also indicate 'hedge ratios' for options. If they are close to 0.5, approximately two calls or puts are necessary to offset one futures contract. If either the call or the put is deep in-the-money, the intrinsic value is highly correlated to changes in the price of the underlying futures and provides closer to 1:1 coverage in hedging.

5.6.2 Gamma risk

An option's delta is not a constant. The delta changes as the futures price changes and makes the option more or less in-the-money, at-the-money, or out-of-the-money. The change in an option's delta is referred to as gamma risk. The formula for gamma risk is the following:

Gamma risk = net change in delta risk / Rand change in futures price

Gamma is a measure of the calculated delta's sensitivity to small changes in the underlying commodity price. Gamma can be both negative and positive. Long calls and puts always have positive gammas, and short calls and puts have negative gammas. If gamma is small, delta changes slowly, and adjustments to keep a portfolio neutral only have to be made relatively infrequently.

5.6.3 Theta risk

The change in option prices due to the days remaining to expiration represents the time decay, or theta risk. The formula for theta risk is the following:

Theta risk = change in option's value / one-day change in time remaining to expiration

All else being equal, an option contract with fewer days remaining is worth less than an equivalent one with more days to expiration, because the extra days add value. There is still time left before expiration when prices can change and the options can move in-the-money.

5.6.4 Vega or kappa risk

Even if there is no change in the underlying commodity futures price risk (delta or gamma) or in time risk (theta), an option price may be affected by changes in the market's valuation of implied volatility. This change in value is referred to as vega. Therefore, vega is the rate of change of the value of the portfolio in respect of the volatility of the underlying futures price. It is the most important risk and is formulated as follows:

Vega risk = rand change in option price / positive one-point implied volatility change

If vega is high in absolute terms, the portfolio's value is very sensitive to small changes in volatility.

6.6.5 Rho risk

The rho of an option contract is measured by the rate of change of the value of the option caused by interest rate changes. Thus, rho measures the sensitivity of the value of an option to interest rate changes. In the case of options, the interest rate represents the cost-of-carry of an option position, or the opportunity cost of trading in options. It represents whatever unoccupied capital may safely earn. A positive cost-of-carry earns interest, while a negative cost-of-carry incurs interest payments. If interest rates change, the cost-of-carry and the value of an option also changes, all else being equal. Change in the cost-of-carry that leads to change in the value of an option is referred to as rho risk.

5.7   OPTIONS VERSUS FUTURES CONTRACTS

Options on futures contracts and futures contracts are similar in the sense that both represent actions that occur in the future. Futures contracts are either to accept or deliver the actual physical commodity, while in the case of options on futures contracts the underlying asset is a futures contract. It is important to compare the advantages and disadvantages of options and futures contracts. Knowing what the advantages and disadvantages of option contracts are will aid producers in optimizing the use of all those different marketing instruments. These advantages and disadvantages, are set out in Table 5.4:

Table 5.4: Comparison between options and futures contracts

OPTIONS	FUTURES CONTRACTS
Advantages	
No margin calls	No premium
Ability to take advantage of favourable price moves	If price moves are favourable, the producer realises the greatest return with this alternative
Limited risk	No risk
Disadvantages	
Premium payable	Subject to margin calls
May yield less return than other strategies due to the premium	Initial margin required
If exercised, a futures position, with all its financial and contract obligations is assumed	Net price subject to basis change

Source: http://www.ianr.unl.edu, 2000 & http://bluehen.ags.udel.edu, 2000

To make a true comparison between futures contracts and an option contract, the producer should set up potential price scenarios based on future market trends.

5.8   DIFFERENT MARKET SCENARIOS

5.8.1 Uptrending market

Suppose that, after planting maize, a producer decides to use a forward pricing technique to market a portion of the crop. Furthermore, suppose that spring rains are good and the weather outlook for the rest of the season is favourable. Also assume that due to bad weather conditions in the USA, a below-average

maize crop is expected in the USA. In addition, the value of the US dollar has increased since planting. Therefore hopes are raised that global buying patterns will shift away from US agricultural products, causing a bullish market from the South African producers' point of view.

Alternative 1: Hedging with futures

During December, July maize futures trade at R820 per ton. Although the producer feels that prices may move higher than R820, a futures hedge (on 15 December) is placed to guard against the risk of a price decrease. The local spot price is R780 per ton. On 1 July, the producer closes the futures position by buying back the July contract that is now trading at R835 per ton. Grain is delivered to the local silo, where the spot price is R795 per ton. The producer's actions and returns are set out in Table 5.5.

Table 5.5: Transactions and returns on futures hedging with price increase

Date	Action	Value
15 December	Sell July maize futures	R820
1 July	Buy July maize futures	R835
Futures profit/(loss)		**(R15)**
1 July spot price	Sell to local elevator	R795
Futures profit/(loss)		(R15)
Net return		**R780**

Even though the prices turned against the producer's position, an assured price for the maize crop was secured. Loss in the futures market was completely offset by the gain in the local spot market (R795 - R780 = R15 vs. R15 loss in the futures market). Due to the nature of a futures contract position, the producer was unable to take advantage of any price increases. As prices traded above the R820 contract position, margin calls also had to be met.

Alternative 2:   Option contract

Suppose an option contract had been used instead. The producer buys a R820 July option for a R25 premium expense. With futures prices trading at R835 on 1 July, the producer allows the put option contract to expire. The producer's actions and returns are set out in Table 5.6.

Table 5.6:   Transactions and returns on a put option with price increase

Date	Action	Value
15 Dec	Put option July maize	R820
	With premium cost	R25
1 July	Futures July maize	R835
	Spot price	R810
	Allows contract to expire and sells maize locally:	
	Spot price	R810
	Less premium	-R25
	Net return	**R785**

This strategy allows the producer to take advantage of the higher local spot price without the offsetting of a loss of R15 in the futures market. The producer is also not subject to margin calls when futures prices rise above the strike price of R820.

When one considers the futures hedge, it may be argued that any price increase would be offset by an equal gain in the spot market. Although there would generally be a price increase in the local market, it may or may not equal the price increase in the futures market. The options contract would generally remain more profitable for the producer than the futures contract alternative,

taken into account the associated price increase in the spot market. As long as the premium value is less than the loss on the futures contract, the option contract alternative would be most profitable in an uptrending market.

5.8.2 Downtrending market

Suppose grain carryover stocks from the previous crop year continue to overshadow and depress prices and the USA is expecting a bumper maize crop. The producer's outlook for the industry is bearish.

Alternative 1:   Hedging with futures

Suppose that on 15 December, the July maize futures are trading at R750 per ton. The current bid price at the local elevator is R710 per ton. Fearing lower prices, the producer hedges maize by selling a futures contract. On 1 July, the producer closes the futures contract position by buying back the July contract that is now trading at R710 per ton. Upon delivery of the maize to the local market, the producer receives a spot price of R670 per ton. The producer's transactions and returns are set out in Table 5.7.

Table 5.7:   Transactions and returns on futures hedging with price decrease

Date	Action	Value
15 December	Sell July maize futures	R750
1 July	Buy July maize futures	R710
Futures profit/(loss)		**R40**
1 July spot price	Sell to local elevator	R670
Futures profit/(loss)		R40
Net return		**R710**

The producer secures an assured price for maize on the futures market. Because prices have traded in the producer's favour, no margin calls were made. In addition, no premium values are associated with futures contracts.

Alternative 2: Option contract

Suppose the producer established an option contract in a downtrending market. The producer decides to purchase a R750 put option contract, which has an associated premium of R35 per ton. With futures prices trading at R710 on 1 July, the producer exercises this put contract. The producer would immediately offset this position by purchasing a July maize futures contract at the current R710. The producer's transactions and returns are set out in Table 5.8.

Table 5.8: Transactions and returns on a put option with price decrease

Date	Action	Value
15 Dec	Put option July maize	R750
	With premium cost	R35
1 July	Futures July maize	R710
	Spot price	R670
	Exercise contract and offset futures position:	
1 July	Sell July maize futures	R750
1 July	Buy July maize futures	R710
Futures profit/(loss)		**R40**
1 July	Spot price	R670
Futures profit/(loss)		R40
Net return		R710
	Less premium	R35
	Net return	**R675**

In this situation, the producer takes advantage of the R35 insurance plan. When prices move below the R715 break-even price (strike price - premium), the producer exercises this option. In this way, the producer profits on the futures market by R40 per ton. With this position, the producer is still free to take advantage of any price increases that occur. The hedging alternative is most profitable in this example of a downtrending market.

5.9   THE WINDOW STRATEGY WITH OPTIONS

There are several marketing strategies that use futures and options to establish a floor price and allow for upside price potential. The problem with many of these strategies is that the option premium is often higher than many producers can justify. One hedging strategy that sets a floor price and allows for limited upside price potential, while also reducing option premium costs, is referred to as a window.

The window strategy involves simultaneously buying a put option and selling a call option. The window, or the range between the floor price and price ceiling, is determined by the two strike prices of the put and call options. Table 5.9 shows how the price floor and ceiling price are derived.

Table 5.9: Floor price and ceiling price with a window strategy

Floor price	Ceiling price
Put strike price - Put premium paid + Call premium received + Local basis (may be negative) - Brokerage/transaction costs = **Window floor price**	Call strike price - Put premium paid + Call premium received + Local basis (may be negative) - Brokerage/transaction costs = **Window price ceiling**

The floor price is derived in a similar way to the purchase of a put option. The difference is that, with a window, the premium received from selling a call option must be taken into consideration.

The selling of a call option requires a margin account to be maintained because the option seller must maintain equity in the position. Call option premiums fluctuate, depending on market conditions. Margin calls are based on the change in the value of the call option premium (http://www.fiafii.org/tutorials.htm). Call option sellers should also be aware of the possibility that the option could be exercised. If the futures price is above the call strike price at expiration, the buyer of the call option has an incentive to exercise the call option. If the option holder chooses to do so, the option seller could be placed in a short position at the strike price, which is likely to result in a loss for the call option seller. When a call option holder exercises a call, SAFEX randomly assigns the short futures position to someone who has sold a call option. Any loss, which is paid through margin calls, will be roughly offset later by a higher cash price received when the grain is sold. However, a short-term cash flow problem could arise.

Several studies have explored the risk-return properties of options as they affect farm business. Many of these studies have found options to be a potentially useful method for stabilising returns (Heifner & Plato,1986; Curtis, Kahl &

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McKinnell, 1989). In an efficient market, the producer's return from buying put options over a series of many years is expected to equal the return either on hedging with futures or on simply selling the crop at harvest, except for commissions (http://www.econ.ag.gov). Although returns are approximately the same in all three cases, hedging with either put options or futures reduces uncertainty about returns.

5.10 SWAP CONTRACTS

Commodity swaps are designed to assist producers to manage the risks associated with the prices of input resources such as energy, precious metals, and agricultural products. Swaps are a contractual agreement between two parties in which one party agrees to protect the other for a predetermined commodity quantity at an agreed price at a future date (Kolb, 1999). Both parties who agree that a specific cash or futures market will serve as the benchmark achieve price transparency, by which the contracts' gain or loss is measured. A fairly common procedure used in commodity swaps is to set the variable payment at the average price of the commodity over a specific period, rather than at the price of the commodity on the settlement date. This type of arrangement makes commodity swaps similar in principle to Asian options. An Asian option is an option whose payoff depends on the average price of the underlying asset or the average of the exercise price. The payoffs are determined by the average price of the asset during a period over the option's life.

A swap is or can be a portfolio or series of forward contracts. In contrast to forward contracts, with a swap there are multiple exchanges instead of just one. There are several reasons for using swaps. According to Ross et al. (1996) the benefits are the following:

- reducing funding cost;
- increasing debt capacity;
- enhancing the yield of assets;
- creating synthetic instruments; and
- modifying the exposure of cash flows.

5.11 OPTION SPREADS

An option spread involves the simultaneous purchase and sale of two options of the same type but with different strike prices, terms until expiration or both (Purcell, 1991). The spread trader becomes simultaneously long on one option contract and short on another option contract. An option spread is similar, in principle, to a futures spread in that offsetting positions are taken in the same market by buying and selling contracts with slightly different contract terms. When a futures spread is constructed, the difference in the long and short legs of the spread are the contract maturities. An option spread is more complicated than a futures spread, because option contracts can either be puts or calls, and may have different strike prices, in addition to having different terms until expiration. A producer normally engages in a bull spread if it is expected that the market could go up marginally, or is at least slightly more likely to rise than to fall. A bear spread is normally used in situations when the producer thinks that the market will fall marginally or is at least slightly more likely to fall than rise.

A spread between different contract months in the same commodity is called an interdelivery or intracommodity spread. These spreads consist of buying one month in a particular commodity, and simultaneously selling a different month in the same commodity. A spread between different commodities is called an intercommodity spread. These spreads consist of buying one commodity and simultaneously selling a related commodity. Examples would be buying silver

and selling gold, or buying hogs and selling pork bellies. A spread of commodities in different markets are called intermarket spreads. Option spreads allow for exceptional variations in risk, from the small changes of the carrying charge spread to the highly leveraged intercommodity spread.

An option straddle is the simultaneous purchase of a put and a call option, or the simultaneous sale of a put and call option (Labuszewski, *et al.*, 1984). A straddle transaction is distinguished from a spread in that a straddle involves two long or two short positions in the same 'type' of option, that is, either a put or call, while a spread involves a sale and purchase of the same type of option. An investor may be inclined to buy a straddle where the investor is not sure of the direction in which the underlying commodity price will move, but the investor is confident that there will be a substantial move in one direction or another. An investor would sell or write a straddle when the underlying price is likely to remain static.

5.12 CONCLUSION

There have always been arguments around harvest time about the level of the Maize Board's prices, and, more recently, about the appropriate level of the Maize Board's floor price. Inevitably, the process has become highly politicised. After deregulation, producers now have an opportunity to set their own floor price, using their own initiative, without waiting for the outcome of a political tug of war between the National Agricultural Maize Producers' Organisation (NAMPO) and the Minister of Agriculture in South Africa.

When prices on the spot market and futures market are relatively low, it is a particularly sound time for buyers to insure themselves against a sudden leap in maize prices such as those after the 1997 harvest when the final carry-over stock differed dramatically from the forecast carry-over value. When spot and

futures prices are relatively high, but the producer is not sure of the crop size, the options market allows a producer to guard against the possibility that prices will come down.

Options on futures contracts give the holder the right, but not the obligation, to take a futures position at a specified price before a specified date. The value of an option reflects the expected return from exercising this right before it expires and from disposing of the futures position obtained. Options provide protection against adverse price movements, while allowing an option holder to gain from favourable movements in the cash price. In this sense, options provide protection against unfavourable events similar to the protection provided by insurance policies.

Hedging, or the shifting of price risk from risk-averse to risk-seeking parties, is a function traditionally accomplished by using futures markets. Commodity option markets have a similar capacity to protect producers against adverse price movements. Option markets therefore represent an alternative hedging vehicle that offers unique advantages not available to the users of futures markets.

In the next chapter, a decision support system to manage the investment risk of grain producers is developed, based on the information gained from the literature review and the hedging mechanisms explained in the chapters.

CHAPTER 6

THE DEVELOPMENT OF A MARKETING DECISION SUPPORT SYSTEM FOR GRAIN PRODUCERS

'There is such a choice of difficulties that I am myself at a loss how to determine.'

- Robert Lowth   (1710 – 1787)

6.1   INTRODUCTION

The previous chapters have paved the way for the development of a model to assist producers in managing investment risk by optimising the use of the various marketing instruments available to producers. In this study, the model, which is presented in this chapter, is called a marketing decision support system (MDSS). The MDSS includes many, although certainly not all, dimensions of a farm portfolio, concentrating on crop production. The decision alternatives will apply to grain producers rather than to processors or middlemen.   At present, producers can market their crops in three different periods. They can sell their crops before harvest, using forward contracts, futures contracts and options on futures contracts; or they can wait and sell in the spot market at or after the harvest.

The general principle underlying portfolio theory is a well-known principle of risk management (Huang & Litzenberger, 1988). The decision-maker, or producer, selects the composition of the farm's portfolio with the aim of maximising expected utility. In this study, utility is assumed to refer to profitability. Utility depends on wealth, and future wealth depends on future returns from the portfolio. Future returns, however, are uncertain. Thus, for the purposes of the

study, the farm portfolios are assumed to be those of diversified producers of multiple crops rather than of just single crops. Since assets and liabilities are an integral part of all portfolios, allowance is made for the possible effects of debt and credit on the choice of producers' marketing instruments.

The dynamics of production and price information and their influence on marketing decisions are mimicked through an updated dynamic (the time variable is explicitly contained in equations) deterministic control approach. A deterministic model is one that makes definite predictions for quantities without any associated probability distribution. The MDSS employs a series of open-loop control problems, each of which is solved while assuming that in each period no additional information is forthcoming. This assumption is however, revised after each period, when the information is directly observable (Gad & Ginzberg, 1991). This means, for example, that the producer uses the information available at planting time to plan the marketing of a certain percentage of the expected output and then implements the decisions that seem most appropriate to the planting period. Later, at the growing stage, an additional plan is made using the information available at that point in time, again marketing a further percentage of the expected output. Similar revisions and actions occur during the later growing stages and at harvest. During these later periods, the rest of the expected crop can either be sold or stored for later selling in the spot market. Such an approach reflects the fact that multiple marketing decisions, dependent on evolving information, are made throughout the whole production-marketing period.

The Free State Province was used as the location where the data necessary to test the MDSS was gathered. The chapter begins with a detailed discussion why the Free State Province was selected and which statistical regions in the Free State were finally used to collect the data from. The discussion of the analytical model begins with an explicit statement of the model's underlying assumptions

and definitions. This is followed by the development of a decision criterion that includes both production and price uncertainty. This criterion in turn yields marketing strategies implied by decision rules. Finally, the solution of the model provides a framework for a discussion of the expected qualitative effects of an individual farm's characteristics on marketing decisions.

6.2   DATA

6.2.1 Farm unit prototypes

In order to test the ability of farmers to manage risk and market astutely by using forward markets and derivatives markets, farm prototypes which epitomise the essential dimensions of commercial grain farms are needed. The details of these prototypes are discussed in terms of marketing period, location, crop production, production stages and statistical regions.

6.2.1.1   *Marketing period*

For the purpose of this study, the period from 1996 to 1999 was chosen because it represents the new agricultural marketing era in South Africa. The marketing boards were abolished in 1996 and every producer now carries the responsibility of marketing his/her own crop. Production patterns (as discussed in Chapter 2) changed after 1996 and therefore any data prior to 1996 would be invalid for this study.

6.2.1.2   *Location*

As a location, the Free State was chosen. The Free State was selected for two main reasons. Firstly, there is the overall prominence of maize, sunflower seed,

North West (cf. Figure 6.2). A farming unit consists of one or more separate farms, holdings or portions of land, whether contiguous or not, provided they are situated in the same magisterial district. Furthermore, the following farming operations are carried out for commercial purposes on such farming units (Central Statistical Services, 1996b):

- the cultivation, in the open air or under cover, of field crops, fruit, grapes, nuts, seed, bulbs, vegetables or flowers;

- the operation of a nursery, except a nursery concentrating on purchasing and reselling;

- the operation of a tea, coffee, sugar, wood, or other plantation;

- the breeding of livestock, poultry, game or other animals, including freshwater fish and furred animals, and including speculation in livestock; and

- the production of milk, cream, wool, fur, eggs or honey.

Figure 6.2: Number of farming units
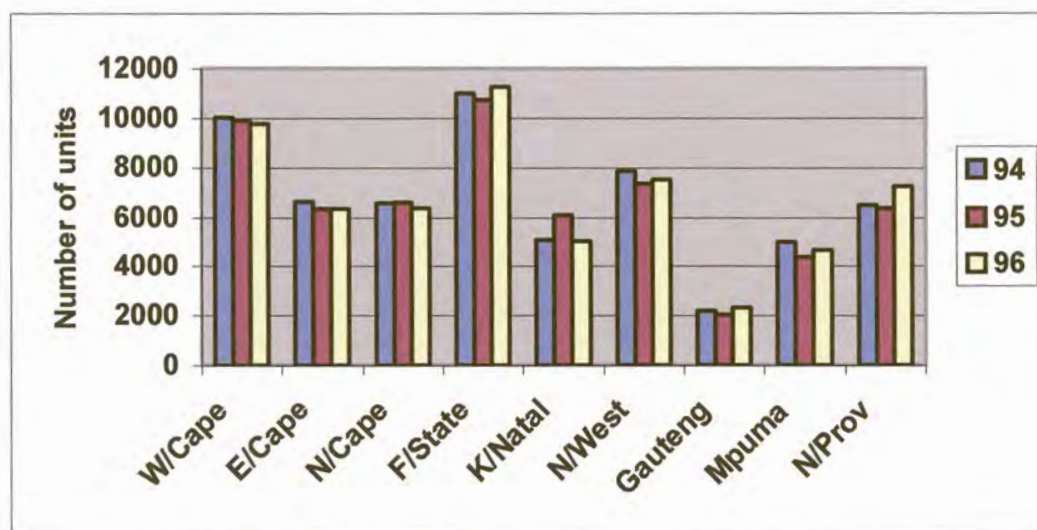
Source: Central Statistical Services (1996b)

At the stage when the study was done, no new data were available on farming units. The study therefore assumes that the greatest percentage of farming units are still in the Free State.

6.2.1.3   Crop production

The next step entailed the justification of the choice of the Free State by looking at the field crops selected for this study (see Chapter 2). Figure 6.3 indicates the total sunflower seed production from 1995/96 to 1998/99 for each of the provinces.

