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SAFEX maize price volatility scrutinised

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Abstract

Commodity prices in general are known to have a high volatility. This is in fact what attracts speculators. The South African futures exchange (SAFEX) is not immune to this volatility. Volatility increases the risk of paying higher prices for a specific commodity, and it also makes the use of derivative instruments to hedge against price risk more expensive. Given the importance of South Africa as a regional supplier of maize and price discovery mechanism, investigations into the volatility of the maize price are not only important, but also indispensable if all parties involved are to manage this risk. The question therefore is whether the SAFEX maize price volatility can be explained by using fundamental factors or whether this volatility is unexplainably high.

Keywords: Derivative, price volatility, call option, hedging, food risk, SAFEX, CBOT

1. Introduction

For various reasons, commodity prices, and in particular agricultural prices, are subject to significant fluctuations on both the international and domestic markets. In order to hedge against this risk, merchandising contracts known as forward contracts were developed. From these contracts, exchange-traded futures and option contracts, which separated risk-management from merchandising functions, evolved.

The market for agricultural products, where supply and demand are inelastic, is characterized by large changes in prices. These price changes create price risk against which those engaged in agriculture seek protection. Agricultural prices are structurally prone to fluctuations because of the short-run inelasticities of supply and demand for agricultural products (Cohen, 1999). Production of an agricultural commodity, for the most part, is fixed in the short-run and is highly dependent on growing conditions, which can vary greatly from one year to the next. This can create periods of under or over

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supply. Similarly, the demand for basic commodities tends to be stable and generally is more responsive to changes in income and taste than to changes in price. In this situation, a small shift in supply or demand conditions can have a major impact on market prices (Valenzuela *et al.*, 2006). As a result of these price swings, farm incomes can be highly variable from one year to the next.

In addition, the supply of agricultural commodities within any one crop year or production cycle is seasonal in nature. Crops are abundant at harvest, and supplies fall during the remainder of the market year. Animal production, though more continuous, is also predisposed to production cycles due to animal birth rates and feeding schedules. Demand for most raw agricultural commodities, however, is steady throughout the year. This contrast can give rise to seasonal cycles of low prices at harvest or production peaks, followed by higher prices as stocks are drawn down.

Agricultural production and marketing includes the production of crops and livestock, and the marketing of this output to elevators, feedlots, and processors, who in turn market to wholesale and retail distributors. For example, a producer sells wheat to an elevator, which resells the wheat to a miller for grinding. The miller sells flour to a bakery, which ultimately sells baked products to consumers. During the time spent to produce a commodity and then to move it through these marketing channels, its value is subject to the price changes described above, hence creating further price risk.

In response to this situation, both private market participants and government have historically undertaken measures to reduce or respond to price risk. Governments around the world, in an attempt to reduce risk have set up programs to stabilize farm incomes through the use of buffer stocks, price floors and land set-aside schemes to manage supply. Food programs were set up for the poor to manage demand (Bower & Kamel, 2003). Due to the increased inefficiencies and cost of these programs, many governments have moved away from a protectionist, interventionist approach to a free market approach. Removing all the various support programs has forced the various players in the agricultural sector at both the primary production level, as well as the processing level to seek alternative methods of managing price risk. These methods have typically developed into various types of marketing arrangements and contractual agreements that allow price risk to be shifted to others.

The purpose of the study is to have a better understanding of how fundamental factors influence the price levels and the volatility of the SAFEX maize nearest contract month price.

2. Defining volatility

To a world still recovering from the bursting of the internet bubble in 2001, the image most likely to be immediately conjured up by the word “volatile” might be that of an unstable stock market; or, in view of the balance-of-payments crises of the late 1990s, of unpredictable capital flows driven by fickle market sentiment to emerging market countries. But the adjective could equally be applied to the weather. In India, for example, even though the share of agriculture in national output has dropped from one-half in the 1960s to one-quarter today, a good monsoon can still make a significant difference to GDP growth (Claessens *et al.*, 1993). “Volatile” can also be used to describe a political climate, such as that prevailing in Iraq or Somalia; or the procyclical response of fiscal policy to fluctuations in the price of oil for an oil exporter such as Nigeria; or even the behaviour of a crowd in downtown Buenos Aires, Argentina, protesting the *corralito* or freeze on bank deposits in December 2001. Depending upon how one looks at it, volatility in mainstream economics has either been around for a long time or else is of more recent vintage.

