FOOD SECURITY: WHEN TO BUY DERIVATIVE INSTRUMENTS

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Abstract

Commodity prices are notoriously volatile which is a major source of instability and uncertainty for commodity-dependent developing countries. Commodity price volatility affects governments, producers (farmers), traders, processors, and local financial institutions financing production inputs in these countries. There have been several attempts to deal with commodity price volatility. A number and variety of international and national institutions and programs were designed for this purpose. Most of the earlier attempts concentrated in trying to stabilize prices through the use of buffer stocks, buffer funds, government intervention in commodity markets, and international commodity agreements. These schemes have not proven satisfactory in dealing with commodity price instability. Academics and policy makers began to emphasize the distinction between programs that attempted to alter the price distribution, either domestically or internationally, with programs that deal with market uncertainty using market-based solutions. The rise in market-based commodity risk management instruments has been significant since the development of derivative instruments. The aim of this study is to determine the optimal time for African countries to buy grain by making use of call option contracts. Chicago Board of Trade contracts and contracts traded on the South African Futures Exchange were compared to determine which exchange would be appropriate, and the optimal time in which the contract should be purchased. The article starts by looking at droughts in Southern Africa, ways available to insure and/or hedge against supply risk. Thereafter, agricultural commodity market variability and volatility were analyzed to end with the determination of an optimal hedging period. The study goes on to assess the optimal timing for Tunisa to hedge their supply risk using the South African Futures Exchange as compared to the Chicago Board of Trade.

Keywords: Food security, call option, hedge, optimal time, volatility, supply risk

Introduction

Drought is a normal recurring event that affects the livelihoods of millions of people around the world, and especially the 200 million people living in southern Africa. Climate variability, including erratic and unpredictable seasonal rainfall, floods and cyclones, contributes to the risk of farming across most of southern Africa. Yield variability is a risk both farmers and governments have to contend with world wide when it comes to extensive course grain production. The African continent is particularly susceptible to high yield variability due to unpredictable weather patterns and frequent droughts (FAO, 1994). When it comes to maize, governments across Africa have used an assortment of intervention strategies to combat yield variability and its consequences on food security. These interventions range from single marketing channels to grain storage schemes and, more recently, crop insurance schemes as well as weather derivatives. These schemes have often proved to be very costly and inefficient in dealing with widespread drought and consequent famine (Gommes, 2006).

A number of factors may lead to agricultural drought, including, reduced rainfall, soil moisture levels, heat, and wind. Low rainfall does not necessarily lead to drought, nor is drought necessarily associated with low rainfall as poor timing of rainfall can lead to crop failure. Agricultural drought occurs when water supply is insufficient to cover crop or livestock water requirements (Abrahams, 1997). Much more than the occasional widespread and severe climatological drought which catches the attention of the media, it is this "invisible" agricultural drought which prevents farmers from achieving regular and high yields. The nature of agricultural drought makes it very difficult for governments and food aid programmes to know when and which intervention method would be most effective. Governments and non governmental organisations (NGO's) such as the world food program, need to have some intervention strategy in place to counter the effects of a wide spread drought in a particular region

Drought conditions frequently require government intervention in the form of emergency food relief, often supported by large amounts of donated food aid. Drought preparedness by governments has generally taken the form of creating food reserves (mainly maize) at national level to compensate for production shortfalls and provide for possible emergency relief. With the development of derivatives and agricultural insurance markets, governments have resorted to these as they are more cost effective than physical grain storage. While costly relief efforts have been perceived as a necessity, such short-term interventions have generally precluded support for longer-term development processes, particularly in those areas with dry climate conditions. As low and erratic precipitation is a key characteristic of these dryland areas, this fact of life must be reflected not only in the preparedness plans drawn up by governments, but also in the longer-term development strategies designed to prevent serious impact of future droughts on the environment and people's livelihoods. This paper not only proposes an alternative view to crop insurance and weather derivatives, but also the optimal time in which this alternative intervention strategy should be implemented.

