AN ESTIMATION OF PRICE AND NON PRICE FACTORS AFFECTING MAIZE SUPPLY RESPONSE IN ZIMBABWE

BY

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CERTIFICATION

I certify that the ideas, experimental work, results, analysis, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged.

The undersigned certify that they have read, and recommended to the Department of Agricultural Economics and Extension for acceptance, the thesis entitled;

AN ESTIMATION OF PRICE AND NON PRICE FACTORS AFFECTING MAIZE SUPPLY RESPONSE IN ZIMBABWE

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COLLABORATIVE MASTERS DEGREE IN AGRICULTURAL AND APPLIED ECONOMICS

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ABSTRACT

Maize is the staple food crop of Zimbabwe and therefore plays an important role in achieving national food security goals. In the past 30 years, the country has experienced both a decline and unstable production in maize. Efforts by government to stabilize maize production seem not to have worked very well as this problem persists. The poor understanding of the maize supply response factors may partly explains this failure as efforts maybe directed at inappropriate/ ineffective factors. This study aims to develop and quantify econometrically a maize supply response model for Zimbabwe. The study evaluated the responsiveness of maize supply to its price and non price determinants. A more recent and appropriate error correction model (ECM) was applied on time series data covering a period 1980-2007 to avoid unrealistic assumptions of the traditional partial adjustment models. To deal with the expected problems associated with time series data the study adopted several diagnostic tests. In addition, Granger's Wald test was used to assess the direction of causality between variables. After making all necessary transformation on the variables, a supply response function was then estimated using the ECM which offers a means of obtaining consistent yet distinct estimates for both short run and long run elasticities. The results show that the elasticity for the price of maize was not significant although positively related to maize output. This finding is exceptional in that most results from previous studies show own prices to significantly affect output. Therefore, the finding implies that pricing policy alone is a blunt instrument for increasing maize supply in Zimbabwe. Credit allocation, fertilizer use, rainfall, consumption and area under maize were found to significantly affect the responsiveness of maize supply. The elasticity for credit estimated at -0.06, was significantly inelastic and unexpectedly negative. A possible reason for this is that these were merely reported allocations and the actual expenditure might not have taken place. For consumption—not included in previous studies—the study found it to have a significant effect on output in the short run with a very elastic coefficient estimated at 9.6. The results also show that there were instances were prices continued to go up above the transaction costs even when imports continued to increase. This finding is unexpected given a simple arbitrage argument. Given the findings, the study recommends policies that focus more on non price factors as a means of doing away with the conventional strong emphasis on price factors as a means of stabilising maize production. The study also recommends that trade policies should be completely liberalised to allow physical arbitrage to bring prices to their pareto efficient levels.

Keywords: Maize Supply Response, Unit Root, Co-integration, Error Correction Mechanism

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To my friends, colleagues and family thanks for the encouragement and support during good times and bad times

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DEDICATION

To my family

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ACRONYMS

ADF	Augmented Dickey Fuller
AMA	Agricultural Marketing Authority
ARDL	Autoregressive Distributed Lag
ASPEF	Agricultural Sector Production Enhancement Facility
BACOSSI	Basic Commodities Supply Side Intervention
CBOT	Chicago Board of Trade
CFU	Commercial Farmers Union
CPI	Consumer Price Index
ECM	Error Correction Coefficient
ECT	Error Correction Term
ESAP	Economic Structural Adjustment Program
EU	European Union
FAO	Food and Agricultural Organisation
FEWSNET	Famine Early Warning Systems Network
FOC	First Order Condition
FTLRP	Fast Track Land Reform Program
GDP	Gross Domestic Product
GMA	Grain Marketing Act
GMB	Grain Marketing Board
GMO	Genetically Modified Organisation
GMR	Grain Market Report

GoZ	Government of Zimbabwe
MAMID	Ministry of Agriculture Mechanisation and Irrigation Department
MLE	Maximum Likelihood Estimation
NPC	Nominal Protection Coefficient
OLS	Ordinary Least Squares
OMIR	Old Mutual Implied Rate
R&D	Research and Development
RBZ	Reserve Bank of Zimbabwe
RWM	Random Walk Model
SAFEX	South African Future Exchange
SAP	Structural Adjustment Program
SOC	Second Order Condition
SPS	Sanitary and Phyto sanitary
TBT	Technical Barriers to Trade
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WTO	World Trade Organisation
ZIMACE	Zimbabwe Agricultural Commodity Exchange

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CHAPTER ONE: INTRODUCTION

1.0 Background

Maize is a staple food crop in Zimbabwe and therefore its availability is of paramount importance in determining the food security goals of the nation. Despite its huge importance, Zimbabwe's agricultural sector has been witnessing continued decline in maize productivity, total production and marketed surplus over the past decade (FAO, 2010; FEWSNET, 2010; Mudzonga and Chigwada, 2009; MAMID, 2007). This followed successive years of a fusion of multifarious ad-hoc agricultural policies from highly regulated dispensation, near free market dispensation to a fully liberalised marketing environment (Rukuni *et al, 2006*). This blend of policies meant that producers had to adjust to different production and macro-economic environments. The Zimbabwean maize policy environment transformed from a highly controlled though lucrative policy environment of the pre 1990 era. It was then followed by the World Bank led liberalisation policies of the early 1990s which saw all the controls being relaxed and maize becoming an uncontrolled product (Moyo, 2006; Rukuni *et al, 2006*). The failure of these policies to boost maize production led to a shift in the policy environment to a highly controlled era in 2000. This policy shift yet again failed to stabilise maize supply thus calling for the more recent market liberalisation reforms in 2009.

Many policy makers in agro-based economies seem to have a tendency of taxing the agricultural sector as justified by the idea that industry is a dynamic sector while the agricultural sector is static and unresponsive to incentives (Mckay, *et al*, 1999). The argument is that if supply response for agriculture is low, then taxing agriculture will generate resources for other sectors of the economy, without significantly affecting agricultural growth. On the other hand, if agricultural supply response is high, and then taxing agriculture can impede agricultural growth, creating food and input supply shortages which will increase reliance on imports to meet food requirements and reduce agricultural exports which is often the principal source of foreign exchange.

In this paper, the agricultural sector is hypothesised to be a dynamic sector highly responsive to incentives. This dynamic agricultural environment call for producers and other key participants in the sub sector to continuously make production and marketing decisions in concomitant with the ever changing environment. The policy makers also need to acquire and understand pertinent information in order to make meaningful policy decisions that will enable sustainable stabilisation of agricultural supply. Moreover, producers make their production and marketing decisions based on these policies. Thus, timeliness and accuracy of this information is relevant in this dynamic sector. More often than not, this information, especially on critical production parameters is not availed timely and accurately. Once these key parameters are understood, they act as a baseline for policy planning and foresting decision within the agricultural and related sectors. Thus, it is against this backdrop that modelling supply can play a key role in assisting role players in sound decision making.

Modelling supply response is not a recent phenomenon in agricultural economics and has been used in various economies. Due to the dynamism of the agricultural sector and lack of reliable data, various techniques have been developed to try and understand the movement of supply especially using time series data on prices, productions and other exogenous variables as will be explained in later sections. The supply response models are useful in policy analysis and forecasting. The models used in understanding supply response have been developed through time and each model faces various strength and limitations. This body of knowledge dates back from the neoclassical approach to supply response which only made use of prices and opportunity costs as the explanatory variables for supply response on competitive markets. However through time the importance of government policies in stabilising supply paved way for the modified convention formulation approach which maintains the neoclassical paradigm while adding effects of risk of exogenous government intervention (Snowdon and Howard, 2005).

In this study an error correction model (ECM) is used to model the supply response of maize in Zimbabwe. The development of a supply function is extended from market theory and trends in the maize sector over time. By employing economic theory and econometric modelling techniques to Zimbabwe's maize market, the ECM provides a basis through which the effects of price and non-price factors impact on maize production. The basic advantage of using the ECM to model supply response studies is how it avoids the partial adjustment model's unrealistic assumption of a fixed target supply based on stationary expectations. This approach is very useful in understanding and predicting the movements in supply as it captures both short run and long run effects of exogenous variables (Gujarati, 1995). Knowledge of the supply response parameters may assist policy makers to determine the most appropriate levels and effective points of government intervention that may effectively enable meeting of sustainable growth targets.

1.1 The context of study

Zimbabwe has a dualistic agricultural sector consisting of large scale farmers and a heterogeneous set of smallholder farmers. Using the ZIMSTAT proportions at the national level, 7.8 million people which account for 69% of the population live in the rural areas while the remaining 3.5

million live in urban or peri-urban areas (ZIMSTAT, 2010). Zimbabwe's farmers can be grouped into the large scale farmers and the small scale farmers. The smallholder or small scale farmers are further sub divided into small-scale commercial sub-sector, the module A1 sub-sector and the communal area sub-sector. The large scale farmers are subdivided into the large scale commercial sub-sector and the module A2 sub-sector. Of Zimbabwe's total land area (39 million hectares), 33.3 million hectares are regarded as agricultural land while the remaining 6 million hectares have been reserved for national parks, wild life and for urban settlements (Rukuni *et al*, 2006).

The Ministry of Agriculture figures show that the smallholder sector (including the communal sector) constituted 50% of the total agricultural land while the large scale farms constituted 34% with the remaining 16% being classified as national land (MAMID, 2007). The fast track land resettlement program saw the government designating approximately 98% of the 11.2 million hectares of large scale commercial farmland for resettlement. There are still mixed figures of the new land distribution patterns as it is part of an ongoing process. Within the smallholder sector, the communal subsector constitutes 64% (1 100 000 farms), the module A1 subsector constitutes 22% (141 656 farms) while the remaining 14% is classified under old resettlement (72 000 farms) (FAO, 2010).

In relation to maize production, the smallholder sector contributes on average over 60% of the national maize output (Rukuni *et al*, 2006). This represented a shift in sub sector contributions since the maize sector in the pre-1980 era was dominated by large scale commercial farmers. The smallholder sector contributed approximately 25% which increased to 31% and 39% of total maize production in the periods 1975-79 and 1980-84 respectively. The drought periods of

1982/83, 1991/92, 1994/95 and 2001/02 reduced the national maize production below the level of national domestic use. However, the potential of Zimbabwe in producing maize can be seen from the national production figures of the years 1980/81, 1984/85 and 1995/96 when the country's maize output was 2.8 million, 2.7 million and 2.6 million tonnes respectively (MAMID, 2007).

The year to year fluctuations not only reflected vagaries of climate, but also influence of price and government policies. The variation in climate, prices and pertinent government policies is complex, and requires a much more encompassing analysis which simplifies the relationship between these variables and the level of maize output.

1.2 Problem statement

Maize is the staple food crop in Zimbabwe and therefore its availability is of paramount importance in relation to achieving the food security goals. Despite this huge importance, the nation has been facing consistent maize shortages in the last decade (Mudzonga and Chigwada, 2009). More recently, the 2009/2010 crop assessment estimated the country’s cereal deficit at 432 540 tonnes (FEWSNET, 2010). Total utilization of cereals (domestic use) was estimated at about 2.09 million tonnes including 1.7 million tonnes for direct human consumption, which, against total domestic cereal availability of 1.66 million tonnes leaves a national cereal deficit of 428 000 tonnes (FAO, 2010).

Fluctuations in maize production can be potentially explained by price and non prices factors. Price factors refer to both product and factor prices which affect the profitability of a farmer. The non price factors include exogenous factors such as biophysical, institutional and various government policies which constrain the farmers in maize production. Macroeconomic factors also affect the agricultural sector in a number of ways and have to be included in the analysis. All these factors if carefully understood and manipulated would be desirable to stir production upwards. The dynamic fluctuations in supply demonstrate that the level and extent to which these factors may be unclear to policy makers.

Improving national maize production may be the panacea to stabilising national maize supply. However, the trends in the Zimbabwean maize industry have not been well understood. In this study, a supply response function for the Zimbabwean maize market is estimated using the error correction mechanism to provide an understanding of how the sector responds to incentives using historical time series data covering a period 1980-2007. Knowledge of the response parameters may assist policy makers to determine the most appropriate levels and effective points of government intervention that may effectively stabilise national maize output.

1.3 Research objectives, questions and hypothesis

The general objective of this study is to estimate the responsiveness of Zimbabwe's maize supply to price and non-price incentives over the period of 1980-2007. The 3 specific objectives of this study are;

- To characterise and explain maize production trends in Zimbabwe over the years
- To estimate the effect of price and non price factors on national maize production.
- To establish whether the local market is integrated with the regional maize

To achieve these 3 specific objectives the following research questions are asked respective of the above objectives.

- What are the main characteristic trends of maize production in Zimbabwe?
- How does Zimbabwean maize supply respond to price and non price factors?
- Is the local market integrated with the regional market?

To answer the above three questions the following tentative answers are hypothesised respectively.

- There has been a declining trend in national maize production and contribution of commercial sector to total maize output.
- Zimbabwean maize supply response is significantly affected by price and non price factors
- The local and the regional maize markets are integrated.

1.4 Justification of the study

The justification of this study falls under two categories which are firstly, the importance of maize production to the Zimbabwean economy and potential implications or contribution of the study to policy making and secondly, the information and methodological gaps that exist in literature.

(i) Importance of maize production and implication on policy

The year to year fluctuations in the maize supply in Zimbabwe is not only important from a historical perspective, but also useful to evaluate the effects of existing and new policies. These fluctuations not only reflect vagaries of climate, but also influence of price and related government policies. The variation in climate, prices and pertinent government policies is complex, and requires a much more encompassing analysis which simplifies the relationship between these variables and the level of maize output. Knowing and understanding the key variables, which affect production of farmers, is of great importance for designing economic policies and their ultimate implementation in Zimbabwe. The importance of maize comes from the fact that it is a strategic crop in Zimbabwe and its unavailability would tap resources that could have been used productively in other sectors towards its procurement. Therefore there is need for stabilisation of its production and minimisation of the harmful cycles.

In order to do so we need to quantify supply response parameters and identify variables responsible for the largest swings or changes. The disillusionment among policy makers with regard to maize marketing with swings from complete market control at one time to full liberalisation shows little understanding as well as the complexity of the maize sector. Practical studies especially in the area of maize supply response have not been able to exhaust all the possible variables responsible for this policy failure and decline in production. A robust study is therefore required to get a deeper understanding and quantify various factors which can be used as policy instruments to stabilise maize production.

(ii) Information and methodological gaps in literature

The study of factors affecting maize production in Zimbabwe has been done using various methods of evaluating performance of the sub sector (Rukuni, 2006; Eicher, 1995, Richardson, 2007). It is important to note that of the supply response studies that has been done so far, especially in the third world countries, most of them tend to face numerous data limitation problems and therefore tend to limit the variables included in their analysis. Apart from pure agricultural incentives captured by prices, there are other factors that affect supply response whose omission generally bring omitted variable bias. These variables include life expectancy, extension, population density, real income level and spending on research and credit some of which are included in this study (Mamingi, 1997).

Most studies use the partial adjustment model to estimate the responsiveness of supply to agricultural incentives. However, modelling supply response using the Nerlovian formulation has been criticised on both empirical and theoretical grounds. The Nerlove formulation is unable to give an adequate clear-cut distinction between short-run and long-run elasticities, while the use of OLS may produce spurious results. When combined with error correction models, cointegration offers a means of obtaining consistent yet distinct estimates of both long-run and short-run elasticities. This study therefore utilises the error correction mechanism to estimate the responsiveness of maize supply to price and none price factors. The rationale for using the error correction model in agricultural supply response studies is how it avoids the partial adjustment model's unrealistic assumption of a fixed target supply based on stationary expectations. More detail on the choice of the model is furnished in the next chapter.

1.5 Thesis organization

This study is organised into six chapters. Chapter 1 provided the introduction, clearly explaining the background and context of study, the statement of the problem, questions and hypothesis to be tested and also the justification for carrying out the study. Chapter 2 present the literature review which start by looking at the origin of maize and its global distribution in terms of production trade and marketing. The chapter then provides a review of the Zimbabwean agriculture sector with particular focus on maize marketing. It goes on to review the models commonly used in estimating agricultural supply response. A review of past studies was also done to assess the research methods used as well as the empirical findings. This gave foundation or basis on the choice of the research methods used in the study and expected results.

Chapter 3 present the research methods employed in the study. Possible link between and among variables is presented in a conceptual framework as well as the tools of analysis. Chapter 3 conclude by giving the expected results which are basically informed by the literature review. Chapter 4 is the first analytical chapter that attempt to answer the first research question and it provides a characterization of maize production tends using secondary data. Chapter 5 give an analysis of the determinants of maize supply over the years and the response to policy incentives using the error correction model and related time series econometric techniques. The second part of chapter 5 continued to investigate price transmission between the local and regional maize market using price and trade flow data. Chapter 6 provides a summary of results and possible policy recommendations from the empirical findings of the study.

1.6 Summary

To conclude, this chapter presented the very basic elements of the study. The chapter introduced the study and provided the background and context of the study. It then goes on to present the problem statement, the research objectives, hypotheses, research questions to be explored in the study. The rationale or justification for carrying out the study was clearly articulated. It then concluded by providing the expected contributions and gains from the project to the knowledge body of economics and in achieving developmental goals. The importance of this chapter therefore is to provide a road map for the development of the thesis as a whole. The next chapter present the literature review.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

The primary purpose of the study is to investigate the responsiveness of Zimbabwe's maize sub-sector to price and non-price incentives using the time series data of the post independence era from 1980 to 2007. This section provides a review of literature by looking at two main elements. The opening section of the chapter provides us with the historical overview of maize crop in terms of its origin, characteristics and global view of maize marketing with particular reference to production, trade and price discovery mechanism. This help to provide an understanding of the position of Zimbabwe in the international market. The chapter then provides a review of maize marketing in Zimbabwe and the related policies that influence the structure and performance of the sector. The chapter proceeds by reviewing the theory of supply response and methods used in time series analysis. Empirical findings of the studies done by previous researchers as well as the methods of analysis employed are reviewed in this chapter. The chapter concludes by drawing out insights inferred from the literature and a sound research method is developed based on the review.

2.1 Maize history and characteristics

Maize (Zea mays) is believed to be one of the oldest domesticated plants and its origins are believed to date back to at least 7000 years ago when it was grown in the form of a wild grass called *teosinte* in Central Mexico (FAO, 2006). Maize is an annual plant which is highly productive and geographically adaptable, an important property that has helped its cultivation to spread throughout the world. Maize grown around the world is generally categorized into two broad groups which are yellow and white maize. Yellow maize constitutes the bulk of total world maize produced and internationally traded. White maize is generally considered a food crop. Globally, around 460 million tonnes which approximates 65%, of global maize production is used for animal feed purposes while around 15% is used for food and the remaining percentage is mainly destined for industrial use (ABSA, 2011). The leading users of maize for animal feeding are the United States, China, EU and Brazil and together they account for almost 70% of the global use of maize for animal feed. The next section goes through maize production in a global context (FAO, 2006).

2.2 Overview of the global maize production, trade and marketing

The global maize economy has undergone major changes over the past two decades in terms of production, utilization and market structure. These changes were driven by a host of factors ranging from rapid advancements in seed and production technologies, changes in national policies, international trade, and more recently, the sudden surge in demand for ethanol (FAO, 2006).

In terms of global production, around 700 million tonnes of world maize production represents over a third of world cereal output (GMR, 2011). Over the past two decades, global maize production has increased by nearly 50%, or 1.8% annual compound growth rate (FAO, 2006). Both area and yield increases contributed to this high level of growth. The potential for maize yield improvements in many countries has remained high as the degree of production efficiency, especially in the developing countries, still falls below major commercial producers. Average maize yields among the developing countries, as an aggregate, are about a third of those of the developed counterparts (GMR, 2011).

The biggest world producers of maize are the United States with a yield of 9 tonnes per hectare followed by China with yield of around 5 tonnes per hectare while in South Africa it stands at around 3 tonnes per hectare (GMR, 2011). The development and spread of the Genetically Modified (GM) maize seeds have led to its rapid adoption because of its increased yields and low cost through improved pest control (FAO, 2006). The international marketing of maize is therefore important in order to understand where the bulk of this maize goes and to establish the leading largest consumers of maize.

International trade accounts for only 12% of world maize production represents over one-third of total cereal trade (Abbassian, 2006). Global trade in maize has increased significantly from 55 million tonnes to around 80 million tonnes (FAO, 2006). The United States is the world's largest exporter of maize followed by Argentina and China (GMR, 2011). Brazil, South Africa and Ukraine are among a few other countries which often have surpluses for exports. Argentina doubled its export volumes the early 1980s. Brazil, traditionally a major maize importing nation, emerged as an important supplier of maize to world markets in more recent years (Abbassian, 2006).

In terms of volume, aggregate imports by countries in Asia make up over half of total world maize imports. The world's leading importer of maize is Japan, with an annual intake of 20% of the world total imports followed by the Republic of Korea with almost 10% of the global share

(ABSA, 2011). Other major importers in Asia include Indonesia, Islamic Republic of Iran, Malaysia and Saudi Arabia. The strong growth in the livestock industry fuelled by rising incomes is the driving forces behind the fast growth in Asian imports. Central America ranks third among the regions with highest imports. While white maize remains a dominant crop in Mexico, the country has become one of the world's leading importers of yellow maize primarily because of its growing demand for cattle feeding (FAO, 2006).

Countries in Africa are also among the major importers of maize. Gradual liberalization of markets in Africa gave rise to higher imports with many countries relaxing their trade barriers by lowering tariffs (Mano, 2001). This development exposed high-cost African farmers who were once protected to lower world prices and resulted in reduced production and increased imports. Egypt is Africa's largest importer in spite of being also the third largest producer after the South Africa and Nigeria. Other major importers in Africa include Algeria and Tunisia, neither of which actually produces any maize of their own. The global marketing of maize and the price discovery mechanism is therefore critical in order to get an understanding of how and where the international price is discovered.

Maize is also assigned different types of grades and classes depending on a set of physical descriptions or qualities such as the minimum test-weight, feeding values, and maximum limits of damaged kernels and foreign material. In the United States, for example, maize classes are determined on the basis of colour such as yellow, white and mixed and are graded from 1 to 5. The No. 2 grade of maize is widely considered as the traditional representative price for maize produced in the United States and is also accepted as the world's most representative price for maize and other coarse grains (Abbassian, 2006).

Market prices are usually higher for white maize compared to the yellow depending on local supply and demand conditions. The maize futures traded at the Chicago Board of Trade (CBOT) are also widely considered as the world's most important price discovery mechanism (FAO, 2006). However periodically, some exceptions may occur as local/regional conditions manage to influence prices. For instance, price movements in the South African Futures Exchange (SAFEX), where both yellow and white maize are traded price discovery may be subject to diverging fundamentals than those in Chicago given that it is the region's main surplus producer and exporter of maize. Other important commodity exchanges include Rosario Futures Exchange in Argentina; EURONEXT, China's Dalian Commodity Exchange (DCE), and the Tokyo Grain Exchange.

There has been growing and continued consumer and legislative pressure to regulate the marketing and trade of GM crops. However, physical isolation of GM maize is difficult since it has to start at the farm level which also implies an extra cost. The other problems include that of cross-pollination in the field and the cost of thoroughly cleaning equipment to avoid contamination. Legislators such as the EU and Japan have passed laws restricting the importation of certain GM crops and products from un-approved varieties (FAO, 2006). GM maize trade also hinges the application of Sanitary and Phyto-sanitary Measures (SPS) and Technical Barriers to Trade (TBT) of the World Trade Organization (WTO). This makes it difficult for trade to occur across international boundaries.