It’s a given in the marketplace that a share will vary in price throughout the trading day. With each successive trade, the price can go up or down, or remain unchanged. If you review a share’s daily closing prices over a period of time, you can observe these net changes, also called **returns**. These changing or fluctuating trading prices represent a share’s **volatility**. Volatility doesn’t represent a bias for up or down price movement, but just fluctuation over a period of time. The degree of fluctuation can vary whether a share’s **price trend** is bullish and advancing, bearish and declining, or remains in a steady sideways range over time.

In common parlance, making a distinction among volatility, uncertainty, risk, variability, fluctuation, or oscillation would be considered splitting hairs; but, going back to Frank Knight’s classic 1921 work, *Risk, Uncertainty, and Profit*, there is a subtle difference in economics. *Uncertainty* describes a situation where several possible outcomes are associated with an event, but the assignment of probabilities to the outcomes is not possible (Eeckhoudt & Schlesinger, 2005). *Risk*, in contrast, permits the assignment of probabilities to the different outcomes. *Volatility* is allied to risk in that it provides a measure of the possible variation or movement in a particular economic variable or some function of that variable, such as growth rate. It is usually measured based on observed realizations of a random variable over some historical period (Hull, 2006). This is referred to as *realized volatility*, to distinguish it

from the *implicit* volatility calculated, say, from the Black-Scholes (Black and Scholes, 1973) formula for the price of a European call option on a stock.

To date there is no consensus on how volatility should be measured. Thurnsby and Thurnsby (1985) and Bailey, Tavlas and Ulan (1986) measure volatility as the absolute percentage change in the price levels, i.e. $V_1 = |p_1 - p_{t-1}| / p_{t-1}$ where p is the "spot" price and t is time. Chowdhury (1993), Klein (1990), Koray and Lastrapes (1989) measure volatility as the moving average of the standard deviation of the growth rate of the nominal price

$$V_t = \left[(1/m) \cdot \sum_{i=1}^m (p_{t+i-1} - p_{t+i-2})^2 \right]^{1/2}$$

Where p is the real price and m is the order of the moving average. Thurnsby and Thurnsby (1987) suggest another method of calculating volatility, namely the variance of the "spot" price around its trend

$$\ln p_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \varepsilon_t$$

More recently, and the ARCH/GARCH approach to modelling volatility has been used. See: Nelson (1992), Engel and Russel (1998), Engel (2000), Zimmerman et al (2001), Szego (2002), Engel and Russel (2005). ARCH/GARCH models are however not without criticism. (See: Nwogugu 2005 and 2006).

Determining the best method for calculating volatility is beyond the scope of this paper. The objective is rather to compare the volatility of the same commodity on two different markets. It is for this reason that any of the above methods, and many others, are suited for the task.

The Chicago Board of Trade states that volatility is a measurement of the change in price over a given period of time. It is often expressed as a percentage and computed as the annualized standard deviation of the percentage change in daily price (CBOT 2006).

$$V_t = \sqrt{250 * \frac{1}{n-1} \sum_{i=1}^n \left(\frac{p_i}{p_{i-1}} - \frac{\bar{p}_i}{\bar{p}_{i-1}} \right)^2}$$

Where p_i is the closing spot price and n is the number of days over which the volatility is calculated. Because this method of determining the volatility of the commodity prices is used by one of the largest grain markets in the world it is the volatility calculation method of choice for this article.

3. How market conditions affect price variability

Agricultural commodity prices respond rapidly to actual and anticipated changes in supply and demand conditions. Because demand and supply of farm products, particularly basic grains, are relatively price-inelastic (i.e. quantities demanded and supplied change proportionally less than prices) and because weather can produce large fluctuations in farm production, potentially large swings in farm prices and incomes have long been characteristic of the sector.