Droughts in the Southern African Region

According to the International Fund for Agricultural Development (IFAD), as cited by Benson, Thomson and Clay (1997), at least 60 percent of sub-Saharan Africa is vulnerable to drought and probably 30 percent is highly vulnerable. From 1980-2000, the Southern African Development Community (SADC) region was struck by four major droughts, notably in the seasons 1982/83, 1987/88, 1991/92 and 1994/95. This corresponds to an average frequency of once every four or five years, although the periodicity of droughts is not necessarily so predictable. FAO (1994) identified three drought cycles in the SADC region during the years 1960 to 1993 with lengths of 3.4, 7.1 and 5.8 years, respectively.

Drought is the most important natural disaster in southern Africa in economic, social and environmental terms (Buckland, Eele and Mugwara, 2000). A report by the United Nations Development Program (UNDP) states that drought is considered by many to be the most complex and least understood of all natural hazards, affecting more people than any other hazard (UNSO, 1999).

Benson and Clay (1998) reported that little research has been done on the macroeconomic impact of drought in SSA. The main reason is that drought is typically perceived as an agricultural or food supply problem. However, for most SADC countries drought represents the most important type of economic shock they are likely to experience. It is important for governments to understand the macroeconomic impacts of drought when developing drought management policies and programs.

Drought has primary and secondary (ripple) effects on a household or national economy. Primary or physical impacts include reduction in agricultural production, hydroelectric power generation, water intensive non-agricultural production (processing), and domestic availability of water, which has health implications. Secondary impacts are those that affect gross domestic product (GDP), e.g. reduction in industrial output may lead to inflation and lay-off of labor, thus increasing unemployment. Collectively, these factors reduce demand, expenditure, savings and GDP.

Insuring and Hedging Against Supply Risks

Governments in the southern African region have a variety of policy options when it comes to drought intervention. The selection of a particular policy will largely be determined by the specific situation of the country and the cost versus benefit of the policy. Policies vary because governments are not only concerned about the financial survivability of the farmers given the drought, but also food security of the country's people, in particular the more vulnerable, poorer segments of the population.

Several reports and calculations show that physical grain storage is very costly, difficult to administer, and may have a significant impact on domestic prices (FPMC 2003). Dana et al. (2006) state that given the likely inefficiencies in the public storage sector, private sector storage, instead of public sector storage, could be subsidised. Continuous government grain storage is inefficient, due to the administrative requirements and costs of storing the grain, which is incurred irrespective of yield. On the positive side, government stored grain is readily available, however, government involvement could crowd out private sector initiatives. Consequently, Coulter (2005) suggests that it should be limited to no more then a small food security reserve.

Crop insurance has a long history, with various permutations of government support, and Hazel et al. (1986) and Skees (2000) explicitly indicate why multiple peril crop insurance programs have failed in developing countries. Skees (2000) states that the rainfall index can be used if the three major challenges of determining the correlation between critical rainfall periods and income, reliable rainfall measuring infrastructure, and the role government versus international reinsures have in protecting against systematic risk is resolved.

Although physical grain storage protects against price risk, crop insurance, and rainfall indexes only protect the farmer/government against crop failures or losses and the subsequent shortages. Given the lack of reliability of rainfall measuring infrastructure in most African countries, rainfall indexes become expensive due to basis risk and burn rates. Assuming a government has purchased insurance in the form of a rainfall index, should there be a drought and consequent crop failure, the onus is on the government to prove the loss before it can claim them. This would result in a time lag that would compound the delay caused by transportation of imported grains. Furthermore, as current grain prices are generally not included in the rainfall index, a lot of uncertainty would remain regarding whether the money received from the rainfall index would be enough to finance the necessary grain imports. A solution to both risks would be to purchase call options either on the Chicago Board of Trade (CBOT) or on the South African Futures Exchange (SAFEX), thus creating a "virtual storage facility". The choice of where to purchase the call option depends on the individual country's needs and transport infrastructure.

Governments and NGOs wanting to set up a "virtual grain storage facility" need to decide when is the most appropriate time to purchase the call options and when to exercise these options. The price of an option is largely influenced by two factors, volatility and time to expiry. Time to expiry of the option is fairly straight forward and requires little attention, volatility of commodity prices however warrants further discussion.