To conclude the above sections helped to give an overview of the global production and marketing of maize. It also helped in understanding how the Zimbabwean maize market is positioned in the global context.

2.3 Relationship between Zimbabwean maize market and international maize

Spatial price transmission or market integration measures the degree to which spatially separated markets share common long-run price or trade information on a homogenous commodity (Amikuzuno, 2010; Traub *et al*, 2010). In a spatial context, allowing for positive transaction costs, this implies that the difference in price between two markets should be exactly equal to cost of moving the commodity from one market to another. If markets are not well integrated one cannot establish or estimate the fundamental law of one price. In this case it is assumed that physical arbitrage will result in the law of one price. Arbitrage or the law of one price is the mechanism by which spatially separated markets return to their long run equilibrium. This usually takes place when traders take advantage of price differences between regions and push volumes to the deficit area until the prices equilibrate.

The reasons for markets to fail to adhere to the law of one price could be attributed to market power, inventories management, ad hoc policy interventions and imperfect information or distorted market information on prices and/or crop projections (Traub *et al,* 2010). Recent literature on price transmission uses the trade flow data, transfer costs as well as the price information to establish the degree of market integration (Li and Barret, 1999). In this study it ins hypothesised that the Zimbabwean maize prices mainly respond to regional prices especially

SAFEX prices as opposed to the global CBOT prices. Chapter 5 will dig deeper into the relationship between SAFEX prices and local prices to establish the extent to which the two markets are integrated. However, for now it is important to understand the role played by the agricultural sector before the maize sector can be reviewed.

The agricultural sector has played a key role in Zimbabwe's economy (Rukuni, 1994; 2006). The importance of the sector is underpinned by its provision of food, employment, value added to GDP and foreign exchange. A cliché drawn from this perception gives credence to the stylised fact that GDP growth is typically elastic with respect to changes in agricultural growth in Zimbabwe's agrarian economy (Richardson, 2007). This means that the agricultural sector growth is expected to yield a more than proportionate increase in the overall economic growth. The rationale underlying this narrative is simple and convincing.

Agricultural products in the Zimbabwean economy are mostly consumed in several economic sectors such as transportation, consumer durables and raw materials for the manufacturing sector. In addition, the agricultural sector itself makes use of products from other industries such as construction, labour and capital equipment and thus leading to ripple growth effects within the rest of the economy. Therefore it can be concluded that the agricultural sector growth dictates the performance of the national economy. Previous research work agrees with this view citing that the pillar of Zimbabwe's economic performance is agricultural export earnings and provision of food surplus beyond the requirements of the agricultural population (Muchapondwa, 2008). The maize subsector is therefore a crucial subsector in the Zimbabwean economy and need to be discussed in great detail in terms of production history, marketing and policy.

2.4 Overview of the Zimbabwean Maize Production

In terms of maize production, some researchers argue that there were two green revolutions that took place in Zimbabwe (Rukuni *et al*, (1994, 2006). However, others disagree with this discourse citing that a green revolution has to be structural not accidental and that it must have globally competitive yields (Mano, 2001). This has not been the case in Zimbabwe. With global yields having reached more than 10 tonnes per hectare some may argue that it is premature to refer the unstructured growth in the Zimbabwean maize yields as a green revolution (FAO, 2006). However, those who agree with this discourse, argue that Zimbabwe's first green revolution (1960-80) was spearheaded by the white commercial farmers (Eicher, 1995). During this period, maize exports grew by 18.8% due to the growing demand of starch in England's industries (Masters, 1993). Land ordinances assured white supremacy to the detriment of the blacks through dispossession of land and suppression of wages where black labourers were subjected to a system next to servitude without remuneration. The licensing act of 1942 made it mandatory for all commercial farmers to buy licence plate from the Rhodesian national farmers union which was renamed commercial farmers union (CFU). This was described as the 'stroke of organisational brilliance' as it assured a strong financial base for the union (Masters, 1993).

The preconditions for the green revolution were both technical and institutional. The new technology in research and investment in human, biological and physical capital such as roads, dams and irrigation to name a few were among the prime movers. In addition, investment in farm support institutions such as marketing, credit, as well as fertiliser and seed distribution systems were among the principal preconditions. New maize varieties such as SR-1 (1949) and SR-52 (1960) increased the yields. Federation of the late 1950s led to the establishment of the regional research network and the substitution of maize for tobacco due to reduction in relative profitability of tobacco in the 1960s (Eicher, 1995).

The second green revolution (1980-1986) was led by smallholder farmers who in 1980 with a population of 700 000 owned half of the arable land with the other half being owned by the 5000 commercial farmers (Rukuni *et al*, 2006). The smallholder farmer maize production doubled in six years from 1980 to 1986 and this was attributed to a number of factors (Jayne and Nuppenau, 1991). These factors included the use of land abandoned during war, use of hybrid varieties and inorganic fertilisers. In addition, the removal of racial and institutional barriers and the expansion of the marketing services were also identified as the preconditions for this second revolution (Eicher, 1995). This occurred at a time when the region was in deficit for instance a famine killed more than a million people in Ethiopia in 1984/85. Again the success of this revolution awarded President Mugabe the African Leadership Award in 1988. A critical lesson from this period is that infrastructure such as roads and institutions such as extension, research and credit played a critical role in boosting maize productivity and therefore analysis should go beyond price incentives as the only factor affecting production response.

The current situation in Zimbabwe shows that the nation needs more than 2 million tonnes of cereal including 1.7 million tonnes for direct human consumption (FAOSTAT, 2010). From a food provision perspective, the country requires approximately 1.5 million tonnes of maize annually (Rukuni & Eicher, 1994; 2006). Whilst Zimbabwe traditionally imported wheat, its maize industry used to be one of the largest in the SADC region (Jayne *et al*, 2006). The Zimbabwean maize sub-sector was traditionally a net-exporting sector and played a prominent role in regional grain markets through maize grain exports mainly to Zambia, Malawi, Mauritius, Kenya and Mozambique. However, Zimbabwe's self-sufficiency ratio of maize dropped from 212% in 1985 (Jayne *et al*., 1994; 2006) to 67% by 2004 (FAO, 2010), signifying the country's shift from a net exporter to a net importer of maize. As a result, Zimbabwe's maize trade policy has seen imposition of export bans, and after the onset of the food crisis, the issuing of government tenders for the importation of subsidized maize.

Grain crop production trends show that output has fluctuated at subsector and national levels (see figure 2.0). Although production has depended more on the availability of rainfall which varies from year to year, prices and government policies have also played a key role in farm production as witnessed in the green revolution periods explained above. Maize is produced by both communal and large scale sectors. However, it is the communal sector that has provided an average of over 60% of the total maize production, as the large scale sector shifted to more lucrative cash crops (Rukuni *et al*, 2006). The figure 1 below shows the trends between smallholder and commercial sector output contributions between 1980 and 2007.

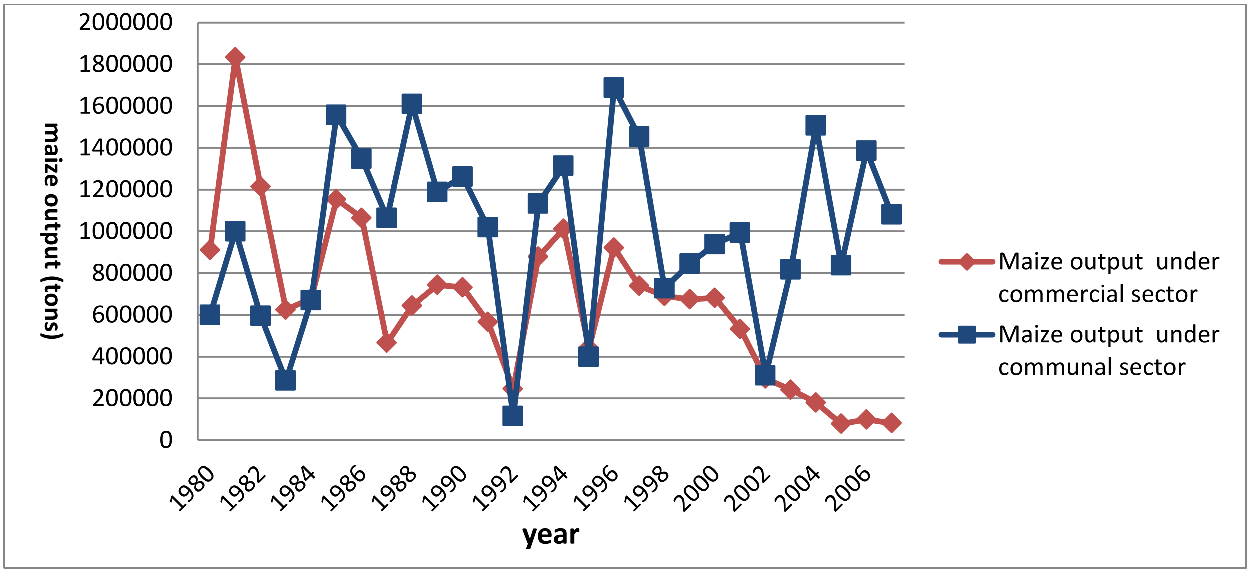

Figure 2.1 Zimbabwe maize production by sector

Source: MAMID, 2008

Trends in output for the three decades show that overall production declined from 2.6 million tonnes in 1996 to 2.1million tonnes in 2000 (see figure 1). Maize production further declined to 1.5 million tonnes in 2001, and further declined to 500 000 tonnes in 2002 (FAO, 2006). This can be attributed to the stalling of farm operations in light of the ‘fast track’ land reform program. Moreover, drops in output recorded 2001/02 and 2002/03 were attributed to the negative effects of droughts during these seasons amid growing concerns of climate change. From 2001 to 2007, Zimbabwe produced an average of 0.8 million tonnes of maize per annum against average consumption requirements of just above 1.5 million tonnes (Richardson, 2007). The smallholder sector has been however, been relatively stagnant. Yields have since not exceeded 1 tonne per hectare. Chapter 4 will look deeper into these trends. The next section goes through the historical overview of the Zimbabwe maize policy.

2.5 Historical overview of Zimbabwe's maize policy

Price controls started in terms of Maize Control Act under Maize Control Board (1931) in reaction to the world depression and the effects of over reliance on exports (Davies *et al*, 2001). In 1980, Zimbabwe was dominated by four parastatals supervised under Agricultural Marketing Authority (AMA) (formed 1967) which acted as a conduit between the government and the producers' interests. Producer and selling prices were fixed by Ministry of Agriculture in negotiation with producers and the prices were pre-planting or pre-harvest, pan seasonal and pan territorial (Sellen, 1993). Policy objectives of the ministry included self sufficiency, retention of expertise and capital within the agricultural sector through incentive pricing and to control supply through stabilising prices and income. There was also cost plus pricing and exports were priced close to export parity price while controlled products such as maize were given more weight than opportunity cost prices (Takavarasha, 1994; Moyo, 2006).

Other factors were the impact of national stocks, export earnings and Grain Marketing Board (GMB) costs. In the period between 1980 and 1985 smallholder maize sales increase from 8 to 45% sales of maize which was found to have been attributed to the doubling of the producer price for maize and its maintenance ahead of inflation over the period (Bratton, 1986). The government also distributed packs of hybrid seed and chemical fertilizer as a means to re-establish farmers on the land in the aftermath of the independence war and the drought of the early 1980s. Marketing boards contributed 16% (1985) and 51% (1986) of government spending which was 2.7% and 5.8% of total spending respectively.

The Structural Adjustment Programs (SAP) of the early 1990s saw the dissolution of AMA and formation of an autonomous board of directors for marketing boards which hitherto were making huge trading loses under the pretext of performing developmental and social obligation functions. Commercialisation of boards was accompanied by setting of targets for subsidy reduction and increased financial position. It was also associated with the conversion of the pricing policy from a system of producer and selling prices to a system of floor prices and deregulation of statutory marketing controls to encourage competition. The 1990's represented an era in which the Grain Marketing Board (GMB) scaled down operations in the maize market as part of the general move towards a more market-oriented development approach. During the Economic Structural Adjustment Programme (ESAP), market policy relegated the Board to residual trading of maize whilst allowing for private sector participation in the market. However, government still maintained control over the foreign maize trading. The Zimbabwe Agricultural Commodity Exchange (ZIMACE) was then established in 1994 as a competing entity to the GMB, and maize was thus marketed within a relatively free market system (Rukuni *et al*, 2006).

This saw a marked annual growth in quantities traded through this board. Maize producers during this period had the autonomy of delivering their produce directly to processors or alternatively embarked on on-farm storage. In 1996, the maize market was fully liberalised with the GMB playing a price and supply stabilisation function. This implied that instead of purchasing the entire marketed surplus, as was the objective during the initial control period, the GMB attempted to manipulate maize market prices through purchase and sale operations, ostensibly for food security and/or price stabilization purposes. Nonetheless the general consensus is that the overall maize marketing system under structural market adjustments largely failed to stabilize farm prices.

Evidence of the failure is the food riots of 1998. This led to the GMB retaining its monopoly power in terms of the Grain Marketing Act (GMA), Grain Marketing (Controlled Products Declaration: Maize and Wheat) (Amendment Notice 2001 N0.1). This also led to the suspension of the ZIMACE. The SAP was described as a “double edged sword “reducing protection coefficients in two ways. The removal of subsidies which had been given to the farmers before the free market regime increased the farmers’ production costs while failure of competition to emerge in markets freed of controls led to the increase in the input prices or cost of inputs due to collusive behaviour of firms (Mano, 2001).

In 2001, statutory instrument (SI-235A) was released under which maize, maize meal, wheat and flour were declared controlled products and movements of these products without permit was illegal across trade zones and private trading was prohibited. Any producer wishing to dispose excess production was to do so within fourteen days of harvest through the GMB as prescribed in terms of the SI 238 of 2001. From 2001 to 2005, prices of controlled products were also controlled and GMB could not keep up with inflation, production fell with private importation prohibited this saw the emergence of the parallel market.

Use of import parity pricing is being used by the government with the average transaction costs being pegged at 25% of the price per tonne from South Africa to Zimbabwe. However it can be deduced that this is just a claim because the Ministry of Agriculture, Mechanisation and Irrigation Development (MAMID) through the GMB has never really used this formulation due to lack of funds. It can announce a price equivalent to the import parity price or even more, but when it comes to implementation, it is the private traders who pay price even below the export parity prices (Moyo, 2006).

Following the more recent market liberalisation reforms in March 2009, which has made a positive contribution to national food availability and security, GMB's main function has changed to being buyer of last resort. In this case, it tries to maintain floor prices to support domestic producers. The removal of duties and import restrictions has also meant inflow of maize easier as private millers/traders are now performing a more prominent role in the importation of cereals to meet the national deficit. At the start of the season, GMB set the producer price at USD 325/tonne, but this was recently reduced by USD50/tonne. At the current level (USD275/tonne), however, it is still higher than the prevailing market price, despite the parastatals' mandate of being the buyer of last resort. Last marketing year GMB procured 63 000 and 20 561 tonnes of maize and wheat, which is higher than the preceding season but 63 and 86%, respectively, below quantities purchased in 2007 (FAO, 2010). There are also other food security policies that have been implemented in Zimbabwe to either augment food availability or to increase its production.

In addressing the critical national food crisis, the Government has employed policies aimed at augmenting the production of food crops. Some policies were successful while others failed before achieving their intended objectives. To start with, a policy called Operation Maguta was launched in November 2005 and it aimed at boosting food security and to consolidate national strategic grain reserves. Under this scheme, farmers are given inputs such as fertilizers, seeds and herbicides in order for them to grow targeted crops such as maize and wheat. The program was launched and primarily targeted model A1 and communal farmers. The farmers were required to pay back the inputs after harvesting their crops at an interest rate 50%, but had the option of paying in the form of produce (through the GMB) or cash. These inputs were supposed to be enough for only one hectare. There was also the GMB input scheme which was aimed at facilitating access to inputs (seeds, fertilizers, chemicals and herbicides) by farmers. The inputs were dispatched to GMB depots countrywide. The Ministries of Finance, and Industry and International Trade set prices for the different inputs that GMB had to sell to the farmers. The prices of the inputs were heavily subsidized and were set way below the market clearing prices (Bird *et al*, 2007)

Secondly, the Mechanization Programme was conceived as part of the broader and swifter measures to revitalize and recapitalize the agricultural sector of the country in the long term and consolidate the gains of the land reform program. It was launched in 2007 as a strategic national developmental program, the intervention has significantly transformed the equipment and productive landscape of the sector by mechanizing both communal and commercial farmers enable them to produce at optimal levels and achieve food security and sustenance. This has resulted in a critical mass of farmers being empowered to achieve the program's strategic long term vision of food security (Mudzonga and Chigwada, 2009).

In addition, Agricultural Sector Productivity Enhancement Facility (ASPEF) was launched in 2007 by the government in order to support facilities, through the Reserve Bank of Zimbabwe, such as livestock production, with a particular emphasis on rebuilding the national herd, the winter wheat program and food crop production to enhance food security. The productivity enhancement facility required the farmers to support their loan applications with evidence of actual past performance and undertaking to sell output through the GMB. Lack of title deeds constrained this programme as banks were reluctant to offer large sums of money to farmers with no collateral security (Dawes, 2009).

The Grain Mobilization Programme commenced in May 2008, and a grain mobilizing committee was set up comprising officers from the Reserve Bank of Zimbabwe, GMB and Agritex. The purpose was to mobilize grain from all farming sectors to a centralized GMB facility in order to build strategic stocks in addition to imports. The main objectives of the intervention were to urgently procure excess maize and small grains from farmers in order to boost the national strategic grain reserve, to ensure timely payments to farmers for their grain and to mitigate inflationary pressures by paying farmers for their produce even before they supply the crop to enable them purchase inputs for subsequent seasons. Another policy that seeks to address food security situation, was called Basic Commodities Supply Side Intervention (BACOSSI) facility of October 2007 which aimed at boosting the supply side or food security through providing targeted financial support to manufacturers of basic goods, as well as selected wholesalers and retailers. The BACOSSI facility was the major contributor to the rise in capacity utilization to 40 per cent in the food sector, from as low as 10 per cent in the year 2008 (Mudzonga and Chigwada, 2009).

The bio fuels policy was instituted due to the country's dire need to provide food security for the population aimed at prohibiting use food crops like maize, palm oil, soyabeans and sugarcane for the production of fuel. The rationale was that fuels should not compete for food. For fuel, a program was launched to grow Jatropha plants in regions 4 and 5, which are not allocated to food production. Food aid policy was also instituted and under this policy, food aid should not postpone the reforms needed to achieve food security, depress commodity prices or act as a disincentive for producers and traders and neither should it cause recipient dependency among other things. Lastly, Zimbabwe’s policy on genetically modified organisms (GMOs) was instituted so that there will be no importation of GM seed. GM food can be imported for consumption, but not for planting purposes. This may potentially reduce Zimbabwe’s relative competitiveness and its comparative advantage in maize production (Esterhuizen, 2010).

In conclusion, the various policies addressed in previous section provided information on the importance of maize as a crop in the country. The next section provides theory of supply response and previous studies that has been done around that area.

2.6 Supply response: an overview

Agricultural supply is defined as the response of agricultural output to changes in prices, all other factors held constant (Mamingi, 1997). The idea embedded in this definition is that a price increase or decrease will have the same absolute change in output making agricultural supply symmetric or reversible. The neoclassical approach to supply response involves the use of prices and opportunity costs as the explanatory variables for supply response on competitive markets (Askara and Cummings, 1977). It therefore fails to account for government intervention that distorts or supplement market mechanisms. The modified convention formulation approach maintains the neoclassical paradigm while adding effects of risk of exogenous government intervention (Mamingi, 1997).

The analysis underlying the theory of the firm assumes instantaneous response between inputs and outputs. This is not the case for agriculture where there are lags between input application and output production. The other factor is that the hypothesized or implied agricultural production function may change during the production process. In addition, farmers' production decisions may be affected by the existence of institutional and technical factors (Mamingi, 1997). Furthermore, the assumption of information symmetry implying perfect foresight does not hold in most agricultural firms. As will be explained in later sections, agricultural firms are rather 'naive' and do not have all the information at their disposal when making production decisions.

From economic theory, there are broadly two frameworks used to conduct supply response analysis namely the supply function derived from the profit maximizing framework and the Nerlovian supply response model (Sadoulet and De Janvry, 1995). The supply function derived from the profit maximizing framework imposes a profit function which allows the analysis to incorporate price effects on input demand and output supply. It also assumes that supply response is likely to be confined mainly to profit allocation between crops or enterprises (Jayne *et al*, 1994). The physical relationship between inputs and the maximum output that can be obtained for a given technology and time is what is called a production function (Varian, 1984).

For maize production, this physical relationship could be expressed in terms of maize output (Q) and inputs such as land (L), labour (W) and capital (K). This can be algebraically represented as follows;

$$Q = f(L, W, K) \tag{2.1}$$

The profit maximizing framework imposes a profit function which allows the analysis to assume that supply response is likely to be confined mainly to profit allocation between crops or enterprises. Therefore, given cost of land rent (*l*L), labour (*w*W), capital (*k*K) and fixed costs TFC, a profit maximising farmer's objective function is represented as follows;

$$Max\ \Pi(p, l, w, k, TFC) = Max\Pi_{L,W,K}\ (Pf(L, W, K) - lL - wW - kK - TFC) \qquad (2.2)$$

Assuming that the production function is well behaved, the supply response function can be derived by taking the first order conditions (FOCs) of the profit function as follows;

$$p\frac{dQ}{dL} = L$$

$$p\frac{dQ}{dW} = W$$

$$p\frac{dQ}{dK} = K$$

(2.3)

The above equation implies that the value of the marginal product is equal to the input cost. However the FOCs are necessary but not sufficient conditions for a true maximum. They just show us that the point that the producer is producing is a turning point without telling us the nature of the point.

The second order conditions (SOCs) are the sufficient conditions. For a true maximum profit the second order conditions can be represented as follows

$$\frac{d\Pi^2}{dL^2} < 0$$

$$\frac{d\Pi^2}{dW^2} < 0$$

$$\frac{d\Pi^2}{dK^2} < 0 \qquad (2.4)$$

Assuming that the production function is invertible we can express the input demand functions in terms of the input and output prices. Substituting these input demand functions into the production function gives us the supply function and substituting the input demand function into the direct supply function gives the indirect profit function which is a function of input and output prices as follows;

$$\Pi(p, l, w, k,) = Pf(L^*, W^*, K^*) - lL^* - wW^* - kK^* \qquad (2.5)$$

Applying the basic principle of the envelope theorem, the dual approach, we are able to obtain the product supply and factor demand functions. Using the Hotelling's Lemma we can obtain the product supply and input demand functions by taking the partial derivatives of the indirect profit function with respect to output price and input prices respectively as follows ;

$$\frac{d\Pi}{dp} = f(L^*, W^*, K^*)$$

$$\frac{d\Pi}{dL} = -L^*(p, l, w, k,)$$

$$\frac{d\Pi}{dW} = -W^*(p, l, w, k,)$$

$$\frac{d\Pi}{dK} = -K^*(p, l, w, k,) \qquad (2.6)$$

This approach has been found to have numerous methodological problems when analysing agricultural supply response. The next section provides an overview of the methods that have been used in analysis agricultural supply response. This was done in order to assess the best method to be employed in this study.

