PRICE DISCOVERY, PRICE BEHAVIOUR, AND EFFICIENCY OF SELECTED GRAIN COMMODITIES TRADED ON THE AGRICULTURAL PRODUCTS DIVISION OF THE JSE SECURITIES EXCHANGE

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CHRISTO VILJOEN

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Price discovery, price behaviour, and efficiency of selected grain commodities traded on the Agricultural Products Division of the JSE Securities Exchange

by:

Christo Viljoen

Agricultural commodity derivatives were first introduced in South Africa in 1996 after the deregulation of the former marketing system. In the context of its proposed functions, namely price discovery and risk management, the question arose as to whether the futures market developed over time to performed its role efficiently. According to the Efficient Markets Hypothesis (EMH) an efficient market is one that accurately incorporates all information available at any point in time. The purpose of the research was to address the issue of price discovery efficiency, firstly, focusing on the weak-form methodology. Secondly, considering the behaviour of futures prices over time, the study addressed the concern of anomalies in daily returns – phenomena contradictory to the EMH by implication. Thirdly, as a means of defining the sources of inefficiency, the role of scheduled public information and its impact on futures prices was examined. Therefore, the primary objective of the research was to investigate and identify the main components of agricultural futures market inefficiency within the unique price formation structure of South African grain markets. The assessment of this problem is important in terms of evaluating the growth and development of the futures market for different grain commodities to date. The Exchange needs to review rules and regulations on a frequent basis in order to ensure proper functioning at all times especially in the case of a relatively new and fast growing market. The study contributed to the knowledge of understanding the price adjustment process and its implications for market efficiency in the context of the three grain markets considered. The weak-form efficiency was tested using a co-integration based model. Analysing daily spot and futures prices of white maize, yellow maize, and wheat, results indicated that all three markets were efficient and unbiased. Non-parametric tests revealed the significant presence of day-of-the-week and turn-of-the-month effects in the futures returns of the three commodities. Further non-parametric analyses suggested a high degree of uncertainty in futures returns around scheduled agricultural and macroeconomic information release dates also contributing significantly to the identified anomalies. It was concluded that (1) the markets' ability to anticipate the contents of future information to be released, (2) the current skewed size distribution of broking members, (3) the significant role of the R/$ exchange rate in the price formation process of South African grains and, therefore, (4) the relationship to and influence of the broader economy enhanced the return effects (anomalies) creating opportunity for profitable arbitrage. This conclusion was mainly attributed to South Africa's status as a price-taker in the world grain complex as well as the relatively short existence of the local agricultural futures markets.

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PREFACE

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Chapter 1

INTRODUCTION

1.1 Problem statement

Two primary functions are generally attributed to commodity futures markets: transferring unwanted price risk through hedging and generating new information about the future value of the underlying commodity. While there is little doubt that futures contracts are effective tools for risk management, there is some question about the usefulness of futures markets for price discovery.

Futures trading, as shown by Carlton (1984: 246), has simply exploded in volume since 1970. As the number of futures markets have grown and the number of participants increased, numerous policy questions regarding futures markets and their regulations have risen. This paved the way for new methodologies and theories surrounding the efficiency of different equity and futures markets. The topic of market efficiency has been researched and debated to some extent over the last few decades.

Eugene Fama (1970:383), in an influential paper divided the "prehistory" of efficient markets associated with the random walk model from modern literature. Fama (1970:383) defined a market to be efficient "if all the information in a specific information set is fully reflected in securities prices, also known as the Efficient Markets Hypothesis (EMH). LeRoy (1989:1592) showed that Fama's theory distinguished between three important versions of the efficient markets model depending on the specification of the information set: a market is "weak-form efficient" if the information set only includes historical prices; a market is "semi-strong efficient" if the information set is broadened to include all information that is publicly available; and, finally, a market is "strong-form efficient" if the set is broadened even further to include private or insider information. Fama's definitions led to the development of many “tests of market efficiency”, for the different forms and for different markets including, amongst others, equity markets, capital markets, foreign exchange markets, and commodity futures markets.

Despite some strong evidence that asset markets are efficient over the long-run, there have been scores of studies that have documented long-term historically predictable returns in the prices of different markets, a result which would have direct implications for market efficiency. Jones *et al* (1998:316) noted that asset prices are volatile and this volatility is predictable over time. Financial economists agree about these facts, but they do not agree on their implications. While the existence of these anomalies is well accepted, the question of whether investors can exploit them to earn superior returns in the future is subject to debate. Of course, investors evaluating anomalies should keep in mind that although they have existed historically, there is no guarantee they will persist in the future. Yet, if returns of specifically commodity futures prices are predictable or at least, predictable to some extent, is it also possible that a market can perform efficiently in terms of price discovery? This is not a question that will be formally addressed in this study as it has been the focus of numerous papers and research articles to date. However, this question laid the foundation for the research questions of the thesis as will be identified in the following section.

In the South African context, the Agricultural Products Division of the JSE Securities Exchange (JSE APD) [previously known as the Agricultural Markets Division of the South African Futures Exchange (Safex AMD)] was opened in 1995 with white and yellow maize futures contracts introduced in 1996 (Bayley, 2000:87). The aim of the market was to provide a vital service in the newly deregulated marketing environment in South Africa after the implementation of The Marketing of Agricultural Products Act of 1996 (Ministry of Agriculture and Land Affairs, 1998:15). The Act abolished all major Control Boards for agricultural products (under the 1968 Marketing Act) and deregulated the previous one-channel regulated agricultural marketing system. Since the first introduction of white and yellow maize commodity contracts on the exchange, the number of commodities expanded and to date also includes wheat, sunflowers, and soybeans. Since 1996, interest in the JSE APD grew tremendously and trading volumes, especially in the white and yellow maize and wheat markets, increased exponentially from year to year. The agricultural futures market now plays an integral part in the marketing and price setting of South African grain commodities (Jooste *et al*, 2000:11).

1.2 Purpose of the study

Futures markets effectively provide a forecast of future spot prices and thus serve as a medium through which traders can manage their risk by fixing price in advance of transactions relating to the physical commodity. From a public policy perspective this attribute would suggest that futures markets are potentially a useful alternative to more established forms of market intervention particularly with respect to price stabilisation policies.

From a more general and private perspective, futures trading is one of the more widely used mechanisms for managing the effects of output and price instability resulting from the production, marketing and purchase of a commodity. The key feature of futures markets in this context is their ability to predict prices at a specified future date both efficiently and in an unbiased fashion. Thus, an empirical analysis of efficiency and unbiasedness is central to any assessment of the value of a specific commodity futures market.

This study will focus on the answering of three main research questions. Firstly, does the South African agricultural futures market function efficiently in terms of its single most important purpose, its price discovery function. This question specifically refers to the weak-form efficiency theory focussing on white maize, yellow maize, and wheat. Taking into consideration the relative short existence of the agricultural futures market, results and answers to this question would be an important indication of the development process of the market and a guideline in evaluating current exchange rules and regulations. Secondly, depending on the results surrounding market efficiency, the question arises whether the possibility exists of predictable behaviour in the price returns of the different commodity markets under consideration. This part of the study would make an important contribution to the general research on price behaviour of agricultural commodity futures markets. Also, it contributes greatly to the relatively small amount of research produced to date in relation to the local agricultural derivatives markets. The results based on this question are expected to help answer the first research question and contribute to a great extent on the theory surrounding return predictability and market efficiency.

The results found will also lay the foundation for the third and final research question: are the possible anomalies found in the prices of the different markets either contradicting the EMH, or do they emerge from the possible presence of an alternative information set (other than historical prices) observed and absorbed by the different markets. This section of the study will consider public information from both agricultural and macroeconomic origin and its possible contribution towards predictable return patterns in the different commodity markets considered. By addressing the different research questions, the study will greatly contribute to the following areas of international and South African economic research:

1. the methodology of efficiency testing of agricultural futures markets,
2. the efficiency of the South African white maize, yellow maize, and wheat markets in terms of price discovery,
3. the general behavioural structure of South African agricultural futures prices in terms of price anomalies and the contribution to this field of research,
4. price behaviour of agricultural commodity futures markets around scheduled agricultural information releases,
5. price behaviour of agricultural commodity futures markets around scheduled macroeconomic information releases (given the very little published international research to date surrounding this topic),
6. the contribution of price behaviour around scheduled agricultural and macroeconomic information releases towards other significant price anomalies and the overall effect on market efficiency, and
7. identifying and explaining the linkages between the macroeconomic environment and the agricultural grains industry in South Africa.

1.3 Outline of the Research

The study is divided into seven further chapters (2 to 8), six containing the relevant theory and empirical analyses concerning the different research questions, and a final chapter that concludes the findings of the study. The basic outline of the chapters are as follows:

First, Chapter 2 will introduce the South African grains industry specifically focussing on the major commodities to be investigated, namely white maize, yellow maize, and wheat. The chapter will review production trends of the SA grain industry as a whole as well as focus on each of three respective sub-sectors. An overview of the marketing environment of grain products is presented with special emphasis on the deregulation of the marketing of agricultural products as introduced in the late nineties, which also led to the introduction of the commodities derivatives market. Finally, the chapter examines the JSE APD both from an historical point of view and its possible future challenges.

Secondly, Chapter 3 provides background theory to commodity derivative markets. A historical review of the origin of futures markets is followed by an analysis of the role futures markets play in risk management. This chapter also focuses on the different market participants and instruments available to them. Because of its importance in the analysis, the value of the futures market in terms of its price discovery and risk management functions as well as the pricing of both futures and option contracts is reviewed in depth. Finally, the operation and functioning of futures exchange are discussed in the last section of the chapter.

Thirdly, the methodology and theory surrounding futures market efficiency and the Efficient Markets Hypothesis (EMH) is presented in Chapter 4. The chapter reviews the theory surrounding the EMH, the Martingale, and Random Walk hypotheses respectively in terms of their origin and its importance to futures and other asset markets. This is followed by a discussion of the co-integration methodology for testing the weak-form EMH and introduces the model to be used to test the efficiency of the different South African commodities under consideration in this study. Fourthly, Chapter 5 presents the data to de used and the results of the intertemporal and cross-sectional efficiency tests conducted on the white maize, yellow maize, and wheat markets respectively. Results for the stationarity, co-integration, and bias tests of intertemporal efficiency are presented in separate sections for the three commodities. Results of cross-sectional efficiency tests are also presented whereafter the final section of the chapter provides a summary of all the results. The purpose of this section of the study is to provide an answer to the important first research question, namely, whether the commodity markets considered comply with the necessary conditions of the EMH.

Fifthly, in order to address the second research question, the behaviour of commodity futures prices, specifically focussing on anomalies and return effects, are presented in Chapter 6. Selected commonly found price return anomalies and patterns are reviewed in the first section, followed by a description of the data. The results of the different regularities examined are presented and consist of anomalies according to the day-of-the-week, holiday, turn-of-the-month, and time-of-the-year. The results of testing for a possible maturity effect are also presented in this section of the chapter. The chapter is concluded by a brief summary of the results and findings.

Sixthly, the focus of Chapter 7 is an investigation into the price adjustment process of futures prices around the release of scheduled macroeconomic and agricultural information. The chapter starts with a literature review of the effects of public information specifically on agricultural commodity futures and spot markets. In order to explain the linkages between the South African economy and the agricultural grain sector, fundamental price determinants and international prices are reviewed focussing on the maize and wheat industries. The selection of the different macroeconomic and agricultural announcements considered is described and the distribution of the data is presented, whereafter the empirical approach to be used in the chapter is explained. Results are divided into three sections namely, announcement-day effects, day-of-the-week effects, and the turn-of-the-month effects in which the findings of the different empirical analyses are provided. Finally the chapter’s results and important findings are provided in a brief summary.

Lastly, all findings and results of the study are concluded in Chapter 8. The main purpose of this section of the study is to formally present answers to the research questions posed.

The final section of this chapter presents recommendations for similar and further research in this field of economics.

Chapter 2

GRAIN PRODUCTION AND MARKETING IN SOUTH AFRICA

2.1 Introduction

With democratisation in 1994, South Africa has undergone major changes in its economic policies. The country embarked on an economic restructuring programme shifting from a relatively closed to a more free market orientated economy (Troskie *et al*, 2000:11). Poonyth and Van Zyl (2000:622) state that, in agriculture, this change is characterised by various new policies including globalisation, market liberalisation, regional market integration, the land distribution programme, and the empowering of emerging small-scale farmers. South African agriculture has in recent years not only witnessed a rapidly changing international trading environment, but it has also experienced a dramatic change in the way the marketing of its products is managed. The implications of these developments were that the agricultural sector was exposed to fluctuations from different sources on a year-to-year basis (Swart, 1996:200).

Since the introduction of the Marketing of Agricultural Products Act (no 47 of 1996) South Africa has deregulated all its former control Boards. This, together with the move towards a more liberalised market, has brought about a freer market environment for agricultural products in which prices are determined by various factors (De Villiers and Jooste 2001:1). Within this dynamic environment producers of agricultural products are not only exposed to production risk, but also to greater price risk and competition. This chapter will, firstly, focus on the recent historical background of the deregulation of the agricultural marketing environment specifically focussing on the maize and wheat industries, and the institutional developments towards a futures market in South Africa. Secondly, an overview of domestic maize and wheat production which will thirdly be followed by a description of the revolution of the agricultural marketing policy and its impact on the agricultural sector. The chapter is concluded with a review of the South African Futures exchange and its role in the marketing of maize and wheat in South Africa.

It is at this stage very important to note that, after the completion of this section of the research, Safex AMD officially started to function under the branding of the Agricultural Products Division of the JSE Securities Exchange (JSE APD). For the purpose of this chapter and the references used, the exchange will still be referred to as the Safex AMD.

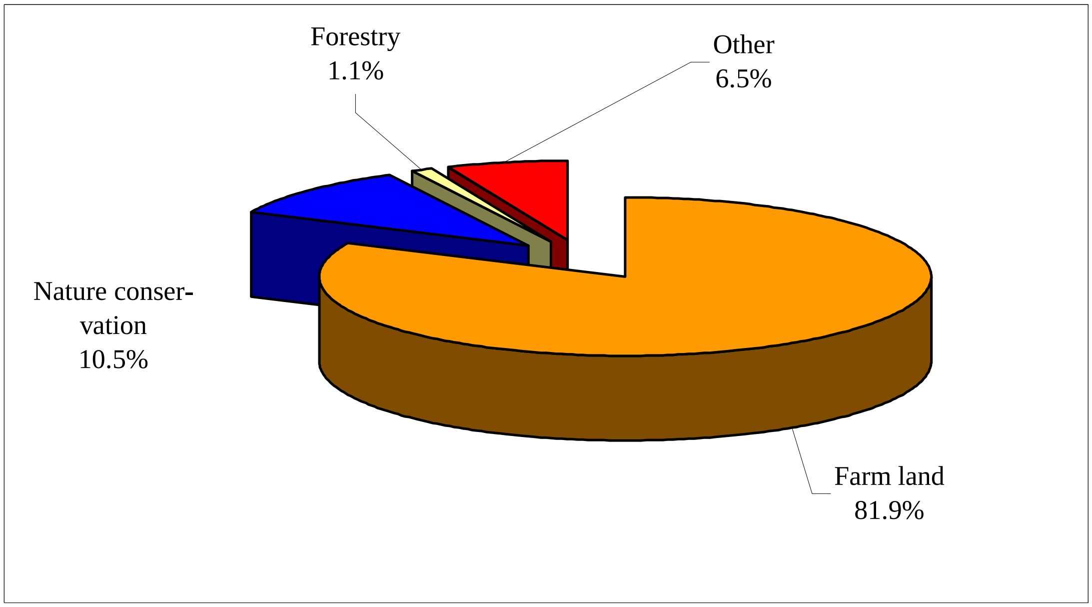
2.2 South African grain production

Agricultural production (or the quantity of a certain product) is the quantity of the product that will be offered for sale per period of time, under a given set of conditions (Kohls and Uhl, 1990:48). Breitenbach and Fényes (2000:298) mention six factors affecting the market supply of a product:

1) the price of the product,
2) the prices of alternative products,
3) the prices of inputs,
4) the objectives of the producers,
5) the number of producers supplying the market, and
6) the size-distribution of farms supplying the market.

Breitenbach and Fényes (2000:293) note that, agriculturally speaking, South Africa is poorly endowed. South Africa's total land area amounts to 122,3 million hectares consisting of 101 million hectares of farmland of which 86 percent is unsuitable for dryland crop production, either because of too low rainfall or unsuitable terrain (Jooste *et al*, 2000:5). Thus, only 14 percent of the total surface area available is arable and suitable for field crop production. Furthermore, according to Agrifutura (1998:20), only 22 percent of this is of high potential while 78 percent is of medium to low potential. Figure 2.1 shows the utilisation distribution of land in South Africa.

Figure 2.1: Utilisation of land in South Africa



Source: Directorate Agricultural Statistics (2001)

South Africa faces many restrictions on agricultural production of which the availability of water is probably the most important. Rainfall is distributed unevenly across the country with humid, subtropical conditions occurring in the east and dry, desert conditions in the west. Almost 50 percent of South Africa's water is used for agricultural purposes (NDA, 2001). Van Zyl *et al* (1996:5) show that about 65 percent of the country has an average rainfall of less than 500 mm which is generally regarded as the minimum for rain-fed cropping. This condition is worsened by evapotranspiration, especially in areas with relatively low rainfall. Despite these restrictions, South Africa is self-sufficient in the production of its major crops (Breitenbach and Fényes, 2000:293).

According to the Directorate of Agricultural Statistics (2001:85), maize is the most important field crop and summer grain (in terms of gross value of production), while wheat is the most important winter cereal produced on average annually. The relative share of field crops in total agricultural production has declined from 48.5 percent to 30.8 percent from 1980 to 1999. This trend, according to Meyer (1998:14) could be attributed to the following factors:

1) the effect of drought and its consequences, i.e. crop failures and lack of drought aid measures such as in the past,
2) the adoption of more market-related policies as regards grain products which force more grain crop farmers to abandon agriculture,
3) market-related interest rates and large carry-over debts resulting from poor crops have weakened the financial position of farmers,
4) the annually deteriorating terms of trade, with prices of production inputs rising faster than producer prices, and
5) the economic impact of macro-economic policies on agriculture.

Table 2.1 shows the contribution of the different agricultural sub-sectors to the annual total gross value of agricultural production.

Table 2.1: Various contributions to the gross value of agricultural production

	Field crops	**Horticulture**	**Animal production**
Gross value[1]	17 496	12 532	19 532
Percentage[2]	35.3	25.3	39.4

[1] Average of 5-year period from 1997/98 – 2001/02 (R million)
[2] Percentage of total agricultural gross value (5-year period average)
Source: Directorate Agricultural Statistics (2003); own calculations

2.2.1 Maize production and consumption trends

The maize industry plays a very important role in the South African economy. Its strategic importance lies in its forward and backward integration with the rest of the economy, the establishment and maintenance of food security, the welfare of the rural areas and foreign exchange earnings (Jooste *et al*, 2000:173). Table 2.2 depicts the world's five largest maize producing countries during 2001/02 in terms of output and market share. The United States of America is the market leader producing 38 % of the world's maize and together with China they produce more than half of the world's crop on an annual basis. South Africa is not a major contributor to world maize production and only produced a total of 9.123 million metric tons (1.5 % of world production) in 2001/02.

Table 2.2: Major world maize producing countries, 2001/02

Country	Production (1 000 tonnes)	% of total world production
World total	602 589	
USA	228 805	38.0
China	123 175	20.4
Brazil	35 478	5.9
Mexico	17 500	2.9
France	16 013	2.7
South Africa	9 123	1.5

Source: FAO (2003)

Almost 40 per cent of South Africa's cropped land of just over 10 million hectares is planted to maize annually, occupying more land than any other crop in South Africa (Jooste *et al*, 2000:182). Maize is regarded as a summer grain and produced in greater capacity towards the eastern half of South Africa where a typical summer rainfall pattern exists. South Africa produces both white and yellow maize with white maize contributing to approximately 60 percent of total maize production and is mostly used for the further production of maize meal (Jooste *et al*, 2000:93). Maize is also the major cereal consumed in the country (Meyer, 1998:72). Elliot (1991:146) mentions that 94 percent of maize meal produced is consumed domestically as it is the staple food for a large percentage of the black population in South Africa. In addition, yellow maize (approximate 40 percent of total maize production) is mainly used by the livestock industry for animal feed and comprises more than 60 percent of total animal feed requirements (Willemse, 1996:15; Briedenhann, 2000:13).

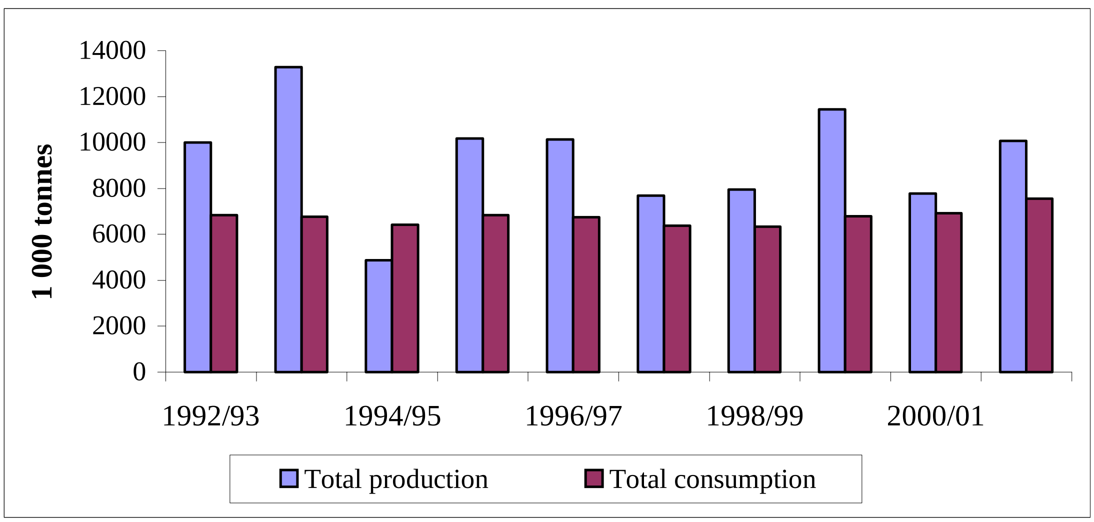
Human demand for maize has been shown to be relatively less price elastic than animal demand but both are considered price inelastic as few substitutes are available (Van Zyl, 1986:46). Animal demand has been steadily increasing due to the increased importance of maize as an animal feed, especially for poultry (Wiseman, 1999:12). From Table 2.3 and Figure 2.2 it is clear that South Africa meets its annual maize requirements almost entirely from domestic production, but often produces surpluses that are exported mainly to neighbouring countries in the Southern African Development Community (SADC) region. The human market has been growing consistently at a growth rate slightly lower than the population growth rate (Meyer, 1998:73). *Per capita* consumption shows a decline that could be attributed to changes in income and expenditure patterns, substitution and income effects and a fast growing population. Table 2.3 also shows that animal feed consumption almost equals that of human utilization.

Table 2.3: Domestic consumption of maize, 1990/91 – 1999/00

Marketing year	Consumption (1 000 tonnes)					Total consumption
	Human	Animal feed	Seed	Industrial	Losses	
1990/91	3302	4204	30	251	0	7787
1991/92	3163	3841	37	233	11	7285
1992/93	3612	3604	30	251	0	7497
1993/94	3449	3601	30	268	8	7356
1994/95	3742	3775	30	260	0	7807
1995/96	3416	3570	30	242	14	7272
1996/97	3092	3300	30	255	14	6691
1997/98	4633	3000	30	260	14	7937
1998/99	4469	3125	30	260	14	7898
1999/00	5002	3150	30	260	14	8456

Source: Directorate Agricultural Statistics (2003)

Figure 2.2: Total production and consumption of maize, 1992/93 – 2001/02



Source: Directorate Agricultural Statistics (2003)

In the 2001/2002 production season, maize was the second largest contributor (R 13.7 billion), after poultry (R 7.95 billion), to the total gross value of agricultural production in South Africa (R 66.05 billion) (Directorate Agricultural Statistics, 2003:80). Table 2.4 reports production figures and percentage contribution of maize (white and yellow) to the total gross value of field crops and the agricultural sector for different years.

Table 2.4: South African maize production for different years

	1993/94	1995/96	1997/98	1999/00	2001/02
Total production[1]	13 275	10 171	7 693	11 455	10 058
Contribution[2]	48.7	45.4	33.8	43.7	51.2
Contribution[3]	17.3	16.5	10.7	13.8	20.9

[1] 1 000 tonnes.
[2] Total gross value of maize production as percentage of total gross value of field crops.
[3] Total gross value of maize production as percentage of total gross value of agricultural production.
Source: Directorate Agricultural Statistics (2003); own calculations

From the table it is clear that the maize industry is a significant contributor to the annual gross value of agricultural production. Briedenhann (2000:12) mentioned six main reasons why maize plays such a dominant role in terms of production:

1) it is well adapted to a large portion of arable soils in South Africa and a rainfall of approximately 500 mm,
2) it is suitable as food and feed crop,
3) the large market and acceptability of maize is conducive to ease of marketing,
4) currently and historically, the producer price is attractive relative to other crops such as soybeans,
5) the lack of understanding of market signals as to which crop would be the most profitable to plant, and
6) the lack of competition from other cereals due to anti-nutritional factors and lower nutritional value inhibiting cost effectiveness of alternatives.

Maize is planted in the summer, primarily in the months of November and December. Depending on actual and expected rainfall, planting can start as early as late October and extend into January. The majority of maize is harvested during June and July, although depending on planting times, harvesting can begin as early as late May and extend to the end of August (Safex, 2001a:3). Table 2.5 shows commercial maize production per province reported as an average of the last five years since 1995/96.

Table 2.5: South African maize production per province[1]

Province	Production[2] (5-year average)	% of total production (5-year average)
Western Cape	9	0.11
Eastern Cape	39	0.48
Northern Cape	287	3.5
Free Sate	2 955	36.2
KwaZulu-Natal	284	3.4
Limpopo	83	1.01
Mpumalanga	1 770	21.7
Gauteng	383	4.7
North-West	2 364	28.9
Total	**8 174**	**100.0**

[1] Average for 5-year period from 1997/98 to 2001/02.
[2] 1 000 tonnes.
Source: Directorate Agricultural Statistics (2003:9); own calculations

South African maize production is concentrated in the Northwest Province, Free State, and Mpumalanga (Bown *et al*, 1999:276) which, according to Table 2.3, contributed to 28.9 %, 36.2 %, and 21.7 % respectively to the 5-year average production over the period 1997/98 to 2001/02. This is indicative that South Africa is not only poorly endowed in terms of arable resources, but that maize production is also highly concentrated to specific regions of the country (Agrifutura, 1998:20) which significantly increase the risk and impact of weather related restrictions, such as droughts or floods, on the production of maize (Aliber *et al*, 1999:874). The economy of maize production in the summer grain areas has deteriorated during the past decades because prices of maize inputs rose more rapidly that the producer's price of maize (Nuppenau, 1994:175). The further impact of recent droughts has weakened the producer's ability to make structural adjustments. Farmers are increasingly reverting to farm activities to enterprises that have a greater comparative advantage (Meyer, 1998:74).

2.2.2 Wheat production and consumption trends

Similarly to the maize industry, South Africa is not a major contributor to the total world wheat production. In comparison with maize, wheat producing countries are more evenly distributed in terms of percentage contribution. China is the world's leading wheat producer followed by India and the Russian Federation. South Africa had a minor contribution of only 0.4 % of world production during 2001/02.

Table 2.6: Major world wheat producing countries, 2001/02

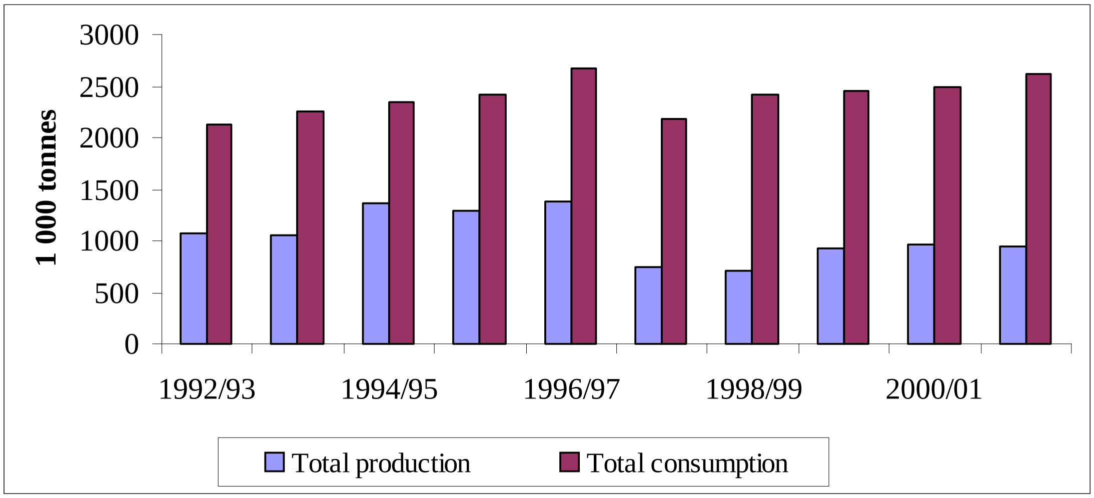
Country	Production (1 000 tonnes)	% of total world production
World total	572 878	
China	91 290	15.9
India	71 814	12.5
Russian Federation	50 557	8.8
USA	43 992	7.7
France	38 986	6.8
South Africa	2 400	0.4

Source: FAO (2003)

In South Africa, wheat is grown as a winter cereal mainly for human consumption, however, small amounts of wheat not fit for milling are marketed as stockfeed (Kirsten *et al*, 1998:538). Roughly 60 percent of the total quantity of flour and meal is used for the production of bread (Breitenbach and Fényes, 2000:300). There are currently between 5 000 and 6 000 producers domestically planting an average of approximately 1 million hectares of wheat on an annual basis (Jooste *et al*, 2000:213). The composition and the various needs of the population have a major impact on the consumption of the product.

Edwards and Leibrandt (1998:242) showed that a fairly large section of the total population of South Africa is poor and is urbanising at a fast rate. Urbanisation causes consumers to require more ready-to-eat food and the demand for convenience type foods is also growing in South Africa (Meyer, 1998:79). Bread is such a product that is a substitute for maize meal. Figure 2.3 and Table 2.7 show the domestic production and consumption trends of wheat for the past 10 years. Wheat demand and supply patterns show that demand outstripped supply for all the years considered and this made wheat imports unavoidable. South Africa is currently a net importer of wheat (Jooste *et al*, 2000:209).

Figure 2.3: Total production and consumption of wheat, 1992/93 – 2001/02



Source: Directorate Agricultural Statistics (2003)

Table 2.7: Domestic consumption of wheat, 1990/91 – 1999/00

Marketing year	Consumption (1 000 tonnes)		
	Human	Other	Total
1990/91	2037	47	2084
1991/92	1969	69	2038
1992/93	1809	61	1870
1993/94	1968	80	2048
1994/95	2084	67	2151
1995/96	2535	89	2624
1996/97	2515	67	2582
1997/98	2284	109	2393
1998/99	2638	109	2747
1999/00	2356	140	2496

Source: Directorate Agricultural Statistics (2003)

Table 2.8 reports production figures and wheat's contribution to the gross value of field crops and to the agricultural sector. Wheat is a significant contributor to the agricultural sector with an annual average gross value of approximately 5 percent of the total gross value of agriculture.

Table 2.8: South African wheat production for different years

	1993/94	1995/96	1997/98	1999/00	2001/02
Total production[1]	1 984	1 977	2 429	1 733	2 468
Contribution[2]	14.9	11.8	15.0	11.6	13.1
Contribution[3]	5.3	4.3	4.7	3.7	5.4

[1] 1 000 tonnes.
[2] Total gross value of wheat production as percentage of total gross value of field crops.
[3] Total gross value of wheat production as percentage of total gross value of agricultural production.
Source: Directorate Agricultural Statistics (2003:80); own calculations

Jooste *et al* (2000:211) noted importantly that wheat production shows a slightly decreasing trend over time and is strongly correlated with the total area planted under wheat. The conclusion is that the expansion of local production is dependent on the availability of suitable wheat cropping land and that there is little unused land available for wheat cultivation. Land available in the traditional cropping areas is almost fully utilised and future expansion of production in these areas is only possible at the expense of other grain crops.

Wheat is generally planted around June, July and August and harvested during November, December and January (Safex, 2001a:6). Wheat production per province is presented in Table 2.9. The Western Cape (33.8 %), Northern Cape (14.4 %), and Free State (36.4 %) are the major wheat producing provinces in terms of the five-year production average over the period 1997/98 to 2001/02.

Table 2.9: South African wheat production per province[1]

Province	Production[2] (5-year average)	% of total production (5-year average)
Western Cape	708	33.8
Eastern Cape	22	1.1
Northern Cape	301	14.4
Free Sate	762	36.4
KwaZulu-Natal	29	1.4
Northern Province	46	2.2
Mpumalanga	75	3.6
Gauteng	13	0.6
North-West	137	6.5
	2 093	**100**

[1] Average for 5-year period from 1997/98 to 2001/02
[2] 1 000 tonnes
Source: Directorate Agricultural Statistics (2003:12); own calculations

It is important to notice the dominant contributions, in terms of production, by the Free State Province for both maize (36.2 % according to Table 2.5) and wheat (36.4 % according to Table 2.9). Troskie *et al* (2000:10), however, note that although the Western Cape is not the largest contributor of wheat to total domestic production, it is certainly the most important in terms of stability of production and wheat quality due to its rainfall pattern and suitable soil quality.

2.3 Marketing of agricultural products

2.3.1 Phasing out statutory intervention

Bayley (2000:37) states that the South African marketing system, prior to the 1980's, proved to be financially, economically, and ultimately politically unsustainable. Between World War II and the 1980s South Africa's industrialisation policy revolved around import substitution, a trend which "was latterly exacerbated by the imperative to reduce the economy's vulnerability to sanctions" (Bayley, 2000:37). The disarray of agriculture after the Great Depression and the political power of commercial farmers resulted in the passage of the Marketing Act in 1937. This Act was re-promulgated in 1968 and together with other specific legislation, put in place a range of schemes affecting a major portion of the agricultural industry (Jooste *et al*, 2000:11). The 1968 Act promoted government intervention, both direct and indirect (Van Dijk and Otto, 1995:205), and control over all agricultural sub-sectors. Kirsten *et al* (1998:538) argue that, as a result of these policy measures, large-scale commercial (mainly white) producers of grain were considered highly protected, inefficient, and subsidised. In addition, according to Bayley (2000:25), black farming was confined to over-populated, resource- and infrastructure-poor homeland areas that accounted for only 4 percent of South Africa's total value of agricultural production in the last quarter of the twentieth century.

The main characteristics of the 1968 Act, compared to the Marketing of Agricultural Products Act of 1996, are shown in Table 2.10. In 1990 there were 21 agricultural marketing boards, the majority of which had a profound influence over the price, export and import, and the manner in which the products they controlled, were marketed. A growing realisation in the sector that statutory marketing systems that had served agriculture relatively unchanged in principle since the mid thirties were no longer sustainable in the nineties, and led to an accelerated liberalisation of statutory marketing (NDA, 1995:14).

Table 2.10: Characteristics of the Marketing Acts of 1968 and 1996

1968 INHERENTLY INTERVENTIONIST	1996 MINIMUM INTERVENTION
Increased productivity	Increased marketing efficiency
Reduction of marketing margins	Optimum export earnings
Increased consumption and food self-sufficiency	Food security at household level
Maximum commercial producers on land	More accent on small-scale farmers
Economic farming units; minimum farm size	Increased sustainability of agriculture
Non participative and bureaucratic introduction of intervention	Participative, transparent and all inclusive
Stabilising product prices	Producers must themselves stabilise income
Intervention inclusive of single channel; pools, surplus removal, fixed prices, quotas; price support; promotion; general and special levies, registration, records and returns	Limited to levies; export control; pools; registration; records and returns
Requested by producers or introduced by Minister	Requested by any directly affected group of provinces
Consultation not always necessary although certain quantified producer support required	Consultation process prescribed by Act inclusive of all directly affected groups
No political process to approve levies apart from Minister	Levies need to be approved by both portfolio committees and the Minister
No maximum period and no interim testing of intervention	All statutory measures to be introduced for fixed period and tested at least every two years

Source: NDA (1995)

Reform began slowly in the 1980s where the process of deregulation has its roots initiated by a previous Minister of Agriculture, Mr Greyling Wentzel, for more market-related production in agriculture. These initial steps were followed in the nineties by a growing debate on statutory marketing in agriculture, which was enthused by the reports of the Kassier Committee (January 1993) and of the Agricultural Marketing Policy Evaluation Committee (AMPEC) in 1993 which were appointed by Minister Kraai van Niekerk (Swart, 1996:200; Kassier, 1992). The AMPEC report was broadly supportive of the Kassier report and, according to Bayley (2000:46), it recommended that government’s agricultural marketing policy should be based on a number of principles, including the following:

1) that market mechanisms rather than controls should be relied upon for the setting of agricultural prices,
2) that uncertainty around marketing policy should be minimised as far as possible, and
3) that decision making processes should be as transparent and consultative as possible.

The report further recommended that:

4) all remaining statutory controls over the movement of agricultural products should be removed,
5) government should promote equality of access to marketing services,
6) the legislative framework should be reformed so as to reduce the extent of institutionalised lobbying,
7) smallholder productivity should be improved through improved access to resources and services,
8) an active competition policy should be pursued,
9) voluntary collective action should be encouraged,
10) a regional agricultural trade policy should be developed, and
11) export marketing arrangements should be reformed so as to increase efficiency.

2.3.2 The Marketing of Agricultural Products Act, 1996

At the end of 1996, the Marketing of Agricultural Products Act (Act No. 47 of 1996) was passed, providing for only certain limited interventions such as registration and information collection (Ministry of Agriculture and Land Affairs, 1998:4). The Act, which came into effect in January 1997, stipulated that all remaining control boards should close by the end of 1997 (NDA, 1995:5). By early 1998, all control boards had ceased operation, and their assets were transferred to industry trusts which would provide services such as market information, export advice, and product development. Price controls were removed and single-channel markets disappeared. As a result, agricultural price determination in South Africa has been transformed, with the main influences for any commodity now being the net regional supply and demand conditions (Bayley, 2000:37). The Act was the final ending of regulation and intervention in the agricultural sector, although the deregulation process, as in the case of the maize industry, was already underway for a number years.

2.3.3 Deregulation in the maize industry

The marketing of maize in South Africa was highly regulated from the early 1930s until the mid 1990s, with maize being marketed through a single-channel system administered by the Maize Board, which also set producer prices (Bown *et al*, 1999:276). Under the system, maize producers faced minimal risks and the greatest challenge was to produce maize as economical as possible given the fixed annual price (Grönum, 2000:6).

Willemse (1996:2) shows that, under the one-channel marketing system, marketing operations were based on the following principles:

1) the Minister of Agriculture would fix the maize price annually after considering the recommendations of the Board and other advisors,
2) maize consumers would carry their fare share of the cost of handling the storage,
3) maize consumers were given the assurance of adequate stocks at predetermined prices, and
4) the Maize Board would be the sole buyer and seller in certain areas (the major production areas).

The fact that the Board was the sole buyer and seller in South Africa meant, according to Willemse (1996:3), that the Board alone determined the purchase and selling price of maize, grading requirements, storage and handling specifications as well as the selling conditions of maize.

As input prices increased, as shown by Kirsten (1999:490), the depressed world price for maize in the late 1970s and early 1980s reduced the net price that South Africa could achieve on the world market (Jooste *et al*, 2000:184). However, according to Bayley (2000:53), pressure on the government’s budget resulted in its refusal to approve maize prices at levels that would relieve the cost price squeeze, causing discontent amongst maize producers. The result was the introduction of the Summer Grain Scheme at the beginning of the 1987/88 marketing season by which prices were not fully governed by the Maize Board, but also influenced by the supply and demand factors in the market. This ensured that prices were more market related and benefited producers in the long run as price signals were disclosed to producers before the planting season (Van Schalkwyk, 1996:23). The result was an incentive for producers to bypass the Maize Board's single channel and sell direct to livestock producers and processors. Van Schalkwyk (1996:23) shows that maize production started to increase and in 1994 South Africa produced its second largest maize harvest on record. This set the scene for further reforms (Bayley, 2000:55).

After the implementation of the Act of 1996, the Maize Board closed down in April 1997 and left the maize industry fully deregulated. This placed the responsibility for the marketing of this important agricultural commodity in the hands of individual producers. The price of maize was now free and determined solely by the market forces. Bown *et al* (1999:278) note that this, together with the price-inelastic nature of maize demand and seasonal shifts in maize supply result in highly volatile maize prices. Producers were now not only exposed to a more competitive domestic market, but also to a much greater price risk.

2.3.4 Deregulation in the wheat industry

Regulation in the wheat industry, as is the case in with maize, also has a long history of intervention. Table 2.11 provides a short summary of major events affecting the wheat and bread industries.

Table 2.11: Historical summary of important events for wheat marketing

Year	Event
1935	Establishment of the Wheat Industry Control Board
1937	Wheat Control Scheme promulgated: Single-channel system implemented
1968	Marketing Act, No 59 introduction of the Winter Cereal Scheme
1995	Termination of bread subsidy as well as price control on bread and flour
1996	Marketing of Agricultural Products Act, No 47 came into effect
1997	Wheat Board closed and single fixed price system revoked

Source: Jooste *et al* (2000:220)

The single-channel fixed price scheme imposed under the Winter Cereal Scheme effectively ossified the distributional linkages between all stages of the wheat commodity chain (NAMC, 1999:12). Not actively engaging in the production and processing of wheat, the Wheat Board acted as an umbrella organisation regulating the activities within and between the agents of the food commodity chain. Edwards and Leibbrandt (1998:223) show that all market transactions such as wheat sales, pricing distribution, storage, and bread flour production were controlled by the Wheat Board. Thus, the Wheat Board was the sole buyer and seller of wheat in the country (Kirsten *et al*, 1998:538). Regulation also extended to the international market with quantitative controls administered solely by the Wheat Board. Edwards and Leibbrandt (1998:235) mention that, during the 1980s, the highly regulated system began to be pressurised from all angles in a number of ways:

1) market orientated policy reforms contributed towards a “cost-price squeeze” and lower profitability in the wheat producing sector,
2) regulation in the processing sector conflicted with the emerging market orientation of the government, and
3) the administration of regulation was getting increasingly more difficult as the production of close substitutes for wheat related products increased.

The replacement of the 1968 Act, under which the Winter Cereal Scheme operated, with the Act of 1996 entailed a comprehensive restructuring of the marketing of wheat and no provision was made for a statutory single-channel system. The abolishment of the Wheat Board in 1997 signified the complete deregulation of all control exerted in the marketing of wheat. As in the case of the maize industry the producers of wheat were now faced with new challenges in a much different marketing environment.

2.4 The South African Futures Exchange (Safex) Agricultural Derivatives

2.4.1 The introduction of Safex AMD

The development of exchange-traded derivative instruments in South Africa started in 1988 when the South African Futures Exchange (Safex) was established and started trading financial futures contracts in 1990 (Safex, 2001d). Safex is an association of members consisting of banks, financial institutions, and stockbrokers who, through purchasing a seat on Safex, acquire the right to trade on the futures market on behalf of clients (Wiseman, 1999:10). Table 2.12 gives a chronological list that summarises some of the major events that have shaped the exchange:

Table 2.12: Historical summary of the development of Safex

Date	Event
Apr 1987	Rand Merchant Bank Limited (RMB) start 5 trading "futures" contracts on various equity indices and long bonds. RMB is the exchange, clearing house and only market maker.
Sep 1988	Twenty-one banks and financial institutions meet and establish the South African Futures Exchange (Safex) and the Safex Clearing Company (Safcom).
Apr 1990	Safcom takes over operation of the informal futures market from RMB. Futures contracts are available on equity indices, long bonds and money market products.
Aug 1990	Enabling legislation (the Financial Markets Control Act, 1990) is enacted and Safex is officially licensed as a derivatives exchange. Officially opened on 10 August 1990 by the Minister of Finance. Monthly volumes are approximately 60,000 contracts, with 10,000 open interest.
Oct 1991	Permission received from the South African Reserve Bank for non-residents to participate on Safex via the Financial Rand system.
Jun 1992	Monthly volumes start consistently exceeding 100,000 contracts.
Oct 1992	Options-on-futures launched together with a world- class, portfolio-scanning- type margining system.
Jan 1993	Monthly volumes exceed 200,000. Open interest exceeds 100,000 contracts.
Dec 1993	Volumes exceed 1 million per month for the first time. Open interest is over 500,000 contracts.
Jan 1995	Safex Agricultural Derivatives Division opened.
May 1996	Introduction of fully-automated trading through a specifically designed system that was written in South Africa.
Jan 1997	Open interest exceeds 1 million contracts.
Mar 1998	Options introduced on agricultural products.
May 2001	Safex and JSE members agree to the buy-out of Safex by JSE Securities Exchange. Effective date of transaction to be 1 July 2001. The JSE agrees to retain the Safex branding and creates two divisions - Safex Financial Derivatives and Safex Agricultural Derivatives.

Source: Safex (2001d)

As a result of deregulation of agricultural marketing, a futures market in agricultural commodities, as shown in Table 2.11, was established by the private sector to provide producers, processors, and traders with a means to manage their price risk (Ministry of Agriculture and Land Affairs, 1998:15). The Safex Agricultural Markets Division (AMD) opened in January 1995 as a separate division of Safex with the issue of 84 seats to 60 members. In February 1996, the AMD took the decision, in consultation with its members and other interesting parties, to launch yellow and white maize futures contracts

(Gravelet-Blondin, 1997:345). Table 2.13 provides a historical summary of contracts introduced and de-listed to date.

Table 2.13: Summary of contracts introduced by Safex AMD to date

Month	Safex AMD contracts introduced
Aug 1995	Beef futures (de-listed January 1999)
Oct 1995	Potato futures (de-listed January 1999)
Mar 1996	White maize futures
	Yellow maize futures
Nov 1997	Wheat futures
Mar 1998	White maize options Yellow maize options
Aug 1998	Wheat options
Feb 1999	Sunflower futures Cape wheat futures
Aug 1999	Sunflower options
Apr 2002	Soybean futures

Source: Wiseman (1999:17); Bayley (2000:87); Safex (2002)

Bayley (2000:94) mentions a number of important factors on the supply side that facilitated the establishment of an agricultural futures market in South Africa:

1) the financial reforms of the 1980s had given rise to the emergence of more sophisticated risk management instruments,
2) as a result of Safex's financial futures markets, there existed a critical mass of expertise in the trading and the use of futures and options amongst financial institutions,
3) there was an existing physical infrastructure in place, namely the bulk grain silos, that serve as Safex delivery points and therefore play an important role in the Safex system,
4) exchange controls have been relaxed, which, together with the liberalisation of agricultural exports, facilitated the increased involvement of international trading houses in the South African market, and
5) government provided a clear, consistent, and predictable agricultural marketing policy framework, particularly after passing the Marketing of Agricultural Products Act, 1996.

Safex AMD provides a fully automated and electronic market in agricultural futures and options. According to Safex (2001b:5), contracts traded on Safex AMD are all standardised, and buyers and sellers of futures on Safex are protected in the following way:

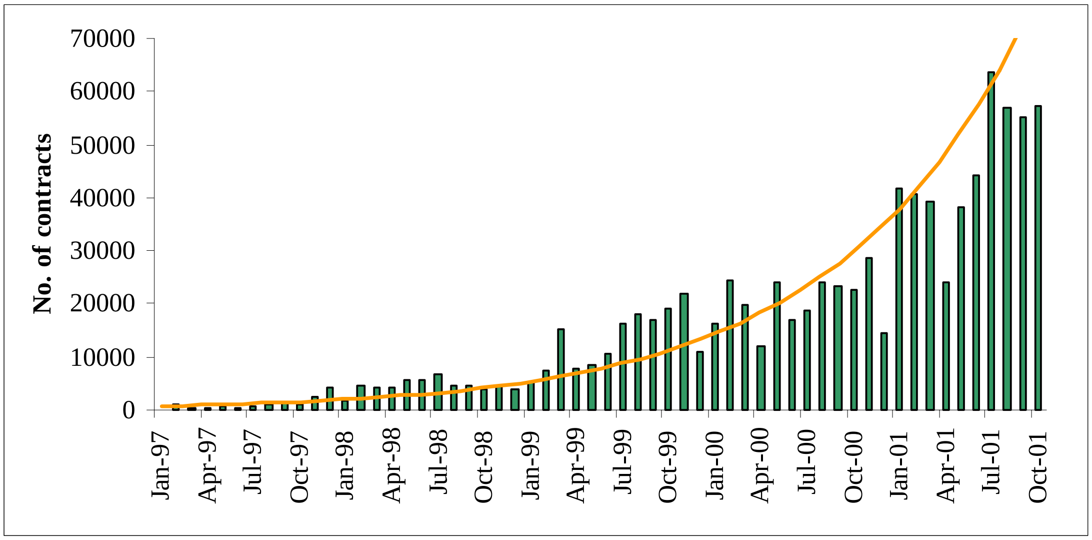
1) all futures contracts established by Safex have to be approved in terms of the Financial Markets Control Act,
2) buyers and sellers of Safex futures contracts are obliged to maintain minimum financial margins with Safex through their brokers,
3) if in the course of closing out a position an individual still owes money, the broker is obliged to cover the losses,
4) if the broker is unable to stand in for losses, then the broker's Safex clearing member (one of a number of large financial institutions) will make good the losses, and
5) if the clearing member defaults then Safex has a reserve to cover such contingencies.

Every time a contract is traded on Safex the buyers and sellers pay a small fee per tonne, which is divided between the broker, the broker's clearing member, and Safex (Safex, 2001b:3). These charges cover the cost of running Safex and the risks incurred by the various parties in the trading process. Safex AMD trades agricultural futures and options contracts five days a week Monday through Friday with trading hours from 09:00 to 12:00.

2.4.2 Growth of participation on Safex

The volume of trading on Safex has increased significantly over time since the introduction of the first maize futures contracts in March 1996. Figure 2.4 shows the monthly number of futures contracts for white maize from January 1997 to October 2001. The figure shows that only 84 contacts were traded in January 1997 while a total of 57 215 white maize futures contracts were traded during October 2001 with a record of 63 759 contracts traded on Safex during July 2001.

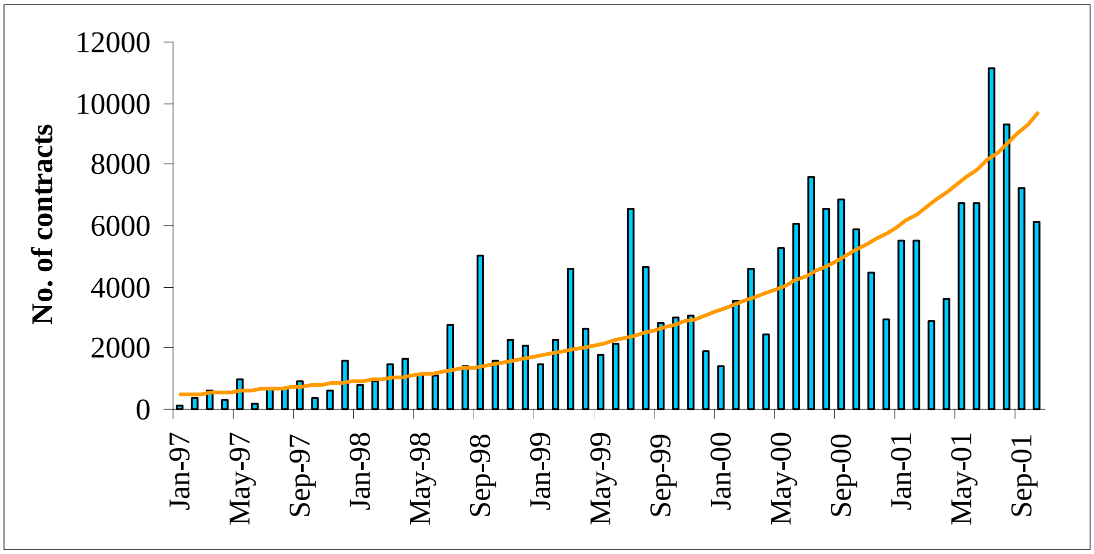
Figure 2.4: Safex white maize futures contracts traded by month (Jan 97 to Oct 01)



Source: Safex (2001e)

A very similar trend is present in the yellow maize market, although not merely as significant as white maize in terms of the actual number of contracts traded. For the months traded in 2001 (January to October), on average, white maize contributed to almost 88 percent of the total number of futures contracts traded for maize with yellow only contributing 12 percent. With 130 futures contracts traded in January 1997, a total of 6 093 contracts were traded during October 2001 with a record of 11 130 in July 2001 (Figure 2.5). Bayley (2000:88) mentioned that, already in 1999, the volumes (in terms of number of contracts) of futures and options traded for maize on Safex provided efficient liquidity for any farmer, trader, and processor who wish to manage their price risk.

Figure 2.5: Safex yellow maize futures contracts traded by month (Jan 97 to Oct 01)

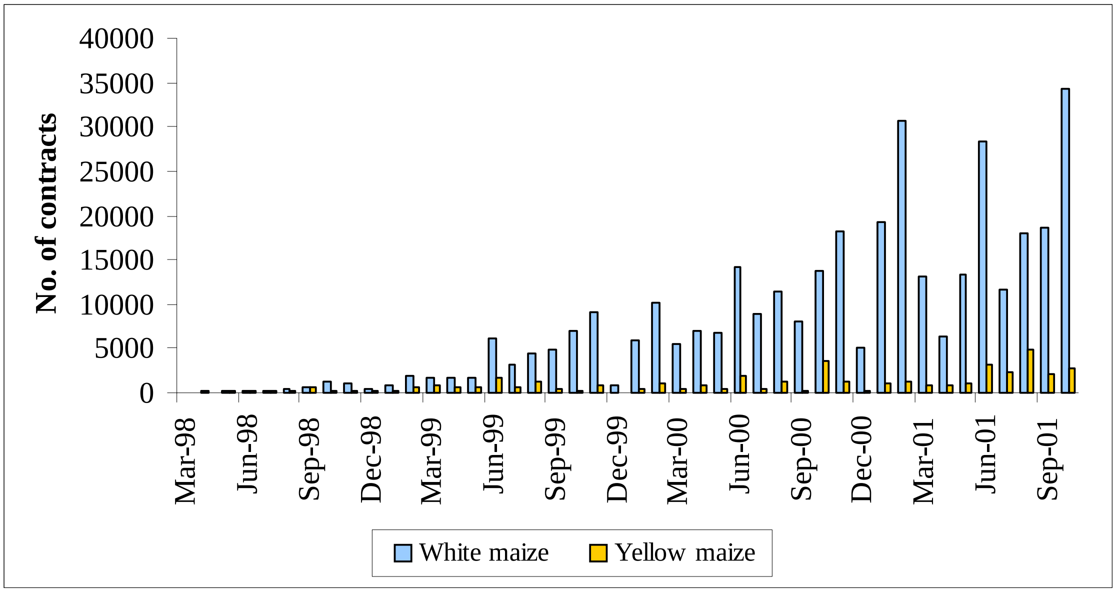


Source: Safex (2001e)

Sturgess (2001) mentioned that, by comparing the annual volume of maize traded with the actual volume produced domestically will provide a very good indication of the actual liquidity in the futures market. In the twelve months of 2000, a total of 30.3 million tons of white and yellow maize were traded on Safex, while domestic production amounted to approximately 10 million tons in the same year showing that the futures market traded an approximate 300 percent of the actual maize produced.

Volumes of options contracts have also been significant both in terms of growth and contributing to the liquidity of the maize market. White and yellow maize options has first been introduced in March 1998 and, as evident in Figure 2.6, have since shown significant growth in terms the number of contracts traded by month. 20 white maize options contracts were traded in March 1998 compared to 34 315 contracts during October 2001. Yellow maize options contracts traded increased from 62 to 2 839 over the same period. In terms of liquidity, a volume of 12.7 million tons of maize (white and yellow) were traded through Safex options contracts during the twelve months of 2000 compared to the approximate 10 million tons produced in total.

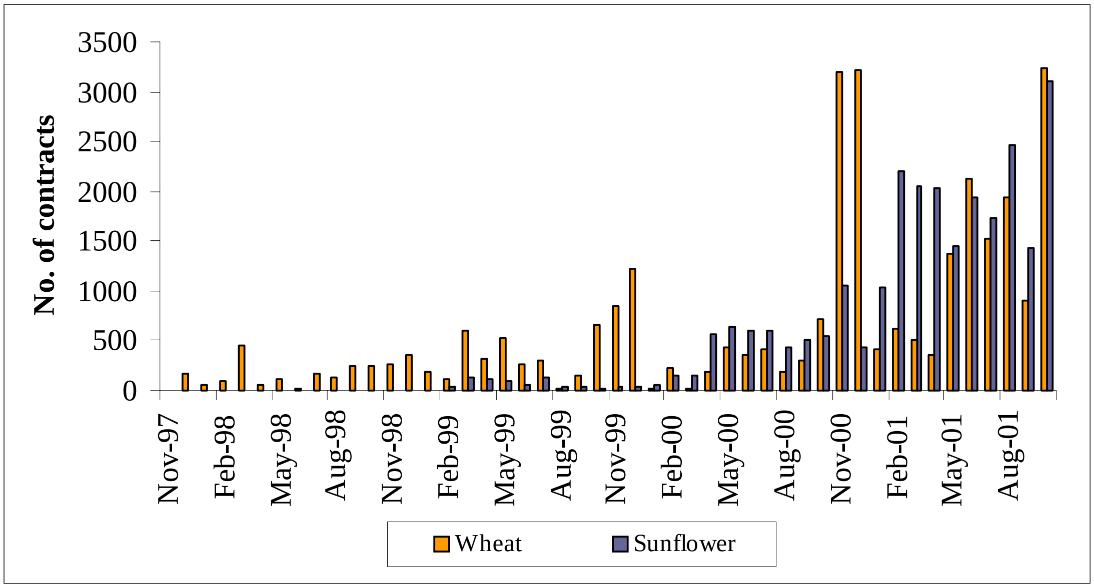
Figure 2.6: Safex white and yellow maize option contracts traded by month (Jan 97 to Oct 01)



Source: Safex (2001e)

Introduced in November 1997, volumes of wheat futures traded showed little improvement over the first three years with trading increasing significantly since November 2000. A record of 3 245 futures contracts was traded during October 2001. In addition, the number of sunflower futures contracts increased from 30 in February 1999 (when sunflower futures were first introduced), to 3 101 in October 2001 also being a record number for Safex sunflower futures. These trends are shown in Figure 2.7. Both the wheat and sunflower markets are not as liquid as the maize market which increases the risk of not finding an opposite position to a futures market transaction (Edwards and Ma, 1992:11), being either for hedging or speculation purposes. For the twelve months of 2000, the volume of wheat and sunflower seed traded on Safex through futures amounted to 463 950 and 287 050 tons respectively. Thus, only 30 percent of the total wheat crop and 51 percent of total sunflower seed produced in 2000 were traded on the exchange.

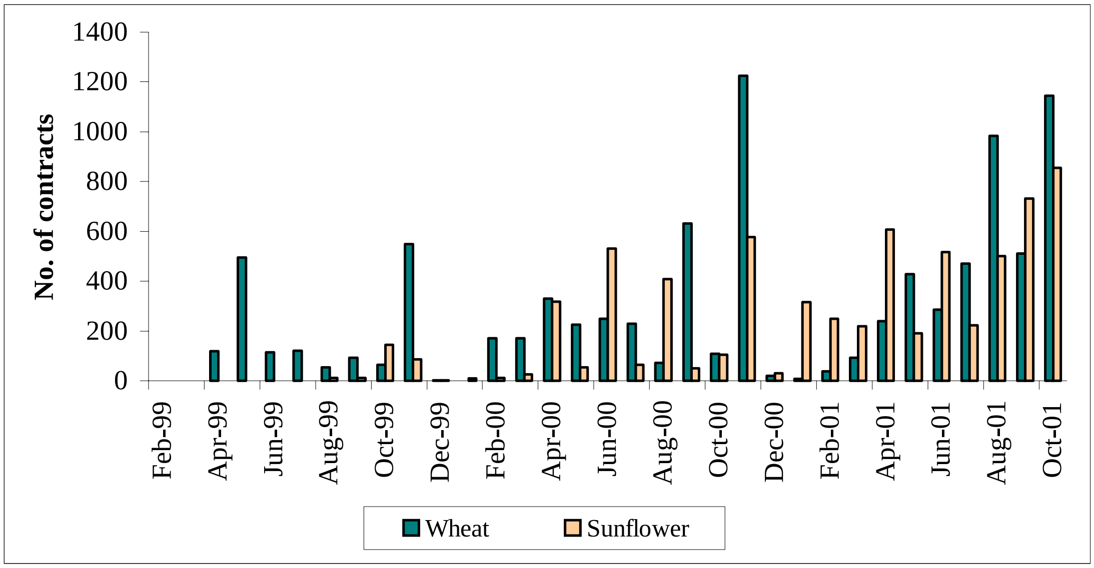
Figure 2.7: Safex wheat and sunflower futures contracts traded by month (Jan 97 to Oct 01)



Source: Safex (2001e)

Safex introduced wheat options in August 1998 during which only 12 contracts were traded in the same month. However, market participants only started to gain confidence in wheat options since April 1999 and the number of monthly contracts fluctuated in an upward trend over time to reach 1 144 contracts traded during October 2001. During the twelve months of 2000, 171 450 tons of wheat were traded through Safex options which is only approximately 11 percent of the total wheat produced domestically in 2000. Sunflower options compare very well with wheat in terms of the weak liquidity of the market. Approximately 19 percent of the total sunflower seed production in 2000 was traded on Safex in the form of option contracts. Sunflower options were introduced in August 1999 and trading volume increased gradually over time and reached a record total of 854 contracts traded in October 2001. Figure 2.8 shows the number of wheat and sunflower options contract traded on a monthly basis.

