

Estimating the supply response of maize in South Africa

By

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DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture (Agricultural Economics) has not previously been submitted by me for a degree at this or any other university; that it is my own work in design and execution, and that all material contained herein has been duly acknowledged.

Surname, Initials (title)

Date

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DEDICATION

I dedicate this work to my lovely mother Isabel Gwesu.

ABSTRACT

Maize is the most important crop in South Africa, being both the major feed grain for livestock and the primary staple food crop for the majority of the South African population. Furthermore, the maize industry contributes substantially to employment, manufacturing, foreign exchange and food security. The importance of maize in contributing to national growth is critical; this makes it meaningful to investigate the nature of maize farmers' production decisions. This study quantifies the supply response of maize farmers to price and non-price factors in South Africa using econometric techniques. The non-price factors considered in this study are rainfall, technology and market policy. A modified Nerlovian partial adjustment model was applied on historical time series data spanning from 1980-2012 to estimate the supply response of maize in South Africa. To deal with the expected problems associated with time series data the study adopted several diagnostic tests. Results indicate a short-run supply elasticity of 0.49 and a long-run supply elasticity of 0.65, signifying that maize farmers are less sensitive to price changes. The results confirm that non-price factors seem to have more effect on maize supply in South Africa. These findings coincide with those obtained in supply response studies for field crops conducted in other developing African countries. The study also showed that non-price factors such as, rainfall, technology and market policies have a positive impact on maize production. Given the findings, the study recommends policies that focus more on non-price factors as a means of stabilising maize production. The study also recommends that Industry stakeholders and policymakers should find means to integrate the significant relationships between non-price factors and production output into future decisions and marketing policies to safeguard a healthy, growing and sustainable maize industry in South Africa.

Key words: Maize supply response, Nerlovian partial adjustment model, price factors, non-price factors.

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
DAFF	Department of Agriculture, Forestry and Fisheries
DW	Durbin Watson
ECM	Error Correction Method
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
<i>ln</i>	Natural Logarithm
JSE	Johannesburg Stock Exchange
OLS	Ordinary Least Square
NDA	National Department of Agriculture
NAMC	National Agricultural Marketing Council
SADC	Southern African Development Community
SAFEX	South African Futures Exchange
SIC	Schwarz Information Criterion
Stats SA	Statistics South Africa

CHAPTER 1: INTRODUCTION

1.0 Background

Agriculture remains the critical source of livelihood and the basis of food security in South Africa. In 2011/12, agriculture accounted for almost 2.5% of the gross domestic product and about 5% of employment (DAFF, 2012). Agriculture is a significant provider of employment, especially in the rural areas and a major earner of foreign exchange.

Furthermore, agriculture has a role in provincial development and for most provinces, provides a source of income as well as being a potential focus for increased economic growth. Agriculture in South Africa has a fundamental role to play in building a strong economy and in the process, reducing inequalities by increasing incomes and employment opportunities for the poor.

South Africa's agricultural sector mainly consists of crop and livestock production. The main crops grown are: maize, wheat, sorghum, barley, sugarcane, sunflower and grapes. Livestock production is comprised of cattle, sheep, goats and pigs. According to DAFF (2011), maize is the most important crop in South Africa, being both the major feed grain and the primary food for the majority of the South African population. It is also a strategic crop affecting food security and agricultural incomes.

Since the democratic dispensation, the South African economy has undergone drastic transformation characterized by rapid urbanisation and increased incomes. The extensive changes in economic and social structure require fast growth in food supply. Maize contributes substantially to food supply in South Africa, therefore, its availability is of paramount importance in determining the food security goals of the nation. Policy incentives, including market liberalisation policies introduced in the 1990s, have been major policy instruments to stimulate maize production in South Africa.

In view of the fact that maize plays an important role in the nation, there is need for proactive formulation of policies with measures to improve maize production. Therefore supply response analysis is imperative to develop a more comprehensive understanding of the incentives that stimulate maize supply in South Africa.

1.1 Problem statement

The South African population has been growing at a very fast rate (from 38,631 million in 1994 to 51.8 million in 2012 (StatsSA, 2012)). The rapid increase in population will likely cause a rise in the demand for maize products. Such a situation necessitates a fairly high rate of growth in the agricultural sector to meet the demand for agricultural products in the country. To achieve this, an efficient utilization of resources is necessary. Farmers' decisions regarding resource allocation are influenced mainly by government policies. Hence, formulation and speedy implementation of policies which will induce a substantial expansion of agricultural production becomes imperative. With the introduction of reforms in the nineties in South Africa, accompanied by widespread deregulation of maize marketing and liberalisation of the maize price controls, it was expected that South African maize farmers would benefit considerably from the increased market incentives. According to Rao, (2003) the impact of liberalisation on the growth of agriculture crucially depends on how the farmers respond to various price incentives. South Africa maize price was 44.4% higher in the first seven months of the year 2012 compared to the first seven months of the previous year (DAFF, 2012). The effect of such a price increase depends on the receptiveness of farmers to price incentives. If we believe that an increase in the price of maize in South Africa would encourage farmers to increase production, then more response is expected in the 2012/13 maize production season. However, there is no firm evidence so far, which support this hypothesis. Therefore this study attempts to quantify South Africa maize farmers' supply response to changes in the price of maize.

Past studies revealed weak supply response for agriculture in developing countries as non-price factors seem to dominate over price factors in farmers' decision making problems (Gulati and Kelly, 1999). The importance of non-price factors has drawn adequate attention in literature; rainfall, market policies, technology and market access. One of the reasons for low response to prices in developing countries is the limited access to technology and poor rainfall (Mythili, 2001). Although the government has made remarkable efforts to liberalise the maize industry and make technology, inputs accessible and improve market access it remains unclear to what extent farmers respond to these incentives. This makes it essential in this study to examine how farmers also react to such non – price factors.

1.2 Motivation of the study

From a South African perspective, the importance of maize in contributing to national food security is critical; this makes it meaningful to investigate the nature of maize farmers' production decisions. With this in mind, the knowledge of the responsiveness of maize producers to variations in both economic and non-economic factors would aid policymakers in formulating policies imperative to economic development. For this reason, the extent to which farm decisions respond to economic incentives should therefore, be of central concern to policymakers and is the focus of this study.

1.3 Purpose of the study

1.3.1 Aim

The aim of this study is to estimate the supply response of the South African maize sector.

1.3.2 Objectives of the study

The objectives of the study are to:

- i. Quantify South African maize farmers' supply response to changes in the price of maize.
- ii. Estimate the supply response of maize farmers to changes in the non-price factors using Nerlovian partial adjustment model.
- iii. Determine the short and long-run price elasticities of supply for maize in South Africa

1.4 Hypothesis

- The production of maize in South Africa is not affected by price incentives
- The production of maize in South Africa is not affected by non-economic factors such as rainfall, technology and market policies.

1.5 Research questions

- i. How do maize farmers in South Africa respond to price changes?
- ii. What is the supply response of maize farmers to changes in the non-price factors?
- iii. What are the short and long run price elasticities of supply for maize in South Africa?

1.6 Structure of the Study

This study is organised into 6 chapters. In the introductory chapter, a general overview of the research problem is outlined. Chapter 2 covers the literature review of supply response studies. It covers previous studies that have been done in this field, the approaches followed and the results that have been obtained from these studies. Chapter 3 gives general overview of the South African maize industry. Chapter 4 present the research methods employed in the study. Chapter 5 provides the results, as well as a quantitative analysis of the study. Chapter 6 provides conclusions and policy recommendations from the empirical findings of the study.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This section reviews relevant literature in a bid to provide the necessary foundation for building up a conceptual and operational response model for an in depth analysis of maize supply response in South Africa.

2.1 Economic incentives and supply response

The total supply response is the response of the total output to price and non-price factors (Rao, 2003). The concept of supply response in economic theory usually refers to output production in response to their prices and supply curves that are anticipated. Over the past years there has been a number of empirical studies on supply response and economic rationale of farmers in developed and developing agricultural economies e.g. Leaver (2003); Rao (2003); Mythili (2001); Muchapondwa (2009) e.tc. However, the nature and extent to which farmers respond to changes in price and non-price factors still remains a debatable issue.

Liu *et al* (2010) claimed that, there are many arguments to support the notion that farmers in developing countries are not responsive to economic incentives such as price. The various crop-level studies available for developing countries have, for the most part, arrived at the same outcome: that the supply response is less elastic than in developed countries. The reasons these studies cite for the poor response range from limitations on irrigation and infrastructure to the lack of complementary agricultural policies and subsidies. Furthermore, there are varying results on the degree of response. Two sets of explanations are offered as to why the results vary and what the analysis overlooks. The first set of reasons focus on conceptual problems in identifying correct prices and exogenous variables. The second set of reasons point to the formulation of empirical models; for instance, the specification of supply function, use of distributed lag, failure to recognise model identification problems and improper choice of non-economic factors (Gulati and Kelly, 1999). Generally farmers do respond to incentives, but the response might be restricted and subject to various constraints.

According to Bhagat (1989) studies on developing countries showed that if farmers did not respond much to changes in incentives, it was not so much due to their

inability to adapt to changing circumstances but rather to the constraints they were facing, and that the potential for a significant supply response did exist if the constraints were relaxed. A badgering and recurring problem concerns the variability of estimated supply response from different studies. In their study Askari and Cummings (1977) documented this variability and attributed it to differences in the quality of estimates, due to differences in the definitions of price and output measures, as well as data measurement errors.

The different predictions of the output response to price incentives have also been explained by Rao (1989) who argued that different predictions of supply response to price incentives may be due to methodological diversity or a result of differing elasticities among crops and among countries in a systematic way.

2.2 Methods to measure supply response analysis

According to Triphati (2008) there are two major approaches to estimation of agricultural supply response; the indirect structural form approach and the direct reduced form approach.

2.2.1 Indirect structural form approach

This approach involves derivation of the input demand function and supply function from the available data. It also includes derivation of the input demand function and supply function from the information relative to production function and individuals' behaviours. This method is more theoretically rigorous but fails to take into account the partial adjustment in production and the mechanism used by farmers in forming expectations. The approach requires detailed information on all the input prices (Triphati, 2008).

2.2.2 Direct reduced form approach

This approach involves the direct estimation of the single commodity supply functions from time series data. Production in agriculture is not instantaneous and is dependent on past investment decisions and expectations', meaning the production in any period or season is affected by past decisions. The supply level is a function of current economic conditions, at the time decisions were made as well as the expectation about future conditions (Colman, 1983). The majority of supply response studies fall in this category. The most prominent directly estimated empirical models

that have been used in previous studies to model supply response of agricultural crops include; partial adjustment model, co-integration and error correction model.

2.2.2.1 Partial adjustment model

In this model the supply response is directly estimated by including partial adjustment and expectations formation. This is also known as Nerlovian model (Tripathi 2008). Most of the existing studies on the agricultural supply response have applied the Nerlovian method. Nerlovian models are built to examine the farmers' output reaction based on price expectations and partial area adjustment (Nerlove 1958). The nature of Nerlovian models is ad hoc specifications of supply response including partial adjustment and expectation formation (Liu *et al*, 2010). Time series data are often used for the commodity under study to capture the dynamics of agriculture production. The Nerlovian supply response approach has the flexibility to introduce non-price production shift variables into the model. According to Nerlove (1958), desired output can be expressed as a function of expected price and supply shifters. The Nerlovian partial adjustment model has been used to estimate agricultural supply response by a number of researchers e.g. Leaver (2003), Belete, (1995), Gurikah (2007), Wasim (2005) and Mythili (2008). The pioneering work of Nerlove (1958) on supply response also enables one to determine short run and long run elasticities. The general static supply function can be mathematically presented as;

$$Q_t^* = a + bP_t^* + cZ_t + U_t \quad \dots\dots (1)$$

Where, Q_t^* is desired output, P_t^* is expected price, Z_t is a set of supply shifters such as technology change, weather condition, etc.

Actual output may differ from the desired level because of the adjustment lags of variable factors. Therefore, it is assumed that actual output would only be a fraction δ of the desired output.

$$(Q_t - Q_{t-1}) = \delta(Q_t^* - Q_{t-1}) \quad \dots\dots (2)$$

Where, Q_t is actual output in period t, Q_{t-1} is actual output in period t-1, and δ is adjustment coefficients. Its value lies between 0 and 1.

The farmers' expected price at harvest time can be observed. So, we have to formally define how decision-makers form expectations built on the knowledge of actual and past price and other observable information. We assume that farmers maintain in their memory the magnitude of the mistake they made in the previous period and learn by adjusting the difference between actual and expected price in t-1 by a fraction γ (Tripathi, 2008).

$$P_t^* = P_{t-1}^* + \gamma(P_{t-1} - P_{t-1}^*) \quad \dots\dots (3)$$

Putting the value of P_t^* and Q_t^* from equation 2 and 3, in equation 1, the equation 1 becomes;

$$Q_t = b_0 + b_1 P_{t-1} + b_2 Q_{t-1} + b_3 Z_t \quad \dots\dots (4)$$

where: b_0 is $a d\gamma$, b_1 is $b d\gamma$, b_2 is $(1-d) + (1-\gamma)$, and b_3 is cd .

According to Braulke (1982) the short and long run price elasticity are calculated as follows;

$\varepsilon = b_1 \frac{\bar{P}}{\bar{A}}$ Where \bar{P} and \bar{A} are the historical mean of prices and output respectively and b_1 is the slope. The long-run elasticities are obtained by dividing the corresponding short-run elasticities with the coefficient of adjustment.

There are significant modifications in the way the model has been employed in actual empirical work. Most of these differences can be grouped in three categories. First are modifications affecting the variables used by Nerlove; second addition of factors of particular interest in the situation under investigation, corresponding to the variable z; finally some attempts to represent quantitatively situations not considered by Nerlove primarily perennial and slow maturing crops (Askari and Cummings, 1977).

2.2.2.2 Co-integration

The co-integration method has been used in agricultural supply response analysis in other countries by a number of researchers, namely; Townsend *et al* (1997), Schimmelpfennig *et al* (1996) and Thiele (2002). One major use of the co-integration technique is to create long-run equilibrium relationships between variables. However,

two conditions must be met for co-integration to hold. First, individual variables should be integrated of the same order. Second, the linear combination of these variables must be integrated of an order one less than the original variables (Engle and Granger, 1987). For example, if the variables under consideration are integrated of order one, or I (1), the error term from the co-integrating relationship should be integrated of order zero, I (0), entailing that any drift between variables in the short run is temporary and that equilibrium holds in the long run. Co-integration analysis can be performed using the Johansen approach.