Figure 6.3: Total sunflower seed production by province for the period from 1994/95 to 1998/99
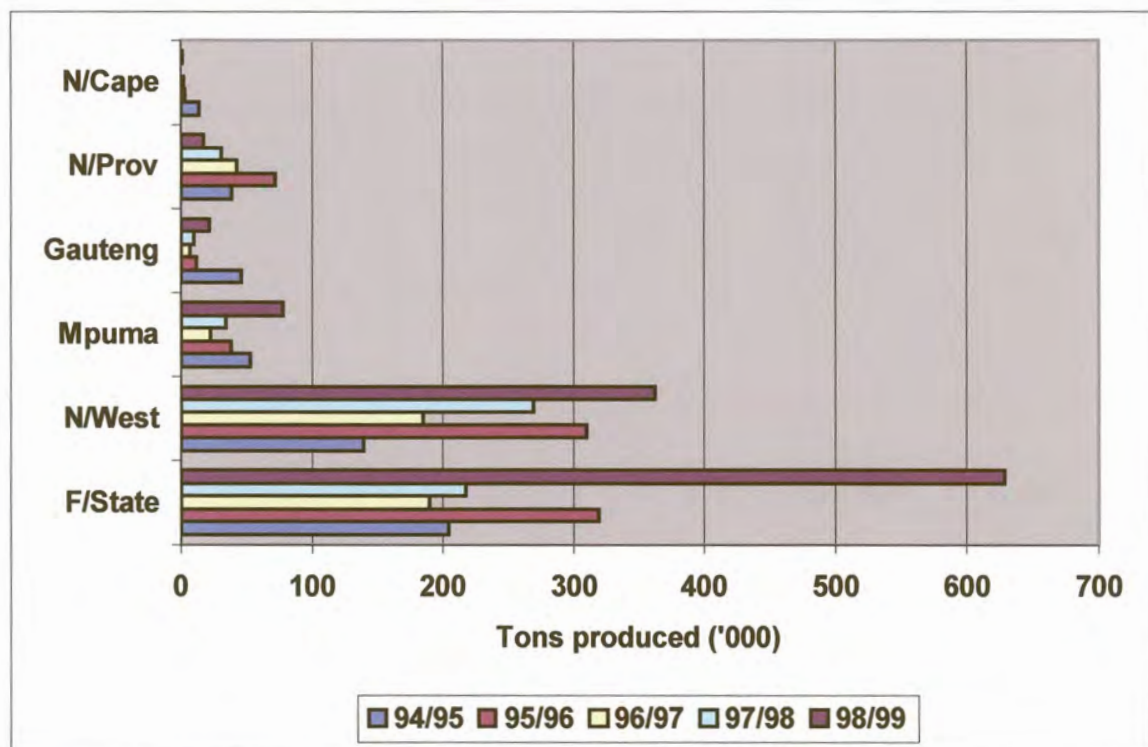
Source: National Crop Estimating Committee (2000a)

More than half the total sunflower seed production comes from the Free State. The average total production over the last six years was 546 579 tons, with the Free State producing 297 669 tons or 54.46% thereof. The Free State produced most of the sunflower seed throughout the study period, except during the 1997/98 marketing season.

Figure 6.4 indicates the total soybean production per province.

Figure 6.4: Total soybean production per province for the period from 1996/97 to 1998/99
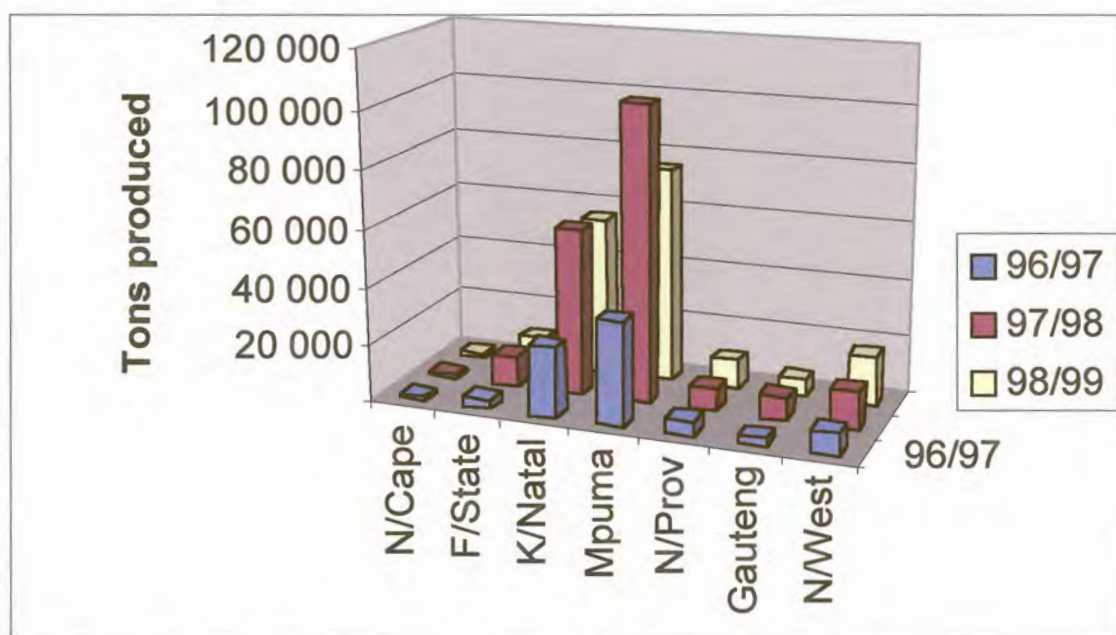
Source: National Crop Estimating Committee (2000a)

The Free State produces only 6.7% (or 10 000 tons) of the total soybean production in South Africa during the 1998/99 marketing season. The primary reason is climatic conditions. Soybeans prefer a colder, more humid climate, indicated by the high volumes produced in Mpumalanga (75 000 tons) and KwaZulu-Natal (55 500 tons) in the 1998/99 marketing season.

Figure 6.5 indicates the total wheat production by province.

Figure 6.5: Total wheat production by province for the period from 1994/95 to 1997/98
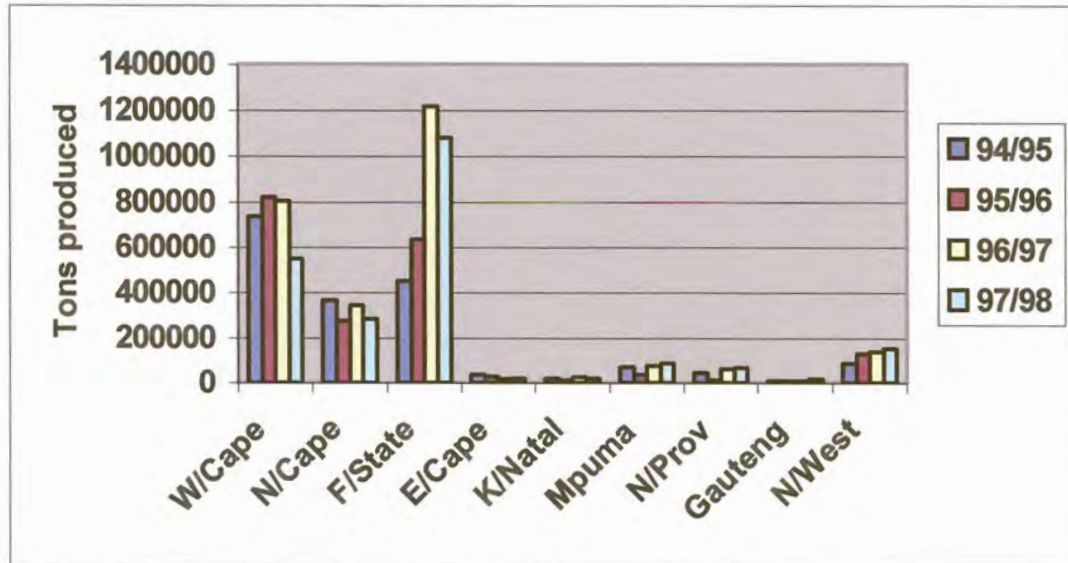
Source: National Crop Estimating Committee (2000b)

Except for a small portion of the southern Free State, the rest of the province produces wheat. The average wheat production in the Free State is 952 000 tons per year. That represents 43.93% of the total yearly wheat production. Except during 1994/95 and 1995/96, the Free State produced most of the wheat in South Africa.

Figure 6.6 indicates the per province production of maize.

Figure 6.6: Maize production by province for the period from 1995/96 to 1998/99
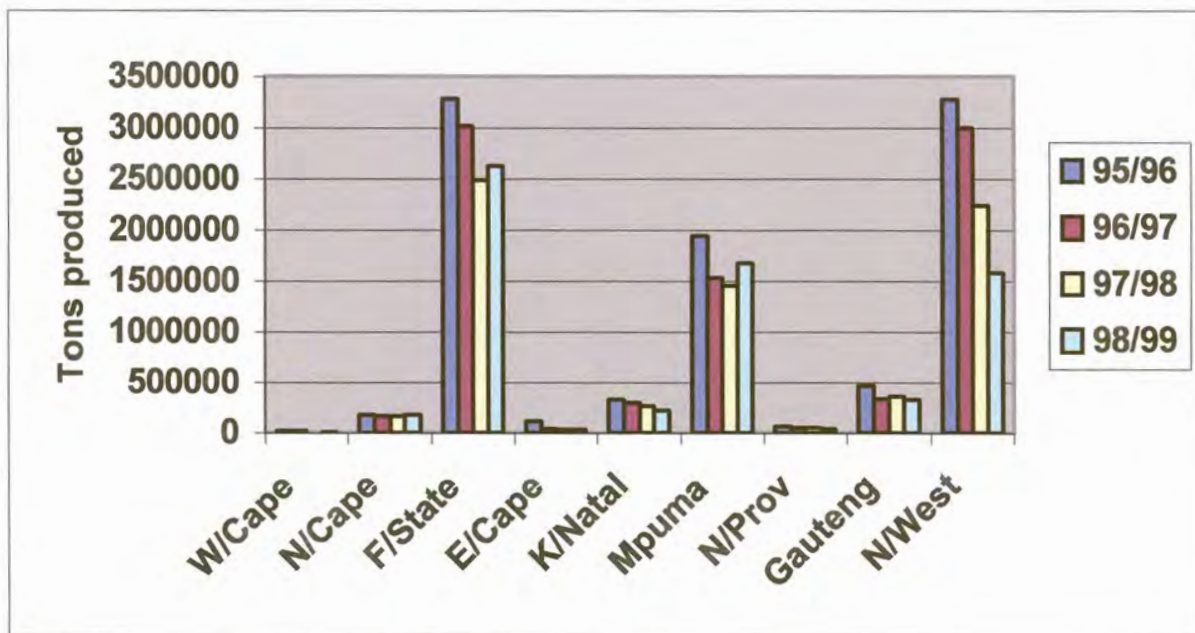
Source: National Crop Estimating Committee (2000a)

The Free State produced most of the maize (33.4%) in the country. However, Mpumalanga produced slightly more yellow maize than the Free State. The Free State produced 980 000 tons of yellow maize on average for the four years from 1995/96 to 1998/99, whereas Mpumalanga produced 1 100 000 tons on average for the same period. Due to the relatively slight difference in quantity and the fact that the same principle applies to the marketing of yellow and white maize, it was decided that the Free State can be used to reflect maize sales.

The Free State produced the most maize, sunflower seeds, and wheat in the country and the fourth most soybeans in South Africa over the period from 1996/97 to 1998/99. This led to the choice of the Free State as the area from which farms were chosen for this study.

Crop varieties and growing techniques vary from one geographical region to another. The products from the farms of a given province are not homogeneous in type and quality. Even within a given province, planting and harvesting does not occur simultaneously on all farms. Because the aim of the model developed in this study is to optimise marketing profits, each farm must be investigated individually. The crop choice, crop input costs and marketing strategies followed by the producers were compared with the strategies proposed by the model.

6.2.1.4   Production stages

The second step was to allocate months to the production-marketing period for planting, growing, harvesting and storage. These allocations are presented in Table 6.1.

Table 6.1:   Allocating months to the production-marketing period of crops

Maize	Planting	October, November, December
	Growing	December to April
	Harvest	May, June, July
	Storage	August to actual selling of crop
Sunflower seed	Planting	November, December, January
	Growing	January to April
	Harvest	May, June
	Storage	July to actual selling of crop
Soybeans	Planting	October, November, December
	Growing	December to April
	Harvest	May, June, July
	Storage	August to actual selling of crop
Wheat	Planting	May, June
	Growing	July to October
	Harvest	November, December
	Storage	December to actual selling of crop

Farm size is the third dimension that needs to be determined for the farm prototypes. Figure 6.7 depicts the average size of a farming unit for the period from 1994 to 1996. Due to the fact that more recent data on the average size of a farming unit in the Free State was not available when the study was done, it is assumed that the same pattern prevailed for the period from 1996 to 1999.

Figure 6.7:   Average size of a farming unit (hectares)
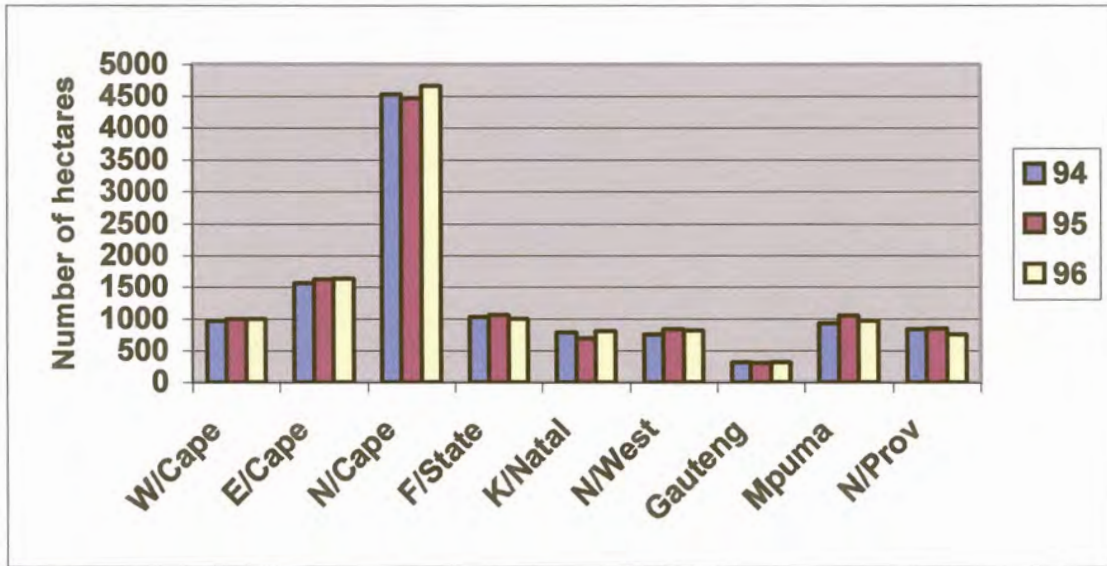
Source: Central Statistical Services (1996)

The largest farming units in South Africa were recorded in the drier areas such as the Northern Cape, where most of the farming land was used for grazing purposes and the average size of a farming unit was more than 4 000 hectares. The smallest farming units were recorded in Gauteng, where the average farming unit was approximately 300 hectares. Some of the size characteristics of commercial grain farms in the Free State are set out in Figure 6.8.

Figure 6.8:   Characteristics of commercial grain farms in the Free State
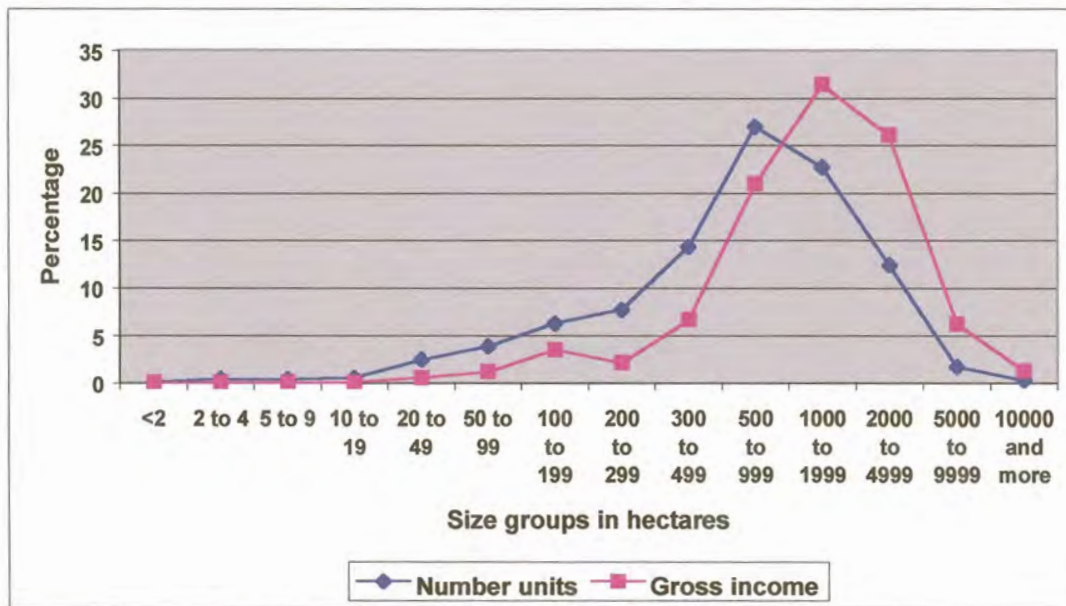
Source: Central Statistical Services (1993)

Table 6.8 indicates that about 21% of the farms fall in the category from 599 hectares to 999 hectares, 31% in the category from 1 000 hectares to 1 999 hectares and 26% in the category from 2 000 hectares to 4 999 hectares. The average farming unit in 1996 in the Free State was 1 006 hectares. Due to the fact that farm size is not an indication of total production (due to differences in irrigation and soil type), the farms are grouped into total tons produced rather than hectares. In order to provide the widest possible range in size and yet be sufficiently large to use futures contracts, the categories indicated in Table 6.2 were chosen.

Table 6.2   Farm production categories

Group A	Total crop production less than 1 000 tons
Group B	Total crop production between 1 000 and 1 999 tons
Group C	Total crop production of 2 000 tons and more

It was not possible to find a farm unit for sunflower seed production for Category C in the Free State. This was due to the fact that the total production of sunflower seed in the Free State for the 1998/99-season was 629 000 tons on 430 000 hectares, resulting in an average yield of 1.46 tons per hectare. On average, 1 370 hectares of sunflower seed have to be planted to qualify for Category C. The average farm size in the Free State is only 1006 hectares, well below the required size for Category C. By looking at the chosen magisterial districts (as discussed later in this chapter), it was again not possible to find a suitable farm unit for Category C.

It is not a prerequisite for the farms chosen for this investigation to have used the futures market or derivatives market as a mechanism to manage their investment risk. Futures markets or derivative markets only provide alternative marketing strategies to producers. It is the aim of the MDSS to determine the optimal strategy, and a producer might achieve optimum results by ignoring the futures market.

6.2.1.5   Statistical regions

The fourth step entailed the identification of statistical regions, in other words the regions that have the biggest total income from summer cereals, oil-seeds, and winter cereals, statistically speaking. Figure 6.9 indicates each statistical region in the Free State with the percentage gross income from summer cereal, oil-seeds and winter cereals.

Figure 6.9: Percentage gross income per statistical region
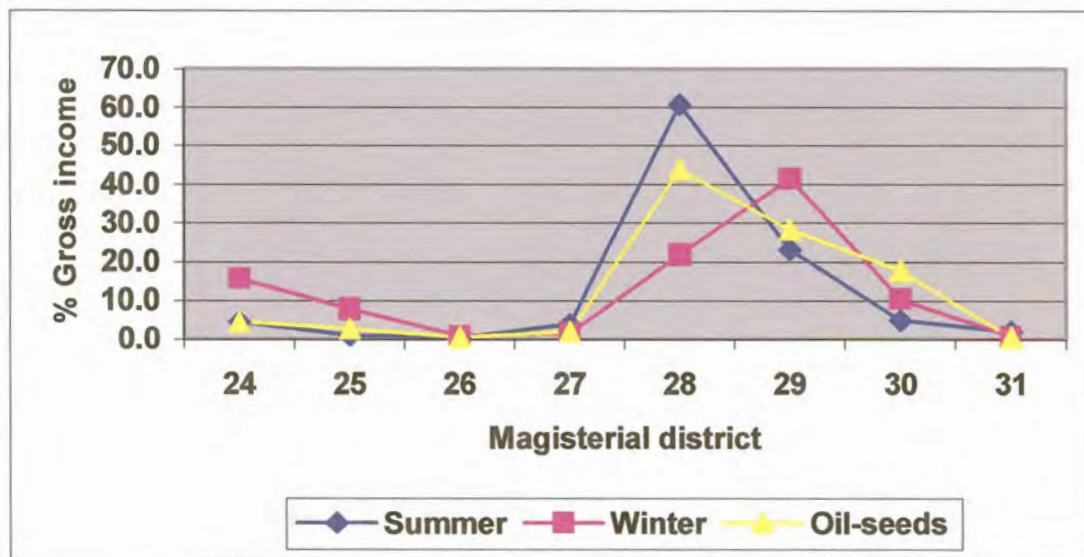
Source: Central Statistical Services (1993)

Statistical Region 28 produced the biggest percentage of gross income for summer cereals (60.8%) and oil-seeds (44%). Statistical region 29 produced the biggest percentage gross income for winter cereals (41.4%). The districts, which are represented as Regions 28 and 29, are named in Table 6.3.

Table 6.3: Districts represented as Statistical Region 28 and 29

Region 28		Region 29	
Kroonstad	Viljoenskroon	Bethlehem	Senekal
Ventersburg	Bothaville	Harrismith	Fouriesburg
Henneman	Wesselsbron	Vrede	Ficksburg
Parys	Hoopstad	Frankfort	
Vredefort	Bultfontein	Reitz	
Koppies	Theunissen	Lindley	
Heilbron			

Districts from Region 28 were used for data on summer cereals and oil seeds, and Districts from Region 29 for winter cereal crops. Farms from the above districts in Category A, Category B and Category C are used in the model. Farm selection, however, was random to ensure that the MDSS could be tested on producers that had used the derivatives market and also on producers that had not used the derivatives market. The only requirement was that at least one crop had been planted and that the total tons produced would be represented in Categories A, B and C.

6.3 ASSUMPTIONS AND DEFINITIONS

6.3.1 Stage definitions

Assumptions of discrete time were the first step towards making the analysis viable. The production-marketing time span was divided into a small enough number of intervals to reduce the dimensions of the model sufficiently to make it manageable. Yet, the time span of the intervals was narrow enough to reflect the evolution of price and yield information.

Price and yield uncertainties are strongly related to the dynamics of information. At planting time, the price of the current forward contract is assumed to be known. This assumption ignores the possibility that inflation could change the value of the forward spot price by the time the contract is exercised. The futures price (for the harvesting period) is also known to the producer. At planting, however, expected yields are only vague expectations and harvest and post-harvest prices already exist, but the final price expected is only a vague expectation. By the growing stage and especially as harvest nears, the uncertainty of yield and price expectations lessens as producers monitor growing and marketing conditions. At harvest, yields and spot prices during harvest

become known and the range of spot prices expected during the storage period narrows.