Figure 2.8: Safex wheat and sunflower option contracts traded by month (Jan 97 to Oct 01)



Source: Safex (2001e)

Since the start of the exchange, the number of broking members has grown to 61, while there are currently a total of 5 clearing members (Safex, 2003). According to Gravelet-Blondin (2003), the top 10 members are responsible for approximately 55 % to 60 % of all contracts traded on the exchange while an estimated 80 % of all transactions are executed by the top 20 broking members. Therefore, approximately 67 % of the active broking members are responsible for only 20 % of the trading volume. However, this does not necessarily equate into the open interest (Gravelet-Blondin, 2003) and this information is not published by the JSE.

2.4.3 The future of agricultural derivatives in South Africa

Van Rooyen (1999:668) reviewed the relevance of derivative instruments for maize marketing in the future. Three points are relevant for the significance of derivative instruments in the future: firstly the significance of future price risk; secondly product characteristics; and finally the future relevance of spot markets for maize and wheat in the food market. Frank (1992:318) notes the importance of price uncertainty and its direct relation with the interest in the market. In a free and deregulated market, as is currently the case, price fluctuate in an unbiased fashion and provides the necessary price risk to producers and processors to use the market as a risk management alternative. This is consistent with Van Rooyen (1999:668).

Van der Vyver and Van Zyl (1989:84) stressed the importance of liquidity as the most important factor that determines the success of a futures market. As evident from section 2.4.2, both the markets for white and yellow maize show signs of high liquidity while the wheat and sunflower markets are also improving at a fast rate. As also noted by Frank (1992:318), the trading activity and market in the future will contribute largely to the future success of Safex. In this chapter the production and marketing of two very important South African grain commodities, maize and wheat, were reviewed. This answered the question of why the South African Futures Exchange was able to emerge and how it functions within the broader perspective of maize and wheat marketing. A brief overview of the performance of the futures market over its short lifetime revealed that there is great interest from producers, apart from the dominant presence of speculators, in the advantages of using the available instruments. Chapter 3 will focus on the theory of commodity derivative markets and the functions it performs from a commodity perspective.

Chapter 3

COMMODITY DERIVATIVE MARKETS

3.1 Introduction

Many believe that derivative instruments are complex, dangerous, and used within the financial services industry to make and use vast sums of money, but that they have little relevance to the rest of the world. Whilst it is true that abuse of these instruments or their uncontrolled use can cause significant losses, it is important to appreciate from the outset that they have a vital role to play in the economy and that they are of significant assistance to real businesses in allowing them to plan and operate efficiently (Houthakker and Williamson, 1996:5). This is especially true for agricultural commodity marketing as the production processes are often complex and influenced by various factors affecting the initial quality and quantity of the underlying product (Breitenbach and Fényes, 2000:93).

The choice of derivatives is made, largely, because of their undoubted benefits but they form only one of a series of risk-management solutions. This chapter will focus mainly on the functions that futures markets perform from a seasonal commodity perspective. Seasonal commodities differ from non-seasonal commodities in that they have a strong seasonal production pattern of which grain is a typical example. In contrast, non-seasonal commodities are produced more or less throughout the year. Note that, although forwards and options are also introduced, the main focus will be on the futures contract in terms of its benefits and pricing. This is due to the fact that the empirical work will be based only on futures data. Nevertheless, options on certain grain commodities have been introduced recently to the South African market which makes the concept worth mentioning. The chapter is concluded with an overview of the operation of futures exchanges and their main function in the market.

3.2 The origin of derivative markets

Historically, the development of futures markets followed the development of forward markets (Edwards and Ma, 1992:5). Burns (1983:52) explains that futures markets develop in response to persistent needs and economic demands of market participants in cash markets. Commercial demand for contracts negotiated today for transactions to be consummated in the future (that is, contracts for future transactions) tend to generate, over time, at first forward markets and later futures markets.

Forward markets host the trading of simple forward contracts which involves an agreement initiated at one point in time and performance in accordance with the terms of the agreement occurring at a subsequent time some point in the future (Kolb, 1991:2). From the simplicity of the contract and its obvious usefulness in resolving uncertainty about the future, it is not surprising that such contracts have had a very long history. According to Kolb (1991:3) the exact origin of forward contracting is not clear. Strong evidence suggest that Roman emperors entered forward contracts to provide the masses with their supply of Egyptian grain, while others have traced the origin of forward contracts back to India and the classical Greek times. Nevertheless, forward contracts still remain an important marketing instrument today.

The Dojima rice futures market in Osaka, Japan, is commonly referred to as the world's first well-established futures market (Wakita, 2001:536; Blank *et al*, 1991:5). Trading of futures contracts on this market date back to even before 1730 and, as Wakita (2001:537) states, futures trading "literally originated in Osaka". In addition to this, Edwards and Ma (1992:4) presents evidence that organised futures markets in the US started with the opening of the Chicago Board of Trade (CBOT) in 1848 with futures contracts well-established and traded by 1860.

Futures and forward contracts are generally referred to as derivative securities, because their payoffs derive from the value of their underlying asset (commodity) (Reynolds, 1995:7). Another derivative security that has been widely traded over the past three decades is the option contract. According to Siegel and Siegel (1990:447) options on commodities have existed in different forms since 1860 for products as diverse as gold, wheat and tulip bulbs. However, the first options traded on an organised exchange were only realised in 1973, when the Chicago Board Options Exchange (CBOE) came into existence (Edwards and Ma, 1992:487).

Today futures and options markets operate around the world and trade in almost any given asset imaginable. Carlton (1984:249) and Edwards and Ma (1992:2) show that futures and options trading exploded globally since 1970 in terms of the number of contracts traded. Carlton (1984:250) attributes this to a number of reasons. The great world oil shocks of 1973 and 1979 coupled with unprecedented inflation rates and uncertain nominal and real prices; increased number of market participants and increased value of transactions; and the move towards deregulated markets where prices are determined only by market forces were all among the most important reasons for the sudden expansion.

3.3 Derivatives and risk management

Everything changes, and changes can be good or bad for those affected by them. Change therefore leads to risk, the prospect of gain or loss, and risk is something that has to be managed. Coming to terms with risk, according to Dowd (1998:3), does not mean eliminating it nor do nothing about it. Risks need to be managed by identifying them, deciding how to avoid them, and which ones to accept.

Firms face much the same problem, and their managers must decide how to deal with them. According to Reynolds (1995:28) the risks firms face can be divided broadly into the following categories:

1) *Business risks* are those risks specific to the industry and market in which the firm is operating.
2) *Market risks* are the risks of losses arising from adverse movements in market prices. Market risks, in turn, can be subdivided into interest rate risks, equity price risks, exchange rate risks, and commodity price risks, depending on the risk factor involved.

3) *Liquidity risks* arise from the cost or inconvenience of unwinding a position. A liquidity risk is borne when an asset or commodity may have to be sold on disadvantageous terms because buyers may be hard to find.
4) *Credit risks* are the risks of losses arising from a failure of a counter party to make a promised payment.
5) *Operational risks* are risks arising from the failure of internal systems or the people that operate them. Operational risks can vary from the very minor to the critical.
6) *Legal risks* arise from the prospect that a contract may not be enforced. A legal risk is borne when an agreement is entered into with another party, not knowing whether the contract will be able to be enforced if the counter party defaults.

From an agricultural commodity perspective, these risks occur on both primary (production) and secondary (processing) marketing levels. Certainly the most important of them all is commodity price risk from where the uncertainty of returns is derived. According to Breitenbach and Fényes (2000:293), agriculture’s exposure to climatic conditions renders most agricultural enterprises susceptible to large fluctuations in product price. The seasonal production of grain commodities can lead to large shifts in the supply and substantial changes in price. Wiseman (1999:5) also mention that these factors, coupled with the price inelastic nature of the demand for commodities such as maize in South Africa, further contributes to significant price variability.

Taking into account both the buyer and seller of a commodity, derivative markets offer a marketing environment through which various risks in the marketing channel can be managed (Chance, 1995:46). Different instruments are available on derivative markets, each with its own unique characteristics to suit the needs of a wide variety of market users.

3.4 Market participants

Large quantities of risk capital are attracted to the futures markets. These markets provide an efficient mechanism for bringing together those who have capital, with those who need capital. According to Fourie *et al* (1992:216), the participants in a futures market can be divided into four main groups. As already discussed, hedgers use the futures market as an instrument to manage price risk. Speculators, arbitrageurs, and investors are also common users of the futures market and each make use of it for a different purpose.

A speculator can be defined as anyone who uses the futures market for capital gain only. Speculators buy and sell futures contracts with the expectation of profiting from changes in the price of the underlying commodity (Blank *et al*, 1991:17). Speculators are confined mainly to brokers and professional traders and provide the liquidity necessary to ensure that, whenever a hedger requires a hedge position, the market is able to absorb his trade without undue disturbance to the current price. This is made possible by the fact that speculation makes out the largest portion of the utilisation of any futures market (Edwards and Ma, 1992:11). A speculator accepts the risk of adverse price changes, thereby allowing the hedger to reduce his risks at the cost of forsaking any potential profits to be gained from favourable price movements (Chance, 1995:15).

Arbitrageurs seek risk-free profits by the simultaneous purchase and sale of the same commodity in different markets (e.g. the cash market versus the futures market, or the South African Futures Exchange versus the Chicago Board of Trade) in order to profit from the price differentials that may exist between these markets (Fourie *et al*, 1992:217). This kind of action ensures guarantees that futures and cash prices will stay close together (Safex, 2001a:3). Thus if either cash or futures prices move away from a fair market value, arbitrage will tend to quickly pull prices back into line and therefore plays an integral part in the price discovery function of futures markets. Arbitrage, therefore, also guarantees that futures provide an effective hedge for cash positions (Kolb, 1991:26).

Instead of purchasing assets in the cash markets as an investment, investors may also establish synthetic cash positions in the futures market as an alternative form of investment. If futures prices were unbiased forecasts of the spot (cash) price at maturity, there will be little need to consider futures contracts as an investment (Houthakker and Williamson, 1996:280). For most commodities and financial instruments, however, there does appear to be a downward bias as suggested by the theory of normal backwardation (see section 3.7.1.1). According to this theory, if a long position (intending to buy) in futures is maintained over a long period of time, it will yield positive returns and will be a successful investment. Chance (1995:11) also mentions that storing a commodity can be a form of investment in which the investor defers selling the underlying good in the hope of obtaining a higher price at a later date. Because prices constantly fluctuate, storage entails risk and derivatives can be used to reduce the risk and set up a profitable investment.

3.5 Derivative instruments

Following Bingham and Kiesel (1998:2), derivative instruments can be grouped under three general headings: forwards and futures, options, and swaps. Having already defined a forward contract in section 3.2, it will be of no further importance to this study.

3.5.1 Futures

According to Edwards and Ma (1992:4) a futures contract is "an agreement between a seller and a buyer that calls for the seller (called the short) to deliver to the buyer (called the long) a specified quantity and grade of an identified commodity, at a fixed time in the future, and at a price agreed upon when the contract was first entered into".

Kolb (1991:18) notes that the types of futures contracts that are traded fall into four fundamentally different categories. The underlying good may be a physical commodity, a foreign currency, an interest-earning asset, or an index and, as Wiseman (1999:5) states, a futures contract is a financial instrument regardless of the category of the underlying asset. Futures contracts can only be traded on organised and designated contract markets, commonly known as commodity or futures exchanges, of which the CBOT is a good example.

3.5.2 Options

An option on a commodity is a contract giving the buyer (holder of the contract) the right, but not the obligation, to trade a given quantity for a fixed price at a future date (Elliot and Kopp, 1999:5). To acquire this right, the buyer pays a premium to the seller and, if he chooses not to exercise his right but allow the option to expire, his loss is limited to the premium paid (Edwards and Ma, 1992:490). In contrast, the potential loss to the seller of an option contract is unlimited. It is important to distinguish between, so called, American options and European options. The American option can be exercised any time prior to the expiration date at the holder's discretion, whereas the European option can only be exercised on the day of contract expiration (Edwards and Ma, 1992:503). Because of its exercise flexibility the American option is generally regarded more valuable than the European option.

Options are divided into call options, that give the buyer (holder) the right to purchase the underlying commodity or obtain a long futures position at a fixed price, and put options that give the buyer (holder) the right to sell the underlying commodity or obtain a short futures position at a specific exercise price at or prior to the option's maturity date (Bingham and Kiesel, 1998:2). Options, whether on physicals or futures, have a tremendous theoretical advantage over futures contracts in that the risk of loss, for the contract buyer is limited to the premium. The seller (writer) of the contract, however, of a call or put is not necessarily limited in this risk. The advantage seems to be overwhelming in that the hedger or speculator using options has tremendous leverage to profit from favourable price moves while having a limited financial exposure (Chance, 1995:65).

3.5.3 Swaps

As a more complex derivative instrument, swaps are briefly mentioned. A swap is an agreement whereby two parties undertake to exchange, at known dates in the future, various financial assets (or cash flows) according to a prearranged formula that depends on the value of one or more underlying assets (Bingham and Kiesel, 1998:4). Swaps can thus be thought of as portfolios of forward contracts, and the initial value as well as the final value of the swap is zero (Elliott and Kopp, 1999:5). There is now a vast range of swap contracts available, with currency swaps (exchange currencies) among the most heavily traded. However, although an important derivative instrument, swaps play no role as a marketing instrument for grain commodities.

3.5.4 Options on futures

An option on a futures contract is like other exchange-traded options except that holders acquire the right, but not the obligation, to buy or sell a futures contract on an underlying commodity, rather than the commodity itself (Dubofsky, 1992:14). Options on futures are very similar to options on physicals (standard options) and Siegel and Siegel (1990:488) explain that arbitrage with options on futures can be less costly then options on physicals. Thus, although more complicated, options on futures are very popular instruments especially for speculative purposes.

3.6 The value of futures markets

The value of futures markets arise from their ability to forecast cash prices at a specified future date and thus provide users with a means of managing the risks associated with trading in a given commodity (Kellard *et al*, 1999:414). Following Carlton (1984:238), the characteristics of futures markets and their underlying contracts have important benefits:

1) Futures contracts have standardized contract terms that make them highly uniform and well-specified. Generally the contract specifies the quantity and quality of the good as well as the delivery date and method for closing the contract. Being standardised, a futures contract improves the co-ordination and planning of the marketing process by removing uncertainty about the reliability of the other side of the trade. Bayley (2000:85) also mentions that this characteristic makes the contract more flexible.
2) Contract obligations are ensured and performance is guaranteed (Wiseman, 1999:6).
3) Futures markets attempt to lower transaction costs (Chiang and Fong, 2001:355) and generate liquidity. According to Edwards and Ma (1992:10), this stems from

the standardised terms where contracts are permitted with a limited number of delivery dates and trading is concentrated in relatively few discrete time intervals so that liquidity is enhanced.

4) Liquid futures markets provide an almost instantaneous transaction. In contrast, it may be difficult to find a buyer quickly in the cash market resulting in higher transaction costs and higher risk.

Burns (1983:62) argues that a futures market brings both direct and indirect economic benefits. The direct benefits derive from the ability to carry out transactions more efficiently, while the indirect benefits derive from the improvement in the quality of the information about the terms of transaction. Direct benefits imply the following:

1) a futures market reduces the cost of hedging and thereby promotes their use of the market,
2) lower hedging costs foster the expansion of output and facilitate the carrying of inventories by producers, users and dealers, and
3) this tends to promote functional specialisation and attendant economies of scale in such activities.

Futures market users that make use of publicly available information about futures prices experience the indirect benefits of futures markets. These include:

1) an improvement of information about future cash prices, and
2) an improvement of the efficiency and integration of related markets.

Apart from these benefits, futures markets also provide two very important social functions, namely price discovery and hedging.

3.6.1 Price discovery

Price discovery in futures markets is commonly defined as the use of futures prices to determine expectations of (future) cash market prices (Yang *et al*, 2001:280). Lapan *et al* (1991:66) also note that, through its price discovery function, futures markets help allocate resources and stabilise prices and incomes by establishing forward contracts.

Following Chiang and Fong (2001:356) and Garcia *et al* (1997:559), the futures market functions in such a way that all the available information at a specific point in time will be reflected in the current futures price. This is consistent with the efficient markets hypothesis that will be discussed in Chapter 4. However, futures markets serve a social purpose by helping people make better estimates of future prices in order to make their consumption and investment decisions more effectively. Wiseman (1999:9) also notes that the futures price strives towards being the best estimate of the future cash price at the day of contract termination and, in addition to cash markets, adds positive dimensions in competition by enlarging the sphere of price-making forces.

According to Black (1976:169), the primary benefits from commodity futures markets are informed production, storage, and processing decisions. Thus, the price discovery performance of commodity futures markets is crucial to the use of these markets. Seasonal commodities traded on futures markets can be divided into storable and non-storable commodities and, in general, commodity futures markets can perform both storage facilitation and forward pricing roles in their price discovery function (Yang *et al*, 2001:280). However, a number of authors (Fortenbery and Zapata, 1993; Brenner and Kroner, 1995; Zapata and Fortenbery, 1996) supply evidence that futures markets do not fulfil its price discovery role efficiently for non-storable commodities. This argument is consistent with futures market literature, emphasising the importance of the storage facilitation role in the price discovery of futures markets. However, in a recent study by Yang, Bessler, and Leatham (2001), evidence shows that commodity storability does, in fact, not affect the efficiency of the market's price discovery function and the usefulness of futures markets in predicting future cash prices.

The price discovery function of commodity futures market forms an integral part of this study and empirical work will primarily focus on the market's ability to discover price and reflect all the information available to the market.

3.6.2 Hedging

Hedging is the "prime social rationale" (Kolb, 1991:26) for futures trading and involves taking a position in the futures market opposite to an exposure in the cash market (Ederington, 1979:159). Hedging is traditionally viewed as a risk reduction strategy and the effectiveness of a hedge is usually judged by the ability of the futures position to reduce the variance inherent in the unhedged or cash position.

Prices in a free market typically move freely up and down in accordance to changes in the supply and demand of the underlying commodity (Gravelet-Blondin, 1997:345). In turn, this places a risk on the shoulders of potential buyers and sellers of that commodity as information about the future trend of prices do not exist in a free market and the price in the cash market, on the day of the transaction, might favour neither the buyer nor the seller. Generally, a buyer would want to procure at the lowest possible price while the seller always seeks profit in the highest price (Kohls and Uhl, 1990:126). Hedging reduces the exposure to price risk by shifting that risk to others with opposite risk profiles, or to investors who are willing to accept the risk in exchange for profit opportunities.

According to Safex (2001b:106), there are several basic reasons why participants use the futures market to hedge. These are also referred to as the primary advantages of hedging and include:

1) to protect profit margins,
2) stabilise cash flows,
3) transfer risk,
4) diversify, and
5) improve liquidity or reduce transaction costs.

While hedging with futures eliminates the risk of fluctuating prices, it also means potentially greater profits that may accrue from favourable price changes are forgone (Safex, 2001b:107). This is the price hedgers pay for not taking the risk of a cash market transaction. However, in the market there are participants who are willing to accept a risky position for the possibility of profiting from it.

3.7 Futures and options pricing

Futures and options markets help establish a publicly known, single price for a commodity (Safex, 2001a:3). Although prices in most commodities change rapidly (Kohls and Uhl, 1990:125), the interplay of buyers and sellers on a worldwide scale in an open, competitive market quickly establishes what a commodity is "worth" at any given moment. In the following sub-sections the underlying fundamentals of futures and option contract pricing will be revealed.

3.7.1 Pricing of futures contracts

According to Edwards and Ma (1992:76), the spot price is the price of a good for immediate delivery in the cash market and is also called the cash price or the current price. There is a distinct difference between spot prices and futures prices. Futures prices are quotes for delivering a designated quality and quantity of grain to a specific place at a specific time. The delivery place is set forth in the rules governing the futures contract while the delivery time consists of certain designated days during the delivery month. It follows that grain delivered to a different place or at a different time is likely to have a different price. Such differences are due primarily to transportation and storage costs (Chance, 1995:56).

Following Fourie *et al* (1992:207), the price of a futures contract can be divided into three main elements, namely:

1) the spot price of the underlying commodity,
2) the cost of carry, including storage, insurance, transportation, and financing costs, and

3) the cash flow, if any, generated by the underlying commodity.

Kolb (1991:95) notes that a mathematical notation for the price of a futures contract can be given as:

$$F_{0,t} = S_0(1+C) \tag{3.1}$$

where $F_{0,t}$ is the futures price at $t=0$ for delivery (expiration) at time t, S_0 is the spot price at $t=0$, and C is the cost of carry, expressed as a fraction of the spot price, necessary to carry the physical commodity forward from the present to the date of delivery. Thus, if the market succeeds in its price discovery function, the difference between the spot price and the futures price at any given point in time [also referred to as the basis (Kolb, 1991:83)] will simply be the cost of carry (*C*) (Edwards and Ma, 1992:77). According to Brenner and Kroner (1995:26), if the futures price at any given point in time is either greater or smaller than the underlying price in the spot market plus the cost of carry, it produces opportunity for profitable arbitrage.

$$Basis_{t,T} = cash\ price_t - futures\ price_{t,T} \tag{3.2}$$

The basis, as given by Kolb (1991:83) through Equation 3.2, will tend to be large at a point in time distant to contract maturity (contract expiration) and will decrease as the contract matures where the futures price and the underlying price in the cash market will only be equal on the day of contract maturity. The basis consists of two main components: differences in location, reflected in transport costs, and differences in time, reflected in storage costs (Safex, 2001c:111).

Price volatility is also an important concept in the pricing process of futures contracts. Price volatility is defined by Kolb (1991:7) as a measurement of the variance of price changes over time. A price that shows large fluctuations implies volatility and is typical when more information becomes available to the market. According to Houthakker and Williamson (1996:266), futures prices become more volatile as they get closer to maturity because of better information flow of the possible cash market price at the day of contract expiry. Price volatility is experienced in any futures market and Wiseman (1999:8) states that the objective of a futures market is "not to curb price swings" but only to "secure a price for a commodity in advance".

3.7.1.1 Normal backwardation

Backwardation is commonly used to refer to a market in which the futures price is less than the cash price and implies that the basis, as in Equation 3.2, is positive (Edwards and Ma, 1992:87). This condition can occur only if futures prices are determined by considerations other than cost-of-carry factors. If the basis is negative, cost-of-carry factors determine the futures-cash price relationship and the market is then referred to as a contango market (Fourie *et al*, 1992:207). According to Chance (1995:58), futures prices should rise over the life time of a futures contract mainly because hedgers generally tend to be net short (selling) and pay the speculators to assume risk by holding long (buying) positions. This phenomenon is known as the theory of normal backwardation and explains a common trend in futures contract prices over time.

3.7.1.2 Seasonality

Many commodities on which futures contracts are traded have a strong seasonal pattern in production (and sometimes in consumption as well) that adds an additional complication to the analysis of futures prices. As new supplies come onto the market during harvest, spot prices begins to fall and beyond some point are expected to rise over the remainder of the year, reflecting the cost of storing the commodity (Safex, 2001a:2). However, according to Houthakker and Williamson (1996:266), the seasonality of a specific grain commodity has no effect on the price behaviour of a specific futures contract, which is determined instead by the supply and demand, which has no constant trend from year to year, and hence the spot price is expected to prevail. On the other hand, Siegel and Siegel (1990:421) show that seasonality has important effects on the relationship between the prices of futures contracts with different maturities and on the behaviour of the basis over time. Seasonal commodities, like grain crops, shift between a backwardation and contango market over the seasonal cycle which implies shifts between a negative and positive basis.

Such a shift usually takes place on the day of contract maturity when the basis is zero because the spot and futures price is equal.

3.7.2 Pricing of option contracts

Following Falkena *et al* (1989:6) and Thomsett (1993:56) the price (or premium) of an option can be divided into two parts: the intrinsic value, and the time value.

The intrinsic value is the amount that the buyer would recover if he exercised the option immediately, which in the case of many options may be zero. According to this criterion option positions are classified into three categories depending on the relation between the exercise price (strike price) and the current market price of the commodity:

1) *in-the-money*, referring to those options that have intrinsic value. For instance, a call option with a strike price lower than the current spot price,
2) *at-the-money*, for example, those options with a strike price equal to or “at” the current spot price, and
3) *out-of-the-money*, referring to those options that have no intrinsic value. In this case the strike price of a call option would be higher than the current spot price.

In addition to the intrinsic value, the time value portion of the premium is the amount that the buyer pays in excess of the intrinsic value (Siegel and Siegel, 1990:468). The amount of time value depends on the time remaining until expiration where, at the day of expiration, the time value must be zero. According to Falkena *et al* (1989:7), the shorter the time to expiration, the less the time value (assuming all other factors remain unchanged) because the chances of the commodity price changing materially before the expiration date become less. Apart from the time to expiration, Safex (2001c:114) also notes that the time value of an option is affected by:

1) the volatility of the market,
2) supply and demand of options in general, and
3) the relationship between the underlying futures price and the option’s strike price.

The time value does not erode on a straight-line basis. Chance (1995:102) shows that the time value decreases much more rapidly during the last few weeks of an option's life as the chances of a material price change diminish progressively. In contrast, at the beginning of a long-term option's life (three months or longer) the effect of time erosion is minimal and only starts to decline significantly during the last four to six weeks.

3.7.2.1 Fundamental pricing determinants

Following Edwards and Ma (1992:528), the value of the underlying commodity at the option's expiration date depends on two variables: the asset price at expiration, and the option's strike price. However, prior to expiration the value of an option depends upon the following variables:

1) the current value of the underlying commodity (S),
2) the option's strike price (K),
3) the anticipated volatility of the price of the underlying commodity (σ),
4) the time remaining until the option expires (t), and
5) the current level of the risk-free interest rate (r).

These variables comprise the general option pricing model and affect both put and call values, although in an exactly opposite way. A more formal and widely used model is presented in the following section.

3.7.2.2 The Black-Scholes model

The breakthrough in option pricing theory came with the work of Fischer Black and Myron Scholes in 1973 with a model designed to price European call options on non-dividend paying stocks (Siegel and Siegel, 1990:472). This meant that options prices no longer had to be based on predictions and subjective methods, but could instead be based on measurable figures. The basic concept behind the model is that of covering the option with a related position in the underlying share in order to create a risk-free portfolio (Nathanson, 2000:13).

The Black-Scholes (B-S) model, similar to the general pricing model, requires only five inputs: the current commodity price, the option's strike price, the risk-free rate of interest, the option's time to expiration, and the expected volatility of the commodity's return. The volatility is the standard deviation of the rate of change of the commodity price over the period until the option expires. Following Kolb (1998:29) the B-S formula is given as:

$$C = SN(d_1) - K\, exp^{-rt}\, N(d_2) \tag{3.3}$$

with

$$d_1 = \frac{\ln(S / K \exp^{-rt})}{\sigma\sqrt{t}} + 0.5\sigma\sqrt{t} \tag{3.4}$$

and

$$d_2 = d_1 - \sigma\sqrt{t} \tag{3.5}$$

where S, K, r, σ, and t are as previously defined in section 3.7.2.1, C is the current market value of the call option (premium), *ln* is the natural logarithm, and N is the cumulative probability distribution function for a standardised normal variable. According to Kolb (1998:30) the value of the option increases with increases in the commodity's price, the interest rate, the time remaining to expiration, and the commodity's volatility. Although the equations seem complicated, they are easy to use and effective in determining the value of a call option at a given point in time.

Nathanson (2000:26) mentions that a number of problems with the B-S model originate from the assumption that the market is efficient. Arguments that the model is the best pricing method, despite these problems, are also rather weak. However, the model proved itself over time and is widely used today as probably the most reliable option pricing estimator.

3.8 The futures exchange

Commodity derivatives are basically traded in two ways: on organised exchanges and over-the-counter (OTC). Organised exchanges are subject to regulatory rules, require a certain degree of standardisation of the traded instruments (strike price, maturity dates, size of contract, etc.) and have a physical location at which trade takes place (Bingham and Kiesel, 1998:6). According to Wiseman (1999:9), the basic functions of a futures exchange include the following:

1) underlying commodities are delivered through a clearing system, and the clearing house guarantees the fulfilment of contracts entered into by clearing members,
2) actual delivery against futures contracts tends to be rare,
3) liquidity has to be very high for a futures contract or such a contract tends to be discontinued,
4) trading costs tend to be low; the standardised nature of the futures contract lowers the transaction and information cost,
5) all futures contract prices are publicly disclosed, and
6) profits and losses have to be settled on a daily basis.

The exchange is a voluntary, non-profit association of its members. Exchange memberships, called seats, may be held only by individuals, and these memberships are traded in an active market like other assets (Kolb, 1991:4). Rothstein (1984:27) mentions that exchange members have a right to trade on the exchange and to have a voice in the exchange’s operation. Members also serve on committees to regulate the exchange’s operations, rules, audit functions, public relations, and legal and ethical conduct of members.

To ensure that futures markets trade in a smoothly functioning market, each futures exchange has an associated clearinghouse. According to Baer *et al* (1996:26) the clearinghouse may be constituted as a separate corporation or it may be part of the futures exchange, but each exchange is closely associated with a particular clearing house.

3.8.1 The clearing house

Clearing houses are key institutions in futures markets. They are the "institutional bedrock foundation" upon which futures markets are built (Kolb, 1991:53). Because every futures transaction involves both a buyer and a seller, it therefore follows that some method must be available to match each purchase with its corresponding sale. When a trade is registered, the clearing house becomes the opposite party to every trade making it directly responsible to clearing members. Thus, according to Rothstein (1984:23), either as a part or in connection with each futures exchange there is a clearing organisation which performs the three primary functions of:

1) matching buy and sell trades,
2) assuring the financial integrity of the contracts traded, and
3) providing the necessary mechanism for delivery.

Futures clearing houses also allow its members to exploit a variety of other economies of scale accessible only by acting as a group. Baer *et al* (1996:26) state that a centralized clearing house simplifies recordkeeping, since members need only keep track of their net positions with the clearing house. Credit monitoring and control is also simplified, since a member's financial standing need only to be assessed once by the clearing house, rather than separately by each trading partner.

In addition to the clearing house, there are other safeguards for the futures market of which the requirements for margin and daily settlement are the most important.

3.8.2 Margin and daily settlement

Before trading a futures contract, the prospective trader must deposit funds, known as a margin, with a broker who uses it to ensure that the individual can make good on his or her losses. Exchanges set minimum margins, but a broker may require larger margins if they are concerned about an individual's financial situation, for they are ultimately responsible for their clients' losses (Edwards and Ma, 1992:38). Siegel and Siegel (1990:23) show that the margin account is used to settle the day-to-day changes in a futures position. Because of the inconvenience for the individual to settle the margin on a daily basis, the broker usually adds to the margin account when futures prices move favourably for a client and subtracts from the margin account when price move against the client.

Reynolds (1995:185) distinguishes between two types of margins: the initial margin and the maintenance margin. The initial margin, approximately 5 per cent or less of the underlying commodity’s value (Kolb, 1991:11), is the original amount that must be deposited into an account to establish a futures position. Siegel and Siegel (1990:23) note that, if it appears that the volatility of the market increases, the exchange typically will increase the size of the initial margin, while the margin usually decreases with a more steady market. In addition to the initial margin, the maintenance margin is the minimum amount that can be kept in a margin account and is generally about 75 per cent of the initial margin. If prices move against a client so that the margin falls below the maintenance margin, the broker will make a margin call and ask the client to replenish the margin account, often to the level of the initial margin. Kolb (1991:11) refers to this as the variation margin and regards it as a third type of margin.

While the clearing house has no direct involvement with the members’ clients and their part of daily cash settlement, it plays the crucial role of settling the price of futures contracts on a daily basis (Rothstein, 1984:30). The system of daily settlement in futures markets is called marking to market and is carried out through the futures clearing house. Shortly after the close of trading every day, the clearing house publishes a settlement price for each delivery month of each futures contract traded during that time. Edwards and Ma (1992:64) mention that, following the publication of settlement prices, all futures transactions, purchases and sales, executed on that day are adjusted to the settlement price and are subsequently considered, for clearing purposes only, to have been made at that price. This emphasises the crucial role the clearing house plays, by taking the opposite position to each individual in a specific trade, to ensure financial security and integrity of each transaction taking place on the futures exchange.

This chapter comprised a brief overview of futures market instruments and their functioning as these are also typical of the South African futures market for agricultural commodities. Chapter 4 will mainly focus on the efficiency of commodity futures markets and places emphasis on the efficient markets hypothesis and the relevant methodology for the testing of market efficiency.

Chapter 4

FUTURES MARKET EFFICIENCY

4.1 Introduction

In stock markets all over the world, traders daily seek profit by buying stocks at a certain value and selling it after a favourable change in price. Price movements are carefully observed and the smallest anticipated movement can result in either a profit gain or loss situation (Edwards and Ma, 1992:13). Prices of stocks are determined by supply and demand and, according to Parkin (1996:413), supply and demand is dominated by one thing: the expected future price.

Kohls and Uhl (1990:275) state that a key function of market information is to improve decision-making. A market in which the actual price embodies all currently available information is called an efficient market (Parkin, 1996:413; Baumol and Blinder, 1988:646). Parkin (1990:145) refers to this as a "rational expectation" of the future price and it is this expectation that motivate traders to make profitable buying or selling decisions in the stock market.

According to Parkin (1990:145) an efficient market has two main features:

1. its price equals the expected future price and embodies all the available information; and
2. there are no predictable profit opportunities available.

Baumol and Blinder (1988:646) note that there is an apparent paradox about efficient markets. Markets are efficient because traders try to make a profit, but the very act of buying and selling to make a profit means that the market price moves to equal its expected future value. Having done that, according to Parkin (1996:414), no trader, not even those who are seeking a profit, can predictably make a profit. Every profit opportunity seen by traders leads to an action that produces a price change that removes the profit opportunity for others.

The aim of this chapter is to define the concept of futures market efficiency and its importance to the overall efficient functioning of commodity futures markets. In attempting to do this, emphasis will be placed on the literature regarding market efficiency, the efficient markets hypothesis (EMH), and the related methodology used to evaluate the efficiency of a futures market. The statistical methodology reviewed in this chapter will be used in the empirical analysis compiled in Chapter 5.

4.2 The importance of market information

An individual who possesses private information about the future value of an asset will want to trade on that knowledge if he expects to profit by doing so (Ng, 1987:252). Just (1983:877) showed that, if futures markets are efficient, they can be useful instruments in transmitting information to commercial decision makers. Rausser and Carter (1983:470) note that an increasing number of theoretical models assume *a priori* that futures markets are efficient. Danthine (1978:80) and Rausser and Carter (1983:470) also demonstrated that, in an efficient futures market, the relevant price signal to be used by producers is simply the futures price. Wiseman *et al* (1999:322) mention that the key feature of well-functioning futures markets is their ability to predict prices at a specified future date both efficiently and in an unbiased fashion.

Over the years, various well-known researchers have defined the concept of futures market efficiency. Fama (1970:384), LeRoy (1989:1592), Zulauf and Irwin (1997:1; 1998:309), Barnett and Serletis (2000:704), and Danthine (1977:2) all state that an efficient market is one that accurately incorporates all known information in determining price and that prices always reflect all available information. According to Fama (1970:387), this characteristic would result from an ideal world in which:

a) there are no transaction costs,
b) all relevant information is costless and available to all market participants, and
c) all agree on the implications of current information for the current price and the distributions of the future prices.

Sabuhoro and Larue (1997:172) mention that there are three widely used definitions for futures market efficiency. According to Barnett and Serletis (2000:705) Fama (1970:388) refer to this as three "types" of informational market efficiency. These are the weak form, the semi-strong form, and the strong from of efficiency. The weak form of efficiency stipulates that the current commodity price incorporates all the information contained in price time series. According to LeRoy (1989:1592) this implies that no trading rule based on historical prices alone can succeed on average. Kolb and Hamada (1988:88) state that if the weak-form version of efficiency is true, then no information about past or present prices is useful for guiding a speculative trading strategy. In this regard, the information set typically includes past and present commodity prices, price of storage and volume.

In claiming that all public information is fully reflected in futures prices, the semi-strong version asserts that analysis of any public information is worthless for directing a speculative trading strategy (Kolb and Hamada, 1988:88). Public information typically includes information on crop size, livestock inventories, grain exports, weather reports and a host of other statistics provided to commodity market participants and it is traditionally argued that such information is crucial to the efficient functioning of commodity futures markets (Garcia *et al*, 1997:559). If the semi-strong hypothesis is true, then analysts researching information such as the above in order to predict the trend in future price is a waste of time and commodity futures market that is semi-strong efficient would already reflect all this information in its current price.

In recent years the value of public commodity information has been challenged and it is argued that private information services can substitute for public programs (Just, 1983:877). Negative evidence regarding the value of public commodity information has recently been reported in a study by Fortenbury and Sumner (1993) in which they came to the conclusion that corn and soybean futures did not react to the release of U.S. Department of Agriculture crop production forecasts after 1984. This can be greatly attributed to the fact that private sector production and dissemination of commodity information has increased rapidly since the late 1970s (Fortenbury and Sumner, 1993:170), and imply that the market only reacts on the release of private information and has certain implications on the value of the weak- and semi-strong type of market efficiency. However, in a more recent study, Garcia *et al* (1997:569) provided empirical evidence that commodity prices do in fact react on the release of public information. Evidence also confirms that the USDA crop forecasts reduce the uncertainty of market participants' expectation of prices.

The most extreme version of the efficient market hypothesis is known as the strong form of efficiency. According to Kolb and Hamada (1988:89), the strong version of the hypothesis states that prices in the futures market fully reflect all information, whether public or private. Private information includes information not regularly available to the rest of the market (insider information) and only market participants in privileged positions might be able to obtain such information. If the strong version of the market hypothesis is true, then private information would also be useless for earning speculative profits. Evidence (Kolb and Hamada, 1988:89), however, supports the conclusion that markets in general, and futures markets in particular, are not efficient in the strong sense and futures markets do not reflect all public and private information.

4.3 The efficient markets hypothesis (EMH)

Fama's (1970:385) definition of an efficient futures market came to be known as the efficient market hypothesis (EMH) (LeRoy, 1989:1592; Zulauf and Irwin, 1998:309). Fama (1970:388) stated that an efficient market is one that accurately incorporates all known information in determining price (Zulauf and Irwin, 1997:2). In a more descriptive definition Barnett and Serletis (2000:703) note that the hypothesis claims that asset prices are rationally related to economic realities and always incorporate all the information available to the market.

In asset-market models, the hypothesis of efficiency is equivalent to the hypotheses that agents are risk neutral, so that the risk premium is zero, and that the agents use all available information rationally so that the expected returns to speculation are zero. If both parts of the efficient markets hypothesis hold, then the current futures price is an unbiased predictor of the future spot price (Serletis and Banack, 1990:373).

Barnett and Serletis (2000:705), however, warn that futures market efficiency should not be confused with allocative efficiency, better known as "Pareto optimality". Striving towards Pareto optimality would imply changes in the combination of goods produced or in the combination of inputs used in such a matter that the changes benefit some people without anyone else being worse off (Sloman, 1991:316). Thus, allocative efficiency concerns the relative quantities of the different commodities to be produced (Lipsey *et al*, 1990:293), while futures market efficiency involves the market's ability to reflect all available information and is known as the intertemporal allocation of recources (Sabuhoro and Larue, 1997:172).

The EMH also implies the absence of exploitable excess profit opportunities (Chowdhury, 1991:577; Wiseman *et al*, 1999:322; Barnett and Serletis, 2000:704) because the market will, according to the hypothesis, adjust instantaneously to all new information. However, Zulauf and Irwin (1998:310) show that profitable returns can occur due to the cost of acquiring and analysing information. As noted earlier, Fama (1970:388) assumed no transaction costs, costless information, and that the implications of current information for both current price and the distributions of future prices are generally accepted by all market participants. Zulauf and Irwin (1998:310) state that at least two of the assumptions are unrealistic. First, transaction costs do exist (such as brokerage fees), and secondly information is costly to acquire.

Transaction and information costs introduce a potential for profitable trading as profit can be earned by using information and analysis to take a position in anticipation of price changes that will occur as the rest of the market learns about the information (Zulauf and Irwin, 1997:4). Kellard *et al* (1999:414) mention the existence of market inefficiencies in the sense that information from the past can be used by agents to predict spot price movements. In fact, to “beat the market” (Edwards and Ma, 1992:11) in terms of future price estimations is the priority of every futures market analyst participating in the market.

Although considerable disagreement exists about the degree to which the EMH holds, it has become the dominant paradigm used by economists to understand and investigate the behaviour of financial and commodity markets (LeRoy, 1989:1593). Zulauf and Irwin (1998:309; 1997:2) and Danthine (1977:2) provide an equation for the simple discussion of the major concepts underlying the EMH:

$$P_{t+1} = \alpha + \beta P_t + \varepsilon_t \tag{4.1}$$

where, P_{t+1} is the price at time $t+1$, P_t is the current price at time t, α and β are parameters, and ε_t is a random error term that is independently and identically distributed with mean 0 and constant variance σ^2. To aid in understanding the EMH, Zulauf and Irwin (1997:2; 1998:309) rearrange Equation (4.1) as follows:

$$P_{t+1} - \beta P_t = \alpha + \varepsilon_t \tag{4.2}$$

Wiseman *et al* (1999:371) note that, if α and β are respectively not significantly different from 0 and 1, the futures price is an unbiased predictor of the spot price. Now assume the intercept term $\alpha = 0$, and the slope $\beta = 1$, then

$$P_{t+1} - P_t = \varepsilon_t \tag{4.3}$$

Finally, taking the expectation of Equation (4.3) yields

$$\mathrm{E}_t(P_{t+1} - P_t) = 0 \tag{4.4}$$

Equation (4.4) shows that the expected difference between price at time *t+1* and the price at time *t* is equal to zero. In other words, the expected price at time *t+1* (spot price) is equal to the price at time *t* (futures price) and that P_t is an estimate of P_{t+1}. According to Zulauf and Irwin (1998:309) this price process is usually referred to as a random walk. At this stage it may be necessary to point out the importance of the random walk characteristic of futures prices and the importance of this concept to efficient futures market functioning.

4.4 The random walk and martingale hypotheses

The ”random walk hypothesis”, forerunner of the efficient capital markets model, was inaugurated with a major statistical study by M.G. Kendall (1953) which examined the proposition that stock prices follow a random walk (LeRoy, 1989:1587; Barnett and Serletis, 2000:705). A commonly used analogy of a random walk is the flipping of a fair coin (Zulauf and Irwin, 1998:309) implying that prices move freely and unbiasedly over time in the fashion of a “fair game”. Fama (1970:386) explains that in the early use of the efficient markets model, the statement that the current price of a security “fully reflects” all the available information was assumed to imply that successive price changes are independent. In addition, it was usually assumed that successive price changes are identically distributed.

According to Freund (1992:66), two events are independent if the occurrence or non-occurrence of either one does not affect the probability of the occurrence of the other. If two events are identically distributed it would imply that they have identical distributions and density functions and that the one has exactly the same probability to change as the other (Thomas, 1997:40), although they are not independent. Together the two hypotheses constitute the random walk model (Fama, 1970:386) and prices will only follow a random walk if price changes are both independent and identically distributed (Nelson and Plosser, 1982:141; Johnston and DiNardo, 1997:59).

The random walk process of commodity futures also implies that prices have a unit root, which plays a crucial role in testing the unbiasedness of futures prices (Pan *et al*, 1997:2). The equation

$$X_t = \alpha + \beta X_{t-1} + u_t \tag{4.5}$$

is said to have a unit root if $\beta = 1$ (Johnston and DiNardo, 1997:59), and Equation (4.5) becomes:

$$X_t = \alpha + X_{t-1} + u_t \tag{4.6}$$

which is called a "random walk with drift". When $\alpha = 0$, Equation (4.6) reduces to a simple random walk and implies that today's price is the same as yesterday's price plus the error term u_t which is independent and identically distributed. In addition, Pan *et al* (1997:2) argue that futures prices in an efficient market follow a martingale process that implies that the futures price is an unbiased predictor of the future spot price. The market efficiency hypothesis has been frequently associated with a martingale property describing changes in asset prices (Danthine, 1977:1). Standard asset pricing models typically imply the "martingale model", according to which tomorrow's price is expected to be the same as today's price (Barnett and Serletis, 2000:704). As Fama (1970:387) pointed out, however, the martingale model is based on two hypotheses: (1) the efficient utilisation of information, and (2) the possibility of expressing market equilibrium in terms of expected returns. Tests of market efficiency thus are simultaneous tests of these two hypotheses (Danthine, 1977:1).

The martingale model has been described by a number of researchers over the years (LeRoy, 1989:1585). In order to formulate this model, consider a sequence of random variables, X_1, X_2, X_3, X_4,…, where the subscripts refer to successive time periods, each such variable has its own probability distribution and together they make up what is known as a stochastic process (Thomas, 1997:373; Johnston and DiNardo, 1997:17).

Barnett and Serletis (2000:704) and LeRoy (1989:1589) show that, symbolically, a stochastic process x_t follows a martingale if

$$E_t(x_{t+1}|\Omega_t) = x_t \tag{4.7}$$

where Ω_t is the time t information set – assumed to include x_t. The equation states that the expected value of stochastic process x_{t+1} (tomorrow's price), given the time t information set, is equal to the value of the stochastic process x_t (today's price). In other words, according to Equation (4.7), if x_t follows a martingale, the best forecast of x_{t+1} that could be constructed based on current information Ω_t would just equal x_t (Barnett and Serletis, 2000:704).

Equation (4.7) can also be rewritten in the sense that the conditional expected value (Freund, 1992:178) of the difference between tomorrow's price (x_{t+1}) and today's price (x_t), given information set Ω_t, is equal to zero and implies that on average these two prices are the same:

$$E_t[(x_{t+1} - x_t)|\Omega_t] = 0. \tag{4.8}$$

Barnett and Serletis (2000:705) and Danthine (1977:4) refer to Equation (4.8) as the "fair game model" and the model says that increments in value (changes in price) are unpredictable and conditional on the information set Ω_t. In this sense, information Ω_t is fully reflected in prices and hence useless in predicting rates of return, which in turn perfectly agrees with the definition of the efficient market hypothesis. In a study by Rausser and Carter (1983), however, the authors revealed considerable evidence that the martingale property, or the search for martingales in commodity futures markets has no direct implications for market efficiency. "The Martingale property is neither a necessary nor sufficient condition for efficiency" (Rausser and Carter, 1983:469).

The search for random walks or martingale processes originated using the weak-form test for market efficiency (Fama, 1970:386). The main difference between the two models is that the martingale is less restrictive than the random walk. The martingale model requires only independence of the conditional expectation of price changes from the available information, whereas the random walk model requires this and also independence involving higher conditional moments of the probability distribution of price changes (LeRoy, 1989:1585; Barnett and Serletis, 2000:705). Nevertheless, these two models are both of great importance to the efficient markets hypothesis and also play an important role in the process of testing for futures market efficiency.

4.5 Market efficiency, co-integration and bias

Although not as fully explored as the stock market, commodity futures markets have received considerable attention (Kolb and Hamada, 1988:87). Most of these efficiency studies attempt to determine whether prices in the futures market fully reflect all the information contained in a given information set. This means that market critics can develop alternative versions of efficiency by specifying alternative information sets.

Testing for futures market efficiency has involved numerous methodologies and techniques used by different researchers over the years. Empirical evidence to date is mixed; for any given market, some studies find evidence of inefficiency, others of efficiency (Rausser and Carter, 1983:469; Kellard *et al*, 1999:413). In part, these apparently conflicting findings reflect differences in the time periods analysed (Kellard *et al*, 1999:413), the methods chosen for testing, and comparing results over a large variety of commodities (LeRoy, 1989:1592). Kellard *et al* (1999:413) also mention that the limitation of existing tests to classify markets as either efficient or inefficient without assessment of the degree to which efficiency is present, further contributes to the controversy surrounding test results.

As mentioned earlier, Fama (1970:389) and Sabuhoro and Larue (1997:172) distinguish between three types of informational market efficiency, namely the weak, semi-strong, and strong type of efficiency. Chowdhury (1991:578) explains that several studies test for market efficiency using either the weak or semi-strong form of tests. The weak form test involves regressing cash price at contract maturity (the day of contract termination) on a previous futures price and this technique has widely been used by a number of researchers (Rausser and Carter, 1983; Elam and Dixon, 1988; Maberly, 1985). Wiseman *et al* (1999:323) and Elam and Dixon (1988:365) define this method using the following equation:

$$Sp_t = \alpha + \beta Fp_{t-1} + u_t \tag{4.9}$$

where Sp_t is the spot price at time t (contract maturity), Fp_{t-1} is the futures price at time $t\text{-}1$ for the futures contract maturing at time t, and u_t is a random error term with mean zero and variance σ^2 (James and Throsby, 1973:276). The hypothesis that the market is efficient is formalised by the null hypothesis $H_0\text{: } \alpha = 0$ and $H_0\text{: } \beta = 1$, against alternate hypotheses (Maberly, 1985:425). If the intercept coefficient (α) is zero and the slope (β) is one, the market is regarded as efficient and the futures price is considered to be an unbiased predictor of the subsequent cash price (Elam and Dixon, 1988:365; Chowdhury, 1991:578). Chowdhury (1991:578), however, criticises this test on the ground that the coefficient estimates are based on the *ex post* knowledge of the data that is not available to the agents in the market forecasting *ex ante*.

The semi-strong test for market efficiency focuses on whether futures prices fully reflect all publicly available information at the time of contracting. This is a stronger form of test for informational efficiency as it assesses the efficient use of additional publicly available information by the market (Neal, 1988:79). Chowdhury (1991:578) states that in this case, an econometric model is employed to compare the forecast error of the model with that of futures price. Results, using this form of testing, are contradictory and show weak support to the efficient markets hypothesis.

Apart from the different types of informational efficiency, as mentioned in this section, testing does not necessarily involve a single commodity from a specific market. Literature generally distinguishes between intertemporal and cross-sectional efficiency of futures markets. Intertemporal efficiency focuses on the relationship between the futures and spot prices of a single commodity (Lai and Lai, 1991:568) and if the futures price is an unbiased predictor of the futures spot price over time. Testing for cross-sectional efficiency, according to Yang and Leatham (1998:107) and Chu (1992:298), examines the question of whether it is possible to profit by trading across commodity markets involving different commodities from different markets. Yang and Leatham (1998:108) note that the latter has two advantages over co-integration tests on intertemporal market efficiency. First, it can be applied to either the futures or the spot market to provide evidence of market efficiency. In contrast, co-integration tests on intertemporal price relationships only test futures market efficiency. Second, the test can show the efficiency or inefficiency of several markets at one time. In this study, both approaches will be applied to the four different commodities under consideration traded on the South African Futures Exchange.

4.5.1 Stationarity

Many economic time series are characterised by a stochastic trend model (Serletis and Banack, 1990:373). In particular, Nelson and Plosser (1982:142) described this property as one of being "difference stationary" – stationary in the first difference. An alternative "trend stationary" model, where a stationary component is added to a deterministic trend term (Johnston and DiNardo, 1997:220), has generally been found to be less appropriate (Nelson and Plosser, 1982:143).

Related to the issue of non-stationarity is the concept of co-integration. Conventional regression analysis, used for testing the weak form of efficiency, is generally inappropriate because the time series data are typically non-stationary (following a random walk) which is denoted as I(1) (Aulton *et al*, 1997:410; Chowdhury, 1991:577). Following Engle and Granger (1987) and Wiseman (1999) a time series is integrated of order d, denoted I(d), if the series can achieve stationarity after differencing d times. Thus, for $d = 0$ the series under consideration will be stationary, whereas for $d = 1$ it contains a unit root (Kwiatowski, 1992:160) and is non-stationary. Consider the following equation:

$$Sp_t = a + bFp_{t-1} + u_t \tag{4.10}$$

where u_t is the error (residual) term. If it is assumed that the spot price (Sp_t) and futures price (Fp_{t-1}) are both non-stationary and I(1), taking the first difference I(1) of Sp_t and Fp_{t-1} respectively will yield two stationary series, therefore, indicating that Sp_t and Fp_{t-1} both contain unit roots and are non-stationary of nature. In addition, I(0) is the notation used to indicate a stationary time series. Given a time series such as Sp_t, I(0) refers to the differences at time zero, which is simply the Sp_t series itself. In this case the time series is said to be stationary and also referred to as white noise.

According to Thomas (1997:374) a time series is said to be stationary if its mean, variance and covariance remain constant over time, and subsequently non-stationary if it fails to satisfy this definition. This implies that expected prices will move constantly sideways and in a straight line over time if stationary, while fluctuating with a definite trend and in typical price series fashion if non-stationary. Kohls and Uhl (1990:169) state that wide and frequent commodity price variations over time are the rule while stable prices of individual commodities are the exception. Various factors play a role in the trend of commodity prices and Poonyth *et al* (2000:612), Grönum (2000:7) and Carlton (1984:241) showed that supply, demand, international commodity prices, exchange rate movements and a host of other unanticipated factors cause commodity prices to fluctuate over time. Given this evidence, it can be concluded that commodity futures prices are generally non-stationary over time (Shen and Wang, 1990:195; Kellard *et al*, 1999:414; Wiseman *et al*, 1999:371).

4.5.2 Co-integration

Co-integration is a relatively new statistical concept used in market efficiency tests and, as cited by Hakkio and Rush (1989:77), was pioneered by Granger and Weiss (1983), and Engle and Granger (1987). Co-integration is a property possessed by some non-stationary time series data and, in general terms, two variables are said to be cointegrated when a linear combination of the two is stationary (Aulton *et al*, 1997:410; Hakkio and Rush, 1989:77).

The use of a co-integration and error correction approach (Fujihara and Mougoué, 1997:78) in testing for futures market efficiency properly accounts for the non-stationary behaviour of futures and spot price series (Chowdhury, 1991:577; Lai and Lai, 1991:568). When two variables are cointegrated, they will tend to move together in a close fashion over time (Johnston and DiNardo, 1997:59) and never drift too far apart in the long run (Aulton *et al*, 1997:410). If the two price series cannot drift apart in the long run, the forces determining the delivery date spot price [Sp_t in Equation (4.11)] are reflected in the current futures price [Fp_{t-1} in Equation (4.11)] and the current futures price can provide forecasts of the future spot price (Engle and Granger, 1987:252; Aulton *et al*, 1997:410).

$$Sp_t = \alpha + \beta Fp_{t-1} + u_t \tag{4.11}$$

Evidence of co-integration between non-stationary spot and futures prices series is, therefore, supportive of market efficiency. In general, findings (Kellard *et al*, 1999:414) suggest that spot and futures prices are indeed cointegrated with a slope close to unity and postulate a long-run relationship.

Sabuhoro and Larue (1997:173) note that prices from two efficient markets for two different commodities cannot be cointegrated. If, for example, the spot prices in two different markets are cointegrated, then one of the prices must help in forecasting the other. Since market efficiency implies that the price at each point in time should include all available information (Rausser and Carter, 1983:470) and, given past prices, no other information should improve prediction of futures price, then, according to Chowdhury (1991:577), co-integration of two speculative markets for two different commodities implies both a direct violation of the weak-form EMH, and inefficiency.

In this study, the weak form efficiency test will be applied to the white and yellow maize, wheat, and sunflower futures markets. The weak form test relies on the historical sequence of prices and is the most commonly used efficiency test (Chowdhury, 1991:578). The semi-strong and strong form tests are less frequently used because, as the given information set becomes more complicated, the results also tend to be more frequently questioned. To test for the weak form efficiency, co-integration analysis will be used specifically following the more recent work of various researchers (Engle and

Granger, 1987; Chowdhury, 1991; Hakkio and Rush, 1989; Kellard *et al*, 1999; Brenner and Kroner, 1995; Wiseman *et al*, 1999; Lai and Lai, 1991).

The conventional process of testing for efficiency requires, first, testing for the presence of co-integration and, secondly, testing that the futures price at contract purchase is an unbiased predictor of the spot price at contract termination (Kellard *et al*, 1999:416). Co-integration between two variables requires that both series are non-stationary of nature. Following Chowdhury (1991:582) and Aulton *et al* (1997:410), assume the following simple equation:

$$y_t = \beta x_{t-1} + u_t \tag{4.12}$$

where y_t is the spot price at contract maturity (time t), x_{t-1} is the futures price prior to contract maturity (time $t-1$) maturing at time t, β is the cointegrating parameter, and u_t is the error term. This co-integration equation can be rewritten as follows:

$$u_t = y_t - \beta x_{t-1} \tag{4.13}$$

where u_t is stationary or I(0) and β is the cointegrating parameter. This statistical relationship in Equation (4.13) is of interest since unless u_t is I(0), y_t and x_{t-1} will tend to drift apart without bound and not show any signs of a long-run (linear) relationship. This is contrary to the market efficiency hypothesis and implies that the futures prices' prediction of the next period's spot price can be improved by using available information (Chowdhury, 1991:581). Thus, following Wiseman *et al* (1999), if u_t is I(0), it indicates that y and x move together over time, never drift too far apart, and show that the two variables are cointegrated. Hence co-integration is a necessary condition for existence of a linear relationship between two variables (Aulton *et al*, 1997:410). In addition to efficiency testing of the subsequent markets, following Yang and Leatham (1998:107), co-integration will also be applied to evaluate the cross-sectional efficiency between the spot markets of the four different commodities. This test considers the possibility of profitable trading across markets. In order to indicate efficiency, results need to show that co-integration does not exist across markets. A bivariate approach will be used and is explained in section 4.6.2.

4.5.3 Bias

Testing for unbiasedness is an integral part in testing for market efficiency. Conventional efficiency tests using regression analysis require that the intercept [α in Equation (4.11)] is not significantly different from zero, the slope [β in Equation (4.11)] is not significantly different from one, and that the residuals are white noise (Kellard *et al*, 1999:416; Aulton *et al*, 1997:410). Having found these results it can be argued that the futures price at contract purchase is an unbiased predictor of the spot price at contract termination (Lai and Lai, 1991:569).

The more recently introduced co-integration-based tests for efficiency also make use of the unbiasedness hypothesis as one of the steps in the procedure to evaluate whether a market is efficient or not. Hakkio and Rush (1989:78) mention that, while co-integration is a necessary condition for market efficiency, it is not sufficient without testing whether the future price is an unbiased predictor of the future spot price.

4.6 The co-integration-based procedure

In this study, market efficiency is tested using two different forms of co-integration applications namely bivariate, and multivariate co-integration analysis. First, the intertemporal market efficiency will be tested mainly using a bivariate approach, whereafter the cross-sectional efficiency between the different commodities will be evaluated by making use of bivariate co-integration analysis. The different procedures are presented in the remaining sections of this chapter.

4.6.1 Testing for intertemporal market efficiency

Following Chowdhury (1991:582) and Aulton *et al* (1997:413), testing the hypothesised relationship in the form of Equation (4.11) for efficiency comprises of three main steps:

1) test whether the *Sp* and the *Fp* series are individually stationary,
2) test for co-integration, and
3) if the null hypothesis of no co-integration is rejected, test for the parameter values consistent with efficiency.

4.6.1.1 Tests for stationarity

4.6.1.1.1 Dickey-Fuller unit root test

Following Wiseman (1999:43) and Chowdhury (1991:582) there are a number of statistical tests available to test for stationarity in time series. A formal and most widely used procedure involves testing for the presence of a unit root and was first developed by Fuller (1976) and Dickey and Fuller (1979) (Wiseman, 1999:43).

The procedure used by Thomas (1997:405), uses an economic time series by the first-order autoregressive process to which the intercept α is added as follows:

$$X_t = \alpha + \phi X_{t-1} + u_t \tag{4.14}$$

$$\Delta X_t = \alpha + \phi^* X_{t-1} + u_t \tag{4.15}$$

$$\phi^* = \phi - 1 \tag{4.16}$$

where X_t denotes the natural logarithms of the values of the series under consideration. From Equation (4.14) (economic time series), it can be assumed that the parameter ϕ will be positive and it therefore follows that X_t will be non-stationary if ϕ equals or exceeds unity (one). The time series will only be stationary if $\phi < 1$. Following Dickey and Fuller (1979:428), Equation (4.15) is the result yielded from subtracting X_{t-1} from each side of the equation, where ϕ^* is explained through Equation (4.16).