The supply elasticity of an agricultural commodity reflects the speed with which new supplies become available (or supply declines) in response to a price rise (fall) in a particular market (Cohen, 1999). Since most grains are limited to a single annual harvest, new supply flows to the market in response to a post-harvest price change, must come from either domestic stocks or international sources. As a result, short-term supply response to a price rise can be very limited during periods of low stock holdings, but in the longer run expanded plantings and more intensive cultivation practices can work to increase supplies. When prices fall, the cost of storage relative to the price decline helps producers determine if commodities that can be stored should be withheld from the market.

Similarly, demand elasticity reflects a consumer's ability and/or willingness to alter consumption when prices for the desired commodity rise or fall. This willingness to substitute another commodity when prices rise depends on several factors, including number and availability of substitutes, importance of the commodity as measured by its share of consumers' budgetary expenditures, and the strength of consumers' tastes and preferences.

Increasing demand for grains for industrial use, whether from processing industries or from rapidly expanding industrial hog and poultry operations, further reinforces the general price inelasticity of demand for many agricultural commodities. Industrial use of grains generally is not sensitive to price change, since industrial users usually try to utilize at least a minimal level of operating capacity year round. Also, in most cases, as with retail food prices, the price of the agricultural commodity represents a small share of the overall production costs of agriculture based industrial products.

4. Price volatility in various markets

Fundamental factors are primary drivers of price. On the South African Futures Exchange (SAFEX), the fundamental factors determining the price of

maize and wheat are: supply and demand at the international level, as reflected in the Chicago Board of Trade (CBOT) price, domestic supply, demand and stock levels, as well as the Rand-Dollar exchange rates as it directly affects the import and export parity price. In light of the fact that the USA is by far the largest grain producer, it is logical that changes in supply and demand in the USA would not only affect the CBOT price but also the prices in other smaller grain producing countries. One of these countries is South Africa. Meyer *et al* (2006) state that the equilibrium price in the smaller market can be estimated as a function of the equilibrium price in the dominant market, the exchange rate and the transaction costs. Thus when trade occurs between markets, the difference in price is equal to the transaction costs. Meyer *et al* (2006) divide trade into three market regimes: near-autarky, import parity, and export parity. Within these regimes Meyer tested the effect of a 10% increase in the world price on the South African producer price of yellow maize. The results reported indicate a 3.4% increase in producer price in the case of a near-autarky regime and an 11.2% increase in the case of an import parity regime. The average percentage change between these two regimes is 7.3% indicating a strong link between the world price and the domestic producer price.

In light of the above, one therefore expects the SAFEX price to follow similar volatility patterns as CBOT and the exchange rate. Figure 1 shows the 10 day annualised volatilities of the CBOT price in Rand terms and the SAFEX yellow maize price since 2001. The Chicago Board of Trade states that volatility is a measurement of the change in price over a given period of time. It is often expressed as a percentage and computed as the annualized standard deviation of the percentage change in daily price. (CBOT 2006)