The production information presented in Chapter 2 shows that wheat is planted in autumn. Therefore, the planting stage for wheat does not correspond with the planting stages for maize, soybeans, and sunflower seeds, which are seeded in early summer. Hence, a multiple production grain farm which grows wheat along with summer crops has a production-marketing period composed of four intervals. These intervals, complete with their specification of production and marketing instruments for each crop, are set out in Table 6.4.

Table 6.4: Production-marketing activities per crop

INTER-VAL	ACTIVITY	MARKETING INSTRUMENT	MAIZE	WHEAT	SUNFLOWER SEED	SOY-BEANS
1	Planting			X		
	Marketing	Forward	X	X	X	X
		Futures	X	X	X	X
		Options	X	X	X	X
	Growing		X	X	X	X
	Planting					
	Marketing	Forward		X		
		Futures		X		
		Options		X		
2	Harvest			X		
	Growing		X		X	X
	Marketing	Forward	X		X	X
		Futures	X		X	X
		Options	X	X	X	X
		Spot		X		
3	Storage			X		
	Harvest		X		X	X
	Marketing	Spot	X	X	X	X
		Options	X	X	X	X
4	Storage		X		X	X
	Marketing	Spot	X		X	X

Source: Adapted from Bernstein (1987)

The four intervals represent three different marketing stages used by the integer linear programme. The different marketing stages are the following:

- **Pre-harvest marketing stage**. The pre-harvest marketing stage represents the time from planting (and any actions taken before planting) to the end of the growing season. The pre-harvest marketing stage is reflected by Interval 1 for wheat and by Interval 1 and Interval 2 for the summer crops, as depicted by Table 6.4.

- **Harvesting stage.** The harvesting stage represents the time span necessary for producers to harvest the crop. The harvesting stage for wheat is represented by Interval 2 in Table 6.4 and the harvesting stage for summer crops is represented by Interval 3.

- **Post-harvesting stage.** The post-harvesting stage reflects only the timespan for crops stored after the harvesting stage. It represents the time from the end of harvesting to the actual selling of the crops. The post-harvesting stage does not have an upper limit on the time it takes to sell the crop. The producer can store the crop until the harvesting season for the next year, or even later before selling the crop. The post-harvesting stage for wheat is represented by Interval 3 in Table 6.4 and for summer crops by Interval 4.

6.3.2 Price assumptions

For the purposes of this study, it is assumed that all farms, no matter what their size, have the same marketing instruments available to them. Large farms do not have any advantages over their smaller counterparts. It is also postulated that, although production costs are stochastic, they are independent of the prices of all marketing instruments.

Hedgers are temporary substitutes for anticipated actual transactions. This definition is reflected by the assumption that obligations from short sales in the futures market are not satisfied through delivery. In addition, once a short position is taken, the hedge is not lifted by an offsetting futures purchase until the corresponding harvest sales occur simultaneously. This implies that, if a producer enters into a futures contract during the planting stages, this futures position will only be offset during harvest time. Speculation is disregarded.

6.3.3 Crop choice

Although the model is based on well-diversified farms, the producer has the option to choose between the four selected crops, namely white maize, yellow maize, wheat, sunflower seed and soybeans, as discussed in Chapter 2. The only prerequisite is that producers must plant at least one of the specified crops.

6.3.4 Marketing decisions

The producer can choose between the marketing instruments available in any of the four production-marketing stages. The producer uses the information available at Interval 1 to plan the pricing of a percentage of the expected output. During the early parts of Interval 2, another percentage of the expected output is priced. The rest of the expected output is priced during the later parts of Interval 2, Interval 3 and Interval 4. The same principle applies to producers who plant only winter crops. They focus on Intervals 1 to 3, and the same principles apply.

6.3.5 Production estimates and marketing constraints

Most production uncertainty results from the effect of weather on crop yields. Although weather is commonly accepted as the principal determinant of annual crop yields, the possible influence it has on the probability distributions of those yields is often overlooked. Figure 6.10 indicates the national average yield for maize for the period from 1980/81 to 1996/97.

Figure 6.10: Average maize yield from 1980/81 to 1996/97
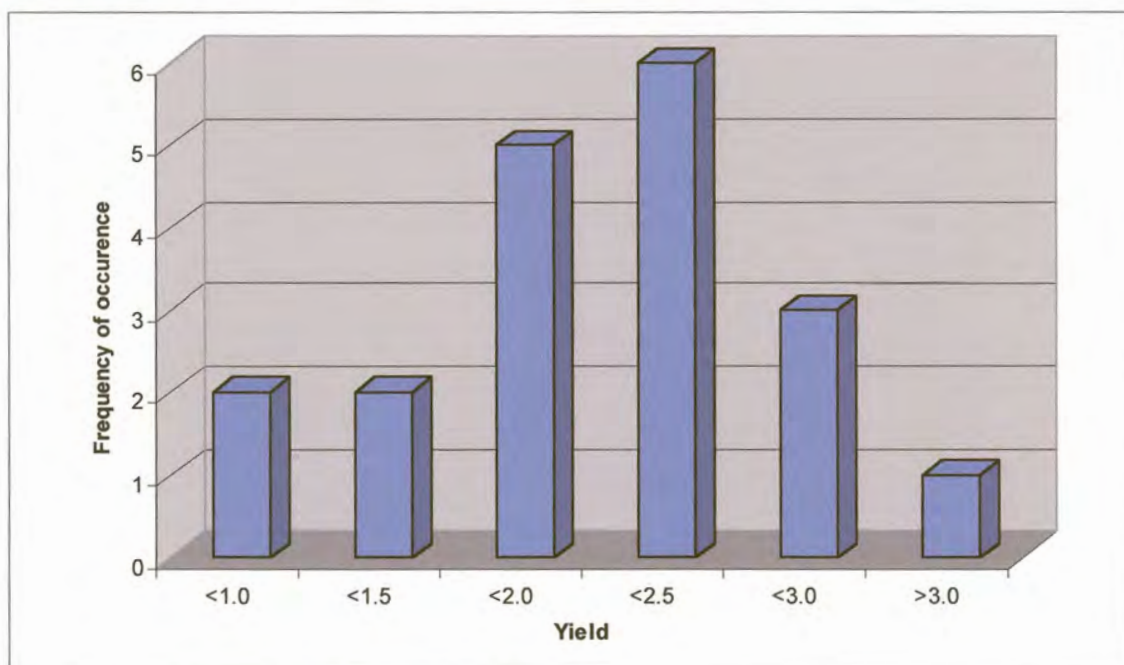
Source: http://www.fao.org (1999)

The average yield from 1980/81 to 1996/97 was 2 tons per hectare. As suggested by Day (1965), positive skewness of the probability distributions of crop yields may mean that the expected output is an overly optimistic forecaster. This being the case, a total commitment of expected output to forward contracts, option contracts or futures positions may often result in a consistent tendency to oversell. Such oversales necessitate compensating cash purchases in the spot market at harvest in the case of a crop shortfall. From the graph in Figure 6.10 is

it clear that this is not the case in South Africa. Table 6.5 indicates the average tons per hectare and the standard deviation thereof for maize, sunflower seeds, soybeans and wheat obtained in the Free State.

Table 6.5   Average tons per hectare and standard deviations from 1995/96 to 1998/99

	Average yield	Standard deviation
Sunflower seed	1.22 t/Ha	0.24
Soybeans	1.44 t/Ha	0.32
Wheat	1.29 t/Ha	0.26
Maize	2.48 t/Ha	0.10

Using the mean as a forecaster of a random variable with a positively skewed distribution does not result in repeated overestimation. It is therefore not necessary to adjust yields by making use of Chebyshev's inequalities (Day, 1965).

It is assumed that the decision-maker does not believe that the probability distributions of crop yields are positively skewed. The MDSS functions on a continuous basis and the producer can adjust the information as the crop nears maturity. No producer is committed to sell 100 percent of the crop at planting. Decision-makers tend to be cautious and want to avoid forward cash and futures oversales. Therefore, a safety-first strategy is assumed. To obtain this safety-first strategy, only a portion of the expected crop is sold before the critical growing stages have passed. The rest of the expected crop can be sold after the critical growing stages or can be reserved to be sold in the harvest or post-harvest stages. These reserves are then available to satisfy forward and futures commitments if an unanticipated production shortfall occurs. If a producer decided not to make use of a safety-first strategy the MDSS then also ignored the safety-first strategy. In order to compare the results obtained by the

producer with those of the MDSS, the MDSS must use the same percentage of crop sold in every stage as the producer.

As the crop year advances and especially as the critical stages of growth for each product are reached, yield uncertainty diminishes. The probability distribution of yields becomes more concentrated around the expected value as weather information is accumulated and the critical growing stages for each crop are passed. Although the yield uncertainties lessen as the season progresses, the price risk faced by producers does not diminish over time. This makes it all the more important to develop an MDSS to assist producers in managing their price risk.

6.4 ELEMENTS OF THE MDSS

Decision support systems (DSSs) are an important application of management information systems (Davis & Olsen, 1985). According to Fang and Puthenpura (1993), DSSs require the use of computers to improve decision-making, and to allow users to retrieve data and evaluate alternatives based on models appropriate to the decisions to be made. **Reports on DSSs to optimize marketing returns for crop farms in South Africa are not available.** The MDSS developed in this chapter allows for the possible effects of farm location, size, and debt on marketing decisions. It also provides for variations in attitude towards production and price uncertainty.

The aim of the MDSS is to maximise net return. Net return is the sum of all the net cash flows generated by all the marketing activities in the different marketing stages. Net cash flow represents the difference between cash inflows and cash outflows associated with crops produced on the farm. Other returns and non-production expenses are excluded.

The MDSS aims to determine the optimal combination of marketing strategies available to producers to maximise net return, given the constraints imposed by the individual producers. In order to present the model logically, all the cost components are discussed, followed by the marketing components.

6.4.1 Input cost components

For the purposes of this study, production costs are grouped into three broad categories:

- **Pre-harvest variable cost**

  Pre-harvest variable costs include items such as seed, fertiliser, weedicides, pesticides, labour, transport, fuel and repairs. Interest on production loans incurred prior to harvesting the crop also have to be included.

- **Harvest cost per hectare**

  Harvesting costs per hectare include costs such as fuel, repairs, labour and contract work when the crop is harvested. These costs are not affected by crop yield. The reason for treating these costs separately from pre-harvest costs is the possibility that the crop may not be harvested due to crop failure.

- **Harvest cost per production unit**

  Harvesting costs per unit of production include cash costs for items such as drying, transport and contract work, which are sensitive to crop yield.

Contract work represents work done by additional labour on a contract basis. This is normally done in one of two ways. The contract worker can either be paid per hectare or per ton, so that contract work is distinguished both in harvest cost

per hectare and harvest cost per production unit. Farm overhead expenses should not be included in any of the three input cost categories. For example, items such as general farm insurance premiums, and returns to operator and family living expenses should be excluded. The aim of the MDSS is to optimize crop return by optimizing the net cash flows generated by the various marketing instruments. Overhead expenses should also be allocated to the rest of the farm operations. Due to the difficulty in deciding the percentage allocation of overhead expenses to the crop production process, overhead expenses were ignored in the development of the MDSS.

Due to the fact that the MDSS aims to maximise net return by choosing an optimal marketing strategy, the MDSS attempts not to determine the type of crop to be planted, but only the marketing strategy to be used for marketing the crop. All input costs used ignore the influence of the time value of money because the aim is to optimise the marketing strategy and not to optimise crop choice.

Production costs in general are assumed to be independent of marketing return. However, marketing strategies cannot be taken in isolation from input costs. There is a direct relationship between input cost and the importance of price risk management. The higher the input cost, the more important effective price risk management is.

The requirements for managing cash flows so as to service debt obligations can also influence marketing decisions. The MDSS incorporates the effects of debt in the input cost categories by allocating the interest on debt proportionally to the above categories, and in the discount rate used to determine the present value of the net cash flow generated by a marketing instrument.

6.4.2 Marketing information

For the purposes of this study, producers can decide between pricing their crops preceding harvest using forward contracts, options on futures contracts and futures contracts or waiting and selling in the spot market at or after harvest. The effect of the time value of money is taken into consideration because the different marketing instruments available lead to different timings of cash flows. All strategies are discounted back to the harvest date of the representative crop. If a producer has debt obligations, the interest rate associated with debt is used as the discount rate to calculate the present value of the relevant cash flows. If the producer has investments, the applicable percentage interest return on these investments is used as discount rate. If the producer has neither debt nor investments, the SAFEX interest rate is used as the appropriate discount rate.

For every marketing instrument, the following information is required:
- selling price (contract price);
- storage cost (if any);
- handling cost (if any);
- transport cost (if any);
- brokerage fees (if any);
- premium costs (option contracts);
- delivery date;
- prevailing interest rate (lending rate or investment rate); and
- initial margin costs (futures contracts).

In order to determine the net cash flow of each marketing instrument, the cash inflows and cash outflows of each marketing instrument must be calculated. Below, cash outflows are defined and discussed, followed by cash inflows.

6.4.2.1 Cash outflows of a marketing strategy

Cash outflows represent all costs that producers incur during the pre-harvest marketing stage, the harvest marketing stage and the post-harvest marketing stage. Cash outflows are therefore all costs associated with the planting, harvesting, storing and marketing of crops. The following costs are used in the equations developed for the model, and they are defined as follows:

- **Storage cost** is the cost producers incur if they choose to store their crops to sell at a later stage.
- **Initial margin** is the initial amount required by SAFEX before a producer can enter into a futures contract. Due to the varying nature of the mark-to-market prices and the fact that all deposits to SAFEX are paid back after the contract has been fulfilled, the influence of the maintenance margin is ignored. It is also assumed that the full amount is always payable.
- **Transaction costs** consist of the SAFEX contract cost and commission fees charged by the trader.
- **Area differential cost** consists of basis cost (the difference between the local spot price and the futures price of a crop), transport cost from the local elevator to Randfontein, and handling costs for loading the crop in and out of the elevator.
- **Premium cost** is the cost per ton to purchase an option on a futures contract.
- **Commission fees** represent the total amount to be paid when engaging in a futures or an option contract. It includes commission fees payable to the trader and all the SAFEX costs (except margin costs) associated with the action.

Table 6.6 indicates the cost item associated with each marketing instrument.

Table 6.6:   Cost items associated with marketing alternatives

	Storage	Initial margin	SAFEX contract	Commis-sion	Handling	Transport	Premium
Spot							
Store	X						
Forward	X						
Futures	X	X	X	X	X	X	
Options	X		X	X	X	X	X

Only spot sales during harvest incur no marketing costs, but the risk associated with spot sales is much greater. The reason being that producers cannot protect themselves against any possible downside movement of prices. Normally, during harvest, the spot price is lower than usual, due to an oversupply of the crop. The opposite can be true as well. Dramatic weather phenomena can push prices upwards, resulting in higher than average spot sales during harvest. Because the price movement during harvest cannot be predicted at any time during the growing season of the crop, it is risky to wait and sell all the crop during harvest only.

6.4.2.2   Cash inflows of a marketing strategy

Cash inflows represent all cash receipts from the sale of the crop. Cash inflows therefore represent all cash receipts of crop sales during the harvesting and post-harvesting marketing stage. The effect of the time value of money is taken into consideration and all cash inflows are discounted back to the harvest date of the respective crop. The MDSS does not take a short put and a short call option into consideration. For the purposes of the study, it is assumed that all producers are not speculative and are only trying to obtain the highest possible price for their crop. SAFEX (2000) confirmed that it is more often larger companies who participate in short puts and short calls. Therefore, the cash inflows from the

various marketing instruments are only the price received for the selling and/or for buying of the crop and not for selling the right to sell the crop or to buy the crop, as is the case with a short put and a short call.

The aim of the MDSS is to determine the optimal combination of marketing instruments to optimize the net return of producers by taking the specific limitations of the producers into consideration. Equations were developed to enable the MDSS to choose the optimal combination of marketing instruments. In order to test the MDSS, the net cash flows of the producers in every marketing stage are compared to the net cash flows of the MDSS. Finally, the net return generated by the producer's decisions is compared to the net return generated by the decisions suggested by the MDSS. The first step was to develop equations to determine the net cash flow of producers for every marketing instrument. Thereafter, these equations are adapted to enable the MDSS to determine the optimal combination of marketing instruments. In Section 6.4.3, the net cash flow of producers, as a result of their marketing actions, is determined. Section 6.4.3 is followed by an explanation of integer linear programming and the development of the MDSS in this study.

6.4.3 Net cash flow per crop of producers

First, the net cash flow per crop is determined. The net cash flow per crop represents the difference between the cash inflows and the cash outflows of a given marketing instrument. The net cash flow per crop is determined by summarising the net cash flows for each instrument used. To obtain the total net cash flow of crop sales, the following determinants of net cash flow and the equations to calculate these cash flows are developed:

6.4.3.1 Net cash flow from spot sales during harvest

The net cash flow from spot sales during harvest is comprised of the following equations. First, the cash inflow from spot sales during harvest is determined:

$$Cf_{s/in} = P*Q \qquad\qquad (6.1)$$

Where:

$Cf_{s/in}$ = cash inflow from spot sales

P = price per ton

Q = number of tons allocated

Thereafter, the cash outflows of crop sold on the spot market during harvest is determined:

$$CF_{input} = \{(PHVC/Y) + (HCPHe/Y) + HCPU\}Q \qquad\qquad (6.2)$$

Where:

CF_{Input} = input cost

Y = yield per hectare (ton)

$PHVC$ = pre-harvest variable cost per hectare

$HCPH_e$ = harvest cost per hectare

$HCPU$ = harvest cost per ton

The combination of Equations 6.1 and 6.2 results in the net cash flow from spot sales during harvest for all the crops covered by the MDSS.

$$NCF_{spot} = Cf_{s/in} - CF_{Input} \qquad\qquad (6.3)$$

Where:

Equations 6.1, 6.2 and 6.3 can only be used to determine the cash flows from spot sales during harvest. The receipts from the spot sales during harvest are received immediately and it is therefore not necessary to take the effects of the time value of money into consideration. If a producer decides to delay the selling and delivery of the crop, the effect of time value of money must be taken into consideration and does not form part of the harvesting marketing stage.

6.4.3.2   Net cash flow from storage

The equations developed to determine the net cash flow from storage (all the sales that occur in the post-harvesting marketing stage) differ from the equations developed in Section 6.4.3.1. The reason for this is the effect of the time value of money. The discount rate used in determining the present value is influenced by the producer's debt position. If the producer uses a production loan from a co-operative, and/or makes use of a bank overdraft facility in the crop production process, the highest debt interest rate is used. If the producer does not use any debt financing and has investments, the percentage interest return on these investments is used in the discounting process. If the producer does not use any debt financing, nor has any investments, the SAFEX interest rate on the day the contract is entered into, is used as a fixed rate throughout the marketing season. To determine the net income from storage, the equations below therefore apply.

First, the cash outflows associated with the storage decision is calculated:

$$CF_{store/out} = \quad PV\{(S*T)Q\} \qquad\qquad (6.4)$$

Where:

$$CF_{store/out} \quad = \quad \text{cash outflows resulting from the storage decision}$$

PV   =   present value

S   =   storage cost per ton per day

T   =   length of storage (in days)

The net cash flow from the storage decision is determined by:

$$\text{Net}_{store} = PV(P{*}Q) - CF_{input} - CF_{store/out} \tag{6.5}$$

Where:

Net_{store} =   net cash flow from store alternative

CF_{input} =   input costs (Equation 6.2)

$CF_{store/out}$ =   cash outflows resulting from storage decision

The cash inflows and cash outflows are discounted to the present value at harvest time. This enables a comparison between the different marketing strategies. The storage alternative only forms part of the post-harvesting marketing stage and the net return generated by storage is therefore only reflected in the post-harvest marketing stage.

6.4.3.3   *Net cash flow from forward contracts*

The net cash flow for forward contracts (all the forward sales that occur in the pre-harvest marketing stage) can consist of two possible equations. If the delivery is made during harvest, the following equation is applicable:

$$NCF_{fwh} = Cf_{s/in} - CF_{Input} \tag{6.6}$$

Where:

NCF_{fwh} =   net cash flow from forward sales delivered during harvest

$Cf_{s/in}$ =   cash inflow from spot sales (Equation 6.1)

Although the producer can already enter into the forward contract during the pre-harvest marketing stage, the payment is only received on delivery. Because the payment is received during harvest, the effect of the time value of money can be ignored and the net cash flow represents a spot sale during harvest.

If delivery on the forward contract is delayed to a later stage, the following equation that takes the storage cost and time value of money into account is used:

$$NCF_{fw} = \quad PV(P^*Q) - CF_{Input} - CF_{store/out} \hspace{3cm} (6.7)$$

Where:

$$CF_{store/out} = \quad \text{cash outflows resulting from the storage decision}$$
$$\text{(Equation 6.4)}$$

6.4.3.4 Net cash flow from futures contracts

In the case of futures contracts, the net cash flow can be influenced by the following two sets of scenarios:

- whether the producer can maintain the margin calls or not; and
- whether the producer closes out his/her futures position, or delivers on the futures position.

Futures contracts are discounted to harvest time to enable comparison between the various instruments. The length of time used in the discounting process is the time from harvest to the expiry date of the futures contract.

If the producer **maintain the margin calls** and decided **to deliver** on the futures position, the net cash flow is determined by the equations below.

First, the **cash inflow** resulting from a futures position is determined:

$$CF_{fut/in} = PV(FP*Q) + (i*Mar) \tag{6.8}$$

Where:

$CF_{fut/in}$ = cash inflow from futures sales

FP = futures price per ton

i = interest rate per day

Mar = initial margin

The **cash outflow** resulting from the futures position is determined:

$$CF_{fut/out} = (TC*n) \tag{6.9}$$

Where:

$CF_{fut/out}$ = cash outflows resulting from futures contracts

TC = total transaction cost per contract

n = number of contracts

The net cash flow from delivery on futures sales is determined by:

$$NCF_{fut} = CF_{fut/in} - CF_{fut/out} - PV(A*Q) - CF_{Input} \tag{6.10}$$

Where:

NCF_{fut} = net cash flow from futures contract sales

A = area differential cost

If the producer **cannot maintain margin calls** and has **decided to deliver** on the futures position, the following equations apply:

First, the cash inflow from the futures position is determined:

$$CF_{fut/in} = PV(FP*Q) \qquad (6.11)$$

Where:

$CF_{fut/in}$ = cash inflow from futures sales

The net cash flows resulting from the futures position is thereafter determined:

$$NCF_{fut/dl} = CF_{fut/in} - CF_{fut/out} - CF_{input} - PV\{(A*Q) + (i*Mar)\} \qquad (6.12)$$

Where:

$NCF_{fut//dl}$ = net cash flow resulting from futures contracts

Due to the fact that the producer has to borrow the initial margin, the interest earned by the margin account (i*Mar) is seen as a cost. If the producer could maintain the margin calls, the interest generated by the margin account is seen as a cash inflow and it is assumed that the producer could have invested the initial margin amount to earn an interest income.