2.2.2.3 Johansen approach to co-integration analysis

The Johansen test of co-integration involves estimating Vector Error Correction Models of the form;

$$\Delta Y_t = c + \sum_j \alpha_j \Delta Y_{t-1} + \delta D_t + \gamma T + \lambda \varepsilon_{t-1} + \vartheta_t$$

where: $\varepsilon_{t-1} = \ln Y_{t-1} - \sum \beta_j Y_{jt-1}$ (error/equilibrium correction term)

$D_t \rightarrow$ vector of stationary exogenous variables

$\delta \rightarrow$ vector of parameters of exogenous variables

$\lambda \rightarrow$ coefficient of error correction term ε_{t-1}

The Johansen technique provides two likelihood ratio tests, namely the Trace and the Maximum Eigen value statistic test, which are mainly used to determine the number of co-integration equations given by the co-integration rank r . A co-integration equation is the long-run equation of co-integrated series. The Trace statistic tests the null hypothesis of r co-integrating relations against the alternative of k co-integrating relations, where k is the number of endogenous variables for $r=0, 1, k-1$. The Maximum Eigen Value statistic tests the null hypothesis of r co-integrating vectors against the alternative of $r+1$ co-integrating vectors (Tripathi, 2008).

In their study Mushtaq and Dawson (2002) examined the yield response of wheat and cotton in Pakistan using the Johansen Approach to Co-integration Analysis. The aim of using this procedure was to overcome the problem of spurious regression. The results revealed that wheat supply was significantly influenced by the prices of

wheat, cotton and fertilizer, the percentage area under high yielding wheat varieties, and water availability.

2.2.2.3 Error correction method

The ECM offers a means of reincorporating levels of variables alongside their differences and hence of modelling long-run and short-run relationships between integrated series. In addition to this, economic time series data contain trends overtime, although regression analysis shows significant results with high R^2 , the results may be spurious. ECM and co-integration analysis is used to overcome the problem of spurious regression (Triphati, 2008).

The ECM overcomes the restrictive dynamic specification and captures the forward-looking behaviour of producers optimizing their production in dynamic situations (Begawy *et al*, 2008). The ECM approach is used to analyse non-stationary time series data that are known to be co-integrated. This method also assumes co-movement of the variables in the long-run. The general form of the ECM method is;

$$\Delta Y_t = c + \sum_k \alpha_k \Delta Y_{t-1} - \lambda (Y_{t-1} - \sum_j \beta_j X_{jt-n}) + \gamma T + \vartheta_t$$

where: $\Delta \rightarrow$ deference operator such that $\Delta Y_t = Y_t - Y_{t-1}$

$\alpha_k \rightarrow$ short run supply elasticity

$\beta_j \rightarrow$ long run supply elasticity

The ECM has been used in a number of studies around the world to measure the supply response of crop producers, e.g. Alemu *et al* (2003), Mesike *et al* (2010).

2.3 Response variables (area and yield)

In general terms, it is the planned total output that responds to price and non-price changes in supply response models. However, due to the non-availability of time series data on planned output it becomes necessary to use some appropriate proxy regarding the response variable through which the farmers' decisions are reflected. There is a great deal of disagreement in the literature on what the precise measure of output is. The three choices for measuring output are the acreage under cultivation, production or yield per unit area, and total production in terms of weight

or tonnage produced (Mshomba, 1989). Some researchers claim that area under the crop could be a better proxy for the planned output. They argue that area statistics are not only readily available and more dependable but also least influenced by external factors.

Rao (2003) indicated that, the choice of the proxy employed influences the results of the study. Most time series studies for particular crops use acreage as the proxy for output. To explain the above statement Belete (1995) postulated that, acreage is mostly used as a proxy for output because acreage is thought to be more subject to the farmers control than production output. In his study on supply response of Indian farmers, Mythili (2008) hypothesized that acreage response underestimates supply response and farmers respond to price incentives partly through intensive application of other inputs given the same area, which is reflected in yield.

Most directly, output is measured in terms of crop weight or volume produced or marketed, but in fact, the basic relationship between expected prices and cultivator reactions seems better expressed in terms, not so much of harvested tonnage, but rather of planted acreage is generally the best available method of gauging how cultivators translate their price expectations into action. Askari and Cummings (1977). From the various studies undertaken on agricultural supply response, some of the researchers who favoured area response are; Nerlove (1958), Singh (1998), Belete (1995), Muchapondwa (2009), Leaver (2003) and Rao (2003).

On the other hand, Choi and Helmberger (1993), Mushtaq and Dawson (2002), Hertel and Keeney (2008), argued that the arrival of land saving technologies in modern agriculture makes land to become a secondary factor in production. Therefore they implored for the yield/output response rather than the area response.

Another group of researchers, Mythili (2008) and Gurikar (2007), worked on both area and yield responses in order to assess the farmers response to price and non-price factors. Singh (1998) estimated the acreage response of the crop rather than its yield response while studying supply response of oilseeds in Uttar Pradesh. To justify this, the author indicated that the area enjoyed by the crops can be considered as a barometer of the farmers land allocation decision. Further, the area allocation under a crop is a function of several endogenous factors, whereas, the yield is

influenced by several exogenous factors. But, Singh also believed that the farmers could keep area constant and increase output by varying yield level.

El-Batran (2003) studied the acreage response for wheat in Egypt. The results indicated that there was a positive supply response to the relative price of wheat and competing crops (i.e. sugarcane and faba beans) and to the relative net profit between wheat and multi cut berseem, and that the positive supply response also reflects the role of technical change in increasing the cultivated area under wheat.

Kumar and Rosegrant (1997) studied on the dynamic supply analysis of cereals with a target to separate the output decision into area and yield. They assumed that the farmer first decides on area allocation among the crops and then the intensity of inputs used and hence yield. Leaver (2003) estimated the supply response functions of tobacco in Zimbabwe. The author postulated that the best measure of output appears to be the use of the actual produce weight because it acknowledges that farmers may respond to price incentives by using either more intensive or more extensive farming techniques. An additional factor in favour of the use of this particular measure is that data on tonnage produced is readily available.

Bhowmick and Ahamed (1993) studied the supply response of major oilseed crops in Assam, India for the period 1972-73 to 1988-1989. The results reviewed that an increase in the price of oilseeds was correlated to increased acreage rather than an increase in production output.

2.4 Price factor

The price factor remains a debatable issue among various supply response researchers. The main question as to which price (the pre-sowing prices, the post-harvest prices, the annual average prices, the absolute prices or the relative prices), influences the farmer's decision-making process remains unanswered. Farm prices are an important determinant of farm incomes which in turn affect the farmers' ability to increase the quantity and improve the quality of resources available to him.

According to Rao (1989), the price variable used is usually a measure of relative prices; prices paid relative to prices received; output prices relative to input prices or crop price relatives. These are alternative measures of incentives and the choice among them is often dictated by the availability of reliable price data. Measures of

price risk which are properly considered an element in price incentives are frequently not included.

Agricultural pricing policy plays a key role in increasing both farm production and incomes and is fundamental to an understanding of this price mechanism in supply response (Rao, 2003). Agricultural supply depends on prices of both output and input. The ultimate result from free market theory is that output price is the most important determinant of supply (Muchapondwa, 2009). If the output prices increase the profit increase and that motivates producers to produce more. Similarly, an increase in input prices leads to increase in production costs that depress supply.

One of the initial decisions meeting the researcher is how to measure output price. In the original model, Nerlove expressed actual prices in terms of those currently obtainable in the market, whilst expected prices are described in terms of past market prices (Askari and Cummings, 1977).

Mesfin (2000) studied the supply response of maize in Karnataka, India. The study was carried out mainly to evaluate the impact of relative price and selected non-price factors and to analyse the short and long run price elasticities. The results showed that the relative price factor had positive and significant effect on hectareage of maize in none of the selected districts but at the state level. Districts; Belgaum and Bijapur demonstrated significant negative impact of price on hectareage of maize.

Singh (1998) employed the Nerlovian lag adjustment model while using farm harvest price to study the supply response of oilseeds in Uttar Pradesh for the year 1966-67 to 1989-90. The result showed that the price variable had negative impact on area allocation for groundnut, linseed and rapeseed-mustard but it was statistically significant only in the case of groundnut. It had positive significant impact on sesame area.

Bhatti *et al* (2011) studied the supply response of Pakistani wheat growers. The results indicated that wheat growers were responsive to changes in the price of wheat in the case of production and acreage under wheat.

2.5 Supply shifters

The total variation in the output is considered as a consequence of changes not only in the price factor but also in several non-price factors that have their bearing on production activity. It could be said that the price variation at best, explains only a part of the variation in the response variable (Gurikar, 2007).

The bulk of studies on supply response highlighting the importance of non-price factors such as weather variations, technology, policies and market access for both inputs and output, have also drawn adequate attention as they have a significant effect on the supply of maize. Non-price factors seem to dominate price factors in farmers' decision-making (Rao, 2003; Mythili, 2008; Askari and Cummings, 1977; and Gulati and Kelly, 1999; Gosalamang, 2010).

A major source of differences among studies has to do with accurately adjusting for non-price factors affecting production such as weather, infrastructure and technological changes which may be associated with prices. This is serious for studies of yield response to prices. Studies differ in this regard depending on the availability of data on the authors judgement as to the relevance of a particular non-price factor (Rao, 1989).

A measure of weather variation seems to be most commonly encountered in most studies, with a wide variety of methods used to capture this concept; indices of rainfall, humidity and frost etc. Concepts essentially related to infrastructure seem important and measurable to most researches, and thus are directly included in the statistical analysis model. In other instances, yardsticks that are difficult to quantify are presented by proxy variables.

According to Askari and Cummings (1977), the time or trend variable is mainly used as a proxy to detect time-related effects on overall output such as advances in agro-technology and secular growth in the demand of the industrial and/or consumption sectors for the output of the agricultural sector. The decision to use a trend variable rather than a more direct measure of postulated influence on supply is generally based on difficulties in obtaining reliable time series data for the factor in question.

According to Thiele (2002) there are several other aspects affecting agricultural production. These factors include; lack of infrastructure, human capital, technology

and agro climatic conditions. Infrastructure includes accessibility of roads, market facilities, farmer access to credit; agro extension services, pesticides, communication and transport services have an effect on the agricultural output.

Raju and Nagabhushanam (1986) indicated that various technological and institutional factors influenced the decision-making behaviour of farmers growing oilseeds in Andhra Pradesh. They included variables such as, the lagged area and the lagged yield of the crop, the sowing period rainfall and the time trend as non-price variables. The regression coefficients of the lagged area of the crop were found highly significant in almost all the cases.

2.6 Review of relevant studies on supply response

Numerous research studies have been undertaken worldwide in the area of supply response. Recent studies increasingly focussed on developing countries in Africa and Asia such as, Zimbabwe, Botswana, Namibia, Zambia, Ethiopia, South Africa, India and Pakistan. Earlier studies on supply response primarily focused on one commodity, where price responsiveness was the major factor which influenced supply. More recent studies used dynamic and improved quantitative methods to measure supply response.

Schimmelpfennig *et al* (1996) analysed South African supply response in agricultural production. The study applied time series techniques to explain production planning decisions of the two dominant crops in the summer-rainfall grain area, maize and sorghum. After establishing the time series properties of the variables, cointegration was determined and used as the theoretical foundation for an error correction model (ECM). Maize area planted in the short run or the long run (or both), was found to depend on two sets of variables. One group changed the quantity or supply (area) of maize directly, like own price, the prices of substitutes like sorghum and sunflowers, and complementary intermediate input prices. The other variables changed the supply environment like, rainfall, farmer education, R&D and cooperative extension. Sorghum was found to be a secondary crop dominated by expected changes in the maize variables, and the area planted depends simply on intermediate input prices and rainfall over both the short and long run. These results further illustrate the dominance of maize and maize policies in production decisions in the summer-rainfall areas of South Africa.

Oyewumi *et al* (2011) studied the supply response of beef in South Africa using the error correction model. The results of the study confirmed that beef producers in South Africa respond to economic, climatic, trade and demographic factors in the long-run. In the short-run, however, the study showed that cattle marketed for slaughtering were responsive to climatic factors (i.e. rainfall) and imports of beef. Animal demographics, producer price of yellow maize and the producer price of beef were found not to have a short-run effect on cattle marketed for slaughtering.

Alemu *et al* (2003) investigated grain-supply response in Ethiopia using the error correction model. From the study it was found that planned supply of grain crops is positively affected by own price, negatively by prices of substitute crops and variously by structural breaks related to policy changes and the occurrence of natural calamities. The results found significant long-run price elasticities for all crop types and insignificant short-run price elasticities for all crops but maize. Higher and significant long-run price elasticities as compared to lower and insignificant short-run price elasticities were attributed to various factors, namely structural constraints, the theory of supply and the conviction that farmers respond when they are certain that price changes are permanent. The study concluded that farmers do respond to incentive changes. Thus attempts, which directly or indirectly tax agriculture with the belief that the sector is non-responsive to incentives, harm its growth and its contribution to growth in other sectors of the economy.

An empirical investigation on the supply of maize and tobacco for commercial agriculture in Zimbabwe was presented by Townsend *et al* (1997). The error correction model, which employs the concept of co-integration to avoid spurious regressions, was used in the analysis. The factors affecting percentage area planted to maize were, expected real maize price, real price of tobacco, real price of fertilizer and government intervention. The factors affecting percentage area planted to tobacco were real price of tobacco, expected real price of maize and institutional factors. The price elasticity of maize was 1.44 and 1.76 in the short and the long run respectively. For tobacco, these were 0.28 and 1.36 in the short and long-run, respectively.

Olwande *et al* (2009) studied the supply responsiveness of maize farmers in Kenya. The results of the study showed that maize price support is an inadequate policy for expanding maize supply. Fertilizer use was found to be particularly important in the decisions on resource allocation in maize production. Of the fixed inputs, land area was found to be the most important factor contributing to the supply of maize. It is suggested that making fertilizer prices affordable to small holder farmers by making public investment in rural infrastructure and efficient port facilities, and promoting standards of commerce that provide the incentives for commercial agents to invest in

Mythili, (2008) estimated supply response for major crops during pre-and post-reform periods in India using Nerlovian adjustment/adaptive expectation model. Estimation was based on dynamic panel data approach with pooled cross section - time series data across states for India. The study found no significant difference in supply elasticities between pre-and post-reform periods for majority of crops. This study also indicated that farmers increasingly respond better through non-acreage inputs than shifting the acreage. This includes better technology, use of better quality of inputs and intensive cultivation.

Mesike *et al* (2010) applied the vector Error Correction Model to measure the Supply Response of Rubber Farmers in Nigeria. Preliminary analysis suggested that estimations based on their levels might be spurious as the results indicated that all the variables in the model were not stationary at their levels. Further results indicated that producers' prices and the structural break significantly affected the supply of rubber. Response of rubber farmers to price were low with an estimated elasticity of 0.373 in the short-run and 0.204 in the long-run due to price sustainability and the emergence of other supply determinants indicating significant production adjustments based on expected prices. Policy efforts in promoting sustainable marketing outlets and promoting high value and high quality products for export were suggested in understanding farmer's responses to incentive changes.

2.6.3 A summary of supply response studies

Table 2.1 below shows a summary of some of the studies on supply response that were conducted in past years.