Agricultural Commodity Market Variability and 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.

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. Various authors follow different methods in calculating volatility. See Thurnsby and Thurnsby (1985, 1987), Bailey, Tavlas and Ulan (1986), Chowurdy (1993), Klein (1990), Koray and Lastrapes (1989), Nelson (1992), Engel and Russel (1998), Engel (2000), Zimmerman et al (2001), Szego (2002), Engel and Russel (2005, 2006), and 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.

Agricultural commodity prices respond rapidly to actual and anticipated changes in supply and demand conditions. 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 weather can produce large fluctuations in farm production and therefore price.

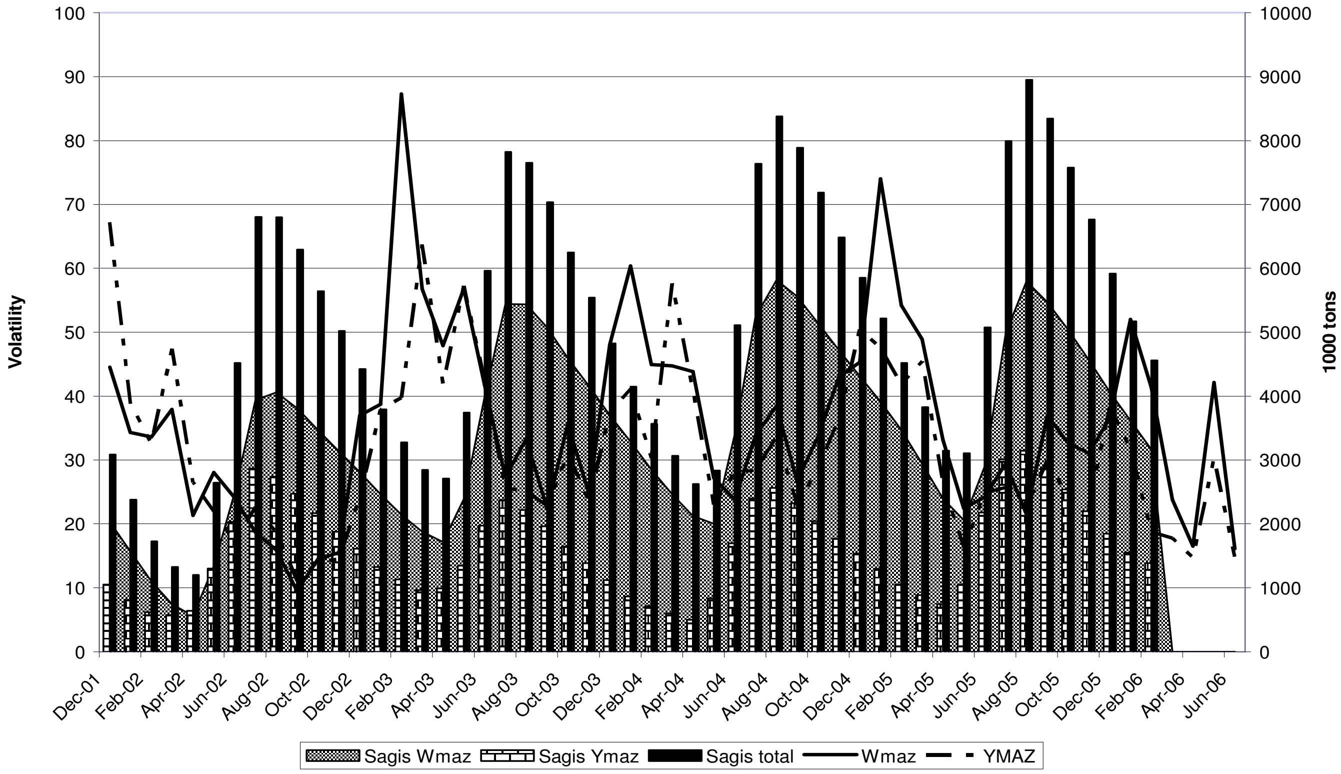
Fundamental factors are primary drivers of price. On the South African Futures Exchange (SAFEX), the fundamental factors determining the price of maize and wheat are: supply and demand at the international level, as reflected in the Chicago Board of Trade (CBOT) price, domestic supply, demand and stock levels, as well as the Rand-Dollar exchange rates as it directly affects the import and export parity price