If the producer **can maintain the margin calls** and decides to **close out** the short futures position with a long futures position, the net cash flow is determined by the following equations:

$$NCFs_{futcl} = PV(FPs - FPl)*Q - (TC*n) \qquad (6.13)$$

Where:

$$NCFs_{futcl} = \quad \text{net cash inflow of short futures position closed out}$$

FPs $\quad = \quad$ short futures price per ton

FPl $\quad = \quad$ long futures price per ton

And if the producer decides to close out the long futures position with a short futures contract, the net cash flow resulting from this action is determined by Equation 6.14:

$$NCFl_{futcl} = \quad PV(FPl - FPs)*Q - (TC*n) \hspace{3cm} (6.14)$$

Where:

$$NCFl_{futcl} = \quad \text{net cash inflow of long futures position closed out}$$

On the other hand if the producer **cannot maintain the margin calls** and decides to **close out** the short futures position with a long futures position, the net cash flow is determined by the following equation:

$$NCFs_{fut} = \quad PV(FPs - FPl)*Q - (TC*n) - (i*Mar) \hspace{2cm} (6.15)$$

Where:

$$NCFs_{fut} = \quad \text{net cash inflow of short futures position}$$

And if the producer **cannot maintain the margin calls** and decides to **close out** the long futures position with a short futures contract, the net cash flow resulting from this action is determined by Equation 6.16:

$$NCFl_{fut} = \quad PV(FPl - FPs)*Q - (TC*n) - (i*Mar) \hspace{2cm} (6.16)$$

Where:

$$NCFl_{fut} = \quad \text{net cash inflow of long futures position}$$

It is assumed that in the pre-harvesting marketing stage the producer will deliver on the futures contract. Equation 6.10 is therefore used in determining the net cash flow of futures sales during the pre-harvest marketing stage.

6.4.3.5 Net cash flow from options on futures contracts

When producers use option contracts, a choice can be made between put options and call options. Producers normally enter into a put option contract if they expect prices to decline. Producers normally enter into a call option contract to protect themselves against a price rise if they used forward contracts to sell a percentage of their crop. If producers choose a call option contract, they have the right to buy the commodity at a specific price. Producers can also use call option contracts to lengthen the marketing time of their crops. Producers sell their crop during harvest and purchase, for instance, a March call option contract if they expect prices to increase. If the price of the grain rises, producers can, for example, exercise their option before the expiry date of the call option, buy the commodity at the predetermined price and sell it immediately in the spot market for a higher price. To determine the net cash flow from options on futures contracts, the following scenarios apply:

- put option contracts exercised and delivered;
- put option contracts exercised and futures position closed out;
- put option contracts expired worthless;
- call option contracts exercised and delivery received;
- call option contracts exercised and futures position closed out; and
- call option contracts that expired worthless.

The following equations were developed to determine the net cash flow for various scenarios of options on futures contracts.

If a producer decides to **exercise a put** option contract and to **deliver** on the contract, the following equation is used to determine the net cash flow:

$$NCF_{put/ex} = PV\{(P*Q) - (A*Q)\} - (TC*n) - (Prem*Q) - CF_{input} \quad (6.17)$$

Where:

$NCF_{put/ex}$ = net cash flow from put option contracts exercised and delivered upon

Prem = premium per ton

If a producer decides to **exercise a put** option contract, to **close out** the futures position and the sell the crop on the spot market, the following equation is used in determining the net cash flow:

$$NCF_{put/cl} = PV\{(P*Q) + NCFs_{fut}\} - (TC*n) - CF_{input} \quad (6.18)$$

Where:

$NCF_{put/cl}$ = net cash flow from put option contracts exercised and closed out

$NCFs_{fut}$ = net cash inflow of short futures position

If the put option contract **expired worthless**, the net cash flow is determined as follows:

$$NCF_{put/nex} = -\{(TC*n) + (Prem*Q)\} \quad (6.19)$$

Where:

$NCF_{put/nex}$ = Net cash flow from put option contracts not exercised

Call options initially lead to a net loss, because the producer buys the right to buy crop at a predetermined price. However, if the producer exercises the option, the producer profits from the higher spot price. To determine the net cash flow from call option contracts, the equations below were developed.

For call option contracts that are **exercised** and for which **delivery** received the net cash flow can be determined as follows:

$$CF_{in/callex} = PV\{Q(CP - SP)\} \tag{6.20}$$

Where:

$CF_{in/callex}$ = cash inflow from call option sales exercised

CP = call option price

SP = spot price

and

$$CF_{call/out} = PV\{(A*Q)\} - (TC*n) - (Prem*Q) \tag{6.21}$$

Where:

$CF_{call/out}$ = cash outflow of call option contract

Resulting in:

$$NCF_{callex} = CF_{in/callex} - CF_{call/out} \tag{6.22}$$

Where:

NCF_{callex} = Net cash flow from call sales exercised

If a call option contract is **exercised** and the position is **closed out**, the net cash flow is determined by:

$$NCF_{callcl} = PV\{(Q^* \, NCFI_{fut})\} - (TC^*n) \qquad (6.23)$$

Where:

$NCFI_{fut}$ = net cash inflow of long futures position

NCF_{callcl} = net cash flow from call option sales exercised and closed out

For call option contracts that **expired worthless**, the following equation is developed:

$$NCF_{callnex} = -\{(TC^*n) + (Prem^*Q)\} \qquad (6.24)$$

Where:

$NCF_{callnex}$ = net cash flow of call option contract that expired worthless

In the pre-harvest marketing stage, it is assumed that all option contracts are exercised and delivered. The net cash flow from put option contracts is therefore determined by Equation 6.17.

Finally, the net return generated by the producer is determined as follows:

$$
\begin{aligned}
\text{Net return} = \quad & \text{NCF}_{spot} + \text{Net}_{store} + \text{NCF}_{fwh} + \text{NCF}_{fw} + \text{NCF}_{fut} + \qquad\qquad (6.25) \\
& \text{NCFs}_{futcl} + \text{NCFI}_{fwcl} + \text{NCFs}_{fut} + \text{NCFI}_{fut} + \text{NCF}_{putex} + \\
& \text{NCF}_{put/cl} + \text{NCF}_{put/nex} + \text{NCF}_{callex} + \text{NCF}_{callcl} + \text{NCF}_{callnex}
\end{aligned}
$$

Where:

Net reurn =   net return of crop sales

Appendix A serves as an example to illustrate how the various net cash flows and returns is calculated and shows the marketing decision making process of producers.

6.5   SOLUTION METHOD

Optimisation problems can be divided into unconstrained and constrained (any restriction the decision variables must satisfy) variables, and the latter into problems with equality constraints (where $x = 0$) and problems with inequality constraints (where normally $x \leq 0$). Inequality constraint problems also exist for $x > 0$. Thus there are three broad categories in which problems can be classified, and the corresponding solution methods were determined in two different eras.

Unconstrained optimisation problems were first solved with the methods of calculus, developed in the seventeenth century by Sir Isaac Newton (1642-1727) and Gottfried Wilhelm Leibniz (1646-1716). The solution to optimisation problems constrained by equalities was found a century later by Joseph-Louis Lagrange (1736-1813). For inequality-constrained problems, the solution

procedures were not found until the 1940's, by John von Neumann and George Dantzig (Fang & Puthenpura, 1993). Optimisation with inequality constraints differs in one fundamental respect from the earlier problems: there is no closed, analytic expression that describes the solution. Therefore, it is necessary to know the optimal basis, or the list of the variables that appear in the optimal solution.

Linear programming is a mathematical model that is often helpful in solving decisions requiring a choice between a large number of alternatives. The theoretical concepts underlying the methods of linear programming have been known for many years. However, it was during World War II and immediately thereafter that the application of linear programming to planning problems was stressed. Since then these techniques have been applied increasingly to management decisions in various industries, including in agriculture. Linear programming is concerned with problems in which a linear objective function in terms of decision variables is to be optimised (i.e., either minimised or maximised) while a set of linear equations, inequalities, and signs (positive or negative values) are imposed on the decision variables as requirements. Optimisation problems for linear programming are made up of three basic ingredients:

- an **objective function** which has to be minimised or maximised;
- a set of **unknowns** or **variables** which affect the value of the objective function; and
- a set of **constraints** that allow the unknowns to take on certain values but exclude others.

If the objective function is for example:

Find x_1 and x_2 so as to:

$$\text{Maximise } Z = 5x_1 + 2x_2$$

Where:

$$x_1 = \text{variable 1}$$

$$x_2 = \text{variable 2}$$

The following step entails the identification of all the different constraints on the problem. Assume the constraints are the following:

$$x_1 + x_2 \leq 8$$

$$4x_1 + x_2 \leq 12$$

$$x_1, x_2 \geq 0$$

The model formulation of the above maximisation problem is presented graphically in Figure 6.11. In order to graph the two constraint inequalities ($\leq$), it is necessary to treat each as an equality (=). By finding two points common to each equation, the lines can be determined and plotted on the graph. A method of plotting a line is to let one variable in an equation equal zero. For example, in $x_1 + x_2 \leq 8$ let $x_1 = 0$, then $x_2 = 8$ and let $x_2 = 0$, then $x_1 = 8$. These points are connected with a line in Figure 6.11 (a). For the constraint, $4x_1 + x_2 \leq 12$ let $x_1 = 0$, then $x_2 = 12$ and let $x_2 = 0$, then $4x_1 = 12$ and $x_1 = 3$. These points ($x_1 = 0$, $x_2 = 12$ and $x_1 = 3$, $x_2 = 0$) are then plotted on each axis and connected with a line in Figure 6.11 (b).

Figure 6.11: Graphic presentation of a maximisation problem

(a)

(b)
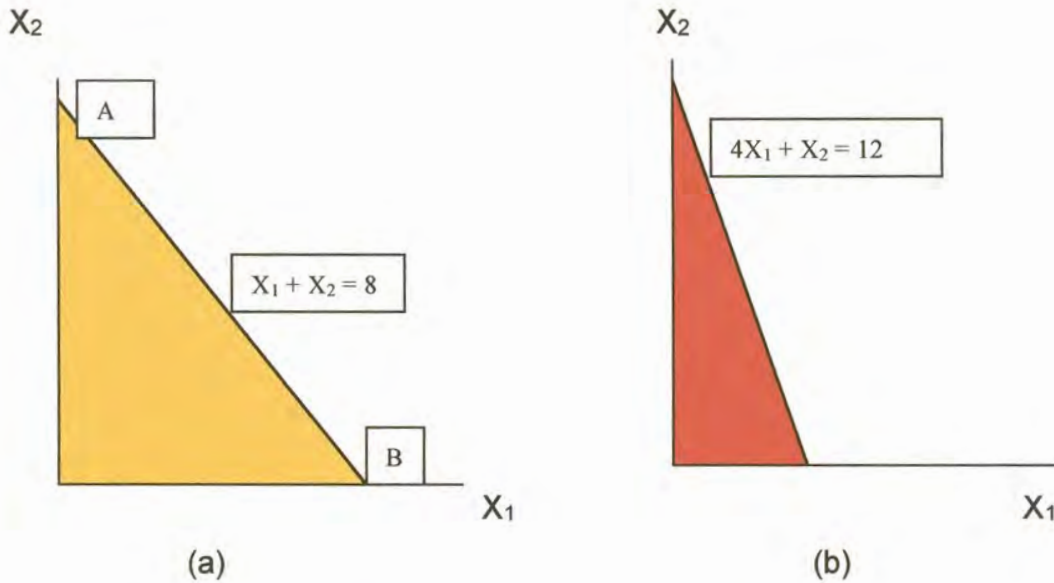
Source: Adapted from (Fang & Puthenpura, 1993)

By reinserting the $\leq$ inequalities in each constraint, a region is formed that simultaneously satisfies both the constraint relationships. This region, the shaded area ABDC in Figure 6.12 is defined as the feasible solution area, because it satisfies all system constraints. The feasible solution area is restricted to positive values because the variables x_1 and x_2 must be positive – x_1, $x_2 \geq 0$. Any set of x_1, x_2 values outside this region is not a feasible solution since it violates one or more of the constraints. For example, in Figure 6.12 point K is a feasible solution, while L is infeasible. Point K is feasible because it lies within the boundaries of ABDC and Point L is infeasible because it is outside the boundary lines. Although Point K is feasible, it is not the optimal combination. The optimal combination will normally fall on the boundary lines (ABDC).

Figure 6.12: Feasible and infeasible solutions
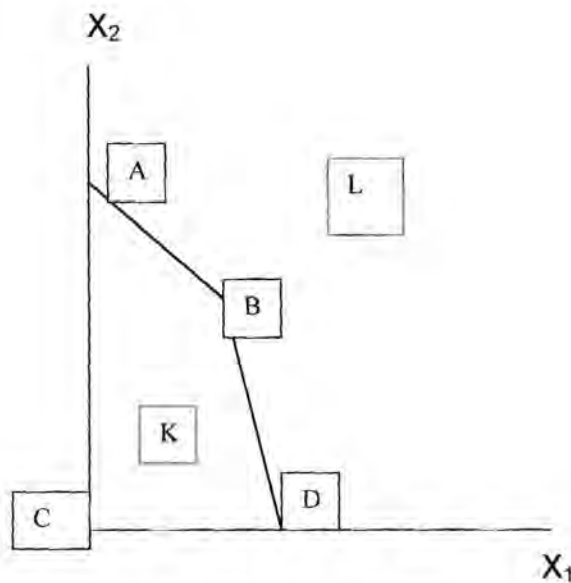
Source: Adapted from (Fang and Puthenpura, 1993)

The final step is to evaluate the objective function ($5x_1 + 2x_2$) at points A, B, D and C to determine which one(s) is optimal. This is accomplished in Table 6.7.

Table 6.7:   Candidate solutions

Extreme points	Co-ordinates (x_1, x_2)	Objective function value ($5x_1 + 2x_2$)
A	0,8	16
B	(4/3),(20/3)	20
C	0,0	0
D	3,0	15

Point B occurs at the intersection of ($x_1 + x_2 = 8$) and ($4x_1 + x_2 = 12$), or {$x_1 = (4/3)$ and $x_2 = (20/3)$}. Since point B gives the maximum value (20) for the objective, it is the optimal combination.

The mathematical specification of an integer linear programming problem is the same as for a linear programming problem, with one exception. In addition to requiring the levels of all variables in a solution to be greater than or equal to zero, some or all variables can be required to take only zero or integer values, as opposed to fractional values. Integer linear programmes have the advantage of being more valuable for the purposes of this study as compared to ordinary linear programming, in the sense that integer values is now also taken into consideration. The most widely used general-purpose approach in integer linear programming requires a series of linear programmes to manage the search for integer solutions and to prove optimality.

Integer programming has proved valuable for modelling many and diverse types of problems in planning, routing, assignment and design. Industries that use integer programming include transport, energy, telecommunications, manufacturing and agriculture (Ferris, 1998).

Mixed integer programming requires that only some of the variables need to have integer values, whereas pure integer programming requires all variables to be integers. The MDSS developed in this chapter is based on **mixed integer linear programming**. The reason for this lies in the fact that futures contracts and options on futures contracts can only be for values of 100 tons and the multiples thereof.

6.5.1 Net cash flow used by MDSS

The mathematical model developed in this chapter consists of marketing activities as the basic building blocks. With the aid of an integer linear programme built on a spreadsheet, various combinations of these actions can be

evaluated in terms of their impact on cash inflows and cash outflows, as well as other constraints that might be placed on their combination, and the objectives of the farm concerned.

The MDSS uses constraint optimisation to determine the optimal combination of marketing instruments that result in the highest net return. The net return is defined as the sum of the net cash flows from all the various marketing instruments available. Before integer linear programming can be used to solve an optimisation problem, certain constraints must be defined. The constraints used in this MDSS were the minimum and maximum number of tons that a producer was willing to allocate to a certain marketing instrument and the cash flow position of the producer. If the producer experienced cash flow problems, futures contract can be excluded from determining the optimal combination.

In order to determine the optimal combination of marketing instruments, the **net cash flow per ton** of each marketing instrument has to be determined. Furthermore, the various equations developed in Section 6.4.3.1 to Section 6.4.3.5 were adjusted for application to the MDSS to determine the net cash flow per ton. The MDSS used therefore the same equations with the only change that the net cash flow is determined per ton.

Appendix A serves as an example to illustrate how the various net cash flows and returns by the MDSS is calculated in determining the optimal combination of marketing actions.

6.6   CONCLUSION

Producers must repeatedly make decisions about what commodities to produce, by what production method, in what quantities, and how to sell them. Decisions

are made subject to the prevailing physical and financial constraints of the farm and often in the face of considerable uncertainty about the planning period ahead. Uncertainty may arise in the expected yields, costs and prices for the individual farm enterprises, in fixed asset requirements and in the total supplies of the fixed assets available.

Traditionally, producers have relied on experience, intuition and comparisons with their neighbours to make their financial decisions. However, formal techniques of budgeting and comparative analysis have now been developed by farm management specialists, and these can be useful aids for making decisions in less complex situations or for analysing selected decisions when all the other farm decisions are taken as given. More recent advances in computers and in mathematical programming software mean that satisfactory procedures have now been developed for total farm planning in more complex situations.

Total farm planning can assist producers to adapt efficiently to a changing economic and technological environment. Mathematical programming in agriculture had its origins in attempts to model the economics of agricultural production, including its spatial dimension. The mathematical programming format is particularly suitable for agriculture. Producers, agronomists, and other agricultural specialists share a common way of thinking about agricultural inputs and outputs in terms of the annual crop cycle, and about input-output coefficients per hectare. Yields are conceived in tons per hectare, fertiliser applications in kilograms per hectare and so on.

By means of integer linear programming, attempts were made to develop the first MDSS suitable for South African producers. The aim of the MDSS developed in this chapter is to determine the optimal combination of marketing instruments to optimize crop net return. First, the net cash flows of producers by using various marketing instruments were determined. Thereafter, the net return per ton for

each marketing instrument was determined. Using integer linear programming the optimal combination of marketing strategies was determined. The next chapter indicates how the MDSS was tested to prove its viability.

CHAPTER 7

APPLICATION OF THE MARKETING DECISION SUPPORT SYSTEM

If a man look sharply and attentively, he shall see Fortune; for though she is blind, she is not invisible

- Francis Bacon (1561 – 1626)

7.1 INTRODUCTION

The previous chapters discussed the changing agricultural environment in South Africa, the different types of risk that producers are faced with and various pricing instruments available to producers who wish to manage price risk. Chapter 6 focused on the development of a Marketing Decision Support System (MDSS) for grain producers in South Africa. This chapter discusses the application of the MDSS and its empirically testing. The MDSS allows for the possible effects of farm location, farm size and debt on marketing decisions. It also provides for variations in attitudes towards production and price uncertainty.

In economic terms, a well-managed farm is one that consistently makes larger net profits than similarly structured neighbouring farms. Because random localized events such as weather patterns often mask differences or similarities in management, it is important to observe differences in profits that persist over time. A crop producer can enhance the farm's revenue by better use and application of technology, improved cost management, improved yields and higher prices due to better marketing strategies. This chapter focuses on the application of the MDSS in its primary function of managing price risk. Producers have many alternatives for managing agricultural risk. They can diversify the

farm business or the financial structure of the business. In addition, producers have access to various instruments, such as insurance and hedging, that can help reduce their farm's level of risk. Indeed, most producers combine many different strategies and instruments and formulate strategies to hedge against the risk of possible losses.

Because producers vary in their attitudes towards risk, risk management cannot be viewed using a 'one size fits all' approach. Different producers have to confront different situations, and their preferences regarding risk and their risk-return trade-offs have an important effect on decision-making in each given situation. This chapter investigates the application and usefulness of the MDSS as developed in this study for grain producers in South Africa.

7.2 AREAS OF RISK EXPOSURE

The preceding chapters discussed the various price risk management instruments available to producers in South Africa. It is essential that producers understand how to use the various pricing instruments to manage price risk and how to select the most appropriate pricing instrument to accomplish their objectives of sustainable, profitable farming. Some instruments manage only one of the primary market risks, while others may manage several types of risk. Knowing how to use the various instruments involves understanding the mechanics of such aspects as opening a trading account with SAFEX, placing orders with a broker and meeting margin requirements. It also includes understanding obligations and responsibilities for delivery, and conditions under which contracts can be cancelled or modified.

Selecting the most appropriate pricing instrument for a farm's financial and marketing situation is complex. The most appropriate pricing instrument is mainly determined by the following aspects:

- the producer's risk management objective(s) and expectations regarding future price movements;

- current price relationships and expectations regarding changes in those relationships; and

- the producer's attitude towards risk.

More than one pricing instrument may be available to accomplish a producer's objective. An important aspect of the decision process is to assess the risk associated with each pricing instrument. The following two questions provide guidelines in choosing the right instrument:

(i)   What does the producer want to accomplish?

(ii)   What is the best way to reach the financial objectives of the producer?

The main areas of farm risk were identified and examined in Chapter 3 as yield risk, price risk, institutional risk, personal risk, exchange rate risk and financial risk. These risks affect a producer's net income and should also be considered in the selection and implementation of pricing instruments. These risks can be summarised as follows:

- **Cash flow risk** is typically associated with trading in futures. It is the risk that the producer is unable to maintain a margin account due to a shortfall of cash on hand. Once a margin account is established and a futures position is taken, adverse price movements may require additional deposits in the margin account. Rising prices from a short futures sale position, for example, would result in margin calls. Conversely, declining prices would result in money flowing into the margin account of a short futures position to offset the decline in the value of the grain owned.

- **Business or counter-party risk** is the risk associated that the grain buyer will not be able to fulfil part or all of the contract agreement. The risk is especially important for producers who have forfeited their title to the grain, but have not yet received payment. Business failure is likely to result in the cancellation of forward contracts, leaving the producer in an open position on grain that was priced earlier.