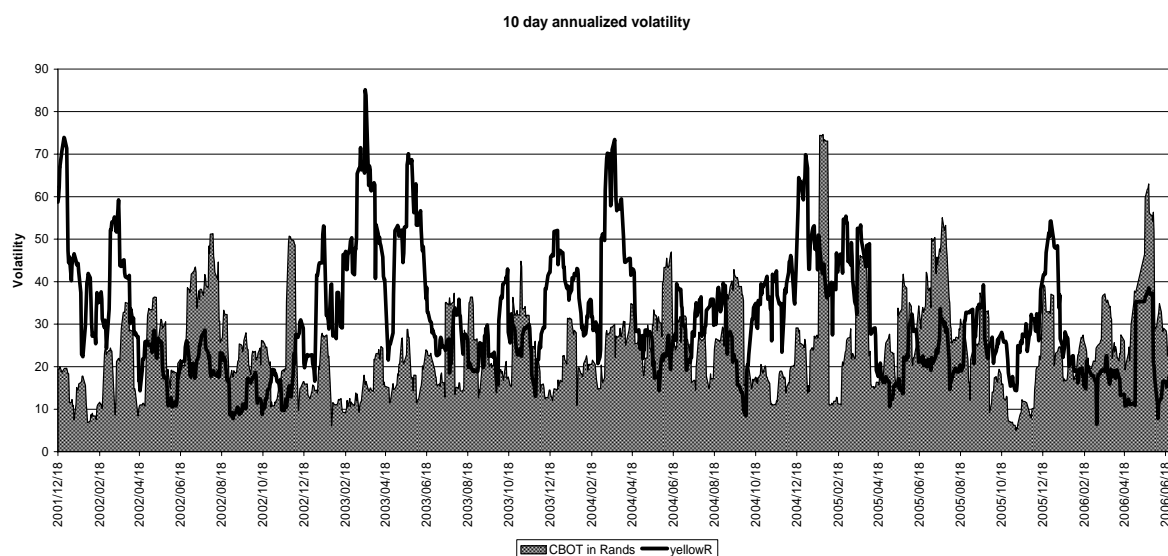


Figure 1: 10 Day Annualized Price volatility of CBOT maize price in Rand Terms and the SAFEX yellow maize price

From the above figure, it is clear that the SAFEX spot price, namely the yellow maize spot price (YMAZ) and the white maize spot price (WMAZ), is generally more volatile than the CBOT price even in Rand terms. For the time period investigated, the SAFEX price was more volatile 61% of the time. It is clear from the above that SAFEX shows consistent higher price volatility than the other markets. When the monthly volatility of the markets is plotted, the similarities and differences are easier to spot, as indicated by Figure 2.

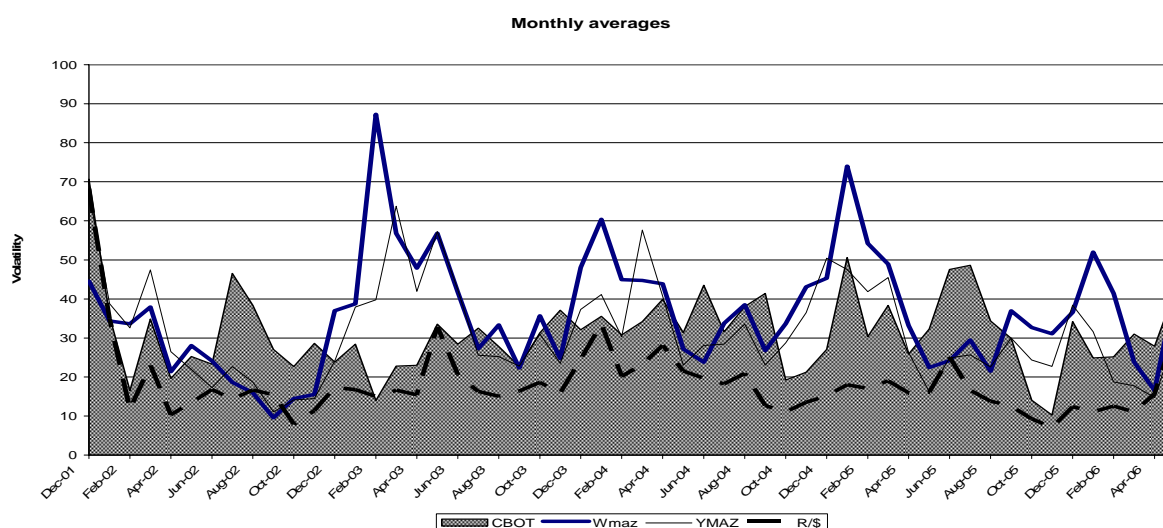


Figure 2: Monthly price volatility on CBOT, SAFEX and exchange rate

CBOT and the exchange rate follow more or less the same up and down trends. The same is true for white and yellow maize on SAFEX. CBOT and SAFEX have periods where the same up and down trends occur, but there are

also periods when the up and down trends do not correspond. What causes these differences?

Fundamental factors, supply in particular, influence the price volatility of SAFEX maize prices, as indicated by Figure 3.