(FPMC, 2003). 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 in smaller grain producing countries, such as 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. Meyer tested the effect of a 10% increase in the world price on the South African producer price of yellow maize, resulting in an average percentage change of 7.3% indicating a strong link between the world price and the domestic producer price. In fact, converting the monthly average CBOT maize price to Rand terms using the Rand/US Dollar exchange rate, the CBOT price and the monthly average SAFEX maize price have a 0.911 correlation.

In light of the above, one therefore expects the SAFEX price to follow similar volatility patterns as CBOT and the exchange rate. A study conducted by Geyser and Cutts (2006) concluded that the SAFEX spot price, namely the yellow maize spot price (YMAZ) and the white maize spot price (WMAZ), is generally more volatile (61% of the time) than the CBOT price. CBOT and the exchange rate follow more or less the same up and down trends if average monthly volatilities are compared. 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 1.

Figure 1: Price volatility on SAFEX and ending stock levels

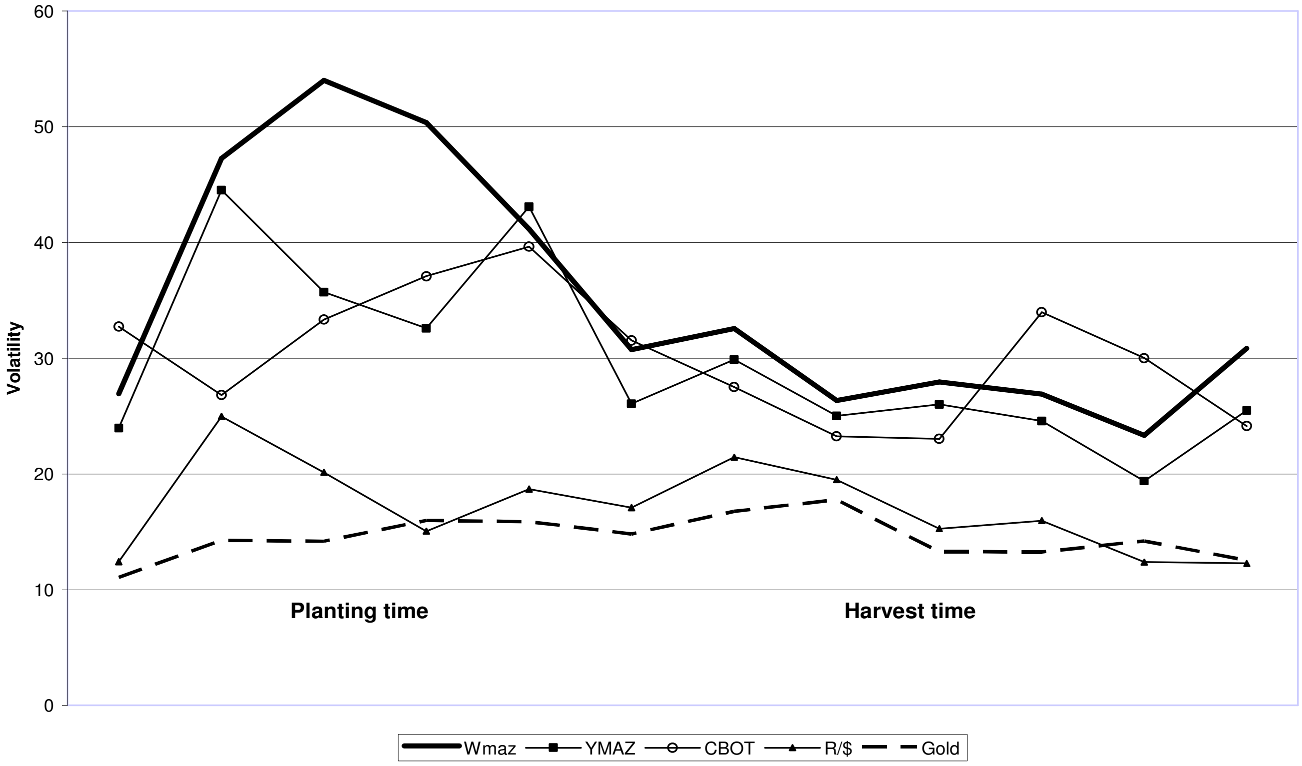


From figure 1 one can see that price volatility tends to be higher in periods with low stock[1] (SAGIS total) levels and vice versa. South African stocks tend to be low between February and June, this is also when there is a lot of uncertainty regarding the current crop. The differences in volatility between SAFEX and CBOT still need to be explained.

[1] Stock levels were obtained from the South African Grain Information Service (SAGIS) http://www.sagis.org.za