- **Volatility risk** (as discussed in Chapter 5) is associated with the options market. The risk lies in the fact that option premiums do not change one-for-one with cash or futures prices, so that the net prices on such contracts do not move one-for-one with the change in price level. The extent of the risk varies with market volatility, the closeness of the options strike price to the underlying futures price, the length of time until the contract expires and whether the producer intends to hold the option position until maturity or to exit early.

- **Yield risk** arises when the producer sells a crop prior to harvest. The primary concern is that production volumes may fall short of expectation. The extent of yield risk varies with the type of pricing instrument used. When a producer enters into a short futures position or a forward contract, the producer is liable to deliver on the size of the contract. When yield is lower than expected, the producer can offset a short futures position by entering into a long futures position. This might occur at a higher price than the original short futures position. Producers can protect themselves against lower than expected production volumes in forward contracts by a *force majeure*. A *force majeure* gives producers the right to deliver volumes smaller than originally signed for. The seller of the forward contract normally grants this protection at a discounted price compared to a forward contract without a *force majeure*.

Although the following risks are not discussed at length in Chapter 3, they also affect price risk management alternatives:

- **Grain quality risk** is the risk that grain is graded lower due to disease or extreme weather conditions, and is subject to price discounts. This risk is associated with all pricing instruments.

- **Tax risk** includes the risk that losses associated with positions in the futures and options markets will be capital losses versus ordinary business expenses.

- **Control risk** is the risk associated with the number of decisions required to implement a pricing instrument fully. Some instruments require only one decision, a cash grain sale, for example. Other instruments, such as futures and options, require an initial decision and one or more subsequent decision(s). When a series of decisions is required, there is a risk of adverse market action that will reduce the net profit before subsequent decisions are made.

Farming, like any business enterprise, involves taking risks to obtain a higher income than might be obtained otherwise. Some producers appear to virtually disregard risk. But for most, the risk they can accept is limited. Thus, price risk management is not a matter of minimising price risk, but of determining how much risk to take, given a producer's alternatives and preference trade-offs. Therefore, the producer's choice between different pricing instruments is also influenced by the sensitivity of the pricing instruments towards the areas of risk exposure, as indicated by Table 7.1.

Table 7.1:   Areas of risk exposure

Pricing alternative	Price level	Cash flow	Volatility	Business	Tax	Control	Yield	Quality	Risk rating
Selling out of inventory or establishing pre-harvest price levels									
Cash sales	x						x	x	Moderate to high
Forward contracts				x			x	x	Low to high
Short futures		x				x	x	x	Low to high
Buy put options	x		x			x	x	x	Low
Price grain & buy call option	x		x	x	x	x	x	x	Low
Minimum price contracts	x		x	x		x	x	x	Low
Retaining ownership									
Storage	x							x	Moderate to high
Sell grain, buy futures	x	x			x	x			Moderate to high
Sell grain, buy call options	x		x		x	x			Low
Minimum price contracts	x		x	x		x			Low
Delayed pricing contracts	x			x		x			Moderate to high

Source: Adapted from Ferris (1998)

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It is clear from Table 7.1 that some grain pricing instruments are exposed to higher risk than others. Some instruments are designed to manage several aspects of risk. Instruments can be used in combination to extend risk management capabilities. The usefulness of the MDSS is compared with the areas of risk exposure of each instrument. Some producers in the study indicated that they are not interested in certain instruments, due to the level of risk exposure of that instrument, and they were consequently excluded from the analysis. Table 7.1 serves as a guideline for producers in their decision-making process and the suggested instruments of the MDSS are examined in respect of risk exposure (see Table 7.16).

7.3   THE SURVEY

A questionnaire was developed to collect data from crop producers in the Free State Province. The data was collected in the form of a postal survey, followed by telephonic interviews and personal interviews. Crop producers in Statistical Regions 28 and 29 in the Free State Province were randomly selected from address lists provided by local co-operatives and agri-businesses. From the postal survey, a response rate of 28% was obtained. The postal survey was augmented by telephonic interviews and personal visits. The data for the analysis were obtained from 14 producers in the above statistical regions. This resulted in a final response rate of 78%. None of the questionnaires were unusable due to incomplete information. Information regarding marketing strategies was collected from the producers during the 1998/99-marketing season for summer crops and the 1999/2000-marketing season for wheat. The reason why the MDSS was not tested for longer periods was that during its initial years SAFEX was used as a guaranteed forward pricing market with high levels of physical deliveries. Options on futures contracts only started trading in March

1998 and therefore the marketing seasons before the 1998/99 marketing season were unusable.

From the responses to the questionnaire, it seems that respondents spend an average of 3.2 hours per week reviewing marketing information. Weekly agricultural magazines were rated the most important sources of price information, followed by subscription-based information providers and SAFEX. When producers were asked to identify their needs for additional information and services to manage their grain marketing better, the most commonly requested service was information on price and production trends in international markets. Producers generally rated their skills in marketing management lower, than their production and financial management skills.

7.4   EVALUATION PROCUDURE FOR THE MDSS

The MDSS is based on the principles of integer linear programming. Firstly, the information pertaining to the producer was entered into the model. Every time a producer made a decision, the result was compared to the net effect suggested by the MDSS. From there on, the decisions suggested by the linear programme were taken into consideration in future decisions. For instance, when the model suggested that the producer should engage in a short futures position, the futures position was reflected in the next set of decisions. All option contracts suggested by the model were at-the-money, due to the difficulty in deciding how much an option must be in- or out-of-the-money.

Secondly, one month prior to harvest, the MDSS was run again to sell a total of about 80% of the producer's crop. If the producer had already sold more than 80% of the crop one month prior to harvest, this action of the MDSS was ignored. The primary reason for this action was that the spot price during

harvest normally tends to be lower than prior to the harvest. By selling about 80% of the crop, a producer protects himself/herself from price risk, and the possibility of yield risk is much smaller than earlier in the season.

It is important to take note that in the case of sunflower seed, the first contracts were traded on 1 February 1999. Any decisions made by producers before that date could not be compared with other marketing alternatives available to producers. Soybean prices and strategies available to producers were limited to local prices. No international price risk instrument was taken into consideration, due to the fact that South Africa is a net importer of soybeans and therefore the soybean prices always reflect the import parity price of international soybeans. All the pricing tools available to producers for maize and wheat were taken into consideration by the MDSS (except in cases where producers specifically excluded certain instruments).

7.5 ANTICIPATED EFFECTS AND CASES INVESTIGATED

The analytical model used in this study allows for the possible effects of farm location, size and debt on marketing decisions. The model also provides for variations in attitudes towards production and price uncertainty. The complexity of the solution presented by the model resulting from the interrelatedness of these factors, however, is not conducive to simple, mathematically derivable comparative statistics. The purpose of this investigation, as stated previously, was therefore to investigate the sensitivity of the model to the instruments used in order to obtain the highest possible profit generated from the crops planted.

7.5.1 Investigation results

The marketing strategies corresponding to the 14 cases investigated are set out in Tables 7.2 to 7.15. For each case, information on the actual quantities (in tons) of each crop sold using each marketing alternative during the 1998/99 marketing season for summer crops and the 1999/2000 marketing season for wheat are also given. The net returns obtained by the producer and the MDSS are calculated using Equations 6.1 to Equation 6.25.

The sales in tons reported in these tables were not conducive to comparisons in terms of farm size or location. Therefore, the information was converted to the percentage of annual output marketed by the producer using each alternative. The marketing actions of the producers and the MDSS were divided into three different marketing stages:

- pre-harvest stage (actions taken before planting, during the growing season until harvest time);
- harvest stage (actions taken during the harvest season); and
- post-harvest stage (actions pertaining to the current marketing season after the harvest period, with no time limitation on the post-harvest stage).

The dates used in the testing of the MDSS are the same dates as those used by the individual producer when a marketing decision was made. Producers did not make marketing decisions on the same date, however, which means that the dates used in the testing of the model also vary for each individual producer.

7.5.1.1   White maize producers

The investigation took into account the different categories discussed in Section 6.2.1.4, Category A with a total crop production of less than 1 00 tons, Category

B with a total crop production between 1 000 tons and 1 999 tons, and Category C with a total crop production of 2 000 tons and more.

- **Producer A1**

The farm unit of Producer A1 is situated in Statistical Region 28 of the Free State Province. Producer A1 planted 133 hectares of white maize with a realised yield of 4,7 tons per hectare (classified in Category A). On 25 February 1999 he entered into a forward contract to deliver 200 tons of maize, which represents 32% of the total white maize crop, to a local elevator owner at a price of R850 per ton. During the harvest period, he sold the remainder of his crop on the spot market, at a price of R700/ton. Table 7.2 displays the results of Producer A1's actions as well as the results of the actions suggested by the MDSS.

Table 7.2   Comparative net returns – Producer A1

Actions	Producer A1	MDSS
Pre-harvest stage		
25/2/99		
Pricing instrument and % sold	Forward (32%)	Forward (32%)
Net cash flow	R93 715	R93 715
14/05/99		
Pricing instrument and % sold	0%	Short futures (48%)
Net cash flow		R99 387
Harvest stage		
14/06/99		
Pricing instrument and % sold	Spot market (68%)	Long futures (48%)
		Spot market (68%)
Net cash flow	R105 768	R115 400
Net return	**R199 483**	**R209 116**
% improvement		**4.85%**

The MDSS suggested the following marketing instruments during the 1998/99 marketing season:

Pre-harvesting stage

In the pre-harvesting stage the MDSS suggested that 32% of the crop should be sold using forward contracts. One month prior to harvest, the MDSS was run again to sell a total of 80% of the expected crop of Producer A1. The instruments suggested by the MDSS were to:

- sell 200 tons of maize on a forward contract on 25 February 1999; and
- engage in a short futures position (three contracts) at a price of R884/ton on 14 May 1999.

Harvest stage

The MDSS suggested that the producer should:

- deliver on the forward contract; and
- close out the short futures position with long futures contracts at a price of R863/ton and sell the rest of the crop on the spot market.

Producer A1 sold all the crop during harvest and did not participate in any post-harvesting strategies. The actions suggested by the MDSS generated an improvement of 4.85% on the net return of Producer A1. Producer A1 received exceptionally good prices from his forward contract compared to the futures contracts at that stage. The prevailing futures price during the same time was only R723 per ton, resulting in a very strong basis. The only negative aspect of the producer's strategy was that the producer had locked himself out of any possible future price increase.

- **Producer A2**

The farm unit of Producer A2 is in Statistical Region 28 of the Free State province. Producer A2 planted 400 hectares of white maize with a realised yield of 4 tons per hectare. The total production volume of Produce A2 is 1 600 tons and he is therefore classified in Category B. The producer followed the following marketing strategies:

- On 15 March 1999 he entered into a forward contract to deliver 800 tons of maize to a local elevator owner at a price of R550 per ton.
- He sold the remainder of his crop (800 tons) on the spot market during the harvest period and received an average price of R550 per ton.

The producer indicated that he did not want to sell any maize on the futures market due to cash flow problems. No further constraints were indicated on any other pricing alternative. Table 7.3 combines the results of Producer A2 to those of the MDSS.

Table 7.3:   Comparative net returns – Producer A2

Actions	Producer A2	MDSS
Pre-harvest stage		
15/03/99		
Pricing instrument and % sold	Forward (50%)	R880 put (50%)
Net cash flow	R129 120	R336 236
21/05/99		
Pricing instrument and % sold	0%	R900 put (30%)
Net cash flow		R249 402
Harvest stage		
20/06/99		
Pricing instrument and % sold	Spot market (50%)	Exercise puts (80%) Spot market (20%)
Net cash flow	R129 120	R511 223
Net return	**R258 240**	**R511 223**
% improvement		**97.96%**

The MDSS suggested the following actions during the 1998/99 marketing season, which generated a 97.96% increase in net returns:

Pre-harvest stage

- Eight put option contracts with a strike price of R880/ton should be purchased on 15 March 1999.
- Six put option contracts with a strike price of R900/ton should be purchased on 21 May 1999, one month prior to harvest.

Harvest stage

- On 21 June 1999 all the put option contracts were to be exercised and 200 tons of maize were to be sold on the spot market.

- **Producer A3**

The farm unit of Producer A3 was in Statistical Region 28 of the Free State Province. Producer A3 planted 850 hectares of white maize with a realised yield of 4.59 tons per hectare (classified in Category C). The producer followed the following marketing strategies:

- On 12 November 1998, he entered into a forward contract to deliver 1 000 tons of maize to a local elevator owner at a price of R540 per ton.
- On 10 December 1998, he bought five put option contracts with a strike price of R680/ton.
- He sold 2 200 tons of his crop on the spot market during harvest and received an average price of R602 per ton.
- He exercised his put option contracts at a strike price of R680/ton.
- The producer chose a storage alternative, storing 200 tons of maize until March and sold the maize for R800 per ton on the spot market.

The producer indicated that he did not want to sell more than 600 tons of maize on the futures market. No further constraints were indicated on any other pricing alternative. Table 7.4 displays the results achieved by Producer A3 actions as well as those of the MDSS proposals.

Table 7.4: Comparative net returns – Producer A3

Actions	Producer A3	MDSS
Pre-harvest stage		
12/11/98		
Pricing instrument and % sold	Forward (25.6%)	Short futures (15.4%)
		R650 put (10.2%)
Net cash flow	R306 363	R374 413
10/12/98		
Pricing instrument and % sold	R680 put (12.8%)	R650 put (12.8%)
Net cash flow	R133 941	R159 766
26/05/99		
Pricing instrument and % sold	0%	R870 put (43.6%)
Net cash flow		R1 049 855
Harvest stage		
22/06/99		
Pricing instrument and % sold	Spot market (56.4%)	Exercise R870 puts
	Exercise R680 puts	Spot market (66.4%)
		Long futures (15.4%)
Net cash flow	R957 838	R1 432 398
Post-harvest stage		
01/07/99 - 01/03/00		
Pricing instrument and % sold	Storage until March	Short futures (5.1%)
	Spot market (5.1%)	Long futures (5.1%)
		Spot market (5.1%)
Post-harvest return	R96 077	R141 641
Net return	**R1 360 278**	**R1 948 452**
% improvement		**43.24%**

The MDSS suggested the following actions which resulted in a net improvement of 43.24%:

Pre-harvest stage

- Four put option contracts with a strike price of R650/ton were to be bought on 12 November 1998.
- A short futures position (six contracts) at R650/ton was to be taken on 12 November 1998.
- Five put option contracts with a strike price of R650/ton were to be bought on 10 December 1998.
- Seventeen put option contracts with a strike price of R870/ton were to be bought on 26 May 1999.

Harvest stage

- The short futures position was to be closed out and the maize was to be sold on the spot market.
- The nine put option contracts, with strike price of R650, were to be allowed to expire worthless and the maize was to be sold on the spot market.
- The 17 put option contracts with a strike price of R870 were to be exercised.

Post-harvest stage

- A short position was to be taken on 1 July 1999 on the futures market for two March futures contracts at a price of R943/ton.
- The short futures position was to be closed out on 1 March 2000 at a price of R816/ton and the 200 tons of maize were to be sold on the spot market at a price of R800/ton.

In all three instances, the MDSS delivered better results than the producers did. Therefore, the development of the MDSS could be regarded as successful in the case of white maize. The MDSS improved the results by 4.83% for the producer in Category A, 97.96% for the producer in Category B and 43.24% for the producer in Category C. The choice of the various marketing instruments varied from forward contracts to futures contracts and options on futures contracts. The

improvement obtained by the MDSS for Producer A1 was relatively low. This was due to the fact that the producer had engaged in a forward contract at a price higher than the prevailing futures contract. The dramatic improvement achieved by the MDSS for Producer A2 was due to the fact that the producer had closed a forward contract for 50% of the crop at a low price and had given up his chances of benefiting from future price increases. The improvement achieved by the MDSS for Producer A3 was mainly due to better post-harvest marketing actions such as engaging into a short futures position. The MDSS improved on the returns of all three producers by engaging in further marketing actions one month prior to harvest, resulting in a sale of 80% of the expected harvest.

7.5.1.2   *Yellow maize producers*

- **Producer B1**

The farm unit of Producer B1 is in Statistical Region 28 of the Free State Province. Producer B1 planted 150 hectares of yellow maize with a realised yield of 3.7 tons per hectare (classified in Category A). The producer did not enter into any pre-harvest marketing strategies. He sold 355 tons of his crop on the spot market during harvest and stored 200 tons until March 2000. On 1 March 2000 he sold the maize for R700/ton. The producer did not place a constraint on any marketing alternative. Table 7.5 sets out the results of Producer B1's actions as well as of those proposed by the MDSS.

Table 7.5:   Comparative net returns – Producer B1

Actions	Producer B1	MDSS
Pre-harvest stage **18/05/99**		
Pricing instrument and % sold	0%	Short futures (36%)
Net cash flow		R143 000
Harvest stage **18/06/99**		
Pricing instrument and % sold	Spot market (64%)	Long futures (36%) Spot market (64%)
Net cash flow	R106 850	R105 429
Post-harvest stage **01/07/99 - 01/03/00**		
Pricing instrument and % sold	Storage until March Spot market (36%)	Short future (36%) Long future (36%) Spot market (36%)
Net cash flow	R74 575	R104 976
Net return **% improvement**	**R181 425**	**R210 405** **15.97%**

The MDSS suggested the following marketing actions:

Pre-harvest stage

- The MDSS engaged in two short futures contracts at a price of R795/ton on 18 May 1999.

Harvest stage

- The MDSS closed out the short futures position and sold the maize on the spot market on 18 June 1999.

Post-Harvest stage

- On 1 July 1999 the MDSS entered into two short futures contracts for March at a price of R895/ton.
- The March futures contract was closed out on 1 March 2000 at R816/ton and the maize was sold on the spot market for a price of R700/ton.

These actions resulted in an improvement of 15.97%. During the harvest stage, the return of the MDSS was smaller than the return of the producer. The reason was that the futures hedge resulted in a loss, due to the fact that there was a small difference between the short and long futures position and a low spot market price.

- ## Producer B2

The farm unit of Producer B2 is in Statistical Region 28 of the Free State Province. Producer B2 planted 250 hectares of yellow maize with a realised yield of 4.8 tons per hectare (classified in Category B). The producer engaged in the following marketing actions:

- On 15 March 1999, he sold 600 tons of his crop on a forward contract at a price of R600/ton.
- The remainder of the crop was sold on the spot market during harvest at a price of R600/ton.

Producer B2 did not place any constraints on any marketing alternative. Table 7.6 sets out the results of Producer B2's actions as well as of those proposed by the MDSS.

Table 7.6: Comparative net returns – Producer B2

Actions	Producer B2	MDSS
Pre-harvest stage		
15/03/99		
Pricing instrument and % sold	Forward (50%)	Short futures (50%)
Net cash flow	R186 250	R210 455
10/05/99		
Pricing instrument and % sold	0%	Short futures (33%)
Net cash flow		R203 367
Harvest stage		
10/06/99		
Pricing instrument and % sold	Spot market (50%)	Long futures (83%)
		Spot market (100%)
Net cash flow	R186 250	R372 500
Net return	**R372 500**	**R401 992**
% improvement		**7.91%**

To achieve an increase of 7.91%, the MDSS suggested the following marketing actions:

Pre-harvest stage

- A short position was to be taken for six July 1999 contracts for R735/ton on 15 March 1999.

- A short position was to be taken for four July 1999 contracts for R795/ton 10 May 1999, one month prior to harvest.

Harvest stage

- The short futures contracts were to be closed out and the crop was to be sold on the spot market during harvest.

- **Producer B3**

The farm unit of Producer B3 was in Statistical Region 28 of the Free State Province. Producer B3 planted 650 hectares of yellow maize with a realised yield of 3.57 tons per hectare. The total production volume of yellow maize for Producer B3 was 2 320ton. Producer B3 was therefore classified in Category C. The producer engaged in the following marketing actions:

- On 19 February 1999, he sold 1 300 tons of his crop on a forward contract at a price of R650/ton.
- The remainder of the crop was sold on the spot market during harvest acquiring a price of R850/ton.

Producer B3 placed a constraint of 800 tons on any futures position. Table 7.7 displays the results of Producer B3's actions as well as of those proposed by the MDSS.

Table 7.7:   Comparative net returns – Producer B3

Actions	Producer B3	MDSS
Pre-harvest stage		
19/02/99		
Pricing instrument and % sold	Forward (56%)	Forward (56%)
Net cash flow	R304 156	R304 156
21/05/99		
Pricing instrument and % sold	0%	Short futures (26%)
Net cash flow		R217 483
Harvest stage		
21/06/99		
Pricing instrument and % sold	Spot market (44%)	Long futures (26%)
		Spot market (44%)
Net cash flow	R442 645	R434 183
Net return	**R746 801**	**R738 339**
% improvement		**(1.13%)**

In this example, the producer obtained better results (1.13%) than the MDSS. The MDSS suggested the following marketing actions, but failed to produce better results:

Pre-harvest stage

- Forward contracts were to be engaged in at a price of R500/ton on 19 February 1999.
- A short position was to be taken for six July 1999 contracts for R795/ton on 21 May 1999.

Harvest stage

- The short futures position was to be closed out and the remainder of the crop was sold on the spot market.

The primary reason for the producer's achieving a higher return was that the spot price he received was R45/ton higher than the prevailing futures price. No marketing instrument of the futures or derivatives market would have beaten the returns obtained by this producer.

The MDSS obtained better results for Producers B1 and B2 but not for Producer B3. Given the explanation, the MDSS may be regarded as having been successfully developed for yellow maize producers.

7.5.1.3   Sunflower seed producers

Only two categories are investigated. This was due to the fact that the total production of sunflower seed in the Free State Province for the 1998/99 season was 629 000 tons on 430 000 hectares, resulting in an average yield of 1.46 tons per hectare. On average, 1 370 hectares of sunflower seed have to be planted to qualify for Category C. The average farm size in the Free State is only 1006 hectares, well below the required size for Category C. It is important also to bear in mind that the first futures contracts on sunflower seed were traded for the first time only on 1 February 1999. Therefore, if a producer engaged in forward contracts before this date, the MDSS can only suggest the same marketing actions.

- **Producer C1**

The farm unit of Producer C1 is in Statistical Region 28 of the Free State Province. Producer C1 planted 135 hectares of sunflower seed with a realised yield of 2.1 tons per hectare (classified in Category A). The producer engaged in the following marketing actions:

- On 7 December 1998, the producer sold 170 tons of sunflower seed on a forward contract at a price of R1 250/ton.