The hypothesis H_0: $\phi^* = 0$ is tested against the alternate hypothesis H_A: $\phi^* < 0$. In terms of Equation (4.15), we reject non-stationarity ($\phi^* = 0$) if the ordinary least squares (OLS) estimate of ϕ^*, that is, $\hat{\phi}^*$, is sufficiently negative. The test statistic to be used is commonly known as the Dickey-Fuller (DF) statistic given as:

$$t_1^* = \hat{\phi}^* / S_{\hat{\phi}^*} \tag{4.17}$$

where $S_{\hat{\phi}^*}$ is the estimated standard error of ϕ^*. Critical t_1^* values, however, cannot be obtained from a standard student's *t* table (Thomas, 1997:406) and is obtained from Fuller (1976:373). A problem that arises from using the straightforward DF test, is that autocorrelation in the residuals of the OLS-estimated Equation (4.15) can occur. This sometimes happens mainly because the time series under consideration is the result of a higher-order process or the disturbance (u_t) is found not to be white noise. In this case the augmented Dickey-Fuller (ADF) procedure accounts for the possible presence of a higher-order process. Nelson and Plosser (1982:150) and Dickey and Fuller (1981:1066) explain that this is very similar to the standard DF test and generalises Equation (4.14) into the rth-order as follows:

$$X_t = \alpha + \phi_1 X_{t-1} + \phi_2 X_{t-2} + \ldots + \phi_r X_{t-r} + u_t \tag{4.18}$$

where X_t denotes the natural logarithms of the values of the series under consideration. Just as it is possible to rewrite Equation (4.14) to (4.15), following Thomas (1997:407), it is also possible to readjust Equation (4.18) to:

$$\Delta X_t = \alpha + \phi^* X_{t-1} + \phi_1^* \Delta X_{t-1} + \phi_2^* \Delta X_{t-2} + \ldots + \phi^*_{r-1} \Delta X_{t-r+1} + u_t \tag{4.19}$$

where $\phi^* = \phi_1 + \phi_2 + \ldots + \phi_r - 1$. Note that, if a first-order process is under consideration, no differenced terms are included and the standard DF test can be used. The ADF procedure further follows the testing of the null hypothesis $H_0\colon \phi^* = 0$ (the presence of a unit root) by applying OLS to Equation (4.19) to examine the *t* ratio on the estimate $\hat{\phi}^*$. If this is sufficiently negative, we reject H_0 in favour of stationarity. The *t* statistic, in this case, is referred to as an augmented Dickey-Fuller (ADF) statistic and denoted as $ADF_{(k)}$, where *k* is the number of differenced terms included on the right-hand side of Equation (4.19).

The estimated *t* statistic, as is the case in the standard DF test, does not follow the student's *t* distribution, so its statistical significance must be assessed by comparing it with critical *t* values derived for *t* distributions tabulated in Fuller (1976) and Dickey and Fuller (1981). This is consistent with Wiseman (1999).

A word of caution is presented by Thomas (1997:410) in which he states that the DF tests should be applied with care and their results interpreted cautiously. Other sources of information, such as the correlogram for the time series, should not be ignored.

4.6.1.1.2 The Phillips-Perron unit root test

An alternative procedure to test for unit roots in time series is the Phillips-Perron (PP) test as proposed by Phillips and Perron (1988:335). This approach is robust to a wide variety of serial correlation and time-dependent heteroscedasticity and accommodates models with drift and a time trend so that it may be used to discriminate between unit root non-stationarity and stationarity about a deterministic trend (Serletis and Banack, 1990:375). Similar to the ADF test, the PP test is a test of the hypothesis $\phi = 1$ in the equation:

$$\Delta X_t = \alpha + \phi X_{t-1} + u_t \tag{4.20}$$

although, unlike the ADF test, there are no lagged difference terms (Equation 4.18) (Phillips and Perron, 1988:343). The Phillips-Perron Z_t–statistic is a simple modification of the standard *t*-statistic for the lagged-level employed in the ADF test. Both the Dickey-Fuller and PP tests have the same asymptotic distributions, hence, the same critical values apply as well (Chowdhury, 1991:584).

4.6.1.1.3 The correlogram

Examining the correlogram for a time series is a well-known procedure in testing for stationarity. Following Johnston and DiNardo (1997:51) the procedure examines the sample autocorrelations, which for a time series X_t is defined as:

$$r_k = \hat{X}_k / \hat{X}_0 \qquad , k = 1, 2, 3, 4, \ldots \tag{4.21}$$

where *k* denotes the time lag,

$$\hat{X}_k = \sum(X_t - \overline{X}_t)(X_{t-k} - \overline{X}_{t-k}) \tag{4.22}$$

and

$$\hat{X}_0 = [\sum(X_t - \overline{X}_t)^2 \sum(X_{t-k} - \overline{X}_{t-k})^2]^{0.5} \tag{4.23}$$

Thus, r_3 for example, is the correlation between X_t and X_{t-3}, its value three time periods previously. In AR models, as *k* increases, sample autocorrelations decline towards zero. A sample correlogram is simply the plot of r_k against *k* and presents a visual indication of the stationarity of the time series. The rate at which the sample autocorrelations decay as *k* increases is generally much more rapid for a stationary series than for a non-stationary series (Johnston and DiNardo, 1997:60). Therefore, the correlograms for stationary and non-stationary variables is likely to be very different. The typical correlogram for a stationary variable shows that r_k falls rapidly to around 0 as *k* increases, whereas in the case of a non-stationary variable, r_k declines in a much more gradual and smooth fashion. The correlogram will provide visual results to support the findings from the unit root tests.

4.6.1.2 Co-integration

In order to test for co-integration, the maximum likelihood estimation procedure is used as proposed by Johansen (1988:231) and Johansen and Juselius (1990:170). This technique is superior to the simpler regression-based technique because it fully captures the underlying time series properties of the data. The technique also provides estimates of all the cointegrating vectors that exist within a vector of variables and offers a test statistic for the number of cointegrating vectors (Fraser and MacDonald, 1992:27).

The test for co-integration is based on the test for unit roots in the residuals of the co-integration regression. In simulation experiments, Engle and Granger (1987) examined a number of alternative methods of testing the residuals for stationarity. It transpired that critical values for the test statistics considered tended to depend on the model used to simulate the data. However, the experiments suggested that the tests for which critical values were least model-sensitive were the augmented Dickey-Fuller (ADF) test. These were also found to have the greatest power of all the tests considered.

The methodology presented here surrounding the co-integration procedure takes into account the literature produced by Hakkio and Rush (1989), Aulton *et al* (1997), Kellard *et al* (1999), Wiseman (1999), and Elam and Dixon (1988). The long-run stationary relationship between two variables is known as an equilibrium relationship while, in addition, a short-run relationship is generally referred to as disequilibrium (Thomas, 1997:383). Consider a simple error correction model (ECM) and equilibrium relationship,

$$y_t = \beta_0 + \beta_1 x_t + u_t \tag{4.24}$$

and, the disequilibrium error is given by:

$$u_t = y_t - \beta_0 - \beta_1 x_t \tag{4.25}$$

which is a linear combination of x_t and y_t. Engle and Granger (1987:253) pointed out that if a long-run relationship [Equation (4.24)] underlying the ECM actually exists, then over time the disequilibrium error [Equation (4.25)] should "rarely drift far from zero" and form a stationary time series with a zero mean, that is, u_t should be I(0) and E(u_t) = 0.

Since the parameters β_0 and β_t in the hypothesised equilibrium relationship (4.24) is unknown, the disequilibrium errors (4.25) are also unknown. Therefore we proceed by using OLS to estimate the equilibrium relationship (4.24) and use the residuals from this regression as estimates of the unknown disequilibrium errors:

$$\hat{y}_t = \hat{\beta}_0 + \hat{\beta}_1 x_t \tag{4.26}$$

Equation (4.26) is known as the cointegrating regression (Thomas, 1997:426) and the estimate of u_t by the residuals from Equation (3.25) yields:

$$e_t = y_t - \hat{\beta}_0 - \hat{\beta}_1 x_t \tag{4.27}$$

Using the Dickey-Fuller, augmented Dickey-Fuller, and Phillips-Perron tests described in section 4.6.1.1, the stationarity of e_t in Equation (4.27) may be tested. As stated earlier, if the two series y_t and x_t are cointegrated, then the linear combination in the form of e_t will be stationary or I(0). The outcome of the stationarity tests will be used to distinguish between the null hypothesis of no co-integration and the alternate hypothesis that the two variables are indeed cointegrated.

4.6.1.3 Testing for bias

Following Wiseman (1999) and Wiseman *et al* (1999), if the null hypothesis of no co-integration is rejected, the second stage of testing for efficiency entails a test of the joint hypothesis that $B_1 = \phi = 0$ in Equation (4.28). This ensures that the lagged futures price and the lagged spot price do not contain additional information that could be used to forecast Sp and giving traders information with which to make abnormal profits (Wiseman, 1999:51).

$$Sp_t = a + b_0 Fp_t + B_1 Fp_{t-1} + \phi Sp_{t-1} + u_t \tag{4.28}$$

According to Aulton *et al* (1997:413), if the null hypothesis of no co-integration is rejected and the null hypothesis that the lagged spot and futures prices do not influence the spot price is not rejected, then it is appropriate to test for unbiasedness, namely that $b_0 = 1$. The test can be carried out by imposing the restriction $b_0 = 1$ and testing the following residual series for stationarity:

$$u_t = Sp_t - Fp_t - a \tag{4.29}$$

If the residuals are stationary then there is evidence to support the hypothesis that $b_0 = 1$ and that the market is unbiased. According to Wiseman (1999:51) and Aulton *et al* (1997:413), the rationale for this approach is that the cointegrating parameter is unique if co-integration exists between two I(1) series, so that if the hypothesis of unbiasedness is incorrect when the two series are cointegrated, the residual series obtained by imposing unbiasedness will be non-stationary. In other words, if unbiasedness holds, then the spot and futures series are cointegrated with a unit parameter. Conversely, if the unbiasedness hypothesis does not hold, the spot and futures prices will diverge without bound.

4.6.2 Testing for cross-sectional market efficiency

Cross-sectional market efficiency implies efficiency across different commodity markets (Copeland, 1991:185). As already mentioned, cross-sectional efficiency testing can involve either the relationship among subsequent futures markets of different commodities or, as will be the case in this study, be applied to the underlying spot markets. The cross-sectional analysis will be conducted using a pairwise (Yang and Leatham, 1998:111) approach where separate co-integration tests will be conducted on the spot price series of two commodities at a time. The testing procedure is identical to that of testing for intertemporal efficiency and implies the use of bivariate co-integration analysis.

The existence of co-integration across markets implies that price information from one commodity can be used to trade profitably using another commodity in a different market and, according to Yang and Leatham (1998:107), is a direct violation of the weak-form EMH. Thus, as the presence of a co-integration relationship is of great importance when testing for intertemporal market efficiency, the absence of a significant co-integration relationship is required to find the market as cross-sectional efficient (Copeland, 1991:187). The testing procedure is identical to that of intertemporal efficiency testing where, first, the different price series is tested for the presence of a unit root. If they are found to be non-stationary they will be included in the different bivariate co-integration tests to evaluate the cross-market efficiency between the different commodities under consideration.

In this chapter we defined the concepts of futures market efficiency and the efficient markets hypothesis (EMH). It is evident that, for a futures market to effectively perform its price discovery function, it has to efficiently consume and reflect all available information and provide an unbiased estimate of the future spot price at all times. The relevant methodologies to test for intertemporal and cross-sectional efficiency were also reviewed and form the basis of the empirical analysis that will be conducted in the proceeding chapter.

Chapter 5 APPLICATION OF THE INTERTEMPORAL AND CROSS-SECTIONAL EFFICIENCY MODELS

5.1 Introduction

In this chapter the proposed empirical model and statistical method for the testing of intertemporal and cross-sectional market efficiency, as discussed in Chapter 4, was applied to the South African yellow and white maize, and wheat futures markets. First an overview of the data is provided, whereafter the results for the stationarity, co-integration, and unbiasedness tests are summarised for the two maize markets and wheat respectively. The meaning and possible effects of the results for the different futures markets are concluded in the final section of the chapter.

5.2 Data

All the data used in the different analyses consist of daily futures prices and were collected directly from The South African Futures Exchange (Safex) and Derived Market Investment and Planning [DMIP (Pty) Ltd]. There are five primary contracts, also referred to as the five hedging months (Sturgess, 2001), traded on the agricultural futures market for white and yellow maize, and wheat on an annual basis. These are July, September, December, March, and May. According to Wiseman (1999:41), for maize, importance to the July contract is possibly the most important year contract as it represents the start of harvesting and both producers and processors would need to decide what action to take with maize orders for the rest of the year. However, since April 1999, constant month contracts were introduced to the market for both white and yellow maize apart from the already existing primary contracts. According to Grönum (2001), the sole purpose of the constant month contract is to improve the basis from which to derive the underlying spot price during the months between primary contract months. These contracts could have interesting effects on the overall price discovery role of the market and were included separately in the analysis as will be described in this section. Constant month contracts are not used in the wheat market and contribute to the fact that there is no continuous spot price time series available for wheat (Sturgess, 2001). The near month futures contract is currently the best anticipated cash price referred to in the wheat market (Geldenhuys, 2001). In the case of wheat, the December contract would be of equal importance as the July maize contract as it expires during the wheat harvesting period and would best indicate the marketing intentions of producers and processors throughout the marketing season of the crop.

In this study the intertemporal and cross-sectional efficiencies of the South African wheat futures market were tested for the first time. The sunflower futures market was also taken into consideration for efficiency evaluation. However, due to its short existence and the way the data series is constructed for the purpose of efficiency testing, very few observations could be included in the different series considered for the analysis. It can be expected that the results would not provide a true indication of the way the market is functioning in terms of futures market efficiency.

For white and yellow maize, data were taken over the period February 1996 to July 2002 and includes all the primary and constant month contracts fully traded over this period. However, as already mentioned, a separate analysis was conducted for the data including constant month contracts, and of that excluding the constant month contracts. For the intertemporal analysis excluding the constant month contracts the data series were constructed by taking spot and futures prices at frequencies according to the months of contract expiry. This is consistent with Aulton *et al* (1997:414). The spot price series ($Sp_{exp\ PCA}$) consist of futures prices taken for each delivery month at contract expiry or the last day of trading. The lagged futures price series were then constructed by taking prices 35 days ($Fp_{35\ PCA}$), and 15 days ($Fp_{15\ PCA}$) prior to the day of contract expiration. The period (number of days) for which the futures price was lagged was determined as follows: the last trading month of each respective contract is limited to approximately three weeks where the last 7 business days of this month and trading are suspended (Safex, 2003). Therefore, the mean number of trading days for all the expiration months over the observation period was calculated as 15 days (rounded off), representing a “one-month” lag from the day of contract expiration. The mean number of trading days in a “normal” month (not an expiration month) was calculated and rounded off to 20 and added to the 15 days to represent the 35 day, or “2-month” lag of the futures price.

Each futures price variable was therefore made up of data taken with the same frequency as that of the corresponding constructed spot price variable. It would be possible, of course, to lag the futures price for periods longer than two months (35 days) prior to the day of contract expiry because primary contracts are each traded for approximately twelve months. A word of caution was sounded by Lai and Lai (1991:571) that data of different contracts should not overlap as the time series analysis will suffer from autocorrelation problems because of informational overlap and the results will be questionable. With consecutive primary contracts for white and yellow maize expiring at least two months apart, it is thus possible to lag the futures price by as much as 35 days from the day of contract expiration before data of successive contracts will start to overlap. Note that the two lagged futures price series ($Fp_{15\ PCA}$ and $Fp_{35\ PCA}$) will be tested for co-integration against the same spot price variable ($Sp_{exp\ PCA}$) as this is not lagged as is the futures price.

For the intertemporal analysis that includes the constant month contracts, the data were constructed similarly. Because of the constant month contracts now included, there is a contract for every month (since April 1999) and the futures price can therefore not be lagged for more than a month (15 business days) prior to the day of expiration because of possible informational overlap. Thus, the futures price variable ($Fp_{15\ CCA}$) was constructed with a 15-day lag only. The spot price variable ($Sp_{exp\ CCA}$) was again constructed by taking the observations at the day of contract expiry of each contract. The only difference between variables of the two separate analyses is that the number of observations will increase because of the constant month contract taken into consideration for the one analysis, but not for the other.

The period under consideration for the wheat market analysis ranges from November 1997 to July 2002 with the December 1997 contract being the first contract to be traded. The data were constructed following the same steps as for the white and yellow maize, however, because of the absence of constant month contracts in the market, the futures price was lagged by both 15 and 35 days respectively and the spot price taken at contract expiration of each traded contract over the period.

For the purpose of the chapter all analyses of data including only primary contract month data will be referred to as “primary contracts analysis (PCA)” and variables will be denoted with a subscript “PCA” (e.g. $Fp_{15\ PCA}$). In addition, the analyses conducted on the data including both primary and constant contract month data will be referred to as “constant contracts analysis (CCA)” with applicable variables denoted with subscripts “CCA” (e.g. $Sp_{exp\ CCA}$).

Note that, because there are no official spot prices for white maize, yellow maize, or wheat available in South Africa (Gravelet-Blondin, 2003), theoretically the spot price equals the futures price on the day of contract maturity of a specific futures contract. This is consistent with the methodology used by Aulton *et al* (1997:410) to test for co-integation. This price was used as the spot price for the underlying commodity based on the following assumptions:

1. There are no price manipulations by players that could affect the futures price in such a way that it would not reflect the true value of the commodity on the day of maturity, and
2. the nearest month futures price at maturity is the best available price from which the cash price can be derived on that specific day.

To extend the testing of futures market efficiency in the South African maize complex, cross-sectional efficiency was tested between the spot prices of white and yellow maize. This cross-market approach will indicate whether information from one market (e.g. white maize) could be used to exploit excess profitable opportunities in another (e.g. yellow maize). The same model for testing intertemporal efficiency was used to test for the presence of cross-sectional efficiency. The existence of co-integration of futures prices across markets would imply a direct violation of the weak-form EMH (Yang and Leatham, 1998:107). Therefore, to show that markets are efficient in a cross-market context, co-integration must not exist between the respective markets under consideration. Data used consisted of futures prices taken at the day of contract expiration as they were realised over the observation period and this represented the different spot price variables under consideration. As in the case of the intertemporal analysis, cross-sectional testing involved separate testing of futures data including and excluding the constant month contracts.

The log-log transformation was applied to all the data, in other words, both price variables in all the analyses. As shown by Johnston and DiNardo (1997:45), many econometric applications involve the logs of both variables since the slopes in log-log regressions are direct estimates of the elasticity of the one variable with respect to the other. This application is of great value to work done in Chapter 7 and the transformations were used throughout the thesis for the sake of consistency. Results were obtained by using the STATISTICA and E-VIEWS statistical computer software.

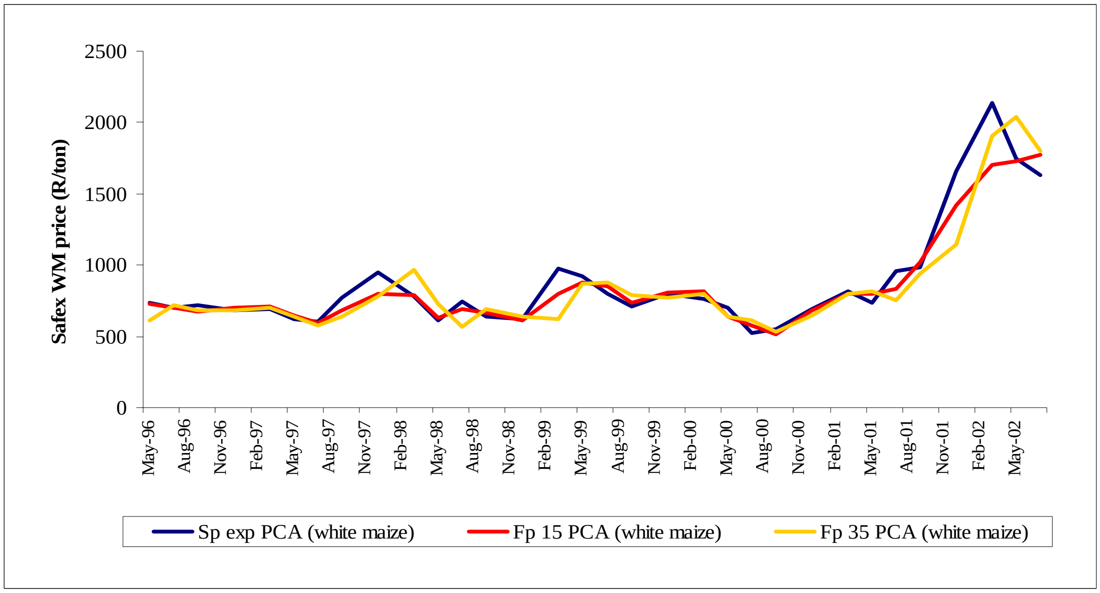
5.3 White maize results

This section presents the results of the intertemporal market efficiency tests for white maize.

5.3.1 Stationarity tests

Prices with unit roots are not stationary; the level of prices with a unit root can become arbitrarily large or small and there is no tendency to revert to their mean level (Yang and Leatham, 1998:108). Testing the different variables for non-stationarity is required in order to continue with the co-integration procedure. Figure 5.1 shows the three variables under consideration for the white maize PCA and Table 5.1 reports the results from the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests conducted on each of the variables. The null hypothesis of a unit root must not be rejected in order to have a non-stationary series.

Figure 5.1: White maize PCA price variables



Source: Safex, 2003

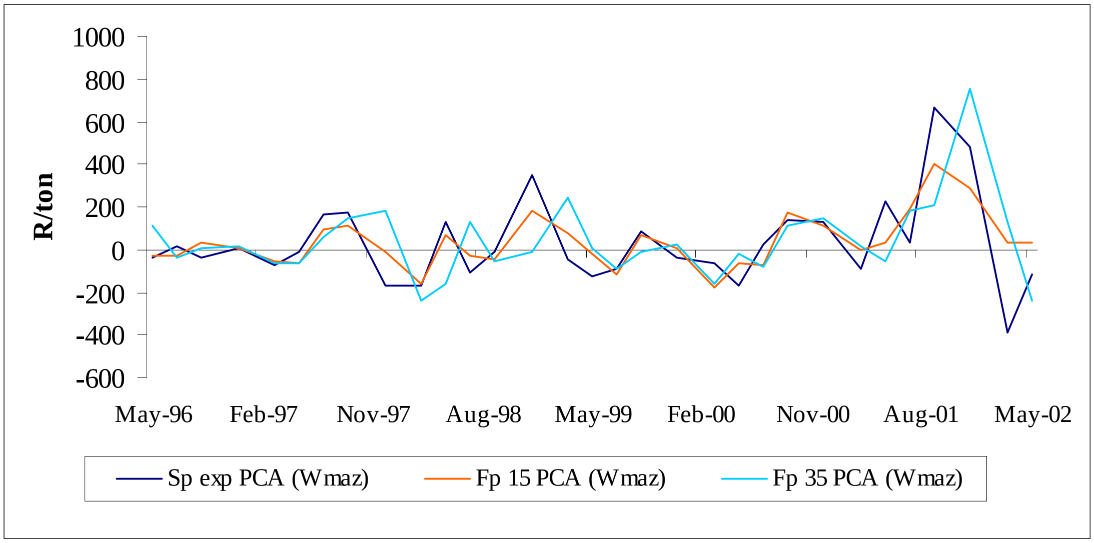
Table 5.1: White maize PCA: results of the ADF and PP unit root tests

Variable	No. of observations (n)	ADF test statistic[4]	PP test statistic[5]	First difference I(1)	
				ADF-test	PP-test
$Sp_{exp\ PCA}$[1]	30	-1.25	-1.01	-4.62**	-4.99**
$Fp_{15\ PCA}$[2]	30	-0.69	-0.03	-4.16**	-4.07**
$Fp_{35\ PCA}$[3]	30	-1.08	-0.64	-4.14**	-4.51**

[1] White maize spot price variable (PCA)
[2] White maize futures price variable at 15 days lag from contract expiry (PCA)
[3] White maize futures price variable at 35 days lag from contract expiry (PCA)
[4] MacKinnon critical ADF-value at 1% level of significance = -3.67
[5] MacKinnon critical PP-value at 1% level of significance = -3.66
** Significant at 1% level of significance

Critical values were obtained from MacKinnon (1991:282) who reported a series of tables for unit root tests, including ADF and PP-tests. The null hypothesis of the unit root should not be rejected if the test statistic is larger than the critical value value and should be rejected if the test statistic is smaller (larger negative) (Yang and Leatham, 1998:109). Calculated ADF and PP test statistics failed to reject the null hypothesis of a unit root in the case of all three variables under consideration suggesting that each of the price variables have a unit root, are non-stationary but are stationary in the first price differences. This is shown in the last two columns of Table 5.1 where, for both Augmented Dickey-Fuller and Phillips-Perron test, the null hypothesis of a unit root was rejected for each of the three variables under consideration. The first differences of the three variables considered in Table 5.1 are shown in Figure 5.2 and provide good visual evidence of I(1) stationarity.

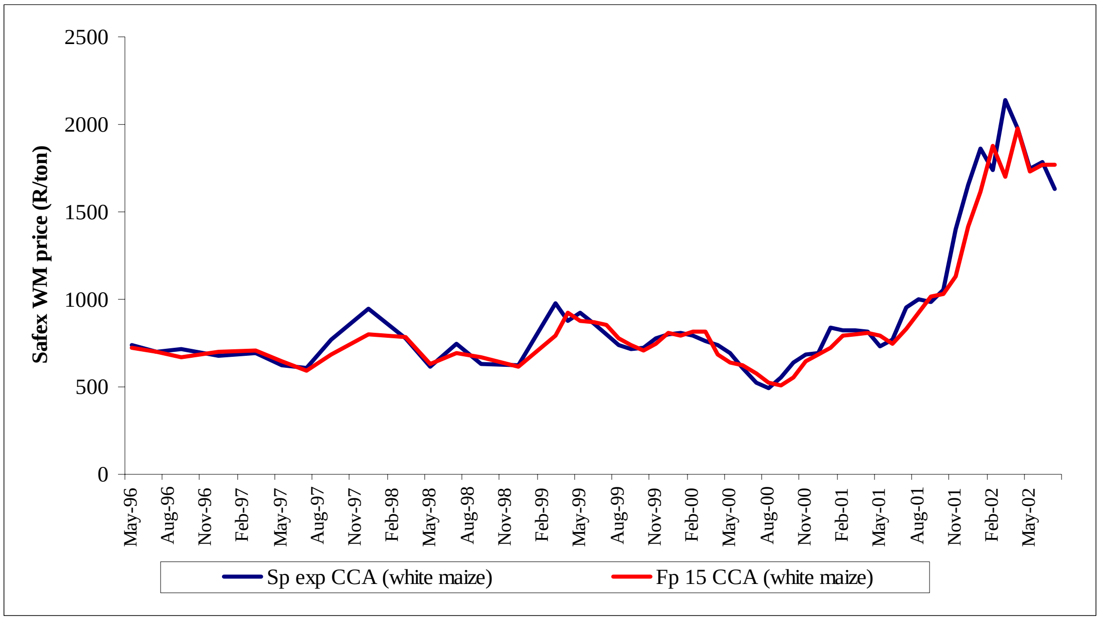
Figure 5.2: White maize PCA price variables (1st differences)



As evident form Figures 5.1 and 5.3, South African white maize prices showed a sudden increase from approximately September 2001. This was also the case in both the yellow maize and wheat markets (Figures 5.5, 5.7 and 5.9). This sharp trend was caused mainly by the sudden devaluation of the Rand against major world currencies following the September 11 World Trade Centre bombings during 2001. The Rand devalued by almost 53 % against the American dollar from 1 September 2001 to 15 December 2001. Being highly correlated with the R/$ exchange rate (Gravelet-Blondin, 2003:1) grain prices followed a similar trend and nearest contract prices increased by approximately 330% from September 2001 to March 2002.The question arises whether this sudden increase in prices could have been the main cause of the non-stationarity found in the variables under consideration and that the data could perhaps have been stationary if these factors did not occur. In order to investigate this, all the variables used were tested for a unit root excluding the observations from September 2001 onwards, therefore taking the observation period from May 1996 to August 2001 (maize) and December 1997 to July 2001 (wheat). ADF and PP unit root results are shown in Table A.1, Appendix A.

Results showed that the sudden increase in grain prices since September 2001 was not the only cause of non-stationarity of the different variables considered in this chapter. Except for one variable, white maize ($Fp_{35\ PCA}$), all the variables were found to contain a unit root and were therefore non-stationary. Results in Table A.1 also indicates stationarity in the first differences [I(1)]. Considering this knowledge, the full observation period (until July 2002) was used for the different analyses in this chapter.

Figure 5.3: White maize CCA price variables



Source: Own calculations

Figure 5.3 shows the white maize CCA price variables while Table 5.2 reports the results from the unit root tests conducted for the spot and futures price variables of the constant contracts analysis. The test statistic failed to reject the null hypothesis of a unit root for both variables, however, the unit root is significantly rejected in the first differences indicating that the two variables are both I(1) and could be used for co-integration testing. Having established the order of integration of the different series, the status of efficiency and unbiasedness could now be examined.

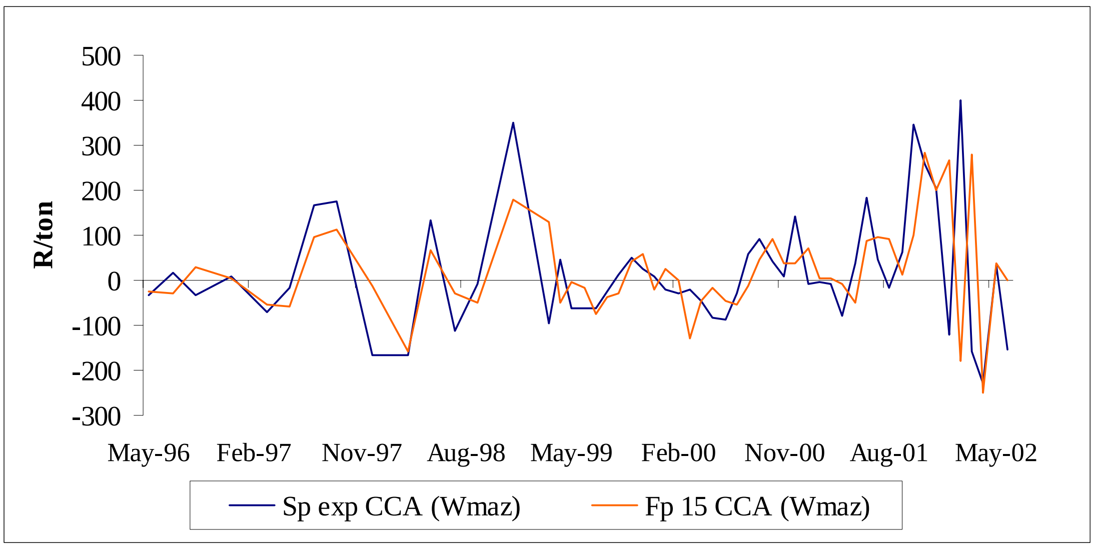
Table 5.2: White maize CCA: results of the ADF and PP unit root tests

Variable	No. of observations (n)	ADF test Statistic[3]	PP test statistic[4]	First difference I(1)	
				ADF-test	PP-test
$Sp_{exp\ CCA}$[1]	54	-0.92	-0.81	-5.63**	-6.75**
$Fp_{15\ CCA}$[2]	54	-0.35	-0.17	-4.88**	-6.06**

[1] White maize spot price variable (CCA)
[2] White maize futures price variable at 15 days lag from contract expiry (CCA)
[3] MacKinnon critical ADF-value at 1% level of significance = -3.56
[4] MacKinnon critical PP-value at 1% level of significance = -3.55
** Significant at 1% level of significance

The first differences of the abovementioned variables (Table 5.2) are shown in Figure 5.

Figure 5.4: White maize CCA price variables (1st differences)



5.3.2 Co-integration results

As explained in Chapter 4, where the price series are non-stationary, co-integration between the spot and futures prices is a necessary condition for market efficiency. For the first stage of testing, the null hypothesis of no co-integration must be successfully rejected in order to make the inference that the two series have a long-run relationship. Table 5.3 shows the results for the Johansen co-integration tests performed for all the price series found to be non-stationary in section 5.3.1. Yang and Leatham (1998:108) suggested that the specific lag order be selected that best fits the co-integration model. To test for the appropriate lag length in this case, a likelihood ratio (LR) test was used, as shown by EViews (1998:517) with the test statistic computed as:

$$LR = -2(\ell_2 - \ell_4) \tag{5.1}$$

where, for example, ℓ_2 and ℓ_4 represent the log likelihoods of lag 2 tested against that of lag 4. The LR test statistic is asymptotically distributed χ^2 with degrees of freedom equal to the number of restrictions under test. For Equation (5.1) the null hypothesis would be in favour of a lag length of 2, while the alternative would suggest the lag of 4. For the three co-integrations shown in Table 5.3, the respective calculated likelihood ratios were 7.94 (0.4394), 1.24 (0.9962), and 3.18 (0.9226) and unable to reject the null hypothesis in all of the three cases (critical value $\chi^2_{8,0.01} = 20.09$) in favour of a lag length of 2.

The null hypothesis of no co-integration was rejected at a 1 percent level of significance in the case of the CCA, and at a 5 % level of significance in the case of the 35 day-lagged PCA. In the case of the 15-day lagged PCA the null hypothesis is not rejected suggesting that there is no long-run relationship between the futures price and the corresponding spot price. The first stage of this process also requires the estimation of the long-run relationship as explained through Equation (4.11).

Table 5.3: Co-integration results for white maize

Futures series	Subsequent spot series	Likelihood ratio	Critical value[1]	Reject H_0: no co-integration
$\mathbf{Fp_{15\ CCA}}$	$Sp_{exp\ CCA}$	28.39**	20.04	Yes
$\mathbf{Fp_{15\ PCA}}$	$Sp_{exp\ PCA}$	13.31	20.04	No
$\mathbf{Fp_{35\ PCA}}$	$Sp_{exp\ PCA}$	15.84*	20.04	Yes

[1] Critical value at 1 % level of significance = 20.04
** Significant at 1 % level of significance
* Significant at 5 % level of significance (critical value = 15.41)

The co-integrating regressions and test statistics are reported in Table 5.4 and the respective co-integration relations shown in Figure 5.5, Panels A to C.

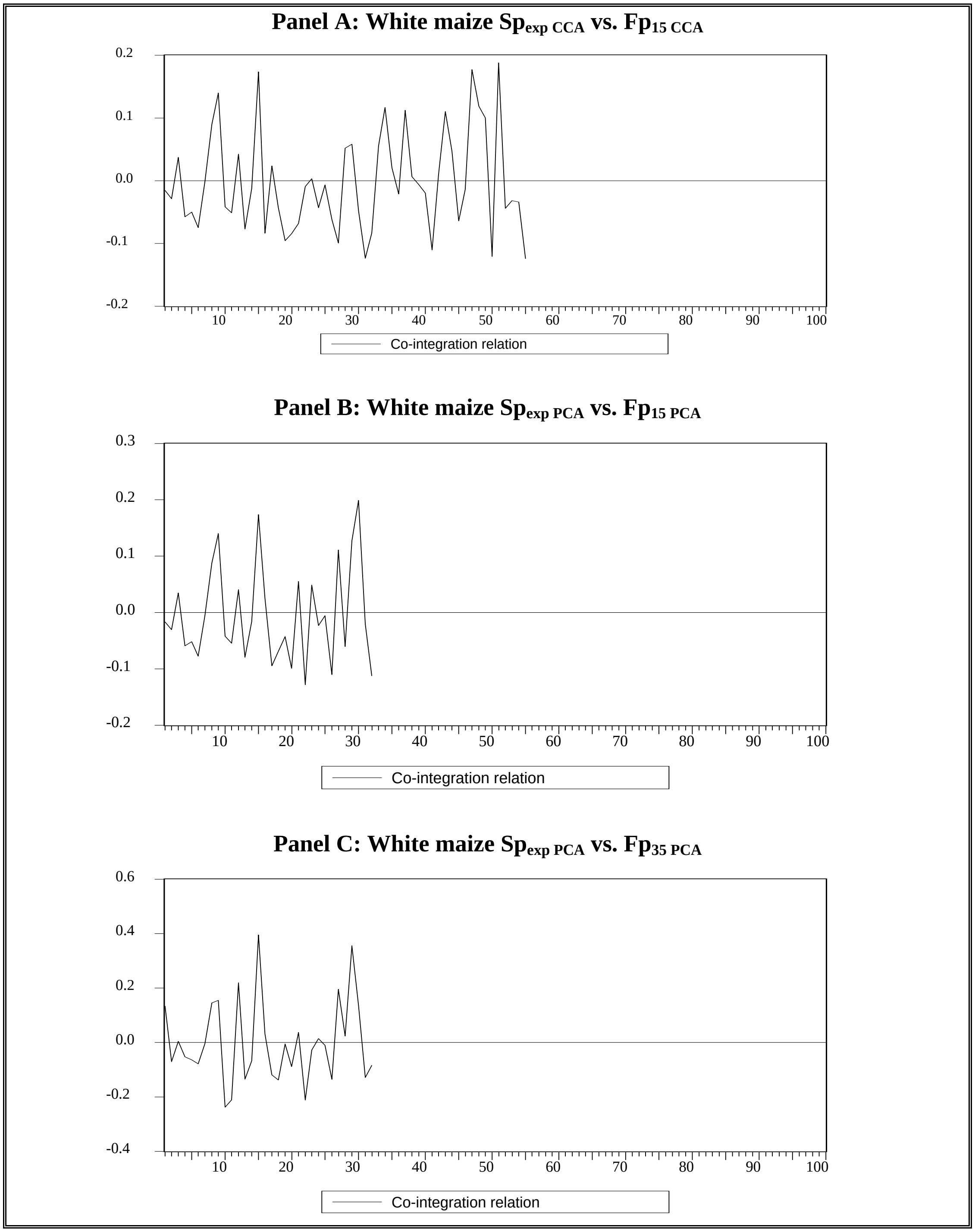
Table 5.4: Co-integrating regressions for white maize

DV[1]	IV[2]	Coefficient	Constant	R^2	DW[3]
$Sp_{exp\ CCA}$	$Fp_{15\ CCA}$	-1.0149 (0.0171)[#]	-0.0693	0.9502	1.8132
$Sp_{exp\ PCA}$	$Fp_{15\ PCA}$	-1.0003 (0.0509)	-0.0284	0.9381	2.015
$Sp_{exp\ PCA}$	$Fp_{35\ PCA}$	-0.9364 (0.0579)	-0.4598	0.7977	1.9514

[1] Dependent variable
[2] Independent variable
[3] Durbin-Watson statistic
[#] Standard error of slope coefficient

From the table it is clear that the slope coefficients (-1.01, -1.00, and -0.94) were found to be relatively close to unity (one) in the case of all three regressions, although the calculated intercept (constant) values tended to deviate more from zero. The constant coefficient (usually zero) is the result of an arbitrary identifying assumption and therefore the standard errors were not provided by the statistical software (EViews, 1998:512). However, although these figures might to some degree be indicative of unbiasedness in the white maize market, the unbiasedness hypothesis (intercept = 0, slope = 1) was only formally tested in section 5.3.3. With the necessary condition for efficiency established, the second stage of testing could now be applied.

Figure 5.5: Co-integration relations for white maize



Following Aulton *et al* (1997:419) and Wiseman (1999:60), the second stage considers whether the spot price is a function of the futures price, the lagged futures price, and the lagged spot price as explained through Equation (4.28). Johnston and DiNardo (1997:95) formulated the test statistic as:

$$F = [(R^2_{ur} - R^2_r) / k_2] \Big/ [(1-R^2_{ur})/ n-k)] \sim F_{k2,\, n\text{-}k,\, \alpha} \tag{5.2}$$

where k is the number of parameters included in the unrestricted equation [Equation (4.28)], k_2 is the number of omitted variables in the restricted equation [Equation (5.3)], R^2_{ur} is the coefficient of determination of the unrestricted equation obtained through Ordinary Least Squares (OLS), and R^2_r is the coefficient of determination of the restricted equation obtained through OLS.

$$Sp_t = \alpha + \beta Fp_t + u_t \tag{5.3}$$

Table 5.5 reports the results obtained from calculating the F-values under consideration.

Table 5.5: Second stage efficiency tests for white maize

Futures series	Subsequent spot series	Calculated F-value[1]	$F_{k2,\, n\text{-}k,\, \alpha}$[2]
$\mathbf{Fp_{15\ CCA}}$	$Sp_{exp\ CCA}$	5.14**	5.08
$\mathbf{Fp_{15\ PCA}}$	$Sp_{exp\ PCA}$	3.69	5.49
$\mathbf{Fp_{35\ PCA}}$	$Sp_{exp\ PCA}$	2.39	5.49

[1] Indicated through Equation (5.2)
[2] $\alpha = 0.01$
** Significant at 1 % level of significance

The joint null hypothesis [from Equation (4.28)] $B_1 = \phi = 0$ was tested against the alternate that at least one of the two parameters is different from zero. Results for the PCA showed that the calculated F-values failed to reject the null hypothesis suggesting that lagged spot and futures prices are not a function of the future spot price and do not contain useful information in forecasting it. This is consistent with the efficient markets hypothesis that past prices are not useful for predicting the future price and implies the absence of exploitable excess profit opportunities (Barnett and Serletis, 2000:704). However, in the case of the CCA, the null hypothesis was rejected indicating a failure to comply with the conditions of the EMH. As the two stages of efficiency testing were now complete, the only task that remained was to test whether there is an unbiased relationship between the spot and futures prices for the two sets of series under consideration.

5.3.3 Testing for bias

The unbiasedness hypothesis tests whether the parameters α and β in Equation (4.11) are equal to zero and one respectively and that the futures price is an unbiased estimate of the future spot price. As mentioned by Wiseman (1999:62) and Brenner and Kroner (1995:34), when dealing with two I(1) series in the co-integration regression, there is no direct way to carry out this test and thus implies that an alternative approach be used. Following Aulton *et al* (1997:420), to test for unbiasedness, the conditions $a = 0$ and $b_0 = 1$ can be imposed on Equation (5.4) and the estimated residual series [taken as simply the difference between the spot and futures price series in Equation (5.4)] is then tested for stationarity using the conventional ADF and PP procedures. If the relationship between the price series is unbiased, the residual series will be I(0).

$$Sp_t - b_0 Fp_t = (a + u_t) = \hat{e}_t \tag{5.4}$$

Table 5.6 reports the results from the ADF and PP unit root tests on the different residual variables.

Table 5.6: Tests for unbiasedness in the white maize market

Futures series	Subsequent spot series	ADF test statistic	PP test statistic	Reject H_0: unit root[1]
$Fp_{15\ CCA}$	$Sp_{exp\ CCA}$	-5.24**	-6.38**	Yes
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	-4.16**	-5.24**	Yes
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	-5.02**	-5.75**	Yes

[1]Critical value = -3.90 (Davidson and MacKinnon, 1993:722)
** Significant at 1% level of significance

The ADF and PP statistics rejected the null hypothesis of a unit root in the case of all three residual variables indicating that they are I(0) and stationary. This implies that, for the white maize CCA, the futures price 15 days prior to contract expiry is an unbiased estimate of the spot price on the day of expiration. This is also true for the 15 day as well as the 35 day lagged futures price analysed in the PCA. The focus will now turn to the yellow maize market where the same procedure was applied to yellow maize spot and futures prices in order to test for market efficiency.

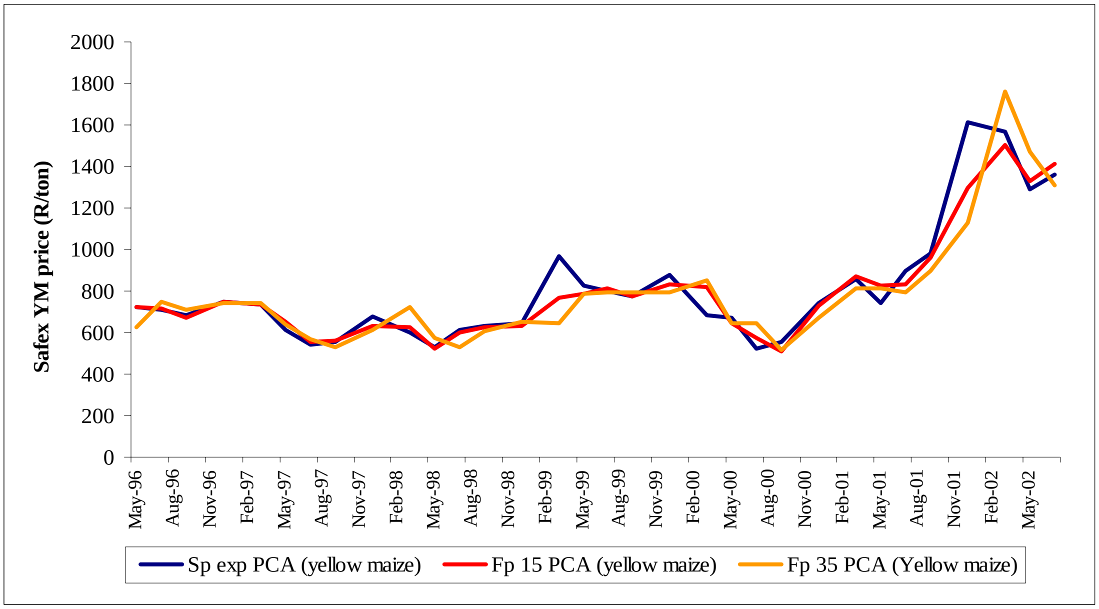
5.4 Yellow maize results

This section presents the results of the intertemporal market efficiency tests for yellow maize.

5.4.1 Stationarity tests

The yellow maize market was tested on the same basis as the white maize market in the sense that the data only included the primary contracts for the first set of tests (PCA), where after both primary and constant month contracts that occurred over the observation period were included in the constant contracts analysis (CCA). Table 5.7 reports the unit root test results conducted for the primary contracts analysis while Figure 5.6 shows three variables under consideration.

Figure 5.6: Yellow maize PCA price variables



Source: Safex, 2003

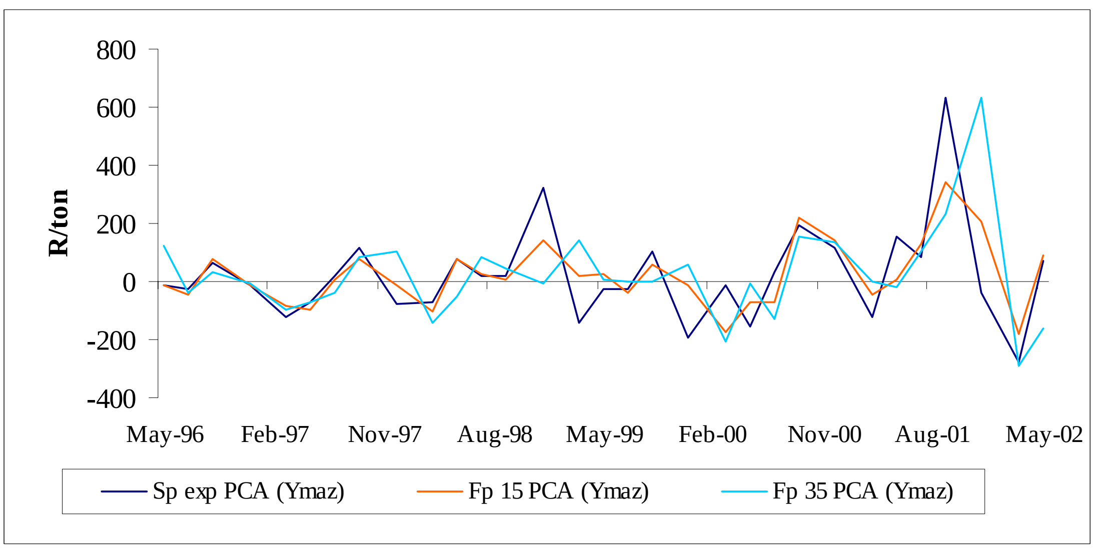
Table 5.7: Yellow maize PCA: results of the ADF and PP unit root tests

Variable	No of observations (n)	ADF test statistic[4]	PP test statistic[5]	First difference I(1)	
				ADF-test	PP-test
$Sp_{exp\ PCA}$[1]	30	-1.05	-1.06	-4.31**	-5.61**
$Fp_{15\ PCA}$[2]	30	-0.92	-0.47	-4.54**	-4.34**
$Fp_{35\ PCA}$[3]	30	-1.17	-1.08	-4.12**	-5.06**

[1] Yellow maize spot price variable (PCA)
[2] Yellow maize futures price variable at 15 days lag from contract expiry (PCA)
[3] Yellow maize futures price variable at 35 days lag from contract expiry (PCA)
[4] MacKinnon critical ADF-value at 1% level of significance = -3.67
[5] MacKinnon critical PP-value at 1% level of significance = -3.66
** Significant at 1% level of significance

The calculated ADF and PP statistics failed to reject the null hypothesis of a unit root in all three cases but reject the hypothesis in the first differences implying that they are all non-stationary and that the futures price variables at both 15 and 35 day lag can be tested for co-integration. The first differences of the three considered variables (also reported and tested in Table 5.7) are shown in Figure 5.7.

Figure 5.7: Yellow maize PCA price variables (1st differences)



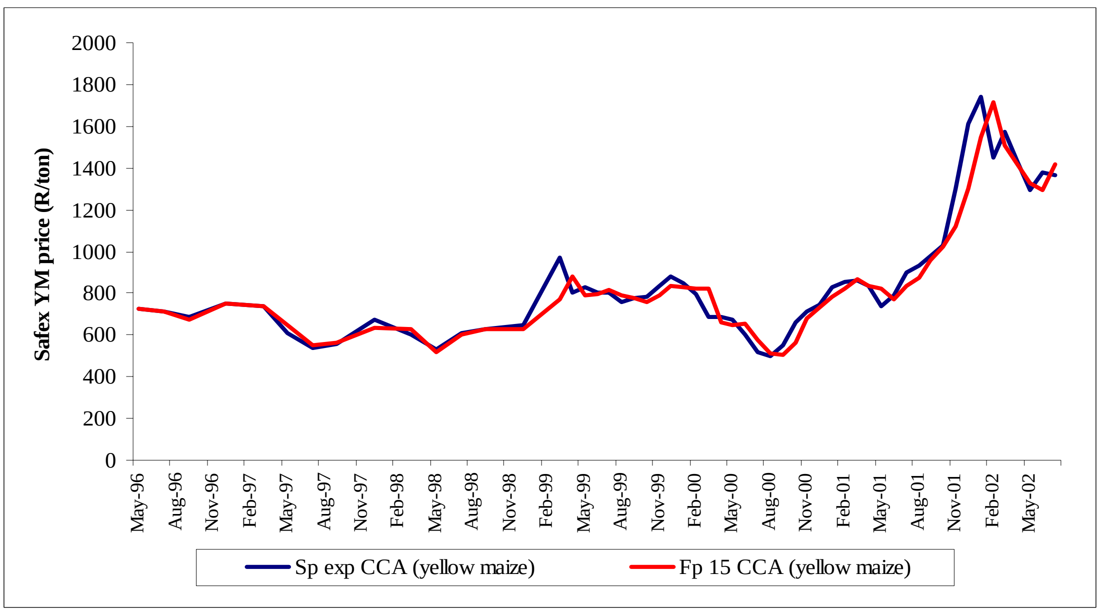
Unit root tests were also conducted on the futures and spot price variables for the CCA. As in the case of white maize, the futures price cannot be lagged for more than a month as the data of the constant month contracts would overlap. Results are shown in Table 5.8 with the two variables plotted in Figure 5.8. Both variables, when tested, were found to be non-stationary. The null hypothesis was only rejected after taking the first differences in both cases indicating that the series contain unit roots. The first differences of the two variables are shown in Figure 5.9 and are indicative that they are I(1) stationary.

Table 5.8: Yellow maize CCA: results of the ADF and PP unit root tests

Variable	No. of observations (n)	ADF test Statistic[3]	PP test statistic[4]	First difference I(1)	
				ADF-test	PP-test
$Sp_{exp\ CCA}$[1]	53	-1.06	-0.99	-5.15**	-6.56**
$Fp_{15\ CCA}$[2]	53	-0.96	-0.72	-5.11**	-5.20**

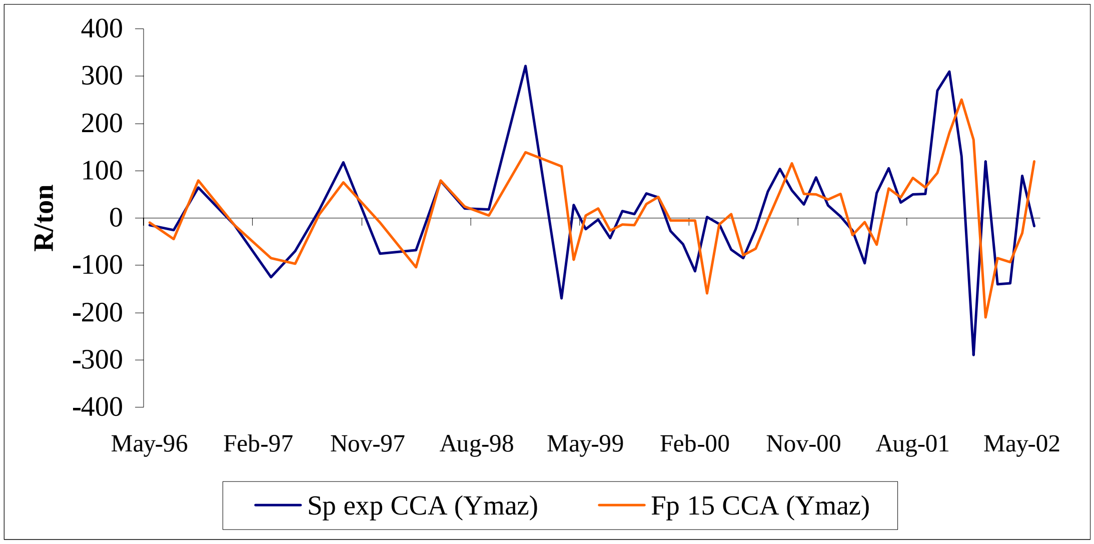
[1] Yellow maize spot price variable (CCA)
[2] Yellow maize futures price variable at 15 days lag from contract expiry (CCA)
[3] MacKinnon critical ADF-value at 1% level of significance = -3.56
[4] MacKinnon critical PP-value at 1% level of significance = -3.55
** Significant at 1% level of significance

Figure 5.8: Yellow maize CCA price variables



Source: Safex, 2003

Figure 5.9: Yellow maize CCA price variables (1st differences)



5.4.2 Co-integration results

The first stage of efficiency testing involved the futures price series and their subsequent spot price series, constructed as described in section 5.2. These were tested for co-integration, while the level of influence of lagged futures and spot prices on the future spot price was evaluated in the second stage. The co-integrating regression results and estimated coefficients are shown in Table 5.9 and the respective co-integration relations shown in Figure 5.10, Panels A to C.

The regressions (Table 5.9) provided relatively significant results. All three slope coefficients tend to be in the region of unity while the intercepts are relatively close to zero. These results are not significant proof of no bias, although this hypothesis was formally tested in section 5.4.3. Likelihood ratios were calculated for the three co-integrations shown in Table 5.9 and were found to be 9.02 (0.3406), 5.14 (0.7425), and 10.28 (0.2459) respectively suggesting that the null hypothesis in favour of a lag length of 2 would not be rejected in all of the three cases.

Figure 5.10: Yellow maize co-integration relations

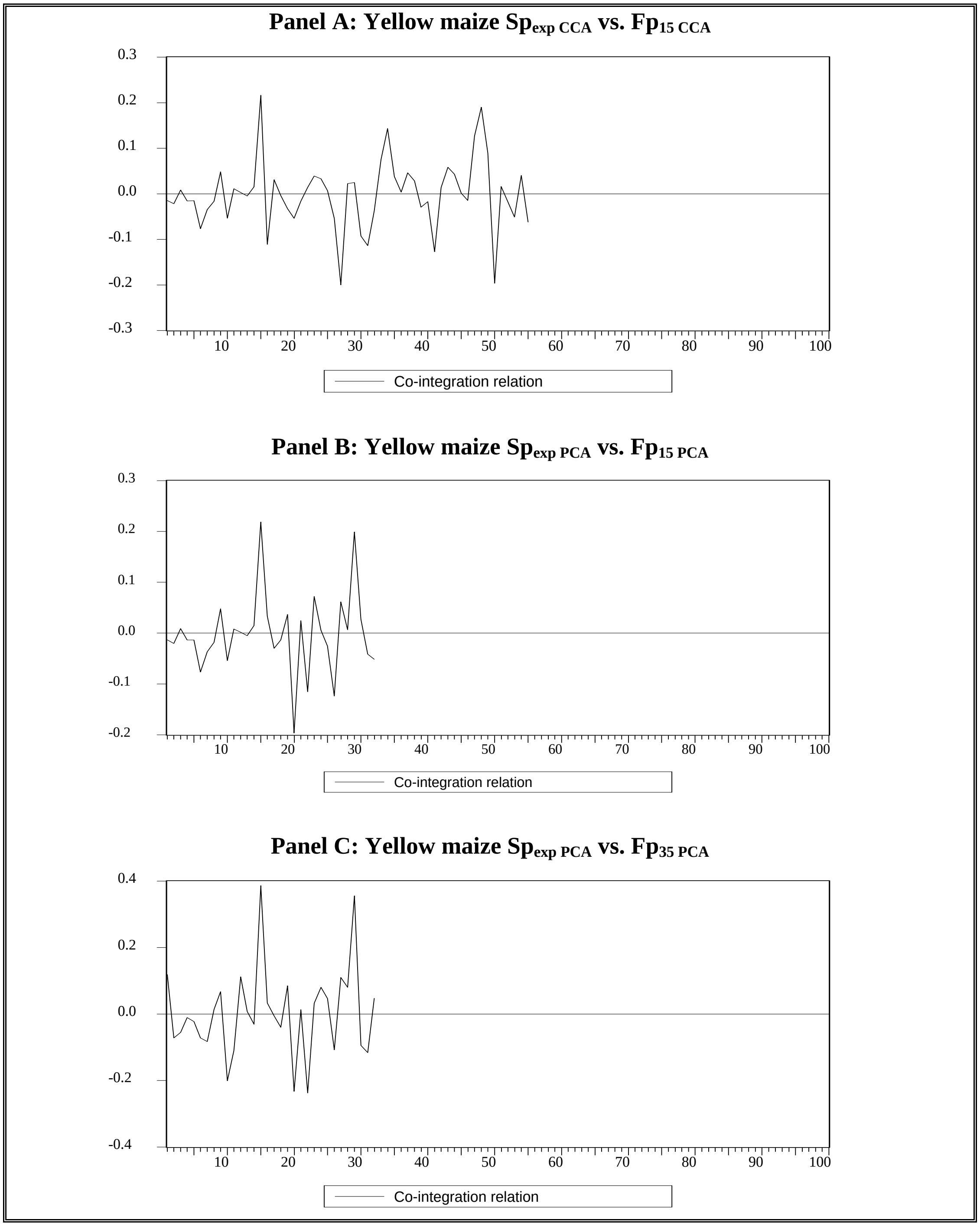


Table 5.9: Co-integrating regressions for yellow maize

DV[1]	IV[2]	Coefficient	Constant	R^2	DW[3]
$Sp_{exp\ CCA}$	$Fp_{15\ CCA}$	-1.0155 (0.0089)[#]	0.0874	0.9397	1.7679
$Sp_{exp\ PCA}$	$Fp_{15\ PCA}$	-1.002 (0.0478)	-0.0003	0.9332	2.1215
$Sp_{exp\ PCA}$	$Fp_{35\ PCA}$	-0.9568 (0.0713)	-0.3034	0.7959	2.0734

[1] Dependent variable
[2] Independent variable
[3] Durbin-Watson statistic
[#] Standard error of slope coefficient

The co-integration tests delivered mixed results as can be seen in Table 5.10. The $Fp_{1\ all}$ and its subsequent $Sp_{exp\ CCA}$ spot series were found to be co-integrated at the one percent level of significance indicating that there is a long-run relationship between them. However, co-integration tests between the $Fp_{15\ PCA}$ and $Sp_{exp\ PCA}$ and $Fp_{35\ PCA}$ and $Sp_{exp\ PCA}$ provided less significant results and were unable to reject the null of no co-integration in both cases. This may be indicative of the important role that the introduction of constant month contracts play in terms of market efficiency.