The difference between the CBOT and SAFEX maize price volatilities can be explained when planting and harvesting seasons are taken into account. Figure 2 reports the monthly average volatilities for CBOT and SAFEX maize prices with planting and harvesting seasons taken into account.

Figure 2: Average monthly volatility on SAFEX and CBOT markets per season



From figure 2 it is clear that volatility of white maize (Wmaz), yellow maize (Ymaz) and Chicago Board of Trade (CBOT) yellow maize number 2[2] is generally high during the planting season, gradually decreasing as the value of the current crop becomes more certain. This understanding of the different levels of volatility can be utilised when deciding when to purchase a call option.

Determining Optimal Hedging Period

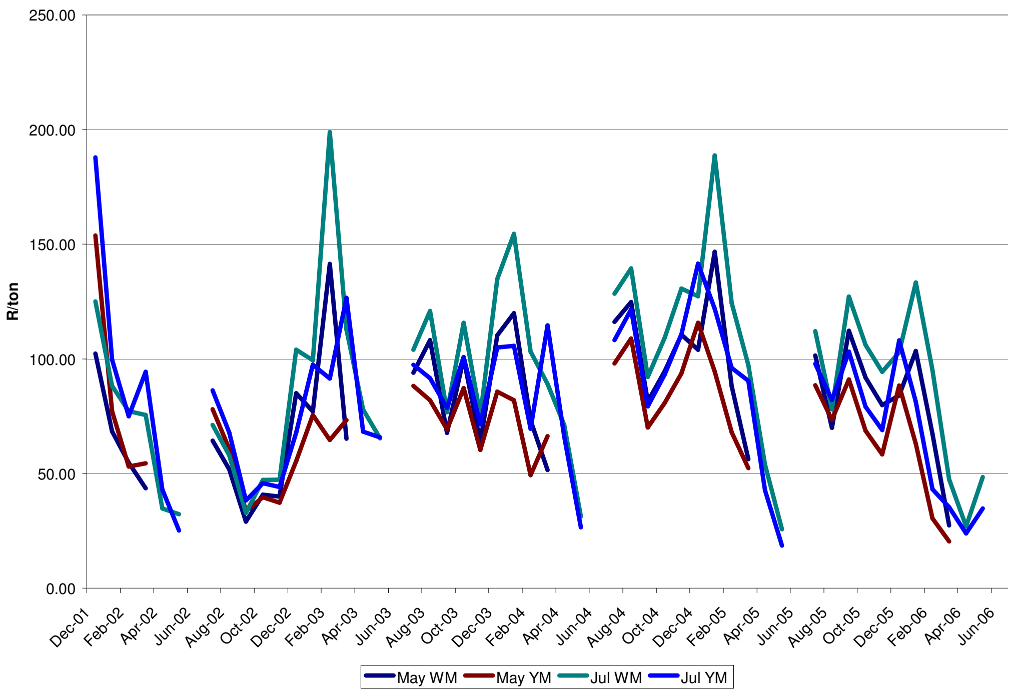
Options can give investors the flexibility to hedge market exposure, speculate on a specific market move, or allow investors to put on simple to complex option positions called spreads. The question is, given the volatile nature of commodity markets, when would it be the advisable for a government, organization,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

The Black and Scholes (Black & Scholes, 1973) model is often used to determine the price of an option. Based on this model, the average monthly annualized volatilities, the time to expiration, the assumption that the interest rate is adjusted to zero, the average price for May and July option contracts on SAFEX and CBOT were calculated. May and July contracts were selected because countries purchasing these options would know if they need to exercise the option due to a crop failure or other, as it coincides with the end of their growing seasons. Based on the above, an assessment was then made on the cheapest time to buy an option.