- The remainder of his crop was sold on the spot market during harvest at a price of R1 150/ton.

The producer did not put a constraint on any marketing alternative. Table 7.8 sets out the results of Producer C1's actions as well as of those proposed by the MDSS.

Table 7.8:   Comparative net returns – Producer C1

Actions	Producer C1	MDSS
Pre-harvest stage		
07/12/98		
Pricing instrument and % sold	Forward (60%)	Forward (60%)
Net cash flow	R132 248	R132 248
12/03/99		
Pricing instrument and % sold	0%	Short futures (35%)
Net cash flow		R70 888
Harvest stage		
12/04/99		
Pricing instrument and % sold	Spot market (40%)	Long futures (35%) Spot market (40%)
Net cash flow	R77 284	R88 907
Net return	**R209 532**	**R221 155**
% improvement		**5.56%**

The MDSS suggested the following marketing actions:

Pre-harvest stage

- 170 tons of sunflower seed were to be sold with a forward contract at a price of R1 250/ton on 7 December 1998.

- In order to secure a selling level of 80%, a short futures position was to be taken on 12 March 1999, one month prior to harvest, for one contract at a price of R1 200/ton.

Harvest stage

- The futures position was to be closed out on 12 April 1999 with a long futures contract at a price of R1 080/ton and the sunflower seed was to be sold on the spot market at a price of R1 150/ton.

These marketing actions resulted in an improved return of 5.56%. It is important to note that the number of marketing instruments available during the first decision was limited due to the fact that contracts on sunflower seed only started trading on 1 February 2000. This example proves that the MDSS can be used by even very small producers. Producer C1 only harvested 284 tons of sunflower seed.

- **Producer C2**

Producer C2 also operated in Statistical Region 28 of the Free State Province. Producer C2 planted 650 hectares of sunflower seed with a realised yield of 1.9 tons per hectare (classified in Category B). The producer engaged in the following marketing actions:

- On 2 October 1998, he sold 370 tons of sunflower seed on a forward contract at a price of R1 250/ton.

- He sold 670 tons of his crop during harvest on the spot market at a price of R1 080/ton.

- The remainder was stored until December and sold on the spot market for R975/ton.

The producer indicated that he did not want to engage in any futures position after harvest. Table 7.9 sets out the results of Producer C2's actions as well as of those proposed by the MDSS.

Table 7.9: Comparative net returns – Producer C2

Actions	Producer C2	MDSS
Pre-harvest stage		
02/10/98		
Pricing instrument and % sold	Forward (30%)	Forward (30%)
Net cash flow	R232 825	R232 825
14/03/99		
Pricing instrument and % sold	0%	Short futures (40%)
Net cash flow		R280 501
Harvest stage		
14/04/99		
Pricing instrument and % sold	Spot market (54%)	Long futures (40%)
		Spot market (54%)
Net cash flow	R305 407	R378 526
Post-Harvest stage		
20/04/99 - 01/12/99		
Pricing instrument and % sold	Storage till December	R1220 puts (16%)
	Spot market (16%)	Exercise puts on
	R51 971	24/11/99
		R63 715
Net cash flow		
Net return	**R590 202**	**R675 066**
% improvement		**14.38%**

The MDSS suggested the following marketing actions:

Pre-harvest stage

- 30% of the expected crop was to be sold on 2 October 1998 with a forward contract at a price of R1 250/ton.
- Five short futures contracts were to be taken on 14 March 1999 at a price of R1 200/ton.

Harvest stage

- The short futures position was to be closed on 14 April 1999 with long futures contracts at a price of R1 050/ton and the crop was sold on the spot market.

Post-Harvest stage

- Two December put option contracts were to be bought on 20 April 1999 with a strike price of R1 220/ton and the contract was to be exercised just before the expiry date of 24 November 1999.

The MDSS provided better results than both producers. The MDSS was successfully developed for sunflower seed producers. Although the choice of marketing instruments was limited by Producer C2, the MDSS could still improve on the return by 14.38%. If producers use a greater variety of marketing instruments, not only forward contracts, producers could ensure higher returns. This proves the importance of using of futures and derivative contracts.

7.5.1.4   Soybean producers

It is important to bear in mind that there are no futures contracts for soybeans in South Africa. Due to the fact that South Africa is a net importer of soybeans, the South African price closely follows import parity prices for soybeans. Because

no SAFEX marketing alternatives are available to producers, the MDSS can only suggest the same marketing actions as those followed by the producers.

- **Producer D1**

The farm unit of Producer D1 is in Statistical Region 29 of the Free State Province. Producer D1 planted 105 hectares of soybeans with a realised yield of 2.23 tons per hectare (classified in Category A). The producer engaged in the following marketing actions:

- On 1 March 1999, he entered into a forward contract to deliver 100 tons of soybeans to a local buyer at a price of R1 200/ton.
- He sold the remainder of his crop on the spot market during harvest, receiving a price of R1 050/ton.

There was no forward contract available to the producer between the date that he entered into the contract and his harvest date. The MDSS did not suggest any other marketing action and the results obtained by the MDSS were thus obviously the same as those of Producer D1. The net return of Producer D1's actions (endorsed by the MDSS) is reflected in Table 7.10.

Table 7.10: Comparative net returns – Producer D1

Actions	Producer D1	MDSS
Pre-harvest stage **01/03/99**		
Pricing instrument and % sold	Forward (42.7%)	Forward (42.7%)
Net cash flow	R49 761	R49 761
Harvest stage **01/05/99**		
Pricing instrument and % sold	Spot market (57.3%)	Spot market (57.3%)
Net cash flow	R42 756	R42 756
Net return	**R92 517**	**R92 514**
% improvement		**0%**

The MDSS followed exactly the same actions as the producer, due to the fact that the MDSS could not propose any other marketing instruments.

- **Producer D2**

The farm unit of Producer D2 is in Statistical Region 29 of the Free State Province. Producer D2 planted 550 hectares of soybeans with a realised yield of 2.3 tons per hectare (classified in Category B). The producer engaged in the following marketing actions:

- On 1 December 1998, he entered into a forward contract to deliver 380 tons of soybeans at a price of R1 100/ton.
- He sold 630 tons of his crop on the spot market, receiving a spot price of R1 050/ton.
- The remainder of his crop was stored until 1 December 1999 and sold on the spot market at a price of R1 300/ton.

The producer could enter into a forward contract during the latter half of March for a price of R1 200/ton. The producer expected higher spot prices and declined the offer. The net returns of Producer D2's actions and of those proposed by the MDSS are reflected in Table 7.11

Table 7.11: Comparative net returns – Producer D2

Actions	Producer D2	MDSS
Pre-harvest stage		
01/12/98		
Pricing instrument and % sold	Forward (30%)	Forward (30%)
Net cash flow	R215 774	R215 774
23/03/99		
Pricing instrument and % sold	0%	Forward (40%)
Net cash flow		R155 348
Harvest stage		
12/05/99		
Pricing instrument and % sold	Spot market (50%)	Spot market (10%)
Net cash flow	R232 466	R122 118
Post-harvest stage		
20/05/99 - 01/12/99		
Pricing instrument and % sold	Storage until December	Storage until December
	Spot market (20%)	Spot market (20%)
Net cash flow	R134 952	R134 952
Net return	**R583 185**	**R628 192**
% improvement		**7.72%**

The higher return obtained by the MDSS was due to the fact that the producer disregarded the forward contract presented to him at a later stage.

- **Producer D3**

The farm unit of Producer D3 is in Statistical Region 29 of the Free State Province. Producer D3 planted 525 hectares of soybeans with a realised yield of 4 tons per hectare. Producer D3 was classified in Category C because the total production volume of soybeans is 2 100 tons. Producer D3 produced soybeans under irrigation, which explains the higher yield. The producer engaged in the following marketing actions:

- On 2 November 1998, he entered into a forward contract to deliver 1 200 tons of soybeans to a local buyer at a price of R1 100/ton.
- He sold the remainder of his crop (900 tons) on the spot market during harvest, receiving a price of R1 080/ton.

No further forward contracts were available to the producer between the date when he entered into the contract and his harvest date. The MDSS did not suggest any other marketing action and the results obtained by the MDSS are the same as those of Producer D3. The net return of Producer D3's actions is reflected in Table 7.12.

Table 7.12: Comparative net returns – Producer D3

Actions	Producer D3	MDSS
Pre-harvest stage **02/11/98**		
Pricing instrument and % sold	Forward (57%)	Forward (57%)
Net cash flow	R392 700	R392 700
Harvest stage **01/05/99**		
Pricing instrument and % sold	Spot market (43%)	Spot market (43%)
Net cash flow	R276 525	R276 525
Net return	**R669 225**	**R669 225**
% improvement		**0%**

From the above examples one can deduce that an MDSS cannot yet successfully be developed for soybean producers in South Africa. The only application for the MDSS so far is that producers can use the model to hedge their crops on the Chicago Board of Trade (CBOT). The usefulness of hedging on the CBOT has, to date, not yet been established, mainly due to the fact that South Africa is not a soybean exporter and the spot prices reflect the import parity prices of soybeans. The MDSS might become more applicable once the total soybean production in South Africa exceeds the total consumption of soybeans and soybean products in this country.

7.1.5.5 Wheat producers

The MDSS used December futures and options contracts in attempting to optimise the returns of the producers in the sample. All contracts referred to represent December contracts, unless a post-harvest action is indicated. In post-harvest actions, the MDSS used May contracts. The December contracts

were used because they reflect the harvesting time of wheat, as with the July contract for maize.

- **Producer E1**

The farm unit of Producer E1 is in Statistical Region 29 of the Free State Province. Producer E1 planted 200 hectares of wheat with a realised yield of 2 tons per hectare (classified in Category A). The producer engaged in the following marketing actions:

- On 2 August 1999, he sold 120 tons of his crop on a forward contract at a price of R1 200/ton.
- The remainder of the crop was sold on the spot market during harvest, attaining a price of R1 150/ton.

Producer E1 did not want to participate in any futures contracts or derivative contracts. Table 7.13 displays the results of Producer E1's actions as well as of those proposed by the MDSS.

Table 7.13: Comparative net returns – Producer E1

Actions	Producer E1	MDSS
Pre-harvest stage		
02/08/99		
Pricing instrument and % sold	Forward (30%)	Forward (30%)
Net cash flow	R82 808	R82 808
06/11/99		
Pricing instrument and % sold	0%	0%
Net cash flow		-
Harvest stage		
21/06/99		
Pricing instrument and % sold	Spot market (70%)	Spot market (70%)
Net cash flow	R179 218	R179 218
Net return	**R262 026**	**R262 026**
% improvement		**0%**

In this example, the MDSS suggested the same marketing actions as those that the producer engaged in. The producer was not interested in any futures or option contracts. Due to the fact that there were no forward contracts available one month before harvest, the MDSS could not suggest any other marketing actions.

- **Producer E2**

The farm unit of Producer E2 is in Statistical Region 29 of the Free State Province. Producer E2 planted 500 hectares of wheat with a realised yield of 2.2 tons per hectare. Producer E2 produced 1 000 tons of wheat and is therefore classified in Category B. The producer engaged in the following marketing actions:

- On 29 June 1999, he sold 400 tons of his crop on a forward contract at a price of R1 100/ton.

- On 1 September 1999, he entered into a short futures position (500 tons), at a price of R1 210/ton.

- The producer closed out his short futures position and sold the remainder of his crop on the spot market during harvest, acquiring a price of R1 170/ton.

Producer E2 imposed no marketing constraints. Table 7.14 sets out the results of Producer E2's actions as well as of those proposed by the MDSS.

Table 7.14: Comparative net returns – Producer E2

Actions	Producer E2	MDSS
Pre-harvest stage **29/06/99**		
Pricing instrument and % sold	Forward (36%)	Short futures (36%)
Net cash flow	R250 509	R281 535
01/09/99		
Pricing instrument and % sold	Short futures (45%)	Long futures (36%) Short futures (82%)
Net cash flow	R358 483	R642 129
Harvest stage **30/11/99**		
Pricing instrument and % sold	Long futures (45%) Spot market (64%)	Long futures (82%) Spot market (100%)
Net cash flow	R458 023	R712 445
Net return	**R708 532**	**R712 445**
% improvement		**0.55%**

In this example, the MDSS improved on the results obtained by the producer by 0.55%. The MDSS suggested the following marketing actions:

Pre-harvest stage

- Four short futures contracts were to be purchased on 29 June 1999 at a price of R1 189/ton.
- The short futures contracts were to be closed out on 1 September 1999 and a short position was to be taken for nine December 1999 contracts at a price of R1 210/ton.

Harvest stage

- The short futures position was to be closed out and the crop was sold on the spot market during harvest.

No marketing action was suggested for 30 October 1999 (one month prior to harvest) because 82% of the expected crop had already been committed.

- **Producer E3**

The farm unit of Producer E3 is in Statistical Region 29 of the Free State Province. Producer E3 planted 800 hectares of wheat with a realised yield of 2.6 tons per hectare (classified in Category C). The producer engaged in the following marketing actions:

- On 10 August 1999, he sold 1 000 tons of his crop on the futures market at a price of R1 200/ton.
- On 4 November 1999, he closed out his futures position at R1 180/ton.
- During harvest he sold 1 300 tons of wheat on the spot market, obtaining a price of R1 150/ton.
- The remainder of the crop was stored until 15 May 2000 and sold on the spot market, acquiring a price of R1 250/ton.

Producer E3 imposed no marketing constraints. Table 7.15 sets out the results of Producer E3's actions as well as of those proposed by the MDSS.

Table 7.15: Comparative net returns – Producer E3

Actions	Producer B3	MDSS
Pre-harvest stage		
10/08/99		
Pricing instrument and % sold	Short futures (48%)	Short futures (48%)
Net cash flow	R304 156	R304 156
04/11/99		
Pricing instrument and % sold	Long futures (48%)	Long futures (48%)
Net cash flow	R15 932	R15 932
Harvest stage		
04/12/99		
Pricing instrument and % sold	Spot market (62%)	Spot market (100%)
Net cash flow	R949 319	R1 575 515
Post-harvest stage		
10/12/99 - 15/05/00		
Pricing instrument and % sold	Storage	Long futures (38%)
	Spot market (38%)	Short futures (38%)
Net cash flow	R591 918	R16 800
Net return	**R1 557 169**	**R1 608 247**
% improvement		**3.28%**

The MDSS achieved an improvement of 3.28% on the producer's actions. The MDSS suggested the following marketing actions:

Pre-harvest stage

- A short futures position was to be taken on 10 August 1999 on ten December wheat contracts at a price of R1 200/ton.

- The short futures position was to be closed out on 4 November 1999 at a price of R1 180/ton.

Harvest stage

- The entire crop was to be sold on the spot market at a price of R1 150/ton.

Post-Harvest stage

- A long futures position was to be taken on eight May 2000 wheat contracts on 10 December 1999 at a price of R1 296/ton.
- The long futures position was to be closed out at a price of R1 320/ton on 15 May 2000.

The MDSS could not improve on the net return of Producer E1. Producer E1 was not interested in any derivative contract, therefore the same net return was achieved. The MDSS obtained better returns for both Producer E2 (0.55%) and Producer E3 (3.28%). It can therefore be declared that the MDSS was successfully developed for wheat producers in South Africa.

7.6 SUMMARY

When one compares the results obtained using the MDSS with the results obtained by the individual producers, the following conclusions can be drawn:
- White maize producers: The MDSS produced better results than the individual producers did in Categories A, B and C.
- Yellow maize producers: The MDSS produced better results in Categories A and B, but failed to produce better results in Category C. Producer B3 received a spot market price of R45/ton more than the prevailing futures price.

- Sunflower seed producers: The MDSS produced better results in both Categories A and B.

- Soybean producers: The MDSS could not improve the returns of producers D1 and D3. This was because no other marketing instrument was available. The MDSS could only improve the results in Category B. The reason for this improvement was that the producer failed to sell more of the crop before harvest on a forward contract.

- Wheat producers: The MDSS improved on the results of Category B and C. It failed to improve on the results in Category A, due to the unwillingness of the producer to participate in any SAFEX contracts.

Figure 7.1 provides an overview of the improvement obtained by the MDSS above the results of the producers.

Figure 7.1: Percentage improvement achieved by MDSS compared to the results of the individual producers
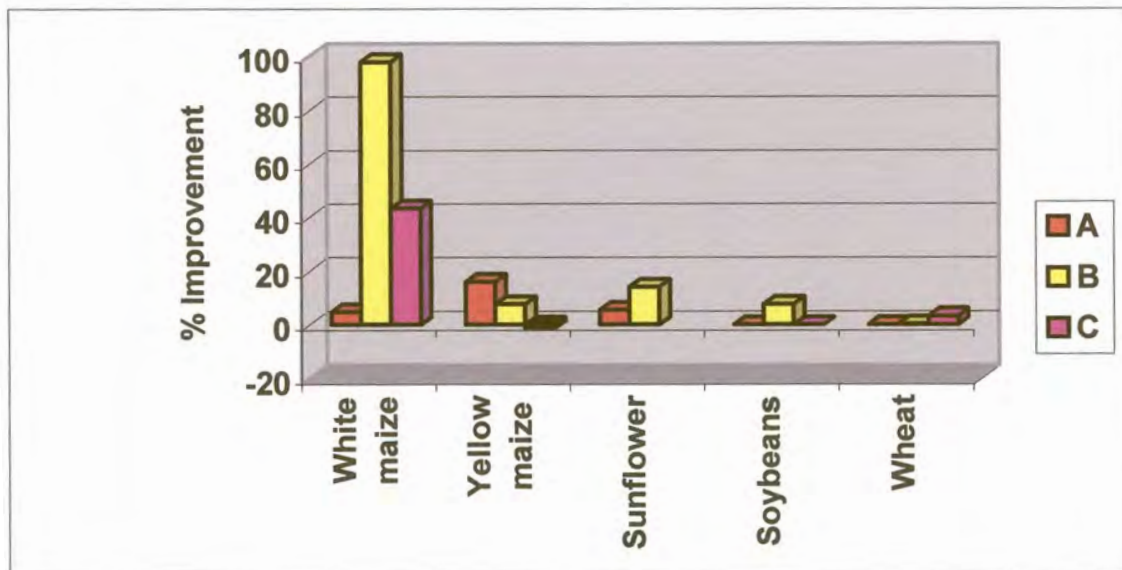
When the different categories are examined in isolation, the following conclusions can be drawn:

- **Category A** (as depicted in Figure 7.2)

  There was an improvement on the returns of three different producers of white maize, yellow maize and sunflower seed. The model failed to obtain better results for soybean and wheat producers. Wheat producer E1 was not interested in any other marketing instrument, and the MDSS could not optimise the net return. There was only one choice available, and that was a forward contract. More than one type of marketing instrument is normally necessary to optimise decisions. Therefore, the development of the MDSS could be regarded as successful in the case of Category A producers.

Figure 7.2: Summary of the results of Category A producers
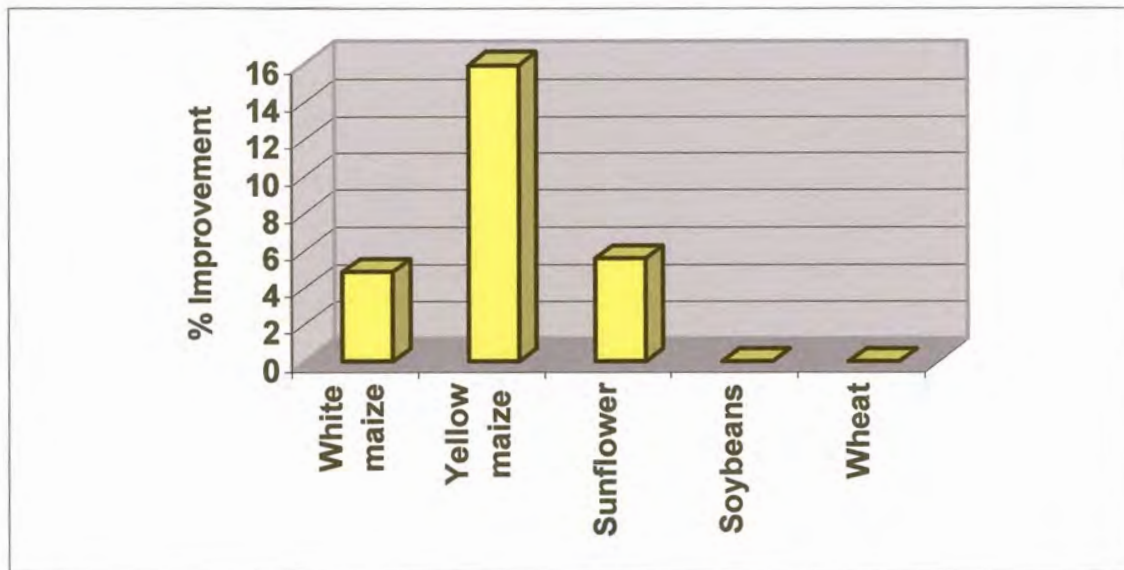
- **Category B producers** (as set out in Figure 7.3):

  The MDSS improved on the returns of all five (white maize, yellow maize, sunflower seed, soybeans and wheat) types of individual producers. The greatest improvement was for white maize and the smallest improvement was

for wheat. Therefore, the development of the MDSS could be regarded as successful in the case of Category B producers.