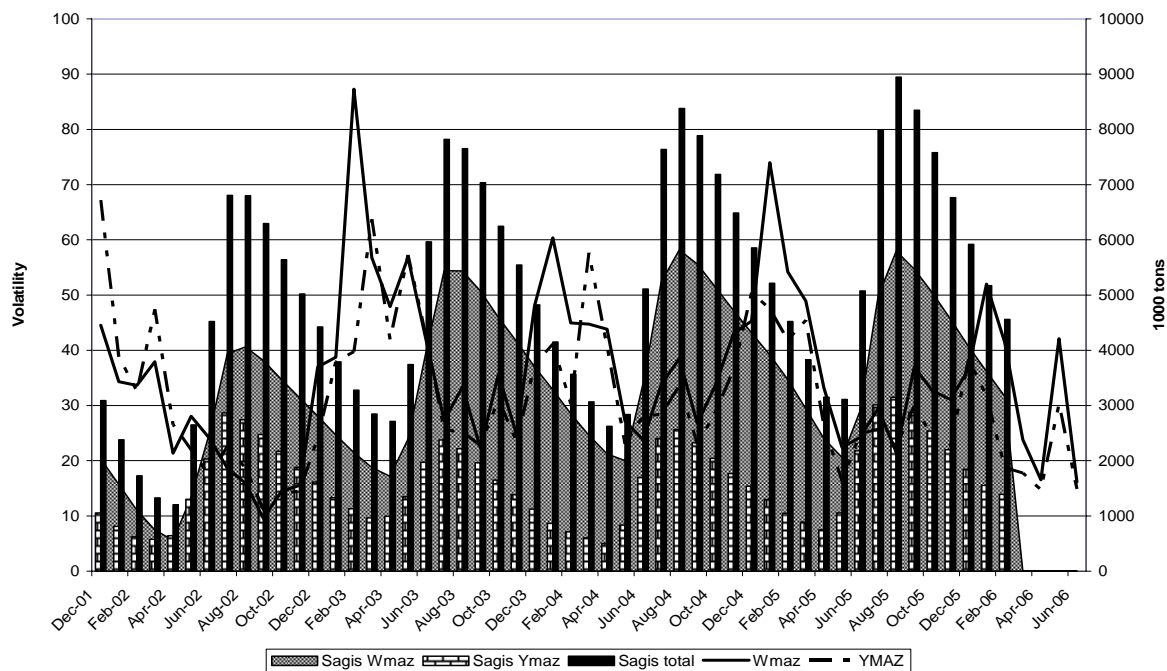


Figure 3: Price volatility on SAFEX and ending stock levels

From the figure, immediately above, one can see that price volatility tends to be higher in periods with low stock (Sagis total) levels and vice versa. The differences in volatility between SAFEX and CBOT still need to be explained.

5. Strong seasonal pattern for within-year price volatility

The principal difficulty analyzing within-year price variability is that while prices can be routinely observed for almost any time period (e.g. year, month, week), the economic supply and demand factors that likely influence price movements are generally reported only on a monthly or quarterly basis. The daily closing prices were used to assess the importance of relevant market information in forecasting within-year price variability (measured as a rate of change) of settlement prices for the selected markets during the period January 2002 and June 2006.

Futures prices play a critical role in facilitating seasonal market operations, because they provide a forum for forward contracting, as well as a central exchange for domestic and international market supply and demand

information. By calculating the average monthly volatility for the SAFEX white and yellow maize price, the CBOT price and the exchange rate it is possible to better understand seasonal variability.