2.7 Agricultural supply response

The above approach has been critiqued for its failure to incorporate the institutional constraints in its objective function by describing a production plan as a purely technical relationship. As explained in the profit maximisation approach, it assumes that the famers are rational and have perfect information at their disposal. It also assumes that the farmers are risk neutral which is not necessarily the case in agricultural firms. The biological nature of agricultural production affects the response of farmers to agricultural incentives.

The strong link between farm production and natural processes can only be speeded with great cost and difficulty. Once a production decision is taken, it can seldom be reversed or modified and the cost incurred become historical or sunk. This phenomenon can also be attributed to increase in the proportion of fixed costs. Fixed costs limit the ability of farmers to change or alter their production system. The dynamism of supply is of importance to agricultural studies. Time lags that occur in agricultural production plays a crucial role since production takes place under less than perfect certainty conditions. The various models that have been designed through time to deal with dynamic supply should be understood. Four models are discussed and they include; the distributed lag model, partial adjustment model, adaptive expectations model and the Nerlovian model.

(i) The distributed lag model

This model states that current agricultural supply is dependent upon the previous period's price (Sadoulet and de Janvry, 1995). Thus farmers adjust their supply using the prevailing prices.

Simply stated, this model implies that farmers are having naive expectations of the prices. A simple example of this is the Cobweb model which has seen to be applicable to the Zimbabwean maize prices (Jayne T.S. *et al*, 1994). In Zimbabwe, if prices are high this year, then farmers are likely to increase their production in the following season expecting the prices to be the same. Increased production, however would lead to lower prices in the succeeding year and the cycle continue in a cobweb fashion. Thus production adjustment is not instantaneous but may become observable in the market after a period of time. This relationship can be expressed as follows;

$$A_t = a + bP_{t-1} + \mu_t \qquad (2.7)$$

If the effect of one variable endures through several periods of time then a distributed lagged relationship can be expressed as follows;

$$A_t = a + b_0P_t + b_1P_{t-1} + b_2P_{t-2} + \cdots \dots \dots + b_kA_{t-k+} + \mu_t \qquad (2.8)$$

The above distributed lag equation faces problems of correlation and loss of observations which makes ordinary least square (OLS) produce estimates that are unreliable and inefficient. Maximum likelihood estimation (MLE) produces estimates with more desirable characteristics.

(ii) The partial adjustment model

This model is used in agricultural production were demand and supply steadily adjust to new equilibrium levels following a changing production environment (Sadoulet and de Janvry, 1995). Thus supply in one period is adjusted as a fraction of the difference between the actual and the expected or the desired long-run output as illustrated below;

$$A_t = (1-\gamma)A_{t-1} + \gamma A_t{}^e + \mu_t \tag{2.9}$$

Where A_t is the actual or current output $A_t{}^e$ is the expected or desired long-run output, A_{t-1} is the previous period's output, γ $(0 \leq \gamma \leq 1)$ is the adjustment factor where 0 represents no adjustment $(A_t = A_{t-1}{}^e)$ and 1 represents complete adjustment that is $A_t = A_t{}^e$. The problem with estimating this equation is that the expected long-run output is not observable. Therefore we have to be expressed in terms of an observable variable that is we assume the following relationship;

$$A_t{}^e = a + bP_t{}^e \tag{2.10}$$

Substituting equation 2.10 into equation 2.9 and assuming naive expectations were $P_t{}^e = P_{t-1}$ we get

$$A_t = a\gamma + (1-\gamma)A_{t-1} + \gamma b P_{t-1} + \mu_t \tag{2.11}$$

Using the adjustment factor, the short-run elasticity can be represented by the coefficient of the of the price variable that is γb and the long-run effect is represented by $\frac{\gamma b}{\gamma} = b$. The problem with estimating this equation is that A_{t-1} is stochastic and not fixed and therefore OLS will produce biased estimates.

(iii) The adaptive expectation model

This model simply states that farmers base their production decisions on the on expected prices at the time of sale of harvest.

$$A_t = a + bP_t{}^e + \mu_t \tag{2.12}$$

Where A_t denotes the current or actual level of output and ${P_t}^e$ represents the expected price level. The prices are revised in each period as expressed below;

$$ {P_t}^e = (1-\gamma){P_{t-1}}^e + \gamma P_{t-1} \tag{2.13} $$

Where $\gamma$is the coefficient of expectation such that$(0 \leq \gamma \leq 1)$ and if $\gamma = 0$ then ${P_{t-1}}^e = {P_t}^e$ and actual prices will have no effect on expected prices and if $\gamma = 1$ then ${P_t}^e = P_{t-1}$ that expected prices will be equal to last period's actual prices that is the actual prices of the previous period have prevailed in the market. Koyck transformation found out that the current price is weighed more than the past prices to give a weighted expression as follows;

$$ {P_t}^e = \gamma P_{t-1} + (1-\gamma)P_{t-2} + \gamma(1-\gamma)^2 P_{t-1} + \gamma(1-\gamma)^2 P_{t-1} \dots \dots \dots \tag{2.14} $$

(iv) The Nerlovian supply response model

The Nerlovian model combines both the partial adjustment model and adaptive expectation model. Most empirical estimates of supply response have been largely based on modifications of Nerlove's 1958 formulation (Askari *et al,* 1977). The model combines the distributed lag model, the partial adjustment model and the adaptive expectation model. The Nerlovian supply response model has been utilized in studies by various researchers such as Carpenter *et al,* (1996), Omezzine and Al-Jabri (1998), McKay *et al.* (1999), Heltberg (2001), Alwan and El-Habbab (2002) Mythili (2008) and Muchapondwa (2008).

In its simplest form Nerlove's model assumes presents of a desired level of supply ${A_t}^e$ which depends on an expected level of price ${P_t}^e$ and a set of exogenous shifters represented by Z_t as illustrated below;

$$A_t{}^e = a + bP_t{}^e + cZ_t + \mu_t \qquad (2.15)$$

Now taking the partial adjustment model and the adaptive model respectively as represented below;

$$A_t = (1-\gamma)A_{t-1} + \gamma A_t{}^e + \mu_t$$
$$P_t{}^e = (1-\beta)P_{t-1}{}^e + \beta P_{t-1} \qquad (2.16)$$

Sadoulet and de Janvry, (1995) noted that this adaptive process can alternatively be interpreted as a weighted sum of all past prices as follows

$$P_t{}^e = \beta \sum_{i=1}^{\infty}(1-\beta)^{i-1}P_{t-i} \qquad (2.17)$$

Where A_t and $A_t{}^e$ are actual and expected area under cultivation or which herein is represented as output at time *t*, and P_t and $P_t{}^e$ are actual and expected price at time t. Z_t is the set of the exogenous shifters like weather. It is also important to note that γ is the partial adjustment coefficient and β is the adaptive expectations coefficient such that $(0 \leq \gamma \leq 1)$ and $(0 \leq \beta \leq 1)$.

Substituting equation 2.15 ($A_t{}^e$) and into the first part of the equation 2.16 (A_t) yield the following equation

$$A_t = b_0 + b_1P_{t-1} + b_2A_{t-1} + b_3A_{t-2} + b_4Z_t + \mu_t$$

Or alternatively represented as

$$A_t = a\beta\gamma + (1-\gamma)A_{t-1} + \gamma b((P_{t-1} + (1-\gamma)P_{t-2}) + \cdots.)) + \mu_t \qquad (2.18)$$

Where $b_0 = a\beta\gamma,\ b_1 = b\beta\gamma,\ b_2 = (1-\beta) + (1-\gamma), b_3 = -(1-\beta)(1-\gamma) and$

$$b_4 = \alpha_4\gamma$$

And $$e_t = \omega_{\ t} - (1-\beta)\omega_{\ t-1} + \gamma(\mu_t - \ (1-\beta)\mu_{t-1}) + \alpha_2\gamma\omega_{\ t}$$

Short run price elasticity can be estimated by b_1 and the long run price elasticity can be obtained as $\alpha_1 = \frac{b_1}{\gamma\beta} \geq b_1$ since $\gamma \ and \ \beta$ are both less than or equal to one. Thus long run elasticity is greater than short run elasticity as expected.

The long-run price elasticity ε can also be obtained from the following

$$\varepsilon = \ \alpha_1 \frac{\boldsymbol{P}}{\boldsymbol{A}} = \ \frac{b_1}{(1 - b_2 - b_3)} \frac{\boldsymbol{P}}{\boldsymbol{A}}$$

Where $\boldsymbol{P}$ and $\boldsymbol{A}$ represent, historical mean of prices and acreage under cultivation here in estimated as total output, respectively (Braulke, 1985).

This Nerlovean formulation has been found to have numerous methodological problems on both empirical and theoretical grounds. The approach involves a one-stage procedure directly regressing production on prices and other exogenous variables. The Nerlove formulation is therefore unable to give an adequate clear-cut distinction between short-run and long-run elasticities. The basic disadvantage of the partial adjustment model stems from its unrealistic assumption of a fixed target supply based on stationary expectations. A Nerlovean formulation therefore makes it impossible to distinguish the respective coefficients when both partial adjustment and adaptive expectations are present, unless if certain subjective restrictions on one or other are imposed (Muchapondwa, 2008).

In addition, the Nerlovian model is usually applied by estimating a single equation independently for each commodity without characterising linkages between them via a matrix of cross-price elasticities. It is also partial equilibrium as it does not model the non-agricultural sector and thus implicitly assume that the interactions between the two sectors are insignificant. Therefore, there is need for more recent time series analytical tools tailor made to capture the weaknesses of the partial adjustment model. Such time series methods include the cointegration and error correction mechanism (ECM). When combined with error correction models, cointegration offers a means of obtaining consistent yet distinct estimates of both long-run and short-run elasticities. The next section gives an outline of these concepts.

2.8 Alternative time series approaches

This section will introduce some esoteric concepts of time series analysis to provide groundwork for the model to be used in this study. It is very essential to define some of these concepts as they form an important foundation to the review of the previous empirical studies and analytical tools that they used. These time series concepts include stationarity (and non stationarity), unit root processes, causality, cointegration and the error correction mechanism (ECM)

(i) Stationarity

Firstly, a random or stochastic process is defined as a collection of random variables ordered in time. Another important concept in time series econometrics is that of stationarity. In general terms, a stochastic process is said to be stationary if its mean and variance are constant or invariant over time and the value of the covariance between the two time periods depends only on the lag between the two time periods and not the actual time at which the covariance is computed (Gujarati, 1995). In other texts, such a stochastic process is known as a weakly stationary, or covariance stationary, or second-order stationary, or in wide sense, stochastic process. It is important to mention a special type of stochastic process (or time series) known as a purely random, or white noise process. A purely random stochastic process is so called if it has zero mean, constant variance σ_2, and is serially uncorrelated. An example is the error or disturbance term in the classical normal linear regression model.

Regressions between levels of variables may have high co-variation because of persistence in the base levels rather than persistence in the changes. However taking the first differences of the variables may eliminate, or at least reduce this dependence. An alternative transformation to differencing is to take the natural logarithm of the ratio of the two levels to generate the percentage rate of change. Ordinary Least Squares regression requires that the time series being evaluated be stationary otherwise, OLS will no longer be efficient, the standard errors understated, and the OLS estimates will be biased and inconsistent. One method to test for stationarity is the unit root test of Dickey-Fuller (1979). If the underlying return generating process exhibits serial correlation of order greater than one, Augmented Dickey-Fuller tests must be used.

If a time series is not stationary, it is called a non-stationary time series that is, its mean or variance or both mean and variance are time varying. An example is the random walk model (RWM). Suppose μ_t is a white noise error term with mean 0 and variance σ_2. Then the series Y_t is said to be a random walk if

$$Y_t = Y_{t-1} + \mu_t \qquad (2.19)$$

If the process started at some time t with a value of Y_0, it can be generalised as

$$Y_t = Y_0 + \sum \mu_t \qquad (2.20)$$

It can also be proven that the expression has a mean of Y_0 which is constant and a variance of $t\delta^2$ and but as t increases, its variance increases indefinitely, thus violating a condition of stationarity. An interesting feature of RWM is the persistence of random shocks (random errors), which implies that the impact of a particular shock does not die away.

It is important to note that if (Equation 2.19) is expressed as follows

$$(Y_t - Y_{t-1}) = \Delta Y_t = \mu_t \tag{2.21}$$

Where (Δ) is the first difference operator, it can be verified that while Y_t is non-stationary, but its first difference is stationary.

The Achilles heel of non-stationary time series is that the behaviour of the time series can only be studied for the time period under consideration and each set of time series data will therefore be for a particular episode. As a result, it is not possible to generalize it to other time periods. Therefore, for the purpose of forecasting, such non-stationary time series may be of little practical value. However, it is also interesting to note that the first differences of a random walk time series are stationary. If you difference once, it is equivalent to removing linear dependence in a time series. Second differencing is equivalent to removing quadratic dependence and so on.

(ii) Unit root stochastic process

If the RWM is expressed as follows

$$Y_t = \rho \mathrm{Y}_{\mathrm{t}-1} + \mu_t \quad where \ -1 \leq \rho \leq 1 \tag{2.22}$$

If $\rho = 1$, (Equation 2.18) becomes a RWM. If ρ is in fact 1, we face what is known as the unit root problem that is, a situation of non-stationarity. Thus the terms non-stationarity, random walk, and unit root can be treated as synonymous. If, however, $|\rho| \leq 1$, then it can be shown that the time series Y_t is stationary.

(iii) Cointegration

The regression of a non-stationary time series on another non-stationary time series may produce spurious or nonsense regression. Co-integrated processes are processes that are random in the short-term but tend to move together in the long-term. If we consider two time series such as personal disposable income and personal consumption income and subjecting these time series individually to unit root analysis and find out that they both contain a unit root and are therefore non-stationary. If consumption is regressed on income and as follows

$$C_t = \alpha + \beta Y_t + \mu_t \tag{2.23}$$

And write it as

$$\mu_t = C_t - \alpha - \beta Y_t \tag{2.24}$$

Engle and Granger (1987) showed that if, a linear combination of non-stationary time series μ_t are stationary, the time series are co-integrated. If μ_t is subjected to unit root analyses and is found to be stationary $I(0)$ which is against the laws of co-integration which states that if two time series are integrated $I(1)$, then their linear combination should also be integrated $I(1)$. This means that their linear combination cancels out the stochastic trends in the two series. Thus, the variables consumption and income are both $I(1)$ and savings defined as (income − consumption) could be $I(0)$ and consequently, a regression of consumption on income as in equation 2.23 would be meaningful not spurious (Gujarati, 1985). Thus, the two variables in this case are said to be co-integrated. Economically speaking, two variables will be co-integrated if they have a long-term, or equilibrium, relationship between them. It is important to note that the concepts of unit root and co-integration is to force us to find out if the regression residuals are stationary. Thus, the test for co-integration can be thought of as pre-test to avoid spurious regression situations. Another very interesting example would be the long-run relationship between local price and boarder parity prices such as the SAFEX or Chicago prices for maize.

(iv) Causality

Cointegration does not say anything about the direction of causal relationship between variables. Variable A is said to Granger cause variable B, if the lags of variable A can improve a forecast for variable B. In a VAR model, under the null hypothesis that variable A does not Granger cause variable B, all the coefficients on the lags of variable A will be zero in the equation for variable B. A Wald test is commonly used to test for Granger causality. Each row of table or matrix reports a Wald test that the coefficients on the lags of the variable in the excluded (exogenous) column are jointly zero in the equation for the variable in the equation column. For example, a small p-value would mean that there is sufficient evidence to reject the null hypotheses of zero coefficients and thus favouring the alternative hypothesis.

(v) Error correction mechanism (ECM)

Error correction models are a class of models that provide insight into the long-term relationship between variables in terms of the impact propensity, long run propensity, and lag distribution for Δy as a distributed lag in Δx where the independent variable is x and the dependent variable is y (McGowan and Ibrahim, 2009). An error correction term is computed based on the past values of both x and y. If past values of y are over-estimated, future values will be moved back toward equilibrium by the error correction factor. Taking the previous example, although consumption and income are co-integrated that is, they have long-term, or equilibrium, relationship, in the short run there may be disequilibrium. Thus, the error term in equation 2.20 can be treated as the equilibrium error and can be used to tie the short-run behaviour of consumption expenditure to its long-run value. In fact the error correction term (ECT) gives the speed of adjustment to reach the long run equilibrium. The error correction mechanism corrects for disequilibrium and it is important to note that if two variables are co-integrated, then the relationship between the two can be expressed as the ECM.

In short, the multifarious methods that have been developed have their own shortcomings and advantages. The four models initially discussed namely; distributed lag model, partial adjustment model, adaptive expectations model and the Nerlovian model had been found to have numerous methodological problems. These problems are addressed by ECM. Besides avoiding non stationarity in variables by removing linear and quadratic trends in variables through differencing, the error correction mechanism provides insight into the long-term relationship between variables in terms of the impact propensity and long run propensity. It also avoids the problem of spurious regression (also called nonsense regression) associated with the partial adjustment model. Therefore, the ECM offers a means of obtaining consistent yet distinct estimates of both long-run and short-run elasticities especially when combined with cointegration. Causality also offers a means of assessing the direction of causal relationship between time series. Therefore chapter 3 will explore how these methods that will be used to test the hypotheses formulated in this paper.

The next section discusses debate underlying the selection of the independent variable in order to get an insight of the choice of the correct measure of maize supply response to incentives.

2.9 Specification of the dependent variable

There is a great deal of disagreement in literature about the correct measure of crop supply response. The available options include acreage, productivity and total output. Using area planted usually measured in hectares is a good estimate as it explains how farmers directly translate their decisions into action. However farmers may respond to incentives by intensifying the use of the current acreage without necessarily increasing the acreage (Muchapondwa, 2008). In addition, farmers may not respond by increasing acreage as this is constrained by the availability of land.

The alternative would to use productivity which is production per unit area or yield sometimes measure in tonnes per hectare. This is because farmers may not necessarily increase acreage but respond by using land more intensively thus, increasing productivity. However this specification of the dependent variable is faulty in the sense that farmers in Zimbabwe have limited good land. Increase in incentives may cause them to use less productive and inferior land. Thus farmers may increase acreage but not yield. The last option would be to use total production usually measured in kilograms or tonnes. The rationale behind this specification is that, whether farmers use more intensive or extensive farming methods output will increase. Again this method has been found to be pragmatic since the data is readily available in most developing countries.

The next chapter gives a review of the previous studies that have been done along the areas of supply response. The studies used various methods namely the Nerlovian approach, vector error correction mechanism, autoregressive distributed lag approach to cointegration and descriptive statistics to answer their questions. A critical examination of these studies is given in the next section paying particular attention to the tools of analysis and empirical results. These results will be compared with the findings of this particular study in the analytical chapters.

2.10 Review of previous research studies

This section reviews cases where the supply response models have been used to empirically estimate aggregate supply response. This section takes a closer look at various studies that have been done in developing countries clearly stating their strength and weaknesses. This provides a platform for developing a well-founded and sound research tool in the next chapter.

Mesike *et al*, (2010) estimated the supply response of rubber in Nigeria using vector error correction model (VECM) for the period between 1970 and 2008. Long-run supply response was estimated using output as a function of independent variables namely lagged output, producer prices, export price, the real effective exchange rate and time trend. A parameter for structural breaks was included as 1 if T > 1985 and 0 otherwise. The study employed Johansen maximum likelihood and the vector error correction methods to analyze the data. The estimation procedure was used to overcome the problems of spurious correlation often associated with non-stationary time-series data. The error correction coefficient indicated that more than 55% of the adjustment towards long-run equilibrium for supply of rubber is completed in one period as compared with 70% found in Tanzania (Mckay *et al* 1999). The result of the price elasticity of rubber show that a 5% increase in the producer price of rubber lead to a 3.73% increase in the supply of rubber in the short-run and by 2.04% in the long-run. The study failed to incorporate variables such as weather, credit, extension, research and price of substitute crop. Again a nominal protection coefficient (NPC) would have been a good proxy for the producer price (Mamingi, 1997).

The relatively recent autoregressive distributed lag (ARDL) approach to co-integration was employed in a study of the estimation of the aggregate tobacco supply response in Zimbabwe (Muchapondwa, 2008). The approach captures both short-run and long-run dynamics when testing for the existence of co-integration. It also took into account the possibility of reverse causality which implies the absence of weak exogeneity of the regressors. The study found that long-run price elasticity was 0.18 and concluded that tobacco is highly unresponsive to price incentives. This result implied that the agricultural price policy is rather a blunt instrument for effecting growth in agricultural supply. The provision of non-price incentives must play a key role in reviving the agricultural sector in Zimbabwe. The short-run elasticities for current price (-1.19) and lagged price (1.21) were both elastic, although the elasticity for the current price was negative. The explanation for this result is that price is endogenous that is, price of tobacco is determined after supply has been observed resulting in low prices during bumper harvests and high prices when supply is low hence the negative elasticity (Muchapondwa, 2008). However, most non price factors were not included such as extension, infrastructure (irrigation and roads), population of farmers, credit and research.

An estimation of aggregate export and food crop supply response in Tanzania was conducted with a view to establishing weather the agricultural sector is static or dynamic (Mckay *et al*, 1999). The study used the error correction model and the results suggested that Tanzanian farmers are quite responsive to prices with a short-run elasticity of 0.35. The error correction coefficient indicated that more than 70 per cent of the adjustment towards long-run equilibrium for food crops is completed in one period. The study was limited by data availability and therefore restricted their analysis to data on official prices and purchases only. The study did not incorporate non-price factors which influence supply response such as weather conditions and structural breaks which affect short-run response. Complementary interventions, to improve infrastructure, marketing, access to inputs, credit and improved production technology can be expected to make producers even more responsive (Mckay *et al*, 1999). The analytical tools used in the research are however good in that they manage to capture the short run and long run effects of agricultural supply response.

Another study estimated agricultural supply response and poverty in Mozambique by splitting farmers in to two groups namely the poor and the non-poor farmers to understand their different responses (Heltberg, 2001). This allowed him to analyse how farmers exposed to different resources response to changes in production incentives or lack thereof. The study found out that the rich farmers responded more than the poor farmers. This study managed to include the effect of wealth on the response of farmers which is a critical factor in production decision making. However the study failed to use recent methods in times series which helps to capture the dynamism of agricultural supply by splitting short run and long run effects of variables on supply response.

In addition study done in India found out that removal of subsidies led to increase in the price of inputs and reduction in technology adoption (Desphende, 1992). It was discovered that 94% of users who indicated reduction in input use showed reduction in productivity. This founding will help in quantifying output as described earlier when it was found that response might not necessarily means increase in area planted. This finding also gives information on the negative effects of market liberalisation policies when no proper institutions exist or are in place to cushion the negative effects which might occur especially if markets fail to emerge. A related study found out that removal of subsidies in Malawi also revealed that 91% responded with reduction in technology adoption. Technology is key to increased productivity therefore the effects of the structural adjustment programs apparently proved to have a negative effect on productivity in most developing economies. Jansen (1977) noted that a price reform, which takes the form of boarder parity pricing, increases efficiency. In the study of 13 African nations the findings noted that farmers are also taxed due to government controls (Jansen, 1977).