Figure 7.3: Summary of the results of Category B producers
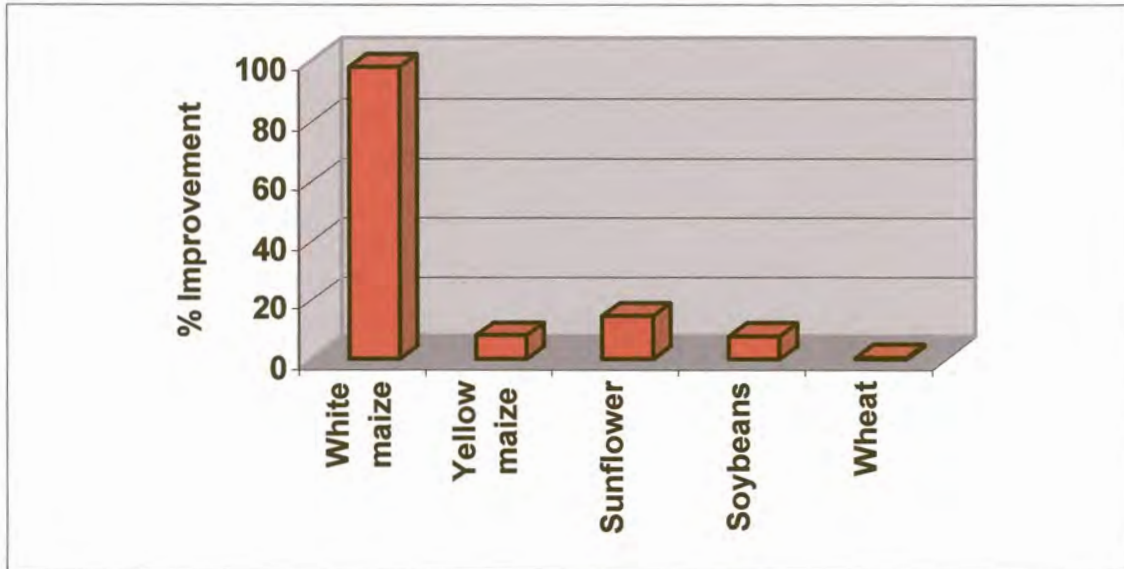
- **Category C producers** (as set out in Figure 7.4):

The model failed to produce better net returns for two of the four producers. The yellow maize producer achieved a better return than the MDSS. The primary reason for the higher return for the yellow maize producer was the high harvest spot price achieved by the producer in question. The harvest spot price was R45/ton higher than the futures price. The spot price during harvest was R95/ton higher than the futures price, considering an average area differential of R50/ton for Statistical Region 28. The MDSS was not successfully developed for soybean producers. Overall, however, the development of the MDSS could be regarded as successful in the case of Category C producers.

Figure 7.4: Summary of the results of Category C producers
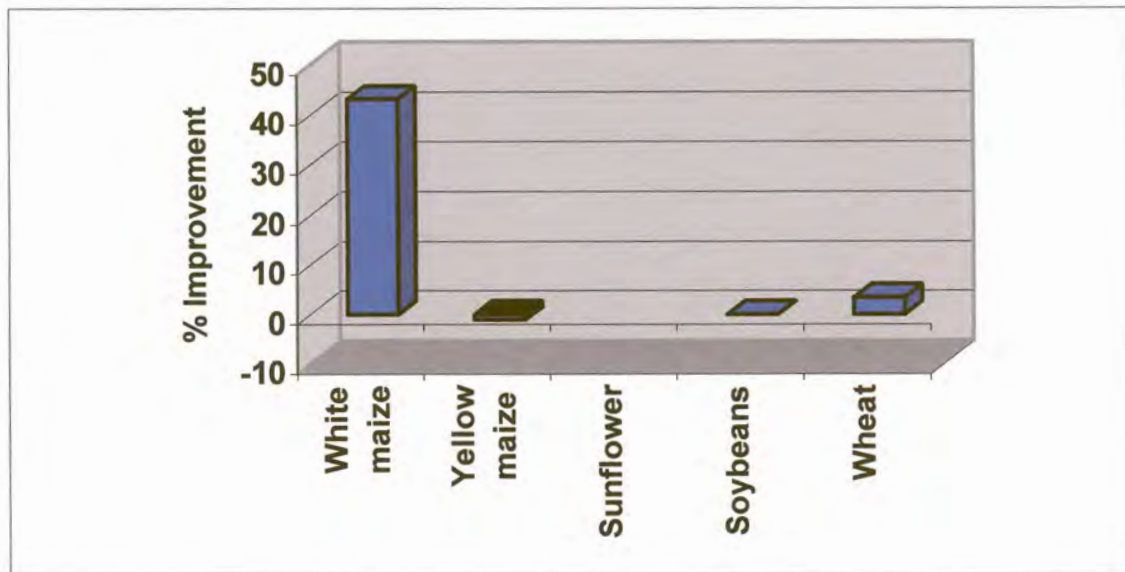
The development of the MDSS for crop producers in South Africa could be regarded as successful overall and the following conclusions can be drawn:

- An MDSS was successfully developed for white maize, yellow maize, sunflower seed, and wheat producers.

- An MDSS could not successfully be developed for soybean producers. For the model to work, it is necessary that futures contracts and options on futures contracts are available. If the producer only has a choice between one forward contract and the next forward contract during each marketing decision, the function is not optimisation, but mere calculation.

- There is no limitation regarding production levels on the usage of the MDSS. The MDSS optimises returns for crops smaller than 500 tons to crops of more than 2000 tons. It is not even necessary to have any crop to participate in the futures market. However, the MDSS was developed to improve the price risk management of crop producers and the aim was not to improve the returns of speculators.

- The MDSS can only be successfully implemented for crops trading on SAFEX. For other crops, the MDSS represents a purely financial system

determining the net returns of the marketing actions taken. Cross-hedging alternatives should be investigated to ensure better price risk management for crops not traded on SAFEX.

- The MDSS also improved the results of producers already participating on SAFEX. Producer A3's return was improved by 43.24%, Producer E2's return was improved by 0.55% and producer E3's return was improved by 3.28%. This indicates that the MDSS was also successfully developed even for producers making use of a wider variety of marketing instruments.

In order to manage price risk effectively, producers should use more than one type of marketing instrument. Producers should strive to secure marketing instruments that protect them from downside price movements, but also provide opportunities to participate in an upward price movement. It is important for producers to sell more of the expected crop during the pre-harvest marketing phase. Prices normally tend to be lower during the harvest period and any pre-harvest decision could enhance the return.

Table 7.16 analyses the sensitivity to risk exposure of the strategies followed by the producers (marked as ♦) and the strategies suggested by the MDSS (marked as ♣).

Table 7.16: Strategy sensitivity towards areas of risk exposure

	Price level	Cash flow	Volatility	Business	Tax	Control	Yield	Quality
White maize								
A1	♦			♦			♦	♦
MDSS	♣	♣				♣	♣	♣
A2	♦						♦	♦
MDSS	♣		♣			♣	♣	♣
A3	♦		♦	♦		♦	♦	♦
MDSS	♣	♣	♣			♣	♣	♣
Yellow maize								
B1	♦							♦
MDSS		♣				♣	♣	♣
B2	♦			♦			♦	♦
MDSS	♣	♣				♣	♣	♣
B3	♦			♦			♦	♦
MDSS	♣	♣		♣		♣	♣	♣
Sunflowers								
C1	♦			♦			♦	♦
MDSS		♣		♣		♣	♣	♣
C2	♦			♦			♦	♦
MDSS	♣		♣			♣	♣	♣
Soybeans								
D1	♦			♦			♦	♦
MDSS	♣			♣			♣	♣
D2	♦			♦			♦	♦
MDSS	♣			♣			♣	♣
D3	♦			♦			♦	♦
MDSS	♣			♣			♣	♣
Wheat								
E1	♦			♦			♦	♦
MDSS	♣			♣			♣	♣
E2	♦	♦		♦		♦	♦	♦
MDSS	♣	♣				♣	♣	♣
E3	♦	♦				♦	♦	♦
MDSS	♣	♣				♣	♣	♣

The actions suggested by the MDSS for all the crops except soybeans increased the areas of risk exposure. The producers should compare this exposure to the higher returns that they could have obtained by following the strategies

suggested by the MDSS. The more complex the strategy, the higher the return and the more the areas of risk exposure. This therefore requires a constant revision of the marketing plan. The risk rating of the various marketing actions was decreased by the fact that the MDSS suggested that about 80% of the crop must be priced prior to harvesting. Doing so decreased the level of price risk dramatically.

Marketing is too often an afterthought in the production process. Consequently, producers are often forced to accept the spot price at harvest in a highly variable spot market. Thus, price variability in the market translates into price risk, which compounds with production risk and increases income variability. Effective management of marketing activities will become increasingly important for farm business survival as the market becomes more volatile.

7.7 CONCLUSION

This chapter investigated the application of the MDSS developed in Chapter 6. This chapter shows how producers can manage investment risk with the aid of an MDSS. While some general conclusions can be drawn from this chapter, they do not apply to all producers because marketing risk varies across different crops. Furthermore, price levels and price variability vary from year to year, depending on market conditions. For example, in years of high planting time prices, the chances that prices will fall increase, because producers (if weather allows) may respond to the high prices with a lot of plantings, resulting in an oversupply of the crop. If the high planting season price is due to short carryover from the previous year, then the chances of a very high price also increases, due to the good chance that crops will be in short supply for two years. Producers need to look at the forward, futures and options markets during planting. They must consider their own yield potential and variability to understand the degree

of investment risk during the marketing season. The MDSS developed in the previous chapter can be used by producers to customise the results obtained in this chapter for their own farm conditions and a particular year's price conditions.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

Nam et ipsa scientia potestas est.

Francis Bacon (1561 - 1626)

8.1   INTRODUCTION

Unfortunately, agricultural producers cannot dictate what price they receive for their products. The price is determined by the market and, given the transition to freer global trade and the abolition of the various marketing boards, the market is likely to become increasingly volatile. All too often, marketing is an afterthought in the production process. Hence, producers are often forced to accept the price at harvest. Thus, price variability in the market translates into price risks, which compound production risks and increase income variability and investment risk. In future, effective management of marketing activities will become increasingly important for the survival of any farm business.

Against this backdrop, the overall objective of this study, as formulated in the introductory chapter, was therefore to develop a marketing decision support system (an MDSS) for crop producers to manage their investment risk. Decision support systems are an important application of management information systems (Davis & Olson, 1985). According to Keen and Morton (1978), decision support systems imply the use of technology to improve decision-making, and allow users to retrieve data and evaluate alternatives based on models fitted for the decisions that have to be made. There are virtually no reports available on decision support systems for crop marketing in South Africa.

8.2 APPROACH FOLLOWED

In order to accomplish the objectives, the following approach was adopted in the study:

- A critical overview of grain production in South Africa was given. In this overview the most important crops were established and the deregulation of the marketing process was discussed.

- Risk management in agriculture was examined. The study also analysed risk management tools available to producers in South Africa to manage investment risk.

- The history and application of the futures market in South Africa was investigated.

- The development and applications of options on futures contracts as viable risk management tools were investigated.

- A theoretical description, and the development and testing of a proposed decision support system to aid producers to manage their production risk were set out.

From this study, a number of conclusions can be drawn, as is set out in Section 8.3 below.

8.3 RESEARCH RESULTS

The aim of the study was to develop a decision support system to help crop producers to manage investment risk. A postal survey, followed by telephonic interviews and personal interviews, was conducted during the 1998/1999 marketing season for summer crops and the 1999/2000 marketing season for wheat, using a sample of grain producers in Statistical Regions 28 and 29 in the

Free State Province. Data collected from producers in the Free State were used in the study for two main reasons. Firstly, there was the overall prominence of the province (27.3% of the total production) in the production of maize (33.4%), sunflower seed (54.5%), wheat (43.9%) and soybeans (6.7%) in South Africa. Secondly, most of the farming units (18,5%) in South Africa are situated in the Free State. From the postal survey, a response rate of 28% was obtained. The postal survey was augmented by telephonic interviews and personal visits. This resulted in a final response rate of 78%. None of the questionnaires were unusable due to incomplete information.

The farm units were divided into three different categories. Category A refers to a farm unit size less than 1000 hectares, the farm unit size for Category B is from 1000 hectares to 1999 hectares, and for Category C, the farm unit size is from 2000 hectares upwards. Due to the fact that the products from farms are not homogeneous in type and quality, each farm was investigated individually. The crop choice, input costs and marketing strategies followed by each producer were compared to the strategies proposed by the model. It was assumed that producers were hedgers and that obligations from short sales in the futures market are not satisfied through delivery. Speculation was disregarded in the testing of the decision support system.

In the testing of the MDSS, the following steps were followed:
- Firstly, the information regarding input costs and marketing strategies followed by the producer was entered into the programme. Every time when a producer made a decision, the result was compared to the net effect suggested by the linear programme. From there on, the decisions suggested by the linear programme were taken into consideration in future decisions. For instance, when the programme suggested that the producer should engage in a short futures position, the futures position would be reflected in

the next set of decisions. All option contracts suggested by the model were at-the-money.

- Secondly, one month prior to harvest, the MDSS was run again to sell a total of about 80% of the producer's crop. If the producer did sell more than 80% of the crop one month prior harvest, this action by the MDSS was ignored.

After comparing the results obtained by the MDSS with the results obtained by the individual producers, the following conclusions could be drawn:

- White maize producers: In all three categories (from 4.8% in Category A to 98% in Category B) the MDSS produced better results than the individual producers.
- Yellow maize producers: In Categories A (16%) and B (7.9%), the MDSS produced better results, but it reduced the return in Category C (-1.1%).
- Sunflower seed producers: The MDSS produced better results in both Categories A (5.6%) and B (14.4%).
- Soybean producers: The MDSS could only improve the results of Category B (7.7%).
- Wheat producers: The MDSS improved the results of Category B (0.55%) and C (3.28%). It failed to improve the results in Category A, due to the unwillingness of the producer concerned to participate in any SAFEX contracts.

Table 8.1 shows the individual and average improvement of the MDSS obtained per crop and per category.

Table 8.1:   Individual and average improvement using the MDSS

| | Percentage improvement | | | |
	Category A	Category B	Category C	Average
White maize	4.8	98.0	43.2	**48.7**
Yellow maize	16.0	7.9	-1.1	**7.6**
Sunflower seed	5.6	14.4		**10.0**
Soybeans	0	7.7	0	**2.6**
Wheat	0	0.6	3.3	**1.3**
Average	**5.3**	**25.7**	**11.3**	

From the table, some conclusions can be drawn:

- An MDSS has been successfully developed, and producers can apply it successfully to manage marketing risk and minimise investment risk.
- An MDSS system has been successfully developed for white maize, yellow maize, sunflower seed and wheat.
- An MDSS system has not yet been developed for crops such as soybeans, which are not actively traded on the South African Futures Exchange.
- Any size producer, from a small producer to a large producer, can use the MDSS developed in this study.
- The MDSS developed in this study incorporates all the different marketing tools available in South Africa to producers to manage their investment risk. It is the first model developed that implements more than one or two strategies at a time.
- The MDSS has added value to agricultural risk management in South Africa.

8.4 RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH

This investigation may be regarded as an exploratory step towards the development of an intelligent decision support system to aid producers to manage their investment risk. The results by no means provide the final answer to understanding the complicated processes involved in price risk management. Within the stated limitations, the findings nevertheless represent, in addition to obvious financial benefits and implications, a new approach to price risk management for producers, with direct implications and research opportunities in the following areas:

- empowering producers with knowledge to make more use of SAFEX in their quest for price risk management;
- empowering producers to see price risk management as part of total farm risk management – producers should focus on the farm's risk-bearing capacity when they develop their marketing plan;
- the proposed model employs very elementary methods for optimising the net returns of producers, but research in the application of synthetic strategies must be undertaken;
- tax implications on the net returns of the various strategies should be investigated;
- daily price changes and their effects on margin accounts were ignored, which implies that an investigation on daily closing price movements could produce additional information that should be taken into consideration when comparing the different marketing alternatives; and
- the proposed model was implemented and tested for one marketing season only, suggesting that testing the model over a longer period with different price movements may provide further proof of the viability of the application of the decision support system.

8.5 CONCLUSION

The risks confronted by crop producers are of particular interest, given the changing role of the government since the 1996 Agricultural Products Marketing Act was passed. A more sophisticated understanding of risk and risk management is important to help producers make better decisions in marketing their produce in the new deregulated environment. An ideal price risk management tool would cost a small amount, reduce the chances of low net returns, and not sacrifice upside price potential. Against this background, the question posed in this study is whether a decision support system could be developed to manage investment risk faced by grain producers in the marketing of their crop. This chapter has provided a summary of the most important conclusions of this investigation. The important limitations and the implications of this investigation have also been discussed and the areas that warrant further research indicated.

Learning from mistakes can be an effective educational tool, but learning from marketing mistakes may be too costly a lesson. Provided they are used with sufficient realism, decision support systems can help producers to explore marketing management matters without having to pay too much for possible mistakes.

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POST GRADUATE DIPLOMA IN INVESTIGATIVE AND FORENSIC ACCOUNTING

	Surname	First name	Present employer	Books Paid
1	Annandale	Buks	National Dept Public Works	R1 290
2	Binnekade	Carol	UNISA	R1 290
3	Booi	Xolisile	MBM Financial Services	
4	Botha	Christo R	Rooth & Wessels Attorneys	R1 290
6	Botha	Cornelius E	Self employed	R1 290
5	Botha	Leon	RAF	R 1290
7	Botha	Martin	Self	
8	De Jager	Ansie	RAF	Deel met Jaco
9	De Jager	Ferdie	Gauteng Gambling Board	R1 290
10	De Jager	Jacobus	RAF	R1 290
11	De Wet	Cobus	Forensic Consultants (Pty) Ltd	R1 290
12	Dlavane	Abbey	Self employed	R 1290
13	Du Toit	Jacques	Deloitte & Touche	R1 290
14	Ehlers	Janet	Self employed	R1 290
15	Ellis	Charmaine	RAF	R1 290
16	Engelbrecht	Anarie	De Graaf (Pty) Ltd	Deel met Gerdi
17	Engelbrecht	Gerdi	RAF	R 1290
18	Erasmus	Monty	Self employed	R1 290
19	Hlungulu	Mvelisi	Dept Trade & Industry	
20	Klopper	Hannes	Self	R1 290
21	Koch	Francois	Gordon & Partners Inc	
22	Louw	Stephanus	Umed	R1 290
23	Maritz	Eksteen	Competition Commission	R1 290
24	Minnaar	Pieter	SBV Services	R1 290
25	Moima	Mosa	RAF	R 1290
26	Moroko	Henry	Self employed	R450 (Fraud)
27	Mothle	Johannes	RAF	R1 290
28	Naudé	Adrian	Savage, Jooste & Adams Inc	Deel boeke
29	Nhleko	Sam	GDE	R700
30	Noko	Mokate	Self	R1 290
31	Nteo	Molotsi	KMMT Inc	R1 290
32	Ogunronbi	Sunday	Vista University	R1 290
33	Pretorius	Christo	SITA (PTY) LTD	R1 290
34	Prinsloo	Jacolene	Weavind & Weavind Prok	
35	Ronne	Tim	Finvest Trust	R1 290
36	Rossouw	Arno	Dept of Justice	R1 290
37	Schlenther	Bernd	SARS	R1 290
38	Sharp	Richard	Dyason Attorneys Inc	R1 290
39	Shibambo	Steven	Lesedi Private Hospital	R1 290
40	Smith	Anneline	Sithole AB & T Inc	R1 290
41	Ströh	Johann	Self	Self aankoop (Leen)
42	Swanepoel	Liesl	RAF	R1 290
43	V d Westhuizen	Gideon	Macrobert Inc	R1 290
44	Van Dyk	Dewald	Willemse & Benade Prokureurs	
45	Van Schalkwyk	Riaan	SA National Defence Force	
46	Van Wyk	Deon	Self employed	R1 290
47	Venter	Lindie	Gouws Prokureurs	R1 290
48	Vermaak	Johannes	SA Pharmacy Council	R1 290
49	Vorster	Andries	Safrich Financial Services	R1 290
50	Wiid	Anton	SBV Services	R1 290
51	Yarrow	John	SA National Defence Force	R1 290

APPENDIX A

ILLUSTRASTION OF THE WORKING OF THE MARKETING DECISION SUPPORT SYSTEM FOR GRAIN PRODUCERS IN SOUTH AFRICA

Farmer Brown has a farm in the Free State Province where he grows white maize, yellow maize and sunflower seed. Farmer Brown farms on a cash basis and does not use any production loans or bank overdraft facilities. The current return that Farmer Brown earns on investments is 12.5% per year. Farmer Brown is able to meet all margin calls if he chooses to use futures contracts as a marketing instrument.

Table A1 indicates how many hectares were planted with each type of crop, as well as the expected yield for Farmer Brown for the 1998/1999-marketing season.

Table A1:   Hectares planted, expected yields and expected harvest dates

	White maize	Yellow maize	Sunflower seed
Hectares planted	800	300	400
Expected yield (tons/Ha)	4.6	4.4	1.7
Expected harvest date	20 June	15 June	10 April

During the marketing season, Farmer Brown incurred the following costs:

- Pre-harvest variable cost per hectare: Pre-harvest variable costs normally include items such as seed, fertilizer, weedicides, pesticides, labour, transport, fuel and repairs. It is basically the input cost that Farmer Brown had to carry in the planting of the crop.

- Harvest cost per hectare: Harvest costs per hectare usually include costs such as fuel, repairs, labour and contract work when the crop is harvested. These costs are not affected by crop yield. The reason for treating these

costs separately from pre-harvest variable costs is the possibility that the crop may not be harvested, due to crop failure.

- Harvest cost per ton: Harvesting costs per ton includes cash costs for items such as drying, transport and contract work. The reason for treating these costs separately from harvest costs per hectare is that harvest cost per ton is sensitive to crop yield.

Contract work refers to work done by additional labour on a contract basis. The contract worker can either be paid per hectare or per ton, and therefore contract work forms part of the harvest cost per hectare or harvest cost per ton. Farm expenses, such as short-term asset insurance, which are not affected by crop yield levels should not be included as a cost. The pre-harvest variable cost and the harvest costs of the various crops planted by Farmer Brown are set out in Table A2.

Table A2: Pre-harvest variable cost and harvest costs per crop

	White maize (R)	Yellow maize (R)	Sunflower seed (R)
Pre-harvest variable cost per hectare	1 300	1 150	1 000
Harvest cost per hectare	63.71	63.71	73.89
Harvest cost per ton	50.02	50.02	53.00

Farmer Brown took the following marketing actions during the 1998/1999-marketing season:

- On 27 October 1998, he entered into a forward contract to deliver during harvest 1 000 tons of white maize at a price of R580/ton, and 400 tons of yellow maize at a price of R630/ton.

- On 17 December 1998, he entered into two (200 tons) yellow maize July short futures contracts at a price of R650/ton. He paid R14 000 into his margin account.

- On 10 January 1999, he entered into a forward contract to deliver 500 tons of sunflower seed during harvest at a price of R1 000/ton.

- On 19 January 1999, he bought five July white maize put contracts with a strike price of R640/ton.

- On 17 February 1999, he entered into a white maize July short futures position for 1 000 tons at a price of R680/ton. He paid R70 000 into his margin account.

- On 26 June 1999, his white maize put option contract expired worthless.