Table 5.10: Co-integration results for yellow maize

Futures series	Subsequent spot series	Likelihood ratio	Critical value[1]	Reject H_0: no co-integration
$Fp_{15\ CCA}$	$Sp_{exp\ CCA}$	55.86**	20.04	Yes
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	11.97	20.04	No
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	11.66	20.04	No

[1] Critical value at 1 % level of significance = 20.04
** Significant at 1 % level of significance

As described in the white maize section, it was now appropriate to proceed with the second stage of efficiency testing. Using Equation (5.2) the calculated F-values and their respective critical values were obtained and reported in Table 5.11. Although not found to be efficient in the first stage, the $Fp_{15\ PCA}$ and $Fp_{35\ PCA}$ variables are included in the second stage of testing in order to evaluate whether information of lagged futures and spot prices causes the market to be inefficient.

Table 5.11: Second stage efficiency tests for yellow maize

Futures series	Subsequent spot series	Calculated F-value[1]	$F_{k2, n-k, \alpha}$[2]
$Fp_{15\ CCA}$	$Sp_{exp\ CCA}$	5.10**	5.08
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	4.83	5.49
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	1.97	5.49

[1] Indicated through Equation (5.2)
[2] $\alpha = 0.01$
** Significant at 1 % level of significance

Results for the PCA showed that the calculated F-values failed to reject the joint null hypothesis that $B_1 = \phi = 0$ in the unrestricted equation as shown in Equation (4.28). These results suggest that for the market including only primary contracts, the lagged spot and futures price contain no additional information to predict the future spot price. The spot price in the future might be influenced randomly by the lagged futures and spot prices, either in a positive or negative direction, but not in a specific trend. The null hypothesis, however, was rejected in the case of the CCA indicating a failure to assume market efficiency in the second stage of testing. Interestingly this result was very similar to that of the white maize market.

5.4.3 Testing for bias

Following the procedure described in section 5.3.3, the conditions for unbiasedness ($a = 0$ and $b_0 = 1$) were imposed on Equation (5.4) and the residual series was calculated for each of the three futures price series and their subsequent spot price series. The results of the stationarity tests conducted on the different residual series are reported in Table 5.12.

Table 5.12: Tests for unbiasedness in the yellow maize market

Futures series	Subsequent spot series	ADF test statistic	PP test statistic	Reject H_0: unit root[1]
$Fp_{15\ CCA}$	$Sp_{exp\ CCA}$	-5.39**	-6.31**	Yes
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	-3.35*	-5.61**	Yes
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	-4.12**	-5.99**	Yes

[1]Critical value = -3.90 (Davidson and MacKinnon, 1993:722)
** Significant at a 1 % level of significance
* Significant at a 5 % level of significance

All three residual variables successfully rejected the null hypothesis of a unit root and were found to be stationary. In all three cases the futures price is an unbiased estimate of the future spot price and the markets show all the signs of being efficient.

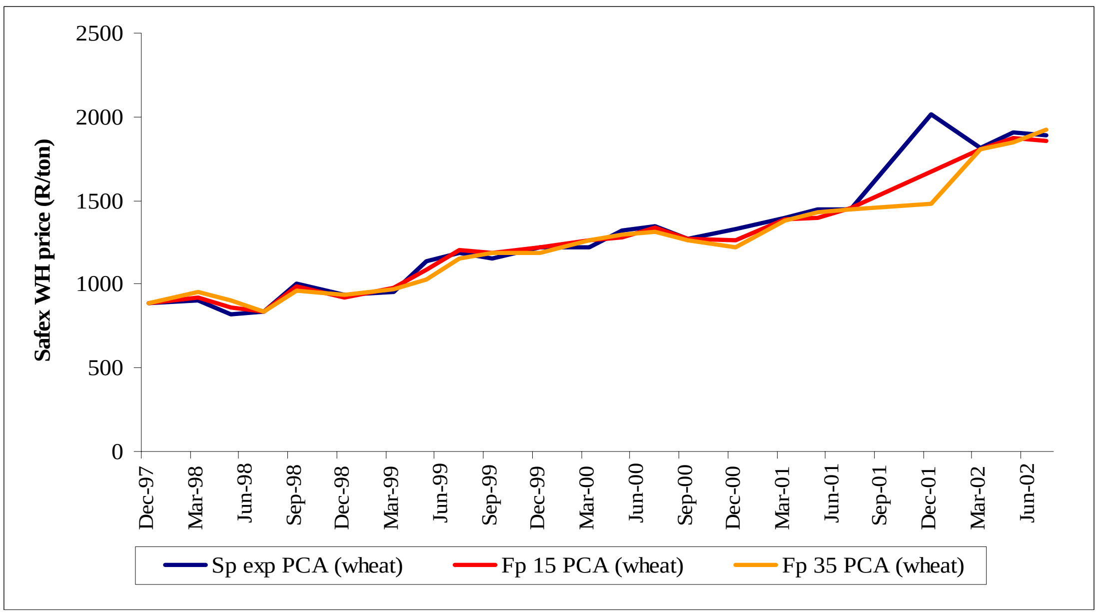
5.5 Wheat results

This section presents the results for the intertemporal market efficiency tests for wheat.

5.5.1 Stationarity tests

The wheat market only consists of the five primary contracts traded each year, as mentioned in section 5.2. As a result of this, only a primary contracts analysis (PCA) could be performed with the futures price lagged for 15 and 35 days respectively on the spot price taken at contract expiration. The results of the ADF and PP unit root tests for the three variables under consideration are reported in Table 5.13 and the variables shown in Figure 5.11.

Figure 5.11: Wheat PCA price variables



Source: Safex, 2003

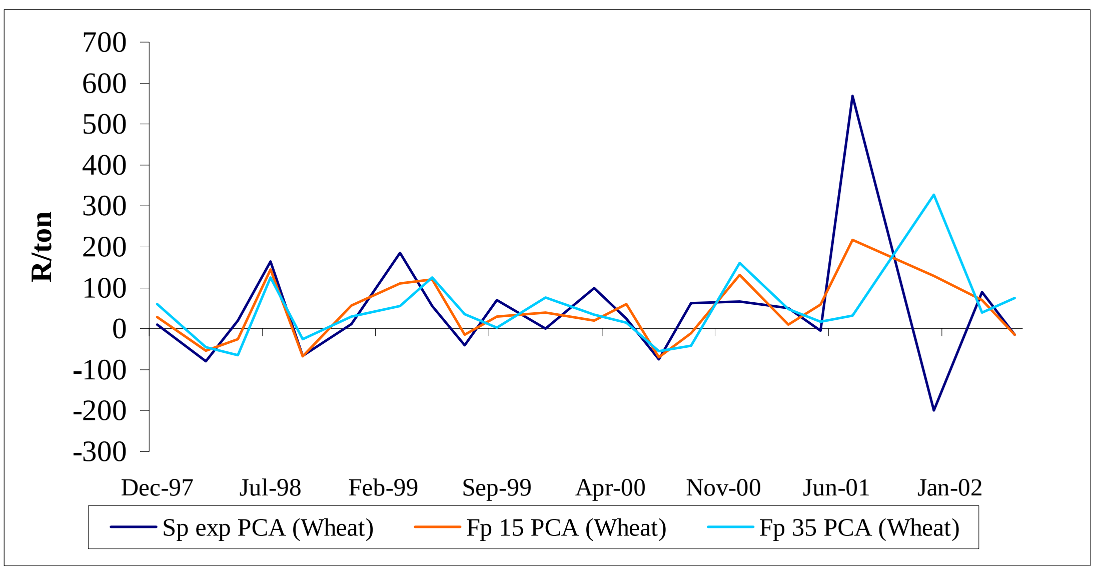
Table 5.13: Results of wheat unit root tests

Variable	No of observations (n)	ADF test statistic[4]	PP test statistic[5]	First difference I(1)	
				ADF-test	PP-test
$Sp_{exp\ PCA}$ [1]	21	-0.12	-0.11	-5.27**	-7.11**
$Fp_{15\ PCA}$ [2]	21	0.16	0.2	-4.24**	-4.98**
$Fp_{35\ PCA}$ [3]	21	0.64	0.63	-4.10**	-5.16**

[1] Wheat spot price variable (PCA)
[2] Wheat futures price variable at 15 days lag from contract expiry (PCA)
[3] Wheat futures price variable at 35 days lag from contract expiry (PCA)
[4] MacKinnon critical ADF-value at 1% level of significance = -3.67
[5] MacKinnon critical PP-value at 1% level of significance = -3.66
** Significant at 1% level of significance

The calculated ADF and PP test statistics failed to reject the null hypothesis of a unit root in all three cases and reject the null hypothesis in the first differences indicating that they are all I(1) and non-stationary series (see Figure 5.12). The relatively low calculated ADF-statistics for both futures price variables indicate strong trends in the data and are consistent with the significant increase in wheat prices over the observed period. The results justify the use of all three series for the co-integration procedure explained in the following section.

Figure 5.12: Wheat PCA price variables (1st differences)



5.5.2 Co-integration results

The results from the co-integrating regressions are presented in Table 5.14. In order for the futures price to be an unbiased estimate of the future spot price, the requirements for unbiasedness (intercept = 0, slope = 1) must be evident in the results from the co-integrating regressions.

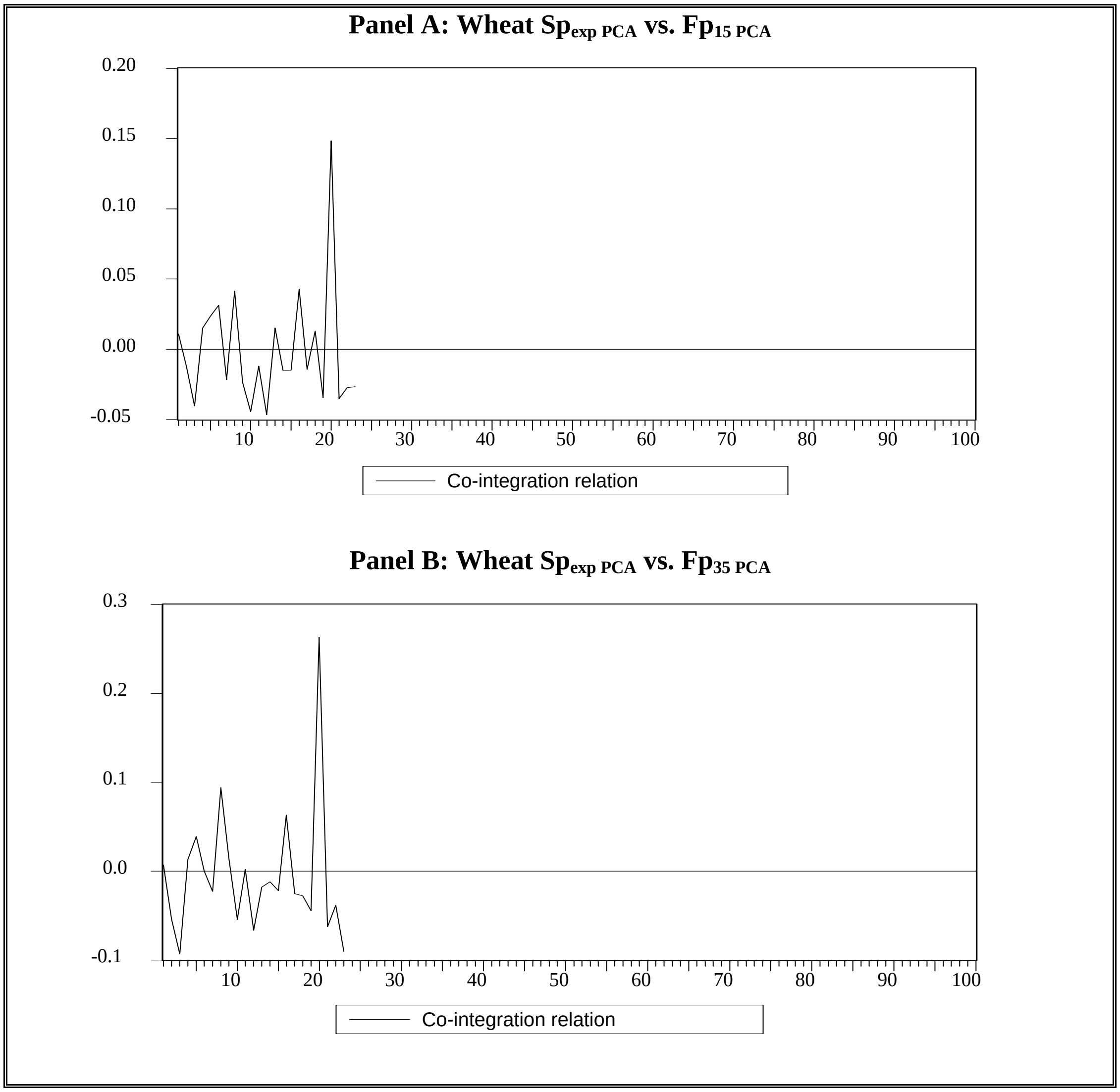
Table 5.14: Co-integrating regressions for wheat

DV[1]	IV[2]	Coefficient	Constant	R^2	DW[3]
$\mathbf{Sp_{exp\ PCA}}$	$Fp_{15\ PCA}$	-1.0728 (0.0267)[#]	-0.5053	0.9747	2.5289
$\mathbf{Sp_{exp\ PCA}}$	$Fp_{35\ PCA}$	-1.1063 (0.0289)	-0.7289	0.9236	2.2476

[1] Dependent variable
[2] Independent variable
[3] Durbin-Watson statistic
[#] Standard error of slope coefficient

The results from the regressions show that the slope coefficients tended to be in the region of unity, although the constant values were not close to zero and may be indicative of bias. Although the unbiasedness hypothesis was only formally tested in the following section, the figures should be viewed as only a possible indication of unbiasedness. The high R^2-values indicate that a relatively large portion of the variation in the spot price is explained by the variation in the futures price. Lag tests were in favour of a lag length of 2 with calculated LR-values of 9.0 (0.3423) and 7.4 (0.4942) respectively for the two co-integrations shown in Table 5.15.

Figure 5.13: Wheat co-integration relations



Co-integration results, as part of the first stage of efficiency testing, are reported in Table 5.15. Results from the wheat co-integration tests were less significant than that of white and yellow maize. The null hypothesis of no co-integration was not rejected for the futures variable lagged at 15 days, while for the 35 day lagged variable, the null hypothesis was only rejected at a five percent level of significance. This is indicative of a co-integration relation between the futures price at a "two month" lag and the subsequent spot price variable and that they show a long-run relationship, although not highly significant. The results from the second stage of testing for efficiency in the wheat market are shown in Table 5.16. F-values were calculated and compared with the F critical values as described in section 5.3.2.

Table 5.15: Co-integration results for the wheat market

Futures series	Subsequent spot series	Likelihood ratio	Critical value[1]	Reject H_0: no co-integration
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	7.97	20.04	No
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	15.49*	20.04	Yes

[1] Critical value at 1 % level of significance = 20.04
***** Significant at 5 % level of significance (critical value = 15.41)

The calculated F-values (Table 5.16) proved to be low and were unable to reject the null hypothesis that $B_1 = \phi = 0$ [Equation (4.28)]. The results suggest that past wheat price information does not have a significant effect on the current spot price. Apart from the fact that the futures price at a 1-month lag was not co-integrated with the spot price, the results may suggest that there is some degree of efficiency 15 days prior to contract expiry and that the futures price, at this point in time, embodies all publicly available information for the prediction of the future spot price.

Table 5.16: Second stage efficiency tests for wheat

Futures series	Subsequent spot series	Calculated F-value[1]	$F_{k2, n-k, \alpha}$[2]
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	2.36	6.01
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	0.32	6.01

[1] Indicated through Equation (5.1)
[2] $\alpha = 0.01$

5.5.3 Testing for bias

The two residual series were calculated and tested for stationarity as explained in section 5.3.3. Results are reported in Table 5.17.

Table 5.17: Tests for unbiasedness in the wheat market

Futures series	Subsequent spot series	ADF test statistic	PP test statistic	Reject H_0: Unit root
$Fp_{15\ PCA}$	$Sp_{exp\ PCA}$	-2.72***	-4.88**	Yes
$Fp_{35\ PCA}$	$Sp_{exp\ PCA}$	-3.13*	-4.54**	Yes

** Significant at a 1 % level of significance
* Significant at a 5 % level of significance
*** Significant at a 10 % level of significance

The ADF statistic for the 2-month lagged futures price rejected the null hypothesis of a unit root indicating that the residual series is stationary and that there is an unbiased relationship between the lagged futures price and the spot price at maturity. However, the 1-month lagged futures price was found to be a biased estimate of the future spot price with a non-stationary residual series. At a ten percent level of significance, the null hypothesis of a unit root was rejected and places some question on the extent to which the market is biased in this specific case. This result is supported by the results from the co-integrating regression in Table 5.14 where the intercept coefficient of the Fp_{15}/Sp_{exp} regression is relatively far from zero indicating some degree of bias in the market at a 1-month lagged futures price. From the results it can be inferred that the market is unbiased and the lagged futures price, both at 1- and 2-months, is an unbiased estimate of the future spot price.

5.6 Results from cross-sectional efficiency tests

Testing the futures market for cross-sectional efficiency is an interesting and important aspect of the functioning of the futures market between different commodities. Of course, there are special relationships between different commodities traded on the same futures market. For example, market factors such as the weather will have similar effects on two summer crops traded on the same futures market. However, the EMH states that information gathered from one market is useless in predicting prices in another market, and cannot be used to exploit a profitable opportunity. As mentioned in section 5.2, white maize and yellow maize are two such commodities traded on the JSE APD that will be tested for cross-sectional efficiency. The variables to be used for the tests are the spot price variables from the constant contracts analyses and the primary contracts analyses used in the respective white and yellow maize co-integration tests.

5.6.1 Stationarity tests

In the case of white maize, the two spot price variables ($Sp_{exp\ PCA}$ and $Sp_{exp\ CCA}$) are both non-stationary as tested in section 5.3 and results are shown in Tables 5.1 and 5.2. The yellow maize unit root tests for the applicable variables yielded similar results as shown in Tables 5.7 and 5.8. All the variables are I(1) and can be used in the co-integration model.

5.6.2 Co-integration results

Bivariate co-integration analysis, as in the case of the intertemporal efficiency testing, are performed separately for the data including and excluding the constant month contract data and will be referred to as the CCA and PCA analysis respectively. This is done in order to evaluate the significance of the presence of constant month contracts in terms of market efficiency. Figures 5.14 and 5.15 show the relationship (R/ton) between the white and yellow maize variables for the CCA and PCA co-integrations respectively. Results are presented in Table 5.18.

Figure 5.14: White and yellow maize CCA cross-sectional spot price variables

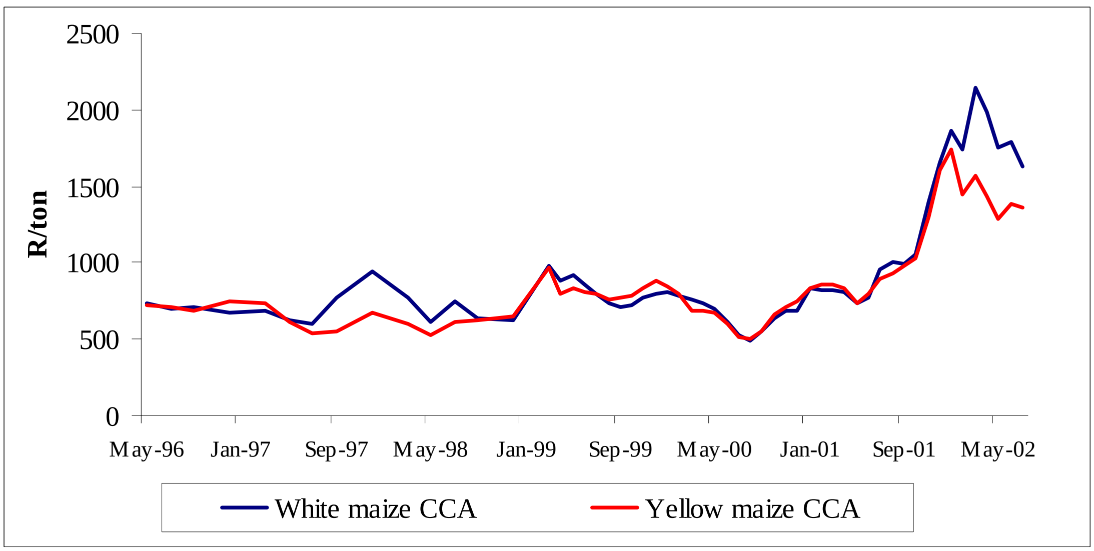
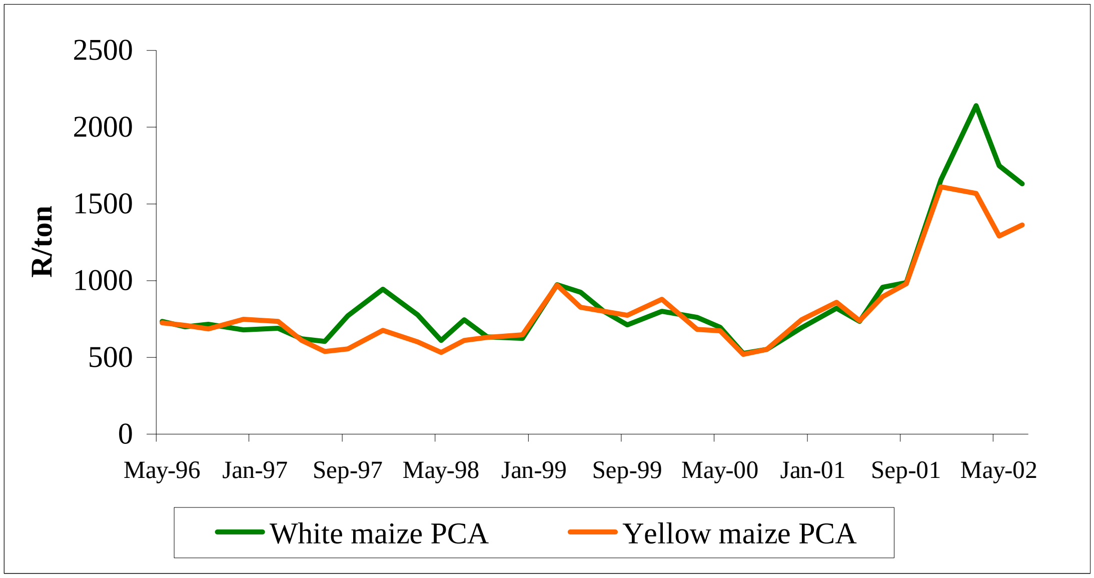


Figure 5.15: White and yellow maize PCA cross-sectional spot price variables



Results from lag tests suggested the use of a lag length of 2. In both cases the null hypotheses were not rejected and critical LR-values were calculated as 13.48 (0.0964) and 5.60 (0.6919) respectively for the co-integrations shown in Table 5.18

Results show that there are no co-integrations between the spot prices of white and yellow maize for both the CCA and PCA. In both cases the tests failed to reject the null hypothesis of no co-integration and suggest that a long-run relationship does not exist between the spot prices of white and yellow maize.

Table 5.18: Cross-sectional co-integration results

Analysis	Likelihood ratio	Critical value	Reject H_0: no co-integration
CCA	13.29	20.04	No
PCA	5.25	20.04	No

The results favour the conclusion of cross-sectional market efficiency as a relationship between prices of different markets would imply a direct violation of the EMH. Results from the co-integration regressions are shown in Table 5.19 and the co-integration relations shown in Figure 5.16. Following the methodology for cross-sectional efficiency used by Yang and Leatham (1998), bias tests are not performed in a cross-market approach.

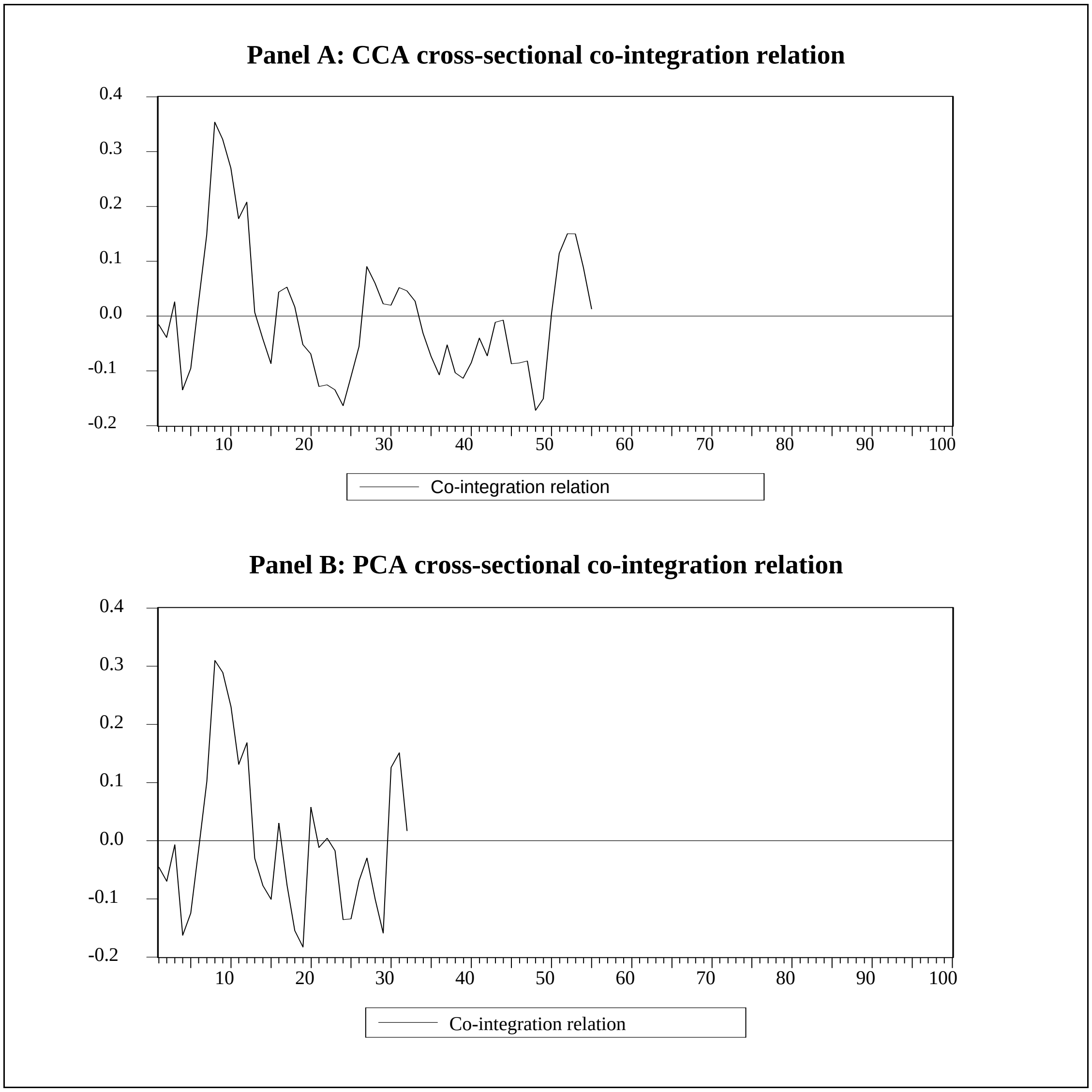
Table 5.19: Cross-sectional co-integrating regressions

DV[1]	IV[2]	Coefficient	Constant	R^2	DW[3]
WM $Sp_{exp\ CCA}$	**YM $Sp_{exp\ CCA}$**	-1.215 (0.1015)[#]	-0.1.3869	0.8996	0.3897
WM $Sp_{exp\ PCA}$	**YM $Sp_{exp\ PCA}$**	-1.1615 (0.2498)	-1.0039	0.8583	0.6870

[1] Dependent variable
[2] Independent variable
[3] Durbin-Watson statistic
[#] Standard error of slope coefficient

Testing for cross-sectional efficiency was not considered between wheat spot prices and the two respective maize markets mainly because of two reasons. Firstly, wheat futures were only introduced some time after white and yellow maize futures making it more difficult to compare the datasets and, secondly, wheat futures only traded primary contracts over the observation period compared to the constant month contracts introduced to the white and yellow maize futures markets.

Figure 5.16: White and yellow maize CCA and PCA cross-sectional co-integration relations



5.7 Summary

5.7.1 Intertemporal efficiency

In order for any futures market to play a role in risk management and price stabilisation, it must be efficient and preferably unbiased. In this chapter the relative efficiency of the white and yellow maize, and wheat futures markets were tested. The model for testing included three steps: first, testing the different futures and spot price time series for non-stationarity; second, testing whether a long-run relationship exists between subsequent futures and the spot price variables; and lastly, testing whether the different markets are unbiased. To some degree the model follows the methodology used by Wiseman (1999) who also tested the South African white and yellow maize markets for efficiency. However, differences in the way the data were constructed clearly yielded different results compared to Wiseman's 1999 study.

In the analysis of the two maize markets, two sets of data were distinguished: the data set excluding the constant month contracts ("primary contracts analysis"), and the set including the constant month contracts ("constant contracts analysis") traded over the period under consideration. This was done primarily to evaluate the effect the constant month contracts (first introduced in 1999) had on the overall efficiency of the market in comparison with only the primary contracts in use. For the primary contracts model the futures price was lagged for 15 and 35 days (one and two months) respectively from the spot price series taken at the day of contract expiry of each contract. In addition, for the model including the constant month contracts, the futures price was lagged with 15 days (one month) only due to possible informational overlap caused by subsequent month contracts. Analyses for white and yellow maize were conducted on a separate basis.

In the wheat market only five primary contracts are traded annually and constant month contracts have not been introduced to the market to date. The futures price was, therefore, lagged one and two months respectively and the spot prices taken at contract expiration of each contract over the period under consideration.

The white maize analysis yielded relatively significant results and overall results suggest that the market is both efficient and unbiased. Results are summarised in Table 5.20.

Table 5.20: Summarised results from the white maize market model

	CCA[1] spot	CCA 15 days	PCA [2] spot	PCA 15 days	PCA 35 days
Non-Stationary?	Yes	Yes	Yes	Yes	Yes
Co-integrated?	n/a	Yes	n/a	No	Yes
2nd Stage efficient?	n/a	No	n/a	Yes	Yes
Unbiased?	n/a	Yes	n/a	Yes	Yes

[1] Constant Contracts Analysis
[2] Primary Contracts Analysis

In order to apply co-integration tests, the series should be non-stationary. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were used to perform the necessary procedure. All variables were found to contain a unit root and could be used in the co-integration model. Co-integration results were significant except in the case of the 15 days PCA. This result could be attributed to a more volatile futures price as trading enters its last month of each contract. Daily price limits are suspended and funds usually either close out, or positions are "rolled over" to other contract months to avoid the risk of higher volatility of the expiration month. The net effect of this may tend to affect the relationship between the futures price and the future spot price specifically at a 15 day (one month) lag in such a way that a long-run relationship would not exist.

The second stage efficiency testing also showed successful results, except in the case of the CCA where the lagged spot and futures price were found to be a function of the future spot price and is contradictory to the EMH. Testing whether there is an unbiased relationship between the futures and spot prices also proved to be successful in favour of unbiasedness in both the PCA cases as well as for the CCA. This suggests that the futures price (at each of the lagged points in time under consideration) is an unbiased estimate of the future spot price.

Interesting to note are the significant results in the case of the PCA 35 day lagged futures price. These show that the market is efficient at a two-month (35 day) lag in terms of all the tests performed. The yellow maize market provided similar successful results shown in Table 5.21.

Table 5.21: Summarised results from the yellow maize market model

	CCA spot	CCA 15 days	PCA spot	PCA 15 days	PCA 35 days
Non-Stationary?	Yes	Yes	Yes	Yes	Yes
Co-integrated?	n/a	Yes	n/a	No	No
2nd Stage efficient?	n/a	No	n/a	Yes	Yes
Unbiased?	n/a	Yes	n/a	Yes	Yes

Co-integration results, however, were less significant in the case of the PCA and failed to reject the null hypothesis of no co-integration for both lagged futures price variables. The same was true for the CCA for the second stage efficiency test. However, results suggest that the market operates in an unbiased fashion for both the CCA and the PCA. All available information to the market is, therefore, absorbed instantaneously and reflected in the futures price that, in addition, is an unbiased estimate of the future spot price at contract maturity.

The introduction of the constant month contracts does in fact tend to improve the efficiency of both the white and yellow maize futures markets. This assumption is made in the light of the relatively large calculated likelihood ratios (WM = 28.39, YM = 55.86) resulting in a strong rejection of the null hypothesis of no co-integration. In both markets the CCA showed that the futures prices, 15 days prior to contract maturity, are both efficient and unbiased estimates of the future spot price the day the contract expires. In contrast, the PCA produced very mixed co-integration results for both white and yellow maize. Overall, white maize results (yes = 12, no = 2) turned out to be more in favour of the EMH than that of the yellow maize analysis (yes = 11, no = 3). Although this is not an indication that the white maize market functions more efficiently than the yellow market, such a result could be expected from a highly liquid white maize market in terms of volumes traded compared to a significantly less liquid yellow maize market.

Promising results were also obtained from the wheat market analysis. All three variables tested were found to be non-stationary as necessary for co-integration analysis (results shown in Table 5.22).

Table 5.22: Summarised results from the wheat market model

	CCA spot	CCA 15 days	PCA spot	PCA 15 days	PCA 35 days
Non-Stationary?	n/a	n/a	Yes	Yes	Yes
Co-integrated?	n/a	n/a		No	Yes
2nd Stage efficient?	n/a	n/a		Yes	Yes
Unbiased?	n/a	n/a		Yes	Yes

At a 15-day lag the futures price is, however, not co-integrated with the future spot price. Co-integration was found between the 35-day lagged futures price and the spot price variable, although not highly significant. This weak relationship can possibly be attributed to the relatively short existence of the wheat futures market in comparison with the more mature white and yellow maize futures markets. The remaining tests for efficiency showed that the wheat market does comply with the necessary conditions of the EMH.

Results for white and yellow maize showed an improvement on the results from relatively similar tests performed by Wiseman in his 1999 study. However, although using similar methodology, it was applied to differently constructed sets of futures time series. In his study, Wiseman identified two year (annual) contracts, July 1997 and July 1998 for both white and yellow maize. "The July contract is the most appropriate year contract as it represents the start of the harvesting, and farmers, millers and traders would need to decide what action to take with maize orders from this time on for the year ahead. As a result, this is a fairly well traded contract month on Safex in terms of contract volumes" (Wiseman, 1999: 41). Daily futures closing prices and corresponding spot market prices were used to test for a long-run relationship and unbiasedness. Also mentioned by Wiseman *et al* (1999:374), a continuous and accurate spot price was difficult to identify partly because no established price reporting system was available at the time of the study. Daily estimated average prices were used as reported by some major role players in the market. Apart from the year contracts (July 1997 and July 1998) used by Wiseman in his analyses, three-month period contracts were also tested for co-integration assuming that "the relationship between the two price series will likely become stronger as the contract nears maturity date because more information is available to participants" (Wiseman, 1999:41). The three-month period contract consisted of the last three months traded of each of the two year contracts namely July 1997 and July 1998. Therefore, a key difference of the model used in this study is that it considers all contract months traded over the sampling period (as shown in section 5.2) whereas Wiseman concentrated on specific contract months only possibly because of the limited amount of futures price data available at the time of his study.

Wiseman's results suggested that, for yellow maize, there was evidence of co-integration in the three-month 1997 contract and in both the 1998 contracts. In addition, for white maize co-integration was found in both the 1998 contracts but not in the two 1997 contracts. Wiseman concluded that his results reflected the fact that yellow maize was traded internationally to a greater extent than white maize and that it was more susceptible to the world market price fluctuations and exchange rates. Biasedness, in contrast with results found in this study, was a problem in the Wiseman model and a violation of the EMH in that it suggested that past spot prices provided information that could have been used to predict current spot prices at the time, thus offering participants the opportunity of making abnormal profits.

Although the model provided a good indication of the functioning of the July contract in different years, it does not consider the efficiency of the futures market over time and take into consideration the functioning of different contract months. However, due to a possible lack of sufficient data at that point in time, Wiseman could not apply the model to the whole market and was forced to concentrate on specific single contract months in order to have a sufficient number of observations in the respective time series.

A further possible factor influencing Wiseman's results was the relatively short existence of the maize futures markets at the time the study was conducted. Trading volume gradually increased as market participants gained confidence in using the futures market. This reflected heavily on the weak results from the 1997 contracts. Bailey (2000:89) shows that trading volume and open interest literally exploded from December 1997 and contributed to the improvement of the functioning of the July 1998 contracts evaluated by Wiseman.

5.7.2 Cross-sectional efficiency

Results from the co-integration tests indicated an efficient relationship between the white and yellow maize markets. The finding of no co-integration across the two markets provides evidence that it would not be possible to exploit the relationship between the spot prices of white and yellow maize and speculate profitably across them. Copeland (1991:190) showed that, although possible to profit from cross-sectionally efficient markets in the short run, no-co-integration between spot markets imply efficiency over the long-run. As the white and yellow maize futures markets are closely related in terms of the different market factors determining the price of maize (as a summer crop and in the South African context) cross-market efficiency is a very important result for the efficient functioning of the South African agricultural futures market.

Results in favour of the weak-form intertemporal and cross-sectional efficiency suggest the market functioned as it should over the long term. Would market participants be able to exploit opportunities over the short and medium-term profitable taking into consideration results found in this chapter? Chapter 6 provides an overview of anomalies in futures price returns and possible evidence of their existence in the South African white maize, yellow maize and wheat futures markets.

Chapter 6

FUTURES PRICE RETURN EFFECTS

6.1 Introduction

Price behaviour in commodity futures markets has been the focus of numerous economic investigations and, in general, most of the evidence is consistent with random behaviour in futures prices (Cornett and Trevino, 1989:87) which is, in turn, consistent with the efficient markets hypothesis (EMH). In Chapter 5, agricultural commodity futures prices that were realised on the JSE Agricultural Products Division were investigated, results of which showed support for the weak-form market efficiency in the long run. This market characteristic implies that no excess profit opportunities exist for speculators as all new information is absorbed instantly and efficiently. The question arises whether anomalous price behaviour can be evident in a market of this nature. Evidence of predictable return patterns or strong seasonal components would, according to Jegadeesh (1990:897), imply an anomalous departure from the EMH. Would it be possible that a market, tested as being efficient in the long run, could present predictable returns over the short- to medium run?

This chapter is organised as follows. Section 6.2 presents an overview of different market anomalies with evidence of their existence in commodity futures markets and other securities with section 6.3 identifying the possible determinants of these effects. A description of the data and procedure of the analyses is addressed in section 6.4 results are presented in section 6.5 followed by an interpretation of results and concluding remarks in section 6.6.

6.2 Common effects and return anomalies

Lakonishok and Smidt (1988:403) noted that, in the few years immediately preceding their publication, there had been a proliferation of empirical studies documenting unexpected or anomalous irregularities in security rates of return. These generally include seasonal irregularities related to the time of day, the day of the week, the time of the month, and the time of the year. Several forms of anomalous calendar dependencies exist which are usually identified by a specific pattern of positive or negative returns or price movements.

6.2.1 Intraday effects

Although there is evidence for the existence of irregularities in the price of a certain security within a single business day, research of short-term patterns has been conducted less intensively compared to longer observation periods. The question arises whether irregularities over such short intervals significantly affect the efficient functioning of the market under the EMH. Research has yet to be thoroughly conducted in this field. Nevertheless, Liu and Thompson (1991:17) analysed intraday tick prices of six different agricultural commodities traded on the Chicago Board of Trade (CBOT). Intervals over which returns were considered included one-hour, half-hour, quarter-hour, five-minute, and tick returns. Results supported a conclusion of market efficiency and a price-adjustment process revealed insignificant intraday return patterns.

Examining transaction prices of S&P 500 futures, Lauterbach and Monroe (1989:371) tested for a weekend effect. Monday and non-Monday one-minute and half-hour intraday returns were calculated and results showed that the mean Monday one-minute return was significantly higher than that of the other days of the week. The opening half-hour return on Monday was found to be positive and higher than the same return on the other days of the week, supporting an intraday regularity associated with a weekend effect. Intraday returns, however, were not examined in this study mainly because of the relatively short existence of the futures market under consideration and associated liquidity problems affecting returns over such short time intervals.

6.2.2 Intra-week effects

Expected returns should not differ according to the day of the week in order to be consistent with the efficient markets hypothesis (Lakonishok and Levi, 1982:883). Generally, according to Ball *et al* (1982:175), two simple models exist representing the stock return generating process: the trading time and the calendar time hypothesis. The trading time hypothesis implies an identical return distribution across all trading days of the week, while the calendar time hypothesis, on the other hand, takes into account of the presence of weekends and implies that the mean and variance of the returns following these periods should be significantly higher.

A day-of-the-week effect has been found to exist in various financial asset markets including stock markets (Lakonishok and Levi, 1982; Keim and Stambaugh, 1984; Herbst and Maberly, 1992), gold (Ball *et al*, 1982), and US Treasury bills (Gibbons and Hess, 1981). The most prominent and widely researched day-of-the-week effect is probably the well-known weekend effect with its characteristic low or negative returns on Mondays and with rates of return tending to be high on the last trading day of the week (Ariel, 1987:161).

Lakonishok and Levi (1982:889) presented an argument that the daily returns on stocks should depend on the day of the week and found valuable evidence that unadjusted returns on Mondays (close Friday to close Monday) were significantly negative, while the opposite was true for Friday returns. In addition, they anticipated that holidays would have complex effects on stock returns on the other days of the week. These findings were supported by Keim and Stambaugh (1984:834) who found consistently negative Monday returns based on bid prices for the 30 individual stocks of the Dow Jones Industrial Index. In contrast, positive returns for the four remaining days of the week were found emphasising the overall effect of the weekend on the stock market. These findings are a direct violation of the two models mentioned which imply that expected returns on Mondays should be positive. Similar to stock returns, Gibbons and Hess (1981:595) showed that US Treasury bills produced substantial negative Monday returns in contrast with the positive returns of the rest of the trading week.

Ball *et al* (1982:179) investigated day-of-the-week effects in gold prices and found that (1) overnight changes were less variable than within-the-day changes; (2) daily variances were not equal; and (3) weekend variances were not very different from daily variances. In contrast to stocks, no negative weekend return was found and this result suggested that, with regard to return variances, a trading time hypothesis better fits the gold data than does a calendar time hypothesis. As further evidence for the puzzling weekend effect, French and Roll (1986:23) estimated the per hour returns of all stocks listed on the New York and American Stock Exchanges (NYSE and AMEX). Their findings showed that the average per hour return variance was about 70 percent larger during a trading hour than during a weekend non-trading hour, thus, assuming that the arrival of public information may be more frequent during the business day and after a weekend.

The consistency of the pattern around the weekend closing suggests that it may apply to any gap in trading. Lakonishok and Smidt (1988:403) studied daily returns of the Dow Jones Industrial Average (DJIA) and found that the preholiday rate of return is 23 times larger than the regular daily rate of return, and holidays accounted for about 50 percent of the price increase in the DJIA. It was also found that the average rate of return after holidays was negative, although much less negative than the rate of return on Mondays.

6.2.3 Intra-month and monthly effects

Turn-of-the-month (TOM) effects, according to Lakonishok and Smidt (1988:407), refer to the evidence relating to within-month patterns of security returns. Similarly, abnormal mean overall month returns are common and referred to as monthly or seasonal effects. These irregularities were previously detected in stock markets (Rozeff and Kinney, 1976; Keim, 1983; Ariel, 1987; Jegadeesh, 1990), and commodity futures (Cornett and Trevino, 1989; Martikainen *et al*., 1995:605).

Monthly rates of return on the NYSE, as calculated by Rozeff and Kinney (1976:401) showed the outstanding feature of the relatively higher mean return of the January distribution compared with most other months. Other seasonal peculiarities included relatively high mean returns in July, November and December and low mean returns in February and June. The so-called “January effect” was supported by Keim (1983:578) who observed a similar effect across a sample of NYSE and AMEX firms. Keim further showed that the January seasonal effect in stock returns was more pronounced for portfolios of small firms than for portfolios of large firms and especially during the early days of January. Jegadeesh (1990:896) documented strong evidence of predictable monthly behaviour of individual security returns. He found the January pattern to be significantly different from that in the other months and, on the basis of his findings, rejected the hypothesis that stock prices follow a random walk. Jegadeesh (1990:897) attributed this predictable behaviour to either market inefficiency or to systematic changes in expected stock returns.

Several hypotheses have been suggested to explain the January seasonal effect in stock returns. Keim (1983:29) formulated an explanation for disproportionately large January returns based on year-end tax loss selling of shares that have declined in value over the previous year. This is known as the “tax loss selling hypothesis”. Rozeff and Kinney (1976:398) also noted that January marks the beginning and ending of several potentially important financial and informational events and marks a period of increased uncertainty and anticipation due to the impending release of important information. This forms the basic idea of what is referred to as the “information hypothesis”. Other possible explanations may be due to spurious causes such as outliers, concentration of listings and de-listings at year-end, or data base errors.

Ariel (1987:162) found supportive evidence of a January effect over a nineteen-year period of equally-weighted stock index returns. Significant positive returns at the beginning of each month were found to be followed by predominantly negative returns after the mid-point of the month. This TOM effect, however, seemed to be less significant when January was left out of the data which further emphasised the extent of the January seasonality. Findings by Cornett and Trevino (1989:103) showed that grain commodity futures contracts, traded on the Chicago Board of Trade (CBOT), produce similar monthly return patterns to those documented in studies of stock returns. They found mean daily returns of corn, soybean and wheat contracts to be significantly higher in the first part of the trading month than in the last. Furthermore, the TOM pattern was found to occur in the first through third calendar quarters of the year, but seems to dissipate during the fourth quarter. Finally, Cornett and Trevino (1989:101) showed that extreme positive returns were not exclusive to January, as was the case in some studies focussing on stock markets.

Martikainen *et al* (1995:605) investigated the TOM regularity in 24 stock markets and 12 different regional indices of the world. They reported significant results in favour of the TOM effect to exist for almost all the countries as well as for the regions. However, the TOM effect was found to be not nearly as significant in the case of the smaller stock markets included in their sample.

6.2.4 The maturity effect

A maturing commodity futures contract has important implications on the behaviour of futures prices. In theory (Kolb, 1991:137) it is shown that price variability increases as time to maturity nears, also known as the "Sameulson hypothesis" (Milonas, 1986:443). Sameulson (1965) showed that, on an intuitive basis, futures contracts far from maturity represented greater uncertainty to be resolved and therefore reacted weakly to given information. The opposite was true with contracts close to maturity. "Since at maturity, the price of an expiring contract must virtually equal the prevailing spot price, nearer contracts tend to respond strongly to new information so that the price of an expiring futures contract will converge to the spot price" (Milonas, 1986:445).

Castelino and Francis (1982:196) mention a number of factors contributing to price volatility increasing as a commodity futures contract matures:

1) The increasing rate of information becoming available about the future cash price at contract maturity,
2) the storability of the commodity, which allows it to be carried virtually indefinitely for delivery against the requirements of any futures contract,
3) the volume of existing supplies, and
4) the substitutability of the commodity.

Castelino and Francis (1982:195) also mention that the increasing volatility of the futures price has important implications for the basis (futures price minus spot price) over the life of the contract and that changes in the basis, other than the futures price itself, decrease in volatility as it moves towards contract maturity. Khoury and Yourougou (1989:408) tested for a maturity effect in the Canadian feed wheat market. Observation periods were divided into weeks to maturity and results showed that return variances were significantly higher for the last three trading weeks for all the contracts. They concluded that results were consistent with Sameulson’s hypothesis and confirmed that futures prices presumably adjust more strongly to new information as maturity nears.

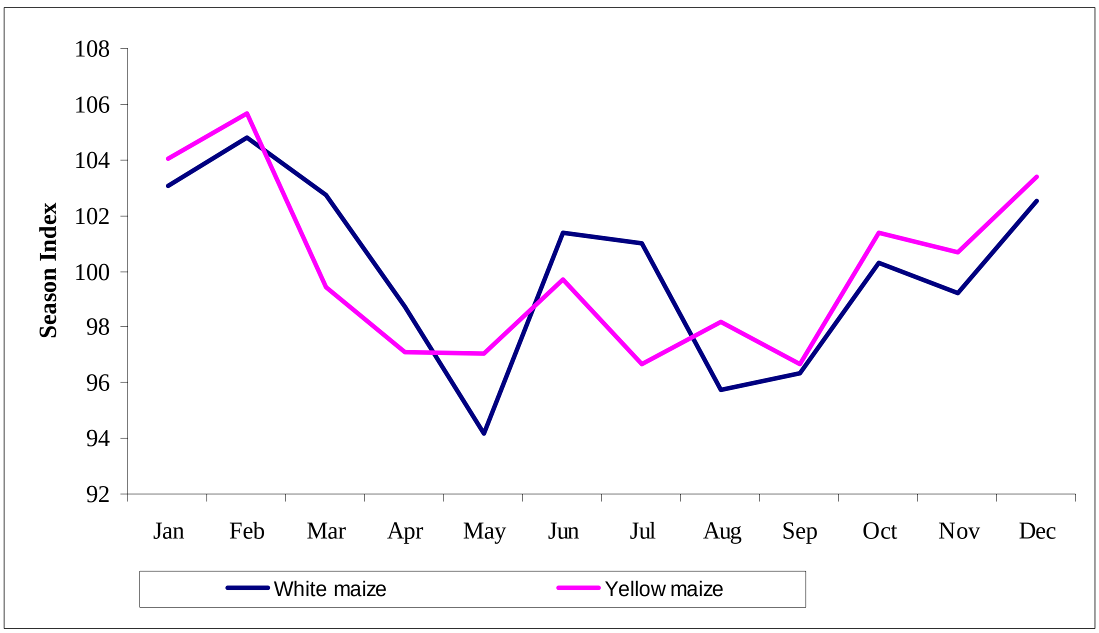
Using data on 4111 futures contracts drawn from 45 commodities over a 23 year period, Galloway and Kolb (1996:809) evaluated the presence of a maturity effect. Strong support was found in agricultural and energy commodities, but not in the case of precious metals and financial commodities. They further concluded that the maturity effect played a significant role in the volatility of futures prices for commodities that experience seasonal demand or supply as in the case of agricultural commodities. Cornett and Trevino (1989:102) tested for a possible maturity effect in the futures contracts of corn, soybeans, and wheat traded on the CBOT. Similar results were found for all three commodities and they concluded that the time to maturity has no effect on the intra-month return patterns and were, therefore, unable to detect significantly higher mean returns as contract maturity approaches.

The futures price of a commodity futures contract, as shown in Chapter 3 experiences increased volatility especially during the last month of trading or the “delivery month”. A factor that also contributes largely to the volatility during the delivery month is the absence of daily limited price ranges. CBOT (2002) indicates contract specifications for US yellow maize traded on the CBOT allow for maximum daily price movement of 20 US cents per bushel either above or below the previous day’s settlement price with no daily limit during delivery month. The South African market for white and yellow maize is based on the same specifications with a R45 per ton daily limit up or down from the previous day’s settlement price and unlimited movement granted during delivery month (Safex, 2001a). Combined with the presence of speculation, especially in the more liquid contracts (such as the July contract for white maize), daily price movements are notably larger compared to other months. This effect is formally tested in this chapter.

6.2.5 Seasonal patterns in agricultural commodity futures prices

Agricultural commodities, in particular, are believed to be subject to noticeable seasonal effects attributable to supply and demand variations where seasonal effects are defined as respective 12-month cyclical price fluctuations arising from similar changes in supply and demand from year to year. According to Vaughn *et al* (1981:93), the shape and magnitude of seasonal price variations depend to a great extent upon the nature of the production cycle, demand for the commodity, and the availability and practicality of storage. Figures 6.1 and 6.2 show the typical seasonal indices for white and yellow maize and wheat respectively calculated as proposed by Steyn *et al* (1989:179).

Figure 6.1: Typical seasonal index for South African white and yellow maize



Seasonal prices generally reach their lowest points during harvest or peak availability periods, and then tend to rise gradually and peak a few months before the next harvest begins. From Figure 6.1 it is evident that, for both the maize commodities, prices gradually start to rise after harvesting lows (July – August) to peak in the beginning of the year when availability is limited. Prices then tend to trade lower towards harvesting with a strong bull run during May/June when late information causes the market to be more volatile. Vaughn *et al* (1981:93) also noted that, under stable supply and demand conditions, the price fluctuations were generally less severe for commodities that are easily stored and, in these cases, seasonal price differences theoretically reflect the storage and handling costs. Bown *et al* (1999:218) showed that the supply of maize in South Africa is highly seasonal, being concentrated in the harvest period two months (June and July), whereas demand for maize is spread throughout the year.

Figure 6.2: Typical seasonal index for South African wheat

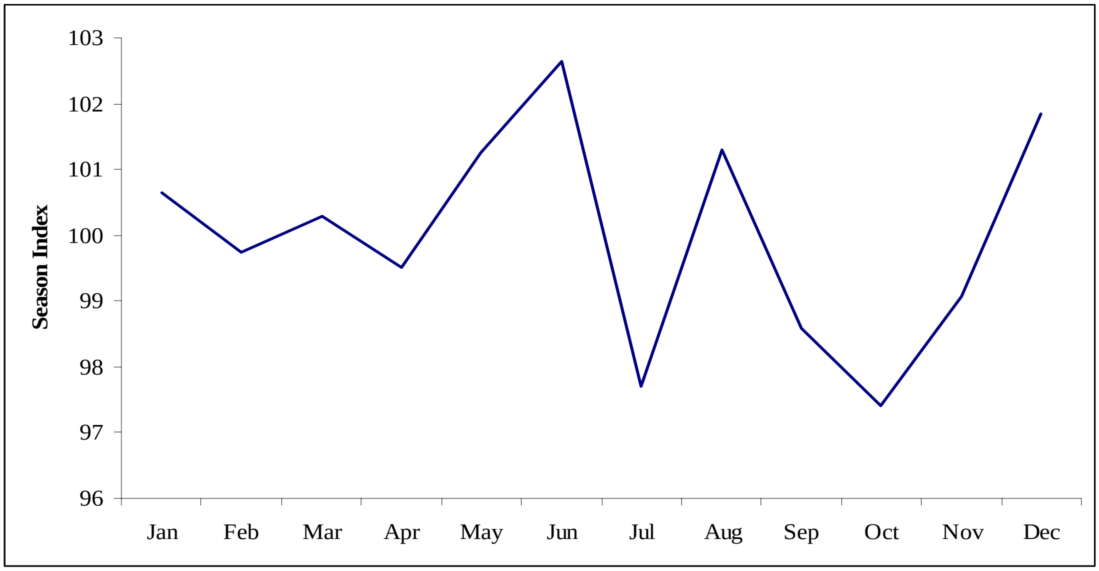


Figure 6.2 indicates that wheat generally experiences a very high mid-year peak caused by tight stock, a very sharp drop during June/July when the rainy season in the Western Cape starts and planting commences, and a gradual price increase towards harvesting as information becomes more regularly available. The spike evident during August is most likely due to a very sensitive weather-based market over this period and prices more likely to overreact than in any other period throughout the year. The issue of seasonality, as explained by Anderson (1985:341), plays an important role in the behaviour of futures prices of agricultural commodities and has certain implications on volatility and return patterns over different short- and medium run observation periods. This could provide sufficient insight to the irregularities observed in this chapter.

6.3 Data

Daily futures prices for the three commodities (white maize, yellow maize, and wheat) were used for the period January 1997 to July 2002. Data were collected directly from the JSE APD. For each of the three respective commodities, five primary contracts (also known as hedging months) were traded on an annual basis (March, May, July, September, December) and only contracts whose entire trading period were encompassed in the observation period were included in the different samples. This resulted in a total of 23 white maize, 23 yellow maize, and 22 wheat contracts.

Due to a lack of liquidity in the markets especially during the first two years of the observation period, a large number of zero-observations were evident in each of the samples as a direct result of no intraday trading activity. These had a notable effect on the significance of the calculated mean returns. For the purpose of the analyses, zero-observations as a result of no trading were removed from each contract of each of the respective commodities. In the cases where zero-returns resulted from one day's settlement being equal to that of the previous day despite trading activity, the zero-observations were not removed. Table 6.1 provides descriptive statistics of the three adjusted samples under consideration.

Table 6.1: Descriptive statistics of daily maize and wheat futures prices, Jan 1997 to Jul 2002

	White maize	Yellow maize	Wheat
Number of contracts	23	23	22
Total daily observations	4920	4326	1129
Mean days traded (per contract)	214	188	52
Overall mean return (%)	0.0701	0.0662	0.0989
Standard deviation (%)	1.6519	1.6272	1.1624
Sample variance (%)	2.7289	2.6477	1.3511
Minimum	-5.9897	-5.6179	-5.3266
Maximum	5.8651	5.6391	5.1565
Skewness	0.1499	0.0882	0.0117
Kurtosis	0.5355	0.7042	2.1867

Daily returns were calculated as a percentage price change from one day's settlement closing price to the next as follows:

$$PR_t\ (\%) = [(CP_t - CP_{t-1}) / CP_{t-1}]\ x\ 100 \qquad (6.1)$$

where, PR_t is the daily percentage futures price return on day t, and CP_t the closing price on day t. The 23 white maize contracts produced a total of 4920 daily returns. The overall mean daily return on the white maize contracts was 0.0719 percent with a standard deviation of 1.6666. A mean of 252 daily returns were available per contract after the adjustment. A total of 4324 daily returns were calculated for the 23 yellow maize contracts, resulting in an overall mean daily return of 0.0683 percent (standard deviation = 1.6498). Yellow maize primary contracts traded for a mean of 188 days after adjusting the samples. Finally, 1129 daily returns existed for the 22 wheat contracts. The overall mean daily return for this commodity was 0.0809 percent (standard deviation = 1.3747). After adjustment the primary wheat contracts included a mean of 52 daily returns. Analyses were conducted to test for five anomalies regularly found in commodity futures markets, namely a day-of-the-week effect, turn-of-the-month effect, holiday effect, monthly effect, and a maturity effect. Data sampling, analysis and results are discussed for each of the irregularities evaluated under their respective headings.

6.3.1 Normality

The full data samples containing all the calculated daily returns were tested for normality for each of the three respective commodities. Results from the Shapiro-Wilk and Kolmogorov-Smirnov tests are shown in Table 6.2.

Table 6.2: Results of normality testing for white maize, yellow maize, and wheat

	White maize	Yellow maize	Wheat
Shapiro-Wilk W (p-value)	0.9906** (<0.0001)	0.9895** (<0.0001)	0.7891** (<0.0001)
Kolmogorov-Smirnov D (p-value)	0.0514** (< 0.01)	0.0432** (< 0.01)	0.1161** (< 0.01)

**Significant at 1% level of significance

Test hypotheses for both Shapiro-Wilk and Kolmogorov-Smirnov were formulated as follows:

H_0: the distribution under consideration is normally distributed, vs.
H_A: the distribution under consideration is not normally distributed.

(6.2)

As shown in Table 6.2, the calculated statistics for both tests (W and D) were found to be significant in the case of all three commodities, respectively rejecting the null hypothesis of normality indicating that the distributions are all not normal. Results from Table 6.1 provide further support in the form of the calculated skewness and kurtosis values. The skewness tended to differ from zero indicating asymmetrical distributions, while the kurtosis also deviates from zero and of the shape of a normal distribution for each of the three data samples respectively. Corresponding histograms for the respective commodities are shown in Appendix B, Figures B.1, B.2 and B.3.

6.3.2 Homogeneity of variances

Levene's test was used to test for equality of the variances between days of the week. The test hypotheses were formulated as:

$$H_0: \sigma^2_1 = \sigma^2_2 = \sigma^2_3 = \ldots = \sigma^2_t \text{ vs.}$$
H_A: at least one of the variances is different

(6.3)

Table 6.3: Levene's test of homogeneity of variances for white maize, yellow maize, and wheat

	White maize	Yellow maize	Wheat
F	2.5649	3.9344	0.4237
p	0.0365*	0.0034**	0.7916

*Significant at 5% level of significance, **Significant at 1% level of significance

Results from the tests are shown in Table 6.3. White and yellow maize daily prices failed tests of homogeneity with the null hypothesis significantly rejected in both cases (WM: $p < 0.05$; YM: $p < 0.01$), whilst wheat daily prices variances were found to be equal ($p > 0.05$). Because of the heterogeneity in the case of the maize commodities together with the non normal distribution of prices, a non-parametric approach was used to analyse the daily prices.