2.11 Conclusion and insights from literature

This chapter reviewed literature on the estimation of maize supply response. The chapter started by providing a review of origins and characteristics of maize of which maize was found tio originate from Mexico. It then goes on to look at the review of global maize production and marketing carefully articulating the major producers, importers and exporters of maize. In this chapter it was found that the major producer of maize is the United States followed by Argentina and China. Brazil, the Republic of South Africa and Ukraine are among a few other countries which often have surpluses for exports. The chapter then goes on to review topical issues in international marketing of maize and found out that there is a recent issue of GM maize which seem to create a maize niche market or segmentation. This technological development has also seen the current rise in maize production. The maize futures traded at the Chicago Board of Trade (CBOT) was found to be widely considered as the world most important price discovery mechanism. However the South African Futures Exchange (SAFEX) seem to determine prices at a regional level and is free from world prices discovered at CBOT.

The chapter then goes on to give an overview of Zimbabwe agricultural sector carefully articulating the current policies especially in relation to maize production and marketing. Maize production was found to have dropped over the years and affected by various government policies. Maize was also found to be a critical crop influencing agricultural policy making and contributing to national food security. The chapter then goes on to review studies that have been done on supply response. It also gave a critical review of these studies carefully identifying the factors or variables that affect supply response and the strength and weaknesses of various methods used. The ECM was found to have more practical and theoretical advantages than other methods. The next chapter present the various research methods used in the study and the expected results.

CHAPTER THREE: RESEARCH METHODS

3.0 Introduction

This chapter provides a general description of the methods used to conduct the study. The chapter starts by providing a conceptual framework developed to show the interrelationship of the variables (cause-effect) analysed in the study. The chapter then goes on to cover data collection approaches, techniques, sources of data and the reliability of data. Data management techniques and empirical models used in the study are also discussed in detail. The strength and weaknesses of the methods used herein are also discussed in greater length.

3.1 Supply response function of maize in Zimbabwe

Various factors which affect supply response of agricultural crops have been identified in chapter 2. These factors are critical components in the maize production process which plays a key role in determining the level of national supply. The rationale behind this aggregation is that aggregate supply curve for a particular product can be obtained by summing horizontally the supply curves of individual producers of that product which are represented by the rising part of the marginal cost curve of each firm. It is therefore not unreasonable to get some insight into the aggregate response to study the reaction of individual farmers even though the idiosyncrasies of individual farmers may be lost in the aggregation process. From a theoretical perspective factors affecting maize supply response and production can be grouped into price and non price factors.

Maize production is affected by own price, price of substitute crop, prices of inputs, lag of output, rainfall and government policies such as market liberalization. Maize supply is also affected by research and extension expenditure, agricultural credit, input usage (for instance fertilizer) and population of farmers. Population is included as Boserup's hypothesis states that increase in population would lead to land use intensification and increase in total area. Variables not captured and technological change can be represented by a trend variable. Variables like rainfall, government policies such as market liberalization, time trend can be incorporated as dummy variables.

Therefore the supply response equation can be expressed as follows;

$$Log(M)_t = \beta_0 + \beta_1 Log(M)_{t-1} + \beta_2(P1_{\,t-1}) + \beta_3 Log(P2)_t + \beta_4 Log(P3)_t + \beta_5 Log(P4)_t + \beta_6 Log(RE)_t + \beta_7 Log(ER)_t + \beta_8 Log(PP)_{t-1} + \beta_9 Log(R)_t + \beta_{10} Log(D)_t + \beta_{11} Log(CRE)_{t-1} + \beta_{12} Log(T) + \beta_{14} Log(T)_t^{\,2} + e_t \quad (3.1)$$

Where: M_t = Maize output at time t (tonnes), M_{t-1} = Maize output at time t-1, $P1_{\,t-1}$= Real producer price of maize (USD$ per tonne) at time t-1, $P2_t$ = SAFEX price of maize (USD$ per tonne) at time t $P3_t$ =Real producer price of fertilizer (USD$ per tonne), at time t, $P4_t$ =Real producer price of substitute (USD$ per tonne), at time t, RE_t= Real expenditure on research and Extension in USD$ at time t, CRE_t = Real agricultural credit (USD$ at time t, ER_t = Real Exchange Rate ZW$/USD at time t PP_t = population of maize producers at time t, R_t = dummy for rainfall at time t-1 D = dummy for government policy at time t $T_t =$ Time trend and time trend squared. $T_t^{\,2} =$ Time trend and time trend squared e_t = assumed normally distributed error term β_i's = parameters.

This specification represents short-run elasticities with respect to that variable. Long-run elasticities are calculated as $E_i = \dfrac{E^{sr}}{1-\beta_1}$, where E^{sr} = short-run elasticity and, β_1 is the coefficient for the lagged dependent variable (de Janvry and Sadoulet, 1995). However, this model has been found to have numerous weaknesses as explained in previous sections. Most importantly, it assumes that the underlying time series data is stationary therefore making radical assumptions which have implications of spurious regression. Table 3.0 shows the factors affecting maize supply response in Zimbabwe.

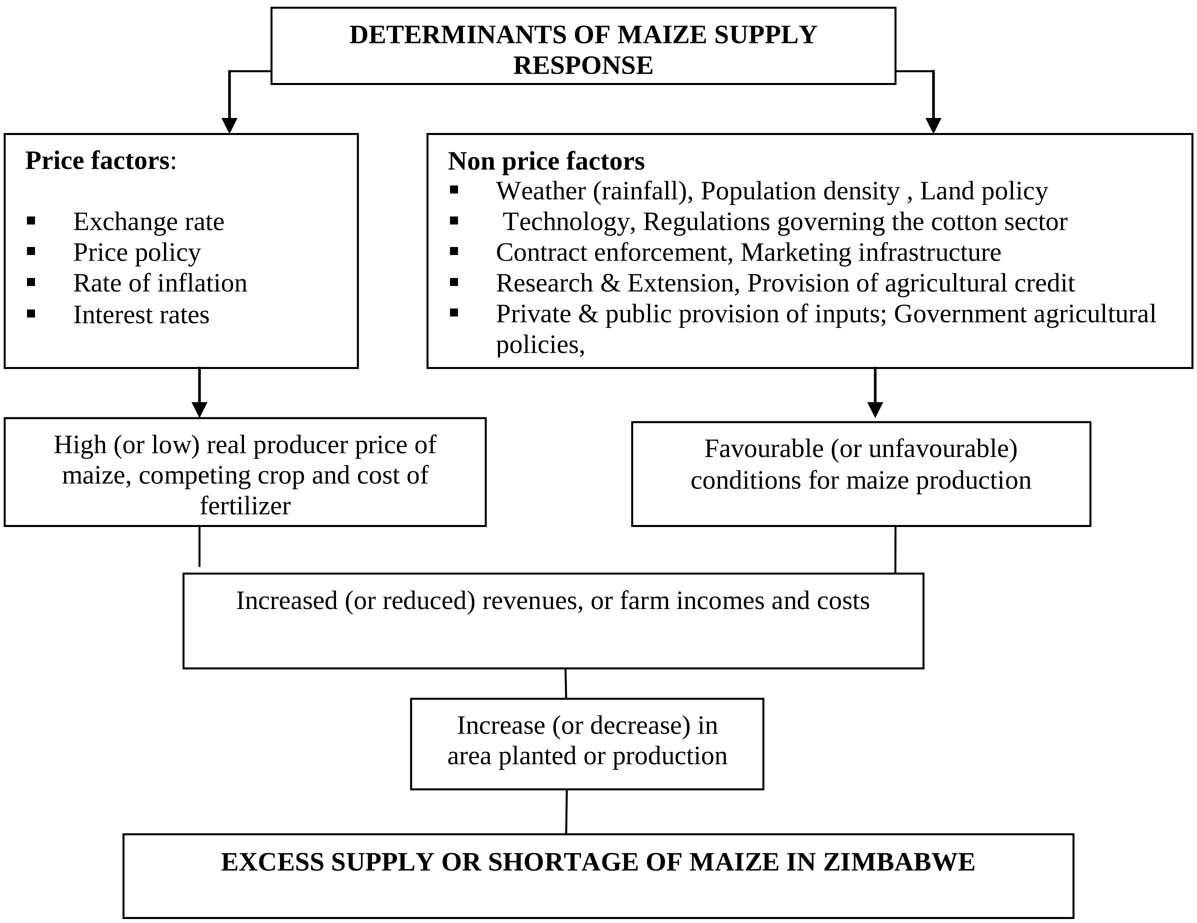

Figure 3.1 Factors affecting maize supply response

3.2 Analytical Framework

Data analysis was separated into three parts. Chapter 4 was the first analytical chapter which is descriptive in nature. In this chapter, descriptive statistics was made use of using time series data from 1980 to 2007. The second analytical chapter was further divided into 2 parts. The first part of chapter 5 deals with the unit root tests and the error correction mechanism (ECM) used to test weather Zimbabwean maize supply is significantly affected by price policy, institutional environment and macroeconomic policies, as well as biophysical environment. The second part of chapter 5 uses almost similar tools to assess whether the regional and the domestic maize markets are integrated. Use was made of graphs, causality and cointegration methods. Table 3 summarizes the relationship between objectives, research questions and method of analysis.

Table 3.1: Relationship between objectives, research questions and method of analysis

OBJECTIVES & QUESTIONS TO BE ADDRESSED		**TYPE OF ANALYSIS**
First Part (characterization)	Objective 1/Question 1	Descriptive statistics-use of mean, max, min, standard dev and graphs
Second Part (Empirical Model Analysis	Objective 2/Question 2	Time series data Analysis Use of unit roots tests and ECM)
Third Part (time series tools and descriptive)	Objective 3/Question 3	secondary data analysis descriptive, cointegration and Causality)

3.2 Descriptive statistics

The study utilised measures of dispersion and central tendency. The measures include mean, maximum, minimum, standard deviation and variance. The mean measures the degree of central tendency. It is obtained by adding the all the observations and then dividing by the number of the observations. The maximum and minimum measures the highest and the lowest values respectively. Observations were expressed out of a hundred called percentages. Percentiles and quartiles enables grouping of data. Standard deviations were also used to calculate the dispersion of data. It is obtained by finding the square root of the variance. Summary tools such as bar graphs, line graphs, tables and pie were also utilized.

3.3 Time series econometric tools (empirical model)

In order to investigate whether Zimbabwean maize supply is significantly affected by price policy, institutional environment and macroeconomic policies as well as biophysical environment, an econometric model, and various statistical tests were carried out using time series tools. Related time series tools were also used to assess whether the regional and the domestic maize markets are integrated.

The long-run estimated model was:

$$\begin{aligned} Log(M)_t = {} & \beta_0 + \beta_1 Log(M)_{t-1} + \beta_2 (P1_{\,t-1}) + \beta_3 Log(P2)_t + \beta_4 Log(P3)_t + \beta_5 Log(P4)_t + \beta_6 Log(RE)_t \\ & + \beta_7 Log(ER)_t + \beta_8 Log(PP)_{t-1} + \beta_9 Log(R)_t + \beta_{10} Log(D)_t + \beta_{11} Log(CRE)_{t-1} + \beta_{12} Log(T) \\ & + \beta_{14} Log(T)_t{}^2 + e_t \end{aligned} \tag{3.2}$$

The model is an autoregressive model because supply of maize is affected by price and output in the previous period. In addition, since the model involves time series data, tests on stationarity was very essential. This was done to overcome spurious regression. Test on cointegration was also conducted to establish whether there is a long run relationship between output and the explanatory variables. The impact of the pricing and the production policy was analysed to show the effects of the price and non price factors using the beta coefficient. This was accomplished through the use of F-test and the coefficient of determination R^2.

To test for stationarity, unit root test was also conducted for all the time series variables namely output, area planted, maize output and lag, price local maize prices and its lags, lagged international price, rainfall, research and extension spending, expenditure on credit, fertilizer use, lagged price of substitutes and consumption. Augmented Dickey Fuller (ADF) test was used to test for the presence of unit root. The null hypothesis of the test is that the data has a unit root or is non-stationary (H0: $\delta=0$ or $\rho=1$) and the alternative hypothesis is that the data has no unit root that is the time series is trend stationary (H0: $\delta<0$ or $\rho\leq1$). To avoid spurious regression due to regression of non-stationary time series on another, unit root test is normally conducted on each of the variables involved. This is similar to the test for cointegration, but they are not identical. While unit root test is performed on univariate time series, cointegration concerns the relationship among a group of variables with each having a unit root. It therefore involves the process of testing for a unit root.

If a time series is found to be non-stationary, it is necessary to difference it that is subtract it from its previous value. If we then perform a unit root test on this time series and find out that it is now stationary the series is said to be integrated to order 1, and is denoted by I(1). However, if the time series is difference ‘m’ times for it to become stationary then it is said to be integrated to order m or I(m). In addition, there can be I(2) series that are cointegrated to produce I(1) or I(0) (Maddala, 2001). In economic theory, two variables are cointegrated if they have along run relationship (Gugarati, 2003). Johansen’s maximum likelihood test was used to test for the presence of cointegration between output, area and all explanatory variables. Residuals were generated and its stationarity was tested if it is in the order of I(1) or I(0). This implies that existence of long-run relationship was realised at first difference, which called for the formulation of the error correction model. Differencing was done using Stata commands.

Cointegration does not say anything about the direction of causal relationship between variables. Variable A is said to Granger cause variable B, if the lags of variable A can improve a forecast for variable B. In a VAR model, under the null hypothesis that variable A does not Granger cause variable B, all the coefficients on the lags of variable A will be zero in the equation for variable B. A Wald test is commonly used to test for Granger causality. Each row of table or matrix reports a Wald test that the coefficients on the lags of the variable in the excluded (exogenous) column are jointly zero in the equation for the variable in the equation column. For example, a small p-value would mean that there is sufficient evidence to reject the null hypotheses of zero coefficients and thus favouring the alternative hypothesis.

An error correction model enables us to study the short-run dynamics in the relationship between two series (Gujarati, 2004). The Engle and Granger two-step error correction model was estimated as follows

$$DM_t = \beta_0 + \beta_1 DM_{t-1} + \beta_2 DP1_{\,t-1} + \beta_3 DP2_{t-1} + \beta_4 DR\&E_t + \beta_5 DCN_t + \beta_6 DCN_{t-1} + \beta_{D7} R_{t-1} + \beta_8 DFU_t + \beta_9 DCRE_{t-1} + \beta_{10}(T) + \beta_{11}(T)_t{}^2 + ECT_{t-1} + e_t \qquad (3.3)$$

D is a first-difference operator; e_t is an error term. The variables include maize output (DM_t) and its lag, lagged own price of maize (P1), lagged SAFEX price (P2), research and extension (R&E), credit (CRE), fertilizer use (FU), consumption and its lag (CN), lag of rainfall (R), linear trend and the quadratic trend (T) and the lag of residuals (ECT). Also the ECT represents the adjustment towards long run equilibrium while coefficients of the rest of the variables represent the short run elasticities. First the model is run and the residuals are predicted in Stata. The lag of the error is tested for unit root and the put back into the model as an explanatory or exogenous variable. The model is run then the coefficient of the lag of the residuals will give the ECT with measure the speed of adjustment. The lag of the residuals or errors can then replace output as a dependent variable and the coefficients of the explanatory variables become the long run elasticities.

3.4 Sources of data and limitations

The study utilised annual data for the period of 1980-2007. The pre-independence data was deliberately excluded due to the effect of war on agricultural production and lack of other important variable needed for the analysis. Post 2007 era was also excluded due to the hyperinflation and massive macroeconomic distortions. The main sources of data were ZIMSTAT publications, Economic Web Institute, World Bank Publications, FAOSTAT, the Meteorological Office, the Ministry of Agriculture Department of Irrigation and Marketing and the Grain Marketing Board (GMB). Other sources of data were found on various economic websites and databases. Data on maize production, area planted, yield and some rainfall figures were obtained from the Ministry of Agriculture. The data on maize output was obtained from the GMB and FAOSTAT. All the price related data of crops were obtained from the FAOSTAT.

Annual data on short-term credit extended to farmers were taken from the Compendium of Statistics, Statistical Yearbook of Zimbabwe and Quarterly Digest of Statistics. Government expenditure on research and extension was taken from estimates of budget expenditure. Consumer price index (CPI) and inflation rate were taken from RBZ publications and FAOSTAT. Other exchange rates such as the Old Mutual Implied Rate (OMIR) were obtained in the Stock Exchange Handbook. South African Futures Exchange market (SAFEX) prices for maize were used as proxy for world prices. SAFEX prices were used instead of CBOT prices since the South Africa seems to be the major supplier of maize Zimbabwe and the rest of the region. Real prices were used for the analysis. Currencies such as agricultural credit and expenditure on research and extension were deflated at 2000 prices using the CPI. Rainfall data was taken from the Department of Meteorological Services although the monthly data could not be provided as a result of the limited budget.

The study used total annual average rainfall figures. This was because the daily or monthly figures were too expensive to get from the meteorological office and could not be covered by the budget. Using monthly averages would mean that the figures for the production period would be used rather than taking annual averages for the whole year inclusive of the non productive period. If rain falls in the after maturity of after harvesting, it will still be recorded in annual averages, however it will of no importance to the crops. In addition, the distribution of rainfall is more important for the physiological growth of crops rather than the mere totals. The total rainfall figures do not tell us anything about the distribution of rainfall. If daily rainfall figures are available, the distribution of rainfall can be estimated by calculating the number of dry spells in a season. A dry spell could be defined as a period of 10 consecutive days with less than 5mm of rainfall. It is the number of dry spells per season that would now be used to replace the total annual averages.

Furthermore, dry spells alone, are necessary but not sufficient to explain the swings in yields and total production. It is the timing of the occurrence of the dry spell would provide more reliable estimates. The physiological growth stages of maize for example include germination, vegetative growth stage, tasseling, silking, grain filling and maturity. It is the flowering and grain filling stages that are critical in affecting yield. If a dry spell coincides with these stages then there will be a very big drop in yield. Therefore, by calculating the number of dry spells that coincide with these stages and creating a dummy variable 1 for those seasons affected and 0 otherwise, the study would have been assured of more accurate and consistent estimates.

The study also faced a limitation of inconsistent exchange rates due to the hyperinflationary environment. Although the Old Mutual Implied Rates (OMIR) were used for the hyperinflationary periods, the fact that exchange rates were changing on daily bases if not on hourly bases meant that the OMIR might either underestimated or overestimated the shadow or equilibrium exchange rate. Therefore, the price data might not clearly explain the phenomena as would be expected under stable macroeconomic conditions especially on price transmission mechanisms.

The data on the prices of competing crops such as cotton, Soya, tobacco and groundnuts was not available for all the years. The study resorted to eliminating the variable because at national level maize has no substitute in terms of area planted since it is a stable food. Therefore, as explained in the literature review section, increase in the profitability of other crops has little or no impact on maize production at national level due to the inelastic nature of maize production stemming from the very importance of the crop as a staple. Competition for land and other resources would however occur at subsector level especially the commercial sector where maize is grown predominantly for sale.

The study also lacked high frequency price and trade volume data (weekly and monthly) which would have provided more accurate estimates, however the budget did not allow for acquiring of such information.

3.5 Expected results

The variables included in the model to explain changes in output of maize are lag of output, acreage, lag of rainfall, allocations to credit, research and extension, consumption and its lag, fertilizer use, ECT, the linear trend and the quadratic trend. The lag of output is expected to have a negative impact on output. If output was high this year then prices would go down due to the excess maize. In the next season farmers would reduce output. The acreage is expected to have a positive sign on output since maize in grown on land. Lag of rainfall is also expected to have a positive impact on output as it represents the wetness of the ground a precondition for maize production.

Allocations to credit and research and extension should have a positive relationship with output of maize. If allocations transform into actual expenditures then farmers borrow money through agricultural loans and acquire new inputs and technologies developed through research. Production is therefore expected to increase. Consumption of maize is a proxy for the demand of maize therefore is expected to have a positive impact on maize output. Fertilizer usage per year is likely to be strongly related to increased productivity and therefore improved yields. The error correction term (ECT) is expected to have a negative since as it corrects for instability in the maize supply. The linear tend would be negative to show the declining trend hypothesised in the study. The quadratic trend would be positive to show that the maize output is declining at an increasing rate.

The next chapter is the first analytical chapter and it provides an analysis of the maize production trends using time series data. The chapter seeks to test the hypothesis that the production of maize over the years shows a declining trend and as well as the contribution of the commercial sector to total output.

CHAPTER 4: CHARACTERISATION OF THE MAIZE PRODUCTION TRENDS

4.1 Introduction

This chapter seeks to give answers to whether there has been a declining trend in the national maize production and contribution of commercial sector. The chapter provides a characterisation of the maize sector in terms of the production performance over the period of 1980 to 2007. This chapter make use of descriptive statistics such as the means, standard deviations, maximum, minimum, growth rates and coefficients of variations. In this chapter graphs were used to illustrate production related aspects such as maize aggregate output, acreage, yield, rainfall and prices. The chapter begins by describing aggregate maize production performance for the period under review then proceeded to separate the performance of the two major subsectors namely the smallholder and large scale sector. The chapter then goes on to investigate which the two sectors contributed more towards maize production for the period under review. This was done to assess whether there is a declining contribution of large scale towards maize production.

4.2 Aggregate maize production performance 1980-2007

The four statistics for the period of 1980-2007 namely the mean, standard deviation, maximum and minimum for the variables that affect maize production and supply response are summarised in Table 4.1 below. Table 4.2 separated the period into two that is from 1980-1996 and from 1997-2007. As shown in table 4.1, the total area planted under maize averaged 1 328 029 hectares with a maximum of 1 729 867 hectares in 2005 and a minimum of 774 800 hectares planted in 1987. For the period of 1980 to 1996 area planted averaged 1 355 919 hectares but from 1997 to 2007 which marks the last ten years of the analysis, maize area averaged 1 432 746 hectares which shows an increase of 5.7%. Maize production averaged 1 641 164 tonnes and varied from a maximum of 2 833 400 tonnes in 1981 to a minimum of 361 000 tonnes in 1992. From 1980 to 1996 total maize production averaged 1 922 821 tonnes but from 1997 to 2007 which marks the last ten years of the analysis, maize output averaged 1 395 458 tonnes which shows a decline of 27.4%.

The national average yield for the period under review was 1.26 tonnes per hectare. A maximum yield of 2.56 tonnes per hectares was recorded in the year 1985 and a minimum of 0.41 tonnes per hectare was recorded in 1992. For the period of 1980 to 1996 yield averaged 1.55 tonnes per hectare but from 1997 to 2007, yield fell to an average of 0.94 tonnes per hectare which shows a reduction in yield of 39.2%. Yield seem to be mainly linked to the annual rainfall received since the lowest figure of 0.41 tonnes per hectare of 1992 corresponds to the lowest rainfall figure of 1991/92 which also match up with the lowest production figure of 361 000 tonnes in the same year. This will be dealt with in greater detail in the analytical chapters to see the impact of each variable on maize production. The marketed surplus both locally and exports averaged 225 743.7 tonnes and a maximum of 350 211 tonnes was sold in 1992 while a minimum of 68 728 tonnes was sold in 1997. The maximum figure recorded in 1992 can be attributed to the fact that the nation was emptying all its reserves as a result of the structural adjustment programme which had been initiated in 1991.