Table 2.1: A summary of agricultural supply response studies

Title	Crop / Product	Supply Elasticity		Reference
		Short run	Long run	
Grain supply response in Ethiopia.	Maize	0.38	0.51	Alemu <i>et al</i> (2003)
	Wheat	0.15	0.28	
	Sorghum	0.09	0.43	
Supply response among beef farmers in Botswana.	Beef	1.511	10.57	Gosalamang <i>et al</i> (2010)
Aggregate supply response in Zimbabwe.	Multiple crops	0.38	*****	Muchapondwa (2009)
Estimation of dynamic maize supply response Zambia.	Maize	0.54	1.57	Foster and Mwaunauno (1995)
Supply response of Pakistani wheat growers.	Wheat	0.184	0.44	Bhatti <i>et al</i> (2011)
Supply response among summer wheat growers in Lesotho.	Wheat	0.25	0.34	Belete (1995)
Supply response of rubber farmers in Nigeria.	Rubber	0.37	0.20	Mesike <i>et al</i> (2010)
Supply responsiveness of maize farmers in Kenya. A farm level analysis.	Maize	0.11	*****	Olwande <i>et al</i> (2009)
Measuring the supply response functions of tobacco in Zimbabwe.	Tobacco	0.34	0.81	Leaver (2003)
Supply response of maize and tobacco for commercial agriculture in Zimbabwe.	Maize	1.44	1.76	Townsend <i>et al</i> (1997)
	Tobacco	0.28	1.36	
Supply response of rice in Ghana: A Co-integration Analysis.	Rice	2.017	3.11	Kuwornu <i>et al</i> (2011)
Maize supply response to prices in Nigeria: Application of ARDL and Co-integration Analyses.	Maize	*****	0.87	Ogundari and Nanseki (2012)
A quantitative analysis of supply response in the Namibian Mutton industry.	Mutton	-4.14	1.97	Van Wyk (2012)
Rice output supply response to the changes in real prices in Nigeria: An Autoregressive Distributed Lag model approach.	Rice	0.043	0.271	Ogazi (2009)
An Error Correction Approach to modelling beef supply response in South Africa.	beef	-0.069	0.33	Oyewumi <i>et al</i> (2011)
Supply response of onion in Karnataka state: An Econometric analysis.	Onion	- 0.0017	- 0.0019	Gurikah (2007)
Production and acreage response of wheat and cotton in NWFP, Pakistan.	Wheat	0.014	0.027	Zaman and Niamatullah (2009)
	Cotton	0.047	0.035	

Source: own design.

2.7 Conclusion

After reviewing literature from numerous studies, some common implications can be drawn. Firstly a lot of the studies have used the same methodology by Nerlove in the original form or with some modifications. These studies generally have reported low supply response elasticities. Earlier studies have also revealed that non-price factors are of the same order of importance than price factors in supply response.

CHAPTER 3: OVERVIEW OF MAIZE INDUSTRY IN SOUTH AFRICA

3.0 Introduction

Crop production, as a sector of agribusiness, is prominent throughout South Africa and makes a considerable contribution to South Africa's agricultural economy in general. Crop production is of superior importance to improve livelihoods in rural areas and alleviating poverty. A wide variety of crops are produced throughout South Africa namely maize, sorghum, wheat, grapes, sugarcane etc. Maize is the most important grain crop in South Africa; being both the main feed grain and the staple food for the majority of the South African population.

This chapter provides a general picture of the South African maize industry. It includes the general description of the industry, market structure, price trends, production area and production trends, value chain, futures market and trade.

3.1 General description of the maize industry in South Africa

The maize industry has developed significantly to become one of the most vital industries in South Africa. According to NDA (2009) maize is the second largest crop produced in South Africa after sugar cane. Almost 40 percent of South Africa's cropped lands of just over 10 million hectares are planted to maize annually, occupying more land than any other crop in the country (Breitenbach & Fényes, 2000).

Maize serves as a major feed grain for livestock and the staple food for the majority of the South African population making it the most important crop in the country. About 60% of maize produced in South Africa is white and the other 40% is yellow maize (DAFF, 2011). Yellow maize is mostly used for animal feed production while the white maize is primarily for human consumption. The maize industry is important to the economy both as an employer and earner of foreign currency. Maize serves as a raw material for manufactured products such as paper, paint, textiles, medicine and food.

3.1.1 Production areas

Maize is produced throughout South Africa with Free State, Mpumalanga and North West provinces being the leading producers, accounting for almost 84% of total

production (DAFF, 2011). Maize is produced mostly on dry land although there is less than 10% that is produced under irrigation. South Africa is divided into 36 grain production regions with regions 21 to 28, which are in the Free State and North West making the biggest input to the total maize production (NDA 2009). The maize sector includes both commercial and non-commercial farmers, the latter mostly in the Eastern Cape, Limpopo, Mpumalanga and northern KwaZulu-Natal provinces. Commercial maize farmers are estimated at 9,000 and the number of developing agricultural farmers is unknown. During 2010/2011 the Free State province produced 39% of all the commercial maize in South Africa. Mpumalanga produced 22% followed by the North West Province which produced 22% of the total Commercial maize grown in the country (Stats SA, 2012).

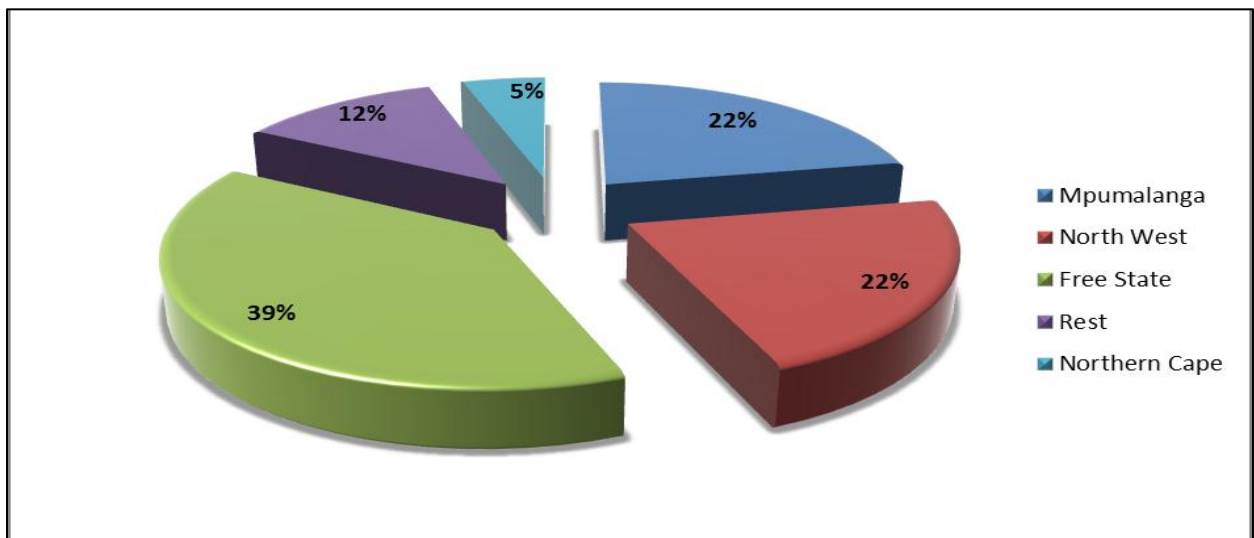


Figure 3.1 Maize production areas by province in South Africa

Source: (DAFF, 2011)

From figure 3.1 it is evident that Mpumalanga, Northwest and Free State province contribute substantially to maize production in South Africa. The estimated area that South African commercial producers planted to maize during the 2011/12 seasons is 2.699 million ha. This is 13.8% or 326 900 ha more than the 2,372 million ha planted the previous season and 4.7% or 120 600 ha more than the five-year average of 2.579 million ha planted up to 2010/11 (DAFF, 2012).

3.1.2 Production and consumption

Supply of maize is composed of maize harvested for a particular season, imports and carryover stocks from the preceding seasons (DAFF, 2011). Commercial agriculture produces about 98% of maize in South Africa, while the remaining 2% is produced by the developing agriculture (DAFF, 2011). Over the past 20 years, maize production has significantly fluctuated, with a peak in 2009/10 season.

Table 3.1 Area planted, total production, total consumption from 1991/92-2011/12

Marketing Year	Area planted (1000ha)	Total Production (1000t)	Total Consumption (1000t)
1991/92	4173	3277	7 022
1992/93	4377	9997	6 828
1993/94	4661	13275	6 773
1994/95	3526	4866	6 417
1995/96	3761	10171	6 842
1996/97	4023	10136	6 738
1997/98	3560	7693	6 383
1998/99	3567	7946	6 341
1999/00	3814	11455	6 362
2000/01	3225	8040	6 852
2001/02	3533	10050	7 151
2002/03	3650	9675	6 983
2003/04	3300	9700	7 243
2004/05	3223	11716	7 283
2005/06	2032	6935	7 462
2006/07	2900	7300	7 660
2007/08	3300	13164	8 029
2008/09	2896	12567	8 613
2009/10	3263	13420	8 658
2010/11	2859	10924	8 857
2011/12	3146	12417	8 895

Source: (DAFF, 2012)

The production of maize experienced an increase from the 2006/07 production year into the 2007/08 year as a result of an increase in the area planted. This increase is attributable to increases in the average producer prices during the two production periods. This was followed by reduced plantings in 2008/09 season leading to lower production volumes.

The continuous rise in population result in a rapid increase in the consumption of maize products. Such a situation demands an increase in maize production. The available statistics on maize production and consumption shows that over the years South Africa has been able to meet its local demand for maize. The South African maize consumption was 8.895million tonnes in the 2011/12 season. This is an increase of 866 000 tonnes (11%) from the 2007/2008 season.

Although the total area planted under maize has decreased in the period after deregulation, South Africa still meets its annual maize requirements almost entirely from domestic production. This is the result of implementing more efficient production technologies and practices by producers, the withdrawal of marginal lands from production and the development of high yielding maize cultivars (Breitenbach & Fényes, 2000).

3.1.3 Employment

The maize industry contributes significantly to provincial and national employment in South Africa. According to DAFF (2011) commercial maize farmers are estimated at 9000 and they cultivate nearly 3 million hectares of land and employ about 150 000 farm workers. Currently the maize milling industry employs approximately 5 300 workers, while the formal animal feed industry employs an estimated 2500 employees; and in the total processing industry between 4000 and 5000 people are employed.

3.1.4 Market structure

The South African maize market has developed considerably since the deregulation of marketing that took place in 1997. Producers, traders and other arbitrators interact freely in the marketing of maize. Most of the maize produced in South Africa is consumed locally; as a result, the domestic market is very important to the industry (NDA, 2009). Before deregulation the maize price was set by the marketing boards.

The price was set lower at a fixed price. Since the implementation of deregulation policy the price of maize increased gradually. This is because of the adoption of perfect competition in the maize marketing environment in which the prices are determined by the inter play between supply and demand.

As a result of maize being an internationally traded product, it is also exposed to the international market conditions. The demand and supply conditions of maize in the international market affect domestic prices directly. Another significant factor that impacts on the domestic market is the import tariff, which is used to protect domestic producers from cheap maize imports. The tariff is determined by the 21- day moving average Free On Board price in the US with the reference on the initial price. In case where the moving average deviates from the reference price then, a new tariff is generated (NDA, 2009).

3.2 Pricing trends

Since the deregulation of the South African agricultural industry in 1997, the maize market has essentially been an open one where maize prices are determined by market forces. Figure 3.2 below displays the real and nominal producer prices of maize from 1980/81 to 2010/11 season. The nominal producer prices of maize were deflated by the producer price index to convert them into real prices.

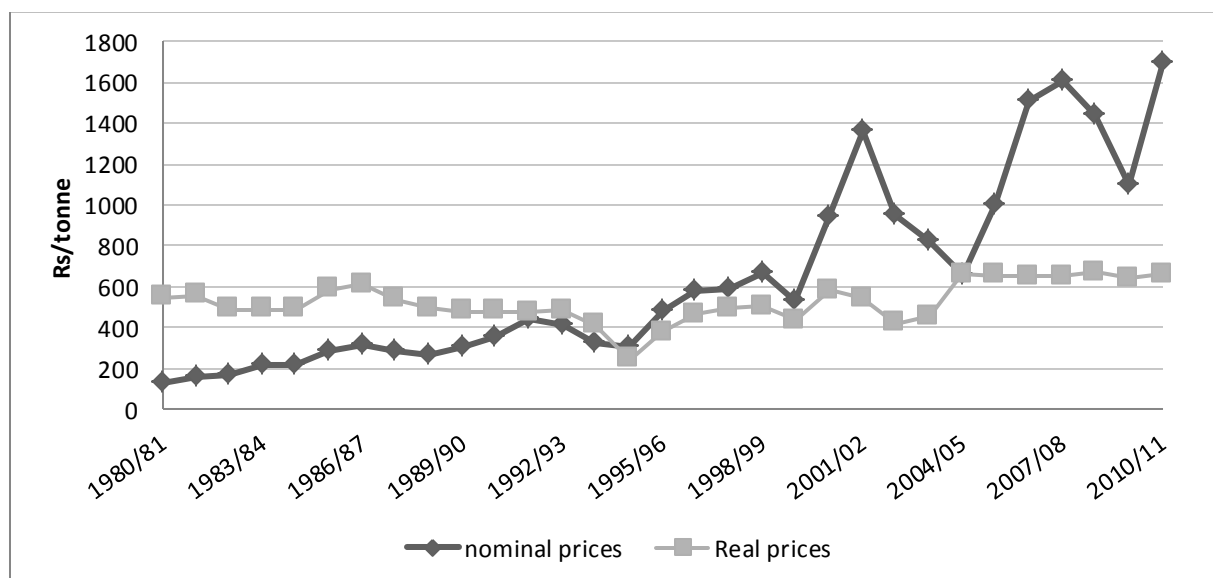


Figure 3.2: Nominal vs Real producer prices of maize.

Source: DAFF (2012)

For various reasons, maize prices are subject to significant fluctuations on both the international and domestic markets. During periods of shortages, the rand price of maize tends to escalate towards import parity, which is the international maize price plus transport and other costs, multiplied by the exchange rate. During surplus periods, the rand price tends to move towards export parity, which is the price of maize on the international market minus transport and other costs, multiplied by the exchange rate (DAFF, 2011).

3.2.1 Determinants of domestic maize prices

It was found that the Rand/Dollar exchange rate and international prices have the strongest influence on maize's domestic price level. DAFF (2011) suggested a number of basic factors that play a role in determining domestic prices of maize.

These factors include:

- International maize prices
- Exchange rates
- Local production (influenced by weather conditions and area planted)
- Local consumption
- Production levels in the Southern African Development Community region (South Africa is usually then main source of white maize for these countries in times of shortage)
- Stock levels (both domestic and international)

Rakhudu (2009) claimed that due to the nature of supply and demand elasticities, producers/consumers have little or no considerable power against maize price increases. This renders them susceptible to possible anti-competitive behaviour in the relevant markets.

3.3 The value chain

The South African maize value chain is structured around five main components, producers of maize (farmers); silo owners (who store maize for their own account and on behalf of others); traders in maize (who market and sell maize); millers of maize (who convert it into usable form); and end users. The South African maize value chain is divided into primary and secondary industries. Section 3.3.1 and 3.3.2

provides a detailed discussion on various value adding activities that take place within the primary and secondary industries.