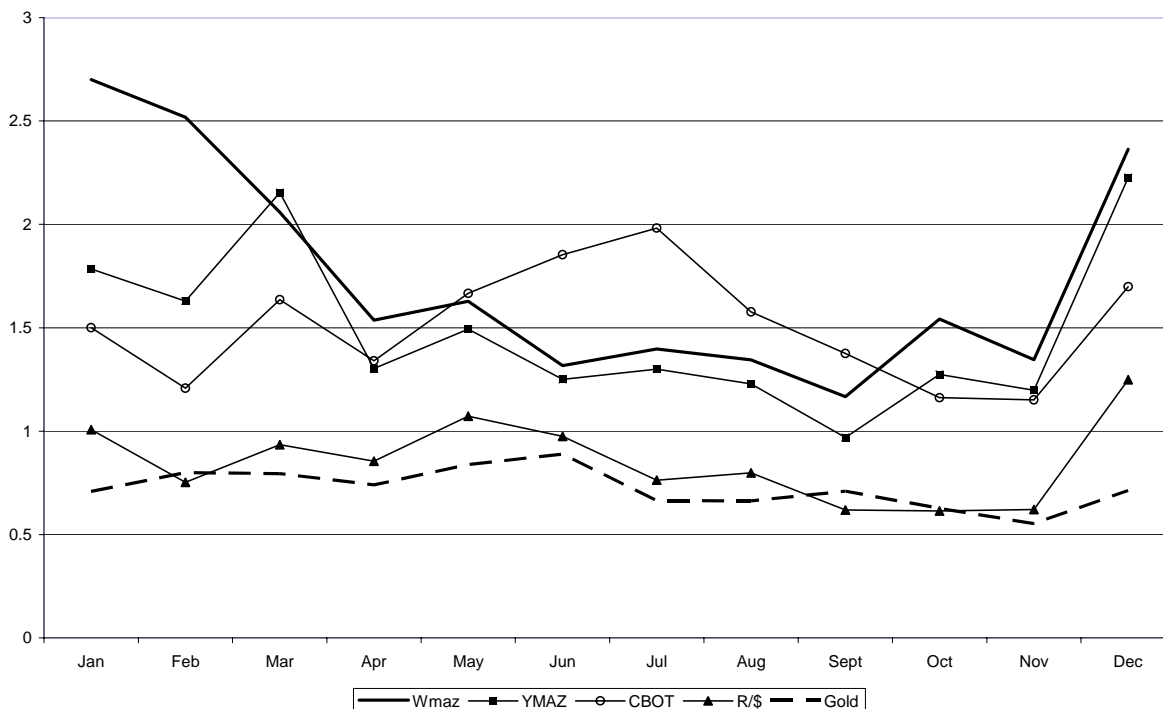


Figure 4: Average monthly price volatility

The Rand-Dollar exchange rate shows no distinct pattern of seasonal variability, as one would expect. CBOT, WMAZ and YMAZ near month futures contract prices display distinct patterns of seasonal variability. For CBOT, a strong variability peak occurs in June when there is a great deal of uncertainty surrounding the true extent of plantings and likely yield outcomes for corn and other spring-planted crops. Much of the acreage uncertainty is resolved with release of USDA’s June 30 Acreage estimate in July after corn pollination has occurred. A second, weaker peak occurs in October and corresponds with the arrival of new information during the peak corn harvest period (Harwood, 2003). This pattern suggests that the bulk of relevant information is synthesized by the corn market during the critical summer growing months when estimates of acreage and yields are largely determined. Supply news then tends to dominate markets into the harvest, with little new information added during the period immediately preceding contract expiration.

Given the strong correlation between the two markets, these differences in volatilities are likely to be the result of the different production seasons in the two markets. To ascertain if this was in fact the case, monthly average

volatilities were calculated for the two markets and then planting and harvesting months were aligned.