The relationship between aggregate area planted, yield and output of maize can be clearly illustrated in figure 4.1 below. In this figure, it can be seen that from 1980, there has been a sharp increase in both area planted under maize and yield and therefore maize output (area multiply yield). This sharp increase can be attributed to the intensification of agricultural production after the end of the liberation war and also good rainfall which was experienced that year. The sharp fall that followed in 1982 can be attributed to the fall in total annual rainfall which fell by more than half from as much as annual rainfall 860.7mm in 1981 to as low as 439.7mm in 1982.

A glimpse at the graph shows yield and area planted moving together with total output. However the peaks of area planted does not necessarily coincide with the output at other points showing the greater effect of yield on output. As an example, in 1987 the area planted of 774 800 hectares was much lower than in that of 881 000 hectares in 1992 however the yield of 1987 of 1.98 tonnes per hectare was much higher than that of 0.41 tonnes per hectare in 1992 which lead to the respective outputs of 1 530 000 tonnes and 361 000 tonnes. It is also important to note that rainfall and output seems to be moving together in most years where years of good rainfall tend to coincide with years of good harvest and years of low rainfall concur with years of poor rainfall. However, this phenomenon does not seem to occur in all the years and therefore there is need to carefully investigate the extent to which rainfall along with other variables affect maize output. This will be investigated in the subsequent chapters.

A quick look at figure 4.1 also shows that production of maize seem to follow an undefined trend from 1980 to 1996 with highs and lows being maintained at higher levels. However from 1995 going on the national maize production seems to follow a downward trend. If a trend line is superimposed from 1995 to 2007 it can be seem that production falls below the average domestic use of 1 242 410 tonnes calculated in table 4.1. There are many factors that could have lead to this as will be explored in the next chapters.

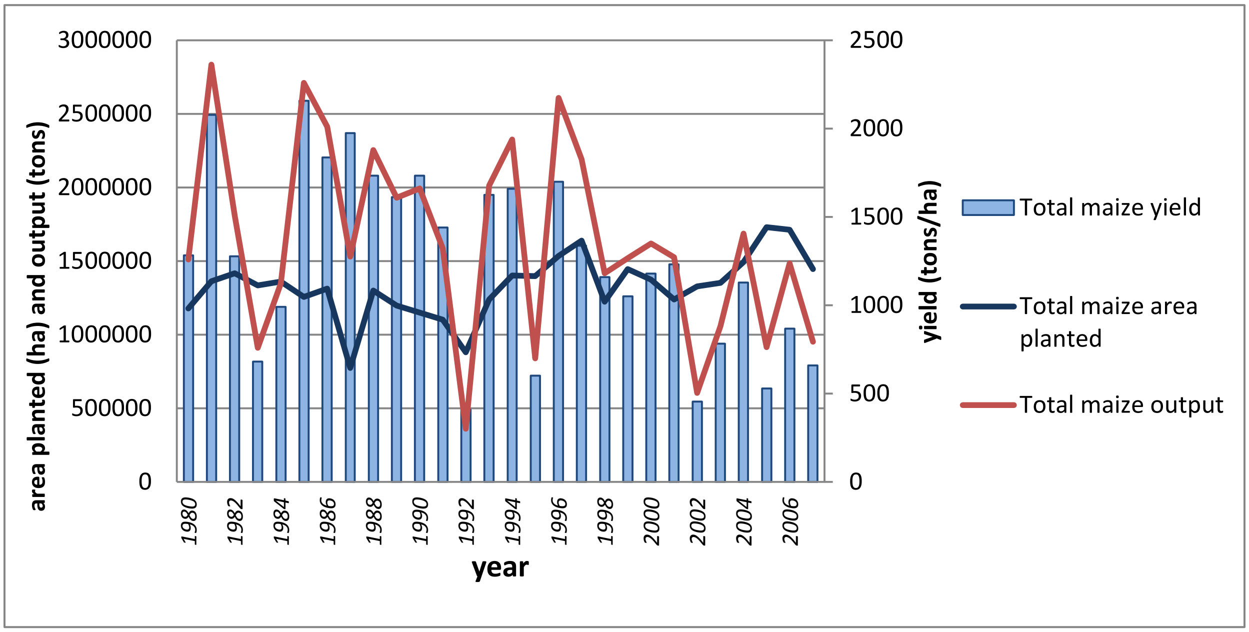

Figure 4.1: Aggregate Maize Area planted, Yield and Production in Zimbabwe

Source: FAOSTAT (2010) and MAMID, (2010)

Table 4.1: Summary of Descriptive Statistics

Variable	Mean	Maximum	Minimum	Standard Deviation
Total maize area planted	1 328 029	1 729 867	774 800	209 915.8
Total maize output	1 641 164	2 833 400	361 000	640 315.8
Total maize yield	1.256	2.158	0.410	0.508
Area planted under commercial sector	182 216.1	363 400	55 683	73 004.25
Maize output under commercial sector	657 759.3	1 833 400	78 062	395 567.30
Maize yield under commercial sector	3.339	5.045	1.108	1.194
Area planted under communal sector	1 145 813	1 659 424	627 700	235 301.7
Maize output under communal sector	990 869.2	1 687 000	115 200	423 373.6
Maize yield under communal sector	0.879	1.695	0.158	0.396
Total GMB purchases	225 743.7	350 211	68 728	84 029.27
Annual rainfall (mm)	615.29	883.5	335.2	152.3195
Real maize producer price ($/ton)	60.31	152.61	34.48	29.12628
Real soya producer price ($/ton)	104.17	267.07	71.52	45.23312
Real cotton price	533.45	844.11	63.51	193.877
Real tobacco price	83.61	147.80	42.97	21.31
Real fertilizer cost ($/50kg)	93.3	251.81	40.18	49.78622
Real maize SAFEX producer price ($/ton)	203.60	396.56	108.59	71.39526
Inflation	62.39	359.6	1.88	95.33354
Real expenditure on research and extension	7.75	10.97	1.55	2.337934
Real expenditure on agricultural credit	18 579.04	47 968.64	2 154.65	14 298.12
Per capita consumption	114.16	128.89	90.35	9.59
Total population	10 800 000	12 500 000	7 282 344	1 774 208
national maize total consumption	1 203 500	1 445 500	913 200	160 060
Domestic use	1 242 410	1 480 190	954 100	160 070

Source Own Computations

Table 4.2 Two period averages and percentage change for area, yield and output

		Area (ha)	**yield (tonnes per hectare)**	**Output(tons)**
National averages and % changes	**1980-1996 average**	1 355 919	1.55	1 922 821
	1997-2007 average	1 432 746	0.94	1 395 458
	% change	+5.7	-39.2	-27.4
Communal sub sector averages and % changes	**1980-1996 average**	1 091 175	1.09	1 052 994
	1997-2007 average	1 329 451	0.74	990 585
	% change	+29.8	-32.1	-5.9
Commercial sub sector averages and % changes	**1980-1996 average**	233 743	3.9	882 953
	1997-2007 average	123 832	2.77	390 001
	% change	-47.0	-29.9	-55.8

Source Own Computations

4.3 The development of maize production performance by sector

The distribution of land in Zimbabwe before the fast track land reform program had been such that on one hand, the fewer large commercial farms (17 135 farms) occupied 34% of the total agricultural land area. On the other hand, the smallholder sector with a larger number of farms (1 000 000 farms) occupied 50% of total agricultural land while the remaining 16% was placed under national land (MAMID, 2009). The distribution of land has since changed as a result of the fast track land reform program (FTLRP). Currently, the number of commercial farms has increased due to the subdivision of larger pieces of land into smaller farms. The commercial sector presently has about 27 349 farms representing 21% of the total land area. The smallholder sector on the other hand has 1 300 000 farms which makes 66% of total land area and the remaining 13% is placed under other uses such as national land. The next 3 subsections present results of the commercial sector production performance, communal sector and the comparison two sectors.

(i) The Commercial subsector

The evolution of the maize subsector has been such that the commercial sector has been the main producer of maize in the country. In chapter two, we found out that Zimbabwe's first green revolution (1960-80) was spearheaded by the white commercial farmers. For the period under review (1980 to 2007) the maize area planted by commercial farmers averaged 182 216 hectares with a maximum of 363 400 hectares in 1981 and a minimum of 55 683in the year 2007. The large acreage recorded can be as a result of the post independence policy which favours the intensification of food production and also the return of farmers from the liberation struggle to partake in agricultural activities such as maize production. However, the low figure in 2007 can be attributed to the effects of the land reform program where large pieces of commercial farms were disintegrated to smaller farmers namely A1 and A2 models. From 1980 to 1996 total area averaged 233 743 hectares but from 1997 to 2007 which marks the last ten years of the analysis the maize area averaged 123 832 hectares which shows a decline of 47.0%.

Productivity averaged 3.34 tonnes per hectare with a maximum of 5.05 tonnes per hectare being recorded in the year 1981 and a minimum yield of 1.11 tonnes per hectare in 2005. The large productivity can be attributed to the use of hybrid varieties while the low figure recorded in 2005 can be attributed to low rainfall figure recorded that year and inability to procure critical inputs caused by the soaring of input prices as a resulting from unstable macroeconomic environment. For the period of 1980 to 1996 yield averaged 3.9 tonnes per hectare but from 1997 to 2007 which marks the last ten years of the analysis, maize yield averaged 2.77 tonnes per hectare which shows a decline of 29.9%.

The maize output under commercial sector for the period under review averaged 657 759 tonnes with a maximum output of 1 833 400 tonnes in 1981 and a minimum production of 78 062 tonnes in the year 2005. The maximum production figure can be linked to the increase in the area under maize among other things since it directly corresponds to the year of maximum acreage under maize and the maximum yield also being recorded the same year. Maize production is literally area planted multiplied by productivity or yield. Therefore, since the year 2005, lowest yield and area were recorded the same explanation goes for the low production figure recorded in 2005. From 1980 to 1996 commercial sector maize production averaged 882 953 tonnes but from 1997 to 2007 which marks the last ten years of the analysis, maize output averaged 390 001tonnes which shows a decline of 55.8%.

A quick look at figure 4.2 shows maize planted, productivity and production in the commercial sector moving together coinciding at both high and low spikes. However, there seem to be a stronger relationship between output and productivity as the two graphs are moving together. In econometric language and as will be investigated later on there seem to be a stronger long term relationship among the three variables as they seem to be co-integrated. In addition, there seem to be a downward trend in area, yield and therefore output if a trend line is to be superimposed on all the three graphs. The fall can be attributed to the departure of the commercial farmers from maize production to other enterprises such as more profitable cash crops like tobacco wheat and soyabeans as maize production became a less attractive venture. Again, the effects of the land reform program can be seen as there is a sharp fall in yield and area planted under maize from 2000 going on. The exact and most influential variable will be explored in the later chapters in terms of the magnitude of influence.

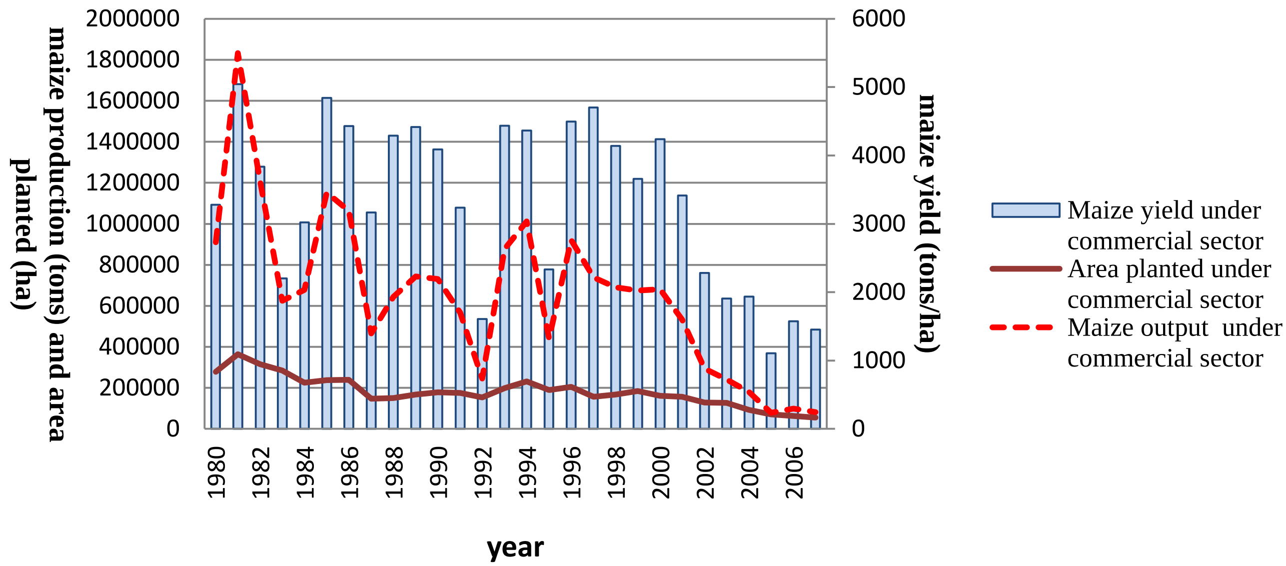

Figure 4.2 Maize area planted, productivity and production in the commercial sector

Source: FAOSTAT, 2010 and MAMID, 2010

(ii) Communal subsector

As explained in chapter 2, the second green revolution (1980-1986) was led by smallholder farmers who in 1980 with a population of 700 000 owned half of the arable land with the other half being owned by the 5000 commercial farmers (Rukuni *et al*, 2006). The average area planted by the communal farmers for the period under review was 1 145 813 hectares with a maximum acreage of 1 659 424 hectares having been recorded in 2005 and a minimum figure of 627 700 hectares in 1987. The high figure of 2005 can be attributed to the FTLRP increasing landholding of the smallholder famers. From table 4.2, from 1980 to 1996 communal sector maize production averaged 1 091 175 tonnes but from 1997 to 2007, maize output averaged 1 329 451 tonnes which show an increase of 29.8%. Productivity averaged 0.88 and had a maximum of 1.7 tonnes per hectare recorded in 1987 and minimum of 0.16 tonnes per hectare recorded in 1992. Again, from 1980 to 1996 communal sector maize yield averaged 1.09 tonnes per hectare but from 1997 to

2007 which marks the last ten years of the analysis the yield averaged 0.74 tonnes which shows a decline of 32.1%.

Maize production for the period under review averaged 990 869 tonnes and had a maximum of 1 687 000 tonnes recorded in 1996 and a minimum of 115 200 recorded in 1992. The high figure can be among other factors attributed to the good rainfall that fell in 1996 with an annual figure of 700.7 millimetres recorded by the meteorological office in Harare. The low figure can be explained by the low rainfall and famous drought of 1992 where an annual rainfall figure of 335.2 millimetres was recorded in 1992 which is an all time low figure recorded for the period being investigated. Thus, one can conclude that smallholder farming in Zimbabwe heavily depends on natural rainfall compared with the commercial sector which did not show strong link with annual rainfall. The smallholder maize production doubled in six years from 1980 to 1986 and this was attributed to a number of factors. These factors included the use of land abandoned during war, use of hybrid varieties and inorganic fertilisers were among the contributing factors. In addition, the removal of racial and institutional barriers and the expansion of the marketing services were also identified as the preconditions for this success story (Eicher, 1995). From 1980 to 1996 communal sector maize production averaged 1 052 994 tonnes but from 1997 to 2007, maize output averaged 990 585 tonnes which shows a decline of 5.9%.

A quick glimpse at figure 4.2 shows that the area under maize has been increasing. This increase can be attributed to the increase in the number of smallholder farms as a result of the FTLRP. Both production and productivity seems to be following a downward trend especially from 1995 to 2007. This could be attributed to a lot of factors such as lack of funds or increase in the cost of hybrid seeds, fertiliser, draught power and labour. Since maize is a strategic crop this compromises the food security situation of the country.

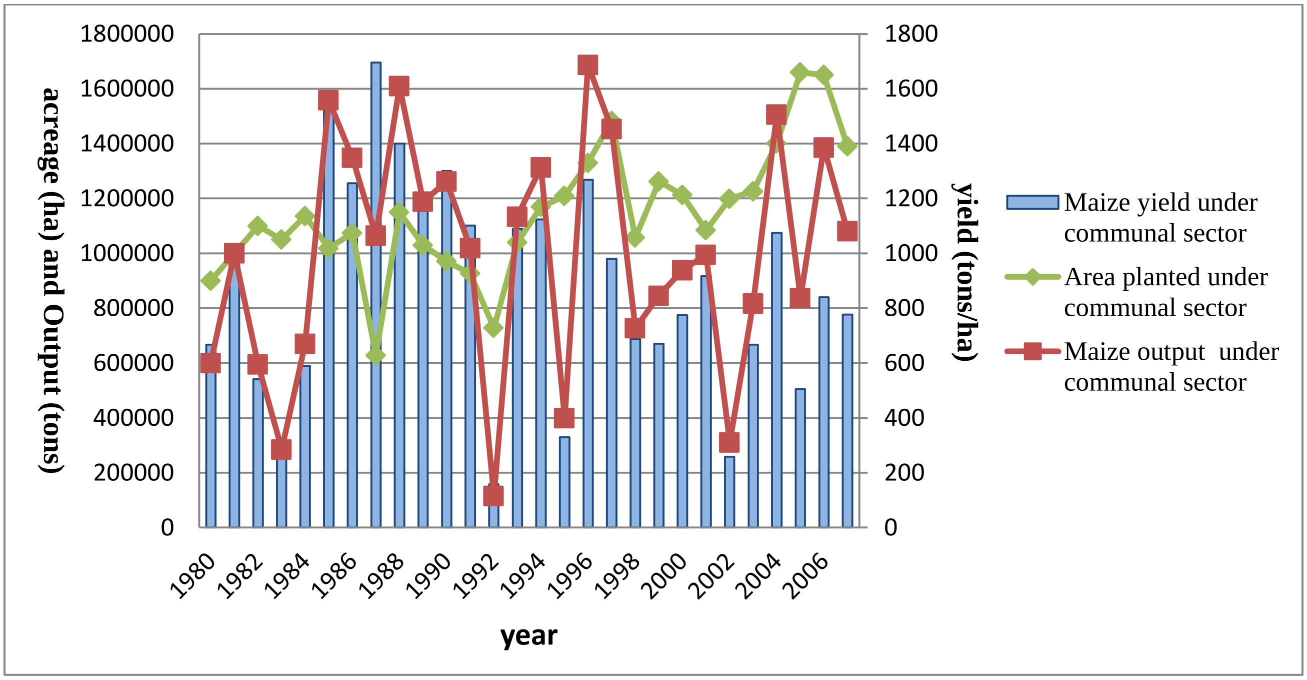

Figure 4.2 Maize area planted, productivity and production in the smallholder sector

Source: FAOSTAT, 2010 and MAMID, 2010

As illustrated in table 4.3, in terms of percentage contributions of the total or national area, the smallholder sector contributed 80.5% of the total area under maize for the period of 1980 to 1996 while the commercial sector contributed 17.3% for the same period. However for the period of 1997 to 2007, the percentage contribution of the communal sector grew to 92.8% against a drop in percentage contribution by commercial counterpart to 8.6% for the same period. This represented an increase in percentage contribution to area of 15.3% for communal and a fall of 50.3% in contribution to area by commercial farmers. In terms of contribution to total output, the communal sector used to make a contribution of 54.8% while the commercial sector contributed

45.9% to total output. However, from 1997-2007 the communal sector contribution to national maize output increased to 71% against a fall in contribution by commercial farmers to 28%. This showed an increase in maize contribution by 29.6% by communal farmers and a fall of 39% by commercial farmers who were moving to new alternative and more profitable enterprises such as more profitable cash crops like paprika, cotton and tobacco.

Table 4.3 Sub sector contributions as a % of total

		area	**output**
communal	**1980-1996**	80.5	54.8
	1997-2007	92.8	71
	% change	+15.3	+29.6
commercial	**1980-1996**	17.3	45.9
	1997-2007	8.6	28
	% change	-50.3	-39.0

Source Own Computations

(iii) Production Performance in Commercial Sector versus the Communal Sector

Figure 4.3 below shows the comparison of the area under commercial sector versus the area under the communal. A glimpse at the figure shows that the area under maize for the commercial sector has been following a downward trend since 1980. Again the area planted under commercial sector is lower than the area planted under the communal sector which is following an upward trend. This could have been attributed to the drift of the commercial farmers from maize production to other more profitable cash crops such as paprika, tobacco and other horticultural crops. Again the increase in area under maize in the communal sector can be attributed to the increase in the number of smallholder farms as a result of the land reform program and the use of land which has been idle during the liberation struggle.

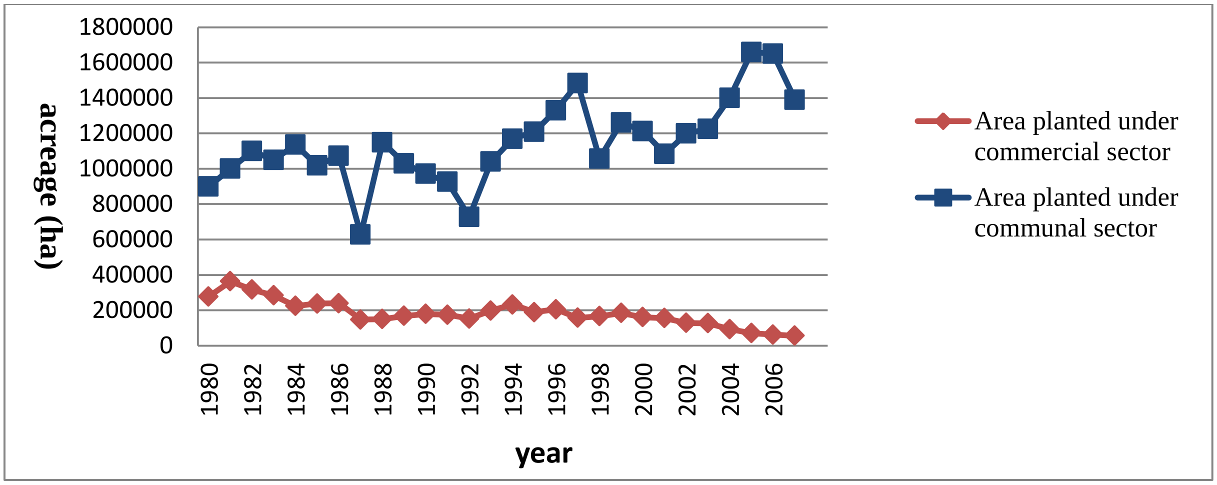

Figure 4.3 Area planted under the commercial and the communal sector

Source: FAOSTAT, 2010 and MAMID, 2010

Figure 4.4 illustrate that maize productivity under the commercial sector is higher than the communal sector for the period under review. However maize yield seem to not follow a defined trend from 1980 to 2000 for both sectors. From 2000 to 2007 productivity fell tremendously for the commercial sector. The inability of the smallholder sector to catch-up with their commercial counterpart can be attributed to insufficient extension, inability to use hybrid seed and fertilisers, lack of education and inadequate labour among other things. The sharp fall in maize productivity in the commercial sector can be attributed to the effects of the FTLRP which saw the dismantling of large pieces of land which were under the commercial sector and were redistributed to the smallholder sector. Again the unstable macroeconomic environment can also be a possible culprit for the dramatic fall in maize productivity under the commercial sector.