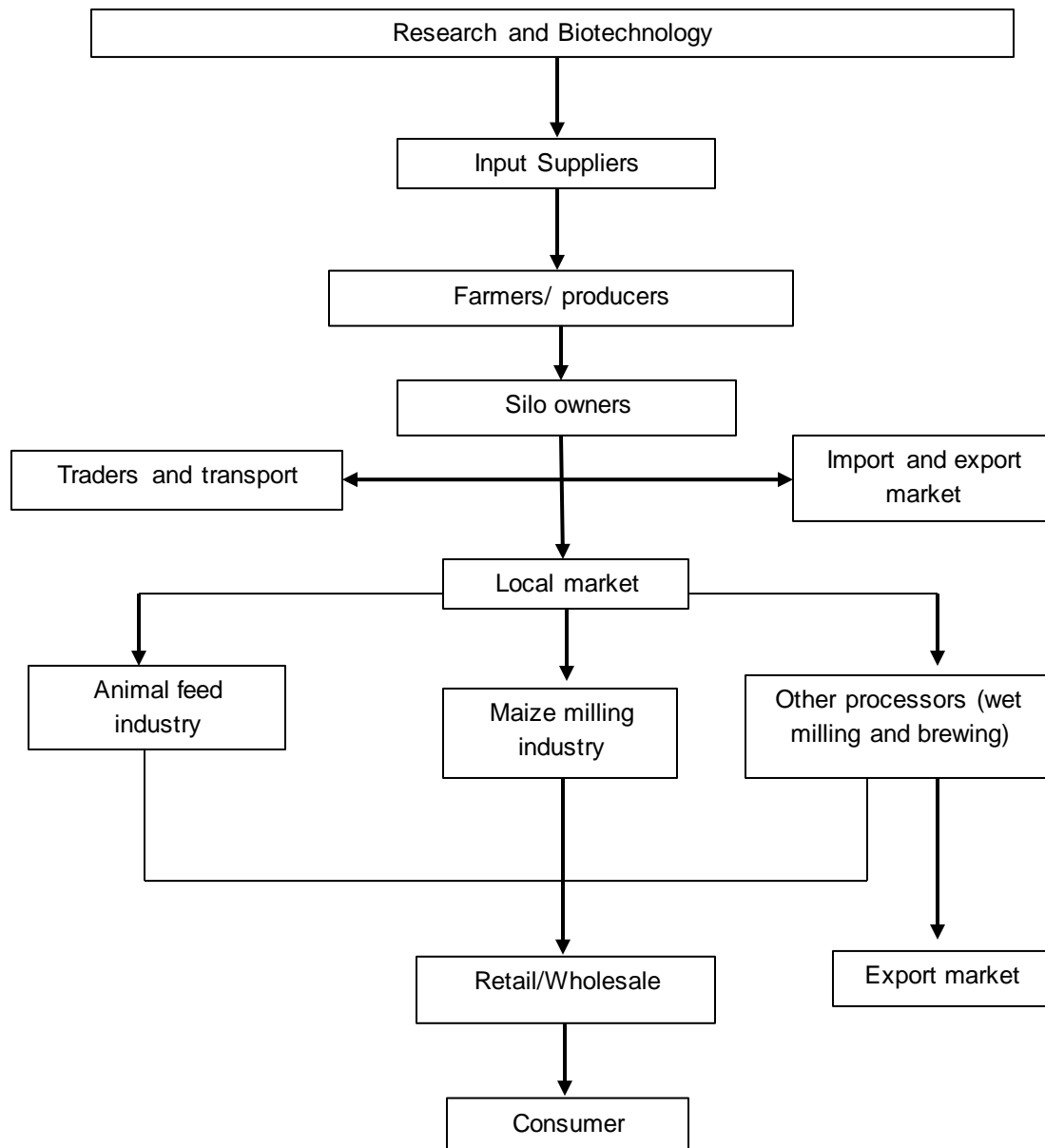


Figure 3.3: Maize market value chain

Source: NDA (2009)

3.3.1 The primary industry

The primary industry is made up of input suppliers, producers and silo owners. Silo owners provide storage facilities to handle the produces, to store maize safely and to

supply it to buyers on a continuous basis throughout the year. The secondary sector is made up of millers and animal feed manufacturers. Millers are involved in the transformation of maize to maize meal for human consumption while animal feed manufacturers use yellow maize for the manufacture of broiler and layer feed rations. Maize products in the form of hominy chop (white maize by-product) are used in feedlots (DAFF, 2011)

3.3.2 The secondary industry

The tertiary industry is made up of traders, retailers and transporters. Traders transfer the produce to the local or export market. NDA (2009) claimed that there are three types of traders in the maize industry: hedgers who use futures and options to safeguard an existing portfolio against any likely adverse market movements; arbitrageurs who profit from price disparities of maize in different markets; and speculators who use futures and options in the hopes of making a profit on short-term movements in prices. The retail sector provides infrastructure and services for the distribution of maize products from the miller to the final consumer. Transport helps to move the maize from the farmers to the silo owner, from the silo owner to the miller and from the intermediaries to the final consumers.

3.4 Futures market

For numerous reasons, maize 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.

Futures markets provide the facilities and platform where buyers and sellers can meet in a transparent way and trade freely among themselves, thereby providing an effective price discovery mechanism. It is the free and unconstrained trading among all buyers and all sellers that determines prices. In providing the facilities for buyers and sellers to meet and conduct their business (NAMAC, 2009).

JSE (2005) defined a futures market as a trading operation that provides market participants with a price determination mechanism and a price risk management facility through which they can manage their exposure to adverse price movements

on the underlying physical market and where performance by both counterparties to the contract is guaranteed.

The collapse of agricultural marketing control boards in South Africa during the early 1990's and extensive deregulation was the circumstance that stimulated the formation of South African Futures Exchange's Agricultural product Division to trade agricultural products. Presently, maize prices are formally traded on SAFEX where the producer price (also known as the farm gate price) is derived from the SAFEX spot price minus the average transport differential and the handling costs. The price for futures and options contracts are generated on the exchange market through 'bids' and 'offers' and reflect the views of market participants on the prices of the specific products at different dates in the future (NAMAC, 2009). SAFEX is recognised as the price discovery facility for grains in South and Southern Africa and presently trade maize, wheat, sunflower seeds and soyabean futures and options contracts (JSE, 2005).

By using the futures market individuals, companies or countries selling or buying maize can protect themselves against price movements in the underlying physical market. This is achieved by selling or buying futures or options contracts through a broker who is a member of the futures exchange (JSE, 2005). Consequently, futures markets allow maize producers and users of the maize commodity to hedge their price risk, thereby limiting their exposure to adverse price movements. This encourages increased productivity in the agricultural sector as farmers and users are able to concentrate their efforts on managing production risks (NAMAC, 2009).

3.5 Trade

The maize industry is an important earner of foreign currency through the export of maize and maize products. The industry exports mostly to Southern African countries which include Lesotho, Zimbabwe, Botswana, Namibia, Swaziland, Mozambique, Zambia and Mauritius. The industry in some years also exports maize to Europe, Asia and America. Figure 3.4 depicts the quantity of maize exports between 1980 and 2010. The highest volumes of maize were exported during the years of 1981, 1989 and 1994 due to the relatively higher volumes of local production at that time. The volume of maize exports declined substantially during the years 2006 and 2007. Figure 3.4 shows evidence of high volumes of maize that

were exported in the 1980's and 1990's. This might have been a result of low consumption levels in the past which enforced the maize industry to export excess volumes of grain.

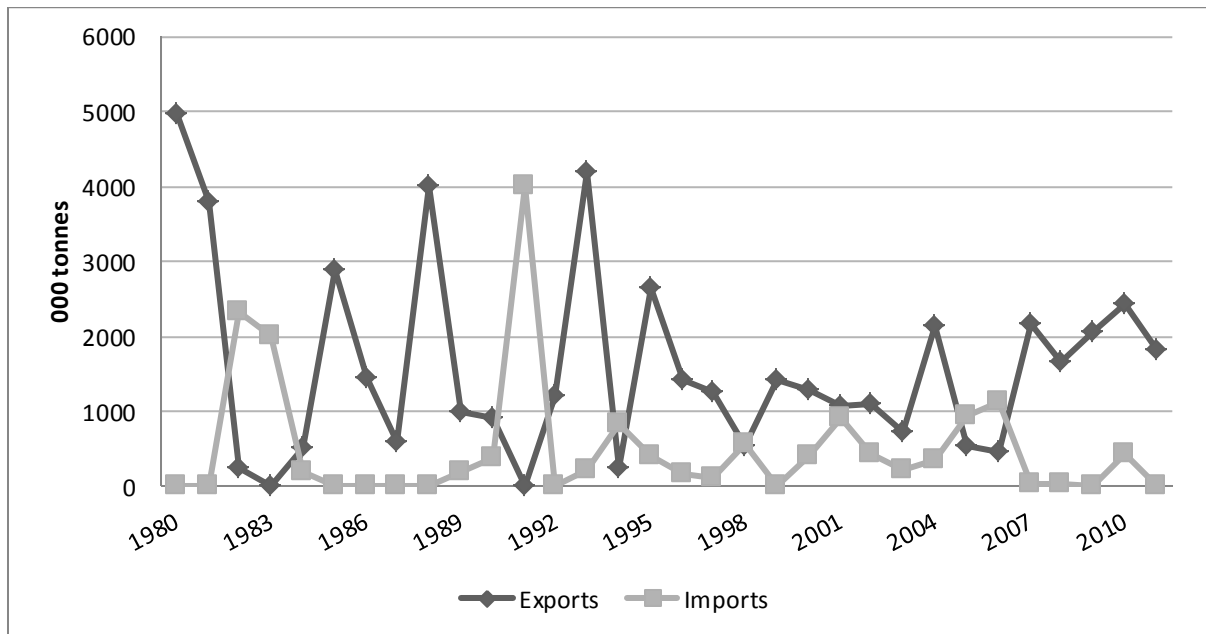


Figure 3.4: Maize exports and imports from 1980-2010 in South Africa

Source: DAFF (2012)

Millers are the main buyers of the maize crop and have the option of importing maize rather than buying locally produced maize. According to NDA (2009) the decision whether to buy from domestic or foreign sources is mainly influenced by, among other factors, transport costs, price and quality. When the product is imported, the exchange rate plays an important role in the actual rand price.

DAFF (2012) claimed that depreciation in the value of the rand against relevant foreign currencies makes import products such as maize, wheat and oilseeds more expensive in rand terms, thereby providing some protection for South African farmers and an incentive to increase production in the longer term. However, if South African producers are unable to meet the needs of the processors, or if processors are uncertain about local supplies, foreign sources can be considered. South African producers, on the other hand, will consider the export market if local processors are unwilling to pay the prevailing local market price. In this manner, the market sets “natural” floor and ceiling prices, i.e. a price band within which such products trade.

The price-setting mechanism for these crops is the Agricultural Products Division of the JSE Security Exchange of South Africa.

3.6 Conclusion

This chapter highlights the Fundamental importance of the maize industry within South Africa's economy, as well as the contribution of crop production and value adding activities to the overall agriculture and forestry GDP. This chapter also depicts the various activities that take place within the maize industry that is from the producer to the final consumer. To conclude, it is clear from this chapter that maize is the most important crop in South Africa as it contributes substantially to employment, manufacturing, foreign exchange and food security.

CHAPTER 4: RESEARCH METHODOLOGY

4.0 Introduction

This chapter provides details of the study area, nature and source of data and techniques of analysis employed in this study.

4.1 General description of the study area

The focus of the study is South Africa. South Africa, officially the Republic of South Africa, is a country located at the southern tip of Africa. It is divided into nine provinces, with 2,798 kilometres of coastline on the Atlantic and Indian oceans. To the north of the country lie the neighbouring territories of Namibia, Botswana and Zimbabwe; to the east are Mozambique and Swaziland; while Lesotho is an enclave surrounded by South African territory.

Maize is produced throughout South Africa with Free State, Mpumalanga and North West provinces being the largest producers, accounting for approximately 83% of total production (DAFF, 2012). Approximately 8 million tons of maize grain is produced in South Africa annually on approximately 3.1 million ha of land. Commercial agriculture produces about 98% of maize in South Africa, while the remaining 2% is produced by the developing agricultural sector (ARC, 2003).

The focus of the study has been chosen primarily because almost 40 percent of South Africa's cropped land of just over 10 million hectares are planted to maize annually, occupying more land than any other crop in the country. Maize is the staple diet for a large section of the population. Furthermore, yellow maize is by far the most important animal feed, representing more than 60 percent of total animal feed requirements (DAFF, 2011).

4.2 Data collection

To build an economic model based on the objectives of this study, it is necessary to have sufficient data relating to maize production and the said stimuli in order to make a quantitative assessment possible. Historical time series data for the period 1980 to 2012 was used in this study. State level data pertaining to the area and aggregate production were extracted from the Abstract of Agricultural statistics (2012) maintained by the Department of Agriculture, Forestry and Fisheries. Data on maize yield were obtained from the World Bank data base (www.data.worldbank.org). In

addition, the data on monthly rainfall were obtained from the South African weather services. Domestic producer prices of maize were also extracted from the Abstract of Agricultural statistics (2012) maintained by the Department of Agriculture, Forestry and Fisheries. Data on the price of wheat and sorghum the main competitors of maize were collected from the same source. The annual inflation rate as measured by consumer price index were also obtained from the Abstract of Agricultural statistics (2012) maintained by the Department of Agriculture.

4.3 Analytical technique

Micro-economic theory states that the main determinant of the supply of a product is its own price. Chabane (2000) quantified that farm output prices generally have three main functions in an economic system, namely to allocate farm resources, distribute incomes and encourage or retard investment and capital formation in agriculture. Therefore an increase in the general level of output prices, all things held constant, will increase returns to all inputs in production, in turn encouraging higher use of variable inputs, as well as providing higher returns to the fixed inputs of land, capital and family labour. Consequently supply response describes the extent to which the quantity supplied changes relative to variations in economic and non-economic factors.

Acreage response has been the dominant feature in estimates of crop supply response, particularly when trying to identify the influence of price on changes in output. There is limited empirical work attempting to estimate the yield response of crop production to price changes. Most direct supply estimation has been focused on changes in acreage planted as a proxy for total supply. This study uses both yield and acreage response functions to identify the impact of economic and non-economic factors on changes in maize output in South Africa.

Keeping in view the objectives set for the study, the Nerlovian partial adjustment lagged model was used to analyse the supply response of maize farmers to economic and non-economic factors. Econometric views version 8.0 is the software package that was used for data analysis.