- On 6 July 1999, he closed his short futures position by buying 10 long futures white maize July contracts at a price of R843/ton, and he closed his two yellow maize short futures contracts at a price of R813/ton.

- He sold the rest of his crop (except 500 tons of white maize) on the spot market. He received R600/ton for white maize, R615/ton for yellow maize and R1 050/ton for sunflower seed.

- Farmer Brown stored the 500 tons of white maize until 1 March 2000, and sold it on the spot market for a price of R740/ton on 1 March 2000. The storage cost was R0.21 per day.

Farmer Brown paid a total of R2 commission per marketing action. Total handling charges amounted to R25/ton. Farmer Brown also indicated that he could not engage in futures positions for more than 2 500 tons for white maize and he could not enter into any futures position after harvest. The integer linear programme compared the returns generated by Farmer Brown's marketing actions and those of the MDSS. In order to determine the net cash flows, **no rounding** was done until the net return was determined. The net cash flows of Farmer Brown's marketing actions as indicated above were determined by the following calculations:

Pre-harvest marketing stage

Farmer Brown entered into forward contracts, futures contracts and options on futures contracts during the pre-harvest marketing stage. The net cash flow for forward contracts was determined using Equation 6.6 of the MDSS:

$$NCF_{fwh} = Cf_{s/in} - CF_{Input} \tag{6.6}$$

For white maize:

$NCF_{fwh} = (580*1000) - \{(1300/4.6) + (63.71/4.6) + 50.02\}1000$

    $= 233\ 521.30$ Line 2

For yellow maize:

$NCF_{fwh} = (400*630) - \{(1150/4.4) + (63.71/4.4) + 50.02\}400$

    $= 121\ 654.73$ Line 2

For sunflower seed:

$NCF_{fwh} = (500*1000) - \{(1000/1.7) + (73.89/1.7) + 53\}500$

    $= 157\ 650$ Line 2

On 17 December 1998, Farmer Brown entered into short July futures positions for yellow maize and on 17 February 1999 for white maize. Farmer Brown could maintain all margin calls. The **cash inflow** from futures sales at a discount rate equal to the investment rate of 12.5% was determined as follows:

$$CF_{fut/in} = PV(FP*Q) + (i*Mar) \tag{6.8}$$

For white maize:

$CF_{fut/in} = PV(680*1000) + (12.5\%*70000) = 675\ 337.73$

For yellow maize:

$CF_{fut/in} = PV(650*200) + 12.5\%*14000) = 129\ 535.57$

    Where:

    $CF_{fut/in} =$ cash inflow from futures sales

FP   =   futures price per ton

i   =   interest rate per day

Mar   =   initial margin

The futures contracts were discounted from the harvest time to the expiry date of the futures contract. For yellow maize, the length of time was 45 days and 40 days for white maize.

The **cash outflow** was determined using Equation 6.9:

$$CF_{fut/out} \quad = \quad (TC*n) \hspace{3cm} (6.9)$$

For white maize

$$CF_{fut/out} \quad = (234.20*10) = 2342$$

For yellow maize

$$CF_{fut/out} \quad = (234.2*2) = 468.40$$

Where:

$CF_{fut/out}$ =   cash outflows resulting from futures contracts

TC   =   total transaction cost per contract

TC comprised of the following costs:

(1) commission fees of R2 per ton (R2*100 tons per contract); and

(2) SAFEX charges amounting to R34.20.

These SAFEX costs were fixed at R34.20 for white and yellow maize, wheat and Cape wheat, but for sunflower seed it amounted to R17.10.

Equation 6.10 was used to determine the **net cash flow** from futures sales:

$$NCF_{fut} = \quad CF_{fut/in} - CF_{fut/out} - PV(A*Q) - CF_{Input} \qquad (6.10)$$

For white maize

$NCF_{fut} = 675\ 337.73 - 2343 - PV(83400) - \{(1300/4.6) + (63.71/4.6) +$

$50.02\}1000 = 244\ 267.17$ Line 3

For yellow maize

$NCF_{fut} = 129\ 535.57 - 468.4 - PV(16680) - \{(1150/4.4) + (63.71/4.4) +$

$50.02\}200 = 47\ 266.35$ Line 3

Where:

$NCF_{fut} =$ net cash flow from futures contract sales

$A \quad =$ area differential cost

A consists out of:

(1) an area differential cost of R47/ton for white and yellow maize and R65/ton for sunflower seed;

(2) handling charges of R25/ton; and

(3) any other costs relating to the transport of the crop from the local silo to Randfontein.

Farmer Brown entered into a put option contract on 19 January 1999 and paid a premium of R53.43/ton. In the pre-harvest marketing stage, it was assumed that Farmer Brown would exercise his put option contract and deliver on the contract. The net cash flow from the put option was determined using Equation 6.17:

$$NCF_{put/ex} = \quad PV\{(P*Q) - (A*Q)\} - (TC*n) - (Prem*Q) - CF_{input} \qquad (6.17)$$

For white maize:

$NCF_{put/ex} = PV\{(640*500) - (56.26*500)\} - (2.17*500) - (53.43*500) -$

$173240 = 90\ 222.83$ Line 4

Where:

$NCF_{put/ex}$ = net cash flow from put option contracts exercised and delivered

Prem = premium per ton

Harvesting marketing stage

Firstly, the cash inflow from spot sales for Farmer Brown was calculated using Equation 6.1:

$$Cf_{s/in} = P*Q \qquad (6.1)$$

For white maize:

$Cf_{s/in}$ = 600*2180 = 1 308 000

For yellow maize:

$Cf_{s/in}$ = 615*920 = 565 800

For sunflower seed:

$Cf_{s/in}$ = 1050*180 = 189 000

Then, the input cost of the various crops was determined using Equation 6.2:

$$CF_{input} = \{(PHVC/Y) + (HCPHe/Y) + HCPU\}Q \qquad (6.2)$$

For white maize:

CF_{input} = {(1300/4.6) + (63.71/4.6) + 50.02}2180 = 755 323.56

For yellow maize:

CF_{input} = {(1150/4.4) + (63.71/4.4) + 50.02}920 = 299 794.13

For sunflower seed:

CF_{input} = {(1000/1.7) + (73.89/1.7) + 53}180 = 123 246

The combination of Equations 6.1 and 6.2 resulted in the net cash flow from spot sales as calculated using Equation 6.3:

$$NCF_{spot} = Cf_{s/in} - CF_{Input} \tag{6.3}$$

For white maize:

NCF_{spot} = 1 308 000 - 755 323.56 = 552 676.44   Line 5

For yellow maize:

NCF_{spot} = 565 800 - 299 794.13 = 266 005.87   Line 5

For sunflower seed:

NCF_{spot} = 189 000 - 123 246 = 65 754   Line 5

The put option contract expired worthless. The net cash flow from the put option contract was determined by means of Equation 6.19:

$$NCF_{put/nex} = -\{(TC^*n) + (Prem^*Q)\} \tag{6.19}$$

For white maize:

$NCF_{put/nex}$ = -{(217.10*2) + (53.43*200) = -27 800.50   Line

Where:

$NCF_{put/nex}$ = Net cash flow from put option contracts not exercised

The short futures white maize position was closed out at a price of R843/ton and the yellow maize short futures position was closed out at a price of R813/ton. The net cash flow was calculated as follows:

$$NCFs_{futcl} = PV(FPs - FPl)^*Q - (TC^*n) \tag{6.13}$$

For white maize:

$NCFs_{futcl}$ = PV(680-843)1000 - (468.4*10) = -166 781.11   Line 7

For yellow maize

$NCFs_{futcl}$ = PV(650-813)200 - (468.4*2) = -33 300   Line 7

Where:

$$NCFs_{futcl} \quad = \quad \text{net cash inflow of short futures position closed out}$$

$$FPs \quad = \quad \text{short futures price per ton}$$

$$FPl \quad = \quad \text{long futures price per ton}$$

Post-harvest marketing stage

To determine the net income from storage, Equation 6.4 was used to determine the cost associated with the storage alternative:

$$CF_{store/out} \quad = \quad PV\{(S*T)Q\} \quad\quad\quad\quad (6.4)$$

For white maize:

$$CF_{store/out} \quad = PV\{(0.21*251)500\} = 25\ 235$$

The discount rate used was 12.5% per annum. After the cost associated with the storage alternative had been determined, the net cash flow from the storage alternative was determined by means of Equation 6.5:

$$Net_{store} \quad = \quad PV(P*Q) - CF_{Input} - CF_{store/out} \quad\quad\quad (6.5)$$

For white maize:

$$Net_{store} = PV(500*740) - \{(1300/4.6) + (63.71/4.6) + 50.02\}500 -$$

$$25235 = 140\ 649.49 \quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \text{Line 7}$$

Table A3 indicates the pricing instruments, percentage of crop sold and the net cash flow generated by the marketing actions at every stage. The percentage crop sold was determined by calculating the percentage sold over the total number of tons produced of the relevant crop. Farmer Brown sold 1 000 tons of white maize on a forward contract. These 1 000 tons represented 27.2% {1000/(800*4.6)} of the total white maize production of Farmer Brown. The percentage of the crop that Farmer Brown sold with forward contracts is depicted by Line 1 in Table A3.

The net return generated by the producer is the sum of Lines 2 to 8 and is indicated by Line 9 in Table 3. The producer generated a total net return over all his crops to the value of R1 310 030.23.

Table A3: Net cash flow of Farmer Brown's marketing strategies

	Line	White maize	Yellow maize	Sunflower seed
Pre-harvest stage				
Pricing instrument and % sold	1	Forward (27.2%) Futures (27.2%) Put (13.6%)	Forward (30.3%) Futures (15.2%)	Forward (73.5%)
Net cash flow - Forward	2	233 521.30	121 654.73	157 650.00
Net cash flow - Futures	3	244 267.17	47 266.35	
Net cash flow - put option	4	90 222.83		
Net cash flow – pre-harvest		**568 011.30**	**168 921.08**	**157 650.00**
Harvesting stage				
Pricing instrument and % sold		Spot market (59.2%)	Spot market (69.7%)	Spot market (26.5%)
Net cash flow - spot	5	552 676.44	266 005.87	65 754.00
Net cash flow - put	6	-27 800.50		
Net cash flow - Futures	7	-166 781.11	-33 300.00	
Net cash flow – harvest		**358 094.53**	**232705.87**	**65 754.00**
Post-harvesting stage				
Pricing instrument and % sold		Storage (13.6%)		
Net cash flow - storage	8	140 649.49		
Net cash flow – post-harvest		**140 649.49**		
Net return	9	**732 265.63**	**354 360.60**	**223 404.00**

In testing the integer linear programme, the following procedure was followed: Firstly, the information pertaining to Farmer Brown was entered into the programme. Every time Farmer Brown made a decision, the result was compared to the actual payoffs from the marketing strategies the model proposed. From there on, the decisions suggested by the integer linear programme were taken into consideration in future decisions. For instance, when the programme suggested that Farmer Brown should engage in a short futures position, the futures position had to be reflected in the next set of decisions. All option contracts suggested by the model were at-the-money. Also, one month prior to harvest, the integer linear programme was run again to sell a total of about 80% of Farmer Brown's crop. The primary reason for this action was that spot prices during harvest normally tend to be lower during harvest than prior to harvest. One month prior to harvest, the expected yield was more certain and Farmer Brown's yield risk decreased.

The optimal marketing strategy combination for the pre-harvest stage was determined first, then the harvesting stage marketing combinations and finally the storage stage marketing combinations were calculated. Farmer Brown took the first decision on 27 October 1998. This was also the first date that the integer linear programme used in determining the optimal combination of marketing alternatives. The integer linear programme based the optimization on the optimal combination of marketing strategies by taking the net cash flow per ton of each strategy into account. The net cash flow per ton was then used to determine the optimal number of tons to be allocated to the different marketing alternatives.

Pre-harvest marketing stage

The net cash flow per ton of all the marketing instruments available had to be determined. On 27 October 1998, Farmer Brown entered into a forward contract at a price of R580/ton for white maize and R630/ton for yellow maize. At the same time the net cash flow of the other marketing instruments had to be

determined. The futures price used was the closing futures price of a July contract and the option price was an at-the-money option based on the closing prices of the July futures contracts. All futures price data were obtained from SAFEX. The option premium was determined by means of an option calculator, downloaded from the SAFEX website (www.safex.co.za). The net cash flow from all the marketing instruments available for white maize and yellow maize on 27 October 1998 were determined.

On 17 December, Farmer Brown sold a further 200 tons of yellow maize by engaging in a short July futures position at a price of R650/ton. The MDSS determined the net cash flows per ton of futures contracts and options contracts and determined an optimal combination, indicated by Line 2 in Table A4. There were no forward contracts available on 17 December 1998. The net cash flow per ton from the futures position was R233.87 and the net cash flow per ton from a put option contract was R219.92. An at-the-money strike price of R640 was chosen and the premium payable on the put option contract was R32.51.

On 10 January 1999 Farmer Brown entered into a forward contract to deliver 500 tons of sunflower seed at a price of R1 000/ton. The MDSS determined the net cash flows per ton of the forward contract, the futures contract and the options contract and determined an optimal combination, indicated by Line 3 in Table A4. The net cash flow per ton from the forward contract was R315.30, the net cash flow per ton from the futures position (with a price of R1 100/ton) was R297.60 and the net cash flow per ton from a put option contract was R276.10. An at-the-money strike price of R1 100 was chosen and the premium payable on the put option contract was R55.00 per ton.

On 19 January 1999, Farmer Brown bought five July white maize put contracts at a strike price of R640/ton. The MDSS determined the net cash flows per ton of futures contracts and options contracts and determined an optimal combination, indicated by Line 4 in Table A4. There were no forward contracts available. The

net cash flow per ton from the futures position (at a price of R607/ton) was R189.96, and the net cash flow per ton from a put option contract was R164.00. An at-the-money strike price of R600 was chosen and the premium payable on the put option contract was R29.96.

On 17 February 1999, Farmer Brown sold a further 1 000 tons of white maize by engaging in a short July futures position at a price of R680/ton. The MDSS determined the net cash flows per ton of futures contracts and options contracts and determined an optimal combination, indicated by Line 5 in Table A4. There was a forward contract available to deliver 1 000 tons of white maize during harvest at price of R620/ton and the net cash flow from the forward contract was calculated at R273.52. The net cash flow per ton from the futures position was R248.81 and the net cash flow per ton from a put option contract was R239.81. An at-the-money strike price of R680 was chosen and the premium payable on the put option contract was R33.98.

Every time that Farmer Brown sold a percentage of his crop, the MDSS was run again to determine the suggested combination of marketing alternatives. The assumption was made in the study that one month prior to harvest, the MDSS had to sell 80% of the expected crop. One month prior to the harvesting of the white and yellow maize, the MDSS was therefore run again. A total of 440 tons of white maize and 336 tons of yellow maize had to be sold to secure the 80% level. In the case of sunflower seed, no more of the expected crop was sold one month prior to harvesting. The primary reason was that only 44 tons (680*0.8-500) of sunflower seed was available to secure the 80% selling level. Futures traded at R905/ton for white maize and R810/ton for yellow maize. An at-the-money put option with a strike price of R900/ton for white maize and R800/ton for yellow maize was chosen. The premium amounted to R19.88 per ton for white maize and R16.63 per ton for yellow maize. The net cash flows per ton were:

- R477.91 for white maize futures contract;
- R391.39 for yellow maize futures contract;

- R456.49 for white maize put option; and
- R378.26 for yellow maize put option.

The optimal combination is indicated in Table A4 by Line 6 for white maize and by Line 7 for yellow maize. Although the highest return per ton was from the short futures, no more futures contracts could be purchased. The total number of contracts that the producer could buy, had already been bought. The net returns for white maize, yellow maize and sunflower seed is indicated by Line 8 in Table A4.

Harvesting stage

In this example, no optimization could occur during the harvesting stage. The put option contract on white maize had been exercised and the maize had been delivered. The short futures positions for white maize and yellow maize had been closed out and the rest of the crop (except for 500 tons of white maize) had been sold on the spot market.

On 6 July 1999, Farmer Brown stored 500 tons of white maize until March 2000. He sold the maize on the spot market, receiving R740/ton. The MDSS determined the net cash flows per ton of futures contracts and options contracts and determined an optimal combination, indicated by Line 9 in Table A4. March white maize futures traded at R920/ton. The net cash flow per ton from the storage decision was R331 and the net cash flow per ton from a put option contract was R331.67. An at-the-money strike price of R920 was chosen and the premium payable on the put option contract was R58.46 per ton. The option contract was exercised and closed out. The maize was sold on the spot market at a price of R740/ton.

Table A 4: Net cash flow generated by MDSS

	Line	White maize	Yellow maize	Sunflower seed
Pre-harvest stage				
27/10/98				
Pricing instrument and % sold		Short futures (27.2%)	Forward (30.3%)	
Net cash flow - futures	1	R251 206.59	R121 654.73	
17/12/98				
Pricing instrument and % sold			Short futures (30.3%)	
Net cash flow - forward	2		R121 654.73	
10/01/99				
Pricing instrument and % sold				Forward (73.5%)
Net cash flow - forward	3			R157 650
19/01/99				
Pricing instrument and % sold		Short futures (13.6%)		
Net cash flow - futures	4	R93 478.22		
17/02/99				
Pricing instrument and % sold		Forward (27.2%)		
Net cash flow - forward	5	R273 521.30		
17/05/99				
Pricing instrument and % sold	6		Short futures (22.7%)	
			R117 418.09	
Net cash flow - Futures				
20/05/99				
Pricing instrument and % sold		Put option (9.2%)		
Net cash flow - put	7	R182 596.01		
Net return - pre-harvest stage	8			
Harvesting stage				
Pricing instrument and % sold		Long futures (40.8%)	Long futures (37.9%)	Spot (26.5%)
		Spot (48.4%)	Spot (84.8%)	
Net cash flow - spot		R451 267.92	R323 833.24	R65 754.00
Net cash flow - futures		(R289 026)	(R33 536.80)	
Net return - harvesting stage		**R162 241.92**	**R290 296.44**	**R65 754.00**
Post-harvesting stage				
Pricing instrument and % sold		Put (13.6%)		
Net cash flow - put		R237 597.50		
Net return - post-harvesting stage		**R237 597.50**		
Total net return		R673 360.72	R411 951.17	R223 404.00
% improvement		-8.3%	16.3%	0%

The same principles apply where one is determining the net cash flows of the various marketing instruments for wheat and for soybeans. The only difference is that for soybeans there are no derivative contracts.

APPENDIX B

QUESTIONNAIRE

1. BASIC FARM INFORMATION AND INPUT COSTS

In which district is the farm situated?...

Number of hectares planted per crop and expected harvest dates

Crop	Number of hectares	Expected harvest date

Maize:
    White
    Yellow		

Sunflower seed		
Soybeans		
Wheat		

Crop yield:

Indicate average yield for the past five years and indicate expected yield for the 1998/99 marketing season.

	White Maize	Yellow maize	Sunflower seed	Soybeans	Wheat
Year 1					
Year 2					
Year 3					
Year 4					
Year 5					
Expected					

INPUT AND HARVEST COSTS

Indicate the various costs **per hectare** for the crops you planted. The average input costs and harvest cost for your region is given as an indication. Please change if not correct.

	White		Yellow		Sunflower seed		Soybeans		Wheat	
	Ave	Yours	Ave	Yours	Ave	Yours	Ave	Yours	Ave	Yours
Input cost per Ha										
Total per Ha	927.28		927.28		704.91		1408.41		846.92	
Harvest cost per Ha										
Total per Ha	63.71		63.71		73.89		120.89		80.45	
Harvest cost per ton										
Total per ton	50.02		50.02		53.00		88.67		46.25	

Input cost includes items such as seed, fertilizer, fuel, pesticides, weedicides, lubrication, repairs, crop insurance, labour and interest on production loans.

Harvest cost per hectare includes items such as fuel, transport, labour and contract work if paid per hectare.

Harvest cost per ton includes items such as pick-up labour, drying cost, transport and contract work if paid per ton.

STORAGE COST

If your crop is stored, please indicate with an (X):

1. how storage cost is determined; and
2. the cost per ton that you pay.

1. Per day	....	Per month	....	Per season	....
2. Cost (R)	....	Cost (R)	....	Cost (R)	....

2. PERSONAL INFORMATION

Indicate the average time you spend per week on determining crop prices and crop price movements:...Hours

Indicate the source you use the most to obtain crop prices and crop price movements. Rank from high to low, with (1) the most frequently used.

Co-operatives	
Traders	
Internet	
Agricultural magazines	
Agri-businesses	
Consultants	

Identify areas or services where you need more information in the marketing of your crop...

INTEREST RATES

Indicate only the rate(s) that is/are applicable to your crop production. If you do not use a production loan or an overdraft facility, please give the interest rates on your fixed deposits.

	%
Production loan (Co-operative)	
Overdraft facility	
Interest earned on fixed deposit	

MARGINS

If you use futures contracts, can you maintain all the margin calls? Indicate with an (X)

Yes............. No...............

3. MARKETING ALTERNATIVES

The following questions refer to the particular marketing alternatives that you used during the 1998/99 marketing season for summer crops, and during the 1999/2000 marketing season for wheat.

	White maize	Yellow maize	Sunflower seed	Soybeans	Wheat
Spot market during harvest: Average price per ton Quantity sold					
Forward contracts: Price per ton Quantity sold Date contract entered into Date of delivery					
Storage Price per ton Quantity sold Date of delivery					
Futures contracts **Contract 1** Short or Long Contract price Number of contracts Date contract entered into Expiry month of contract Contract closed out? Yes/No If yes, date If yes, price					
Futures contracts **Contract 2** Short or Long Contract price Number of contracts Date contract entered into Expiry month of contract Contract closed out? Yes/No If yes, date If yes, price					
Option contracts **Contract 1** Put or Call Strike price Number of contracts Date contract entered into Expiry month Premium Contract exercised? Yes/No If yes, date If yes, price Contract delivered? If yes, date					

	White maize	Yellow maize	Sunflower seed	Soybeans	Wheat
Option contracts **Contract 2** Put or Call Strike price Number of contracts Date contract entered into Expiry month Premium Contract exercised? Yes/No If yes, date If yes, price Contract delivered? If yes, date					

4.   MARKETING COST

Indicate the cost associated with futures and option contracts.

	Futures contracts	**Option contracts**
Commission fees		
Handling costs		
Area differential		
Other costs		