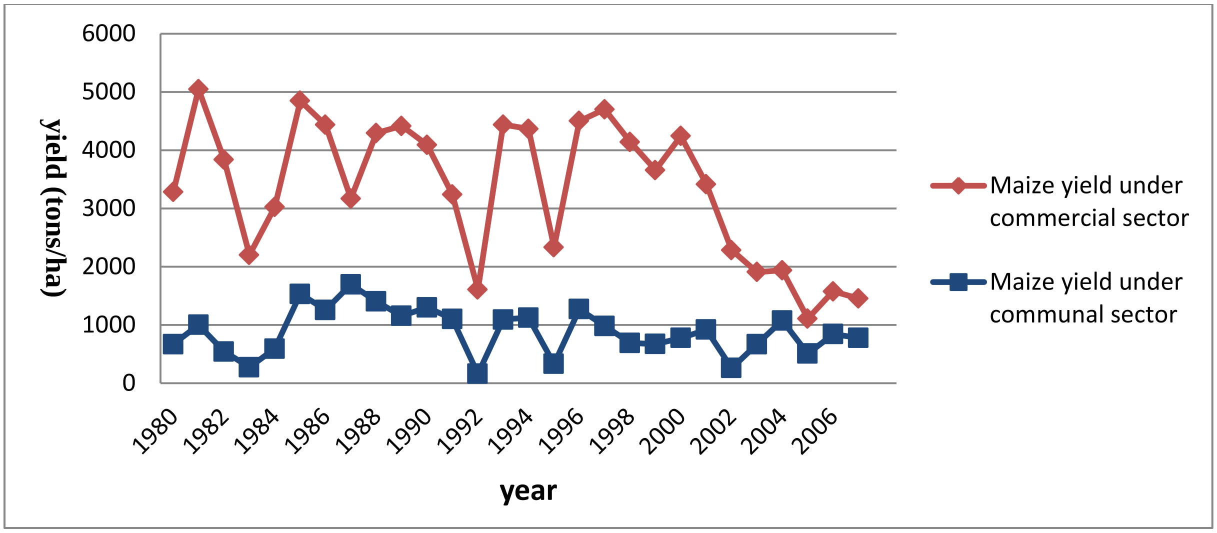

Figure 4.4 Maize productivity under commercial and communal sector

Source: FAOSTAT, 2010 and MAMID, 2010

Figure 4.5 show maize production under the commercial and the communal sector. A quick look at the two graphs reveals that from 1980 to 1984 maize production of the commercial sector was higher than that of the communal sector. However from 1984 to 2007 maize production under the communal sector became higher than their commercial counterparts. The reasons for this phenomenon can be linked to productivity and area since production is literally area multiplied by yield. It can however be seen that although not exactly coinciding on every points, the major ups and downs are coinciding for both the smallholder and the commercial sector production. A closer look at the graphs illustrate that the points of convergence are either years of good rainfall or of droughts. Instances where they coincide at low levels are the major drought periods of 1987, 1992, 1995 and 2002. The major peaks are 1985, 1988, 1994 and 1996. It can therefore be concluded that for the period under review the communal farmers are the major producers of maize in the Zimbabwe maize sub sector.

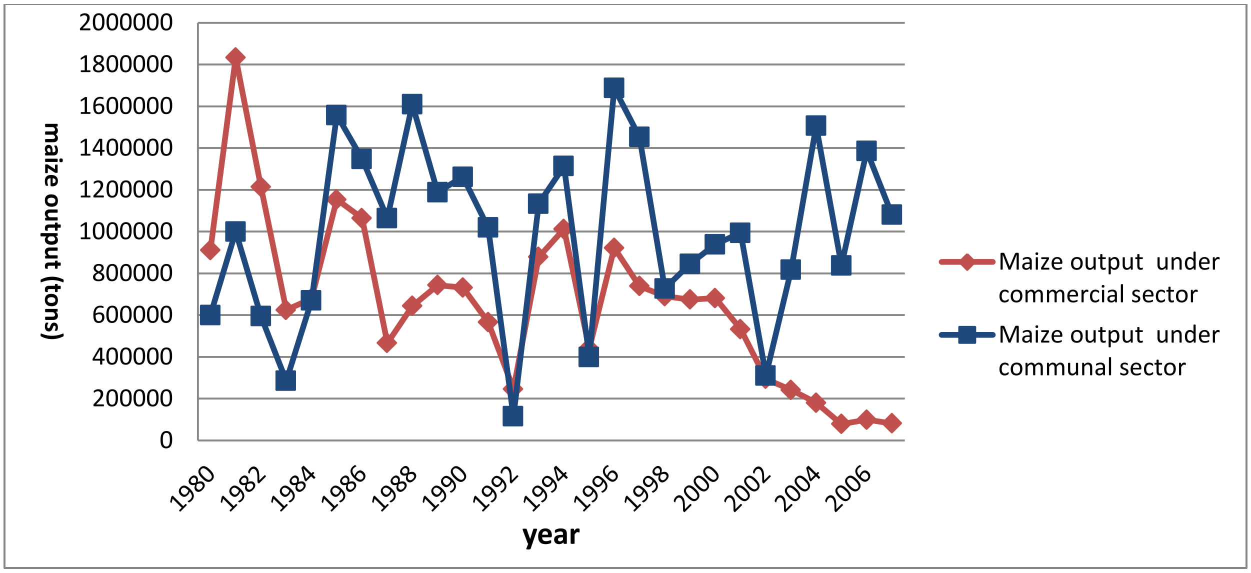

Figure 4.5 Maize production in the commercial and the communal sector

Source: FAOSTAT, 2010 and MAMID, 2010

4.4 Factors Affecting Maize Production in Zimbabwe

There is a multitude of factors that affect maize production in Zimbabwe. These include rainfall, input costs (seed and fertiliser), maize prices and prices of competing crops such as (tobacco, cotton and soyabeans). These factors predominantly influence planting decisions and therefore the amount produced in that particular season. Other factors such as parity prices, residual stock and government policies indirectly affect maize production through their effect on local prices. Some of the factors listed above and their relationship to area planted under maize and then on maize output is clearly illustrated in the figures below. Figure 4.6 illustrates the relationship between area under maize, maize production and annual rainfall.

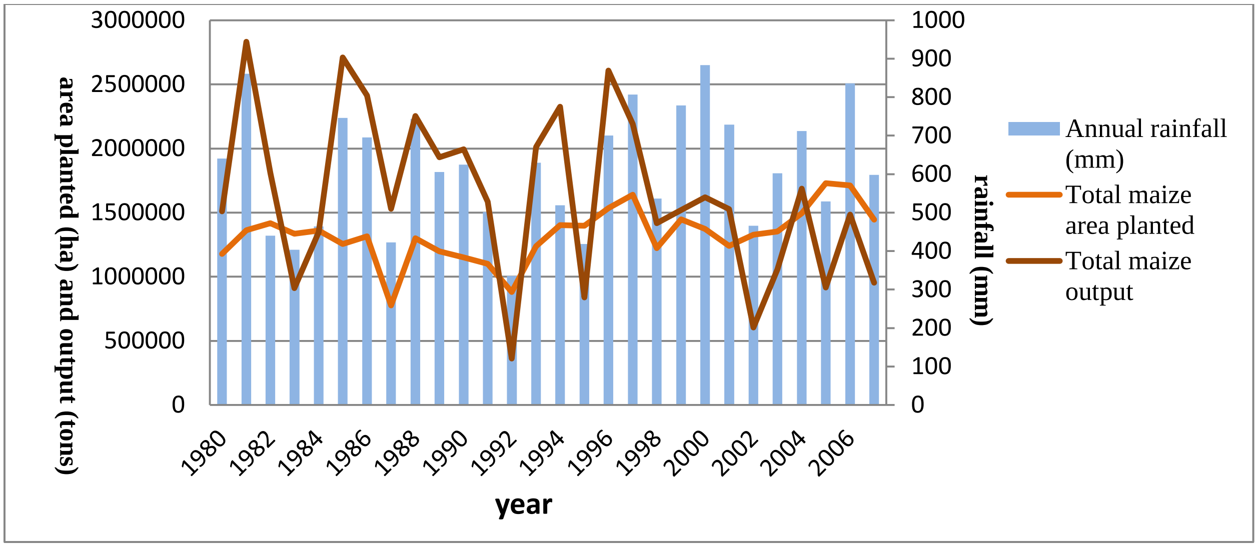

Figure 4.6: Area, maize production and annual rainfall in Zimbabwe.

Source: FAOSTAT, 2010 and MAMID, 2010

From figure 4.6 above there seem to be a close relationship between annual rainfall, area under maize and total maize production. However, there seem to be a closer link between maize output and annual rainfall than there is between area and annual rainfall. This means that rainfall affects output mainly through productivity. This relationship is illustrated in figure 4.7 below. From the graph it can be seen that maize acreage continued to follow a steady upward trend regardless of the movement in annual rainfall especially from 1998 to 2007. However, rainfall only necessarily explain the movement in maize output, but to make a sufficient explanation there is need to look at other factor and see if they in any way relate to movements in maize production or area planted. This is so because there are years where rainfall increase while output falls and others where rainfall decreases but output falls. Therefore, the next chapters will do a more robust work on how these multifarious factors affect production in terms of the magnitude of effect of each explanatory variable.

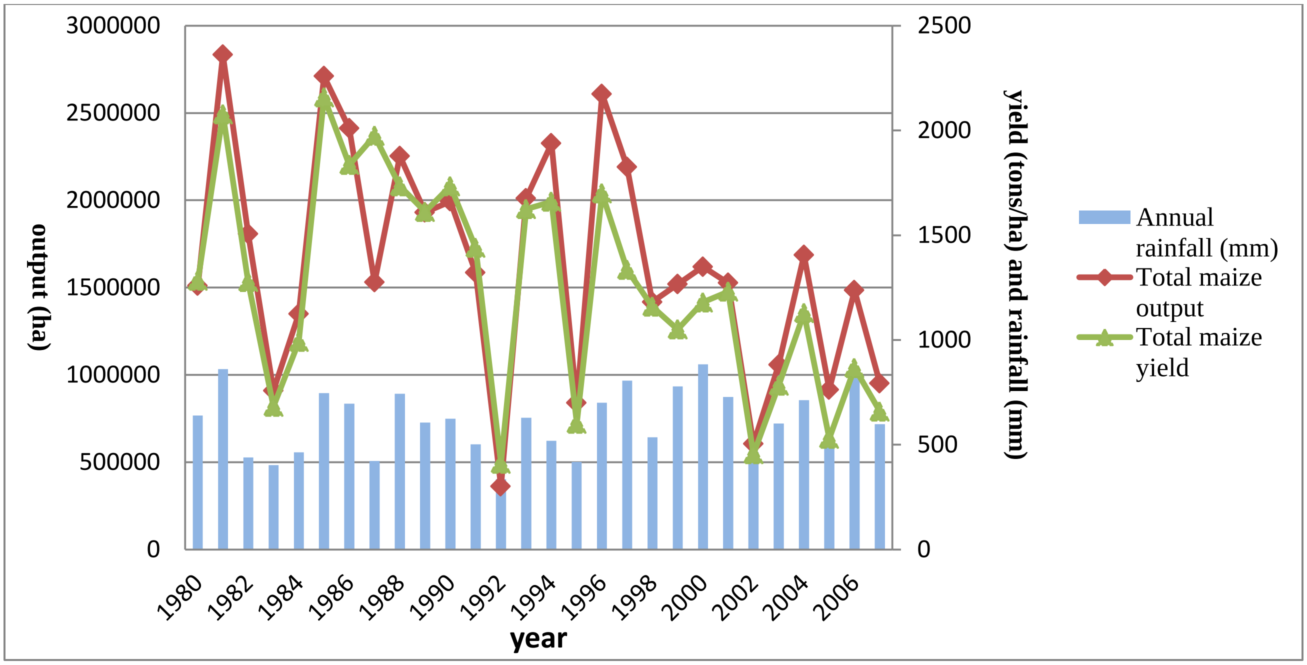

Figure 4.7 Maize productivity, production and annual rainfall in Zimbabwe

Source: FAOSTAT, 2010 and MAMID, 2010

Area under maize and output can also be determined by the real own prices. The theory behind this is comes from the classical supply theory. This states that the supply of a product is positively influenced by own prices that is, if prices increase, then there is an incentive to supply more of that product as profits are higher. Thus rational firms would supply more of the product if they experience a high price or if they expect the price to increase before the planting period. Figure 4.8 show the relationship between the maize output and lagged own real prices. Theory says that increase in prices this year would lead to increase in output in the next year. This might be due to increase in use of inputs and or increase in area planted. The graph shows that the output and the real own prices reasonably move together as we would expect from theory of supply. For example in the 1992, 2002 and 2005 fall in output correspond to sharp increase in prices. 1982, 1992 and 1998, sharp fall in real prices led to a sharp fall area planted. Thus we can see that prices are important determinants of planting decisions but in other years they are not really moving together with maize supply as theory would assume. Thus, there are other important variables which work together with own prices to determine planting decisions. Also important to note is that the prices used in plotting the graph are previously year prices. This assumes naive expectations of farmers and thus production occurs in a distributed lag fashion.

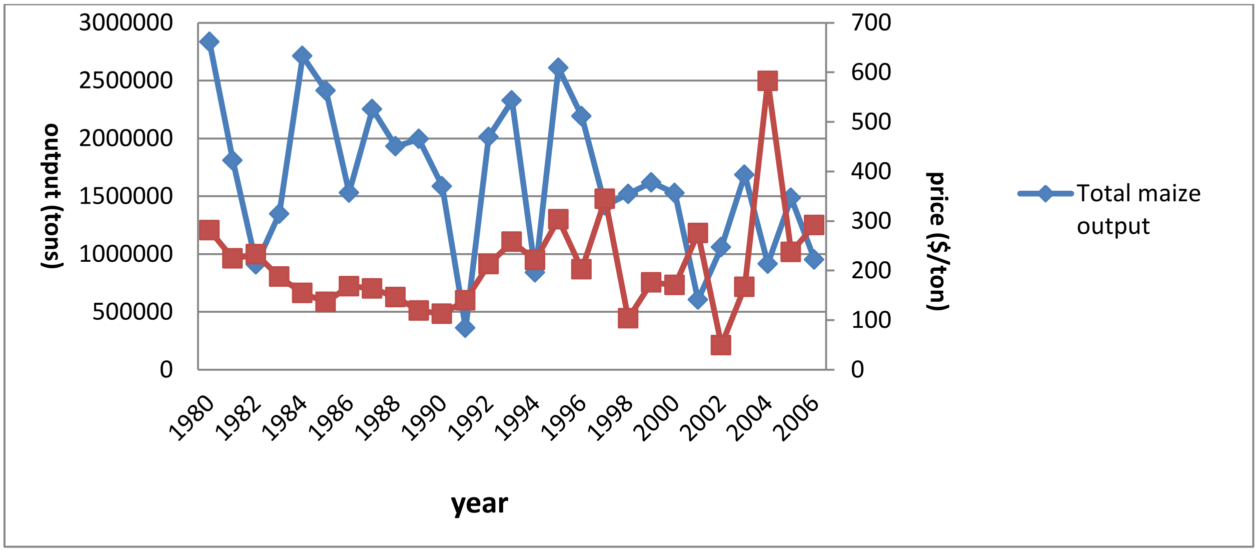

Figure 4.8 Real maize prices and area under maize in Zimbabwe

Source: FAOSTAT, 2010 and MAMID, 2010

4.5 Summary

The findings of this chapter show that in deed maize production has been showing a declining trend. This has been linked to various factors such as reduced productivity, government policies such as ESAP, unstable macroeconomic environment and the pricing policy. National maize output fell by 27.4% as a result of a 39.2% fall in productivity. It is important to note that this was against a 5.7% increase in total area under maize. The contribution of the commercial farming sector to total output of maize also showed a declining trend. In fact, in terms of percentage changes, the contribution of the commercial sector to maize output fell by 39%. In terms of percentage change in contribution to total area under maize, the commercial sector reduced it by 50.3%. The communal sector, contrary to their commercial counterparts increased their contribution to total output by 29.6% and their contribution to total area under maize increased by 15.3%. The results therefore support the hypotheses that maize output was showing a decreasing trend for the period under review and that the contribution of the commercial sector has been following a downward trend.

CHAPTER 5: ECONOMETRIC ESTIMATION OF MAIZE SUPPLY RESPONSE TO ECONOMIC POLICIES AND BIOPHYSICAL FACTORS IN ZIMBABWE

5.0 Introduction

This chapter seeks to give answers to weather Zimbabwean maize supply is significantly affected by the price policy, institutional environment and macroeconomic policies, as well as biophysical environment. Use of the error correction mechanism among other related time series tools was made to come up with a solid decision of whether this hypothesis can be accepted or rejected. The chapter then goes on to analyse and assess whether the Zimbabwe maize market is integrated with the regional maize market. Descriptive statistics, cointegration and Granger causality methods were used to answer this question. Firstly, the chapter explains various processes of time series analysis such as unit root and cointegration diagnostic test processes to ensure that the data is corrected for stationarity before an error correction model (ECM) was developed and run using Stata software version 10. Furthermore use of cointegration and Granger causality was then made to see if there is a long run relationship between the local and the regional markets.

5.1 Unit root test

The results for unit root test are summarized in appendix A. Using Dickey Fuller test (DF) for stationarity, unit root test was conducted for each of the variables used in the regression. The variables include prices of maize (local and SAFEX) and, price of cotton, output, credit, research and extension, fertilizer use, domestic consumption as a variable that reflects the demand for maize, area, population, rainfall and yield. The results show that most variables were not significant at levels. Therefore the results suggest that the researcher failed to reject the null hypothesis of the presence of a unit root. The lags of all the variables were also tested for unit root and the same results appeared that there was presence of unit root implying that the data was not stationary. Only output, rainfall and local price of maize were found to be stationary that is I(0).

As a result of the results shown in the appendix A and appendix B, the variables and their lags were differenced to become stationary. The unit root test results of the ADF test are shown in appendix C for the variables at period t and appendix D for the variables at period (t-1). Most variables were only differenced once to become stationary except for population which had to be differenced three times and in inflation which had to be differenced twice to become stationary. Thus the findings show that most the variables are integrated to order one, I(1) except population which is integrated of order three I(3) and inflation which is integrated of order I(2). The series are therefore Autoregressive processes, AR (1) AR (2) and AR (3). Consequently, co-integration test is necessary to establish a long run relationship between the supply of cocoa and the other variables in the model.

5.2 Cointegration analysis

Cointegration was done to test for the long run relationship between two or more variables. The method that was used to test for cointegration is called the Engle and Granger Method which is based on OLS and tests for the long-run relationship between two time-series variables. There are three steps involved. First one time series was regressed on another time series. The next step was to obtain the residuals. The final step was to test the residuals for unit root. If there is cointegration the residuals should be stationary. To test the residues for stationarity Dickey-Fuller method was used and the errors were found to be stationary. This would imply that there was a long run relationship among variables. A Johansen Maximum Likelihood method can be used to test for cointegration in more than two variables. The rank of cointegration was found using the Johansen Maximum likelihood test to see the number of cointegrating relationships within the model. Table 5.1 shows that there is sufficient evidence to reject the null hypotheses of no cointegration that is r=0 and therefore favour the alternative hypotheses of more than 5 cointegrating relationships. This is shown clearly in table 5.1 below where the trace statistic is less than the critical value. A one on one cointegration analysis can be done to see if each variable is cointegrated to the other. However the long run model was run and the residuals were tested for stationarity and found to be stationary implying the presence of cointegration among the variables. The results of the cointegrating equation are shown in table 5.2 and can be represented in the equation 5.1 below.

$$Q_t=-429-0.77Q_{t-1}+4.2Area_t+2.89SAFEXPrice+1.57LocalPrice+4.29Rainfall+3.6Consumption_{t-1}-0.07Credit_t+10.15Consumption_t-118Reseach\ and\ Ext_{t-1}+0.13Cottonprice+0.13fertuse \tag{5.1}$$

In model, the R-square shows that 91% of the change in output is explained by the exogenous variables. The F statistic is highly significant at 1% level. In table 5.2 below, 6 out of 11 variables included in the model were found to be significant. The variables include lagged maize output, area harvested at period t, fertilizer use at t, lag of rainfall, maize consumption and real credit. The results of this equation show that a 10% increase in area harvested would increase the output by 42.9%. The area harvested is also significant at 1%. Moreover a 10% increase in lagged maize output would lead to a fall in output by 7.7%. This was significant at 10%. Fertilizer use was found to be significant at 10% and a 10% increase in fertilizer use would lead to a 0.13% increase in output. Rainfall was highly significant at 1% and a 10% increase in rainfall would lead to a 42.9% increase in the quantity of maize produced. Real credit and lag of research expenditure had wrong signs although research expenditure was not significant. We would expect that an increase in credit allocation and research allocation would mean increase in maize produced. However, this phenomenon can be explained by the fact that most of these funds are mere budgetary allocations to credit, research and extension, but this does not usually convert to actual expenditure in practice. Consumption was also significant and had an elasticity of 10.1. Consumption is a proxy or reflection of the demand for maize therefore contains a positive sign as expected.

Other variables such as real SAFEX price of maize, real price of cotton, real maize price, research and extension allocation, and lag of consumption were not significant although most of them contained the correct sign. In addition, a 10% increase in the SAFEX price of maize although not significant would lead to an increase in maize production by 28.9%. Moreover, it can also be seen that a 10% increase in the domestic price of maize would lead to a 15.7% increase in the supply of maize. Yet again, 10% increase in the lagged real price of cotton a substitute would lead to a 1.3% increase in maize output. Lagged consumption has the correct sign but was not significant. A 10% increase in lagged consumption of maize although not significant would lead to a 36.5% increase in maize output.

Table 5.1 Test for Cointegration

Johansen tests for cointegration among the variables; fertilizer use Lmaize output Lrainfall Lreal producer price of maize Lreal credit Lconsumption Lreal SAFEX maize price Lreal price cotton

Maximum rank	**Parms**	**LL**	**Eigen value**	**Trace statistic**	**Critical value**
0	72	-1134.597	.	849.2659	156.00
1	87	-812.78537	1.00000	205.6427	124.24
2	100	-774.11035	0.96016	128.2926	94.15
3	111	-751.16298	0.85226	82.3979	68.52
4	120	-734.40769	0.75248	48.8873	47.21
5	127	-721.43195	0.66085	22.9358*	29.68
6	132	-713.80842	0.47022	7.6888	15.41
7	135	-711.53666	0.17247	3.1453	3.76
8	136	-709.96404	0.12283		

Source Own Computations

Table 5.2 Cointegration analysis

Dmaize output	Coefficient	Std. Err.	t-value	P>t	[95% Conf.	Interval]
DLmaizeoutput	-0.7655253	.3471822	-2.20	0.055	-1.550906	.0198553
Darea	4.287082	1.107152	3.87	0.004	1.782529	6.791634
Dfertuse	0.0139127	.0066372	2.10	0.066	-.0011017	.028927
DLrealprice of cotton	0.1326858	.6878445	0.19	0.851	-1.423327	1.688698
DLrealSAFEX price	2.8857	2.8888	0.25	0.603	-3.374998	13.2356
DESAP	-588.1903	685.818	-1.44	0.193	-2609.892	633.5115
DLreal maize price	1.565817	1.575167	0.99	0.346	-1.997459	5.129093
DLrainfall	4.285646	1.2445	3.44	0.007	1.470391	7.100901
DLconsumption	3.649276	4.053194	0.90	0.391	-5.519685	12.81824
Drealcredit	-.0650195	.0280497	-2.32	0.046	-.1284724	-.0015666
Dconsumption	10.14539	3.905566	2.60	0.029	1.31039	18.9804
DLreal R&E	-118.2878	72.45389	-1.63	0.137	-282.1899	45.6143
Constant	-429.1357	595.2291	-0.72	0.489	-1775.637	917.3659
F(14, 9)	6.32					
Prob > F	0.004					
R-squared	0.91					
Adjasted R-squared	0.74					
Durbin-Watson(15,24)	2.2					

Source Own Computations

Table 5.3 Stationarity test for the lag of residuals

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
LResidual	-5.409	-3.750	-3.000	-2.630	I(0)

Source Own Computations

5.3 Causality

Cointegration does not say anything about the direction of causal relationship between variables. Variable A is said to Granger cause variable B, if the lags of variable A can improve a forecast for variable B. In a vector autoregressive model (VAR), under the null hypothesis that variable A does not Granger cause variable B, all the coefficients on the lags of variable A will be zero in the equation for variable B. A Wald test is commonly used to test for Granger causality. Each row of table 5.4 below reports a Wald test that the coefficients on the lags of the variable in the excluded column are zero in the equation for the variable in the equation column. As an example, the small p-value (0.000) in the first row means that we have sufficient evidence to reject the null hypotheses of zero coefficients and thus favouring the alternative hypothesis that area harvested granger cause maize output. In this case we say that the coefficients of the lags or past values of excluded variable were jointly not equal to zero. The rest of the p-values show that all the excluded variables granger cause output except for real expenditure on research and extension which had also showed a wrong sign in the cointegration equation. The first difference of consumption also does not individually granger cause output of maize implying a conditional effect of output on maize in the cointegration equation. In other words consumption is only impaction output if it is combined with other variables.