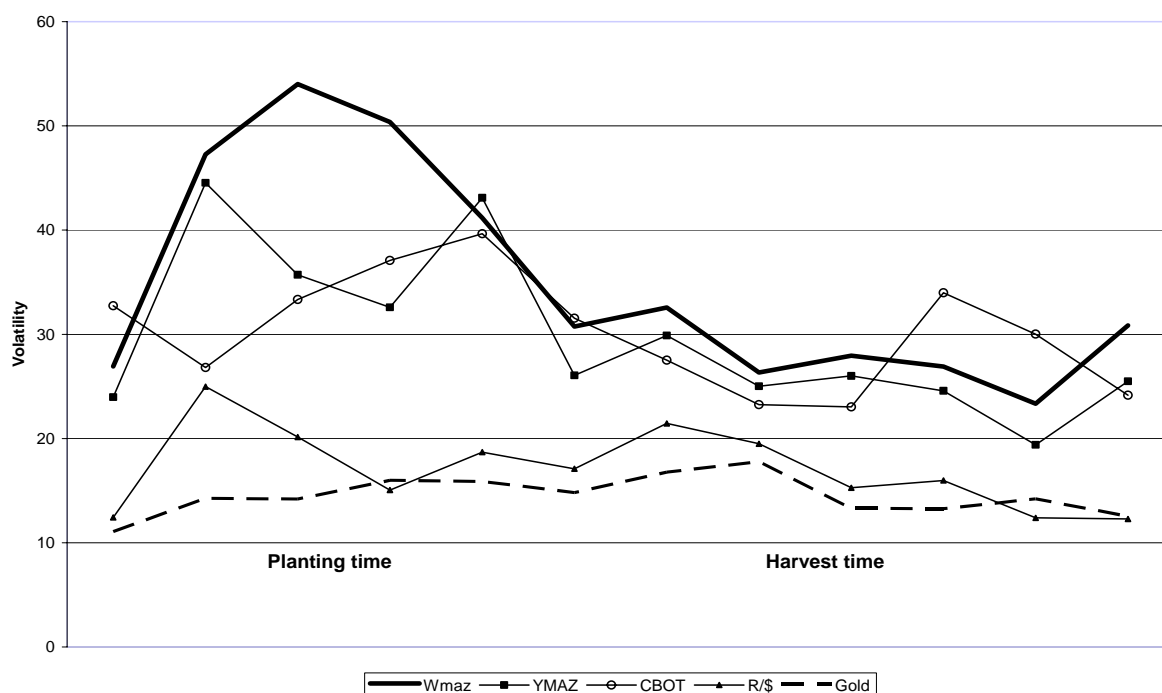


Figure 5: Price volatility during marketing season

By adjusting the monthly average price volatility graph so that planting and harvesting seasons coincide in the two different countries, several things can be noted. Firstly, the uncertainty increases in all markets during the planting and initial growth period. Volatility decreases throughout the growth period and finally reaches a minimum once accurate crop estimates have been released. The WMAZ futures price shows strong variability in December to February when there is a great deal of uncertainty surrounding the likely yield outcomes. This high price variability corresponds with the typical “weather market” period when SAFEX is sensitive towards weather due to the possible impact on maize production. YMAZ follows the same pattern, but the period of uncertainty extends into March. This suggests that YMAZ might not pose the same sensitivity towards weather as WMAZ, but rather sensitivity towards world supply, and thus, the exchange rate. CBOT also has a typical “weather market” starting in June continuing until the beginning of August. This can be seen by the higher volatility periods between planting and harvest time for CBOT.

Secondly, the South African market for maize is consistently more volatile than the CBOT maize price, with white maize being more volatile on average than the yellow maize price. The extended period of volatility for YMAZ (to

March) shows the sensitivity of YMAZ to world supply (pre-planting period in US). During this period, the US is very sensitive to weather (soil moisture) since timing of rainfall is critical in the US.

6. Determining optimal hedging period

Options can give investors the flexibility to hedge market exposure, speculate on a specific market move, or allow investors to put on simple to complex option positions called spreads. The question is, given the volatile nature of the South African maize market traded on SAFEX, when would it be the advisable for a government, organization, or user of maize to hedge his exposure and protect himself against future price increases?

The Black and Scholes model (1973) was used to determine the optimal time based on the following assumptions:

- At the money call option values were determined.
- May and July expiry option contract months on both white maize and yellow maize were used.
- The interest rate was adjusted to zero, as used by SAFEX.
- The monthly average volatility was used as variable in the model.

The Black and Scholes formula for the price of a call option with exercise price K on a stock currently trading at price S , i.e., the right to buy a share of the futures contracts at price K after T years. Where T is the time to expiration of the contract expressed as a fraction of years. The constant interest rate is r (zero in this instance), and the constant stock volatility is σ .

$$C(S, T) = SN(d_1) - Ke^{-rT} N(d_2)$$

where

$$d_1 = \frac{\ln(S/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}.$$

And N is the standard normal cumulative distribution function.

Figure 6 indicates the cost of a call option per ton, using the average monthly price volatility as calculated above.