4.3.1 Conceptual framework for analysing supply response

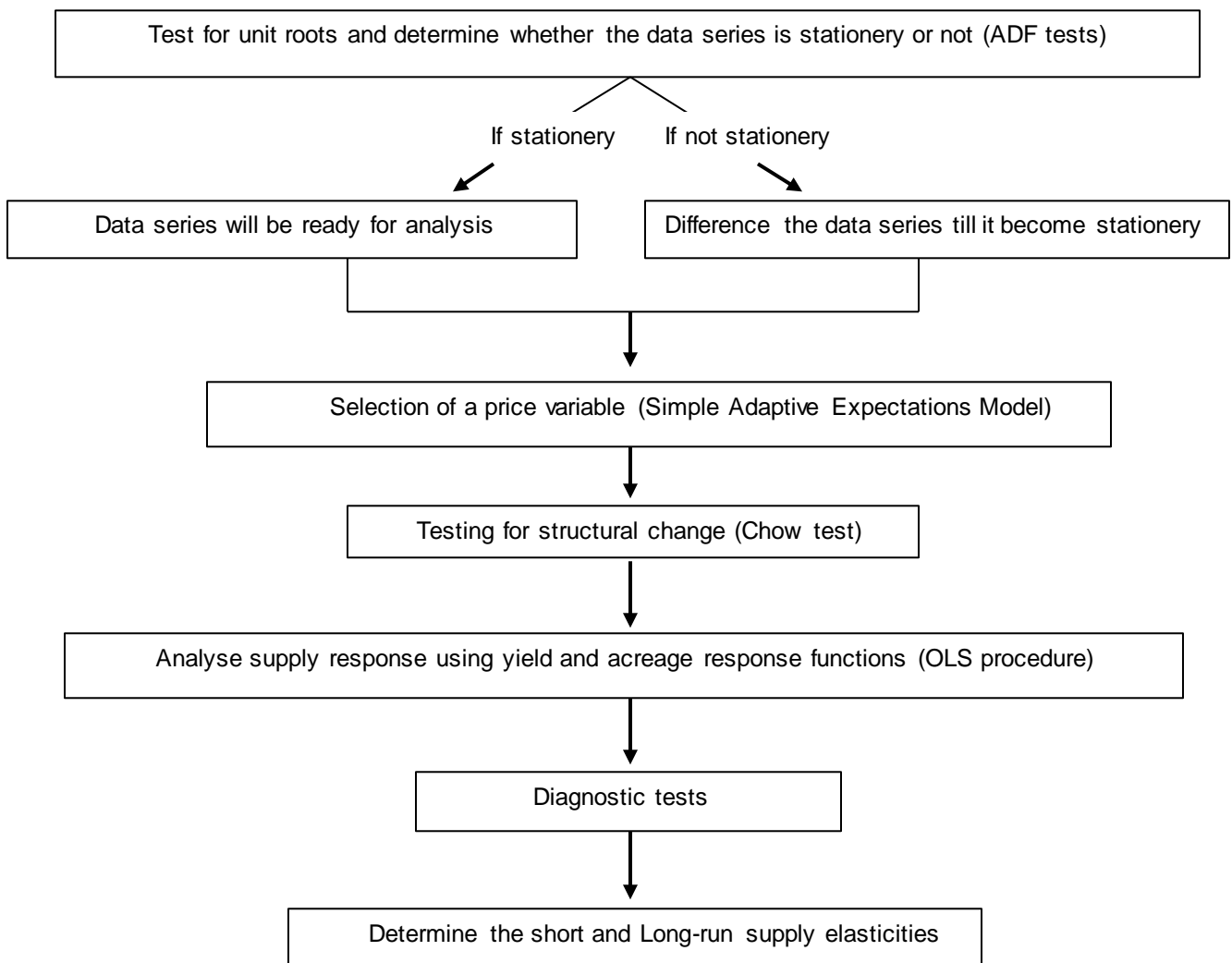


Figure 4.1: Framework for analysing supply response

Source: Own design

Figure 4.1 above displays the conceptual framework for analysing the supply response of maize in South Africa. Firstly each data series was tested for stationarity using the Augmented Dickey Fuller test (ADF test). Non-stationery data was made stationery by differencing. This was done to avoid spurious regression results and unstable models. The Simple Adaptive Expectation Model was applied to select the best price variable. Thereafter the chow test procedure was performed in order to test for any structural breaks within the maize series. To analyse the supply response of maize the yield and acreage response functions were applied. The OLS

method was applied to calculate the supply parameters of the functions. Diagnostic tests were performed to validate quality of the supply model and then the short and long-run supply elasticities were determined.

4.3.2 The Nerlovian model

Of all the econometric models used to estimate agricultural supply response, the Nerlovian model is considered one of the most prominent and effective, judged by the large number of studies which utilise this approach (Leaver, 2003). The pioneering work of Nerlove (1958) on supply response enables one to determine short run and long run elasticities; also it gives the flexibility to introduce non-price shift variables in the model. The partial adjustment lagged model is considered appropriate for crop producers and is widely used by researches like Rao (1989), Belete (1995), Leaver (2003), Wasim (2005), Mythili (2008), to measure the producers behaviour.

The basic form of the Nerlovian model for an annual crop consists of the following three equations.

$$1. Z_t^* = \vartheta_0 + \vartheta_1 P_t^* + \vartheta_2 X_t + U_t \quad (4.1)$$

$$2. P_t^* = P_{t-1}^* + \gamma(P_{t-1} - P_{t-1}^*) \quad (4.2)$$

$$3. Z_t - Z_{t-1} = \delta(Z_t^* - Z_{t-1}) \quad (4.3)$$

where:

Z_t = actual output at time t

Z_t^* = desired output at time t,

P_t = actual price at time t,

P_t^* = expected price at time t,

X_t = other observed, non-economic factors affecting supply at time t, γ and δ are labelled the expectation and adjustment coefficients respectively.

Nerlove (1958) adjustment model postulates that the desired output Z_t^* is a function of 'expected normal price,' while the actual output Z_t adjusts to the desired output with some lag. Equation (4.1) is a behavioural relationship, stating that the desired output of maize depends upon the relative prices in the preceding year. According to

Seay *et al* (2004), equation (4.3) states that the current maize output Z_t will move only partially from the previous position to the target level Z_t^* . The amount of the adjustment of maize farmers to various factors between time t and $t-1$ is equal to $\delta(Z_t^* - Z_{t-1})$.

δ measures the speed of adjustment and assumes values from 0 to 1. It is interpreted as the coefficient of adjustment which characterises the fact that there are limitations to the rate of adjustment of Z_t due to economic and non-economic factors like technological constrains, weather variability, prices and various inflexibilities. Relations with equation (4.1) and (4.3) give the reduced form which eliminates the unobserved variable Z_t^* by an observed variable Z . By eliminating these variables, the estimating or the reduced form Nerlovian equation is achieved.

The reduced form equation is given by;

$$Z_t = b_0 + b_1 P_{t-1} + b_2 Z_{t-1} + b_3 X_t + V_t \quad (4.4)$$

where: $b_0 = \delta B_0$, $b_1 = \delta B_1$, $b_2 = 1 - \delta$, $b_3 = \delta B_3$, $V_t = \delta U_t$

The reduced form would basically remain the same if we include more independent variables than the ones included in equation (4.4).

In this study the short-run and long run price elasticities were computed as follows;

The short run supply elasticity was calculated as follows;

$$\varepsilon = b_1 \frac{\bar{P}}{\bar{Z}} \quad \text{Where } \bar{P} \text{ and } \bar{Z} \text{ are the historical mean of prices and output respectively}$$

and b_1 is the slope. The long-run supply elasticities will be obtained by dividing the corresponding short-run elasticities with the coefficient of adjustment δ .

4.4 Specification of variables used in the supply models

The selection of variables influencing supply is the basis of the supply response study. Variables that have been used in the various supply response models for field crops are weather (rainfall), policy changes, seed and fertiliser prices, producer prices, prices of substitutes and technology. Variables included in this study were selected based on economic theory and previous work done in the field of supply

response. Due to the non-availability of data some variables were excluded from the maize supply models. The output factor (dependent variable) of the model may vary according to the scope of study. In this study the output variables used are yield and acreage for the yield and acreage response functions respectively.

The price and non-price variables selected for this study are defined as under;

4.4.1 Price variable

The producer price of maize, lagged by one period, has been introduced as an explanatory variable in the supply response equation. This is justified by the fact that farmers are assumed to take past price experience into account when forming their production expectations (Seay *et al*, 2004). Furthermore output price increases profit and an increase in profit provides an incentive for producers to produce more of a specific product. Data on South Africa consumer price index for the period 1980 to 2012 were obtained and converted into a common series with a base year of 2005. The producer prices of maize were then deflated using the consumer price index.

4.4.2 Competing crops

The quantity of a product produced and supplied depends on its own price, the prices of substitute and complementary products, and the prices of inputs. Based on grain consumption in South Africa, possible competitive crops to maize are wheat and sorghum. To embrace this in our analysis we have considered three price variables. These are: (i) maize price, (ii) maize price relative to wheat price; (iii) maize price relative to sorghum price. One or all of these may be appropriate to the analysis. To select the best price variable a regression was run for each of these price variables using simple adaptive expectations model. A statistical comparison of the three estimated functions using t-tests and R^2 was done in order to select the best price variables to include in the supply equation.

The simple adaptive expectations model was formed as follows;

$$Y_t = \theta_0 + \theta_1 P_{t-1} + \theta_1 Y_{t-1} + U_t \quad (4.5)$$

where: Y_t = dependent variable (maize yield)

P_{t-1} = selected price variable

Y_{t-1} = maize yield in period t-1

U_t = disturbance term

4.4.3 Output variables (dependent variables)

The three choices for measuring output are the acreage under cultivation, production or yield per unit area, and total production in terms of weight or tonnage produced (Mshomba, 1989). This study uses yield and area as output variables because these are the most common output variables that have been extensively employed in literature.

Yield (Y_t) was used as the dependent variable in the yield response model. This may be justified by the fact that farmers may display response by adopting better technology of production with no change in area or by adopting intensive cultivation by using more or better quality of inputs. This will change the output without changing the area, something that is hidden in the acreage function.

A lag variable of maize yield (Y_{t-1}) was included as an independent variable in the yield response equation leading to a general Autoregressive Distributed Lag Model. The reason for this inclusion is that it can also be hypothesised that last year's supply affects this year's maize supply due to changes in stock quantity.

Area (A_t) was introduced as a dependent variable in the acreage response function. To justify this Rao (1989) indicated that farmers have greater control over area than that on the yield or production. A lag variable of maize acreage (A_{t-1}) was also included as an independent variable in the acreage response function.

4.4.4 Supply shifters

In this study rainfall was included to capture variations in weather. It was not the total annual rainfall that was important, but the rainfall received during the production months was relevant. This was so because, it was felt that favourable moisture conditions during production period would encourage farmers to bring more area under cultivation of the crop in question (Singh, 1998). Therefore, the average rainfall received in the six production months (October, November, December, January, February and March) was used in the hectareage response model as a proxy for the weather factor.

Due to the fact that maize is grown between October to March, and yield is negatively affected by heavy rains early in the season, the rainfall variable is lagged by one period. This means, for example, that the 1995 maize crop, which includes maize grown during both October to December 1994 and from January to March 1995, is affected by the 1994 rain.

Technology is a factor of production having an influence on supply. The time trend variable was included in both the hectare and yield models as a proxy for improvements in technology, market access changes and other farming methods over time.

Just (1998) work is of great interest for his close attention to including policy variables in the response function. According to Kirsten *et al* (2008) the Marketing of Agricultural Products Act, No. 47 of 1996 changed the way in which agricultural marketing policy was managed in South Africa by opening the sector to world market influences in a manner that could hardly have been expected in previous years. The Act, publicised on 1 January 1997, set up the National Agricultural Marketing Council (NAMC), whose direct task was to dismantle the existing Control Boards by 6 January 1998 and consequently to manage and monitor state involvement in the sector. Before the marketing act, maize marketing was controlled under a single-channel, fixed-price administration. The maize board was the sole buyer and seller of maize at a price fixed annually by the parliament's Cabinet.

Breitenbach and Fényes (2000) argued that deregulation and liberalisation of South African grain markets has given rise to a general downward trend in grain production. Thus, to capture the effect of maize industry liberalisation that took place in 1997, a dummy variable is included in this study, with years before and after liberalisation of the maize industry taking the value of 0 and 1 respectively.

4.5 Estimating the maize supply response

The model used for this study is based on economic theory and previous work done in the field of supply response for field crops. However, it is not always possible to estimate a model suggested by theory, because it is not always possible to include all the variables initiated by theory due to the non-availability of data and quantification problems. The supply model used in this particular study is based on

supply models for field crops used by Belete (1995), Leaver (2003) and Mythili (2008). The models used by these research studies were used as a framework for constructing a maize supply model for this study

Ordinary Least Squares (OLS) technique was used to estimate the parameters of the models. The estimation of the Nerlovian model may result in residuals that violate the assumption of normality of the error terms (Leaver, 2003). To ensure normality of the residuals, the estimating equations used in this study were expressed in logarithmic form. The transformation is acceptable because it ensures that the errors are both homoscedastic and normally distributed (Maddala, 2001). An additional benefit of using the logarithmic form is that the coefficient of the price variable can be directly deduced as the short-run supply elasticity.

To estimate the impact of price and non-price factors on changes in maize output this study uses yield and acreage response functions. The area and yield response estimating equations were simplified from the Nerlovian partial adjustment model in section 4.3.2.

4.5.1 Yield Response function

Using the adjustment lag model as the basic frame for analysis, the yield response relationship in the study was estimated with the following equation:

$$Lg Y_t = Lg\phi_0 + \phi_1 Lg P_{t-1} + \phi_2 Lg Y_{t-1} + \phi_3 Lg R_{t-1} + \phi_4 T_t + \phi_5 D + U_t \quad (4.6)$$

Where; Y_t = dependent variable (maize yield)

$Lg P_{t-1}$ = log of real producer price of maize (Rands/tonne) in period t-1.

$Lg R_{t-1}$ = log of average rainfall October – March (mm) in year t.

$Lg Y_{t-1}$ = log of actual maize yield (tonne/hect) in year t-1.

T_t = is the time trend representing changes in technology.

D = Dummy variable for years before and after liberalisation of the maize industry (period 1: 1980-1997; period 2: 1998 – 2012). Period 1 and 2 takes the value of 0 and 1 respectively.

U_t = is the random disturbance term.

4.5.2 Acreage response function

The simplified acreage response function is computed as follows;

$$Lg A_t = Lg\phi_0 + \phi_1 Lg P_{t-1} + \phi_2 Lg A_{t-1} + \phi_3 Lg R_{t-1} + \phi_4 T_t + \phi_5 D + U_t \quad (4.7)$$

Where; A_t = dependent variable (maize acreage)

LgP_{t-1} = log of real producer price of maize (Rands/tonne) in period t-1.

LgR_{t-1} = log of average rainfall October – March (mm) in year t-1.

LgA_{t-1} = log of actual area under maize cultivation (1000hec) in year t-1.

T_t = is the time trend representing changes in technology.

D = Dummy variable for years before and after liberalisation of the maize industry (period 1: 1980-1997; period 2: 1998 – 2012). Period 1 and 2 takes the value of 0 and 1 respectively.

U_t = is the random disturbance term.

The price variables for both yield and acreage response functions were directly interpreted as the short-run supply elasticity. The long run elasticities are obtained by dividing short run elasticities by (1- coefficient of the lagged output variables).

4.6 Testing for unit root non-stationarity

In order to compute supply elasticities, relevant tests are done beforehand to avoid spurious regression results and unstable models. The time series data of the selected variables first have to be tested for unit roots. The Augmented Dickey Fuller test was performed on each of the logarithmic series of Maize prices (MP), maize Yield (MY), maize acreage (MA) and rainfall (Rn) to formally ascertain whether they contained a unit root.