It would be important to see the effect of rainfall on fertilizer use. Practically and theoretically we expect increase in rainfall to trigger use of fertilizer. This would be due to loss of fertilizer due to leaching and also little fertilizer being used during drier periods to avoid wilting of crops. However, rainfall does not seem to affect fertilizer use in Zimbabwe’s maize sector. This agrees with the dropping of the interaction of fertilizer use and rainfall as a variable in the ECM equation. It would also be interesting to comment on whether SAFEX maize prices affect local prices. It can be clearly shown in the table that indeed the SAFEX price affect the domestic price of maize as shown by a small p value. In addition SAFEX prices do not Granger cause local consumption of maize. A reasonable explanation would be due to the inelasticity of maize as a staple food. This is in line with theory, if the price of maize go up consumption may not fall as people need maize for living.

Table 5.4 Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
Maize output	Aggregate area harvested	38.488	2	0.000
Maize output	Real R&E	1.0739	2	0.585
Maize output	Fertuse	19.701	2	0.000
Maize output	Lreal price cotton	3.5036	2	0.173
Maize output	Lrealsafexmaize price	33.665	2	0.000
Maize output	Lrealmaizedomesticprice	17.391	2	0.000
Maize output	Lrainfall	25.739	2	0.000
Maize output	Consumption	.28782	2	0.866
Maize output	ALL	112.12	14	0.000
Fertilizer use	Lrainfall	84.404	2	0.000
Lreal price cotton	Lreal safex maize price	3.5565	2	0.169
Lreal safex maize price	Maizeoutput	14.428	2	0.001
Lreal safex maize price	Lrealmaizedomesticprice	2.8457	2	0.241
Lrealmaizedomesticprice	Lreal safex maize price	10273	2	0.000
Consumption	Lreal safex maize price	2.7831	2	0.249

Source Own Computations

5.4 Error Correction Model (ECM)

The rationale for using the ECM to agricultural commodity supply response is based on the dynamism of the sector. The ECM avoids the Nerlovian partial adjustment model’s unrealistic assumption of fixed target supply based on stationary expectations. It therefore provides a nexus between short run and long run equilibrium and the short run disequilibria dynamics. The results of the short run and the long run error correction mechanism are presented in appendix E. In its simplest form the ECM contains the first differences of the dependent variable and exogenous variables as functions of the distributed lags of both variables and also the once lagged equilibrium error called the error correction term which shows the adjustment towards long run equilibrium. In the short run model, an R-squared value of 0.92 indicated that 92% of the changes in output were explained by the explanatory variables included in the model. The F value was also highly significant at 1%. From the short run ECM the significant variables included; lag of output, area, rainfall, real credit and consumption at period t. Of the significant variables, credit did not contain the correct sign. It is also important to note that of the non significant variables research and extension allocation also did not contain the correct sign.

The lag of maize output was found to be significant at 10% and the results showed that a 10% increase in the lag of maize would reduce output at period t by 8% through the cobweb theory. Since maize is grown on land the area under maize was highly significant at 1% and a 10% increase in area under maize would increase maize output by 45%. The dummy for government policies such as ESAP was not significant both in the short run and in the long run. However ESAP had a very strong effect on reducing output. This is in line with previous studies finding that referred to the ESAP as a double edged sword reducing production in two ways. First, the removal of subsidies reduced protection coefficients while failure of markets to emerge and the monopolistic effect of players in the input markets meant that factor prices were pushed up (Mano, 2001). This was the same result obtained in a study done in India which found out that removal of subsidies led to increase in the price of inputs and reduction in technology adoption (Desphende and Ratna, 1992). It was also discovered that 94% of users who indicated reduction in input use showed reduction in productivity.

Fertilizer use was not significant in the short run but contained the expected positive sign with an elasticity of 0.01 which is inelastic. These results are also similar to Muchapondwa, (2008) finding that fertilizer usage was insignificant and had a short run elasticity of 0.39 which is also inelastic (Muchapondwa, 2008). In the long run model, fertilizer use was insignificant and had a negative sign. A 10% increase in fertilizer use would increase output by 0.1% in the short run. This shows that Zimbabwean farmers need to use more fertilizer in maize production. However, the long run elasticity was estimated at -2.56, showing that in the long run fertilizer usage can result in output decreasing due to its negative effect on output. The negative effect is that continued use of fertilizer disturbs the soil structure and also may lead to wilting of crops especially if the amount of rainfall is low. This finding agrees with the long run elasticity for rainfall which was still positive in the long run meaning that increase in rainfall was still increasing output.

The lag of rainfall was highly significant at 1% with a short run elasticity of 4.62. A 10% increase in the lag of rainfall would lead to an increase in maize output in the current period by 46.2%. This is because Zimbabwe does not receive enough rainfall therefore a percentage increase in rainfall still produce positive results in maize output. The lag of rainfall was insignificant in the long run but had the correct sign with an estimated long run elasticity of 0.27. These results compare with the findings of Muchapondwa, (2008) who found rainfall to be significant at 5% and had the short and long run elasticity of 0.44 and 0.53 respectively. However, the findings of that study are likely to be more accurate as the study did not model rain as a linear function but as a dummy variable. In fact, years of optimum rainfall for tobacco production were represented by 0 and years of suboptimal rainfall were represented by 1. Therefore, the positive coefficient meant that rainfall was positively related to output. In addition, most studies of supply response have concluded that there is a positive relationship between rainfall and output.

The lag of price of cotton a cash crop and a possible substitute for maize was found to be insignificant in the short run but significant in the long run. The lag of price of cotton also contained a wrong sign. The short run and the long run elasticities were estimated at 0.43 and

0.84 respectively. We would expect that if the lagged price of cotton goes up current period maize output would fall as farmers shift from maize to cotton production to acquire more revenue. However the positive sign may be explained by the concentration of communal farmers in maize production who have been seen to produce more than 70% of the national maize output. Thus the smallholder farmers need maize for predominantly for subsistence and sell surplus meet their debts, sent their children to school and to buy other assets and inputs. Therefore, they might be unwilling to shift from maize production due to inertia or importance of maize production to their livelihoods. In addition, the short run insignificance and significance of cotton price in the long run can explain the short run rigidity or unwillingness of farmers to shift from maize to cotton. This may be due to asset fixity and lack of cotton farming knowledge. However in the long run they may start to learn to grow new crops and start to move from maize to cotton production.

Real SAFEX and domestic prices had the correct sign although both were not significant both in the short run and in the long run. The short run elasticities were estimated at 2.15 and 1.35 respectively which is highly elastic. The results show that in the short run, a 10% increase in the domestic price of maize would increase output by 13.5% which is in line with the typical theory of supply. A 10% increase in SAFEX prices which is a proxy for farmers' expectations would increase maize output by 21.5%. An increase in SAFEX prices would inform the farmers although not directly like the domestic prices. The long run elasticities for real SAFEX and domestic prices were estimated at 0.08 and 0.6 respectively. Most researches however find prices to be significantly affecting the supply of food crops. The price elasticities for 53 developing countries was found to elastic and significant with short run elasticities of 1.66 and 1.27 (research included) (Peterson (1979). However, when research and irrigation was added to explanatory variables, the price elasticity was found to be inelastic Chhibber (1989) as cited in (Thiele, 2000). Most researches however, found prices to significantly affect the responsiveness of supply although the elasticities were inelastic (Mesike *et al.* 2010; Muchapondwa, 2008; Mckay *et al.* 1998). Thus, in Zimbabwe, the pricing policy is a blunt policy for augmenting maize supply.

On the demand side, consumption and its lag had the correct sign although the lag was not significant. Consumption at current period was found to be significant at 10% with an elasticity of 9.60. This implies that a 10% increase in consumption which is a proxy for the demand of maize would increase maze produced by 96%. This shows that maize supply had been significantly and positively responding to local demand. Most researches however do not include this variable which explains the low R squared values, for instance 0.48 estimated by Mesike *et al.* (2010).

Real credit and research and extension had the wrong signs. This is the same result that was obtained in Ghana on the effects of pricing and production policy on cocoa production (Poku, 2009). In this study Poku (2009) concluded that this was so because credit and research funds are mere budgetary allocations and the fact that money has been allocated to the programme does not mean the expenditure has actually occurred (Poku, 2009). In any event, due to the fangibility of money, if farmers get credit or loans from banks they may actually use the money for other purposes such as paying schools fees, buying food stuffs and clothes. They may also invest it other profitable enterprises which are more commercial and have higher returns. Likewise, the expenditure allocated to research and extension may not necessarily be used for developing new varieties or technologies linked to maize production. This is due to the nature of the subsector that is the smallholder farmers are numerous and scattered. The theory of collective action explains how difficult it is for them to lobby and convince the research and development industry to come up with new technologies. Another visible explanation can be attributed to the decrease in extension worker to farmer ratio although funds are allocated to these areas every year. The short run and long run elasticities for credit allocations were estimated at -0.06 and 0.002. It is important to note that credit allocation was seen to start to respond positively in the long run.

The error correction term contains contained the correct negative sign and was estimated to be of 0.41 shows that 40% of the disequilibrium in maize output is corrected in a given year. In other words distortions in maize supply from its long run equilibrium level are corrected by 41% per annum. This is lower than those estimated in other researches. For example, Mesike *et al.* (2010) estimated 56% adjustment in the first period while Muchapondwa (2008) and Mckay *et al.* (1998) found estimated the ECT at 0.82 and 0.72 respectively. Thus, maize supply in Zimbabwe disequilibrium takes longer to be corrected to its long run equilibrium. The constant term shows that if there are no explanatory variables maize supply would remain at 79 000 tonnes. The time trend was negative and it shows that there was a declining trend in maize production which is clearly explained by the graphs in chapter 4. The time trend squared is positive and it shows that shows a positive sign meaning that the decline is happening at an increasing rate.

5.5 Measuring the extent of market integration and price transmission between Zimbabwe and South Africa

This section attempts to answer the hypothesis that the local and the regional maize market are integrated. Various tools were used in an attempt to assess the long run relationship between the two markets. These include descriptive statistics, Engle and Granger causality tests as well as cointegration analysis.

As described in chapter 2, spatial price transmission or market integration measures the degree to which spatially separated markets share common long-run price or trade information on a homogenous commodity. Thus, the difference in price between two markets should be exactly equal to cost of moving the commodity from one market to another. If markets are not well integrated one cannot establish the fundamental law of one price. In this case it is assumed that physical arbitrage will result in the law of one price. Arbitrage or the law of one price is the mechanism by which spatially separated markets return to their long run equilibrium. Figure 5.1 illustrate the movement between the local, import and the export parity prices in the Zimbabwean maize market.

Real prices although not so reliable in Zimbabwe due to unavailability of accurate price indices were estimated using the US Consumer Price index. The exchange rate was obtained from the Zimbabwe Stock Exchange (ZSE) Handbook and the Economic Web Institute. The reliability of the exchange rate depends on whether it was derived from the equilibrium exchange rate or the official exchange rate which could be overvalued. The exchange rate obtained from the ZSE handbook seemed to be more realistic as it used the Old Mutual Implied Rates (OMIR) as well as the RTGS rate appeared to provide closer estimate of the true opportunity cost of foreign currency.

According to the theory of market integration, in an efficient market, the domestic prices should move between the export parity price and the import parity price lines. An exporting country should trade at the export parity price and an importing country should trade at the import parity price. If the local price goes below the export parity price it suggests that the farmers are being paid less than what they should get at social prices. Thus the process of physical arbitrate should move the prices up as traders take advantage of the low prices and buy maize until the two prices are separated by the transaction costs of moving the maize between the two markets. It also suggests that there might be strong government policies and lack of information to allow the law of one price to take effect. The effect of government policies can allow price differences to prolong for years as they tend to restrict arbitrage. If prices go above the import parity prices it suggests that the farmers are paid more than they are suppose to get at equilibrium and therefore the process of physical arbitrage will imply that imports will come in until the price goes down to its long run equilibrium.

Figure 5.1 shows that the Zimbabwean local prices had been moving below the two parity price band from 1980 to 1992. This implies heavy taxing of farmers and lack of physical arbitrage to reduce prices to their social prices. Using trade flow data net trade (export-imports) should be positive as the country is experiencing surplus which is explained by the positive net trade figure 5.1 below. In addition, the prices are below the price band suggesting surplus and this is in line with the surplus production of the period as described in chapter 4. There is an observable price regime switch from 1991 and a trade regime switch becomes clear in 1998 as the country shifts from being a net exporter to being a net importer. The SAP of 1991 led to the involvement of private traders in maize markets which explains the shift in the price regime. The drought of 1992 also triggered a sharp increase in the local prices as a reflection of shortages. The price data suggest that the prices moved above the parity band although the trade data show that the country was still a net exporter.

Market integration can also be described in terms of the direction, speed of adjustment and magnitude of integration. In terms of direction the prices seemed to be moving together with the regional prices. This finding suggests a positive relationship between local prices and SAFEX prices which is consistent with theory. The impact of a drought in Zimbabwe is likely to be felt in South Africa as we tend to share almost similar weather conditions due to proximity in terms of geographical location. The 1992 drought for example led to a sharp increase in prices in both Zimbabwe and the Republic of South Africa (RSA). However after 1998 only RSA prices explain the Zimbabwe trade flow data. The 2002 drought in Zimbabwe is clearly explained by RSA prices which short up in response to the drought.

The price data however does not show this result as it is below the export parity line for most of the years. However, in some years, the data seems to show no evidence of a long-run relationship between Zimbabwean and South African maize prices. This is because in some years, SAFEX prices keep going down while Zimbabwean prices continue to go up. For instance, after 1992, the local prices continue to go up above the SAFEX prices exceeding transaction costs. The simple process of physical arbitrage would ensure that through increase in imports, the prices would go down to their long run equilibrium. However under certain regimes, the Zimbabwean prices continued to go up above the transaction costs even when imports continued to increase especially from the year 2000. In theory, such large price deviations which exceed transaction costs should not continue to grow with no tendency towards equilibrium. Traubel *et al.* (2007) in a study that was done to measure integration and market efficiency between the Mozambican and South African markets found the same result where under certain trading regimes, there was no evidence of a long-run relationship between Mozambican and South African maize grain prices (Traub *et al*, 2007).

These results are therefore unexpected given a simple arbitrage argument. Traub *et al.* (2007) clearly articulated the possible explanations for this phenomenon. Firstly, the existence of market power was found to limit the extent of arbitrage. Therefore, price discrepancies could continue to hang on well above the pareto efficient level. Unplanned policy interventions, such as export or import bans can result in increased risk and uncertainty for grain traders. For example the Zimbabwean government continue to impose ad hoc import tariffs and other non tariff barriers on maize especially during deficit years. As previously discussed in chapter 2, the Zimbabwean government has a non GMO policy which prohibits importation of GMO grain but only allows the importation of milled GMO products into the country (Esterhuizen, 2010). Another example would be the import licences in which only designated or licensed traders are allowed to import maize into the country. This process therefore prevents physical arbitrage form bringing prices to their efficient levels. The process of physical arbitrage can also be prevented from occurring through distorted market information on prices thus preventing market actors engaging in profit-maximizing behaviour. Even in cases of perfect information poor storage facilities and lack of sufficient funding can prevent the importing nation taking advantage of the price differential (Traub *et al*, 2007).

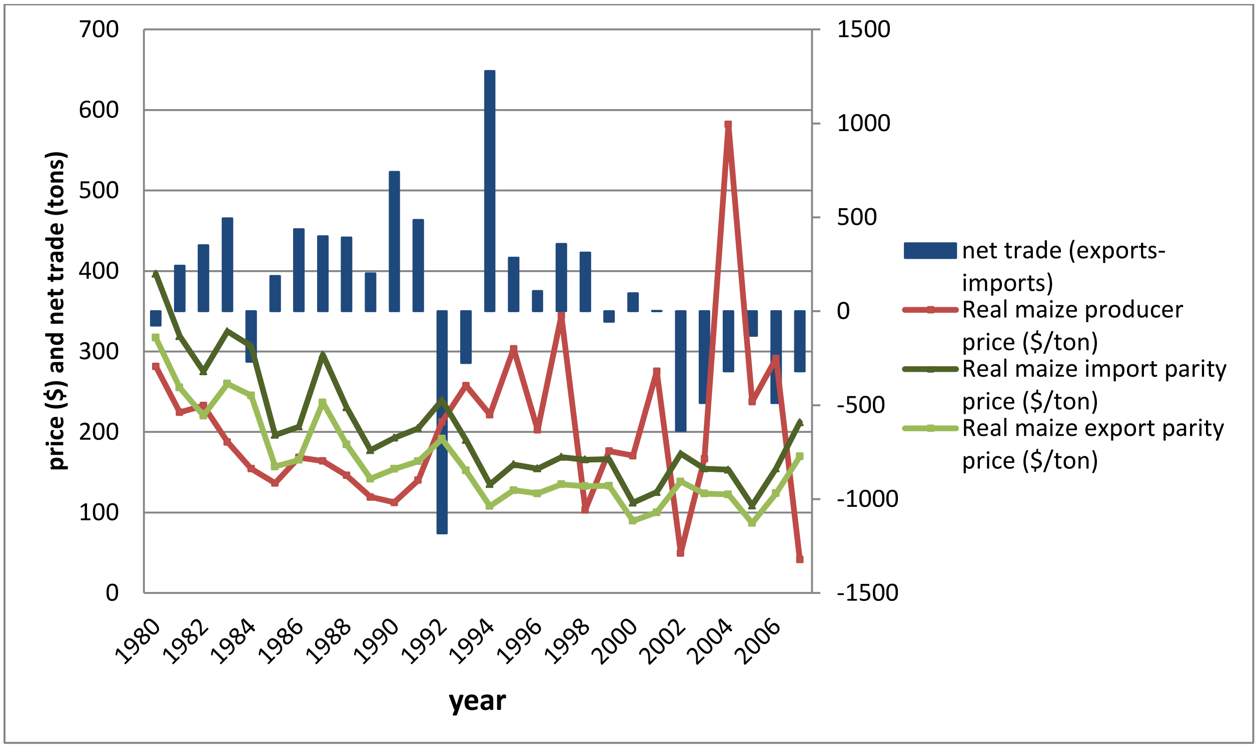

Figure 5.1 the movement between the local, import and the export parity prices in the Zimbabwean maize market (1980-2007)

Source: FAOSTAT, 2010 and MAMID, 2010

In order to be perfectly convinced that SAFEX prices indeed show a positive relationship with domestic prices and that SAFEX prices indeed influence the local prices the researcher embarked on two critical time series analysis. The first was the Granger causality Wald tests described in the section above. In table 5.4, a null hypotheses of whether SAFEX prices do not Granger cause domestic prices was tested against an alternative hypotheses that SAFEX prices Granger cause local prices. A very low and highly significant p-value of 0.000 suggested that there was enough evidence to reject the null hypotheses and therefore concluded favour of the alternative hypotheses that SAFEX prices Granger cause local prices. It was therefore the same result that was illustrated figure 5.1. The results of the Wald test also showed that SAFEX prices Granger cause local maize output. This also provides information on how the local market is integrated with the regional market.

There was then need to establish the magnitude and direction of integration between the two markets. This was done through testing the long run relationship between domestic prices and SAFEX prices. Cointegration is a very important tool that can be used to establish the long run relationship between and among variables. A one on one cointegration test was done through the use of Engle and Granger's three step method. This method is based on OLS and tests for the long-run relationship between two time-series. The three steps involved regressing local price on SAFEX prices. It was then followed by predicting the residuals, which were supposed to be stationary in the presence of cointegration. The third step was to test for stationarity on residuals. Table 5.9 shows the results of the regression.

Local price of maize was found to be positively related to SAFEX prices as expected. The market transmission elasticity or the coefficient of integration was estimated at 0.11 without policies and 0.07 with ESAP as dummy for government policies. A 10% increase in SAFEX prices would lead to a 1.1% increase in local price although not significant. The government policy was also included through ESAP and the relationship remained positive as expected. Again, the result of the effect of ESAP on local prices was found to be positive as found on the graph although not significant. The graph had clearly illustrated that there was a sharp increase in prices after 1992 which showed a price regime switch. Table 5.8 shows the results of the Augmented Dickey Fuller unit root test. Local prices were integrated I(1) as well as the SAFEX prices but the residuals were stationary I(0) showing that there is a long run relationship (cointegration) between SAFEX prices and local prices as expected. Theses price transmission elasticities could have been lower if the research had included high frequency data. A study in Ghana revealed that adjustment parameters estimated from the low frequency data were higher than those estimated from the high frequency data (Amikuzuno, 2010). Thus, annual data led to an overestimation of price adjustment parameters.

Table 5.6 Cointegration analysis

Dreal maize domestic price	Coefficient	Std. Err.	t-value	P>t	[95% Conf.	Interval]
Dreal SAFEX price	.1045438	.7695681	0.14	0.893	-1.480411	1.689499
_cons	-8.323401	28.81144	-0.29	0.775	-67.66167	51.01487

Source Own Computations

Table 5.7 Cointegration analysis

Dreal maize domestic price	Coefficient	Std. Err.	t-value	P>t	[95% Conf.	Interval]
Dreal SAFEX price	.0708168	.8054334	0.09	0.931	-1.591516	1.73315
DESAP	11.52073	61.773	0.19	0.854	-115.9742	139.0157
_cons	-15.76161	49.53916	-0.32	0.753	-118.0054	86.48218

Source Own Computations

Table 5.8 Unit root test for the lag of residuals

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
Residual	-7.957	-3.743	-2.997	-2.629	I(0)

Source Own Computations

5.6 Summary

The findings of this chapter gave enough evidence to conclude that maize is not affected by the price policy. However, it is affected by the institutional environment such as access to credit and macroeconomic policies which determines consumption as well as biophysical environment which was represented by rainfall. This is because although the domestic producer price of maize was found to be positively related to maize supply both in the short run and in the long run, was not significant both in the short run and long run. The SAFEX price was also found to be positively related to maize output both in the short run and in the long run but was also not significant. However, the results of the Granger Wald test also showed that all the variables included in the model were found to Granger cause maize output except for consumption; although consumption was found to significantly affect local supply of maize in the ECM. An R-square value of 0.92 also showed that 92% of the changes in maize output were explained by the variables included in the ECM. Thus the results simply mean that the hypothesis cannot be rejected given the evidence provided.