6.4 Results

6.4.1 Day-of-the-week effects

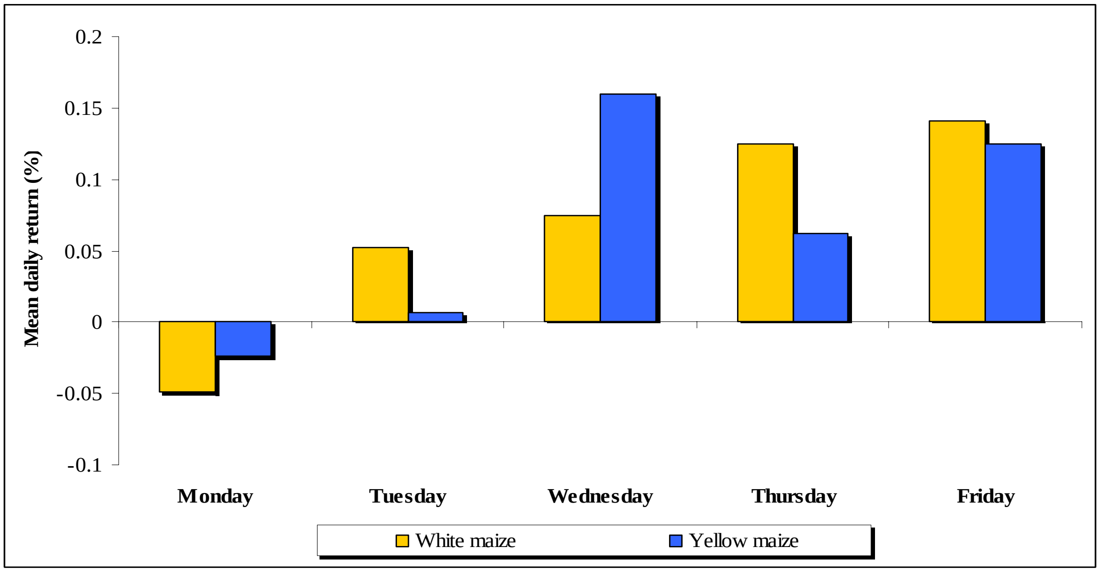
Mean daily returns on commodity futures contracts described above were calculated according to the day of the week. In order to determine return patterns, observations were sampled and returns grouped under the five business days of the week, Monday through Friday. This was done for each of the three commodities respectively. Table 6.4 provides descriptive statistics of the grouped samples.

Table 6.4: Descriptive day-of-the-week statistics for white maize, yellow maize, and wheat

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
White maize					
No. of observations	934	1011	995	1007	973
Mean return (%)	-0.0488	0.0524	0.0747	0.1251	0.1411
Standard deviation (%)	1.7747	1.6272	1.6648	1.5615	1.6297
Yellow maize					
No. of observations	842	884	875	877	848
Mean return (%)	-0.0241	0.0069	0.1599	0.0624	0.1252
Standard deviation (%)	1.6856	1.6157	1.6821	1.4627	1.6795
Wheat					
No. of observations	204	235	228	242	220
Mean return (%)	0.0933	0.0795	0.1121	0.1735	0.0293
Standard deviation (%)	1.1910	1.2042	1.1175	1.1538	1.1506

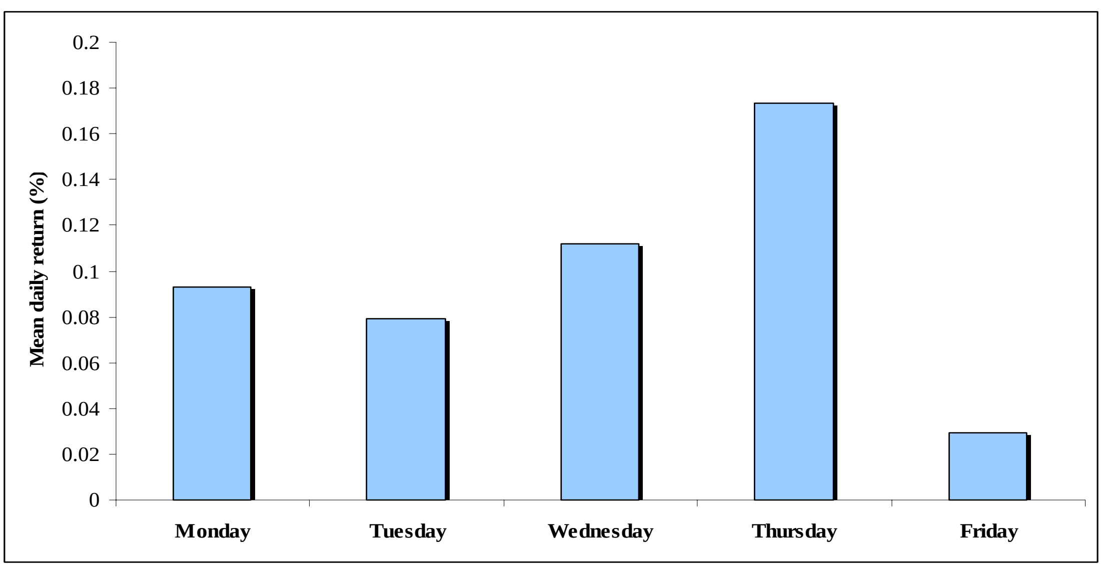
Negative mean Monday returns were evident in the case of both white and yellow maize compared to the positive mean returns observed every other day of the week. Daily returns tended to increase as the week progressed forming a distinctive pattern as shown in Figure 6.3. Friday provided the highest weekday return (0.1411 %) in the case of white maize compared to Wednesday being the highest mean return (0.1599 %) in the yellow maize market. White maize returns, however, produced a much smoother pattern with mean returns increasing gradually compared the pattern produced by yellow maize. Visual inspection of mean day-of-the-week returns for both commodities indicated the possibility of a Monday-effect similar to that found by various authors as mentioned in this chapter.

Figure 6.3: Mean percentage day-of-the-week returns for white and yellow maize



The wheat market, in contrast with maize, yielded only positive mean weekday returns. Figure 6.4 shows a pattern inconsistent with that of either white or yellow maize. The mean Monday return was relatively large positive with Thursday showing the highest return (0.1121 %) and Friday the lowest (0.0293 %). Mean returns did, in fact, tend to increase as the week progressed although mean wheat returns of Friday and Monday do not show the same pattern as that of white and yellow maize.

Figure 6.4: Mean percentage day-of-the-week returns for wheat



Kruskal-Wallis ANOVA was conducted for each of the three commodities respectively to test whether differences between weekday returns were significant. For this test, the null hypothesis of equal medians was tested against the alternative hypothesis that at least one of the medians is different from the others:

$$H_0\!: <_1 = <_2 = <_3 = \ldots = <_t, \; vs.$$
$$H_A\!: \textit{at least one of the medians is different} \tag{6.4}$$

Table 6.5: Results from day-of-the-week Kruskal-Wallis ANOVA for white maize, yellow maize, and wheat

Kruskal-Wallis ANOVA	White maize	Yellow maize	Wheat
H	13.3472**	11.6664*	4.0268
p	0.0097	0.0200	0.4024

*Significant at 5% level of significance, **Significant at 1% level of significance

Results in Table 6.5 indicate that the null hypothesis of equal medians were significantly rejected for both white and yellow maize, however, the result for wheat proved to be different. In order to test for a possible Monday-effect, post-hoc comparisons were conducted in the form of the Mann-Whitney U test. The level of significance was adjusted using the Bonferonni method using $\alpha = 0.05/k$, where k is the number of paired comparisons. Because of the insignificance of the Kruskal-Wallis result, wheat was left out of the post-hoc analysis. The test hypotheses were formulated as:

$$H_0\!: <_1 = <_2, \; vs.$$
$$H_A\!: <_1 \neq <_2 \tag{6.5}$$

where the null hypothesis of equal medians is tested against the alternate hypothesis that they are not equal. Post-hoc results from Table 6.6 show that the Monday returns turned out to be significantly different from every other day of the week in the case of white maize with the exception of only Friday in the case of yellow maize. The fact that the mean calculated Monday returns were not only negative, but also significantly different from the rest of the week could be seen as strongly supportive of the Monday-effect or so-called "weekend effect". Corresponding p-values are presented in Appendix B, Table B.1.

Table 6.6: Day-of-the-week Mann-Whitney Z values for white and yellow maize

White maize	Monday	Tuesday	Wednesday	Thursday	Friday
Monday		5.3322**	4.6243**	5.9621**	4.5233**
Tuesday	5.3322**		0.7505	0.6193	0.9119
Wednesday	4.6243**	0.7505		1.3653	0.1530
Thursday	5.9621**	0.6193	1.3653		1.5420
Friday	4.5233**	0.9119	0.1530	1.5420	
Yellow maize	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Monday		3.4886**	4.5572**	3.6692**	2.7242
Tuesday	3.4886**		1.0506	0.1666	0.8377
Wednesday	4.5572**	1.0506		0.8827	1.9049
Thursday	3.6692**	0.1666	0.8827		1.0072
Friday	2.7242	0.8377	1.9049	1.0072	

**Significant at 1% level of significance

6.4.2 Holiday effects

To examine the possible occurrence of irregularities due to the presence of public holidays, daily returns were grouped and divided into two samples: the business day directly preceding and the business day following a public holiday. If a day after the holiday happened to be a Monday (e.g. the Friday before was a holiday) it was not included in the sample because the return on a Monday could be largely affected by the weekend before. For each of the respective commodities the two constructed samples were compared and tested as to whether their medians differed significantly from each other or not. Results of the 2-sample Mann-Whitney tests are presented in Table 6.7.

Table 6.7: Mean holiday returns and Mann-Whitney test results for white maize, yellow maize, and wheat

	White maize	Yellow maize	Wheat
Mean return: day preceding holiday (n#)	0.0498 (126)	-0.1566 (74)	0.3422 (13)
Mean return: day following holiday (n)	0.2124 (120)	0.2443 (66)	0.2626 (22)
Mann Whitney U tests			
U	7124	2141	122
Z	0.7815	1.2565	0.7169
p	0.4345	0.2089	0.4734

No of observations included in the sample

In the case of the two maize commodities the pre-holiday mean returns were found to be either small or negative compared to a positive post-holiday return. Once again, wheat results deviated from that of maize with relatively large positive returns on both days under consideration. Returns on business days directly preceding and following a public holiday tend to be not significantly affected by the presence of the holiday, according to results in Table 6.7. In the case of all three commodities, mean returns of the two days under consideration were not significantly different from each other.

In order to further evaluate the effect of public holidays, pre- and post-holiday returns were respectively grouped under the five days of the week and mean returns were calculated. These samples were then compared to the mean daily returns of a "normal" week without the presence of a holiday. For example, all the Monday returns preceding a holiday that were sampled were compared to the "normal" sample of Monday returns not preceding or following a holiday. This was done for each day of the week and for both pre- and post-holiday returns respectively. Mann-Whitney results are shown in Table 6.8. Wheat was left out of the analysis due to a lack of sufficient observations resulting from the further grouping into smaller samples.

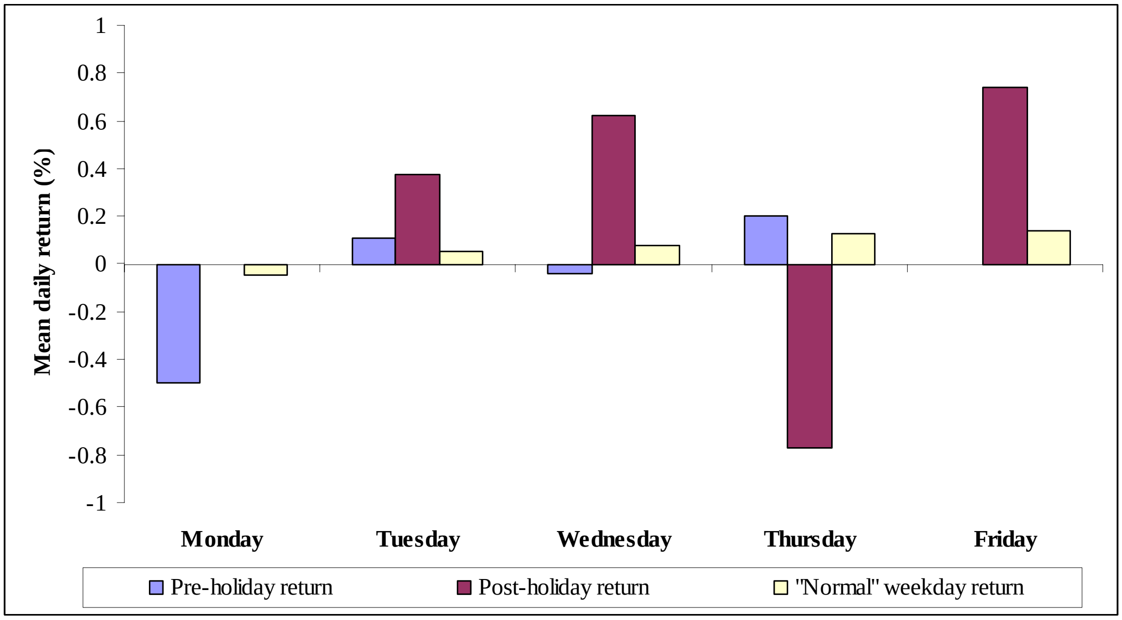
Table 6.8: Pre- and post-holiday Mann-Whitney results for white and yellow maize

		Mean return (%)	**Z**	**P**
White maize: Day preceding holiday	Monday	-0.5006	-0.6766	0.4987
	Tuesday	0.1094	0.6539	0.5132
	Wednesday	-0.0396	-0.5153	0.6063
	Thursday	0.2033	-0.1562	0.8759
	Friday	n/a	n/a	n/a
White maize: Day following holiday	Monday	n/a	n/a	n/a
	Tuesday	0.3751	1.3767	0.1686
	Wednesday	0.6232	1.1781	0.2309
	Thursday	-0.7721	-2.9474**	0.0032
	Friday	0.7373	1.8728	0.0611
Yellow maize: Day preceding holiday	Monday	-2.3135	-3.1359**	0.0017
	Tuesday	-0.6754	-0.9819	0.3261
	Wednesday	-0.0532	-0.9509	0.3416
	Thursday	0.2999	0.7565	0.4494
	Friday	n/a	n/a	n/a
Yellow maize: Day following holiday	Monday	n/a	n/a	n/a
	Tuesday	0.3915	1.5426	0.1229
	Wednesday	n/a	n/a	n/a
	Thursday	-0.3537	-1.4032	0.1606
	Friday	0.0421	0.0933	0.9257

**Significant at 1% level of significance

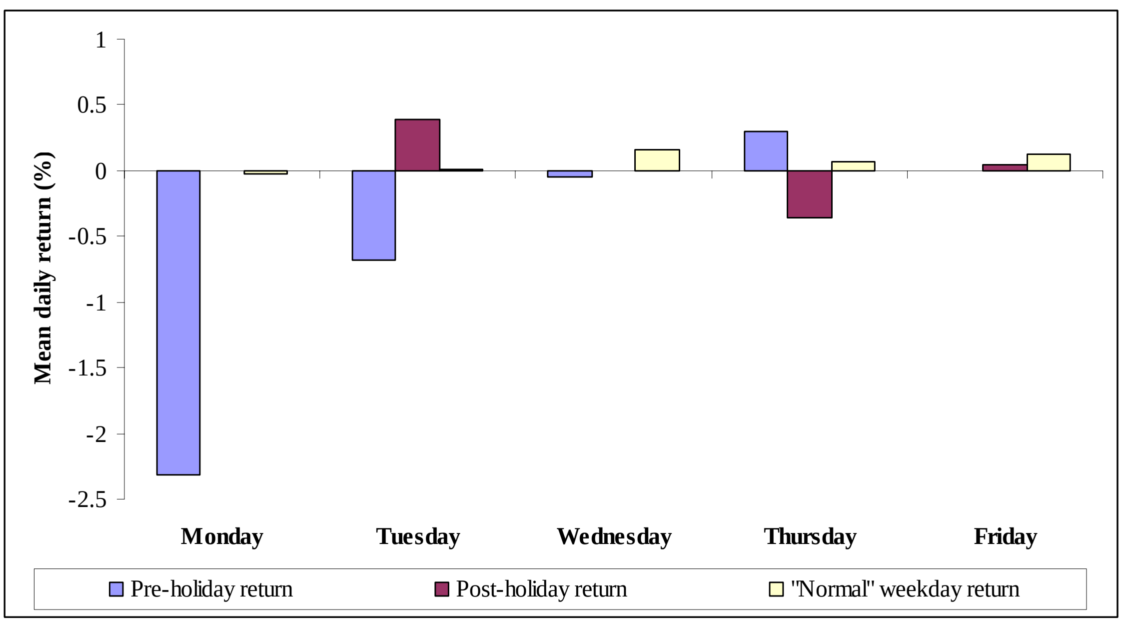
For white maize, the Thursday post-holiday returns tended to be significantly affected by the presence of the public holiday, while in the yellow maize market a Tuesday holiday affected the return of the preceding Monday significantly. Overall, results turned out relatively insignificant in detecting a possible effect in futures prices due to the presence of public holidays. Figures 6.5 and 6.6 show the pre and post-holiday returns of each day of the week compared with the "normal" day-of-the-week returns for white and yellow maize respectively. The significant post-holiday Thursday return is evident in the case of white maize being negative and clearly different from the "normal" weekday return. It is also inconsistent with the rest of the post-holiday returns all being relatively large and positive.

Figure 6.5: Pre and post-holiday day-of-the-week returns for white maize



Yellow maize holiday returns somewhat lacked any significant pattern. A significant pre-holiday Monday return, as evident from Table 6.8, can be viewed in Figure 6.5 with Tuesday also showing possible inconsistency in the rate of the pre-holiday return.

Figure 6.6: Pre and post-holiday day-of-the-week returns for yellow maize



6.4.3 "Turn-of-the-month" effects

The importance of intra-month irregularities, according to Cornett and Trevino (1989:99), is emphasised by the striking difference in returns between month-end and month-beginning. Daily returns were sorted into subintervals of nine trading days before (days -9 through -1) and from the first business day (days 1 through 9) as shown in Table 6.9. It was calculated that a mean month constituted of 20.83 business days of which, due to the presence of public holidays, 19 days are the minimum number of business days in any month. Therefore, to eliminate the possibility of data overlapping from one month to another, the period was set on 18 days which would then divide a mean business month in two 9 day halves.

Table 6.9: Example of turn-of-the-month data grouping

Month	**January 2002**																					
Day#	2	3	4	7	8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31
Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**					**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
	February 2002																					
Day#	1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22	25	26	27	28		
Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**			**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**		

#Only includes business days

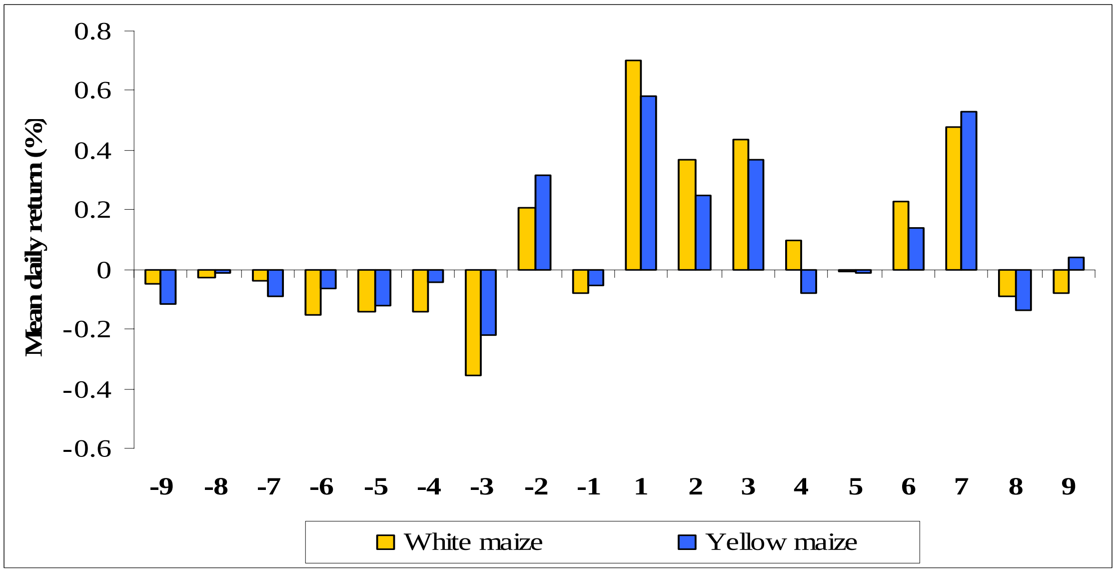
The first business day of each month was coded "1" while the preceding and following days were coded accordingly from -9 to 9 as shown in the example. Observations were then grouped according to its code and mean returns were calculated. This was done for each of the three commodities under consideration respectively. Table 6.10 presents descriptive statistics of the constructed samples.

Table 6.10: Turn-of-the-month descriptive statistics for white maize, yellow maize, and wheat

	White maize		Yellow maize		Wheat	
Day	**n**	**Mean return (%)**	**n**	**Mean return (%)**	**n**	**Mean return (%)**
-9	230	-0.0472	196	-0.1155	50	-0.0193
-8	226	-0.0265	204	-0.0097	39	-0.2021
-7	228	-0.0366	194	-0.0881	43	-0.1397
-6	221	-0.1509	201	-0.0655	40	0.0802
-5	218	-0.1411	195	-0.1187	47	0.2716
-4	227	-0.1439	183	-0.0428	50	-0.0637
-3	224	-0.3549	199	-0.2193	48	-0.2508
-2	233	0.2083	200	0.3185	44	-0.1164
-1	232	-0.0778	205	-0.0537	37	-0.1459
1	221	0.6992	208	0.5833	40	0.1197
2	225	0.3672	209	0.2491	51	0.1917
3	232	0.4378	197	0.3691	45	0.1849
4	232	0.0959	200	-0.0801	46	0.0053
5	232	-0.0073	199	-0.0106	47	0.0901
6	228	0.2277	209	0.1384	40	0.0149
7	237	0.4778	198	0.5284	43	0.2665
8	231	-0.0918	205	-0.1364	50	0.3444
9	226	-0.0802	206	0.0403	43	0.3855
Total	4103	0.0765	3608	0.0734	803	0.0605

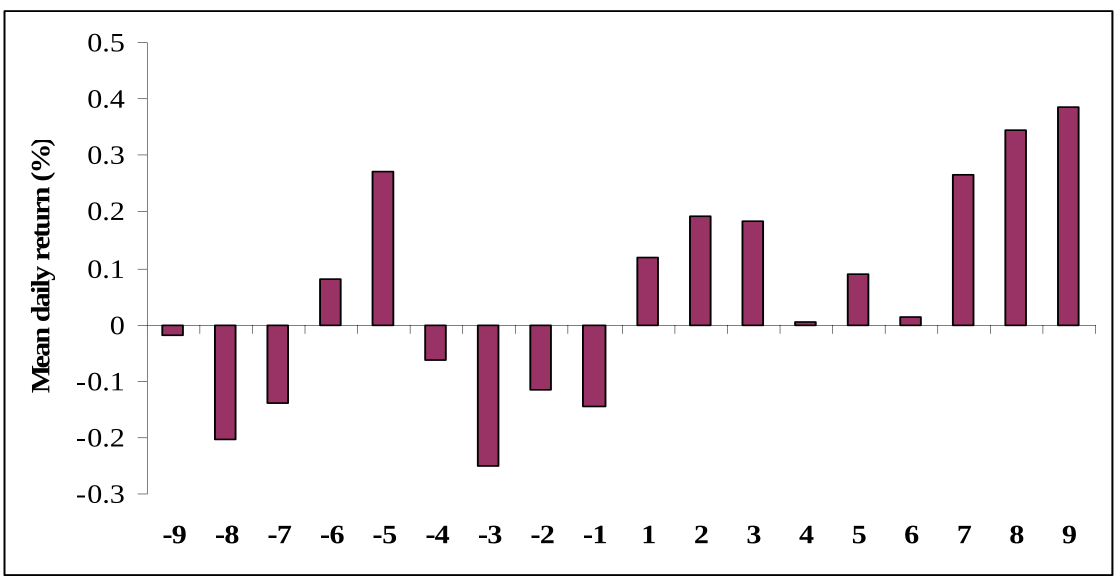
Figures 6.7 and 6.8 present bar charts for the calculated mean returns for the three respective commodities. As evident from the calculated mean returns shown in Table 6.10 daily returns, in the case of both white and yellow maize, tended to be overwhelmingly negative in the second half and towards the end of the month (period -9 to -1). In contrast, returns were found to be relatively large positive on the first day of the month and positive throughout the first half (period 1 to 9). A clear difference and possible effect is visible between the mean return of the last day of the month (-1) and the first day of the following month (1).

Figure 6.7: Calculated turn-of-the-month returns for white and yellow maize



A very similar pattern was evident in the case of wheat with most of the mean daily returns being negative in the second half of the month in addition to a positive first half. Kruskal-Wallis ANOVA was conducted for the three commodities respectively in order to establish whether calculated daily returns differ significantly over the 18- day period (-9 to 9).

Figure 6.8: Calculated turn-of-the-month returns for wheat



Results in Table 6.11 indicate that the null hypothesis of equal medians was significantly rejected in all three cases. It was therefore assumed that mean daily returns do, in fact, deviate from each other over the period. Post-hoc analyses were conducted accordingly. These results are presented in Appendix B in the form of multiple comparison Z and p-values. However, the focus of the analyses remains on the significance of the effect between month-end and month-beginning of two consecutive months.

Table 6.11: Turn-of-the-month Kruskal-Wallis results for white maize, yellow maize, and wheat

Kruskal-Wallis ANOVA	White maize	Yellow maize	Wheat
H	78.4231**	58.8468**	28.4202*
p	<0.0001	<0.0001	0.0403

*Significant at 5% level of significance, **Significant at 1% level of significance

The observation interval (-9 to 9) was divided into two subintervals, -9 to -1 and 1 to 9, and overall mean returns were calculated accordingly. This was done for the three commodities respectively and tested using the Mann-Whitney U test. The subintervals were further decreased from a period of nine days to five days and three days respectively. Comparing the 5-day periods would represent the last trading week of a month compared to the first week of the following month. Finally, 3-day subintervals were used to more intensively evaluate the specific effect of "change-over" between consecutive months. Table 6.12 shows results from the respective subintervals as they were tested for each respective commodity.

Table 6.12: Turn-of-the-month Mann-Whitney results for white maize, yellow maize, and wheat

Mann-Whitney U test		White maize	Yellow maize	Wheat
"9 day" comparison	**Mean return -9 to -1** **Mean return 1 to 9**	-0.0453 0.2513	-0.0423 0.1981	-0.0765 0.1782
	Z	5.2795**	3.4623**	2.1192*
	p	<0.0001	0.0005	0.0341
"5 day" comparison	**Mean return -5 to -1** **Mean return 1 to 5**	-0.0717 0.3052	-0.0404 0.2526	-0.0782 0.1645
	Z	5.3843**	3.1863**	1.7049
	p	<0.0001	0.0014	0.0882
"3 day" comparison	**Mean return -3 to -1** **Mean return 1 to 3**	-0.0547 0.4814	0.0068 0.4165	-0.1985 0.1779
	Z	4.5415**	3.6997**	2.4075*
	p	<0.0001	0.0002	0.0161

*Significant at 5% level of significance, **Significant at 1% level of significance

Results for the 9-day and the two decreased subintervals were found to be significant in the case of both white and yellow maize. This is indicative of significant differences between first and second half mean returns with a noted effect as one month expires into the following.

6.4.4 Monthly effects

A "time-of-the-year" effect regularly exists in the prices of securities and commodity futures which was also the focus of this section. Daily calculated returns were grouped according to the month of the year and mean monthly returns were calculated accordingly. Therefore, for the three commodities respectively, 12 samples were created representing the 12 months of the year. Table 6.13 presents sample size and mean returns of the respective created samples.

Table 6.13: Monthly returns for white maize, yellow maize, and wheat

	White maize		Yellow maize		Wheat	
Month	**n**	**Mean return (%)**	**n**	**Mean return (%)**	**n**	**Mean return (%)**
Jan	23	0.0397	22	-0.0823	10	0.3150
Feb	24	0.1174	23	-0.1419	11	-0.1482
Mar	25	0.1498	24	-0.0987	14	-0.7788
Apr	23	-0.2119	21	0.0748	9	-0.2962
May	25	-0.2132	22	-0.1062	13	0.1518
Jun	26	0.2483	23	-0.0569	10	-0.0012
Jul	27	0.0361	26	-0.1798	12	0.3566
Aug	24	0.0827	23	0.0756	9	0.4823
Sep	24	-0.0115	25	0.0702	9	-0.0615
Oct	23	0.2914	24	0.4655	9	-0.1044
Nov	23	0.2873	24	0.2001	12	0.1565
Dec	24	0.3495	25	0.4012	10	0.1778
Total	291	0.0966	282	0.0542	128	0.0054

Prices of agricultural grain commodities are highly seasonal according to their production cycle. It is expected that mean monthly returns would closely follow and indicate the seasonal pattern involved. Figures 6.9 and 6.10 show mean monthly returns for white and yellow maize, and wheat respectively compared with their corresponding typical seasonal indices. In the case of white and yellow maize, monthly returns were typically consistent with mid-year lows and end-of-year highs. Wheat monthly returns followed the mid-year high trend, with prices also being expensive at the end of the year due to a possible spill-over effect from gains in the maize markets.

Figure 6.9: Mean monthly returns and typical seasonal indices for white and yellow maize

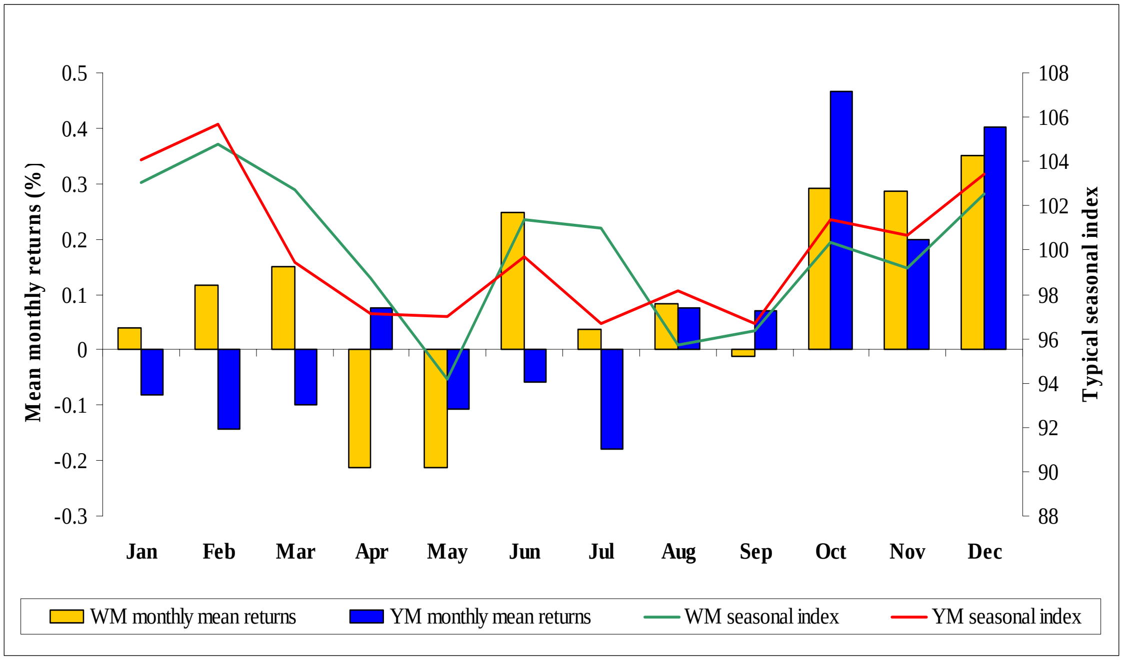
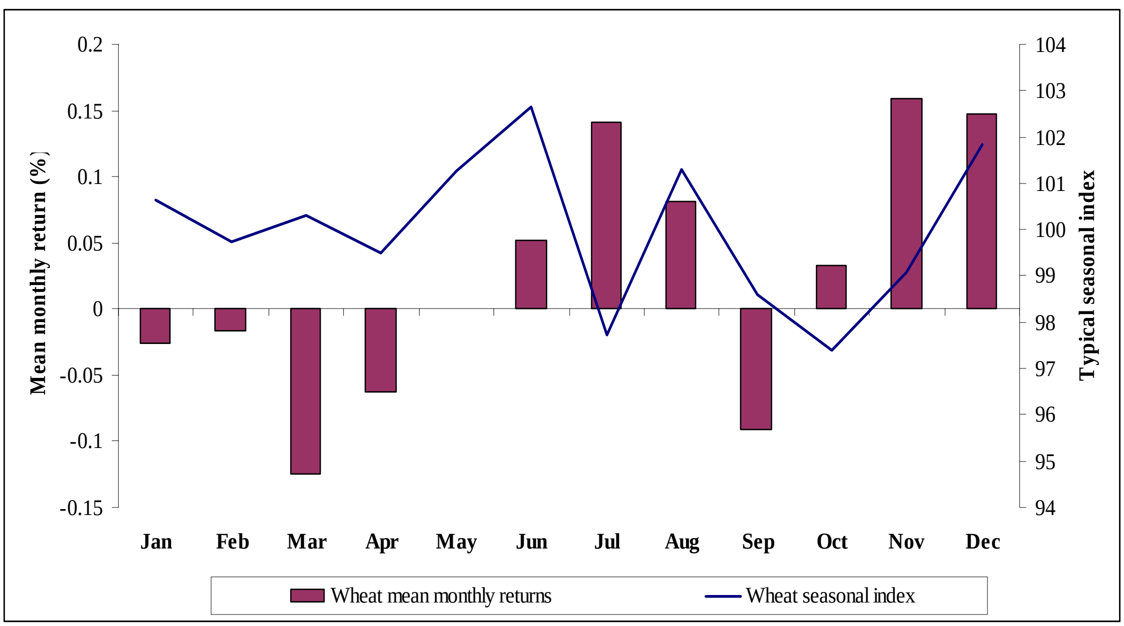


Figure 6.10: Mean monthly returns and typical seasonal indices for wheat



In order to evaluate whether specific monthly returns are responsible for a significant effect, Kruskal-Wallis ANOVA were applied.

Table 6.14: Kruskal-Wallis monthly results for white maize, yellow maize, and wheat

Kruskal-Wallis	White maize	Yellow maize	Wheat
H	20.1546*	38.1109**	16.9192
p	0.0433	0.0001	0.1103

*Significant at 5% level of significance, **Significant at 1% level of significance

Results from Table 6.14 are indicative of significant deviations between monthly returns in the case of both white and yellow maize, however, the calculated H value for wheat was unable to reject the null hypothesis of the medians being equal. For this reason wheat was eliminated from further analysis. Post-hoc comparisons were done in the form of Mann-Whitney U tests where Z values were calculated taking each of the months in pairs. Tables 6.15 and 6.16 present the results under consideration with corresponding p-values available in Appendix B.

Table 6.15: Mann-Whitney multiple monthly comparison Z-values for white maize

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan		0.4699	0.7461	1.2230	0.7125	1.4650	0.7665	0.1595	0.1560	1.4490	1.5997	1.7375
Feb	0.4699		0.2857	1.7031	1.1730	1.0135	0.3234	0.3104	0.6260	0.9689	1.1196	1.2675
Mar	0.7461	0.2857		2.0009	1.4587	0.7333	0.0485	0.6020	0.9176	0.6710	0.8217	0.9759
Apr	1.2230	1.7031	2.0009		0.4604	2.6153	1.8953	1.3567	1.0411	2.6720	2.8227	2.9348
May	0.7125	1.1730	1.4587	0.4604		2.1637	1.4522	0.8867	0.5711	2.1919	2.3426	2.4648
Jun	1.4650	1.0135	0.7333	2.6153	2.1637		0.6711	1.3653	1.6809	0.1086	0.0420	0.2126
Jul	0.7665	0.3234	0.0485	1.8953	1.4522	0.6711		0.6535	0.9691	0.6185	0.7691	0.9245
Aug	0.1595	0.3104	0.6020	1.3567	0.8867	1.3653	0.6535		0.3156	1.2860	1.4367	1.5780
Sep	0.1560	0.6260	0.9176	1.0411	0.5711	1.6809	0.9691	0.3156		1.6084	1.7591	1.8936
Oct	1.4490	0.9689	0.6710	2.6720	2.1919	0.1086	0.6185	1.2860	1.6084		0.1506	0.3190
Nov	1.5997	1.1196	0.8217	2.8227	2.3426	0.0420	0.7691	1.4367	1.7591	0.1506		0.1715
Dec	1.7375	1.2675	0.9759	2.9348	2.4648	0.2126	0.9245	1.5780	1.8936	0.3190	0.1715	

Table 6.16: Mann-Whitney multiple monthly comparison Z-values for yellow maize

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan		0.7792	0.5911	0.9063	0.1016	1.5223	0.4166	1.7175	2.1087	**4.1646****	3.0389	**3.8030****
Feb	0.7792		0.1716	0.0908	0.6950	0.7430	0.3162	0.9383	1.3613	**3.4017***	2.2761	3.0555
Mar	0.5911	0.1716		0.2743	0.5157	0.9184	0.1513	1.1137	1.5295	**3.5734***	2.4477	3.2237
Apr	0.9063	0.0908	0.2743		0.7838	0.6562	0.3979	0.8515	1.2780	3.3168	2.1911	2.9723
May	0.1016	0.6950	0.5157	0.7838		1.4228	0.3230	1.6181	2.0133	**4.0672****	2.9415	**3.7076***
Jun	1.5223	0.7430	0.9184	0.6562	1.4228		1.0151	0.1952	0.6485	2.6743	1.5486	2.3428
Jul	0.4166	0.3162	0.1513	0.3979	0.3230	1.0151		1.2746	1.6838	**3.7309***	2.6053	**3.3781***
Aug	1.7175	0.9383	1.1137	0.8515	1.6181	0.1952	1.2746		0.4612	2.4831	1.3575	2.1555
Sep	2.1087	1.3613	1.5295	1.2780	2.0133	0.6485	1.6838	0.4612		2.0123	0.8867	1.6942
Oct	**4.1646****	**3.4017***	**3.5734***	3.3168	**4.0672****	2.6743	**3.7309***	2.4831	2.0123		1.1256	0.2774
Nov	3.0389	2.2761	2.4477	2.1911	2.9415	1.5486	2.6053	1.3575	0.8867	1.1256		0.8254
Dec	**3.8030****	3.0555	3.2237	2.9723	**3.7076***	2.3428	**3.3781***	2.1555	1.6942	0.2774	0.8254	

*Significant at 5% level of significance, **Significant at 1% level of significance

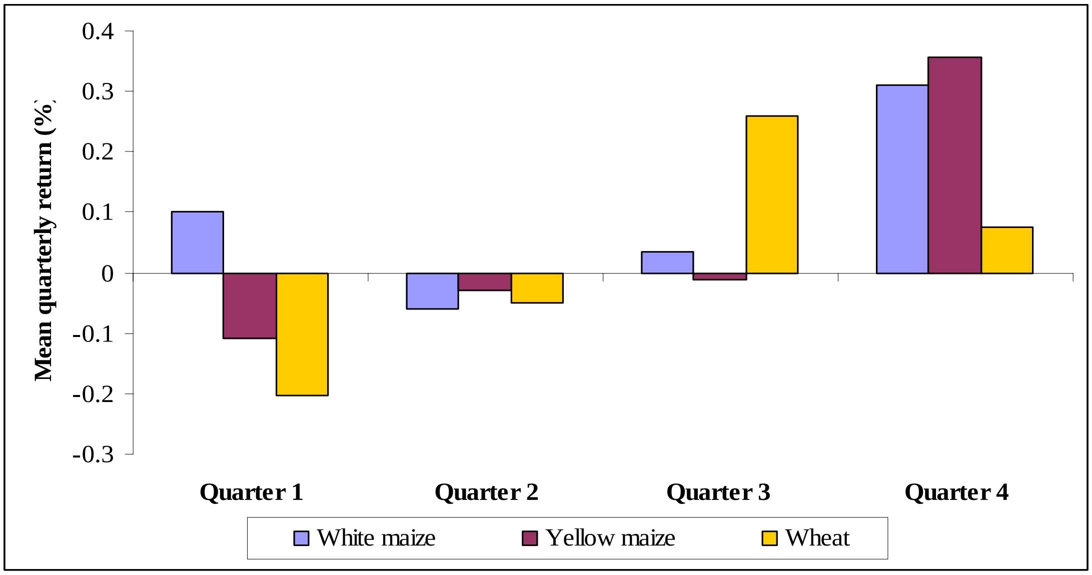
Apart from a significant Kruskal-Wallis result, white maize paired monthly comparisons were unable to point out any specific effect between respective months. However, monthly effects in the yellow maize market turned out to be more useful. Effects were noted between months in the first and fourth quarters of the year with specific isolated months in the second and third quarters also significantly deviating from fourth quarter months. As results were clearly affected by the time of the year, quarterly returns were calculated for each of the three commodities and results shown in Table 6.17.

Table 6.17: Mean quarterly returns for white maize, yellow maize, and wheat

	White maize		**Yellow maize**		**Wheat**	
	Mean return (%)	n	Mean return (%)	n	Mean return (%)	n
Mean return: Quarter 1[1]	0.1023	72	-0.1076	69	-0.2039	35
Mean return: Quarter 2[2]	-0.0589	74	-0.0294	66	-0.0485	32
Mean return: Quarter 3[3]	0.0358	75	-0.0113	74	0.2591	30
Mean return: Quarter 4[4]	0.3095	70	0.3556	73	0.0766	31

[1] January, February, March
[2] April, May, June
[3] July, August, September
[4] October, November, December

Figure 6.11: Mean quarterly returns for white maize, yellow maize, and wheat



Mean quarterly returns were found to be positive in the first, third and fourth quarters of the year and only negative during the second quarter. A strong positive return was noted in the fourth quarter. In contrast, yellow maize produced negative mean returns in the first three quarters with only the fourth quarter being large positive. In addition to white maize, yellow maize yielded a clear pattern of quarterly returns increasing constantly as the year progressed. Wheat produced negative mean returns in the first two quarters and positive returns during quarters three and four. The mean quarterly return was the lowest in the first, and the highest in the fourth quarter. Kruskal-Wallis ANOVA was conducted for each of the three respective commodities to test for a possible quarterly effect. Results are shown in Table 6.18.

Table 6.18: Kruskal-Wallis quarterly results for white maize, yellow maize, and wheat

Kruskal-Wallis	White maize	Yellow maize	Wheat
H	14.6125**	30.0101**	7.0556
p	0.0022	<0.0001	0.0701

**Significant at 1% level of significance

Significant results were obtained in the case of both white and yellow maize indicating that at least one of the quarterly means is different from the rest. In the case of wheat, the calculated H value failed to reject the null hypothesis of equal medians and it was therefore eliminated from further analysis. The wheat result could have been expected given the insignificant results from the testing for a monthly effect. Post-hoc analyses were conducted and Mann-Whitney U test results are presented in Table 6.19.

Table 6.19: Quarterly Mann-Whitney Z values for white and yellow maize

White maize	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Quarter 1		0.9289	0.2348	2.0438
Quarter 2	0.9289		0.6879	2.9990*
Quarter 3	0.2348	0.6879		2.2869
Quarter 4	2.0438	2.9990*	2.2869	
Yellow maize	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**
Quarter 1		0.6521	1.6590	5.5795**
Quarter 2	0.6521		1.0432	4.9595**
Quarter 3	1.6590	1.0432		3.9091**
Quarter 4	5.5795**	4.9595**	3.9091**	

*Significant at 5% level of significance, **Significant at 1% level of significance

The post-hoc evaluations revealed a significant effect between the second and fourth quarters of the year in the case of white maize, while a significant fourth quarter effect was present for yellow maize where the mean return of Quarter 4 was found to deviate significantly from all three other quarters. Corresponding p-values are shown in Appendix B, Table B.10.

6.4.5 The maturity effect

For each futures contract and for each respective commodity, daily settlement prices were used to calculate daily futures returns, mean monthly returns, and monthly variances of these returns for each of the six months preceding the expiration month. Analysis was limited to the six months preceding expiration because, especially in the case of agricultural commodities, open interest is low and trading volume relatively thin in periods long before maturity. As for the expiration month itself, Galloway and Kolb (1996:814) mention that trading volume typically decreases as expiration nears as a result of traders closing out their positions to avoid making or taking physical delivery of the underlying commodity.

Trading months for each contract were grouped according to the time to contract expiration month and coded -1 to -6 where -1 represents the first month preceding the expiration month, -2 representing two months prior, etc. Using the daily returns, mean monthly returns and variances were calculated according to the code with results shown in Tables 6.20 through 6.22. This was done for each of the three commodities respectively. Mean returns and variances were also calculated for the expiration months, as shown in the different tables, although not included in the actual analysis for the abovementioned reason.

Table 6.20: Mean white maize monthly returns and variances according to the time to expiration month

White maize	White maize – All contracts		White maize – July contracts only	
	Mean return (%)	Variance (%)	Mean return (%)	Variance (%)
Expiration month	0.1759	3.4235	0.0504	3.2288
-1	0.0298	2.8751	0.1602	2.5051
-2	0.0388	2.4555	-0.1032	1.9036
-3	0.1013	3.1159	-0.0805	2.2313
-4	0.0197	2.6763	0.0793	3.8587
-5	0.1154	2.9487	0.0116	5.0281
-6	0.0751	2.7548	-0.0558	3.1573

Table 6.21: Mean yellow maize monthly returns and variances according to the time to expiration month

Yellow maize	Yellow maize – All contracts		Yellow maize – July contracts only	
	Mean return (%)	Variance (%)	Mean return (%)	Variance (%)
Expiration month	0.1371	4.4881	0.0074	2.5261
-1	0.0871	2.5941	0.1394	2.0393
-2	0.0182	2.6086	-0.0601	1.8328
-3	0.0766	2.6721	-0.0451	2.0018
-4	0.0372	2.5809	0.0494	3.4328
-5	0.1233	3.0028	-0.0468	4.1731
-6	0.0031	2.5832	-0.1777	3.1676

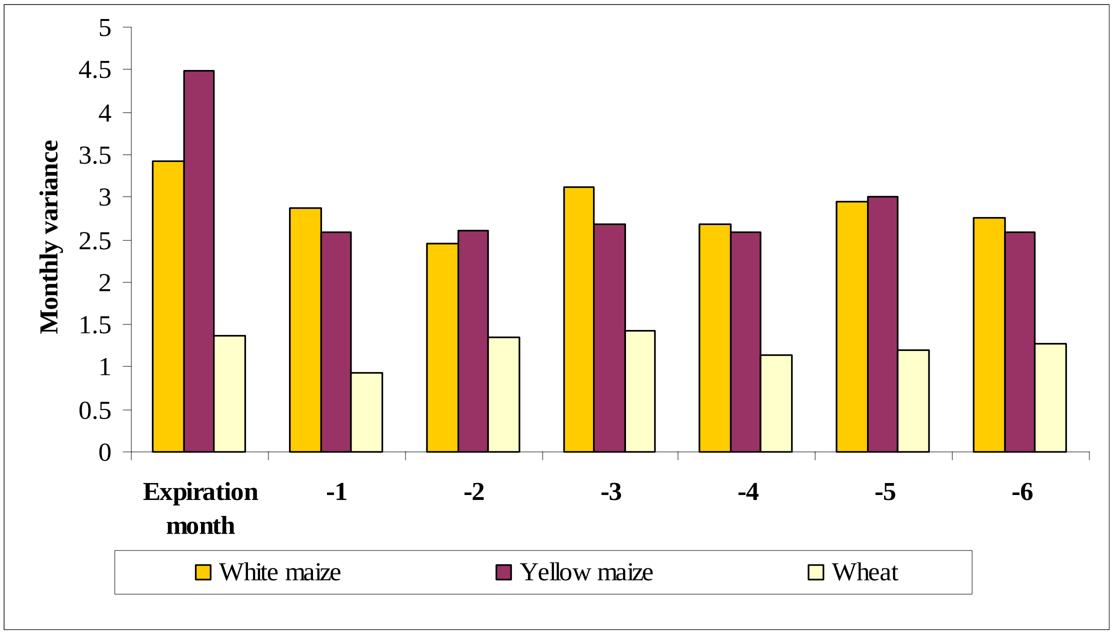
Table 6.22: Mean wheat monthly returns and variances according to the time to expiration month

Wheat	Wheat – All contracts		Wheat – December contracts only	
	Mean return (%)	Variance (%)	Mean return (%)	Variance (%)
Expiration month	0.1307	1.3596	0.3848	0.8542
-1	0.1749	0.9328	0.3261	0.7573
-2	-0.0554	1.3555	0.0069	0.5593
-3	0.0176	1.4236	-0.2483	0.5781
-4	0.0676	1.1421	0.1579	0.5495
-5	0.2552	1.1908	0.2645	0.6847
-6	0.0097	1.2819	0.0561	0.8289

Calculating mean monthly returns lagged from a specific point in time causes different futures contracts of the same commodity to overlap, as is the case of all three commodities under consideration. This may cause calculated means and variances of different contract months to influence each other and have a possible effect on results. To overcome this possible effect, a specific single contract month was identified for each of the three commodities respectively and coded according to the time to expiration as already explained in this section. This implies that only one contract per year was now used in addition to the five overlapping contracts when all contract months are taken under consideration. For both white and yellow maize the July contracts were used as they represent the most liquid forecast of the future spot price at delivery because of their expiration at the end of the crop harvest. For wheat the December contracts were used for the same reason mentioned in the case of maize and as they also bear the necessary significance in terms of their liquidity. Calculated monthly means and variances for the specified months are also shown in Tables 6.20 through 6.22.

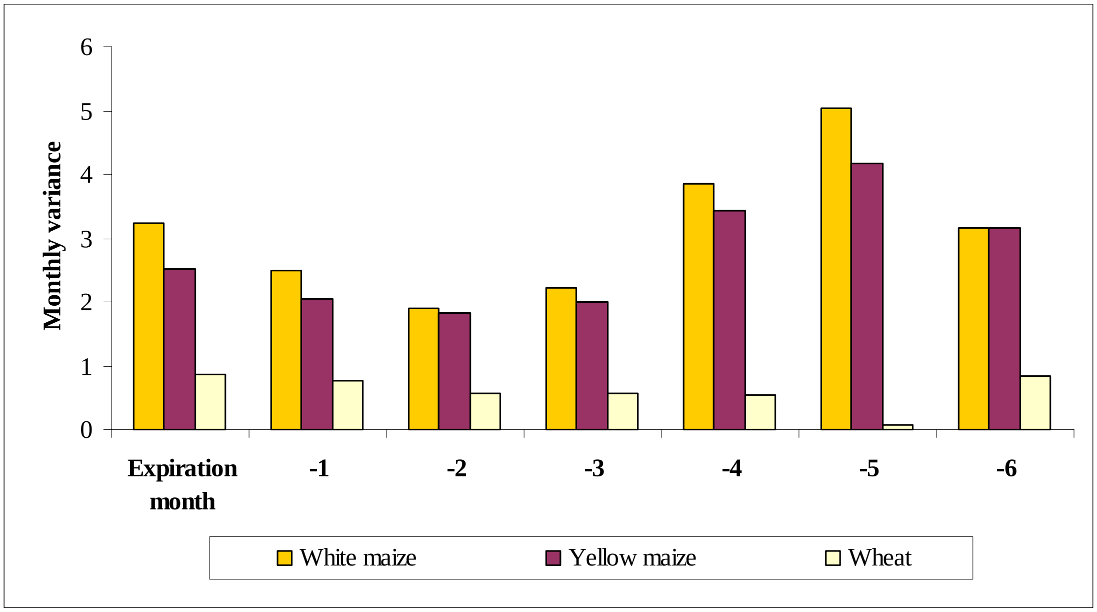
Figure 6.12 shows the calculated monthly variances for all contracts included according to the time to contract expiry. The figure clearly highlights the increase in monthly price variance during the expiration month in the case of both white and yellow maize (Levene's test: white: F=1.06 with (6, 2931) df, p=0.3872; yellow: F=1.76 with (6, 2742) df, p=0.1032). However, from the histogram there is no definite pattern of a monthly price variance maturity effect as the expiration month approaches.

Figure 6.12: Calculated monthly variances according to the time to expiration for white maize, yellow maize, and wheat – all contracts.



In the case of wheat, variances resulted in even less significance in terms of a possible maturity effect as observed in Figure 6.12 (Levene's test: wheat: F=0.73 with (6, 875) df, p=0.6224). In comparison, the calculated monthly variances only including the specified contract months are shown in Figure 6.13. A possible effect was noted from month -2 through expiration month with monthly variances gradually increasing in the case of all three commodities. However, this effect is quickly eroded as the time to maturity increases further with month -4 and -5 producing large variances relative to the other contract months in the case of both white and yellow maize. In addition, wheat shows a more consistent maturity pattern.

Figure 6.13: Calculated monthly variances according to the time to expiration for white maize, yellow maize, and wheat – specific contracts.



The volatility of the daily returns for the different months of the different contracts was calculated using the statistical estimator of variance:

$$\sigma^2_{j,k} = \sum_{t=1}^{n_{j,k}} \frac{(A_{j,k,t} - \overline{A}_{j,k})^2}{n_{j,k}}$$

(6.6)

where $\sigma^2_{j,k}$ is the volatility of the daily returns for contract j in month k, $A_{j,k,,t}$ is the observation on day t in month k of contract j, $\bar{A}_{j,k}$ is the arithmetic mean of the daily futures returns for contract j in month k, and $n_{j,k}$ is the number of observations for contract j in month k. Following Milonas (1986, 448) and Galloway and Kolb (1996, 815), the examination of the maturity effect in an univariate setting would include the calculated monthly variances being used to determine the percentage of contracts of which the futures price volatility in a given month before expiration is larger than the volatility in the prior month. This pattern would be expected if a significant maturity effect exists as there will be an inverse relationship between the time to maturity and the variability of futures price changes. Unfortunately, because of the relatively short existence of the market, using only the specific identified contract months for each commodity, as explained above, would limit the number of observations extremely. Therefore, apart from the fact that observed contract months would cause monthly observations to overlap, the total sample of contract months was used and monthly variances grouped accordingly. For each of the three respective commodities monthly variances were grouped according to the specific month (-1 through -6) preceding the expiration month, which itself was not included in the analysis. In each case the percentage of monthly variances that is greater than the month directly preceding it was calculated (σ^2_1 = variance of one month preceding expiration month, σ^2_2 = variance of two months preceding expiration month, etc.). Also, for each contract the mean variance of months 1 to 3 and months 4 to 6 were calculated. Percentage observations greater in the first period (1 to 3) were calculated and results tabulated.

Table 6.23: Calculated monthly variances according to the time to expiration month for white maize, yellow maize, and wheat

	White maize	Yellow maize	Wheat	
Number of contracts	23	23	14	
Number of contract months	138	138	86	
	Percentage of contracts following maturity effect rule			**Total**
$\sigma^2_1 > \sigma^2_2$	69.56	47.82	46.67	**54.68**
$\sigma^2_2 > \sigma^2_3$	34.78	52.17	40.00	**42.32**
$\sigma^2_3 > \sigma^2_4$	56.52	43.48	57.14	**52.38**
$\sigma^2_4 > \sigma^2_5$	52.17	47.83	50.00	**50.00**
$\sigma^2_5 > \sigma^2_6$	52.17	56.52	45.45	**51.38**
$\sigma^2_{1-3} > \sigma^2_{4-6}$	52.17	43.48	45.45	**47.03**
Total	**52.89**	**48.55**	**47.45**	**49.63**

Calculated monthly variances were grouped and compared as shown in Table 6.23. For each of the three commodities the percentage of contracts for which the futures returns variance in a given month before expiration is larger than the variance of the previous month, as would be expected if a maturity effect is present. In the case of white maize, 69.56 % of the contracts have a variance in the month before expiration month greater than in the second month prior to expiration month ($Z=4.60$, $p<0.01$). This effect, although not significant ($p>0.05$), tended to exist throughout except for the variances in the second month of which only 34.78 % were greater than that of the third month prior to expiry. The maturity effect, however, tended to be less significant in the case of yellow maize. An effect was only present between months 2 and 3 as well as months 5 and 6 prior to expiration month. On average only 48.55 % of the observed contract months produced larger variances than the corresponding preceding month compared to the 52.89 % found in the case of white maize. Wheat monthly variances did not produce consistent variances according to the maturity effect rule. A possible effect was only evident between months 3 and 4 prior to maturity.

6.5 Summary

In this chapter the daily futures prices of three commodities traded on the JSE APD were evaluated for the presence of regular price behaviour over different time horizons. White maize, yellow maize, and wheat were respectively tested for a day-of-the-week effect, holiday effect, turn-of-the-month effect, monthly and quarterly effect, and a possible maturity effect. Analyses were conducted on daily future contract prices that realised over the period January 1997 to July 2002.

Results, summarised in Table 6.24, suggest the significant presence of a Monday effect in the day-of-the-week futures prices of white and yellow maize. Mean Monday returns were not only found to be significantly different from the other days of the week, but also produced the only negative mean return of the week. Daily price return also produced a definite pattern especially in the case of white maize. Wheat return yielded no negative Monday return and a day-of-the-week pattern inconsistent with that of the two maize commodities. No Monday-effect could also be found.

In the case of white maize, the Thursday return directly following a public holiday on Wednesday tended to be significantly different from normal Thursday returns. This post-holiday return was also large and negative. This was the only holiday anomaly found for white maize, while the mean Monday day-of-the-week return preceding a holiday on Tuesday also tested to be remarkably different from normal Monday returns.

Return effect due to the time of the month proved to be significant in the case of all three commodities under consideration. Daily futures price returns showed a clear effect going from the last day of a month to the first day of the following month. The difference between the mean returns of the two halves of each month was found to be statistically significant. Futures prices tended to be small and negative towards month-end, increasing drastically from the first day of the next month. This effect was further supported by reducing the 9 day periods to 5 and 3 days respectively. Significant results suggested that the effect was in fact concentrated around the turn of the month and not only between the first and second halve of the month.

Analysis of the time of the year revealed that there was indeed a pattern of significantly higher monthly price returns during October and December in the case of the yellow maize market, although no specific effect could be identified in the monthly returns of white maize or wheat. The time-of-the-year effect was further emphasised through the quarterly returns of the commodities under consideration. In this case, both white and yellow maize produced a significant year-end effect with fourth quarter returns being different to that of the other three quarters, however, this effect was once again not as strong in the case of white maize compared to that of yellow.

Finally, the maturity effect was tested by comparing monthly variances according to the time to expiration month. Although a definite increase in the variance of the expiration month could be noted from visual inspection, statistical results revealed no significant effect of maturity. In a somewhat different approach a maturity effect was noted in the case of white maize where months nearer to contract expiration tended to yield more volatile daily returns. The effect was, however, not as significant in the yellow maize and wheat markets.

Table 6.24: Summary of results

Anomaly	White maize	Yellow maize	Wheat
Day-of-the-week (Monday-effect)	Yes	Yes	No
Holiday-effect	No	No	No
Turn-of-the-month-effect	Yes	Yes	Yes
Time-of-the-year-effect	Yes	Yes	No
Maturity effect	Yes	No	No

Chapter 7

AGRICULTURAL FUTURES PRICE BEHAVIOUR AND PUBLIC INFORMATION

7.1 Introduction

The price discovery efficiency of South African agricultural commodity markets has been the focus of the study thus far. In Chapter 5, the Efficient Markets Hypothesis (EMH) was modelled and applied to the white maize, yellow maize, and wheat futures markets as they are traded on the JSE APD. The weak-form efficiency test results failed to reject the EMH and suggested that all three markets functioned efficiently and unbiasedly over the periods under consideration. These results provided an answer to the important research question, that is, whether the respective agricultural commodity markets functioned efficiently in terms of their price discovery function.

Contradicting the EMH, price return irregularities or seasonal anomalies are common phenomena among various equity and futures markets. Five of the most frequently found anomalies were selected and tested for their existence in the price returns of the three commodities under consideration. Results showed strong evidence of some patterns existing in price returns. In theory, general explanations are provided for these phenomena, of which the most important are cited and mentioned in the study. The question arises as to whether the price anomalies found were the result of predictable return patterns in agricultural futures prices, and therefore indicative of market inefficiency, or whether an alternative price adjustment process could have been responsible for contributing towards the significance of the relevant anomalies. In the latter case it would not necessarily imply futures market inefficiency, or at least, not inefficiency caused by the existing predictable return pattern.

Fortenbery and Sumner (1993:157) noted that the identification of price risk in agricultural markets is an important component in developing a marketing strategy for market participants. Recognising and adjusting for the potential price risk associated with anticipated events is an integral part of market participants' approach to agricultural futures markets. Some events that affect prices are largely unanticipated, making it difficult to manage the associated price risk. Other events, however, are fully anticipated and the risk associated with these events can be the key factor in, for example, the overall performance of a market participant's market strategy. Identifying the market's reaction with the knowledge of an anticipated event, specifically public information releases, will be the main focus of this chapter. Also, whether the behaviour of the different commodity markets around scheduled events significantly contributed to the anomalies found in the previous chapter, is a key research question to be answered in this chapter. The outline of this chapter is as follows:

1. evidence from previous studies will be reviewed in section 7.2,
2. section 7.3 focuses on the fundamental price determinants for the South African maize and wheat markets, while
3. international maize and wheat prices are discussed as a determinant of domestic prices.
4. Section 7.5 provides a detailed description of the data used as well as the selection of the different announcements,
5. the empirical approach is formulated in section 7.6,
6. results of the different tests are provided in section 7.7, and
7. section 7.8 briefly summarises the findings of the chapter.