Four autoregressive forms of models were set up, each for the four respective data series of MP, MY, MA and Rn in the manner demonstrated below:

$$\Delta \ln MP_t = \phi_1 + \phi MP_{t-1} + \sum_{i=1}^p \alpha_i \Delta MP_{t-i} + U_t$$

$$\Delta \ln MY_t = \phi_1 + \phi MY_{t-1} + \sum_{i=1}^p \alpha_i \Delta MY_{t-i} + U_t$$

$$\Delta \ln MA_t = \phi_1 + \phi MA_{t-1} + \sum_{i=1}^p \alpha_i \Delta MA_{t-i} + U_t$$

$$\Delta \ln Rn_t = \varphi_1 + \phi Rn_{t-1} + \sum_{i=1}^p \alpha_i \Delta Rn_{t-i} + U_t \quad (4.8)$$

Where; φ_1 = an intercept term,

t = a trend term,

$\ln MP_t$ = natural logarithm of maize price series to be tested,

$\ln MP_{t-1}$ = natural logarithm of maize price series lagged by 1 period,

$\sum_{i=1}^p \alpha_i \Delta MP_{t-i} + U_t$ = the 1st, 2nd ... pth lagged 1st-differenced values of $\ln MP$,

$\ln MY_t$ = natural logarithm of the maize yield series to be tested,

$\ln MY_{t-1}$ = natural logarithm of maize yield series lagged by 1 period,

$\sum_{i=1}^p \alpha_i \Delta MY_{t-i} + U_t$ = the 1st, 2nd ... pth lagged 1st-differenced values of $\ln MY$,

$\ln MA_t$ = natural logarithm of the maize acreage series to be tested,

$\ln MA_{t-1}$ = natural logarithm of maize acreage series lagged by 1 period,

$\sum_{i=1}^p \alpha_i \Delta MA_{t-i} + U_t$ = the 1st, 2nd ... pth lagged 1st-differenced values of $\ln MA$,

$\ln Rn_t$ = natural logarithm of the rainfall series to be tested,

$\ln Rn_{t-1}$ = natural logarithm of rainfall series lagged by 1 period,

$\sum_{i=1}^p \alpha_i \Delta Rn_{t-i} + U_t$ = the 1st, 2nd ... pth lagged 1st-differenced values of $\ln Rn$,

φ_1, ϕ, α = coefficients

U_t = a stochastic non-auto correlated error term with zero mean and a constant variance.

In each of the cases above, the null hypothesis $H_0: \phi = 0$ (unit root) was tested with the alternative hypothesis specified as $H_1: \phi < 0$ (time series is stationary). The decision rule that guided the test required that the null hypothesis be rejected only if the Augmented Dickey Fuller test statistic < MacKinnon critical values. Rejecting H_0 would imply that the process that generates MP series of data is time invariant (i.e. MP is stationary); otherwise the series would be non-stationary raising the need to difference the data to get rid of the unit root.

4.7 Testing for structural change

A series of data can often contain a structural break, due to a change in policy or sudden shock to the economy. South Africa experienced a transition to a democratic government in 1994 and this resulted in a change in policies. Consequently the maize series was tested for structural breaks to examine whether a change in policies had a significant effect on maize supply. The chow method test was used to test the hypothesis that H_0 : no structural breaks in 1994, against H_1 : there were structural breaks in 1994.

4.8 Diagnostic testing

The consequences of model mis-specification in regression analysis can be severe in terms of the adverse effects on the sampling properties of both estimators and tests (Greene, 2002). Therefore, several misspecification tests must be employed in order to test for the validity of the supply model. These diagnostic statistics include tests for heteroskedasticity, serial correlation, stability of long-run coefficients, and the Jarque-Bera normality test of the residuals. Table 4.1 below summarises relevant diagnostic tests that were used in the study.

Table 4.1: Diagnostic tests employed in the study

TEST	METHOD
Heteroskedasticity	white test
Serial correlation	Breusch -Godfrey test
Normality	Jarque-Bera test
Stability	Ramsey RESET test

Wasim (2005) argued that whether the model suffers from the auto-correlation problem or not, it cannot be tested by using the DW d-statistics, since the model includes a lagged dependent variable in the set of regressors. Therefore for such an equation an alternative test statistic known as Lagrange Multiplier Test or the h-statistic, defined as;

$$h = \left(1 - \frac{1}{2}d \sqrt{\frac{n}{1-n\hat{v}(\hat{\phi}_2)}}\right) \quad (4.9)$$

where;

$\hat{v}(\hat{\phi}_3)$ = Least squares estimate of variables

d = DW d- statistic

n = number of observations

Under the null hypothesis of no autocorrelation, 'h' is asymptotically normal with zero mean and unit variance. The test statistic can also be used to test the hypothesis of no serial correlation against first-order-auto-correlation, even if the set of regressors in an equation has higher order lags of the dependent variable. However, if $\hat{v}\hat{\phi}_3 > \frac{1}{n}$, it cannot be computed (Greene, 2002).

4.9 Conclusion

In this chapter the maize supply model was constructed. Work done by Belete (1995), Leaver (2003) and Mythili (2008) was used as a framework for the supply model for this study. A review of the methodology used in the estimation of the elasticities is provided as well as the data used in the study. Variables used were selected based on economic theory and data availability. Acreage and yield response functions were selected to identify the influence of price and non-price factors on changes in maize output. Emphasis is placed on model diagnostic tests in order to validate the quality of the model. Satisfactory results on the diagnostic tests ensure reliable results from the supply models and are therefore an important part of the study.

CHAPTER 5: EMPIRICAL RESULTS AND DISCUSSION

5.0 Introduction

This chapter presents the results of empirical analysis of the maize supply response analysis. The analysis integrates the hypothesised model, estimation procedure and data described in Chapter three in order to obtain the required model elasticities. Firstly descriptive statistics are used to describe variables and data used for the model. The data is then tested for stationarity. The pre-test is required to determine the statistical properties of the variables before they are entered into the partial adjustment model. Long-run and short-run supply elasticities are obtained from the model and are interpreted according to theory and previous work done in the field. The chapter concludes with a final discussion of the results obtained.

5.1 Descriptive statistics

Table 5.1 shows the statistical properties of the data used in the maize supply function. The mean, standard deviation, maximum and minimum of the variables of the model are presented for the specified time frame. On average, 2.64 tonnes/hectare of maize are produced yearly with an average standard deviation of 0.96 tonnes/hectare. The average real producer price of maize is R543.06/tonne with a standard deviation of R101/tonne. The average maize acreage is 3826.15 hectares with a standard deviation of 726.13 hectares. The average annual rainfall is 79.14 mm with a standard deviation of 13.89 mm per year. Table 5.2 shows the logarithmic statistical properties of the variables of the maize supply model. The transformation of data into logarithmic form ensures that the errors are normally distributed.

Table 5.1: Statistical properties of the original data

	Yield (t/hectare)	MP (R/tonne)	Rn (mm)	Area (1000hec)
Mean	2.64	543.06	79.14	3826.15
Std deviation	0.96	101	13.88	726.13
Maximum	4	672.4	115.06	5063
Minimum	1	243.78	53.55	2032

Note: All figures were rounded off to 2 decimal places

Table 5.2: Statistical properties of the natural logarithm of the original data

	LYield	LMP	LRn	LArea
Mean	0.89	6.26	4.36	8.23
Std deviation	0.43	0.21	0.18	0.20
Maximum	1.38	6.51	4.75	8.53
Minimum	0.00	5.50	3.98	7.62

Note: All figures were rounded off to 2 decimal places

5.2.1 Rainfall variability

Rainfall is a key determinant of maize supply in developing countries. In South Africa rainfall varies from season to season fluctuating above and below average. Below is a graphical presentation of the standardised rainfall series from 1980 to 2012.

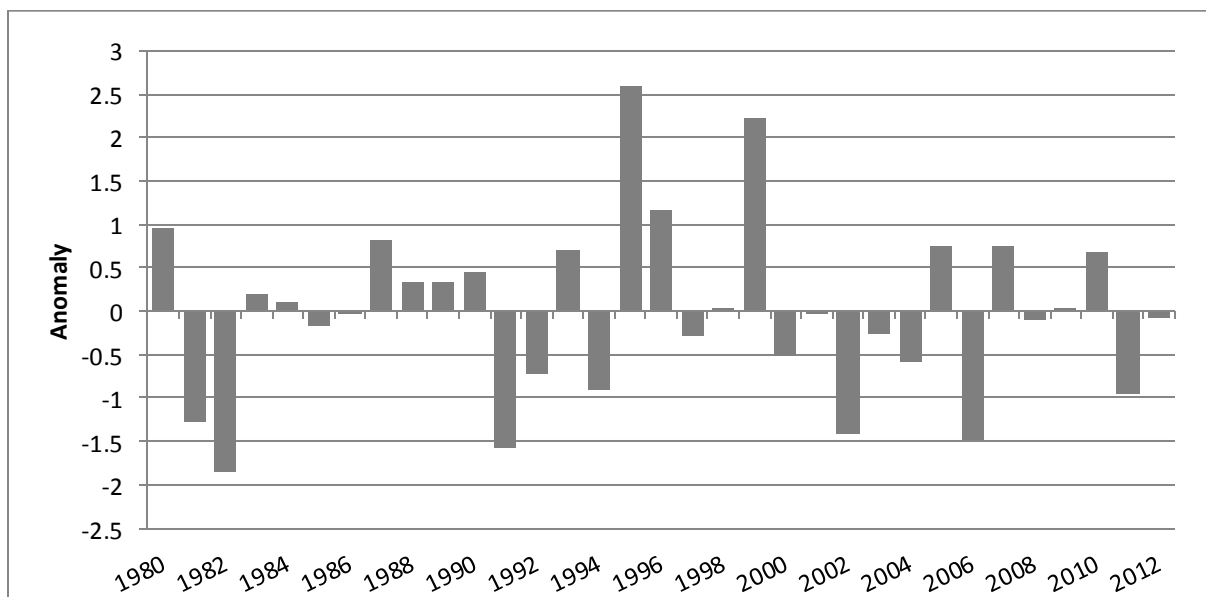


Figure 5.1: Standardised rainfall series from 1980 to 2012

Figure 5.1 above shows that rainfall was predominantly below average from 1981 to 1995. This period concurs with the droughts of the eighties and early nineties i.e. 1982, 1986 and 1992. From the mid-nineties, rainfall has been fluctuating above and below the rainfall average in a more or less regular manner.

5.3 Unit roots test

The logarithmic form of the Nerlovian model was estimated in E- views 8 using ordinary least squares. Although this approach does not require the pre-testing for unit roots, we follow the general times series procedure and test the variables for unit roots. The data series on annual yield, real price of maize (MP), real price of wheat (WP), real price of sorghum (SP), rainfall and area was tested for unit root for the study period 1980-2012. The Augmented Dickey Fuller test was used for this test with the optimal lag length chosen on the basis of the Schwarz Bayesian Criterion. The unit root test results are presented in table 5.3 and 5.4.

Table 5.3: Results of unit root tests at levels

Note: All variables include intercept and linear trend.

Series	ADF test statistic	Critical value	Lag-length	Probability	Conclusion
Lyield	6.14145	3.55776	0	0.0001	stationary
LMP	2.72464	3.55776	0	0.02341	non-stationary
LRain	6.01118	3.55776	0	0.0001	stationary
Larea	4.58900	3.55776	0	0.0047	stationary
LWP	2.51472	3.55776	0	0.3194	non-stationary
LSP	2.98972	3.55776	0	0.1505	Non-stationary

Note: All variables include intercept and linear trend.

Table 5.4: Results of unit root test at first differences

Series	ADF test statistic	Critical value	Lag-length	Probability	Conclusion
LMP	5.75294	3.56837	1	0.0000	stationary
LWP	6.92857	3.67932	1	0.0000	stationary
LSP	6.52279	3.56837	1	0.0000	stationary

Note: All variables include intercept and linear trend

All variables are in log form. The ADF method test the hypothesis that $H_0: X \sim 1(1)$, that is, has unit root (non-stationary) against $H_0: X \sim 1(0)$, that is, no unit root (stationary). The critical values for the rejection of the null hypothesis of unit root are all significant at 5%. Lyield denotes log of yield, Larea denotes log of area planted, LWP denotes log of wheat price, LSP denotes log of sorghum price and LRn denotes log of rainfall. The results of the unit root tests showed that yield, area and rainfall are stationary at levels except for maize price, wheat price and sorghum price which are non-stationary at levels as shown in table 5.3 above. However, as expected all the non-stationary series became stationary after first differencing. From table 5.3 the null hypothesis of unit root could not be rejected at levels since not all series except yield, area and rainfall of the ADF test statistics were greater than the relevant critical values. Hence the null of the presence of unit root is accepted. However, the hypothesis of unit root in all series was rejected at 5% level of significance for all series after first difference since the ADF test statistics are greater than the respective critical values as shown in table 5.4.

5.4 Results for selection of a price variable

Three price variables were considered in our analysis and these are; wheat price, maize price and sorghum price. Figure 5.2 below displays the time series data of the price variables.

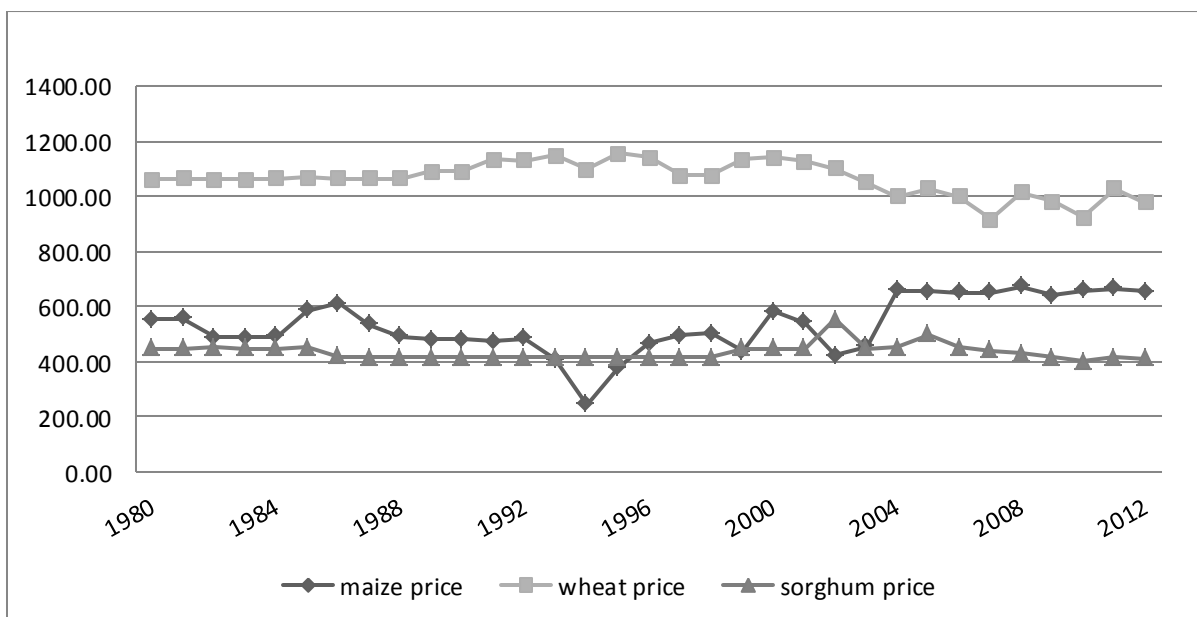


Figure 5.2: Graphical presentation of price data

To select the best price variable a regression was run for each of these price variables using simple adaptive expectations model. The regression results of each of the price variables are presented in table 5.5 below. A statistical comparison of the three estimated functions using t-tests and R^2 revealed maize price only as the best price variable to include in the supply response equation. Thus, wheat and sorghum price variables are dropped from the model.