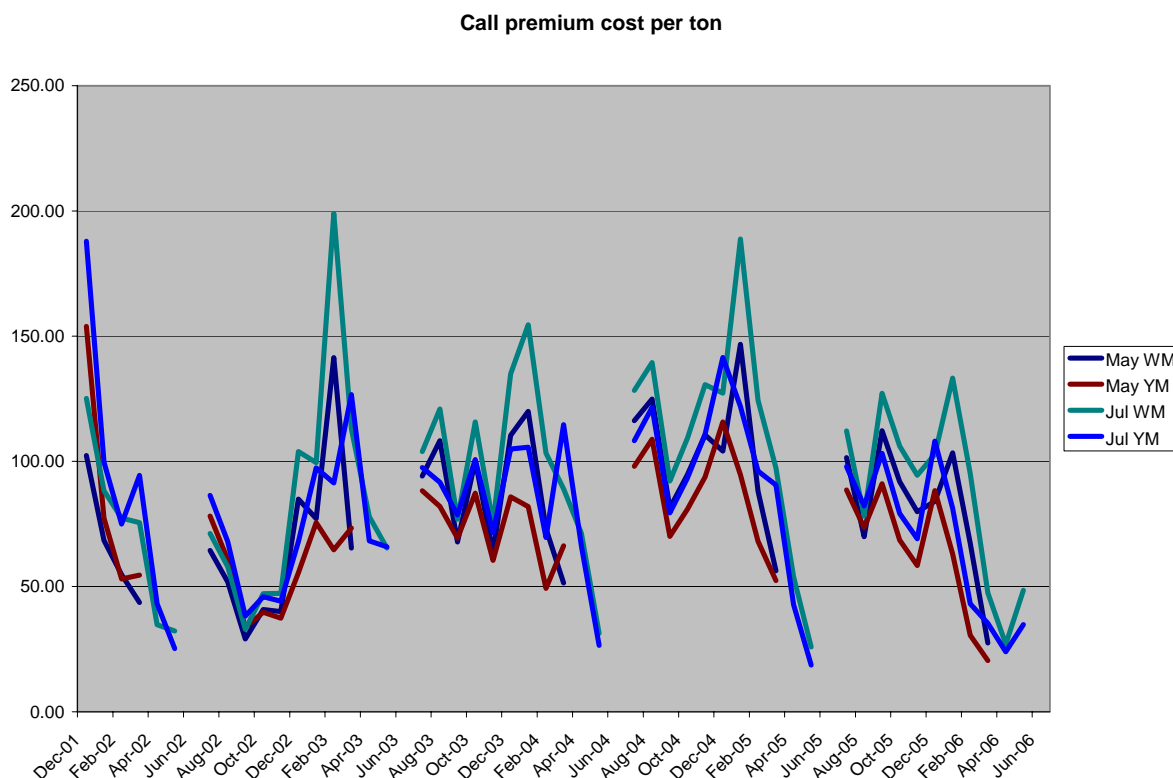


Figure 6: Call premium cost/ton/month

It is clear from the table that the most expensive time for obtaining a white maize (WM) July call option is during the typical weather months, when maize yield is more sensitive towards the amount and timing of rain, especially January and February when the maize is in the dent phase. The same is true for the May white maize contract months, except during the 2005/06-marketing period when September 2005 was calculated as more expensive than January 2006. This might be explained by the low intentions to plant report, coupled with low futures prices, and farmers struggling to obtain input cost financing at those price levels.

The yellow maize (YM) contract for May and July showed mixed results. The most expensive time varies between July, the December-January weather period, and March (a high price volatility period as discussed previously). A possible reason for this might be the fact that the South African yellow maize market is also influenced by the US CBOT price volatilities.

7. Conclusion

Price volatility in a given market may be caused by business fluctuations affecting all market places and commodities, i.e. a systematic market risk. In addition, there may be a specific price risk for a given commodity, independent of the general business cycles, i.e. a commodity price risk. Finally, there may be a unique risk for a given regional or local market, i.e. weather and the size of the market.

Decomposing price risk along these dimensions may substantially improve our understanding of how commodity markets function and how risks arise. Such improved understanding may be of substantial value for market participants trying to manage and reduce risk. Furthermore, a deeper understanding of the composition and characteristics of price risk may be crucial for politicians and NGOs making decisions related to investments in infrastructure, food aid and market surveyance.

Daily SAFEX maize prices are more volatile than their counterpart on the CBOT-market. When compared at a production season level, it is clear that the South African market is more strongly affected by domestic stock levels and weather than CBOT. The South African market has a stronger relationship with weather than the US market has, because of the inherent variability of the African weather patterns. Notwithstanding all of the above, the SAFEX price levels are determined by the fundamentals, namely, CBOT, Rand/Dollar exchange rate, weather patterns and domestic stock levels.

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