7.2 Futures prices and the release of scheduled public information

Asset prices change in response to public and private information and as a result of pricing errors (French and Roll, 1986:7). To date a number of studies, such as Daigler (1997), Ederington and Lee (2001), Fortenbery and Sumner (1993), Han *et al* (1999), and Jones *et al* (1998), have focussed on the effect of anticipated public information releases on the daily and intraday price changes of various securities. In general, results are consistent with the fact that volatility increases around information releases as a direct effect of uncertainty and reaction about the outcome of the scheduled information released.

The effects of reports or announcements on specifically agricultural commodities have also been studied recently to some extent. Hoffman (1980:150) investigated the effects of quarterly livestock reports on hog and cattle prices. Pre-report prices were measured as a 5-day average price leading up to and including the report day, while the post-report prices were the average of the 5 days following the report. Hoffman found a significant announcement effect in cash markets, although not in the case of the futures markets. He concluded that futures markets were more efficient in anticipating the underlying supply characteristic in the cattle and hog markets.

The impact of USDA crop size forecast announcements on the cash prices of corn, wheat, soybeans, soybean meal, and soybean oil was investigated by Milonas (1987:571). Price changes of daily cash prices were calculated for the twenty days surrounding a report release. In general, Milonas found that cash markets reacted to the USDA announcements, but that not all markets reacted with equal strength. He concluded that the markets were generally efficient in incorporating the new information. Sumner and Mueller (1989:1) examined the informational content of USDA domestic crop production reports by measuring their impact on corn and soybean futures prices. They calculated the absolute differences between price changes following the release of a report and price changes on non-report trading days as a measure of market participants' reactions. Mean absolute price changes following announcements were found to be greater than that of non-announcement days. As such, they concluded that the USDA reports did provide news to the market which changed the overall supply and demand perceptions of market participants.

The effect of USDA crop production reports and USDA World Agricultural Supply and Demand Estimates on US soybean and corn futures and option contracts were investigated by Fortenbery and Sumner (1993:157). In their study they calculated the absolute daily price changes as a measure of market reaction and tested the days following a report release against non-report trading days. Their findings suggested that the market impact of USDA reports has declined in recent years prior to the study. The conclusion was drawn that market participants had become sufficiently skilled to anticipate the information forthcoming. Finally, Colling and Irwin (1990:85) focussed on the reaction of live hog futures prices to the USDA Hogs and Pigs Report. They differentiated between anticipated and unanticipated information and measured the extent to which live hog futures reacted efficiently to the unanticipated information. They concluded that the live hog futures market was efficient relative to the report and that prices did not react to previously anticipated information.

Numerous studies also focussed on price behaviour around information releases of other securities. Jones *et al* (1998:315) investigated the effects of macroeconomic news on bond market volatility. They found evidence of a "calm before the storm" effect and suggested that, when the market knows that a large shock is forthcoming, return volatility generally decreases. They further attributed this effect to changes in trading volume during this period prior to the announcement, private information, preferences towards risk, and portfolio rebalancing. Ederington and Lee (1996:513) explored the determinants of market participants' uncertainty regarding future prices of different securities. They found that scheduled announcements generally led to a drop in the standard deviation of daily returns after the particular announcement as uncertainty is resolved. They further distinguished between scheduled and unscheduled announcements and suggested that the volatility only rises after the unscheduled announcements as this causes a sudden increase of uncertainty.

Monroe (1992:1) studied the profitability of volatility spreads in interest rate futures around information releases. Monroe evaluated trading strategies and concluded that changes in volatility sometimes proved to be significantly profitable, even in the absence of significant volatility changes. However, the trading profits disappeared with the inclusion of transaction costs in the profit calculations. He also suggested that, while the market appeared to be inefficient with respect to the effects of some economic announcements, these inefficiencies disappear after accounting for transaction costs. Graham *et al* (2003:153) investigated the relative importance of scheduled macroeconomic news for stock market investors. Similarly to Ederington and Lee (1993:1161) and (1996:513), they concluded that implied volatility increases prior to the macroeconomic announcement and then drops immediately after the information is released. They further explained this behaviour of implied volatility when investors expect that volatility will be constant on non-announcement days and twice as much as non-announcement day's volatility on the actual announcement day. They finally suggested that the size of the volatility effect can be used to measure how important the different macroeconomic announcements are considered by stock market investors.

Similar findings of volatility effects for different securities around scheduled and unscheduled information releases have been documented by Ederington and Lee (2001:517), Daigler (1997:45), Runkle (1992:635), and Leistikow (1990:377). Although plenty has been documented on the reaction of prices after information is released in a market, the effect of uncertainty on volatility before, and on the day of the actual announcement has been investigated to a much lesser extent. Generally, if the market reacts with higher volatility after the announcement, the days prior to the announcement, would experience a decline in price volatility due to participants' unwillingness to risk position-taking ahead of the scheduled report. This chapter mainly focuses on the level of uncertainty in terms of price volatility associated with anticipated announcements.

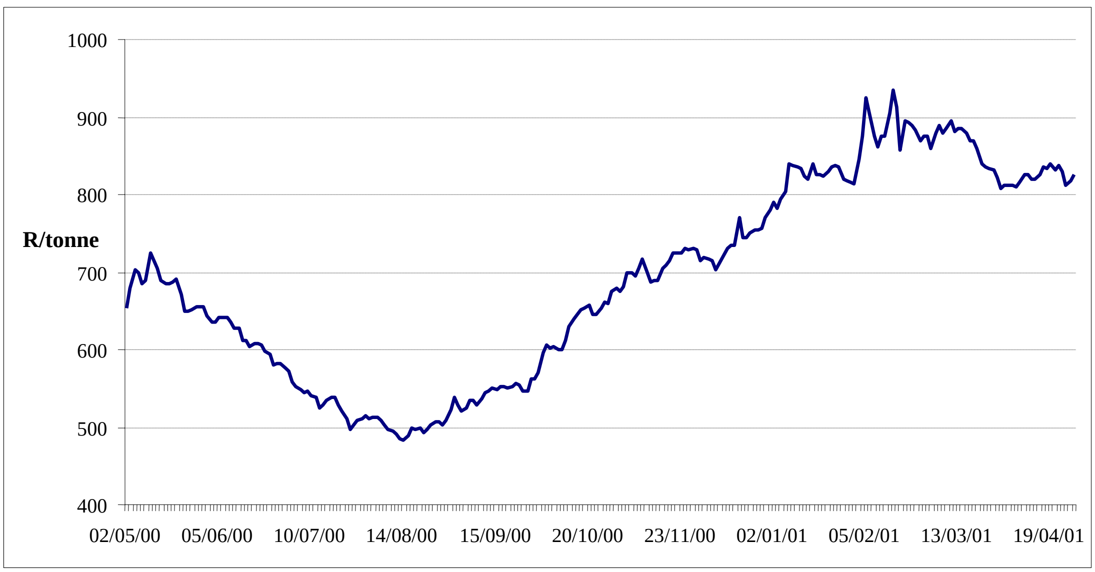
7.3 Fundamental price determinants of maize and wheat futures prices

Fundamental factors refer to the basic underlying and everyday occurrences that have a direct influence on, for example, the price of maize. According to Grönum and Van Schalkwyk (2000:505), Edwards and Leibbrandt (1998:239) and Gravelet-Blondin (2003:1) prices of South African grain commodities, particularly those of maize and wheat on the commodities market are determined by the interpretation of the information related to the following factors:

1. the international supply and demand situation and international prices,
2. the Rand/Dollar exchange rate,
3. basic domestic supply of and demand for maize and/or wheat,
4. the regional supply and demand situation, and
5. seasonal weather patterns and occurrences.

Generally, the relative importance of each of the determinants can vary according to the time of the marketing season (as defined in Chapter 2). Taking into consideration one maize marketing season, for example the 2000/2001 yellow maize marketing year ranging from 1 May 2000 to 30 April 2001, a seasonal low in price is common during late June to approximately early August. This is mainly due to harvesting pressure and physical stocks being sold on the market by producers, normally having the effect of downward pressure on maize prices. The Rand/Dollar exchange rate and international prices play a significant role as fundamental determinants over this period. Weather is of less concern as the crop is at a stage of not being significantly affected by severe conditions. The currency remains an important factor and weather starts to play a more dominant role from about September as planting intentions for the new season start to develop. Taking into consideration the relatively low average annual rainfall of the major maize production areas, good spring and early summer rains are necessary in order to sustain a sufficient level of deep soil moisture throughout the growing period of the crop (Van den Berg, 2003a: 9).

Figure 7.1: Yellow maize nearest month futures price for the 2000/2001 marketing season ranging from 1 May 2000 to 30 April 2001



Source: GSA (2003)

Annually from September the National Crop Estimates Committee (NCEC) releases, on a bi-monthly basis, the planting intentions for the new crop and, on a monthly basis from January, the production and total area under production estimates. Table 7.1 shows the order of summer crop-reports produced by the NCEC through the marketing season as provided by Sagis (2003).

From the first report in September the market also starts to focus on future supply associated with the new crop taking into consideration factors such as carry-over stocks from the previous season, import and export possibilities and local demand. Accompanied by the start of the rainy season, the market is usually very sensitive and more volatile over this period as changes in weather patterns can and do occur very suddenly. The market remains volatile until approximately April where the larger part of the maize crop reaches a stage where it is less sensitive to the weather. By this time the size of the crop is estimated relatively accurately and changes to the figures are normally small and well anticipated by the market. From this point in time trade is less volatile and, with very little local fundamental news to drive prices, the Rand/Dollar exchange rate and international prices play a key role in determining price direction.

Table 7.1: Order and contents of NCEC summer and winter crop reports

Month	Summer crop reports	Winter crop reports
January	Preliminary area planted – summer crops	Area and 6th production estimate – winter crops
February	Revised area and 1st production estimate – summer crops	Final production estimate – winter crops
March	Area and 2nd production estimate – summer crops	First planting intentions – winter crops
April	Area and 3rd production estimate – summer crops	-
May	Area and 4th production estimate – summer crops	Revised planting intentions – winter crops
June	Area and 5th production estimate – summer crops	-
July	6th production estimate – summer crops	Preliminary area planted – winter crops
August	Final production estimate – summer crops	Area and 1st production estimate – winter crops
September	First planting intentions – summer crops	Area and 2nd production estimate – winter crops
October	-	Area and 3rd production estimate – winter crops
November	Revised planting intentions – summer crops	Area and 4th production estimate – winter crops
December	-	Area and 5th production estimate – winter crops

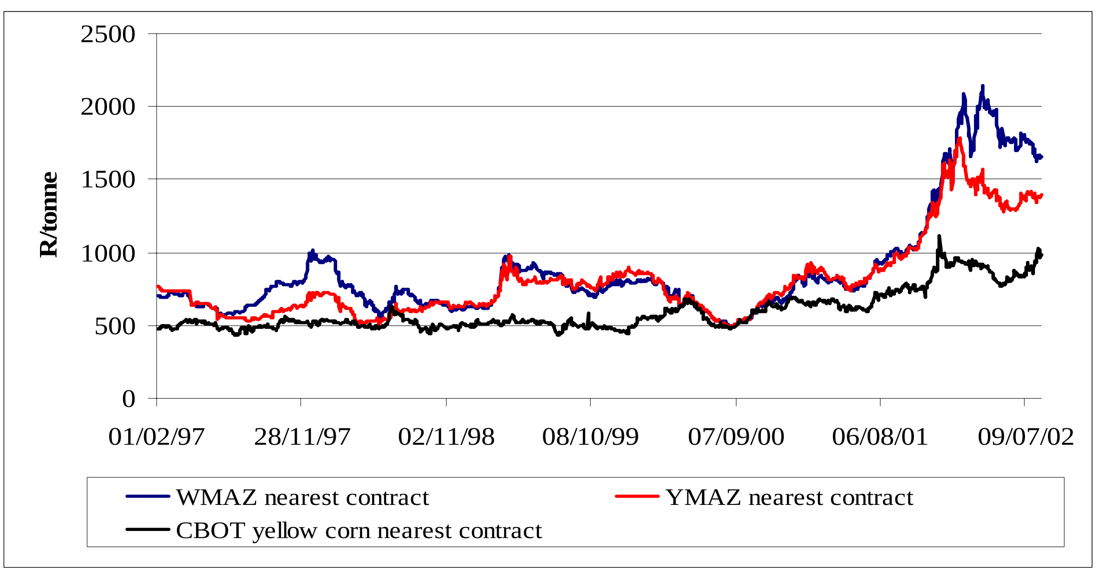
Source: Sagis (2003)

The wheat market generally follows a similar type of trend, although over a different period of the year because of the fact that it is a winter crop. The domestic marketing season for wheat ranges from 1 October to 30 September the following year (De Klerk, 2003:2). Weather is of importance to the market before and around the start of the planting season (June/July) and during critical stages of the crop's development. Table 7.1 shows the order of NCEC winter crop area and production estimates compared to that of maize. Apart from the weather, international wheat prices and the Rand/Dollar exchange rate also plays a very important price determining role (Edwards and Leibbrandt, 1998:239), especially during periods when the market is not much driven by the weather or supply situation of wheat. This relationship is pointed out in the following section.

7.4 International maize and wheat prices

The Chicago Board of Trade (CBOT) #2 yellow corn price is used domestically as the official world price for yellow maize (Gravelet-Blondin, 2003). Figure 7.2 shows the nearest contract prices for US #2 yellow corn, South African white maize, and yellow maize that was realised over the period January 1997 to July 2002. The relationship between Chicago and South African maize prices is best explained through the local import and export parity realization prices.

Figure 7.2: Relationship between Safex white and yellow maize and CBOT #2 yellow corn, January 1997 – July 2002



Because of the current free market situation, in contrast with the regulated environment prior to 1996, the elastic nature of supply and demand results in volatile maize prices, as evident from Figure 7.2. Van der Vyver and Van Zyl (1989: 80) noted that surpluses and deficits necessitate exports and imports respectively and South African maize prices may thus vary between the landed import and net export realization prices. The size of this price difference, according to Bown *et al* (1999: 278) and Wiseman (1999: 12), and thus the degree of possible local maize price fluctuation, is dependent largely on transport costs to and from the rest of the world. This is also true for the domestic wheat market. The calculation of the respective import and export parity prices is shown in Table 7.2 as cited from the South African Grain Information Service (Sagis, 2003).

The CBOT #2 yellow corn is used as base price (Van der Vyver and Van Zyl, 1989: 81) or world price from which yellow maize import and export parities for the local market are calculated. Figure C.1 (Appendix C) shows the historical daily parity prices compared to the Safex nearest month yellow maize contract price for the period under consideration. During periods of surplus maize stocks and ample supply, local maize prices will trade close to the calculated export parity levels. If prices go below export parity, it would mean that the local product becomes very attractive in terms of price for overseas buyers and export orders quickly dissolve the surplus stocks.

Table 7.2: Calculation methods of South African yellow maize import and export realisation prices

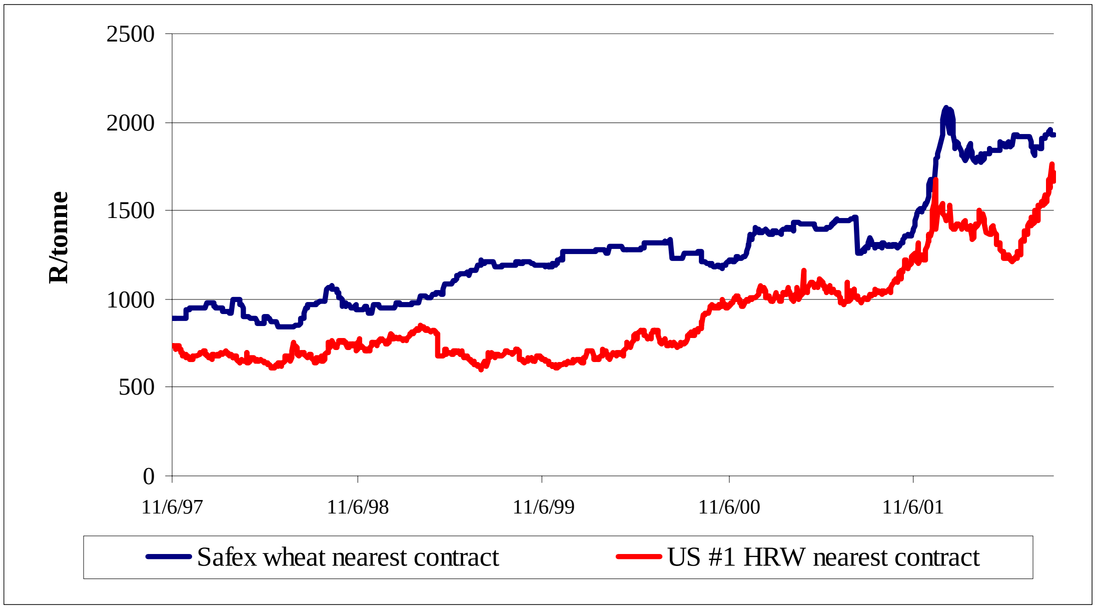
Import Parity Price	Export Parity Price
FOB Gulf value[1] ($/tonne) *Plus:* Freight rate ($/tonne) *Plus:* Insurance ($/tonne)	FOB Gulf value ($/tonne) *Plus:* difference in quality and locality
Price in Durban[2] (converted to R/tonne)	**SA FOB price (converted to R/tonne)**
Plus: Financing costs (R/tonne) *Plus:* Discharging costs[3] (R/tonne) *Plus:* Import tariff[4] (R/tonne)	*Minus:* Financing costs (R/tonne) *Minus:* Transport costs[6] (R/tonne) *Minus:* Loading costs[7] (R/tonne)
F.O.R.[5] at Durban harbour (R/tonne)	**Export realisation (R/tonne)**
Plus: Transport costs to Randfontein (R/tonne)	
Delivered Randfontein price (R/tonne)	

[1] Free-on-board US no.2 yellow corn price quoted in the Persian Gulf
[2] Price in Durban harbour (not landed)
[3] Discharging in Durban harbour
[4] When applicable
[5] Free-on-rail
[6] From Randfontein to Durban
[7] Durban harbour
Source: Sagis (2003)

In times of deficit, local prices would realise close to the import parity level and, if trading above this level, it would mean that local maize buyers would be able import the product at a lower price than available on the local market. These two price parity levels change practically on a daily basis as international price, the R/$ exchange rate, and shipping and other transport costs fluctuate over time.

Wheat parity prices are calculated on a similar basis and the actual calculation methods are shown in Appendix C, Table C.1. Note that, as in the case of maize, the level of the R/$ exchange rate would largely affect the value of imported or exported grain at any point in time. The international base price generally used for wheat is the Kansas City Board of Trade #1 Hard Red Winter (HRW) wheat. Depending on the price and class required, South Africa also imports wheat from other destinations such as US Dark Northern Spring wheat, Argentine Trigo Pan wheat, Australian Standard White wheat, and Canadian Western Red Spring wheat (Geldenhuys, 2003). The wheat of preference at any point in time is used to calculate the import parity price. Figure 7.3 shows the relationship between the nearest contract month US HRW and Safex wheat prices that were realised over the period November 1997 to July 2002.

Figure 7.3: Relationship between Safex and US #1 HRW wheat nearest contract months, November 1997 – July 2002



It can be noted that a degree of correlation existed between the US and domestic prices of wheat quoted in rand per ton over the period under consideration. The nearest contract price for wheat is shown together with the realised import and export parity prices over the same period in Figure C.2, Appendix C. Similarly to maize, domestic wheat prices traded between these two levels for most of the period and only for short periods at or above the import parity level. Also of note is the high correlation between the wheat price and the two parity prices. The purpose of this section was to emphasise, among others, the importance of international prices and especially the Rand/Dollar exchange rate on the domestic maize and wheat futures prices. This characteristic is of great importance to the methodology used to test the effect of public information from different sources on these two local commodity markets.

7.5 Data

Daily nearest contract month futures price returns or changes were used that were realised over the 31-month period from January 2000 to July 2002. These prices were sampled for white maize, yellow maize, and wheat futures respectively. All data were collected from the Agricultural Products Division of the JSE Securities Exchange. The announcement dates of 9 macroeconomic indicators and 5 agricultural reports were collected from various sources. Due to the contradicting nature of the report dates from different sources, especially of the macroeconomic announcements prior to 2000, the observation period was chosen to start from January 2000.

The measure of uncertainty used in this study was based on the absolute difference (return) between daily closing prices. Note that the term "return", for the purpose of the analyses in this chapter, refers to the price change between closing prices and does not relate to an actual return or dividend from, for example, a portfolio or speculative position. For report days the relevant return was calculated as the difference between the closing price on the day the report was released and the closing price of the preceding day. For example, if a report was released on March 10, the relevant measure of market uncertainty was the absolute difference between the closing price on March 10 and the closing price on March 9. Differences between prices on all other trading days represent non-report price movements, although, as also noted by Fortenbery and Sumner (1993:161), any other influence by an upcoming or recent report of whatever nature cannot be ruled out. The relative price change variable used to measure uncertainty accounted for differences in price levels over the observation period and was defined as:

$$|\Delta P_t| = Abs[(P_t - P_{t-1})/(P_{t-1})] \times 100 \tag{7.1}$$

where, *Abs* refers to the absolute value, and P_t represents the futures price on day t. Note that, for the purpose of the study, the absolute daily price change (formula 7.1) will be referred to as the volatility of the price on that specific day. *A priori*, it is not known whether the market price change will be positive or negative on a report day or following a report because it is not clear in which direction perceptions change.

On average, according to Fortenbery and Sumner (1993:160), price changes following a report are likely to be zero, while the average absolute value of price changes are likely to be positive. In addition, the magnitude in change in traders' perceptions will be reflected in the magnitude of price change. Therefore, above-average changes in perceptions will result in above average changes in market price. The focus of the analysis is not the direction of price change, but the magnitude in reaction to a scheduled announcement. This line of reasoning has also been employed by Turnovski (1983:1366), Sumner and Mueller (1989:3), and Fortenbery and Sumner (1993:160). More specifically, the analysis in this chapter will focus on the calculated measure of uncertainty on the day of the announcement rather than the reaction in price after the relevant information was made public. Uncertainty about the information to be released would also mean uncertainty about the future direction in price. Therefore, prior to the release of an important information-bearing report, market participants would be hesitant to position themselves speculatively and this will reflect in smaller price changes as the level of uncertainty increases to reach its maximum on the day of the information release. As evident from work produced by Hoffman (1980:150), high levels of uncertainty and reaction implies more inefficiency as the market does not anticipate the change in the underlying fundamentals very well. The lower the reaction to released information, the better the anticipation of market-moving news and therefore, the more gradual the price adjustment process rather than a drastic reaction.

In Chapter 6 the presence of a possible maturity effect was evaluated and, although the significance of the statistical results was mixed, calculated expiration-month volatility tended to be higher than that of the preceding months in the case of all three commodities under consideration. In order to avoid the possibility of excessive price changes generally found in expiration months it was necessary to control for the maturity effect and its possible impact on results. Therefore, the expiration month was left out of the time series by moving to the second nearest contract month instead of including the data from the nearest contract expiration month. For example, if September 2000 was the nearest contract the data were taken from that contract until the last trading day in August 2000 then moving to the second nearest contract, which would be December 2000, from which futures prices were taken from the first trading day in September. This method of data series construction was consistent with work produced by Leng (1996:832), Han *et al* (1999:670), and Wei and Leuthold (2000:14).

Using this method had three important implications. First, the expiration months were avoided and this eliminated the effect of above average daily price changes as a result of no daily price limits in the expiration month. Secondly, excluding expiration months of the samples also affected the inclusion of constant month contracts. As these contracts only trade for approximately one month each in the months between primary contracts it almost automatically excluded their use in the constructed maturity-controlled samples. Although some of the observations from the constant month contracts do occur outside their own expiration month, it was decided to exclude them and use the nearest primary contract instead as it is generally a much better estimate of futures prices in terms of its volumes and liquidity. Thirdly, the change from one primary contract to the following nearest primary contract implicated a significant price "jump" mainly because of the cost-of-carry between the two contracts. To avoid this effect a specific "roll-over" technique was developed by Wei and Leuthold (2000:14). When switching contracts, on the last day of the old contract, the difference between the old contract price and the new contract price was observed, whereafter this difference was added or subtracted to all prices of the new contract. Table 7.3 illustrates this procedure by assuming September and December contracts switch at the end of August and beginning September.

Table 7.3: Illustration of roll-over technique to adjust samples: example for white maize

	29 Aug	**30 Aug**	**31 Aug**	**01 Sept**	**04 Sept**	**05 Sept**
September contract price	508	523	538			
December contract price			558	555	547	550
Adjusted series	***508***	***523***	***538***	***535***	***527***	***530***

This adjustment caused the new price series to represent price levels different from the true value of the commodities in comparison to the normal nearest month contract prices. However, in this chapter the focus was on the day-to-day price changes and the price changes from the adjusted series was accurate without jumps between contracts and was thus suitable for analysis. This adjustment was made for the daily futures prices of the three commodities respectively and Table 7.4 presents the descriptive statistics.

Table 7.4: Descriptive statistics for white maize, yellow maize, and wheat adjusted price samples

	White maize	Yellow maize	Wheat
N	640	640	640
Mean absolute return (%)	1.2222	1.0347	0.4447
Median	0.8961	0.7973	0.8933
Minimum	0	0	0
Maximum	5.9627	4.7468	5.1806
Standard Deviation	1.0421	0.8703	0.7185
Variance	1.0858	0.7575	0.5162
Skewness	1.1186	1.0727	1.8684
Kurtosis	0.8265	0.6314	3.2806
Tests for normality:			
Kolmogorov-Smirnov D	0.1315** (p<0.01)	0.1205** (p<0.01)	0.2545** (p<0.01)
Shapiro-Wilk W	0.8793** (p<0.0000)	0.8881** (p<0.0000)	0.7054** (p<0.000)

**Significant at 1% level of significance

Zero observations did occur in the samples as a result of the closing prices of two consecutive days being equal. Fortunately, in contrast with the analyses conducted in Chapter 6, the observation period excluded periods (1996-1998 for maize and 1998 – 1999 for wheat) representing thin trading volumes and a general lack of liquidity because of a relatively young futures market. Zero observations as a direct result of no trading activity were removed from the samples, although to a greatly restricted extent to the observation period from January 2000, which favoured the integrity of the results. Two tests for normality, namely Kolmogorov-Smirnov and Shapiro-Wilk were conducted for each of the three samples. Procedures test the null hypothesis of a normal distribution against the alternative that the distribution under consideration is not normal. In the case of all three samples under consideration the null hypothesis was rejected, at the 1% level of significance, suggesting non-normal distributions. This feature limited the use of conventional parametric statistics and, similarly to Chapter 6, a non-parametric approach had to be applied.

7.5.1 Selection of announcements

The announcement dates of 9 macroeconomic reports and 5 agricultural reports were collected from different sources over the 31-month observation period from January 2000 through July 2002. The macroeconomic announcements selected were: (i) consumer price index (CPI); (ii) producer price index (PPI); (iii) Monetary Policy Committee (MPC) interest rate announcements; (iv) gross domestic product (GDP); (v) gold and forex reserves; (vi) volume of manufacturing production; (vii) value of retail sales; (viii) M3 money supply; and (ix) the trade balance. Agricultural reports were identified as: (i) National Crop Estimates Committee (NCEC) summer crop report; (ii) NCEC winter crop report; (iii) United States Department of Agriculture (USDA) corn production report; (iv) USDA wheat crop production report; and (v) the USDA crop progress report.

The macroeconomic announcements were further divided into “Type A” announcements (i to iv) and “Type B” announcements (v to ix), done primarily because of their possible influence on the Rand/Dollar exchange rate. As explained in section 7.2.2, the Rand/Dollar exchange rate plays a very significant role as a price determinant of both maize and wheat prices. Therefore, it was argued that macroeconomic information that would influence or impact on the exchange rate, would also impact on local grain prices. This line of reasoning was used to select and divide the macroeconomic announcements under consideration into the two groups: “Type A”, which were the announcements of greater importance to the local currency and “Type B”, the announcements that played a less important role in this regard. Note that “Type B” announcements are not simply regarded as less important but, for the purpose of the analyses, the assumption is made only that the indirect impact of this type of announcements would be less significant than that of agricultural and the selected “Type A” macroeconomic announcements.

7.5.2 Macroeconomic announcements

Monetary policy in South Africa forms part of a broader macro-economic policy, the prime objective of which is to improve the standard of living of the country’s people. The combination of monetary policy in accomplishing this objective is to create and maintain a stable financial environment by pursuing persistent and transparent monetary policies that facilitate decision-making and encourage business enterprise. To this end the South African Reserve Bank (SARB, 2003) stated the following goals:

- a rate of expansion in domestic bank credit extension that is consistent with the objectives of money supply growth;
- a market-determined level of sustained positive real interest rates in the medium and longer term;
- a relatively stable Rand exchange rate, reflecting underlying changes in the purchasing power of the Rand;
- well-functioning money, capital and foreign exchange markets that react with reasonably short time lags and in a consistent way to the changes in demand and supply conditions; and
- sound and efficient banking institutions to provide in the financial needs of the community.

The Reserve Bank also recently adopted a very strict monetary policy framework concentrating on reaching certain inflation rate targets (SARB, 2000:67). On a quarterly basis, but not on a fixed schedule, the Reserve Bank's Monetary Policy Committee (MPC) meets in order do decide what action to take on the general level of interest rates in order to produce a sound economy both in terms of increasing growth and declining inflation. Key figures for their decision-making about the Bank's repo rate, as shown by Smal and De Jager (2001:5), are generally the consumer price index, which is a direct indicator of the inflation rate, and the producer price index. Casteleijn (1999:65) also indicated that other indicators of relative importance for monetary policy includes movements in the money supply, the capital account of the balance of payments, movements in the exchange rate of the rand, gold and foreign exchange reserves, and the actual and expected movements in the rate of inflation.

The current inflation-targeting policy is aimed at controlling inflation through the adjustment of interest rates. As shown by Kahn and Farrel (2002:4), higher levels of interest rates supported the Rand in terms of a net inflow of foreign currency with rates relatively attractive compared to other international economies. Therefore, the Reserve Bank's decisions regarding adjustments to interest rates would also greatly affect grain commodity prices, which are highly correlated with the R/$ exchange rate. It is therefore suggested that macroeconomic variables of importance to the level of interest rates would also be of great value for the grain commodity markets. All macroeconomic announcements considered in this study are primarily information released by the South African Reserve Bank on a monthly and Quarterly basis.

7.5.3 Agricultural announcements

Agricultural announcements selected consist of two domestic reports and two important reports released in the United States. On a monthly basis the National Crop Estimates Committee (NCEC) releases summer and winter crop production and area estimates, as shown in section 7.2. This is probably the most important report domestically in terms of production estimates and confidentiality before actual release and futures price usually reacts sharply on information from this report. Although released on a monthly basis, there are months when only winter crop and area estimates are released, while other months only contain summer crop reports (see Table 7.1). The NCEC constitutes of representatives for the Department of Agriculture, different research institutes, Statistics South Africa, the National Agricultural Marketing Council, and a private consultant (Van den Berg, 2003b:10). These representatives do not have personal interest in the grain markets and each use their own methods of estimating the areas under different crops as well as production.

Two different reports were selected released by the USDA providing information on American and world maize and wheat production and demand. The World Agricultural Supply and Demand Estimates (WASDE) are published by the USDA on a monthly basis containing annual supply and demand forecasts for major crop and livestock commodities for the US and the world (USDA, 2003). This is also the most important monthly report on crops and other commodities in the US and the USDA commits a large amount of resources in order to ensure the accuracy and confidentiality of their estimates. On a weekly basis, the USDA announces crop progress and conditions for selected crops each week from early April to the end of November. Released every first business day of the week (NASS, 2003:7), this report contains estimates based on survey data that includes a sample of more than 5 000 reporters. Based on standard definitions, these reporters subjectively estimate progress of farmers' activities and progress of crops through their stages of development. They also provide subjective evaluations of crop conditions.

Table 7.5 shows the distribution of all the announcements under consideration. In total, 399 announcements took place on 350 days over a sample period of 640 trading days. Agricultural announcements tended to be concentrated on a Monday with 58 % or 93 announcements out of a total of 161. "Type A" macroeconomic announcements were concentrated on a Tuesday and a Wednesday, 34 and 30 announcements respectively out of a total of 91. "Type B" macroeconomic announcements showed the same distribution with Tuesday (47) and Wednesday (37) being the two most important days of the week in terms of the number of announcements made. Overall, announcements made seemed to be concentrated early in the week with a notable pattern declining as the week progressed. 30.5 % of all announcements were made on a Monday while only 9.8 % were made on a Thursday.

Table 7.5: Distribution of announcements

Agricultural	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**
NCEC summer crop	11	8	4	2	3	28
NCEC winter crop	11	6	2	4	2	25
USDA corn production	0	2	1	2	7	12
USDA wheat production	0	2	3	1	6	12
USDA crop progress	71	13	0	0	0	84
Total agricultural announcements	93	31	10	9	18	161
Number of announcement days	75	23	7	7	12	124
“Type A” macroeconomic	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**
CPI	4	26	0	0	1	31
PPI	2	3	26	0	0	31
GDP	4	4	1	0	1	10
MPC announcement	1	1	3	9	5	19
Total “Type A” announcements	11	34	30	9	7	91
Number of announcement days	10	29	30	9	7	85
“Type B” macroeconomic	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**
Gold and Forex	4	10	4	6	6	30
Manufacturing production	5	26	0	0	0	31
Retail sales	1	4	23	1	0	29
M3 money supply	5	5	5	5	6	26
Trade balance	3	2	5	9	12	31
Total “Type B” announcements	18	47	37	21	24	147
Number of announcement days	18	44	36	21	22	141
All announcements	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**	**Total**
Total of all announcements	122	112	77	39	49	399
Total number of announcement days	103	96	73	37	41	350
Percentage of total	30.5	28.1	19.3	9.8	12.3	

Figure 7.4 shows the percentage of total announcements distributed across the week together with the mean percentage day-of-the-week futures price returns for white maize, yellow maize, and wheat respectively as calculated in Chapter 6. Overall there tended to be an inverse relationship between concentration of announcements and the mean size of futures price returns across the days of the week where mean percentage daily returns tended to be low early in the week where the highest concentration of announcements was found. Mean daily returns of all three commodities gradually increase through the week as the number of announcements decrease.

Figure 7.4: Distribution of announcements compared to day-of-the-week returns of white maize, yellow maize, and wheat

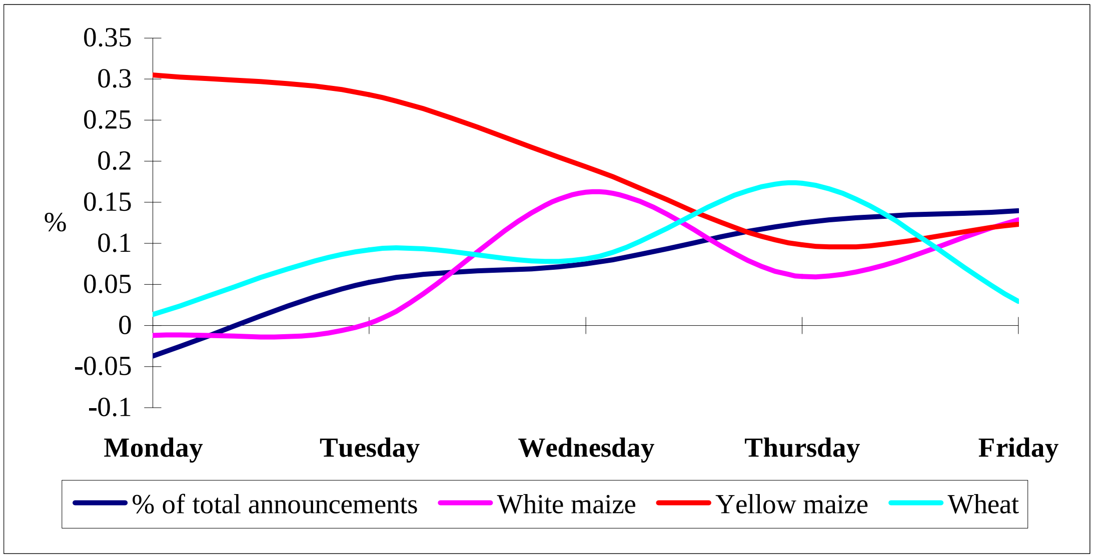
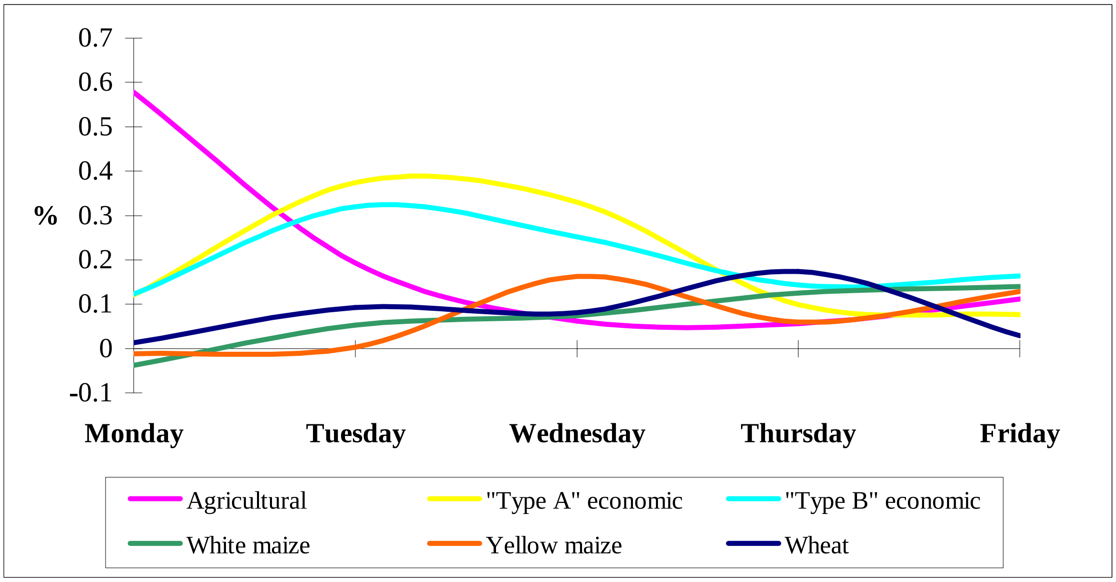


Figure 7.5 shows the distributions of the three respective types of announcements namely agricultural, Type A, and Type B macroeconomic announcements compared to the mean day-of-the-week returns of the three agricultural commodities (as calculated in Chapter 6). The inverse relationship tended to be the strongest with the agricultural announcements that were highly concentrated on a Monday and could have played a significant role in the day-of-the-week effect as found in Chapter 6.

Figure 7.5: Distribution of different types of announcements compared to day-of-the-week returns of white maize, yellow maize, and wheat



7.6 Empirical approach

The empirical approach used in this chapter was based on the assumption that market participants' reservation prices are a function of their fundamental information like supply and demand. If, for example, a NCEC report altered the supply and demand perceptions of a sufficient number of market players, then the newly perceived supply and demand situation should have been reflected in a market price change.

The impact of the different reports released and scheduled announcements were tested in a number of ways. Firstly, absolute returns or price changes on the day of a scheduled announcement (report day) was compared to the absolute returns on non-report trading days. This was done for each of the three announcement categories and for each of the three commodities under consideration respectively. Because the absolute return on report days was used as the measure of uncertainty, it would be expected that the mean absolute return on the day of the report or announcement would be significantly lower than on a non-report day, especially in the South African case where all the agricultural announcements are released after agricultural market trading hours on the scheduled day of the report. This line of reasoning implies that, despite the presence of other important market fundamentals, traders would be hesitant to position themselves ahead of a report limiting excessive price movements or returns on the day of the scheduled announcement (Graham *et al*, 2003:155). Therefore, it is important to note that the focus in this chapter was not on the market participants' reaction on scheduled announcements, but an examination of changes in traders' level of uncertainty around agricultural and macroeconomic announcements (as measured by % absolute returns). Table 7.6 presents information regarding the different announcements to be investigated in this chapter.

Secondly, in order to specifically focus on the volatilities surrounding the announcement day, the period of four days preceding and four days after the scheduled announcement were also investigated. This was again done for each of the announcement categories and for each of the three commodities respectively. Tests were also done for each individual announcement and for each of the three commodities respectively in order to emphasise the relative importance of each individual announcement on the futures returns of the commodities under consideration.

Finally, an investigation into two strong effects found in Chapter 6, namely the day-of-the-week and the turn-of-the-month effect, was conducted in order to evaluate the possible contribution of each announcement category to the realisation of the market anomalies under consideration. This was once again also done respectively for each of the three commodities.

Table 7.6: Information on different individual announcements

Report/announcement	Issued	Time of announcement#	Issuing authority	Source
Agricultural announcements:				
NCEC Summer crop report	Monthly (Jan-Sep, Nov)	15h00	National Crop Estimates Committee	Sagis (2003)
NCEC Winter crops report	Monthly (Jan-Mar, May, Jul-Dec)	15h00	National Crop Estimates Committee	Sagis (2003)
USDA corn crop production	Monthly (Jan, Aug-Nov)	14h30# (08h30##)	United States Department of Agriculture	USDA (2003)
USDA wheat crop production	Monthly (Jan, May-Aug)	14h30# (08h30##)	United States Department of Agriculture	USDA (2003)
USDA crop progress report	Weekly (Apr-Nov)	22h00# (16h00##)	United States Department of Agriculture	USDA (2003)
Type A econ. announcements:				
Consumer Price Index	Monthly	11h30	South African Reserve Bank	SCMB (2003)
Producer Price Index	Monthly	11h30	South African Reserve Bank	SCMB (2003)
MPC announcement	Quarterly	15h00	South African Reserve Bank	SCMB (2003)
Gross Domestic Product	Quarterly	11h30	South African Reserve Bank	SCMB (2003)
Type B econ. announcements:				
Gold and forex reserves	Monthly	08h00	South African Reserve Bank	SCMB (2003)
Manufacturing production	Monthly	13h00	South African Reserve Bank	SCMB (2003)
Retail sales	Monthly	11h00	South African Reserve Bank	SCMB (2003)
M3 money supply	Monthly	08h00	South African Reserve Bank	SCMB (2003)
Trade balance	Monthly	14h00	South African Reserve Bank	SCMB (2003)

South African time on scheduled announcement day
Eastern Time (United States of America)

7.7 Results

7.7.1 Announcement-day effects

The historical dates of the 5 agricultural and 9 macroeconomic announcements made over the observation period were sorted and categorised as shown in Table 7.5. For each respective announcement, the measure of uncertainty or the volatility was taken on every announcement day and sampled. This was compared to the sample of returns on non-announcement days. The analysis was done for each of the three commodities respectively. First, all the announcements in each category were sampled together and tested for an overall categorical effect, where after the announcements were each considered individually. Mann-Whitney non-parametric results are shown in Table 7.7. In the case of both agricultural and "Type A" macroeconomic announcements, all three commodities showed a possible effect of uncertainty on the day of announcement rejecting the null hypothesis of equal medians at either a 1% or 5% level of significance:

$$H_0\!: <_1 = <_2, \ vs.$$
$$H_A\!: <_1 \neq <_2 \qquad (7.2)$$

Table 7.7: Mann-Whitney tests for announcement day effect in the three categories of announcements

		White maize	Yellow maize	Wheat
Agricultural announcements	Z[1] (p)	2.39* (0.0164)	2.81** (0.0049)	10.69** (0.0000)
	Median[2]	0.7949	0.6815	0.0000
	Median[3]	0.8935	0.8022	0.6261
"Type A" econ. announcements	Z[1] (p)	1.65*** (0.0996)	2.35* (0.0191)	5.30** (0.0000)
	Median[2]	0.8206	0.5865	0.1121
	Median[3]	0.9040	0.7968	0.4897
"Type B" econ. announcements	Z[1] (p)	2.36* (0.0182)	0.59 (0.5573)	0.37 (0.7129)
	Median[2]	0.6038	0.7918	0.0538
	Median[3]	0.9337	0.8021	0.0893

**Significant at 1% level of significance *Significant at 5% level of significance
***Significant at 10% level of significance
[1] Absolute value of test statistic
[2] Median absolute price change for announcement day
[3] Median absolute price change for non-announcement day

Results suggest that the median absolute price changes on announcement days were significantly different from the non-announcement days considered. This effect, however, was less evident in general for "Type B" macroeconomic announcements. Only white maize showed an effect at a 5% level of significance. In order to examine the possible effect of each individual announcement on each of the markets, Mann-Whitney tests were performed for each of the individual announcements under each of the three announcement-categories. Results are presented in Table 7.8.

Table 7.8: Mann-Whitney announcements day effect results[1] for individual announcements (p values given in parentheses)

	White maize	Yellow maize	Wheat
Agricultural announcements:			
NCEC Summer crop report	4.43** (0.0000)	4.17** (0.0000)	
NCEC Winter crops report			2.52* (0.0118)
USDA corn crop production	2.52* (0.0118)	1.46 (0.1432)	
USDA wheat crop production			1.50 (0.1358)
USDA crop progress report	4.69** (0.0000)	4.11** (0.0000)	3.85** (0.0001)
"Type A" econ. announcements:			
Consumer Price Index	4.24** (0.0000)	3.17** (0.0015)	4.46** (0.0000)
Producer Price Index	5.57** (0.0000)	3.95** (0.0000)	4.46** (0.0000)
MPC announcement	3.11** (0.0019)	3.83** (0.0001)	3.24** (0.0012)
Gross Domestic Product	0.22 (0.8231)	2.37* (0.018)	1.56 (0.1189)
"Type B" econ. announcements:			
Gold and foreign exchange reserves	2.27* (0.0229)	0.52 (0.6027)	0.77 (0.4407)
Manufacturing production	2.19* (0.0286)	1.91 (0.0566)	1.09 (0.2771)
Retail sales	1.63 (0.1022)	0.07 (0.9447)	0.41 (0.6789)
M3 money supply	1.63 (0.1028)	1.81 (0.0698)	1.30 (0.1934)
Trade balance	2.73** (0.0064)	1.50 (0.1332)	1.30 (0.1929)

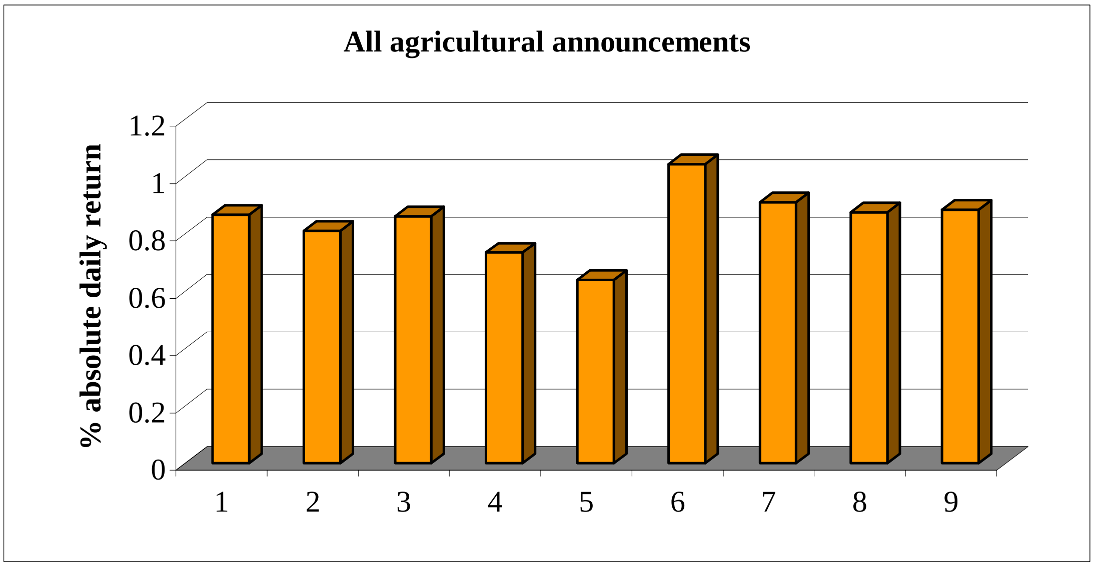
**Significant at 1% level of significance *Significant at 5% level of significance
[1] Absolute value of test statistic

Results found proved to be very interesting. Local agricultural markets showed a significant difference between the median absolute returns on an announcement day than on any other non-announcement day. Results of equal significance were also found for the USDA crop progress reports, although the yellow maize and wheat market tended to show no sign of uncertainty in the presence of monthly USDA crop reports. The uncertainty of the agricultural futures markets ahead of macroeconomic announcements was clearly different between “Type A” and “Type B” announcements. All three commodity markets revealed significant effects of uncertainty on the expected release of CPI, PPI, and MPC interest rate information. Only yellow maize provided a significant result in the case of the GDP announcement. Results in the case of “Type B” announcements showed almost no significant effect of uncertainty. Only the white maize market showed an effect on the announcement day of gold and foreign exchange reserves, manufacturing production, and trade balance information releases.

Although there are clear statistically significant effects of futures returns between announcement days and that of normal non-report days, the question arises whether it could be an effect of reaction rather than uncertainty. Because the measure of uncertainty would imply that price movements would on average be lower on the day awaiting the announcement than on any other non-announcement day, the effect noted here could also be the result of a higher than normal absolute return levels on announcement day as the market anticipates the information to be released. Another problem which could be affecting the results is the fact that, in the case of each individual announcement, the sample size for the announcement dates are much smaller than that of the non-announcement dates which could have an influence on the calculated medians. In order to evaluate whether the results are in fact indicative of an effect of uncertainty, all data was arranged to focus on the absolute returns of the days surrounding the announcement day.

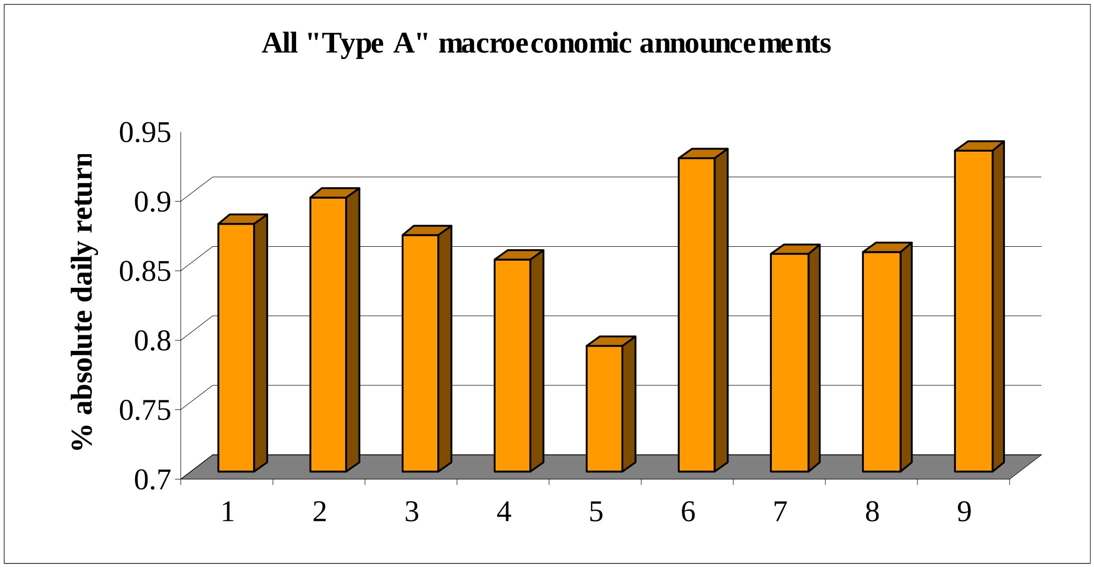
In the case of each individual announcement under consideration, the four preceding days, and the four days following the specific announcement were coded 1 through 9 where 5 represented the actual announcement day. Note that, for this specific analysis, the weekly announced crop-progress report was not considered as the observations from consecutive reports will constantly overlap and might influence the overall agricultural results negatively. The returns were then sorted according to the codes and the results plotted and shown in Figures 7.3 through 7.5. These figures show the combined mean effect of all the announcements in each category on the mean absolute daily price changes (volatilities) of the three commodities. In the case of the agricultural announcements the daily absolute return levels tended to decrease gradually from day 3 through day 5 (announcement day) increasing sharply on day 6 as the market reacts to the information released. This pattern is consistent with the market becoming less volatile as uncertainty increases towards the actual day of information release. The market reacts sharply on day 6 mainly because of the fact that all the agricultural reports under consideration are only released after the trading hours of the agricultural market, as shown in Table 7.6. This causes the market to absorb and reflect the information only the day after the release (day 6) as evident in Figure 7.6

Figure 7.6: Mean overall absolute daily returns for agricultural announcements



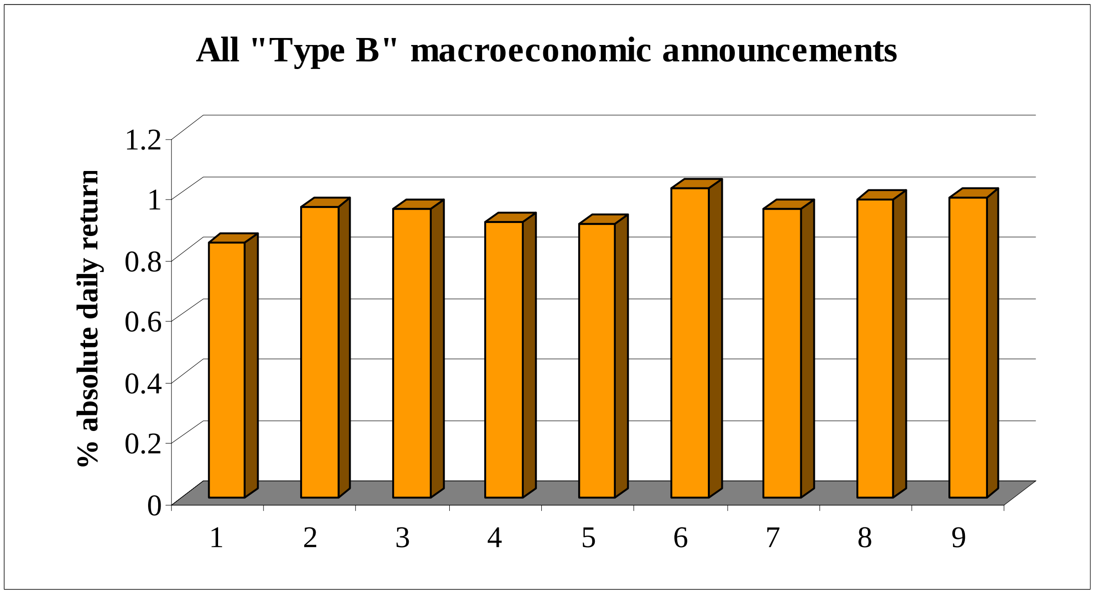
“Type A” macroeconomic announcements (Figure 7.7) provided a similar and even stronger pattern with the mean absolute return levels decreasing to its lowest on announcement day. Thereafter the market reacts sharply on day 6 as a possible reaction on the announcement and daily absolute return levels following a random pattern from that point forward.

Figure 7.7: Mean overall absolute daily returns for "Type A" macroeconomic announcements



Finally, daily absolute price changes from "Type B" announcements tended to be much less volatile in the days around the information release. However, a similar but much smoother pattern was detected as shown in the third figure. Absolute return levels slowly decreased from day 2 through day 5 and showing a possible reaction on day 6. Considering the weaker "Type B" results from Table 7.8 it is clear that an announcement day effect is not as significant as in the case of the agricultural and "Type A" macroeconomic announcements.

Figure 7.8: Mean overall absolute daily returns for "Type B" macroeconomic announcements



The abovementioned 9-day period around the announcement day was also considered for each individual announcement. This was done in order to evaluate how each commodity market reacts individually to each announcement. Results were plotted and shown in Appendix C. White and yellow maize (Figures C.3 and C.4) provided similar strong patterns over the periods surrounding the USDA corn production reports and the domestic NCEC summer crop report release dates. In the case of the wheat market (Figure C.5) the volatility measure also tended to be the lowest as a result of uncertainty on the announcement releases of both USDA wheat production reports and NCEC winter crop reports. Wheat futures prices reacted significantly on the day directly following the announcement especially after the USDA report. From Table 7.8, however, both yellow maize and wheat did not show a statistically significant effect on the announcement days of the USDA corn and wheat production reports.

All three commodities reacted similarly to the MPC announcements (Figure C.6) with uncertainty on the day of the release and a strong reaction on the day following the announcement. This pattern was also evident in the case of the producer price index announcement for all three commodities (Figure C.9). Absolute return levels on the announcement day of gross domestic product figures (Figure C.7) tended to be higher than on the days directly preceding or following the release. Interestingly, all three commodities reacted similarly. This could be either a result of the market anticipating the information before it is released, or the agricultural markets not perceiving the GDP announcement as important. Results from Table 7.8 show similar weak announcement day results suggesting significance only in the case of yellow maize which could probably be attributed to the higher than normal absolute return levels on announcement day. Although significant, this result is contradictory to the expectation that absolute return levels are below normal on the day of the announcement. Finally, only white maize showed the pattern consistent to that of the MPC and PPI announcements in the case of the consumer price index announcement (Figure C.8). Yellow maize absolute daily returns decreased gradually towards the announcement day, although no significant market reaction was evident on the day following the release of the report, while the wheat market showed above normal volatility compared to the days directly preceding and following the actual announcement day.

Evidence of the perceived report day pattern also existed when the mean absolute daily returns of white maize, yellow maize, and wheat were taken for all the “Type B” macroeconomic announcements under consideration (Figure 7.8). For the individual “Type B” announcements, only retail sales (Figure C.11) provided no visual evidence of an effect for neither of the three commodities markets, as also noted from the results in Table 7.8. The wheat market reacted differently to the volume of manufacturing production (Figure C.10) and M3 money supply (Figure C.13) information releases. It is important to note, however, that although some markets showed potential graphical evidence of a possible announcement day effect, results from Table 7.8 could suggest that it was not statistically significant.

7.7.2 Day-of-the-week effect

In Chapter 6, a very strong and statistically significant day-of-the-week effect was detected in the form of a Monday or weekend effect. Mean Monday futures price returns were found to be significantly different (and also negative in the case of both white and yellow maize) from mean daily returns of the other days of the week as shown in section 6.4.

In order to answer an important research question in this chapter, the contribution of the announcement effect towards the day-of-the-week effect had to be investigated. For each of the three announcement categories (agricultural, “Type A”, and “Type B” macroeconomic) the absolute announcement-day returns of each of the three commodities were sorted according to the day of the week (Monday through Friday). This was also done for the non-announcement day returns. This was tested for differences in absolute return levels according to the day of the week, for example, the median announcement-day volatility (absolute return) on a Monday was tested against the absolute return levels of the rest of the Mondays on which announcements did not take place. This would then give an indication as to whether announcements from different categories had an equal or different effect on different days of the week. Non-parametric Mann-Whitney U-tests were once again used as the best alternative to the conventional t-tests. Results for the three announcement categories are shown in Tables 7.9 through 7.11.

Agricultural announcement-day median price changes on a Monday were found to be significantly different from that of non-announcement days for the white maize, yellow maize, and wheat futures markets. Only white maize and wheat indicated a possible day-of the-week effect on Tuesdays while no effect for either of the three commodities was evident on a Wednesday, Thursday, or Friday. The medians of the absolute price changes are also shown in each case for the announcement and non- announcement samples used. Results suggest that the medians, found to be significant in Table 7.9, were not only different, but also lower on the days that announcements were made. Taking into consideration the distribution of agricultural announcements (Table 7.5) where they are concentrated mainly on Mondays and Tuesdays, it can be argued that traders’ uncertainty on days of agricultural announcements contribute to a great extent to the Monday effect found in Chapter 6.