Table 5.5: Results for selection of a price variable

Series	Coefficient		R^2
	P_{t-1}	Y_{t-1}	
Maize price	0.8918 (2.3934)	0.531 (3.4744)	0.311
Wheat price	-0.5254 (0.3517)	-0.4919 (2.9093)	0.189
Sorghum price	-0.0158 (0.0145)	-0.4872 (2.9278)	0.175

Note: Figures in parentheses are t-ratios

5.5 Structural change results

The maize series was tested for structural breaks to examine whether a change in policies in 1994 had a significant effect on maize supply. The results of the chow test (see table 5.6 below) evidently confirm that no structural breaks were realised in 1994 as the p- value of 0.1767 is not significant at 5% level thus we fail to reject the null hypothesis. Therefore from the findings of this test we conclude that the policy change that took place in 1994 did not have any significant effect on maize production in South Africa.

Table 5.6: Chow test results

1994 break point	H_0 =No breaks at specified breakpoints	
F- statistic 1.695	Prob F (6 19)	0.1767

5.6 Maize supply response

As explained in Chapter 4, two common output variables can be used in estimating the maize supply response. These are yield and area planted. The logarithmic form of the acreage and yield response functions were estimated in E- views using ordinary least squares method. Table 5.7 and 5.8 provide the estimates of the acreage and yield response functions respectively.

5.6.1 Acreage response of maize

Table 5.7: Regression results for acreage response of maize

Dependent variable: Larea		
Observations = 32		
Explanatory variables	Coefficient	t-value
Constant	7.09	4.009**
LMaizePrice	-0.0173	-1.02
LArea(-1)	0.187	1.88*
LRain	-0.085	-1.77*
Technology	-0.124	-2.33**
Policy	-0.129	1.03
Adjusted R ² = 0.65		Durbin -Watson= 2.13

** Significant at the 5% level

*significant at the 10% level

Durbin-h statistic = -1.06

Note: All variables except technology and policy are in logarithmic form.

The price variable turned out to be insignificant and negative with a coefficient of 0.017. This result indicates that the price factor is not a significant variable explaining area changes in South Africa. The negative price coefficient is unexpected and does not concur with economic theory.

Interestingly, the rainfall and technology variables turned out to be significant indicating that weather and technological changes are causing a shift in the maize acreage function annually.

The policy variable is insignificant indicating that the introduction of the maize liberalisation policy in the late nineties had little impact on maize annual acreage changes. The lagged dependent variable turned out to be significant and positive signifying that the current area under maize production is affected by maize acreage in the previous period.

Based on the results of the acreage response function only three explanatory variables were found to be significant. Most importantly the low and unexpected acreage response parameters make it difficult for the researcher to conclude on maize supply estimates based on the acreage response analysis. Gurikar (2007) faced with a similar challenge confronted the situation by considering other supply functions (yield response function) to compute the supply elasticities.

5.6.2 Yield response of maize

The yield response function was used as the basis of our maize supply response analysis. This is because in terms of significance of individual coefficients, the yield response function is of better fit as compared to the acreage function. With this in mind, we assume that maize farmers in South Africa respond to price changes to some degree by intensive application of inputs besides extending the area.

With the view to estimate the response of maize producers in terms of yield towards price and non-price factors the actual yield in the current year was expressed as function of lagged yield, price, rainfall, area and technology (see table 5.8).

The size of the adjusted coefficient of determination (adjusted R^2) and the F-statistic shows the supply model's goodness of fit. Based on the volume of the adjusted coefficient of determination, the explanatory variables explain 68 percent of the variation in the dependent variable.

Table 5.8: Regression results for yield response of maize

Dependent variable: LYield		
Observations = 32		
Explanatory variables	Coefficient	t-value
Constant	-10.03	-2.672*
LMaizePrice	0.492	1.846*
LYield(-1)	0.232	1.621*
LRain	0.773	2.879**
Technology	0.004	4.33**
policy	0.321	1.96*
Adjusted R ² = 0.68		Durbin -Watson=2.057

** Significant at the 5% level

*significant at the 10% level

Durbin-h statistic = -1.28

Note: All variables except technology and policy are in logarithmic form

The coefficient of the real price variable has a positive sign with the value of 0.49 and is significant at the 10 percent level signifying that a price increase will be followed by an increase in output in the following period. There is a significant response of yields to prices. Thus, if price is good, farmers will continue to grow the crop. The coefficient of rainfall was observed to be positive with the value of 0.77 and is significant at 5 percent level. This value indicates that an increase in rainfall will be followed by an increase in maize supply in the subsequent period. If we look at the magnitude of the rainfall coefficient it seems that rainfall is a key determinant of agricultural supply both in the short and long-run.

Yield lagged once is suggesting that an increase in yield in one period will be followed by an increase in yield in the next period. This behaviour can be assigned to the fact that producers' are assumed to include past production experiences when forming production expectations. These results agree with findings obtained by

Alemu *et al* (2003) and Ogazi (2009) whose studies that have been conducted in this field. The coefficient of lagged yield is 0.23 which is significant at 10 percent level.

The coefficient of the technology variable indicates that technological change is causing a shift in the maize supply function of 0.004 percent per year. The coefficient is positive and significant at 10 percent level. The positive and significant relationship between this variable and yield of maize suggest that maize production in the South Africa increased over time as a result of adaptation of new technologies. The low technology coefficient value indicates that maize producers in South Africa may be averse to technological changes which result in low yield response.

The policy dummy variable represents the maize market liberalisation in 1997. The co-efficient is positive, as was expected with a value of 0.320 and significant at 5 percent level. The positive influence of maize market liberalisation on yield might be due to changes in price policies that favoured maize producers to increase production.

Input price variables were not included in the model as a result of data deficiency. However, Nerlove (1958) stated that, although inclusion of input prices is important, if the necessary series are not available, these may be omitted without significantly affecting the results.

The results confirm that maize supply in South Africa does not respond well to price incentives because the numerical estimates of supply response parameters are very small. Mythili (2008) argued that reasons for low response to prices in developing countries are the limited access to technology and poor rainfall.

The results of the study support the findings of Alemu *et al* (2003) where the short-run elasticity of maize in Ethiopia is 0.31 which shows weak supply response.

A comparison of the acreage and yield response functions (see table 5.7 and 5.8) demonstrate that maize farmers have shown better yield response better than acreage response. Therefore variations in maize prices do not significantly explain area adjustments in South Africa. These findings coincide with other results obtained by Mythili (2008) when the author concluded that crop producers in Pakistan have shown better yield response better than acreage response.

Based on these observations the main findings and conclusions of this study will be drawn from the yield response function because its supply parameters are satisfactory in terms of economic theory and previous literature conducted in the field of supply response.

5.7 Diagnostic tests

Misspecification in the regression is possible and therefore it is important to test the assumptions of the statistical model. Therefore the validity of the maize supply model is confirmed by utilising relevant diagnostic tests. The tests included the Jarque-Bera test for normality, the Breusch-Godfrey test for serial correlation, the white test for heteroskedasticity, the Ramsey RESET test for model stability.

The Jargue Bera statistic of 0.27 and the associated p-value of 0.87 confirm that the residuals are normally distributed. This finding is important because it ensures the validity of the t and F tests (Leaver, 2003).

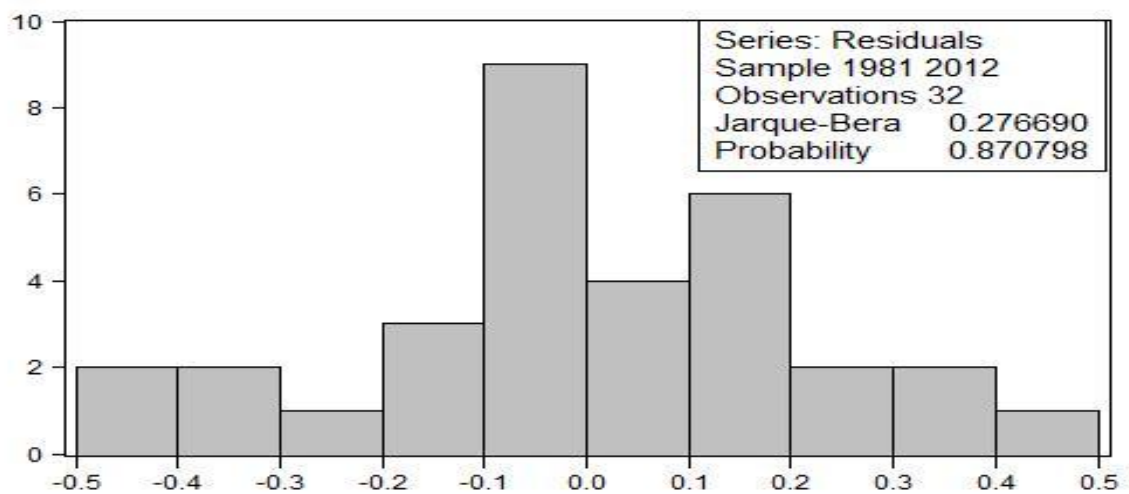


Figure 5.3: Normality test results

The Durbin-Watson statistic of 2.05 does not allow a decision to be made regarding the presence of autocorrelation among the residuals. Therefore the Durbin h test was conducted and the h-statistic value of -1.28 was obtained confirming no sign of serial autocorrelation.

The Breusch-Godfrey serial correlation LM test was conducted and the LM statistic of 0.665 and a p-value of 0.72 confirm that the residuals are not autocorrelated. The

White test was conducted in order to test the model for heteroskedasticity problems and a p-value of 0.98 was obtained indicating no sign of heteroskedasticity problem.

Ramsey Reset test validate the stability within the model parameters over the adjusted sample period of the maize supply model. The likelihood ratio of 0.56 and the associated p-value of 0.45 show evidence of stability within the model parameters. Based on these results, the model seems to be satisfactory in terms of its specification.

5.8 Estimated maize supply elasticities

The estimated short-run and long run elasticities for yield response under maize are summarized in table 5.9 below. The maize elasticity for yield shows that with the increase in the price of maize by 1 percent during the period of analysis, the quantity of maize yield increased by 0.49 percent in the short run and 0.65 percent in the long run. Both the short-run and the long-run elasticities with respect to the lagged price variable are inelastic and significant and their degrees fall in the range of elasticities found in other studies. These findings demonstrate that it will be difficult for maize producers in South Africa to react swiftly to changes in price.

Table 5.9: Maize supply elasticities for South Africa from 1980 to 2012

Short-run elasticity	0.49
Long-run elasticity	0.65

As expected the long-run elasticity with respect to the lagged price is higher than the short-run elasticity. This is an important characteristic of individual crop supply elasticities and occurs due to the fact that in the short-run some factors of production are fixed, whilst in the long-run all factors are variable (Leaver, 2003).

Given the low response of maize supply to own price in the short-run and long run it does not necessarily imply that domestic maize supply is unresponsive to maize price. But, it is likely that non-price incentives may be hindering the transformation of price incentives to stimulate maize supply in South Africa. This remark is in acknowledgment that non-price factors could dominate price factors in factors affecting decision-making process (Mythili, 2008).

The findings of this study coincide with results obtained by Alemu *et al* (2003) who calculated the short-run price elasticity and the long-run price elasticity of maize in Ethiopia to be 0.38 and 0.51 respectively. The inelastic short-run and long-run price elasticities clearly show us that not only price factors stimulate maize producers in South Africa but a package of various non-price factors may elicit a better response.

Conclusion

This chapter has detailed the empirical results obtained from the annual data from 1980–2012. Results obtained from the analysis are as expected for the long-run and short-run supply elasticities. The results also match well with those obtained in the literature on similar studies on supply response analysis.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 Summary

Supply response studies are important to understand the supply mechanics and supply relationships between factor application and output production. The study of farmers supply response to price and non-price incentives is of significant importance for formulating appropriate policies and planning development programmes for the agricultural sector of any economy, particularly in South Africa where agriculture contributes substantially to the food security.

The aim of this study was to estimate the supply response of the South African maize sector. The objectives of the study were to quantify South Africa maize farmers' supply response to changes in the price of maize, estimate the supply response of maize farmers to changes in the non-price factors and to determine the short and long-run price elasticities of supply for maize in South Africa. Two hypotheses were tested in this study; first it was hypothesised that production of maize in South Africa is not affected by price incentives and second it was hypothesised that production of maize in South Africa is not affected by non-economic factors such as rainfall, technology and policy change.

This study estimated the supply elasticities of maize in South Africa using the Nerlovian partial adjustment model. National historical time series data for the period 1980-2012 was used. Production variables for the supply model with the capacity to evaluate the stated hypotheses were identified and selected according to data availability. The yield and acreage response functions were applied to identify the impact of price and non-price factors on changes in maize output in South Africa. Ordinary least square procedure was applied to estimate the parameters of the acreage and yield functions. All data series were converted to logarithmic form and were also tested for stationarity before being used in the supply functions. Several diagnostic tests which include the Jarque-Bera test for normality, the Breusch-Godfrey test for serial correlation, the white test for heteroskedasticity and the Ramsey RESET test for model stability were applied to validate the quality of the model.

The results revealed that maize farmers showed better yield response better than acreage response in terms of significance of individual coefficients. Based on these

observations the main findings and conclusions of this study were drawn from the yield response function. The main findings indicated that both the short and long-run supply elasticities were inelastic, indicating that South African maize farmers are relatively unresponsive to output prices. The short-run elasticity was 0.49 and the long-run elasticity 0.65. Therefore based on these results the study failed to reject the null hypothesis set for the study and concluded that maize producers in South Africa are less sensitive to changes in price and non-price incentives. These results correspond with past studies which revealed weak supply response for field crops in developing countries; Gulati and Kelly (1999), Muchapondwa (2009), Leaver (2003), Foster (1995).

6.1 Conclusions

Based on the findings of the study the following inferences are drawn;

Maize supply in South Africa does not respond well to price incentives because the numerical estimates of supply response parameters are very small. These findings basically suggest that an increase in the producer price of maize will not essentially elicit an increase in maize production. Reasons cited for poor response varied from factors such as constraints on technology, rainfall to lack of complementary policies. Rao (1989) attributed frequent price fluctuations as the main reason for the low supply response to prices. This is because as farmers become aware of these price fluctuations they are reluctant to immediately respond positively to price rises.