The premium cost for various ATM options traded on SAFEX were calculated and are shown in figure 3.

[2] CBOT nr 2 are used for export purposes, therefore the usage of CBOT nr 2 maize

Figure 3: Call premium cost/ton/month for SAFEX option contracts



From the above graph, it is clear that the most expensive time to purchase a July call option is January, a typical weather month. From the above it is also clear that the cheapest time to buy a call option is just before harvest time, this is however impractical, and therefore the cheapest time to purchase a call option is just before planting, and in the South African case this would be in September. Figure 4 indicates the call premium cost for ATM options traded on CBOT for the various contract months.

Figure 4: Call premium cost/ton/month for CBOT option contracts

As with the SAFEX market, the cheapest time to purchase a call option on the CBOT-market is just before planting, which in the American case is in March.

The decision that still remains is which market should be used for hedging purposes for food security. This decision will be based on a number of factors including among others, transport costs. For this reason, cost comparisons between the CBOT and SAFEX market were calculated for Tunisia. Transport costs from the USA to Tunisia were obtained from the International Grains Council, while those from South Africa to Tunisia were obtained from Cargill South Africa.

Table 1: Total cost of at the money call option and transport costs of maize to Tunisia

	Tunisia			
	CBOT		SAFEX	
Contract month	**May**	**July**	**May**	**July**
Call option R/ton	35.68	45.36	73.46	82.11
Transport $/ton	45	45	33	33
Average exchange rate R/$	6.05	6.41	6.05	6.41
Total cost $/ton	50.90	52.08	45.14	45.81

Table 1 clearly shows that purchasing a call option in March or April on the CBOT market is cheaper than purchasing the same option in September on the SAFEX market. This difference in price is mainly due to the different times to expiry of the option and the underlying volatility. The above allows for two different policy options. The first option is the annual purchase of a call option on the SAFEX market in September, as a form of insurance against crop failure as price and volumes would be secured prior to the coming planting season. The second option is a reactive measure, when is appears that there is going to be a drought or crop failure for whatever reason, then a call option can be purchased on the CBOT market. This option would be purchased in March or April, requiring policy makers to have a good understanding of the crop situation throughout the year.

Conclusion

Production of maize in southern Africa is dominated by South Africa, which accounts for the bulk of production in this region. Both poor harvests and bumper crops in South Africa will have a major impact on price formation and trade flows in southern Africa. Food security in the face of frequent droughts and other natural disasters is a common problem on the African continent. Governments across the continent have used a variety of policies to mitigate the effects of substantial crop losses, but very few have been sustainable in the long term due to their high cost and administrative requirements. An alternative policy option available to the policy maker that has not been widely used is the purchase of call options for course grains as a way of guaranteeing a certain volume at a predetermined price, while lowering administrative costs. This paper further suggests that the optimal time of the year in which governments and NGOs should purchase May and July call options, based on seasonal volatility and the time to expiry of the contracts is September on the SAFEX market and March or April on the CBOT market.

Stocks, insurance schemes, and forward markets or other derivatives all impose known costs to reduce unpredictable risks. For each, if the costs are low enough, it may be possible for countries (or producers) to make their own arrangements; if the costs are high (and for poor developing countries, costs may be considered 'high' at a lower level than for developed), it may be necessary to share some of these costs with donors.

Although this paper presents a strategy to reduce the effect of yield and price risk, research still needs to determine how to finance the exercising of the call option. Stocks, insurance schemes, and forward markets or other derivatives all impose known costs to reduce unpredictable risks. Commodity risk management needs to fit into a country's overall strategy for managing external risk and liability. In some countries, financing can be linked to the price of a commodity and financial instruments can serve a financing and hedging function. They have the advantage of relying on market determined prices and shifting risk away from the government to entities better able to manage and willing to assume risks.

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