Table 7.9: Mann-Whitney U-test day-of-the-week results for agricultural announcements

		Monday	Tuesday	Wednesday	Thursday	Friday
WMAZ	Z[1] (p)	4.38** (0.0000)	2.65** (0.008)	0.72 (0.4706)	0.16 (0.8692)	0.94 (0.3474)
	Median[2]	0.6269	0.6188	1.7483	0.7729	1.4440
	Median[3]	1.4762	0.9570	0.9568	0.8873	0.8529
YMAZ	Z[1] (p)	2.95** (0.0032)	1.09 (0.2731)	0.41 (0.6823)	1.08 (0.2822)	0.02 (0.9868)
	Median[2]	0.6816	0.5999	0.6757	0.7081	0.8344
	Median[3]	1.0152	0.8651	0.8683	0.7289	0.7225
WHEAT	Z[1] (p)	3.83** (0.0001)	3.01** (0.0026)	1.10 (0.2698)	0.25 (0.8049)	0.78 (0.4312)
	Median[2]	0.0000	0.0000	0.0000	0.2481	0.0872
	Median[3]	0.6875	0.6724	0.3404	0.0968	0.1079

**Significant at 1% level of significance
[1] Absolute value of test statistics
[2] Median absolute price change for announcement day
[3] Median absolute price change for non-announcement day

Table 7.10: Mann-Whitney U-test day-of-the-week results for "Type A" macroeconomic announcements

		Monday	Tuesday	Wednesday	Thursday	Friday
WMAZ	Z[1] (p)	2.72** (0.0065)	1.92*** (0.0549)	2.77** (0.0056)	0.24 (0.8071)	0.43 (0.6636)
	Median[2]	0.5704	0.8096	0.7199	1.0169	0.7600
	Median[3]	1.2064	1.0000	1.3102	1.0139	0.8436
YMAZ	Z[1] (p)	2.37* (0.0179)	2.07* (0.0428)	1.11 (0.2659)	0.19 (0.8497)	1.34 (0.1815)
	Median[2]	0.5305	0.4027	0.7829	0.9695	0.5501
	Median[3]	0.8299	0.9132	0.8245	0.7134	0.8353
WHEAT	Z[1] (p)	2.53* (0.0117)	0.24 (0.8066)	0.41 (0.6787)	1.45 (0.1481)	0.29 (0.7652)
	Median[2]	0.0000	0.5075	0.2063	0.0000	0.0000
	Median[3]	0.3168	0.2454	0.3034	0.0989	0.1079

*Significant at 5% level of significance **Significant at 1% level of significance
***Significant at 10% level of significance
[1] Absolute value of test statistic
[2] Median absolute price change for announcement day
[3] Median absolute price change for non-announcement day

Day-of-the-week test results from "Type A" macroeconomic announcements are shown in Table 7.10. Similar significance on Mondays was found for all three commodities. Other weekdays of importance were white maize that showed an effect of uncertainty on a Tuesday and Wednesday also, while yellow maize provided a significant effect on

Tuesday. Results are consistent with that of the agricultural announcements with the effect found mainly early in the week and no evidence of significance on Thursdays or Fridays. Table 7.5 indicated that "Type A" announcements were concentrated mainly on Tuesdays and Wednesdays. The strong effect on a Monday could possibly be attributed to a spill-over effect from important agricultural announcements overlapping with "Type A" macroeconomic announcements. In the case of all the days in Table 7.10 found to have a significant effect, the calculated medians are lower for announcement days than for the non-announcement days and are indicative of the uncertainty associated with the release of the "Type A" macroeconomic information. Finally, test results for "Type B" macroeconomic announcements are presented in Table 7.11. Results showed significance for Monday announcements in the case of white maize, while yellow maize revealed an effect for "Type B" macroeconomic announcements on a Tuesday. No effect was detected in the case of the wheat futures market.

Table 7.11: Mann-Whitney U-test day-of-the-week results for "Type B" macroeconomic announcements

		Monday	Tuesday	Wednesday	Thursday	Friday
WMAZ	Z[1] (p)	2.1896* (0.0286)	1.5451 (0.1223)	0.5418 (0.5879)	1.1229 (0.2615)	1.2253 (0.2205)
	Median[2]	0.5878	0.7555	0.9915	1.2635	0.5343
	Median[3]	1.0791	0.9049	0.8942	0.9722	0.8841
YMAZ	Z[1] (p)	1.0662 (0.2863)	1.9326*** (0.0533)	0.9236 (0.3557)	0.7749 (0.4384)	0.4105 (0.6814)
	Median[2]	0.6912	0.7100	0.9864	0.9165	0.8283
	Median[3]	0.7189	0.9413	0.8651	0.7013	0.8289
WHEAT	Z[1] (p)	0.3738 (0.7008)	0.8893 (0.3739)	0.6888 (0.4909)	0.6225 (0.5336)	0.0821 (0.9346)
	Median[2]	0.0000	0.0000	0.2868	0.0000	0.2058
	Median[3]	0.0000	0.1088	0.0899	0.0973	0.0952

***Significant at 10% level of significance
[1] Absolute value of test statistics
[2] Median absolute price change for announcement day
[3] Median absolute price change for non-announcement day

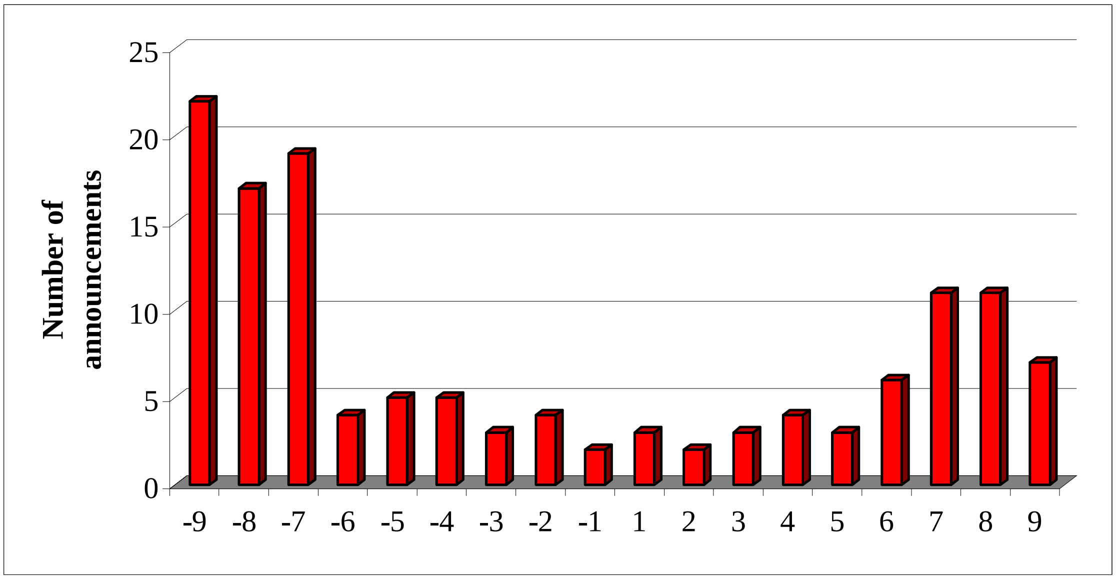
Compared to the results found in Table 7.5, it is clear that "Type B" announcements are mainly concentrated on Tuesdays and to a lesser extent on Wednesdays. Considering this information, the weaker white maize and wheat results are indicative of how market players perceive the announcements of "Type B" macroeconomic information as less important compared to "Type A" and agricultural announcements. Note that, although not statistically significant, sample medians on Mondays and Tuesdays are smaller for announcement days than for non-announcement days in the case of white and yellow maize indicating some degree of uncertainty. The relatively large number of zero observations in the wheat market, due to closing prices of consecutive trading days being equal, could have affected the outcome of the wheat results.

7.7.3 Turn-of-the-month (TOM) effect

Chapter 6 presented evidence of a price effect around the end of one month and the beginning of the next. Mean daily futures price returns were found to be significantly different between the last and first days of two consecutive months in the case of white and yellow maize, and wheat (see Table 6.12). Mean returns were also significantly higher at the beginning of the month than that of the last days of the preceding month. Using the knowledge that agricultural and macroeconomic announcements significantly impacted on daily price absolute return levels over the observation period, the monthly distributions of the different announcements were investigated in order to evaluate whether they contribute to the anomaly under consideration found in Chapter 6.

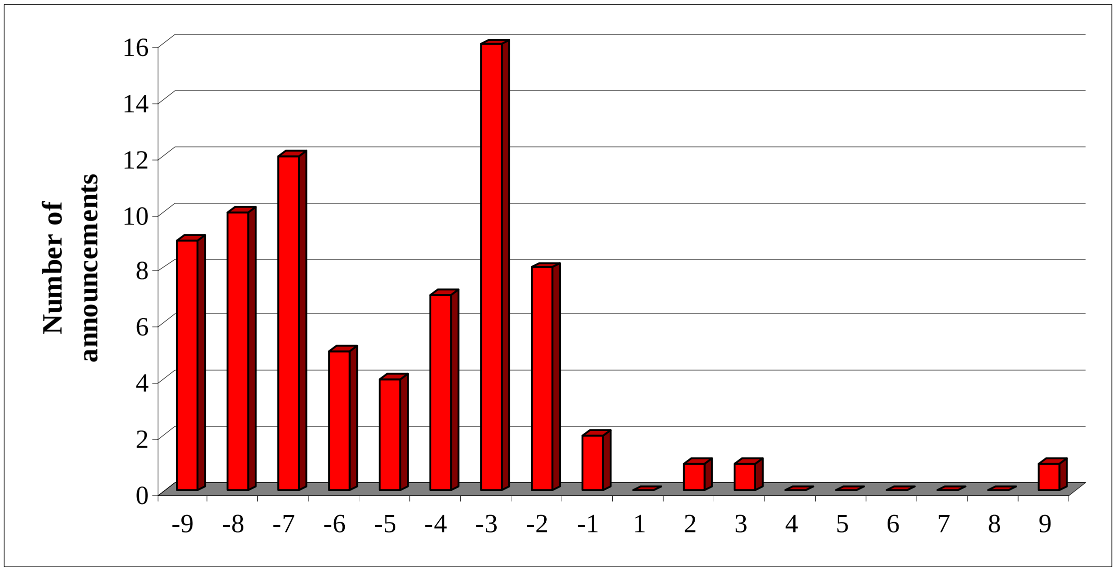
The data for each commodity was sorted using the same methodology as shown in section 6.4.3. The days coded –9 to –1 represented the last 9 business days of the month while 1 through 9 represented the first nine business days of the following month. Therefore, an 18-day period was used representing two consecutive mean month-halves (see section 6.4.3). However, some months in the observation period included more business days, for example 19 or 20. As the analysis only focussed on the days and announcements around the turn-of-the-month, these "lost" days were observations exactly around the middle of the month and therefore would not affect results. Announcements for each of the three categories were sorted according to their respective code (-9 through 9) and results are shown in Figures 7.9 through 7.11. Note that days -9 to -1 represented the second half of the mean month, while the first half was indicated by the days 1 to 9.

Figure 7.9: Turn-of-the-month distribution of agricultural announcements



Agricultural announcements tended to be concentrated around the middle (days –9 to –7; 6 to 9) rather than around the end or beginning of the month. Announcements were distributed evenly in small numbers from days –6 through 5. This is mainly the result of the relatively large number of USDA crop progress reports released on a weekly basis. USDA WASDE reports were mostly released late in the first half of each month, while NCEC reports for maize and wheat were concentrated around the beginning of the second half of each month. Results from Table 7.12 support the abovementioned pattern with a higher percentage of reports released in the second half of the month than in the first. These percentages decrease markedly as the period around the turn-of-the-month approaches, indicating that a relatively small percentage of the total announcements are concentrated around this period.

Figure 7.10: Turn-of-the-month distribution of "Type A" announcements



Interestingly, the "Type A" macroeconomic announcements tended to be concentrated mostly in the second half of the month (96.1 %) compared to only 3.9% of the announcements under consideration appearing in the first half as shown in Figure 7.10. As the number of days to the turn-of-the-month decreases, the percentage announcements also decreases, although a relatively high number of announcements (34.2 %) are found over the –3 to –1 3-day period compared to 2.6 % of the announcements found in days 1 to 3 (Table 7.12). "Type B" announcements provided an almost opposite pattern with more announcements in the first half of each month as evident from Figure 7.11. In both the 9- and 5-day periods, "Type B" announcements were concentrated in the first half of each month, although over the 3-day period, the percentage of second half announcements exceeded that of the first. Also note from Table 7.12 that all the second half announcements were found in the 3-day period –3 to –1.

Figure 7.11: Turn-of-the-month distribution of "Type B" announcements

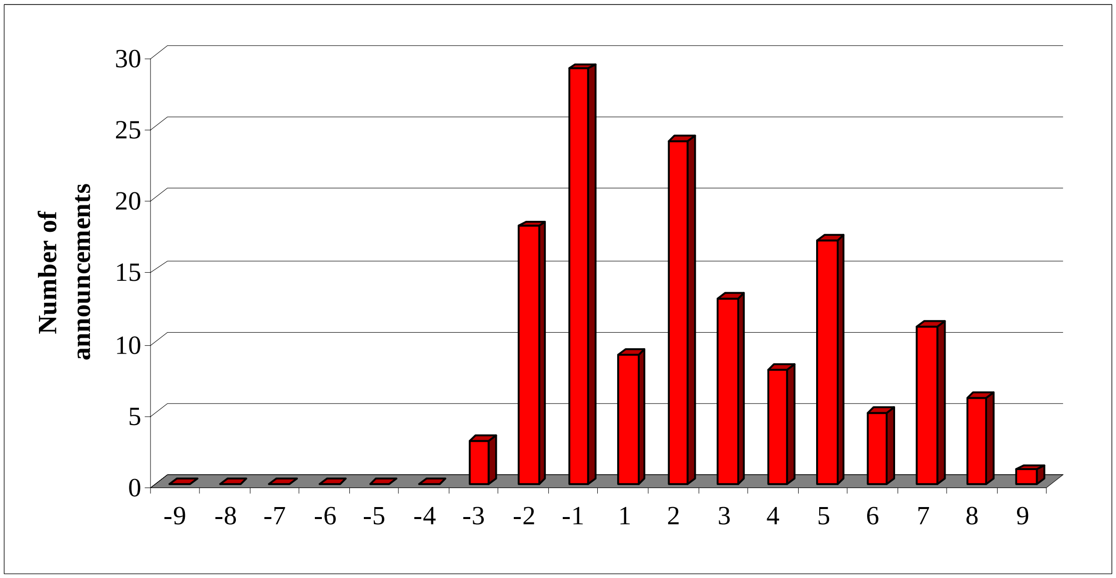


Table 7.12: Percentage turn-of-the-month announcements for the different categories over different periods

	% Agricultural announcements	% "Type A" announcements	% "Type B" announcements
Days -9 to –1	61.8	96.1	34.7
Days 1 to 9	38.2	3.9	65.2
Days -5 to –1	14.5	48.7	34.7
Days 1 to 5	11.4	2.6	49.3
Days -3 to –1	6.9	34.2	34.7
Days 1 to 3	6.1	2.6	31.9

Because the turn-of-the-month effect was already tested in Chapter 6, it would be of no value to test this effect again here. However, the analyses in Chapter 6 focussed on the mean percentage daily futures returns of each of the three commodities, while here the measure for uncertainty or volatility was the absolute percentage futures price return. In this chapter it was found that daily price absolute return levels was affected by the distribution of agricultural and macroeconomic announcements. The analysis in this section would, therefore, focus on how significant the daily absolute return levels caused by the turn-of-the-month distribution of the different announcement categories contributed to the turn-of-the-month effect.

The approach used here was similar to that used to test for the turn-of-the-month effect in section 6.4.3. The observation interval (-9 to 9) was tested for difference of the median returns between the second half of the month (-9 to –1), and the first half (1 to 9). The intervals were further decreased to 5 and 3 days respectively in order to concentrate more on the days surrounding the actual point of turn-of-the-month. For example: for the 9–day period test a mean sample was calculated for the 9 days from –9 to –1 as well as for the 9 days 1 to 9. These two samples were then tested as to whether their medians are significantly different. Results of Mann-Whitney U tests conducted for each commodity are shown in Table 7.13. In the case of white maize the calculated means of the absolute price returns were higher in the first half of the month than in the second for each of the three periods considered. This result was also found in the case of yellow maize as well as wheat. All three periods showed significant differences between first and second half month medians suggesting a definite effect in the absolute return levels as one month ends and the next begins.

Table 7.13: Mann-Whitney turn-of-the-month absolute return levels results for white maize, yellow maize, and wheat

		White maize	**Yellow maize**	**Wheat**
9-day period	**Median: -9 to -1**	0.9606	0.9185	1.0551
	Median: 1 to 9	1.2172	1.1829	1.3778
	Z **(p)**	2.32* (0.0203)	1.97* (0.0493)	0.63 (0.5298)
5-day period	**Median: -5 to –1**	0.8858	0.8149	0.7612
	Median: 1 to 5	1.0675	1.1185	1.0579
	Z **(p)**	2.08* (0.0372)	1.99* (0.0459)	0.52 (0.5997)
3-day period	**Median: -3 to –1**	0.3582	0.3361	0.1975
	Median: 1 to 3	0.4056	0.3547	0.1816
	Z **(p)**	2.11* (0.0345)	1.33 (0.1833)	0.16 (0.8708)

*Significant at 5% level of significance

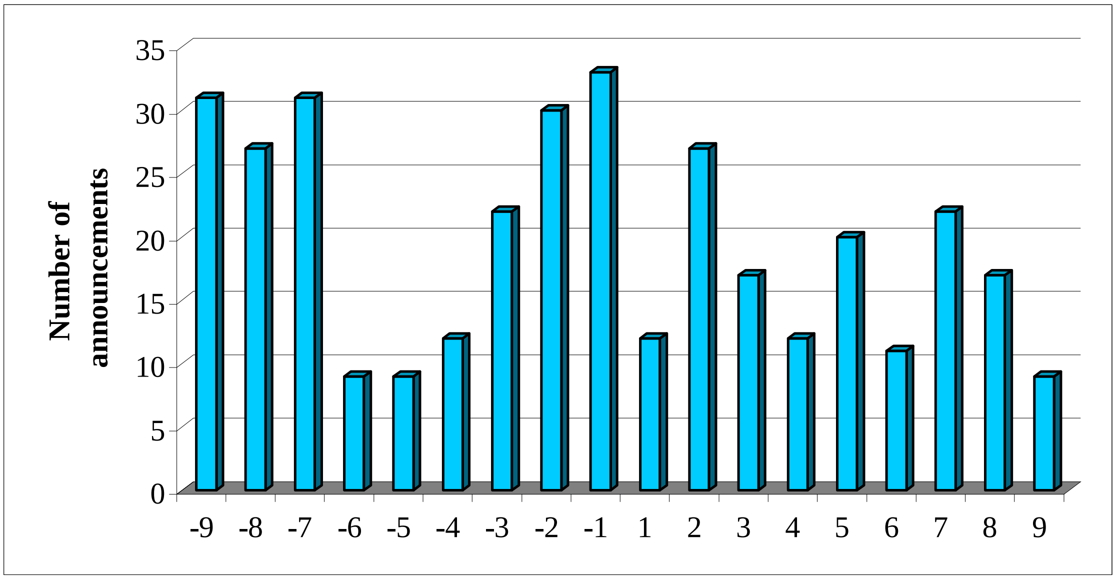
Similar results were found in the case of yellow maize, however, there was no significance over the 3-day period around the turn-of-the-month was evident. This result suggests that the volatility effect over the longer periods (5-day and 9-day) could have contributed to a TOM effect of futures returns although a definite change in absolute return levels around the last 3 days of the months through the first 3 days of the next month were not statistically significant. Weaker results were found from the wheat market with none of the three periods considered showing a significant effect as in the case of the two maize commodities. Results found in Table 7.13 are supported by Figures C.15 through C.17 shown in Appendix C. In the case of both white maize and wheat a definite “jump” in the absolute return levels was evident between days –1 and 1 as the last day of the month and the first day of the next. Overall, absolute return levels in the first half of the month (1 to 9) tended to be higher for most days compared to that of the second half of the month (-9 to –1). Results from Table 7.13 seemed relatively weak for wheat compared to the strong pattern shown in Figure C.17. In this case, results could have been negatively affected by the number of zero observations in the different wheat samples as explained previously in this chapter. Yellow maize produced a similar pattern with a clear difference in the daily absolute return levels of the month-halves. However, daily absolute return levels tended to increase somewhat more gradually around the end of the month and beginning of the next, compared to the more drastic changes as in the case of white maize and wheat.

The contribution of the abovementioned findings to the actual TOM effect found in Chapter 6 was argued as follows. Taking into consideration the findings in Table 7.7, it is clear that all three commodities showed an effect in the presence of both agricultural and “Type A” macroeconomic announcements while only the white maize market reacted this way in the case of the “Type B” announcements. In this section, agricultural announcements, according to the TOM, were mainly concentrated around the middle of the month (Figure 7.9) while a smaller number were evenly distributed around the days closer to month-end and month-beginning. The larger concentration (61.8 %) of the agricultural announcements in the beginning of the second half of the month (see distribution in Table 7.12) could have contributed to the general lower daily absolute return levels (Table 7.13) found to be common to this time of the month. This argument is supported by the knowledge from Table 7.7 that daily absolute return levels was generally lower due to a degree of uncertainty on the days of agricultural announcements. The generally lower absolute return levels in the daily futures prices of the three commodities over the second half of the month could therefore, or at least partly, be attributed to the turn-of-the-month distribution of agricultural announcements.

The distribution of the “Type A” macroeconomic announcements supports this argument to a great extent. “Type A” announcements were found to be mainly concentrated (96.1 %) in the second half of the month. Strong results (Table 7.7) suggested that daily absolute return levels was also relatively lower in the presence of this type of announcement in the case of all three commodities considered. Combined with the concentration of agricultural announcements in this half of the month, this would have significantly impacted on the volatilities of the different days over this period of the month. In contrast, the “Type B” macroeconomic announcements were mainly concentrated in the first half of the month (65.2 %). However, taking into consideration results from Tables 7.7 and 7.8, only white maize showed some significant effect of lower absolute return levels in the presence of these announcements. No such effect was found in the case of yellow maize or wheat. With the knowledge of this much weaker result it can be argued that the effect of “Type B” announcements were much smaller on the daily volatilities of the first half of the month compared to the combined effect and impact of “Type A” and agricultural announcements on the daily volatilities of the second half of each month. Figure 7.12 shows the combined distribution of all three categories of announcements according to the TOM. Note the significant increase in the number of announcements from day –5 to the end of the month (-1) and the large difference in the number of announcements between days –1 and 1. In total, 58.2 % of all announcements were concentrated in the second half, while the rest (41.8 %) were in the first half of the month.

Therefore, considering the distributions and significance to absolute return levels of the three different announcement categories, it is argued that agricultural and “Type A” macroeconomic announcements contribute to a large extent to the TOM anomaly identified in Chapter 6. “Type B” announcements, apart from the fact that they do not share equal significance in terms of their impact on daily absolute return levels, could have contributed to this effect mainly based on their distribution and lesser impact on absolute return levels in the first half of the month.

Figure 7.12: Turn-of-the-month distribution of all announcements



7.8 Summary

In this chapter, agricultural and macroeconomic sources of public information were tested for two main purposes. Firstly, it was investigated what the actual effect or impact of different agricultural and macroeconomic announcement and report dates were over the period under consideration. Announcements were divided into three categories, namely agricultural, "Type A", and "Type B" macroeconomic announcements. Announcement dates for each of the categories were sampled and tested for an effect on the absolute percentage price returns (effect of uncertainty) of white maize, yellow maize, and wheat respectively. Returns on announcement days were tested against returns realised on non-announcement days. It was found (Table 7.14) that all three commodities showed a significant effect in the presence of agricultural and "Type A" macroeconomic announcements, while only white maize returns tended to be significantly affected on "Type B" macroeconomic announcement days.

In order to investigate what the exact effect on uncertainty was over the days surrounding the announcement, the 9-day period (4 days before, announcement day, and 4 days after) was sampled for all the announcement dates individually for each of the three categories, as well as the announcement dates of each of the individual announcements respectively. The effects were tested for the absolute returns of each commodity respectively. Results revealed a striking pattern of absolute returns declining towards the announcement day with a very low mean absolute return on the actual announcement day indicating a high degree of uncertainty on that specific day. Returns also increased sharply on the first day following the announcement as the market reacted to the information released. This section revealed uncertainty in the significantly lower absolute return levels associated with absolute price changes on the days of most agricultural and “Type A” announcements. Findings of the different individual announcements are shown in Table 7.14.

Results found here answered an important research question of whether agricultural futures markets do experience a high degree of uncertainty on days of agricultural and macroeconomic announcements by being associated with a significantly lower than normal daily absolute return levels in the price of the underlying commodity. The question was also raised whether the presence of agricultural and macroeconomic announcements cause, or at least partly contribute to the most significant anomalies found in Chapter 6. Calculated absolute announcement day returns were sorted according to the five business days of the week (Monday through Friday). This was also done for the non-announcement returns and each respective day was tested for a possible effect.

Results presented indicate a significant effect on Mondays and, to a lesser extent, on a Tuesday, suggesting that the fact that announcements for all three categories are mainly concentrated early in the week, contributed to the significant effects found. It was also found that agricultural and “Type A” announcements could have largely contributed to the Monday effect anomaly identified in Chapter 6.

Table 7.14: Summarised results of analyses conducted in Chapter 7

	A[1]	**B[2]**	**C[3]**	**D[4]**
ALL THREE ANNOUNCEMENT CATEGORIES:	n/a	n/a	n/a	Wmaz, Ymaz
Agricultural announcements:				
All agricultural announcements	Wmaz, Ymaz, Wheat	n/a	Wmaz, Ymaz, Wheat	n/a
NCEC Summer crop report	n/a	Wmaz, Ymaz,	n/a	n/a
NCEC Winter crops report	n/a	Wheat	n/a	n/a
USDA corn crop production	n/a	Wmaz	n/a	n/a
USDA wheat crop production	n/a	-	n/a	n/a
USDA crop progress report	n/a	Wmaz, Ymaz, Wheat	n/a	n/a
"Type A" econ. announcements:				
All "Type A" announcements	Wmaz, Ymaz, Wheat	n/a	Wmaz, Ymaz, Wheat	n/a
Consumer Price Index	n/a	Wmaz, Ymaz, Wheat	n/a	n/a
Producer Price Index	n/a	Wmaz, Ymaz, Wheat	n/a	n/a
MPC announcement	n/a	Wmaz, Ymaz, Wheat	n/a	n/a
Gross Domestic Product	n/a	Ymaz	n/a	n/a
"Type B" econ. announcements:				
All "Type B" announcements	Wmaz	n/a	Wmaz	n/a
Gold and foreign exchange reserves	n/a	Wmaz	n/a	n/a
Manufacturing production	n/a	Wmaz	n/a	n/a
Retail sales	n/a	-	n/a	n/a
M3 money supply	n/a	-	n/a	n/a
Trade balance	n/a	Wmaz	n/a	n/a

[1] Significant announcement day effect
[2] Effect of uncertainty through significantly **lower** announcement day absolute return levels
[3] Significant Monday effect
[4] Significant turn-of-the-month effect

Finally, announcement dates were sorted according to the 18-day period representing the 9 days before (second half) and the 9 days since the start of a new month (first half of month). The focus was on the actual distribution of each of the three announcement categories according to this period, better known as the turn-of-the-month, and how this contributed to the actual anomaly. Results revealed that the combined effect of the agricultural and "Type A" announcements greatly contributed to the generally lower second-half-of-the-month daily volatilities, while this was supported by the interesting distribution of "Type B" announcements. These results provided a valuable answer to the second research question, namely, whether announcements of different sources of public information do in fact contribute to regular and predictable behaviour in the futures prices of the three commodity markets considered.

Chapter 8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary of results and conclusions

In this study, the futures price behaviour of the three agricultural commodities was investigated in order to answer important research questions mainly based on the price discovery function of the South African agricultural futures market. The white maize, yellow maize, and wheat futures markets, as traded on the Agricultural Products Division of the JSE Securities Exchange (JSE APD) were examined mainly for three different aspects:

1. the weak-form efficiency and as to whether they function in compliance with the Efficient Markets Hypothesis (EMH), both efficiently and unbiasedly,
2. the presence of predictable patterns or anomalies in the daily futures price returns of the three markets, and
3. the behaviour of the futures prices around selected scheduled agricultural and macroeconomic announcements, in other words, the release of public information.

The value of futures markets arise from their ability to forecast cash (spot) prices at a specified future date and thus provide agents with a means of managing the risks associated with trading in a given commodity. Kellard *et al* (1999:414) stated that, in its simplest form, the EMH can be reduced to the joint hypothesis that agents are, in an aggregate sense, endowed with rational expectations and are risk neutral so that the futures price is an unbiased estimator of the future spot price. The EMH further implies that no profit opportunities are left unexploited and that agents form their expectations rationally and rapidly to arbitrage away any deviations of expected returns with abnormal profits (Yang and Leatham, 1998:107). In Chapter 4, the model and methodology used to test the three commodity markets for weak-form efficiency were presented. First, the model included a co-integration test that examines the possibility of a long-run relationship between the futures price and the underlying value of the future spot market generally on the day of the specific contract's expiry. Therefore, the futures price at any given point during the lifetime of a specific contract should always be the best possible estimate of the cash price on the day of contract expiry and, on average, the futures price should not consistently over- or under-predict the future cash price. The co-integration approach was chosen as it properly accounts for the non-stationarity in the price series (Lai and Lai, 1991:568) as generally the case with economic time series data (Nelson and Plosser, 1982:139). Secondly, the methodology of efficiency includes the test as to whether the futures price is an unbiased estimate of the future cash price (Aulton *et al*, 1997:410). Chapter 4 provided a detailed description of the model used to test the different variables for market efficiency.

The analyses, as described in Chapter 5, distinguished between two different sets of data considered for each of the three commodity markets, the data including the constant month contracts [constant contracts analysis (CCA)], and the data excluding the constant month contracts which considered only the primary contracts or hedging months [primary contracts analysis (PCA)]. The main purpose of this separation was to examine as to whether the introduction of the constant month contracts improved efficiency in terms of price discovery in the respective markets.

Co-integration was found to exist for both white and yellow maize in the case where the constant month contracts were considered (CCA). Results implied that an efficient price discovery process existed (over the observation period) between the futures price and the future spot price for each respective market. CCA second stage efficiency tests, however, indicated that future spot prices could have been a function of lagged spot and futures prices. Nonetheless, further CCA testing revealed that the co-integration relationships from the three markets were all unbiased suggesting that futures prices were unbiased estimates of future spot prices.

PCA efficiency tests involved two different sets of futures prices, namely 15-day and 35-day lagged variables. Significant co-integration results were found for all three commodity markets in the case of the 35-day lagged futures price analyses. Only yellow maize presented a possible long-run relationship between the 15-day lagged futures price and the spot price variable. Second stage and unbiasedness results were significant for both lagged futures prices and in the case of all three commodities.

Especially in the case of the co-integration tests it was evident that the CCA results were more significant than that of the PCA tests for both white and yellow maize suggesting that the introduction of the constant month contract had a definite effect of improving the efficiency of the observed markets. Calculated Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) statistics were also greater for the CCA indicating the same suggestion. Maize market PCA analyses clearly produced less significant results, although co-integration was found in the case of the white maize 35-day lagged futures price PCA. Unbiasedness results for the white and yellow maize PCA also indicated that the 35-day lagged price, especially for yellow maize, were more significant than that of the 15-day or 1-month lagged futures price. Higher price variance and uncertainty associated with the expiration month could have affected the relationship of the spot price and the 15-day lagged futures price in the case of the PCA. Because of the fact that the CCA considered only the 15-day lagged futures price, this was a further indication that the constant month contracts helped stabilise prices and improved price discovery when compared with the 15-day PCA results.

The domestic wheat market is also much smaller in terms of economic contribution than the maize market (as indicated in Chapter 2). Taking into consideration the very thin trading volumes, especially during the first few months after the introduction of wheat futures contracts, the results show that the wheat market has developed to a great extent in its price discovery function.

Chapter 5 indicated that the results of the weak-form efficiency tests by Wiseman (1999) for the white and yellow maize markets were different to some degree to those of this study. The explanations for the differences were: 1) Wiseman used a shorter observation period as that was the only available data at the time, 2) his study was conducted at a time when the futures market was still relatively young and his results could have been influenced by problems associated with thin trading volumes and low liquidity directly affecting the market's price discovery ability, and 3) as a means of overcoming this problem, Wiseman constructed his data differently concentrating only on specific contract months with the highest trading volumes in order to get the best indication of the efficiency of the futures market.

Similarly to Wiseman, this study also faced the problem of identifying a related spot price as no official spot market exists for either of the commodities considered in this study. Wiseman (1999:40) used an average weekly and daily spot price as reported by a few of the main futures market players and he concluded this as the best available estimate of cash market prices at the time. Wiseman's methodology also opted for a continuous spot price series, other than was the case in this study which only requires spot price observations on the day of contract maturity. Theory holds that the basis narrows as a futures contract approaches maturity, known as convergence (Kolb, 1991:85) and that the basis should be zero, therefore the futures and the cash price must be equal at the maturity of the futures contract (Edwards and Ma, 1992:82). Although this is subject to discrepancy due to transportation costs, the futures price at maturity was taken as the spot price from which the different spot price variables were constructed. This price was also consistent with the daily Randfontein Spot Price derived and reported by Safex (2003).

Chapter 6 investigated the general behaviour of daily futures price changes (returns) over different time frames. The main purpose was to answer the relevant research question, as to whether predictable return patterns or anomalies existed and, if found, what the implications would be for the different markets which were seemingly efficient and unbiased in price discovery over the long run. Five anomalies regularly identified in the returns of different securities were selected and tested for their presence in the futures price returns of white maize, yellow maize, and wheat. The five anomalies selected included the day-of-the-week effect, holiday effect, turn-of-the-month effect, time-of-the-year, and maturity effect.

Day-of-the-week effects were found in each of the three commodity markets considered. The white maize market revealed a strong pattern of negative mean Monday returns compared to the positive returns on every other day of the week. Mean returns also increased progressively from day-to-day with the highest return on Fridays. Similarly, yellow maize produced a negative mean Monday return, however, the distribution of returns across the week were different with the highest return found to occur on a Wednesday. Wheat day-of-the-week returns indicated positive returns Monday through Friday, with the highest return on a Thursday. Mean percentage Friday returns were much smaller than any other day of the week, although positive. The model for testing these effects statistically was proposed in Chapter 6. Kruskal-Wallis analysis of variance (ANOVA) results indicated that the day-of-the-week effect was statistically significant in the case of both white and yellow maize, but not in the case of the wheat market.

Public holidays tended to affect futures returns on the first day before and after. Mean pre- and post-holiday returns were isolated and tested for a possible effect compared to normal weekday returns. Mean white and yellow maize daily returns tended to be smaller (and negative in the case of the yellow market) on the day preceding, than the day following a public holiday. Once again, wheat results deviated from that of maize with relatively large positive returns on the day before and after a public holiday. Mann-Whitney test results revealed no significance statistically between mean pre- and post-holiday returns. These returns were also grouped according to the day-of-the-week in order to further examine whether they were different from their respective "normal day-of-the-week returns. For white maize, the Thursday post-holiday returns tended to be significantly affected by the presence of the public holiday, while in the yellow maize market a Tuesday holiday affected the return of the preceding Monday significantly. Overall, results from this section turned out to be relatively insignificant. As there were not a large number of public holidays during the course of a calendar year, sampling the different holidays according to the day-of-the-week resulted in very small samples compared to the normal day-of-the-week samples. This could have severely affected the interpretation of the results and the statistics from this section should be treated with caution.

The turn-of-the-month (TOM) effect was also investigated in Chapter 6. All three commodities showed a distinctive pattern around the turn-of-the-month period considered. Mean daily returns tended to be negative on the last few days of the month while turning out to be large and positive on the first three days of the next month. For both white and yellow maize, the 9-day, 5-day, and 3-day comparisons showed significant differences between mean returns of month-end, and month beginning. Mean daily returns also tended to be smaller (and negative in most cases) at the end of the month compared to mean returns at the beginning of the month. Wheat results were less significant, but indicated a significant effect in the 9- and 3-day comparisons.

An investigation into the time-of-the-year effect was divided into a monthly and quarterly analysis. Kruskal-Wallis ANOVA results showed that a significant effect existed in the mean monthly returns of both the white and yellow maize markets. In contrast, no such effect was evident for wheat. Monthly returns for the three commodities showed a distinctive pattern of relative large positive returns during the last three months of the year compared the rest of the year. It is also indicated that a strong correlation exists between the monthly returns and the typical seasonal indices of the different commodities. This observed trend in returns according to the time of the year was further enhanced when grouped into quarters. Especially in the case of yellow maize, fourth quarter results were significantly different from the other three quarters. White maize only produced significance between the second and fourth quarter returns, while again no effect was found in the wheat market.

The time-of-the-year results, however, could have been largely enhanced by the sudden increase of grain prices over the period from September 2001 mainly due to the sharp depreciation of the Rand against the US dollar. Chapter 7 indicated that the yellow maize futures price generally should have a closer relationship with the R/$ exchange rate than that of white maize. This is mainly because the US world price is also a yellow corn price and therefore the domestic yellow maize price depends highly on the US corn price and the R/$ exchange rate.

Finally, Chapter 6 investigated the presence of a possible maturity effect. Calculated mean monthly variances tended to be higher during the last trading month of each contract (expiration month) than during the observed preceding months in the case of all three commodities. Although some visual evidence was found of a possible maturity effect, statistical tests revealed no significance of this. Following a different approach, white maize indicated the strongest results concerning a pattern of higher monthly variances as expiration month approached. Yellow maize and wheat results, however, were less significant.

Despite the evidence that the three markets under consideration were efficient, Chapter 6 revealed the presence of anomalies in the historical futures prices of these markets. The first part of the question, as to whether such anomalies existed in the futures prices of the observed agricultural commodities, was sufficiently answered. Strong evidence of a day-of-the-week effect (in the form of a Monday-effect) and a turn-of-the-month effect was found. Less significant results suggested monthly or quarterly (time-of-the-year), holiday, and maturity effects. Generally, although over different time frames, all these effects point to returns either at the beginning or the end of a period, being different from the rest. For example:

1. negative returns on Monday compared to positive and relatively high returns on a Friday (especially in the case of white maize),
2. low and negative daily returns at the end of the month, compared to high and positive returns on the first couple of days of the mean month observed,
3. low or negative monthly returns at the beginning of the year compared to relatively high and positive returns around the last three months (with a similar pattern in the case of the observed quarters), and
4. higher monthly variance of daily returns at the end of a contract's life (maturity) compared to the preceding months.

Although this study only considered daily prices, a number of researchers, such as Ederington and Lee (2001:517), Han *et al* (1999:665), Daigler (1997:45), Lauterbach and Monroe (1989:371), and Chatrath and Song (1998:201), also found similar patterns existing in the intra-day returns of different securities. Higher volatility and mean returns were found to be generally concentrated around the beginning and end of the session where the trading volume was usually at its highest, as shown by Malliaris and Urrutia (1998:53). Daigler (1997:49) and Wang (2001:929) reasoned that position-based sentiment of market participants plays an important role in activity around the beginning and the end of a certain period (intra-day, intra-week, intra-month, etc.) Following this line of reasoning, potential reasons for differences in returns between period-end and beginning were identified:

1. Participants usually have greater divergences of opinion at the beginning of a period. Although greater volatility and volumes could be common in this situation (Daigler, 1997:49), uncertainty about actual price direction could also have been a contributor, for example, to the negative Monday returns of white and yellow maize. This was also evident in the monthly returns over an annual period, however, inconsistent with the returns at the beginning of the month (TOM effect). At the beginning of a session participants also have to adjust net positions according to the new information that became available after the close of the previous session.
2. At the end of a session or period, participants are often pressured to either close out, or hedge their net positions. This is mainly because participants cannot monitor or change their positions overnight, or over a weekend when fundamental factors can change to influence the market. This activity of closing out and hedging is associated with greater volume and activity and can be the cause of higher mean returns around this time of the observed period. Again, results from the TOM effect was different where daily returns were lower at the end of the month compared to the relatively high end of period returns in the case of the day-of-the-week and time-of-the-year analyses.

However, the factors that caused predictable patterns in futures prices were not the focus of this part of the research. Chapter 6 answered the question whether predictable anomalies exist in the commodity markets considered. The other part of the question was whether the presence of the predictable patterns in returns implies a contradiction of the market efficiency results found in Chapter 5. The evidence of strong day-of-the-week and turn-of-the-month effects over the long run would pose the question as to whether information about past regular price behaviour can be used to exploit and earn superior returns in the future. In any market, although these patterns have existed historically, there is no guarantee that they will persist in the future (Lauterbach and Monroe, 1989:374) and, if they do, transactions and hidden costs may prevent possible outperformance.

Results from Chapter 5 indicated that, for the markets considered, the relationship between futures prices and future spot prices were co-integrated and unbiased. Therefore, results met the necessary conditions for the weak-form market efficiency. However, in the case of both the white and yellow maize CCA's, results showed a failure of the second stage efficiency tests suggesting that historical spot and futures prices could have been useful in predicting the future value of the spot price over the period under consideration. Although there is no evidence to suggest otherwise, there is also no other evidence to indicate that the observed irregularities are in fact a possible source of inefficiency, that is, unless the anomalies could have been largely enhanced, for example, by a price adjustment process that happened over the period under consideration due to the release of timely information.

The effect of the sudden increase in grain prices from September 2001 not only could have affected the time-of-the-year results, but also contributed to the strong day-of-the-week pattern of increasing weekday returns. In addition, the theory of normal backwardation (Kolb, 1991:139) also states that futures prices tend to rise over time and over the lifetime of a contract. Considering these two factors, the general trend of increasing returns can be partially explained. Yet, the strong day-of-the-week and turn-of-the-month anomalies pose the question as to whether they were purely the outcome of the coincidental September 2001 occurrence in the observation period, or that there were possible other sources of price behaviour contributing to their existence. In order to sufficiently answer the research question as to whether their presence was a concern for market efficiency, other sources of fundamentals had to be considered.

Analyses in Chapter 7 focussed on the futures price behaviour around scheduled agricultural and macroeconomic announcements. As shown in the chapter, South African grain prices are a function of, amongst others, international grain prices and the R/$ exchange rate suggesting that there is also a special relationship between grain prices and the domestic macro-economy. As a price taker in terms of the world grain complex, this study finds that grain prices in South Africa largely depends on factors other than normal fundamentals. Grain prices were found to be sensitive towards a number of macroeconomic variables apart from factors that influence basic supply and demand perceptions.

It has been shown previously, Ederington and Lee (1993 and 1996), Chatrath and Song (1998), and Graham *et al* (2003), that markets process the release of information in a certain way. Ederington and Lee (1996:513) argued that a news announcement's impact on market uncertainty depends largely on whether the announcement is scheduled or unscheduled. As was the case in this study, since market participants know that important scheduled releases have the potential to cause large changes in the underlying price it can be hypothesised that uncertainty will be high prior to its release with an effect in prices after the information is made public. Of course, as indicated in Chapter 7, the purpose of this section of the study was not to investigate the reaction of futures prices to scheduled public information releases, but specifically the price behaviour of commodity prices around scheduled announcements and, more importantly, how this behaviour contributed to the anomalies found in the different markets.

Empirical results showed evidence of a significant effect for all three commodities on the day of agricultural and "Type A" macroeconomic information releases. This effect also indicated below average absolute returns on the observed announcements days. "Type B" macroeconomic announcements were found to have a less significant impact on futures price behaviour.

The investigation of individual announcements produced a distinctive pattern of declining absolute returns towards the announcement day mainly caused by the uncertainty about the content of the information to be released. The fact that most agricultural and "Type A" macroeconomic reports are only released either late morning (11h30) or in the afternoon (see Table 7.6) contributed to the high level of uncertainty on the actual announcement day. Since the Agricultural Products Division (APD) trading hours close at 12h00, the information is released effectively at the very end of the trading day and sometimes after the close of the trading day. There is also sufficient evidence of the markets' reactions on the day after the different announcements were made. Absolute returns tended to be relatively very high on this day as the market had absorbed the new information and uncertainty was resolved. Results further indicated that the observed announcement day effect greatly contributed to the day-of-the-week anomaly also identified in this study. Again, this contribution was much less significant in the case of the "Type B" macroeconomic announcements.

The distribution of the observed announcements over the period of a month proved to be a major contributor to the turn-of-the-month anomaly also found to exist in the futures prices of the three different markets. In this case, the distribution of the less significant “Type B” announcements also contributed valuably to enhance the TOM effect. Therefore, the question as to whether futures price behaviour due to the release of anticipated public information contributed towards the observed price return anomalies has been sufficiently answered in the affirmative.

The issue concerning the effect on market efficiency has yet to be resolved. Firstly, the results of Chapter 7 concluded that the agricultural, “Type A” and, to a lesser extent, “Type B” macroeconomic announcements did provide news to the market. This was evident through the relatively much higher absolute daily returns on the first business day following the information release compared to the significantly lower return on the day before. In the case of the agricultural announcements it is concluded that the information released changed the overall supply/demand perceptions of market participants. However, the relationship between the macroeconomic announcements and the uncertainty of the agricultural futures prices can only be explained through the R/$ exchange rate. Especially in the case of the “Type A” information releases, uncertainty before and the effect after the respective individual announcements were highly significant. It is suggested that the agricultural markets reacted to the knowledge that the macroeconomic information could result in a change in the value of the Rand to which grain prices would have to adjust. Results also indicated that both categories of macroeconomic announcements significantly contributed to the unexplained return irregularities observed in the prices of the markets.

Secondly, Chapter 7 produced an insight into the extent to which market participants face abnormal risks associated with the release of the agricultural and macroeconomic reports. Addressing the question of market efficiency, the declining absolute daily returns before a specific announcement is attributed to the higher level of uncertainty regarding the possible impact of the information on grain prices. This uncertainty limits extensive positioning by speculators and hedgers generally contributing to a more quiet trading session with a below average movement in price. Assessing this constant pattern of uncertainty prior to the different announcements questions the market’s ability to anticipate the contents of the information to be released. Of course, especially in the case of the agricultural reports, authorities allocate plenty of resources towards ensuring the confidentiality of the information prior to its release. The futures market's relatively short existence partly explains this problem as a small percentage of private resources are allocated towards competitive and intensive market research. Currently the South African agricultural futures market consists of only a few large players and a relatively large number of smaller firms (Gravelet-Blondin, 2003) with less available resources for competitive market research. This distribution partly explains the high degree of uncertainty prior to scheduled announcements as participants from smaller firms would be more likely to avoid the market unwilling to accept the higher risk associated with the uncertainty about the future. After the information is released these players return to the market in order to position themselves based on the outcome of the report and most likely will cause prices to overreact and cause above average daily movements in price.

The observed pattern of uncertainty contradicts some past evidence, such as that of Ederington and Lee (1993:1162; 1996:514), and Graham *et al* (2003:156), showing that daily absolute return levels generally increases prior to the announcement and reduces considerably after the information is realised. However, the commodity and stock markets considered in these studies were all well established and massive in size and volume compared to the market examined in this study. As the South African agricultural futures market grows and develops over time it will establish a much more even distribution of larger participants making it more efficient in stabilising prices and predicting public information.

However, in these studies the implied volatility was used as the measure of uncertainty and reaction. The absolute price return measure has also been favoured by Fortenbery and Sumner (1993:157) and Sumner and Mueller (1989:1). Results found were more similar to those in this study with higher than normal returns following a scheduled announcement. The particular authors also pointed out that the greater the report-effect, the greater the uncertainty and thus the less efficient the markets are in anticipating the underlying supply and demand and other fundamental characteristics.

Finally, the question remains as to whether it is possible to exploit the market predictability and earn abnormal profits. Transaction costs generally limit excess profits

(Miffre, 2002:126), although this aspect was not examined in this study, it is recommended that the effect of transaction costs on the profitability of certain investment strategies applied to the different commodity markets be investigated. As shown by Garbade and Silber (1983:289), the essence of the price discovery function of a futures market hinges on whether new information is reflected in changed futures prices and then leads to changes in spot prices. This effect was confirmed in Chapter 5. Based on the evidence from the results in this study, it is therefore argued that the irregularities found were largely the outcome of the markets' behaviour around scheduled announcements of certain agricultural and macroeconomic information. It was further shown that other factors could also have played an important role in enhancing the anomalies and seasonal patterns found. These were:

1. the close relationship between grain commodity prices and the R/$ exchange rate, referring mainly to the substantial increase in grain prices following the devaluation of the Rand from September 2001, and
2. the distribution of small and large firms currently participating in the agricultural futures market. It was argued that the unbalanced distribution between small and large firms enhanced the effects of uncertainty and reaction around scheduled announcements.

It would have been inaccurate to argue that participants could have profited from trading these anomalies found to be efficient in the long run. However, firstly, the failure of the CCA second stage efficiency tests suggested that information about lagged spot and futures prices could have been useful in predicting the future value of the spot market. This suggests, for example, that past information about negative mean Monday returns could have been used by speculators to earn excess profits over the long run. This is also the case for the TOM effect.

Secondly, the significant report-day effects are indicative of the fact that most of the observed announcements provided news to the different markets and suggests that they were less efficient in anticipating the information to be released, as mentioned earlier in this chapter. This is a possible source of "semi-strong" inefficiency identified in this study. If the three markets were generally more efficient in its anticipation of information, the observed announcement-day effects would have been less significant caused by a lower degree of uncertainty amongst market participants about possible future price direction.

Finally, it has been shown in the study that (inefficient) futures price behaviour around scheduled announcements greatly contributed to the anomalies under consideration, thus implying the anomalies was largely the outcome of inefficient components from a "semi-strong" (public information) source. The fact that the public information announcements considered in the study were all scheduled effectively means that traders would have been able to foresee different than usual price patterns around the release date suggesting a high possibility of exploitation.

Results and conclusions in the study contributed to the field of financial economics and specifically research in the field of agricultural commodity derivative markets. Valuable contributions are summarised as follows:

1. New evidence suggesting intertemporal weak-form long run efficiency in the three markets considered. Results showed that the white and yellow maize markets developed over time and fulfilled its function of price discovery. New research was also conducted on the more recently introduced wheat futures market and results also suggesting successful development and efficient functioning. Results should be of great value to exchange authorities specifically reviewing the functioning and regulations of the different.
2. The model also introduced a cross-sectional evaluation that was applied to the maize markets for the first time. Results further supported the abovementioned findings of efficiency. Generally this section of the study introduced valuable new ideas to the field of futures market research in South Africa specifically referring to the evaluation of futures market efficiency.
3. New and significant evidence was presented in the form of futures price anomalies and also tested for the first time on the South African markets. This research contributed to a relatively small amount of international research regarding agricultural commodity futures. It also introduced a brand new area of research with respect to futures markets and other securities in South Africa.

4. The study also focussed on price behaviour and produced new evidence of the effects of scheduled public information releases on agricultural commodity futures markets. The concept and methodology used was newly introduced regarding futures market research in South Africa. This study joins and contributes to the small amount of evidence of agricultural futures price behaviour in the presence of specifically scheduled macroeconomic announcements. Results were indicative of significant uncertainty and response to a number of macroeconomic variables and explained a unique relationship between grain markets and the macro-economy in South Africa.
5. Overall, contributions were made to different aspects and current issues regarding international agricultural futures market research. This included the introduction of a number of new ideas, methodologies, and findings in relation to agricultural futures market research in South Africa.

8.2 Recommendations

Considering problems and challenges encountered during the research, some recommendations are proposed for similar or related work in this particular field.

1. It is recommended that the issue of an official spot market for the different grain commodities be assessed. The current reported cash market prices, reported by the JSE APD, is the only available estimate and further research is recommended in order to properly investigate as to whether this is the best and most efficient indicator.
2. The possible introduction of the efficiency model (or related models) to the other commodities, namely sunflowers and soybeans, traded on the JSE APD. As these two markets were only introduced during the time of the study, they were not considered.
3. It is also recommended that "semi-strong" and possibly "strong-form" efficiency models be developed and applied to the different commodity markets in order to further evaluate the status of futures market efficiency.

4. Further research into price effects and irregularities should include intraday periods which would provide additional insight in understanding the factors that create these return patterns.
5. In the case of the public information, it is suggested that a model is introduced that would control for the different announcements in order to further investigate the relative importance of the different categories as well as for each of the individual announcements. This includes an investigation of sources of public information other than that used in this study.
6. The price adjustment process after the release of public information is a valuable indication of the markets' ability to efficiently absorb new information and whether the information is quickly and efficiently incorporated into futures prices. It is recommended that future research concentrate on this price adjustment process focussing on the time futures prices take to fully reflect such new information. Such research would greatly contribute to current market efficiency methodology.
7. Daily price limits as an exchange regulation on the JSE APD should have implications for market efficiency as well as other aspects like return irregularities. This aspect of the market was not covered in the study and it is recommended that the effect of this regulation on issues such as market efficiency be investigated in future research.
8. The co-integration results suggest that efficiency was improved by the introduction of the current month contract. However, the PCA contract months were unevenly spaced in time whereas the CCA data were evenly spaced (after the introduction of constant month contract data). When further data become available, there would be the possibility to test if the uneven data spacing affected the efficiency results.
9. Finally, this study concentrated on futures prices and their behaviour specifically. Options were also introduced since the inception of the agricultural futures market and an assessment of their development and functioning would contribute greatly to research regarding the performance of the various derivative instruments available for grain marketing in South Africa.