Based on the supply parameters of the acreage and yield response function, maize farmers have shown better yield response better than acreage response. The study also found out that variations in maize prices do not significantly explain area adjustments in South Africa. This is because the coefficient of the price variable in the acreage response function was negative and insignificant which is not consistent with economic theory. The yield response function confirmed that farmers respond to prices to some extent by intensive application of better technologies given the same area, as the flexibility to shift acreage could be restricted in farming.

Non-price factors are important means of affecting maize production and resource allocation, demonstrated by the magnitudes of the elasticities of yield response with respect to these factors. The most important non-price factors determining maize yield in South Africa are technology, policy and rainfall. Various discussions on the

supply response subject in literature clearly acknowledged the significance of non-price factors in stimulating crop production in developing countries.

An important conclusion drawn from the study is that climatological factors, such as rainfall have a significant effect on maize supply. Therefore an increase in rainfall has a positive influence on maize production both in the short and long-run.

Given the low response of maize supply to own price in the short-run and long run it does not necessarily imply that domestic maize supply is unresponsive to maize price. But, it is likely that non-price incentives may be hindering the transformation of price incentives to stimulate maize supply in South Africa. This could indicate that non-price factors dominate price factors in factors affecting decision-making process.

6.2 Recommendations

The recommendations discussed in this section are based on the findings of the study.

This study found that maize supply in South Africa does not respond well to price incentives both in the short and long-run. Therefore it is recommended that the government should set up distinctive market price mechanisms which should be acceptable for farmers to attain self-sufficiency in production, such as setting a minimum procurement price and providing input subsidies. Subsidies for producing grain and purchasing input encourage farmers to improve maize production. Given the effectiveness of the subsidy on grain yield response, it is sensible to carefully evaluate the overall effect of subsidy policies and design a comprehensive policy package to ensure long-term food security in South Africa. Consequently, if prices are properly regulated and stabilised, farmers will adopt scientific and improved methods of cultivation and due to this agricultural production especially maize production will be enhanced to meet the national food requirements of the country.

The study also found that non-price factors are important means of affecting maize production and resource allocation, demonstrated by the magnitudes of the elasticities of the yield response with respect to these factors. One of the most important non-price factor determining maize yield, and hence the major source of productivity advance in South Africa, is technology. Given the high impact of technology on farming, the government focus should be centred on the promotion of

modern technology. Consequently, the government should invest extensively on research and development in a bid to stimulate new technologies that will benefit maize farmers both in the short and long-run. Therefore given the significance of technology on production, maize supply should be stimulated through technical progress and mechanisation rather than just pricing policies.

The study also established that climate factors such as rainfall affect both maize production and farmers' decision-making. The impending droughts have had a negative impact on maize yield in South Africa. As a short term adaptation strategy, farmers use previous season's rainfall information to adjust the current season's production. Future climate change would further affect the rainfall variability. These results have valuable policy implications in the formation of climate change mitigation and adaptation strategies in South Africa. Government policy cannot affect natural conditions like rainfall, but it can compensate for the negative impact of climate change by increasing investments in irrigation, promoting efficient use of water and encouraging adoption of drought-resistant varieties. Improving farmers' access to seasonal weather information can be another tool of effective adaptation for rainfall variability.

From the maize supply analysis grain responsiveness to non-price factors is greater than that to price factors. This suggests that provision of non-price incentives in the form of seeds, fertilisers, fuel and machinery to maize farmers by the government must play a key role in heightening the maize sector. The grain marketing and pricing policy of the 1990s by the South African government has had a positive effect on maize yield, and this also promoted greater efficiency in the agricultural sector as prices became more closely linked to international prices. Given the positive influence policies have on maize production the government should constantly review and adjust agricultural policies to ensure their relevance to the modern day farming system. Furthermore, formulation and speedy implementation of policies which will induce a substantial expansion of agricultural production is also needed.

6.3 Areas of further study

This study was conducted using national historical time series data which can be limiting. It is therefore vital for future studies to narrow down to farm level analysis in order to capture household facets such as technical efficiency and socioeconomic

characterization of farmers using cross sectional data. This study did not include input cost variables because of unavailability of data. Therefore future studies should include more explanatory variables like costs of fertiliser and seed as they have effect on maize supply. An institutional analysis of factors affecting maize production should also be studied in the future to embrace issues such as market access in order to evaluate the impact of institutional activities especially in the post-apartheid era.

REFERENCES

- ALEMU, Z.G., OOSTHUIZEN, K. & SCHALKWYK, H. D. V. (2003). "Grain-Supply Response in Ethiopia: An Error-Correction Approach", *Agrekon*, Vol 42, No 4, 389-404.
- ARC (AGRICULTURE RESEARCH COUNCIL). (2003). *Annual report 2003-2004*. Retrieved May 2013, 15, from, www.pmg.org.za/docs/2004/arcreport.pdf.
- ASKARI, H. & CUMMINGS, JT. (1977). *Estimating agricultural supply response with the Nerlovian model: A survey*. *International Economic Review*, Vol 18, No 2, 25-92.
- BHATTI, N., ALI SHAH, A., SHAH, N., SHAIKH, S.M & SHAFIQ K (2011) *Supply Response Analysis of Pakistani Wheat Growers*. *International Journal of Business Management*, Vol 6, No 4, 66-78.
- BEGAWY, K.H. EL-WAKIL M, ABOU-TALB & MOHY AL-DIN M. (2008). "Supply Response for Some Crops in Egypt: A Vector Error Correction Approach," *Journal of Applied Sciences Research*, Vol. 12, No. 4, 1647-1657.
- BELETE, A. (1995). *Econometric analysis of supply response among summer wheat growers in Lesotho*. *UNISWA journal of agriculture*. Vol 4, 73-80.
- BHAGAT, L.N. (1989). *Supply responses in backward agriculture*, Ashok Kumar Mittal publishers, New Delhi, India.
- BHOWMICK, B.C. & AHMED, A.U. (1993). *Behaviour of trend and growth of area, production, productivity and supply response of major oilseed crops in Assam*. *Argil. Situ, India*, Vol 48, No 1, 3-7.
- BRAULKE, M. (1982). 'A note on the Nerlove model of agricultural supply response'. *International economic review*, Vol 23, No 1, 241-246.
- BREITENBACH, M.C. & FÉNYES T.I. (2000). *Maize and wheat production trends in South Africa in a deregulated environment*. *Agrekon*, Vol 39, No 3, 292-312.
- CHABANE, N. (2000). *An Evaluation of the influences on price and production in the maize market following liberalisation*. *Trade and industrial policy strategies*. Retrieved August 2013, 22, from, www.tips.org.za/files/566.pdf

- CHOI, J.S. & P.G. HELMBERGER. (1993). "How Sensitive are Crop Yield to Price Changes and Farm Programs?" *Journal of Agricultural and Applied Economics*, Vol 25, 237-244.
- COLMAN D. (1983). "A Review of the Arts of Supply Response Analysis," *Review of Marketing and Agricultural Economics*, Vol 51, No 3, 201-230.
- DAFF (DEPARTMENT OF AGRICULTURE FORESTRY AND FISHERIES). (2011). Maize market value chain profile 2010/2011. Retrieved March 2013, 11, from <http://www.daff.gov.za>.
- DAFF. (2012). Abstract of Agricultural statistics 2011/2012. Retrieved February 2013, 09, from <http://www.daff.gov.za>.
- EL BATRAN, M. M. (2003). *Supply response for wheat in Egypt*. Bull. of Faculty of Agric., Cairo Uni, Vol 54, No 1, 21-30.
- ENGLE, R. F. & GRANGER, C.W.J. (1987). "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*, Vol 55, 251-275.
- FOSTER, A. K. & MWANAUMO A. (1995). *Estimation of dynamic maize supply response in Zambia*, *Agricultural Economics journal*, Vol 12, 99-107.
- GOSALAMANG D.S. BELETE A. HLONGWANE J.J. & MASUKU M. (2010). *Econometric analysis of supply response among beef farmers in Botswana*, pdf. *African Journal of Agricultural Research*, Vol 7, No 31, 4383-4389.
- GREENE, W.H. (2002). *Econometric analysis*. 5th Ed, New York University. USA.
- GULATI, A. & KELLEY, T. (1999). *Trade Liberalisation and Indian Agriculture*. Oxford University Press, United Kingdom.
- GURIKAR, Y. (2007). *Supply response of onion in Karnataka State – An Econometric Analysis*, University of Agricultural Sciences, Dharwad – 580005, India.
- HERTEL W.T. & KEENEY R. (2008). *Yield response to prices; Implications for policy modelling*, pdf. Working paper. Vol No 3, 08-13.
- JSE (2005). *Equity Market and Trading Functionality Overview*, version 24.

- JUST, R.E. (1998). *Econometric analysis of supply response and demand for processing tomatoes in California*, California Agricultural Experiment Station report., (Berkeley) .USA.
- KIRSTEN, J.F., EDWARDS, L. & VINK, N. (2008). *Distortions to Agricultural Incentives in South Africa*. Retrieved September 2013, 9, from <http://www.scholar.sun.ac.za>
- KOWORNU, K.M.J., IZIDEEN, P.M. & OSEI-ASARE, Y.B. (2011). *Supply response of rice in Ghana: A co-integration analysis*. IISTE, Vol 2, No 6, 1-14.
- KUMAR, P. & ROSEGRANT, M. W. (1997). *Dynamic supply response of cereals and supply projections: A2020 vision*. Agril. Econ. Res. Rev, Vol 20, No 1, 1-22.
- LEAVER, R. (2003). *Measuring the supply response function of tobacco in Zimbabwe*. Agrekon, VOL 43, 113-129.
- LIU, F., YOU, L. & YU, B. (2010). *Dynamic Agricultural supply response under economic transformation. A case study of Heran province*. IFPRI discussion paper 00987.
- MADDALA, GS. (2001). *Introduction to Econometrics*. 3rd Ed, Sussex, United Kingdom: John Wiley and Sons Ltd.
- MESFIN, A. (2000). *Supply response of maize in Karnataka state – An econometric analysis*. University of Agricultural Sciences, Dharwad, India.
- MESIKE, CS., OKOH, RN & ONONI, OE. (2010). *Supply Response of Rubber Farmers in Nigeria: An Application of Vector Error Correction Model*, pdf, Agricultural journal. Vol 5, No 3, 146-150.
- MUCHAPONDWA, E. (2009). *Supply response of Zimbabwean agriculture: 1970–1999*. Afjare, Vol 3, No 1.
- MSHOMBA, R.E. (1989). *'Price elasticity of supply of Tanzania's major export crops'*. Eastern Africa economic review, Vol 5, No 1, 9-23.
- MYTHILI, G. (2001). *A Note on Acreage Response for Major Crops in the Selected States*. Macmillan publishers. India.

MYTHILI G. (2008). *Acreage and Yield Response for Major Crops in the Pre- and Post-Reform Periods in India: A Dynamic Panel Data Approach*, Report prepared for IGDR – ERS/ USDA Project: Agricultural Markets and Policy. Mumbai, India.

MUSHTAQ, K. & DAWSON, P.J. (2002). *Acreage response in Pakistan: a co-integration approach*. *Agricultural Economics*, Vol 27, 111-121.

NAMAC. (2009). *Value Chain - Maize to Maize Meal*, FPM Report Part 4: Ch.2.

NDA. (2009). *Maize profile*, Obtained from the resource centre directorate communication. Retrieved December 2012, 17, from <http://www.nda.gov>.

NERLOVE, M. (1958). *The Dynamics of Supply: Estimation of Farmers' Response to Price*. Johns Hopkins, Baltimore.

OGAZI, C.G (2009). *Rice output supply response to the changes in real prices in Nigeria: An autoregressive distributive lag model approach*. *Journal of sustainable Development in Africa*, Vol 11, No 4, 83-100.

OGUNDARI, K. & NANSEKI, T. (2012). *Maize supply response to prices in Nigeria. Application of ARDL and co-integration analysis*. Retrieved on July 2013, 5, from <http://www.docs.business.auckland.ac.za>.

OLWANDE, J., NGIGI, M. & NGUYO, W. (2009). *Supply responsiveness of maize farmers in Kenya: A farm-level analysis*. Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China, August 16-22, 2009. Retrieved November 2012, 13, from <http://www.ageconsearch.umn.edu>.

OYEWUMI O.A., JOOST, A. & OGUNDEJI, A.A. (2011). *An error correction approach to modelling beef supply response in South Africa*, pdf, Agrekon, Agricultural Economics Association of South Africa. Vol 50, No 2, 44-58.

RAJU, KSR. & NAGABHUSHANAM, TDJ. (1986). *Supply response of major oil seed crops in different regions of Andhra Pradesh*. *Agricultural Journal. Situ*, Vol 41, No 9, 747-750.

RAKHUDU, M. (2006). *Structure and pricing within the maize value chain*. Extracted from competition news, the official news letter of the Competition Commission, VOL 25, 1-2.

RAO, J.M. (1989). Agricultural supply response: A survey. *Journal of Agricultural Economics*, VOL 30, No 3, 1-22.

RAO, C.H.H. (2003). "Reform Agenda for Agriculture: EPW Perspectives, *Economic and Political Weekly*, VOL 15, 615-620.

SEAY S.S., PITTS S.T & KAMERY H.R. (2004). *An explanation of the partial adjustment adoptive expectations (PAAE) model*. *Proceedings of the Academy of economics and Economic education*, Vol 7, No 1, New Orleans.

STATSSA. (2012). *Census publications*. Retrieved March 2013, 15, from <http://www.statssa.gov.za/Publications>.

SCHIMMELPFENNIG, D. THIRTLE, C. & VAN ZYL, I. (1996). "Crop level supply response in South African Agriculture: An error-correction approach", *Agrekon*, Vol 35, No 3, 111-122.

SINGH, O.P. (1998). *Growth and supply response of oil seeds in Uttar Pradesh*. *Agril. Situ. In India*, Vol 55, No 1, 3-6.

THIELE, R. (2002). *Price Incentives, Non-Price Factors, and Agricultural Production in Sub-Saharan Africa: A Cointegration Analysis*, Kiel Institute for World Economics, Kiel, Working Paper 2002.

TOWNSEND, R., THIRTLE, C. & REVELL, B.J. (1997). *Dynamic acreage response: An error correction model for maize and tobacco in Zimbabwe*. *International Association of Agricultural Economists, Occasional Paper, No 7, 198-209*.

TRIPHATI A. (2008). *Estimated Agricultural supply response by co-intergration approach.pdf*. Report submitted under visiting research scholar programme available at [http://works, bepress.com](http://works.bepress.com).

VAN WYK D.N. and TREURNICHT N.F. (2012). *Supply response analysis of the Namibian mutton industry; a methodology overview.pdf*. *South African Journal of Industrial Engineering*, Vol 23, No 1, 201-215.

WASIM P.M. (2005). *Milk Production Response in Pakistan*. The Lahore Journal of Economics, VOL 10, NO 1, 105-121.

ZAMAN K & NIAMATULA M. (2009). *Production and acreage response of wheat and cotton in NWFP Pakistan*, Pakistan journal of agriculture. Res, Vol 4, No 5, 3-4.