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APPENDIX A

Table A.1: ADF and PP unit root tests for all variables excluding data from September 2001 onwards

	Variable	No. of observations (n)	ADF test statistic[4, #, ###]	PP test statistic[5, ##, ####]	First difference I(1)	
					ADF-test	PP-test
WMAZ	$Sp_{exp\ PCA}$[1]	27	-3.47	-2.99	-4.99**	-4.84**
	$Fp_{15\ PCA}$[2]	27	-3.46	-2.77	-4.51**	-4.49**
	$Fp_{35\ PCA}$[3]	27	-3.94**	-3.25	-4.92**	-4.82**
	$Sp_{exp\ CCA}$[4]	44	-2.79	-2.62	-5.49**	-6.32**
	$Fp_{15\ CCA}$[5]	44	-2.56	-2.15	-5.35**	-5.05**
YMAZ	$Sp_{exp\ PCA}$	27	-2.28	-2.46	-4.09**	-5.30**
	$Fp_{15\ PCA}$	27	-2.70	-2.26	-4.15**	-4.24**
	$Fp_{35\ PCA}$	27	-2.63	-2.63	-3.89**	-5.17**
	$Sp_{exp\ CCA}$	44	-2.16	-2.13	-4.83**	-6.13**
	$Fp_{15\ CCA}$	44	-2.28	-2.00	-5.03**	-5.12**
WHEAT	$Sp_{exp\ PCA}$	19	-0.64	-0.46	-6.88**	-5.37**
	$Fp_{15\ PCA}$	19	-0.40	-0.38	-4.12**	-5.17**
	$Fp_{35\ PCA}$	19	-0.23	-0.41	-3.96**	-4.76**

[1] Spot price variable (PCA)
[2] Futures price variable at 15 days lag from contract expiry (PCA)
[3] Futures price variable at 35 days lag from contract expiry (PCA)
[4] Spot price variable (CCA)
[5] Futures price variable at 15 days lag from contract expiry (CCA)
** Significant at 1% level of significance
[#] MacKinnon critical ADF-value for PCA at 1% level of significance = -3.67
[##] MacKinnon critical PP-value for PCA at 1% level of significance = -3.66
[###] MacKinnon critical ADF-value for CCA at 1% level of significance = -3.56
[####] MacKinnon critical PP-value for CCA at 1% level of significance = -3.55

APPENDIX B

Figure B.1: Histogram for white maize

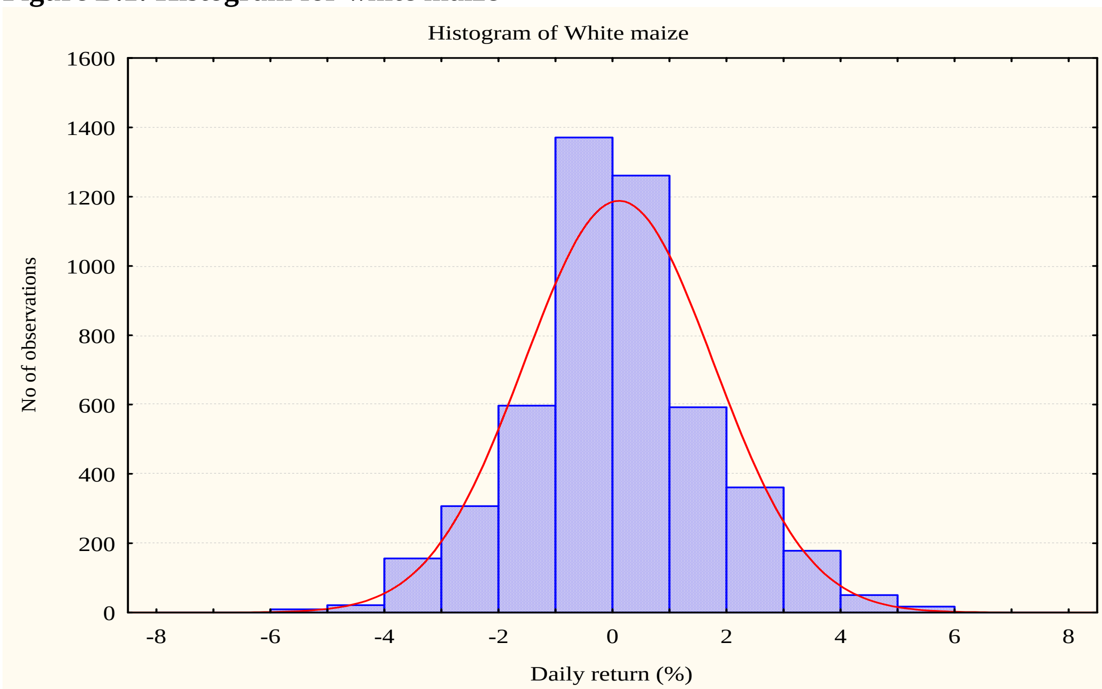


Figure B.2: Histogram for Yellow maize

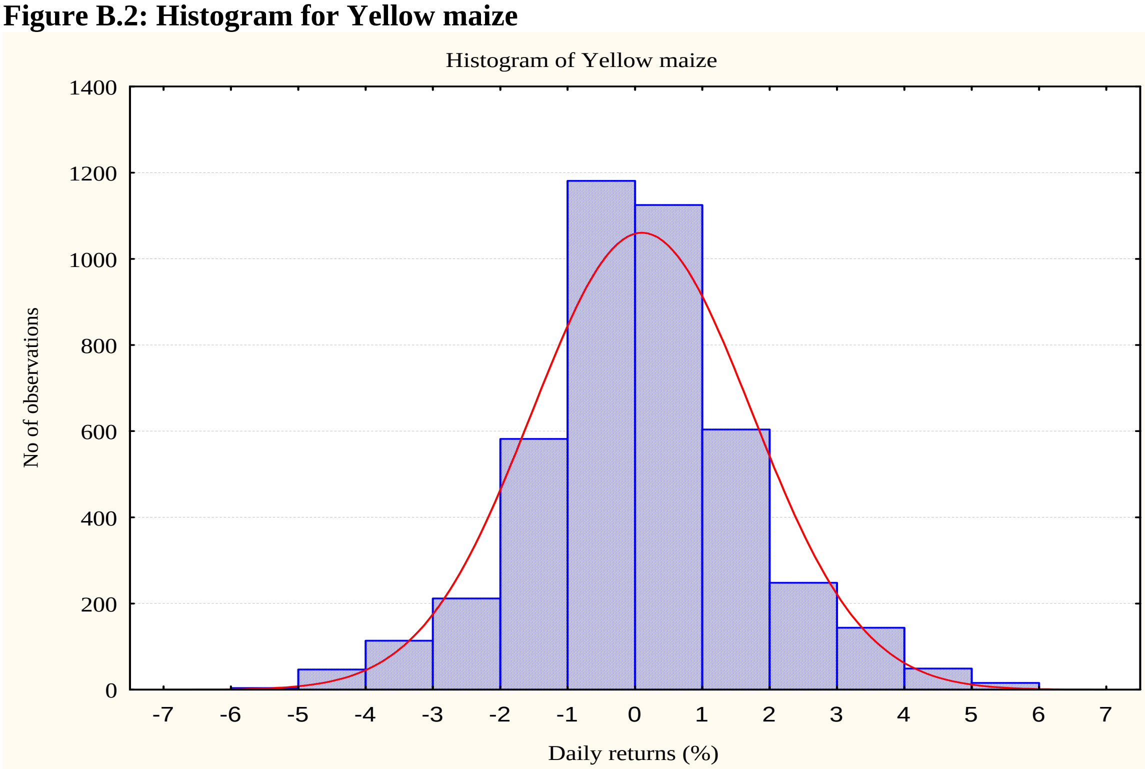


Figure B.3: Histogram for Wheat

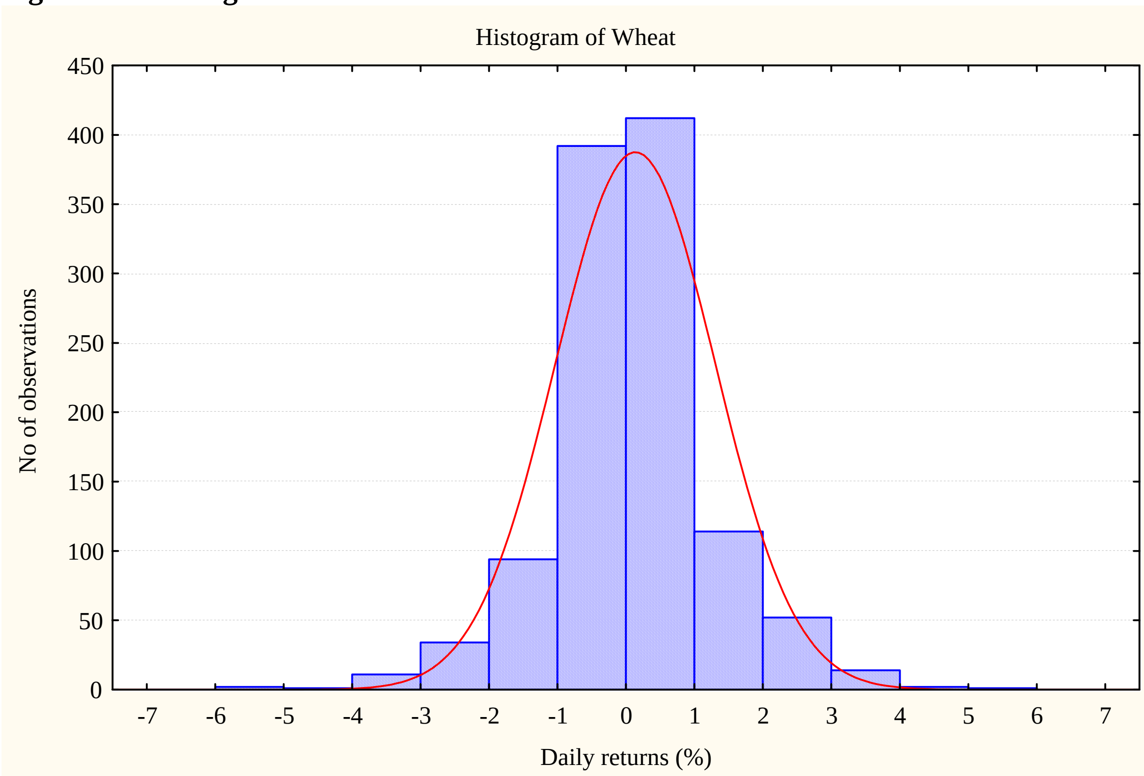


Table B.1: Day-of-the-week Mann-Whitney p values for white and yellow maize

White maize	Monday	Tuesday	Wednesday	Thursday	Friday
Monday		**0.0000**	**0.0000**	**0.0000**	**0.0001**
Tuesday	**0.0000**		1.0000	1.0000	1.0000
Wednesday	**0.0000**	1.0000		1.0000	1.0000
Thursday	**0.0000**	1.0000	1.0000		1.0000
Friday	**0.0001**	1.0000	1.0000	1.0000	
Yellow maize	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Monday		**0.0048**	**0.0001**	**0.0024**	0.0644
Tuesday	**0.0048**		1.0000	1.0000	1.0000
Wednesday	**0.0001**	1.0000		1.0000	0.5678
Thursday	**0.0024**	1.0000	1.0000		1.0000
Friday	0.0644	1.0000	0.5678	1.0000	

Table B.2.1: "Turn-of-the-month" multiple comparison Z-values for white maize, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		0.7206	0.0520	0.9665	1.2213	0.7334	1.8978	2.2672	0.0687
-8	0.7206		0.7694	1.6953	1.9551	1.4524	2.6217	1.5575	0.6425
-7	0.0520	0.7694		0.9137	1.1681	0.6812	1.8453	2.3187	0.1202
-6	0.9665	1.6953	0.9137		0.2481	0.2202	0.9377	3.2085	1.0120
-5	1.2213	1.9551	1.1681	0.2481		0.4635	0.6929	3.4486	1.2526
-4	0.7334	1.4524	0.6812	0.2202	0.4635		1.1595	2.9911	0.7941
-3	1.8978	2.6217	1.8453	0.9377	0.6929	1.1595		4.1280	1.9335
-2	2.2672	1.5575	2.3187	3.2085	3.4486	2.9911	4.1280		2.2034
-1	0.0687	0.6425	0.1202	1.0120	1.2526	0.7941	1.9335	2.2034	
1	3.4895	2.7607	3.5423	4.4560	4.7025	4.2328	5.4002	1.1615	3.4191
2	1.2956	0.5734	1.3480	2.2535	2.4978	2.0323	3.1892	1.0115	1.2258
3	3.2597	2.5484	3.3113	4.2031	4.4436	3.9852	5.1245	0.9876	3.1910
4	1.0232	0.3119	1.0748	1.9666	2.2071	1.7487	2.8880	1.2488	0.9545
5	1.0854	0.3741	1.1369	2.0287	2.2693	1.8108	2.9502	1.1867	1.0167
6	1.9489	1.2314	2.0009	2.9005	3.1432	2.6807	3.8300	0.3430	1.8796
7	3.7092	3.0055	3.7603	4.6426	4.8806	4.4270	5.5543	1.4612	3.6413
8	0.2866	0.9994	0.2349	0.6587	0.8999	0.4404	1.5822	2.5636	0.3554
9	0.3597	1.0803	0.3074	0.5960	0.8398	0.3752	1.5296	2.6618	0.4293

Table B.2.2: "Turn-of-the-month" multiple comparison Z-values for white maize, section II

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
-9	3.4895	1.2956	3.2597	1.0232	1.0854	1.9489	3.7092	0.2866	0.3597
-8	2.7607	0.5734	2.5484	0.3119	0.3741	1.2314	3.0055	0.9994	1.0803
-7	3.5423	1.3480	3.3113	1.0748	1.1369	2.0009	3.7603	0.2349	0.3074
-6	4.4560	2.2535	4.2031	1.9666	2.0287	2.9005	4.6426	0.6587	0.5960
-5	4.7025	2.4978	4.4436	2.2071	2.2693	3.1432	4.8806	0.8999	0.8398
-4	4.2328	2.0323	3.9852	1.7487	1.8108	2.6807	4.4270	0.4404	0.3752
-3	5.4002	3.1892	5.1245	2.8880	2.9502	3.8300	5.5543	1.5822	1.5296
-2	1.1615	1.0115	0.9876	1.2488	1.1867	0.3430	1.4612	2.5636	2.6618
-1	3.4191	1.2258	3.1910	0.9545	1.0167	1.8796	3.6413	0.3554	0.4293
1		2.1627	0.1460	2.3825	2.3203	1.4866	0.3395	3.6997	3.8104
2	2.1627		1.9837	0.2527	0.1905	0.6618	2.4468	1.5653	1.6525
3	0.1460	1.9837		2.2365	2.1743	1.3392	0.4841	3.5533	3.6624
4	2.3825	0.2527	2.2365		0.0621	0.9167	2.6968	1.3120	1.3964
5	2.3203	0.1905	2.1743	0.0621		0.8540	2.6353	1.3743	1.4594
6	1.4866	0.6618	1.3392	0.9167	0.8540		1.7977	2.2228	2.3172
7	0.3395	2.4468	0.4841	2.6968	2.6353	1.7977		4.0437	4.1582
8	3.6997	1.5653	3.5533	1.3120	1.3743	2.2228	4.0437		0.0699
9	3.8104	1.6525	3.6624	1.3964	1.4594	2.3172	4.1582	0.0699	

Table B.3.1: "Turn-of-the-month" multiple comparison p-values for white maize, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-8	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-7	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-6	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.2040	1.0000
-5	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.0861	1.0000
-4	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.4252	1.0000
-3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		**0.0055**	1.0000
-2	1.0000	1.0000	1.0000	0.2040	0.0861	0.4252	**0.0055**		1.0000
-1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
1	0.0740	0.8822	0.0606	**0.0012**	**0.0003**	**0.0035**	**0.0000**	1.0000	0.0961
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2182	1.0000	1.0000
3	0.1706	1.0000	0.1420	**0.0040**	**0.0013**	**0.0103**	**0.0000**	1.0000	0.2168
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.5930	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.4857	1.0000	1.0000
6	1.0000	1.0000	1.0000	0.5699	0.2556	1.0000	**0.0196**	1.0000	1.0000
7	**0.0318**	0.4056	**0.0259**	**0.0005**	**0.0001**	**0.0014**	**0.0000**	1.0000	**0.0415**
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table B.3.2: "Turn-of-the-month" multiple comparison p-values for white maize, section II

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
-9	0.0741	1.0000	0.1706	1.0000	1.0000	1.0000	**0.0318**	1.0000	1.0000
-8	0.8822	1.0000	1.0000	1.0000	1.0000	1.0000	0.4056	1.0000	1.0000
-7	0.0606	1.0000	0.1420	1.0000	1.0000	1.0000	**0.0259**	1.0000	1.0000
-6	**0.0012**	1.0000	**0.0040**	1.0000	1.0000	0.5699	**0.0005**	1.0000	1.0000
-5	**0.0003**	1.0000	**0.0013**	1.0000	1.0000	0.2556	**0.0001**	1.0000	1.0000
-4	**0.0035**	1.0000	**0.0103**	1.0000	1.0000	1.0000	**0.0014**	1.0000	1.0000
-3	**0.0000**	0.2182	**0.0000**	0.5930	0.4857	**0.0196**	**0.0000**	1.0000	1.0000
-2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-1	0.0961	1.0000	0.2168	1.0000	1.0000	1.0000	**0.0415**	1.0000	1.0000
1		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**0.0330**	**0.0212**
2	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.0581	**0.0382**
4	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		**0.0080**	**0.0049**
8	**0.0330**	1.0000	0.0581	1.0000	1.0000	1.0000	**0.0080**		1.0000
9	**0.0212**	1.0000	**0.0382**	1.0000	1.0000	1.0000	**0.0049**	1.0000	

Table B.4.1: "Turn-of-the-month" multiple comparison Z-values for yellow maize, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		1.2853	0.7266	0.2808	0.0419	0.8623	0.5012	2.1377	1.1082
-8	1.2853		2.044808	1.5758	1.3566	2.2194	1.8027	0.8395	0.1739
-7	0.7266	2.0448		0.4330	0.6829	0.1140	0.2162	2.8534	1.8152
-6	0.2808	1.5758	0.4330		0.2432	0.5679	0.2190	2.4192	1.3863
-5	0.0419	1.3566	0.6829	0.2432		0.8190	0.4597	2.1791	1.1491
-4	0.8623	2.2194	0.1140	0.5679	0.8190		0.3256	2.9625	1.9230
-3	0.5012	1.8027	0.2162	0.2190	0.4597	0.3256		2.6377	1.6021
-2	2.1377	0.8395	2.8534	2.4192	2.1791	2.9625	2.6377		1.0032
-1	1.1082	0.1739	1.8152	1.3863	1.1491	1.9230	1.6021	1.0032	
1	4.6383	3.3654	5.3402	4.9144	4.6789	5.4472	5.1287	2.5421	3.5381
2	2.3483	1.0784	3.0484	2.6237	2.3888	3.1552	2.8374	0.2571	1.2507
3	2.3775	1.0695	3.0987	2.6612	2.4192	3.2086	2.8813	0.2236	1.2469
4	0.1429	1.4411	0.5727	0.1385	0.1015	0.6818	0.3570	2.2807	1.2650
5	0.9771	0.3243	1.6946	1.2593	1.0186	1.8040	1.4784	1.1659	0.1477
6	2.1510	0.8811	2.8512	2.4265	2.1915	2.9579	2.6402	0.0598	1.0534
7	3.3058	2.0011	4.0251	3.5888	3.3474	4.1348	3.8083	1.1573	2.1781
8	0.0502	1.3325	0.6566	0.2278	0.0093	0.7644	0.4436	2.1617	1.1585
9	1.2038	0.0752	1.9090	1.4813	1.2446	2.0166	1.6965	0.9024	0.0982

Table B.4.2: "Turn-of-the-month" multiple comparison Z-values for yellow maize, section II

	1	2	3	4	5	6	7	8	9
-9	4.6383	2.3483	2.3775	0.1429	0.9771	2.1510	3.3058	0.0502	1.2038
-8	3.3654	1.0784	1.0695	1.4411	0.3243	0.8811	2.0011	1.3325	0.0752
-7	5.3402	3.0484	3.0987	0.5727	1.6946	2.8512	4.0251	0.6566	1.9090
-6	4.9144	2.6237	2.6612	0.1385	1.2593	2.4265	3.5888	0.2278	1.4813
-5	4.6789	2.3888	2.4192	0.1015	1.0186	2.1915	3.3474	0.0093	1.2446
-4	5.4472	3.1552	3.2086	0.6818	1.8040	2.9579	4.1348	0.7644	2.0166
-3	5.1287	2.8374	2.8813	0.3570	1.4784	2.6402	3.8083	0.4436	1.6965
-2	2.5421	0.2571	0.2236	2.2807	1.1659	0.0598	1.1573	2.1617	0.9024
-1	3.5381	1.2507	1.2469	1.2650	0.1477	1.0534	2.1781	1.1585	0.0982
1		2.2789	2.3885	4.8732	3.7650	2.4762	1.4482	4.7224	3.4569
2	2.2789		0.0412	2.5435	1.4295	0.1972	0.8931	2.4214	1.1615
3	2.3885	0.0412		2.5026	1.3884	0.1572	0.9342	2.3809	1.1211
4	4.8732	2.5435	2.5026		1.1204	2.2909	3.4495	0.0909	1.3447
5	3.7650	1.4295	1.3884	1.1204		1.1976	2.3262	1.0129	0.2434
6	2.4762	0.1972	0.1572	2.2909	1.1976		1.0958	2.2222	0.9628
7	1.4482	0.8931	0.9342	3.4495	2.3262	1.0958		3.2991	2.0371
8	4.7224	2.4214	2.3809	0.0909	1.0129	2.2222	3.2991		1.2540
9	3.4569	1.1615	1.1211	1.3447	0.2434	0.9628	2.0371	1.2540	

Table B.5.1: "Turn-of-the-month" multiple comparison p-values for yellow maize, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-8	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-7	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	0.6617	1.0000
-6	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
-5	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
-4	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.4667	1.0000
-3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
-2	1.0000	1.0000	0.6617	1.0000	1.0000	0.4667	1.0000		1.0000
-1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	
1	**0.0005**	0.1169	**0.0000**	**0.0001**	**0.0004**	**0.0000**	**0.0000**	1.0000	0.0616
2	1.0000	1.0000	0.3518	1.0000	1.0000	0.2453	0.6956	1.0000	1.0000
3	1.0000	1.0000	0.2973	1.0000	1.0000	0.2040	0.6057	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	0.6663	1.0000	1.0000	0.4738	1.0000	1.0000	1.0000
7	0.1448	1.0000	**0.0087**	0.0508	0.1247	**0.0054**	**0.0214**	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table B.5.2: "Turn-of-the-month" multiple comparison p-values for yellow maize, section II

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
-9	**0.0005**	1.0000	1.0000	1.0000	1.0000	1.0000	0.1448	1.0000	1.0000
-8	0.1169	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-7	**0.0000**	0.3518	0.2973	1.0000	1.0000	0.6663	**0.0087**	1.0000	1.0000
-6	**0.0001**	1.0000	1.0000	1.0000	1.0000	1.0000	0.0508	1.0000	1.0000
-5	**0.0004**	1.0000	1.0000	1.0000	1.0000	1.0000	0.1247	1.0000	1.0000
-4	**0.0000**	0.2453	0.2040	1.0000	1.0000	0.4738	**0.0054**	1.0000	1.0000
-3	**0.0000**	0.6956	0.6057	1.0000	1.0000	1.0000	**0.0214**	1.0000	1.0000
-2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-1	0.0616	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1		1.0000	1.0000	**0.0001**	**0.0254**	1.0000	1.0000	0.0003	0.0835
2	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	**0.0001**	1.0000	1.0000		1.0000	1.0000	0.0859	1.0000	1.0000
5	**0.0254**	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	0.0859	1.0000	1.0000		0.1483	1.0000
8	**0.0003**	1.0000	1.0000	1.0000	1.0000	1.0000	0.1483		1.0000
9	0.0835	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Table B.6.1: "Turn-of-the-month" multiple comparison Z-values for wheat, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		3.1176	1.8144	2.0536	1.0321	0.2744	1.5763	1.5949	3.2676
-8	3.1176		1.1545	1.0247	3.8721	2.4789	1.2338	1.3401	0.0669
-7	1.8144	1.1545		0.1723	2.7681	1.4082	0.1410	0.1987	1.3115
-6	2.0536	1.0247	0.1723		2.9270	1.5624	0.2983	0.3630	1.1324
-5	1.0325	3.8724	2.7680	2.9270		1.2754	2.5980	2.6621	4.4313
-4	0.2744	2.4789	1.4082	1.5624	1.2754		1.2962	1.3024	2.9486
-3	1.5763	1.2338	0.1410	0.2983	2.5980	1.2962		0.0514	1.4722
-2	1.5949	1.3401	0.1987	0.3630	2.6621	1.3024	0.0514		1.5283
-1	3.2676	0.0669	1.3115	1.1324	4.4313	2.9486	1.4722	1.5283	
1	1.9429	1.1353	0.0616	0.1106	3.0622	1.6361	0.2161	0.2701	1.1997
2	0.6877	3.4139	2.3538	2.5064	0.3035	0.9594	2.2169	2.1691	3.4709
3	0.2206	3.1229	1.9943	2.1568	0.8345	0.5098	1.8486	1.7977	3.1836
4	1.3340	1.5365	0.4202	0.5809	2.3777	1.0479	0.2762	0.2258	1.5965
5	0.2419	3.0818	1.9774	2.1364	0.7906	0.5249	1.8349	1.7851	3.1411
6	1.8263	1.2520	0.0549	0.2272	2.9455	1.5195	0.0995	0.1535	1.3163
7	0.3117	3.2807	2.1262	2.2924	0.7677	0.6076	1.9772	1.9251	3.3428
8	1.0782	3.8316	2.7609	2.9150	0.0771	1.3526	2.6227	2.5744	3.8891
9	0.3168	3.2858	2.1313	2.2975	0.7626	0.6127	1.9823	1.9302	3.3479

Table B.6.2: "Turn-of-the-month" multiple comparison Z-values for wheat, section II

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
-9	1.9429	0.6877	0.2206	1.3340	0.2419	1.8263	0.3117	1.0782	0.3168
-8	1.1353	3.4139	3.1229	1.5365	3.0818	1.2520	3.2807	3.8316	3.2858
-7	0.0616	2.3538	1.9943	0.4202	1.9774	0.0549	2.1262	2.7609	2.1313
-6	0.1106	2.5064	2.1568	0.5809	2.1364	0.2272	2.2924	2.9150	2.2975
-5	3.0622	0.3035	0.8345	2.3777	0.7906	2.9455	0.7677	0.0771	0.7626
-4	1.6361	0.9594	0.5098	1.0479	0.5249	1.5195	0.6076	1.3526	0.6127
-3	0.2161	2.2169	1.8486	0.2762	1.8349	0.0995	1.9772	2.6227	1.9823
-2	0.2701	2.1691	1.7977	0.2258	1.7851	0.1535	1.9251	2.5744	1.9302
-1	1.1997	3.4709	3.1836	1.5965	3.1411	1.3163	3.3428	3.8891	3.3479
1		2.4084	2.0525	0.4777	2.0343	0.1166	2.1857	2.8161	2.1908
2	2.4084		0.5114	2.0581	0.4744	2.6028	0.4372	0.3837	0.4321
3	2.0525	0.5114		1.5522	0.0260	2.0603	0.0860	0.8689	0.0911
4	0.4777	2.0581	1.5522		1.5616	0.3957	1.6915	2.3578	1.6966
5	2.0343	0.4744	0.0260	1.5616		2.0885	0.0588	0.8437	0.0639
6	0.1166	2.6028	2.0603	0.3957	2.0885		2.0732	2.7117	2.0783
7	2.1857	0.4372	0.0860	1.6915	0.0588	2.0732		0.7891	0.0051
8	2.8161	0.3837	0.8689	2.3578	0.8437	2.7117	0.7891		0.8458
9	2.1908	0.4321	0.0911	1.6966	0.0639	2.0783	0.0051	0.8458	

Table B.7.1: "Turn-of-the-month" multiple comparison p-values for wheat, section I

	-9	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**
-9		0.2789	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1659
-8	0.2789		1.0000	1.0000	**0.0164**	1.0000	1.0000	1.0000	1.0000
-7	1.0000	1.0000		1.0000	0.8627	1.0000	1.0000	1.0000	1.0000
-6	1.0000	1.0000	1.0000		0.5235	1.0000	1.0000	1.0000	1.0000
-5	1.0000	**0.0164**	0.8627	0.5235		1.0000	1.0000	1.0000	**0.0014**
-4	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	0.4883
-3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
-2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000
-1	0.1659	1.0000	1.0000	1.0000	**0.0014**	0.4883	1.0000	1.0000	
1	1.0000	1.0000	1.0000	1.0000	0.3361	1.0000	1.0000	1.0000	1.0000
2	1.0000	0.0979	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0793
3	1.0000	0.2739	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2225
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	0.3147	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2574
6	1.0000	1.0000	1.0000	1.0000	0.4931	1.0000	1.0000	1.0000	1.0000
7	1.0000	0.1583	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1268
8	1.0000	**0.0194**	0.8818	0.5440	1.0000	1.0000	1.0000	1.0000	**0.0153**
9	1.0000	0.1555	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.1245

Table B.7.2: "Turn-of-the-month" multiple comparison p-values for wheat, section II

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
-9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-8	1.0000	0.0979	0.2739	1.0000	0.3147	1.0000	0.1583	**0.0194**	0.1555
-7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.8818	1.0000
-6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.5440	1.0000
-5	0.3361	1.0000	1.0000	1.0000	1.0000	0.4931	1.0000	1.0000	1.0000
-4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
-1	1.0000	0.0793	0.2225	1.0000	0.2574	1.0000	0.1268	**0.0153**	0.1245
1		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.7436	1.0000
2	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
8	0.7436	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Table B.8: Mann-Whitney multiple monthly comparison p-values for white maize

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Feb	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Mar	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Apr	1.0000	1.0000	1.0000		1.0000	0.5883	1.0000	1.0000	1.0000	0.4975	0.3142	0.2202
May	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9046
Jun	1.0000	1.0000	1.0000	0.5883	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Jul	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000
Aug	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000
Sep	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
Oct	1.0000	1.0000	1.0000	0.4975	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000
Nov	1.0000	1.0000	1.0000	0.3142	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000
Dec	1.0000	1.0000	1.0000	0.2202	0.9046	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	

Table B.9: Mann-Whitney multiple monthly comparison p-values for yellow maize

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**0.0020**	0.1566	**0.0094**
Feb	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**0.0441**	1.0000	0.1482
Mar	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	**0.0232**	0.9486	0.0834
Apr	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	1.0000	0.0600	1.0000	0.1950
May	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	1.0000	**0.0031**	0.2155	**0.0138**
Jun	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	0.4941	1.0000	1.0000
Jul	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	**0.0125**	0.6058	**0.0481**
Aug	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	0.8593	1.0000	1.0000
Sep	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000
Oct	**0.0020**	**0.0441**	**0.0232**	0.0600	**0.0031**	0.4941	**0.0125**	0.8593	1.0000		1.0000	1.0000
Nov	0.1566	1.0000	0.9486	1.0000	0.2155	1.0000	0.6058	1.0000	1.0000	1.0000		1.0000
Dec	**0.0094**	0.1482	0.0834	0.1950	**0.0138**	1.0000	**0.0481**	1.0000	1.0000	1.0000	1.0000	

Table B.10: Quarterly Mann-Whitney p values for white and yellow maize

White maize	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Quarter 1		1.0000	1.0000	0.2457
Quarter 2	1.0000		1.0000	**0.0162**
Quarter 3	1.0000	1.0000		0.1332
Quarter 4	0.2457	**0.0162**	0.1332	
Yellow maize	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**
Quarter 1		1.0000	0.5825	**0.0000**
Quarter 2	1.0000		1.0000	**0.0000**
Quarter 3	0.5825	1.0000		**0.0005**
Quarter 4	**0.0000**	**0.0000**	**0.0005**	

APPENDIX C

Figure C.1: Historical Safex yellow maize futures price and realised import and export parity prices

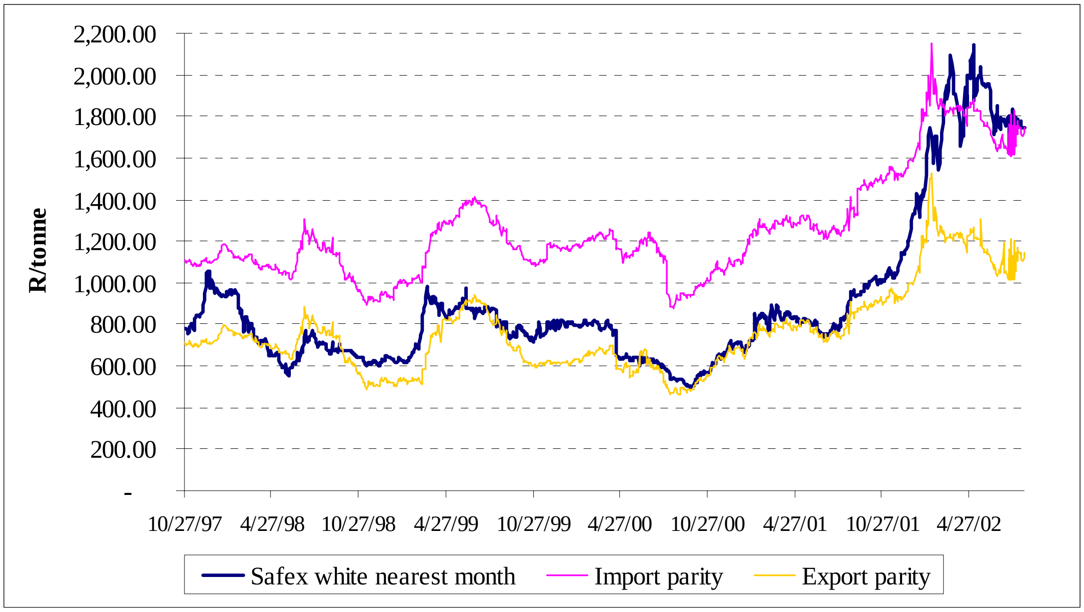


Table C.1: Calculation methods of SA wheat import and export realisation prices

Import Parity Price	Export Parity Price
FOB Gulf value[1] ($/ton) *Plus:* Freight rate ($/ton) *Plus:* Insurance ($/ton)	FOB Gulf value ($/ton) *Plus:* difference in quality and locality
C.I.F. price in Durban[2] (converted to R/ton)	**SA FOB price (converted to R/ton)[8]**
Plus: Financing costs (R/ton) *Plus:* Discharging costs[3] (R/ton) *Plus:* Import tariff[4] (R/ton)	*Minus:* Financing costs (R/ton) *Minus:* Transport costs[6] (R/ton) *Minus:* Loading costs[7] (R/ton)
F.O.R.[5] at Durban harbour (R/ton)	**Export realisation (R/ton)**
Plus: Transport costs to Randfontein (R/ton)	
Delivered Randfontein price (R/ton)	

[1] Free-on-board US #1 HRW wheat price quoted in the Persian Gulf
[2] Price in Durban harbour (not landed)
[3] Discharging in Durban harbour
[4] When applicable
[5] Free-on-rail
[6] From Malmesbury to East-London
[7] Durban harbour
[8] SA fob price = 90% of US fob
Source: Sagis (2003)

Figure C.2: Historical Safex wheat futures price and realised import and export parity prices

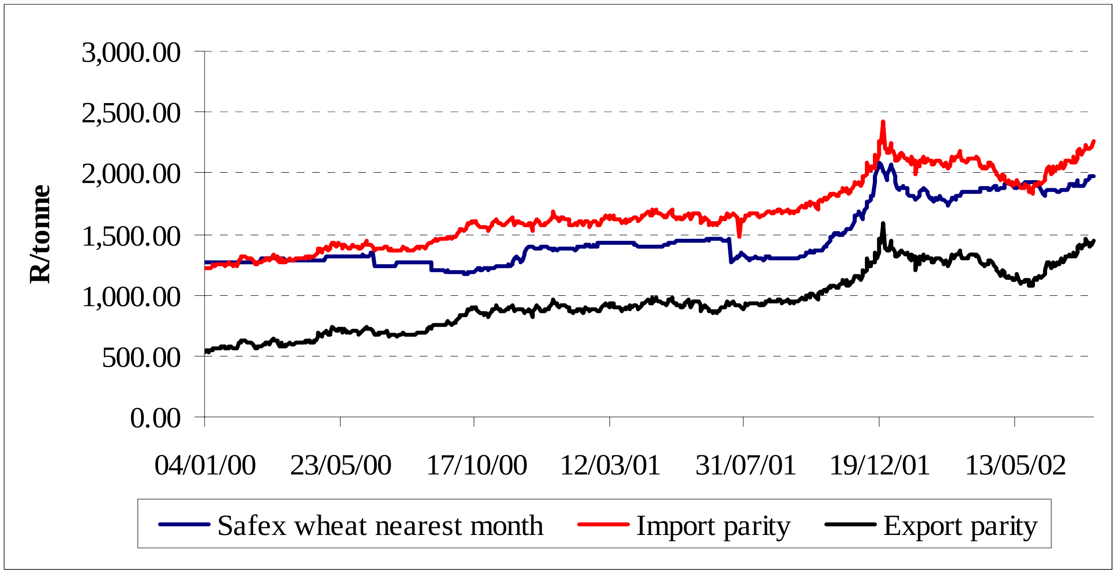


Figure C.3: White maize absolute daily returns around different agricultural announcements

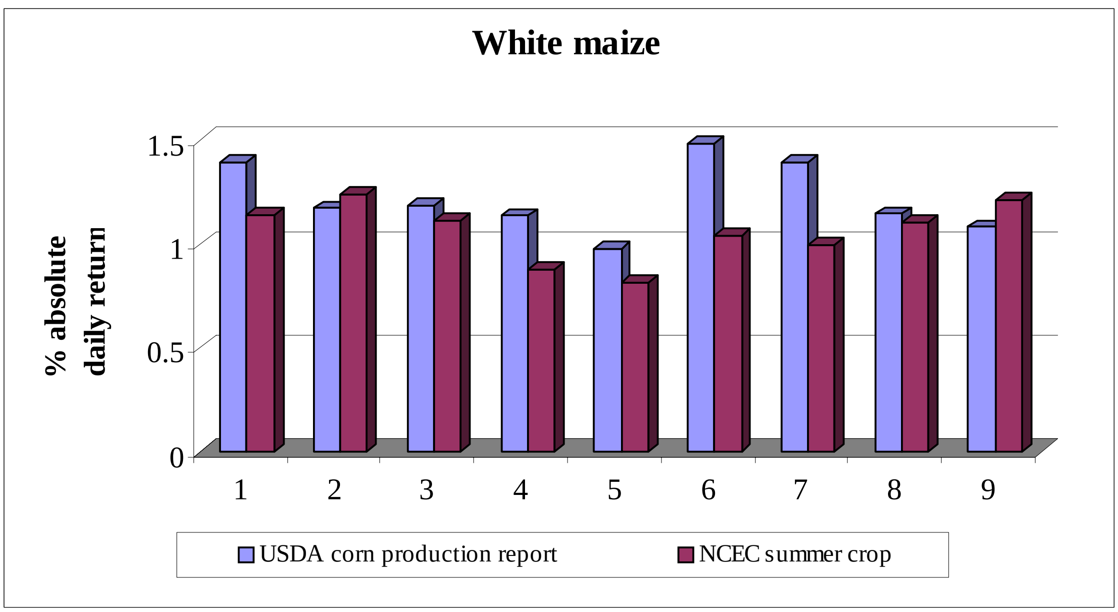


Figure C.4: Yellow maize absolute daily returns around different agricultural announcements

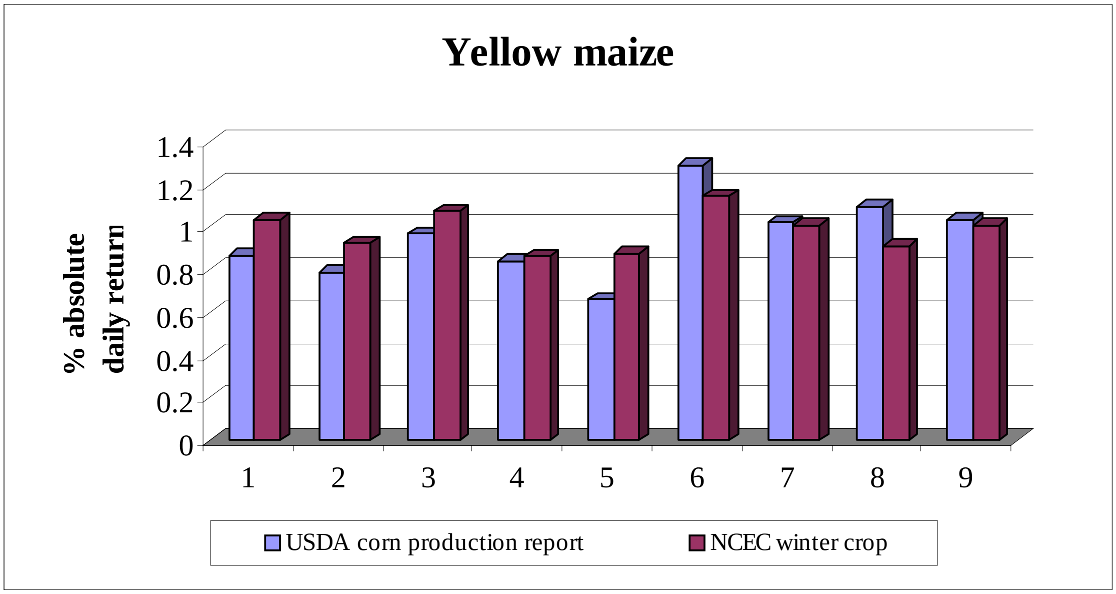


Figure C.5: Wheat absolute daily returns around different agricultural announcements

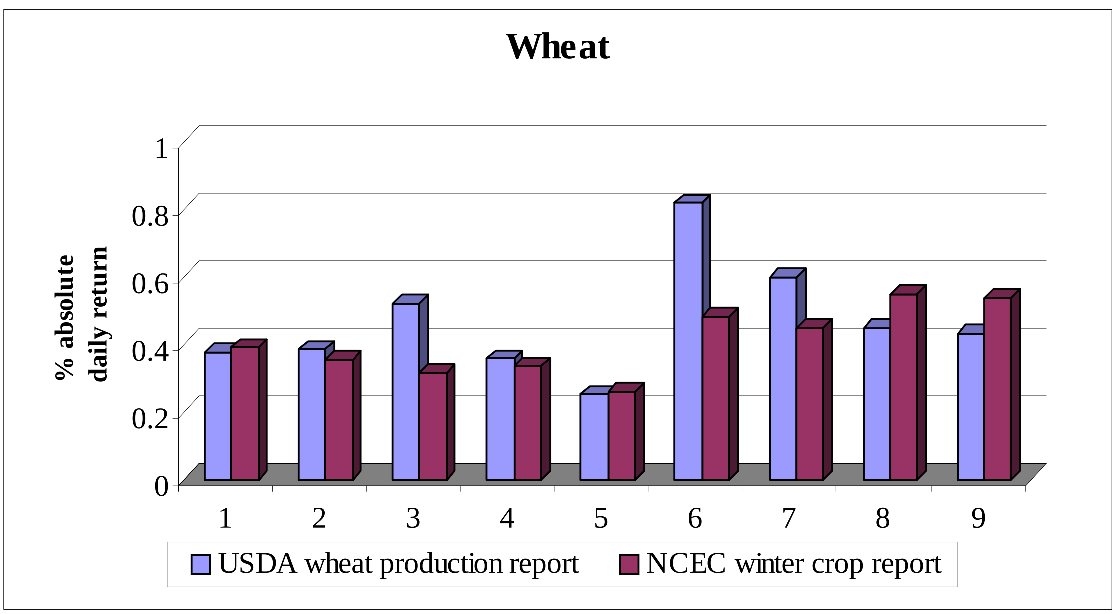


Figure C.6: White maize, yellow maize, and wheat absolute daily returns around MPC announcements

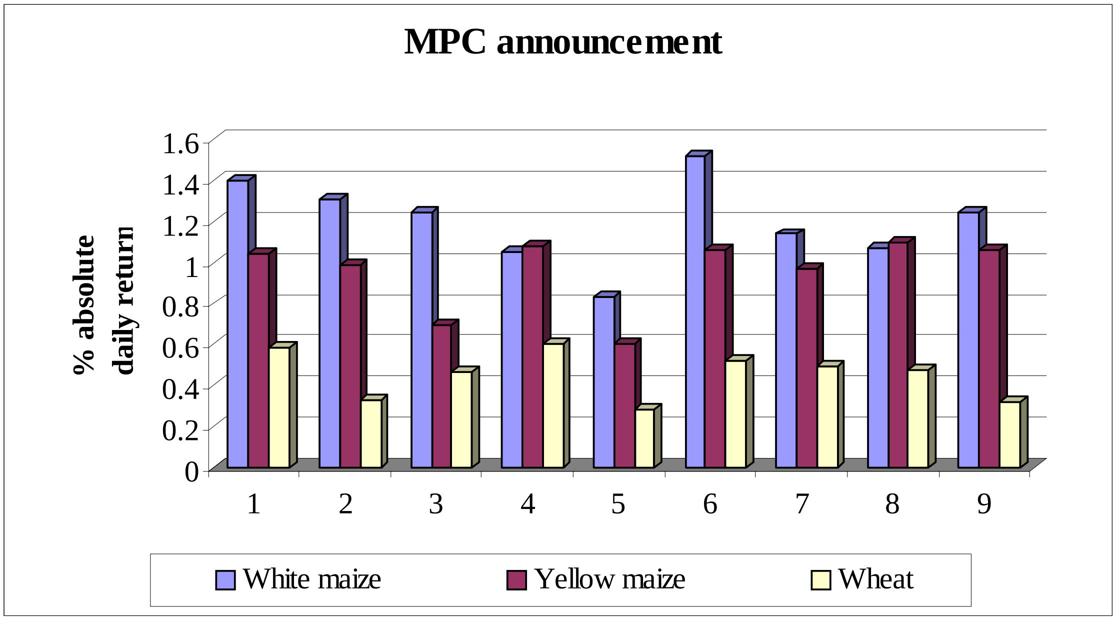


Figure C.7: White maize, yellow maize, and wheat absolute daily returns around GDP announcements

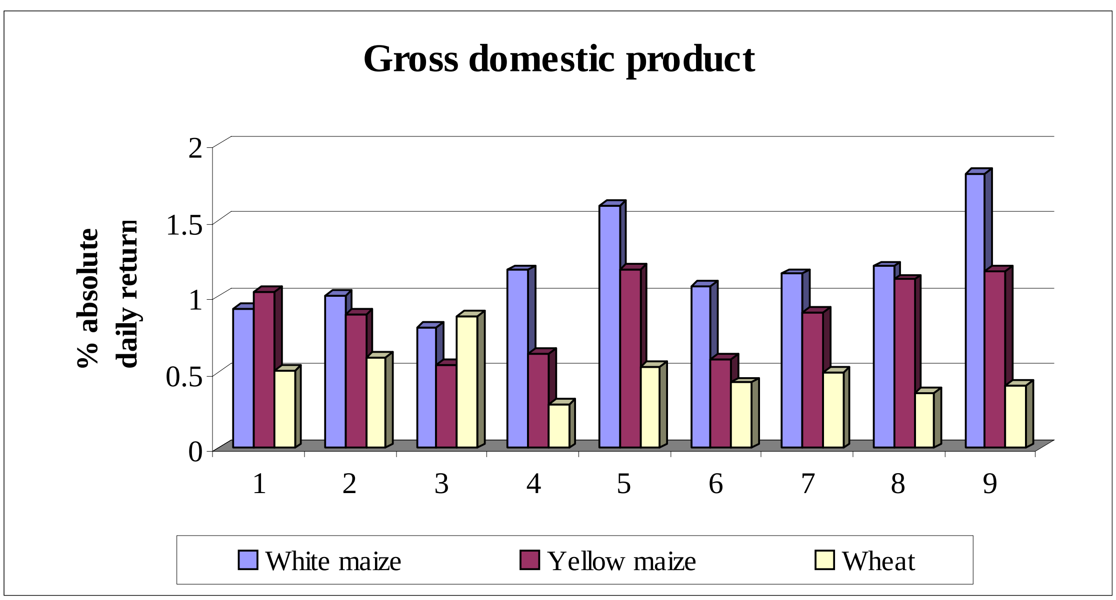


Figure C.8: White maize, yellow maize, and wheat absolute daily returns around CPI announcements

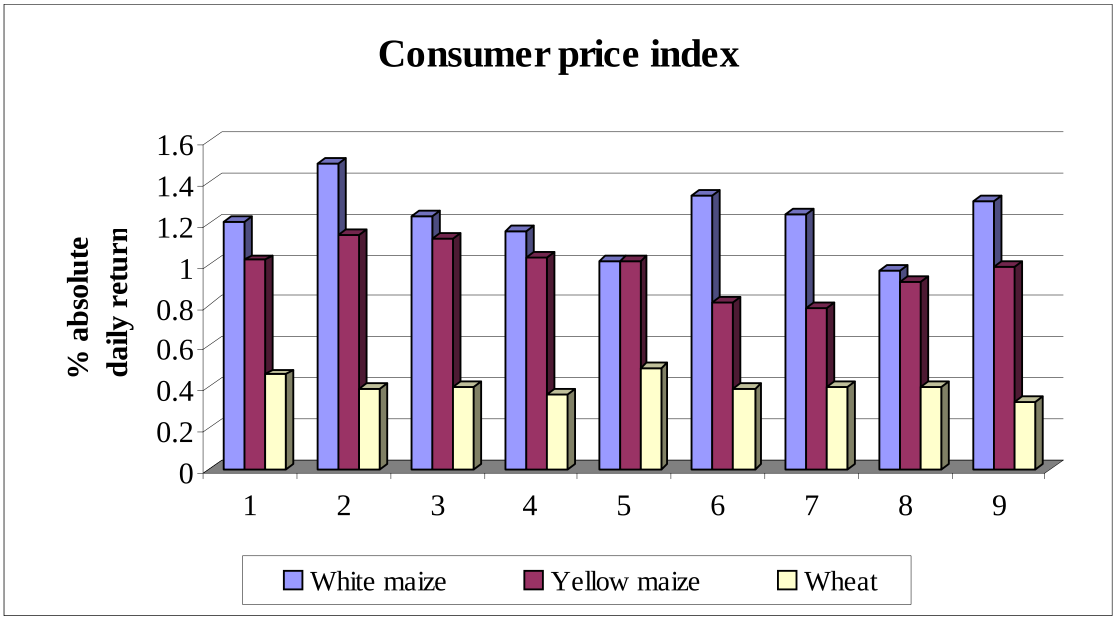
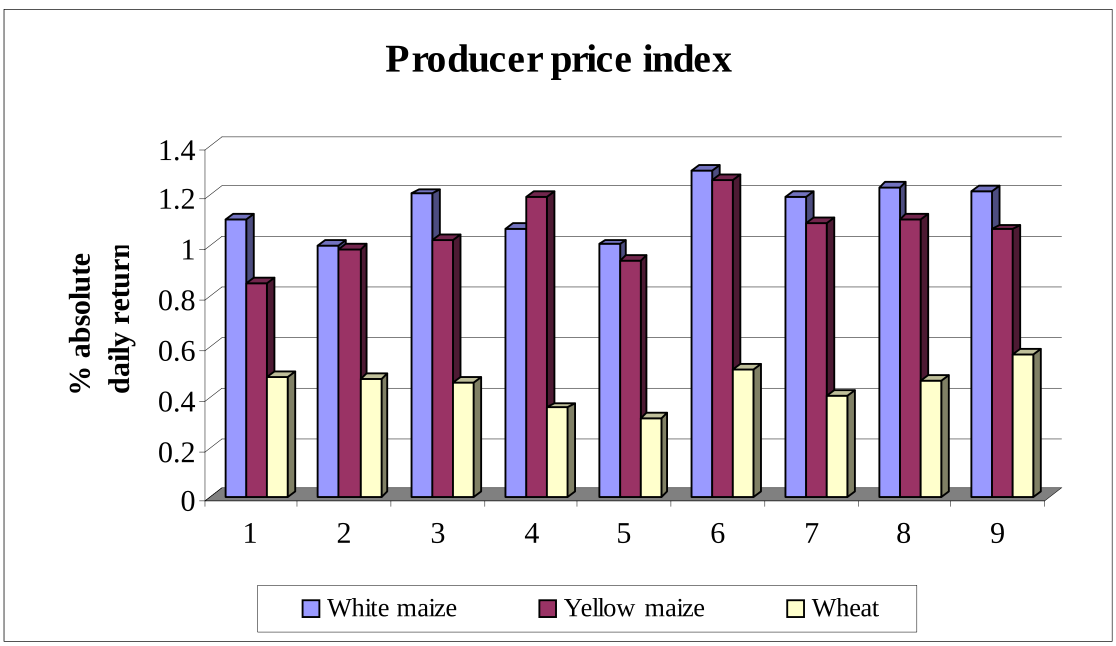
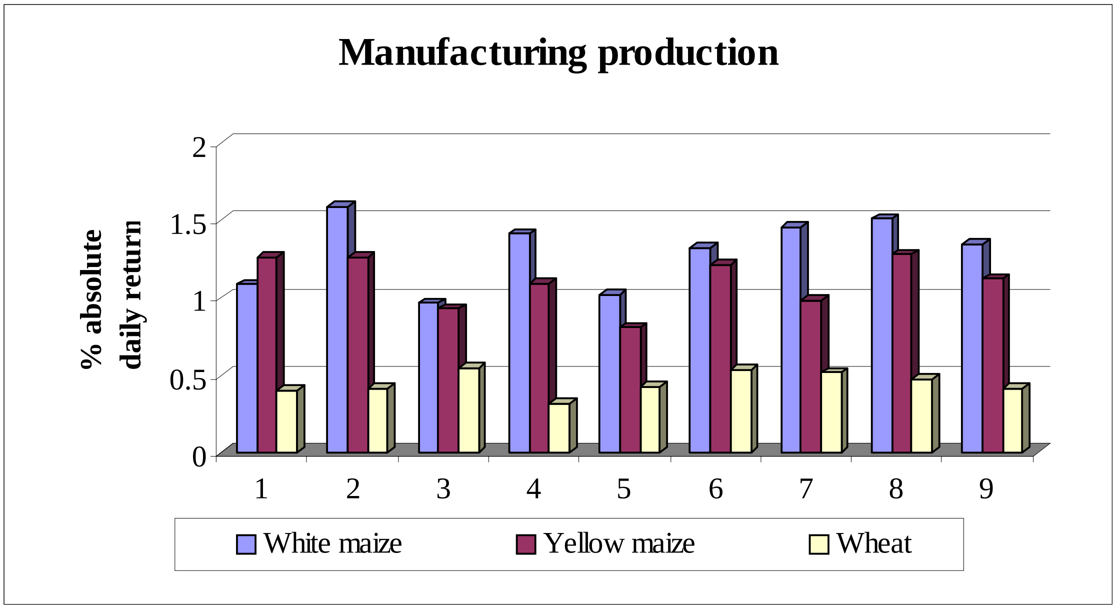


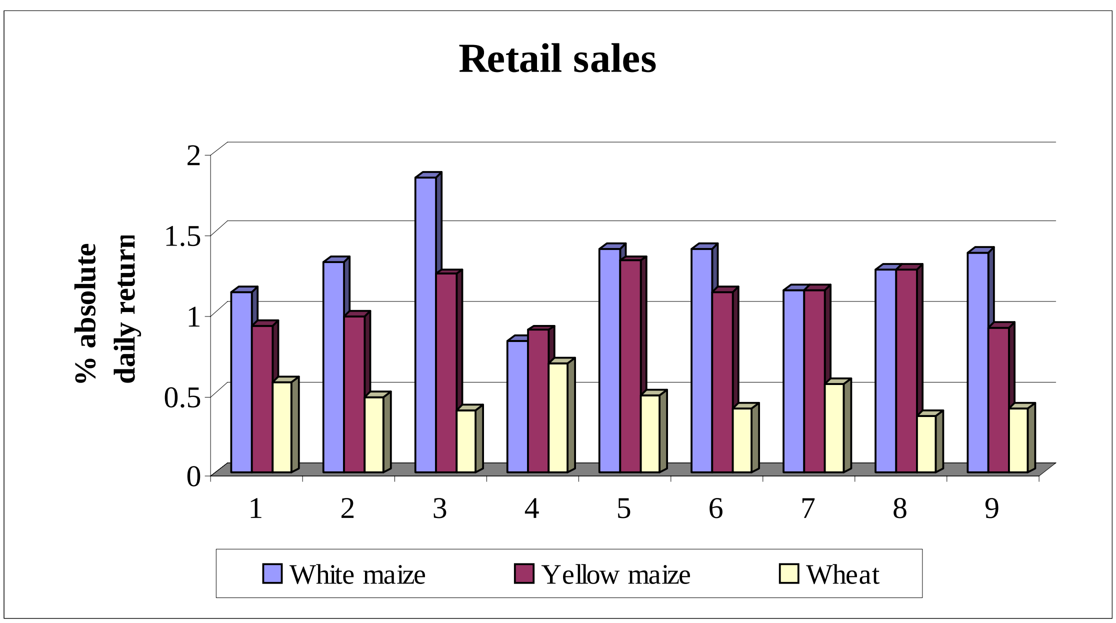
Figure C.9: White maize, yellow maize, and wheat absolute daily returns around PPI announcements



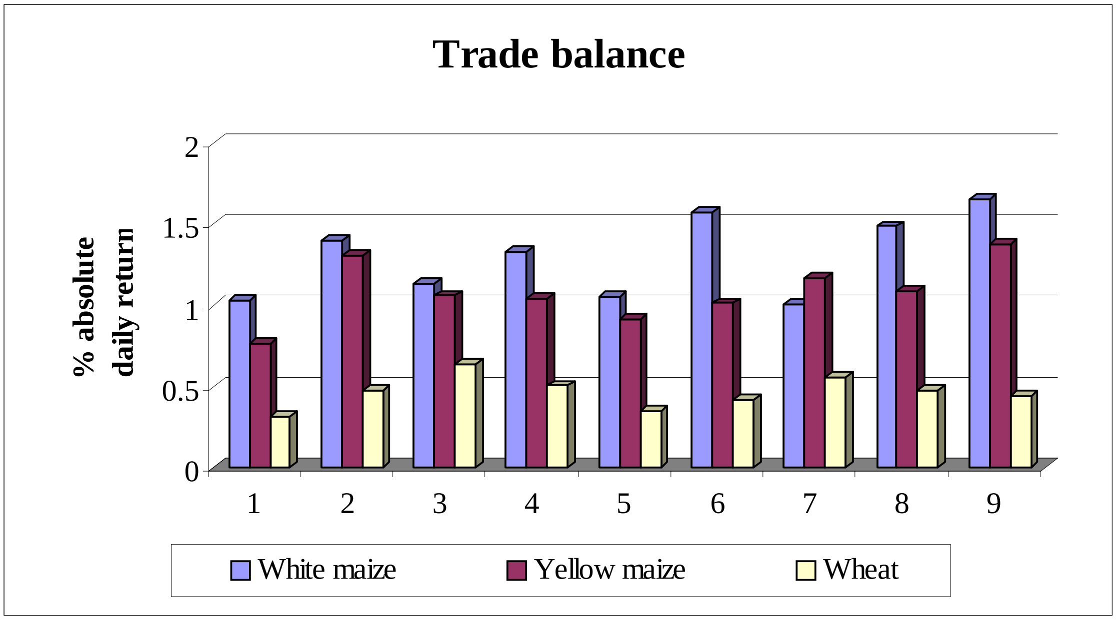
C.10: White maize, yellow maize, and wheat absolute daily returns around manufacturing production information releases



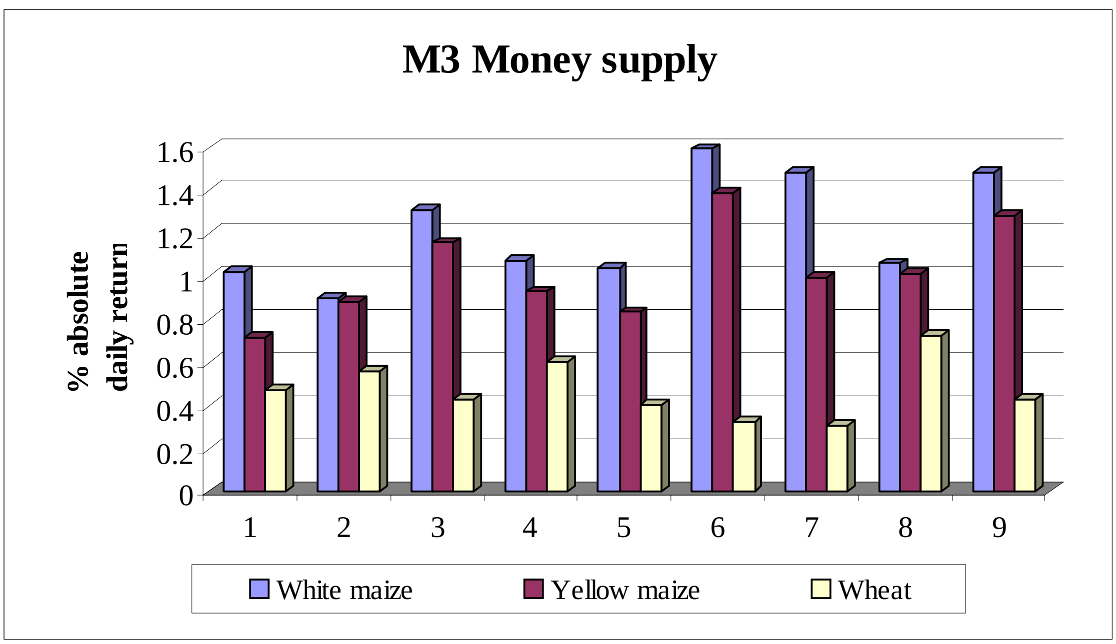
C.11: White maize, yellow maize, and wheat absolute daily returns around retail sales information releases



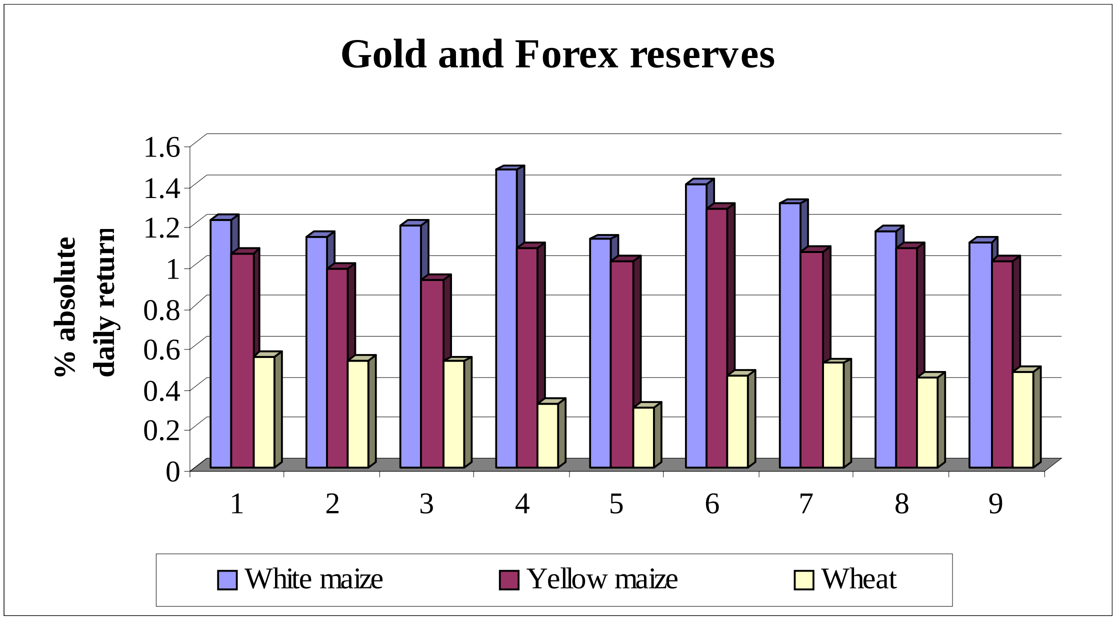
C.12: White maize, yellow maize, and wheat absolute daily returns around trade balance information releases



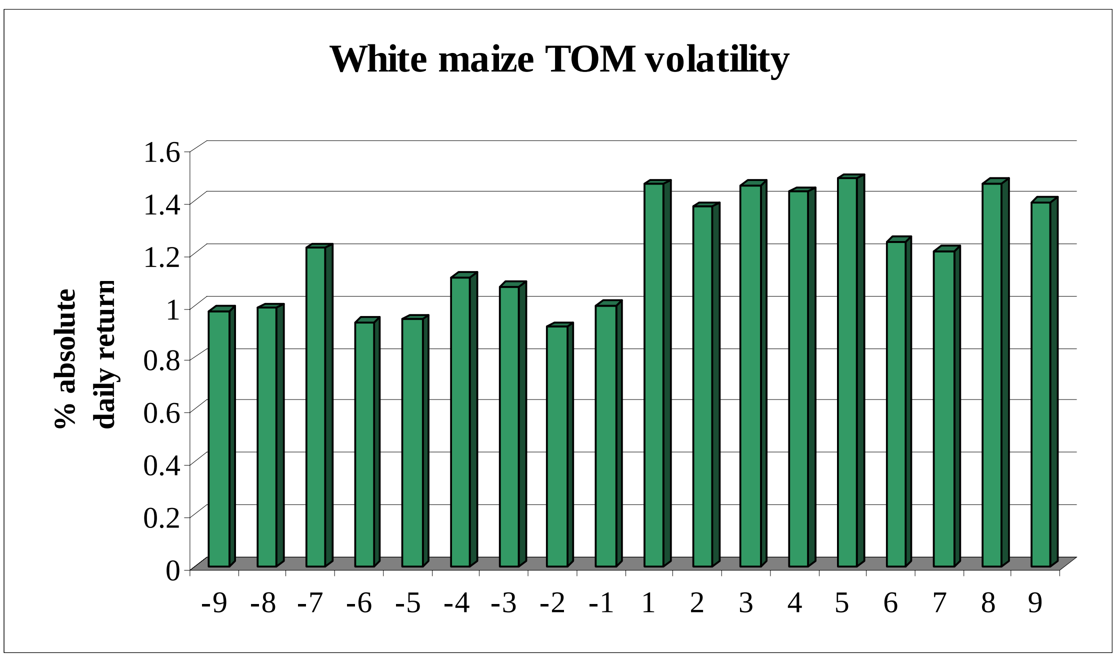
C.13: White maize, yellow maize, and wheat absolute daily returns around M3 money supply information releases



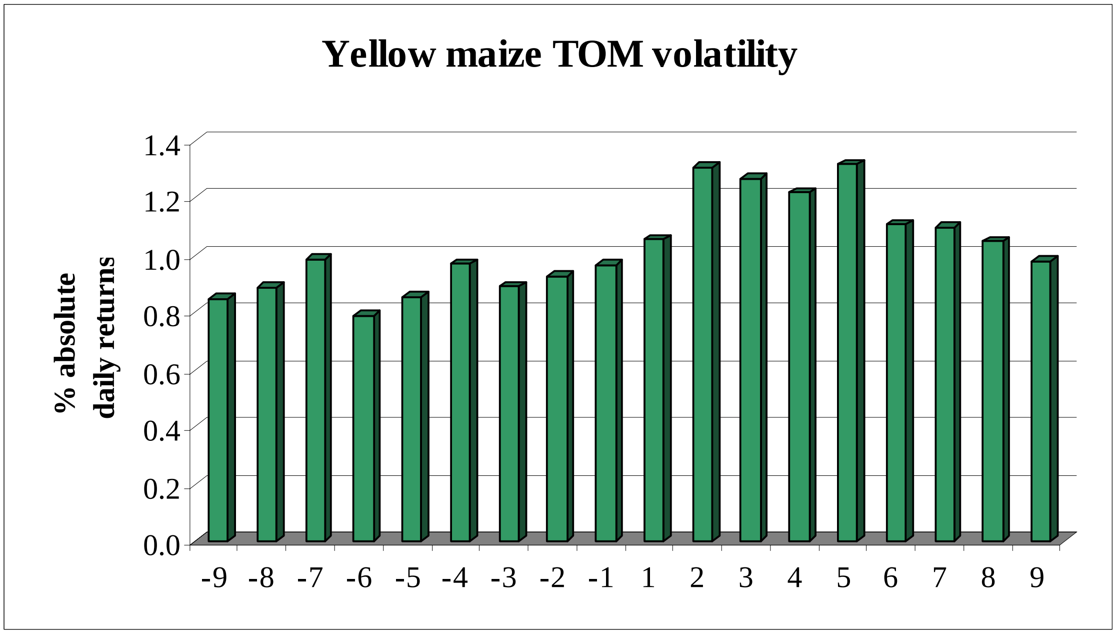
C.14: White maize, yellow maize, and wheat absolute daily returns around gold and foreign-exchange reserves information releases



C.15: White maize daily volatility around the turn-of-the-month



C.16: Yellow maize daily volatility around the turn-of-the-month



C.17: Wheat daily volatility around the turn-of-the-month