For the second hypotheses of whether the local and regional markets are integrated, the evidence was not enough to accept or reject the null hypotheses. Firstly, the figure 5.1 provided some evidence that the two markets are integrated as explained by the movements in prices and net trade. However, under certain trading regimes, deviations larger than transaction costs continued to exist with no tendency to return to long run equilibrium thus making it difficult to conclude that the markets are integrated. The results of the Wald test provided enough evidence to support the hypothesis. The results showed that SAFEX prices Granger-cause domestic prices of maize as would be expected. The results also showed that SAFEX prices of maize Granger-cause domestic output of maize. In terms of actual cointegration, SAFEX prices were found to be cointegrated with the local market after the residuals were tested for unit root and were found to be stationary. The elasticity of price transmission was found to be 0.1 without ESAP and 0.07 with ESAP and also contained the correct sign. When included in the ECM, the SAFEX price also was found to positively affect local output although it was not significant. The elasticities however might be misleading as in literature it was found out that low frequency data used in this study overestimate the transmission elasticities. Therefore, this evidence results in the failure to reject the hypothesis that the Zimbabwean market and the South African markets are integrated although under certain trade regimes the two markets showed signs of lack of integration a feature that might have been attributed to factors explained above. The next chapter summarises the study and present areas for further study.

CHAPTER 6: SUMMARY, CONCLUSION AND POLICY IMPLICATION

6.1 Introduction

Maize is a stable food crop and therefore its availability is of importance to the growth of the Zimbabwean economy. Besides its food security function, maize production as a subsector siphons resources from the economy through expenditure on agricultural credit, input procurement, subsidies as well as spending on research and extension. In addition, if maize production goes below domestic consumption, resources are also drained off for the importing of maize and maize meal from surplus markets. The Zimbabwean government has spend so much resources on this sub sector yet not much is known about the responsiveness of output to these production and pricing policies.

It is very crucial for policy makers to have knowledge on whether the maize subsector in particular or the agricultural sector in general is a static sector unresponsive to incentives or a dynamic one that is sensitive to the policy and biophysical environment. Many policy makers in agro-based economies seem to have a tendency of taxing the agricultural sector as justified by the idea that industry is a dynamic sector while the agricultural sector is static and unresponsive to incentives (Muchapondwa, 2008). In this study the argument is that, if supply response for maize is low, then taxing farmers will generate resources for other sectors of the economy, without significantly affecting maize availability. On the other hand, if maize supply response is high, it would imply that taxing farmers could impede achievement of food security goals, creating food and input supply shortages which would increase reliance on imports to meet food requirements and reduce agricultural exports which often are the principal source of foreign exchange.

This paper has thus examined the effects of pricing policy and production policies on maize production in Zimbabwe using time series data for the period of 1980 to 2007. The paper has observed various information and methodological gaps in literature in modelling and estimating the maize supply function. Such multifarious information and methodological gaps in literature have been clearly explained in the paper. Therefore, using the time series data, the study has modelled and estimated the maize supply function addressing issues such as Dickey-Fuller (DF) diagnostic tests (unit root or stationarity tests), cointegration, Engle and Granger's causality tests as well as the error correction mechanism. These processes, for instance the cointegration and error correction mechanisms are used to test for long-run equilibrium relationship among the variables.

In view of the fact that the study is an extension of the work previously done by other researchers, effort has been done to fill in the gaps for instance studies on the effect of government intervention policy on maize supply have been based exclusively on the price policy ignoring the effects of non price factors. However more research work needs to be done to investigate and examine the effect of omitted variables and structural or policy breaks. This chapter will provide a summary of the results of the investigation. The chapter will first state the hypothesis postulated by the study and then discuss the methods used to come up with the findings. Policy recommendations and conclusions will then be drawn from these findings and areas of further research will be proposed.

6.2 Summary of results

The first hypothesis tested in this study was:

(i) There has been a declining trend in the national maize production and contribution of commercial sector

Using the descriptive statistics, the study found out that for the period under analysis, that is 1980-2007, maize production has seen to decline from as high as 2 833 400 tonnes in 1981 to as low 498 tonnes in 2002. The period was then separated then into two phases that is from 1980-1996 and from 1997-2007. In terms of national maize output, from 1980-1996 total maize production averaged 1 922 821 tonnes but from 1997-2007, maize output averaged 1 395 458 tonnes which shows a decline of 27.4%. This fall has been found to coincide with the decline in total and sub sector productivity and also the fall the in area under maize by commercial farmers. However the fall in area contribution by commercial farmers cannot be used to explain this fall prime factors for this fall since total area has been seen to increase which leaves the fall in productivity as the main culprit. In fact, for the period of 1980 to 1996 total area planted averaged 1 355 919 hectares but from 1997 to 2007 which marks the last ten years of the period under analysis the maize area averaged 1 432 746 hectares which shows an increase of 5.7%.

As such, for the period of 1980 to 1996 yield averaged 1.55 tonnes per hectare but from 1997 to 2007 which marks the last ten years of the analysis the maize yield fell to an average of 0.94 tonnes per hectare which shows a decline of 39.2%. Moreover, maize average yield for the period 1980-2007 which is the period under review was 1.26 tonnes per hectare. A maximum yield of 2.56 tonnes per hectares was recorded in the year 1985 and a minimum of 0.41 tonnes per hectare was recorded in 1992. Also, in the communal subsector from 1980 to 1996, communal sector maize yield averaged 1.09 tonnes per hectare but from 1997 to 2007 yield dropped to an average of 0.74 tonnes which shows a percentage decline of 32.1%. From 1980 to 1996 total maize production averaged 1 922 821 tonnes but from 1997 to 2007 which marks the last ten years of the analysis the maize output averaged 1 395 458 tonnes which shows a decline of 27.4%.

Furthermore, in terms of percentage contributions of the total or national area, the smallholder sector contributed 80.5% of the total area under maize for the period of 1980 to 1996 while the commercial sector contributed 17.3% for the same period. However for the period of 1997 to 2007, the percentage contribution of the communal sector grew to 92.8% against a drop in percentage contribution by commercial counterpart to 8.6% for the same period. This represented an increase in percentage contribution to area of 15.3% for communal and a fall of 50.3% in contribution to area by commercial farmers although total area grew by 5.7% as explained earlier on. In terms of contribution to total output, the communal sector used to make a contribution of 54.8% while the commercial sector contributed 45.9% to total output. However, from 1997-2007 the communal sector contribution to national maize output increased to 71% against a fall in contribution by commercial farmers to 28%. This showed an increase in maize contribution by 29.6% by communal farmers and a fall of 39% by commercial farmers and a total fall of 27.4% in national output as explained above. The smallholder farmers were found to contribute more than 70% of the total output. This the same the same result that found in a study of how much commercial farmers contribute in the food insecurity situation of Zimbabwe when they were found to have been contributing an average of 60% of the country's total maize output since the mid 1980's (Anderson 2007).

By and large, total productivity and production has been declining as shown by the results by 39.2% and 27.4% respectively. In addition, commercial sub sector's yield and output fell by 29.9% and 55.8% as well as a fall in commercial sector area under maize of 47.0%. This profound evidence and the results stated above gave enough evidence to conclude that the hypothesis stated above cannot be rejected.

The second hypotheses tested in the study stated

(ii) *Zimbabwean maize supply response is significantly affected by price and non price factors*

This hypothesis was tested in chapter 5 where time series data was taken through Dickey Fuller diagnostic tests for unit root. The times were then differenced to make them integrated processes. Stationary time series data enables long run relationship among dynamic variables to be studies via the process of cointegration. Engle and Granger three step method was used to test for cointegration as well as the Johansen Maximum likelihood method. An error correction model was then run to estimate the short run and long run impact of exogenous variables on the maize output. An error correction term (ECT) was also included in the short run ECM to assess the speed of adjustment. It was formulated through regressing output against exogenous variables as well as the lagged values of the residuals.

The results are presented in chapter 5 and the ECM gave an R-squared value of 0.92 indicating that 92% of the changes in output are explained by the explanatory variables included in the model. This implied that the ECM estimated had a considerably high explanatory power. The F value was also highly significant at 1%. From the ECM, the variables that were significant at least at 10% included the lag of output, area, rainfall, real credit and consumption at period t. Of the significant variables, credit did not contain the correct sign.

The lag of maize output and area under maize were found to be significant with short run with the short run elasticities of -0.8 and 4.5 respectively. In the long run area under maize was not significant. The dummy for government policies such as ESAP was not significant although it was found to have a very strong effect on reducing output as explained by the negative sign. Fertilizer use was not significant in the short run but had the correct positive sign. The short run elasticity was estimated at 0.01. In the long run fertilizer use was significant and had a negative sign implying that continued fertilizer use induces a decrease in output. The price of cotton was insignificant in the short run and contained a wrong sign. The long run the price of cotton was significant and but still had a positive sign with an elasticity of 0.84.

Real SAFEX and domestic prices had the correct sign although both were not significant both in the short run and in the long run. The short run elasticities were estimated at 2.15 and 1.35 respectively which is highly elastic. The long run elasticities for real SAFEX and domestic prices were inelastic and estimated at 0.08 and 0.6 respectively. On the demand side, consumption and its lag had the correct sign although the lag was not significant. Consumption at current period was found to be significant at 10% with an elasticity of 9.60. This shows that maize supply had been significantly and positively responding to local demand. Real credit and research and extension contained the wrong signs although credit was significant in the short run and had the expected positive sign in the long run. The short run and long run elasticities for credit allocations were estimated at -0.06 and 0.002. Thus credit allocation significantly affects maize production in the short run although negatively. In the long run maize supply responds positively to credit expenditure. Rainfall, a proxy for biophysical factors was significant with a short elasticity of 4.5. In the long run rainfall still had a positive elasticity of 0.08 but was insignificant.

The error correction term contained the correct negative sign and was estimated to be of 0.41 shows that 41% of the disequilibrium in maize output is corrected in a given year. In other words distortions in maize supply from its long run equilibrium level are corrected by 41% per annum. The time trend had the expected negative sign and it shows that there was a declining trend in maize production which is clearly explained by the graphs in chapter 4. The time trend squared was positive implying that the decline is happening at an increasing rate. The findings, from the R squared value of 0.92 shows that in the 92% of variations in output is explained by the exogenous variables included.

The study therefore concluded that indeed Zimbabwean maize supply not significantly affected by price policy and that the pricing policy is a blunt instrument for increasing maize supply. Maize supply is therefore found affected by fertilizer use, credit, biophysical environment, area under maize, as well as price of cotton.

The third hypothesis tested in the study was:

(iii) The local market is integrated with the regional maize market.

Knowledge of the theory of market integration, theory of price transmission, process of physical arbitrage and the law of one price was used to test the hypothesis. To support the findings of the descriptive statistics, time series techniques such as causality and cointegration were also used.

Results from both the descriptive statistics and econometric tools suggested that the two markets are integrated although it was found out that under certain trading regimes, deviations larger than transaction costs continued to exist with no tendency to return to long run equilibrium thus making it difficult to conclude that the markets are integrated. SAFEX prices were found to Granger cause local prices and local maize output. In addition, through the use of the Engle and Granger method of cointegration, the two markets were found to be cointegrated that is they exhibited a long run relationship. The price transmission elasticity or the elasticity of integration was estimated at 0.11 without policies and 0.07 with ESAP as dummy for government policies. A 10% increase in SAFEX prices would lead to a 1.1% increase in local price although not significant. The government policy was also included through ESAP and the relationship remained positive as expected.

However, as discussed before annual price and trade data was used to test this hypothesis. In fact, high volume data such as weekly or monthly data was needed in order to come with accurate estimates. The elasticities therefore could give misleading results since literature says that low frequency data used in this study overestimate the elasticities. These facts therefore imply that these results should be treated with caution as more robust studies are recommended in future as will be stated in the next sections. To conclude, the study failed to reject the hypothesis that the Zimbabwean market and the South African markets are integrated although under certain trade regimes the two markets showed signs of lack of integration a unique feature that show strong influence of government policies preventing physical arbitrage from bringing prices to their long run equilibrium. The next section discusses the implications of the results to policy.

6.3 Policy Implications

The results discussed above have major implications to policy. Firstly, the study concluded that the smallholder farmers have become the major producers of maize in Zimbabwe contributing more than 70% of total output. The socioeconomic characteristics of smallholder farmers are such that they are poor and use maize as a crop which provides several functions. Maize is a staple food crop in Zimbabwe and therefore the smallholder farmers rely on this crop as food. In addition, maize has over the years especially in the 1980s and 1990s been a source of foreign currency for the nation and therefore it also act as a source of wealth for both the farmers and the nation. Moreover, these smallholder farmers use maize for payment of debts and school fees for children. Maize can also be added value when used for brewing beer or as feed for domestic or commercial birds and animals such pigs, cattle and donkeys. Commercial farmers, although they seem to show a declining trend in maize production they also need payment maize for of salaries for their workers and to feed their commercial birds and domesticated animals. Maize also siphons resources that would have been used productively in other sectors of the economy as government embarks on input subsidies, input supply programs and as it purchases food maize imports during deficit periods. Import of inputs such as seed and fertilizer also shows how strategic this crop is to the nation.

In view of the fact that maize plays an important role in the nation, there is need for proactive formulation of policies equipped with measures to improve maize production. This would relax the strain on resources that would otherwise be used on maize production while at the same improving the livelihoods of smallholder farmers. Given that this study found out that productivity as well as production in the smallholder sector was declining aligned with an increase in area under maize there is need for robust policy measures that will address this hitch. Thus a policy that will address productivity issues is needed for example conservation agriculture would be critical in increasing yield. Commercial farmers should also be encouraged to increase area under maize as a way of increasing total production.

The findings of the study also reveal that, the supply of maize is unresponsive to own prices. The short run elasticity of own price was high but insignificant. This implied that the pricing policy is rather a blunt instrument for effecting growth in maize supply. Policy should therefore focus more on other non price factors which were found to be significant for example fertiliser use, credit, rainfall and area. In terms of fertiliser use, policy should be designed such that sufficient fertiliser is in the country before the planting season. Local companies can be capacitated so that that they can produce enough fertiliser for the season. Shortages can therefore be supplemented by imports from surplus markets way before the growing season starts to give farmers enough time to procure the crucial input. Funds targeted for this process should therefore be mobilised towards fertiliser production, procurement and delivery.

In terms of credit, the results showed that to allocate funds towards credit expenditure is a necessary but not sufficient condition for increasing maize supply. Budgetary allocations do not necessarily imply that the actual expenditure has taken place. Therefore a system should be put in place that ensures that all budgetary allocations are actually used or spend for the intended purpose. In addition farmers who get farming loans should be monitored to ensure that the funds are used for the purpose for which the loan was applied for. This means that farm visits by loans officers should be encouraged to ensure that the farmers would not diver funds for other uses.

Funds should therefore be provided for this process because it would mean regular farm visits by loans officers who would require transport and other ancillary expenses attached thereto.

Rainfall was also found to be very significant and positively influencing the supply response of maize. Policy should therefore be designed such that funds should be mobilised towards irrigation investment as this would supplement rainwater. In addition cloud seeding should also be encouraged to that potential cloud can produce rainfall. Policy should also bias towards capacitating the meteorological department to provide timely and correct information to farmers to allow them to make accurate and well-timed decisions.

However under certain regimes, the Zimbabwean prices continued to go up above the transaction costs even when imports continued to increase. In theory, such large price deviations which exceed transaction costs should not continue to grow with no tendency towards equilibrium. This suggests that there were policies which were preventing physical arbitrage to bring prices to their pareto efficient levels. Policy should therefore avoid unplanned policy interventions, such as export or import bans can result in increased risk and uncertainty for grain traders. Policy should also be designed such that it allows perfect market information on prices thus ensuring market actors to engage in profit-maximizing behaviour. This should be followed by efficient storage facilities and sufficient funding that would facilitate the process of physical arbitrage. Physical arbitrage is important as it allows prices to go down to the efficient level. Perfect price transmission also imply that price reflect the true opportunity cost of a good or service.

6.4 Areas of further research

This study was done at an aggregate level using time series data which can be misleading. It is therefore imperative for future studies to narrow down to farm level analysis in order to capture household dynamics such as technical efficiency and socioeconomic characterization of farmers using cross sectional data. In addition since this study provided a broader picture of the maize sector, the findings of this study provided a solid foundation for future studies. For example the study found out that the smallholder farmers are the main producers of maize accounting for more than 70% of total national production. It is therefore imperative that future studies should analyse supply response in the smallholder sector. Productivity variability can therefore be studied in the smallholder sector using historical data. These studies should utilise seasonal rainfall data and also try to include a variable that capture the distribution and effectiveness of rainfall to estimate its impact on maize supply response.

An institutional analysis to factors affecting maize production should also be studied in the future to include issues such as market access and collective action in order to assess the effect of the institutional arrangements especially in the post land reform era. Further studies should also be done on value chain analysis to marry the demand side with the supply side. There is also need for further study to focus on the measures of protection and welfare effects of various agricultural policies on maize producing households. There is also need for further studies to measure the degree of integration using high frequency data as opposed to the annual data used in this study. The high frequency data could be monthly or weekly trade data which was found to provide more accurate elasticities. Low frequency data has been found in literature to overestimate price transmission elasticities.

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APPENDICES

Appendix A: Unit root test for all the variables at period t

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
total area$_t$	2.949 (0.0399)*	3.736	2.994	-2.628	**Non-stationary**
total yield$_t$	3.606 (0.0056)***	3.736	2.994	-2.628	**Non-stationary**
Total output$_t$	-4.785 (0.0001)***	3.736	2.994	-2.628	**Stationary**
consumption$_t$	-1.892 (0.3358)	3.736	2.994	-2.628	**Non-stationary**
rainfall$_t$	-4.812 (0.0001)***	3.736	2.994	-2.628	**Stationary**
Price$_t$	-4.766 (0.0001)***	3.736	2.994	-2.628	**Stationary**
realcredit$_t$	-2.093 (0.2473)	3.750	3.000	-2.630	**Non-stationary**
Population$_t$	-2.093 (0.0000)***	3.736	2.994	-2.628	**Non-Stationary**
GMB purchasest$_t$	-3.762 (0.0033)***	-3.750	-3.000	-2.630	**Non-Stationary**
Real SAFEX price$_t$	-3.210 (0.0194)	-3.736	-2.994	-2.628	**Non-stationary**
inflation$_t$	-1.105 (0.7131)	-3.750	-3.000	-2.630	**Non-stationary**
Fertuse$_t$	2.903 (0.0450)	-3.743	-2.997	-2.629	**Non-stationary**
Realpricecoton$_t$	-2.543 (0.1053)	-3.750	-3.000	-2.630	**Non-stationary**

Source Own Computations

Appendix B: Unit root test for all the lagged variables at levels

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
total area$_{t-1}$	2.949 (0.0370)*	3.736	2.994	-2.628	**Non-stationary**
total yield$_{t-1}$	-3.712 (0.0040)***	-3.743	-2.997	-2.629	**Non-stationary**
total output$_{t-1}$	-4.571 (0.0001)***	-3.743	-2.997	-2.629	**Stationary**
consumption$_{t-1}$	-1.847 (0.3572)	-3.743	-2.997	-2.629	**Non-stationary**
rainfall$_{t-1}$	-4.479 (0.0002)***	-3.743	-2.997	-2.629	**Stationary**
Price$_{t-1}$	-4.589 (0.0001)***	-3.743	-2.997	-2.629	**Stationary**
Real RE$_{t-1}$	-3.986 (0.0015)***	-3.750	-3.000	-2.630	**Stationary**
realcredit$_{t-1}$	-2.093 (0.2473)	3.750	3.000	-2.630	**Non-stationary**
Population$_{t-1}$	-7.558 (0.0000)***	-3.743	-2.997	-2.629	**Non-Stationary**
GMB purchasest$_{t-1}$	-3.582 (0.0061)***	-3.750	-3.000	-2.630	**Non-Stationary**
Real safex maize price$_{t-1}$	-3.050 (0.0305)*	-3.743	-2.997	-2.629	**Non-stationary**
inflation$_{t-1}$	-1.105 (0.7131)	-3.750	-3.000	-2.630	**Non-stationary**
Fertuse$_{t-1}$	-2.903 (0.0450)*	-3.743	-2.997	-2.629	**Non-stationary**
Realpricecoton$_{t-1}$	-2.543 (0.1053)	-3.750	-3.000	-2.630	**Non-stationary**

Source Own Computations

Appendix C: Stationary test for differenced variables

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
total area$_t$	-6.853 (0.0000)***	-3.743	-2.997	-2.629	I(1)
total yield$_t$	-7.496 (0.0000)***	-3.743	-2.997	-2.629	I(1)
Total output$_t$	-6.963 (0.0000)***	-3.743	-2.997	-2.629	I(1)
consumption$_t$	-5.934 (0.0000)***	-3.743	-2.997	-2.629	I(1)
rainfall$_t$	-7.479 (0.0000)***	-3.743	-2.997	-2.629	I(1)
Price$_t$	-8.000 (0.0000)***	-3.743	-2.997	-2.629	I(1)
Real RE$_t$	-6.402 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Realcredit$_t$	-6.235 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Population$_t$	-8.139 (0.0000)***	-3.750	-3.000	-2.630	I(3)
GMB purchases$_t$	-6.568 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Real SAFEX maize price$_t$	-5.168 (0.0000)***	-3.743	-2.997	-2.629	I(1)
Inflation$_t$	-4.874 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Fertuse$_t$	-6.371 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Inflation$_t$	-4.874 (0.0000)***	-3.750	-3.000	-2.630	I(2)
Realpricecotton$_t$	-6.841 (0.0000)***	-3.750	-3.000	-2.630	I(1)

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source Own Computations

Appendix D: Stationary test for differenced lagged variables

Variable	Test statistics	1%critical	5%critical	10%critical	Decision
total area$_{t-1}$	-6.140 (0.0000)***	-3.750	-3.000	-2.630	I(1)
total yield$_{t-1}$	-7.285 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Total output$_{t-1}$	-6.941 (0.0000)***	-3.750	-3.000	-2.630	I(1)
consumption$_{t-1}$	-5.754 (0.0000)***	-3.750	-3.000	-2.630	I(1)
rainfall$_{t-1}$	-6.907 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Price$_{t-1}$	-8.171 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Real RE$_{t-1}$	-6.402 (0.0000)***	-3.750	-3.000	-2.630	I(1)
realcredit$_{t-1}$	-6.235 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Population$_{t-1}$	-7.988 (0.0000)***	-3.750	-3.000	-2.630	I(3)
GMB purchasest$_{t-1}$	-6.414 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Real safexmaize price$_{t-1}$	-5.490 (0.0000)***	-3.750	-3.000	-2.630	I(1)
inflation$_{t-1}$	-4.874 (0.0000)***	-3.750	-3.000	-2.630	I(2)
Fertuse$_{t-1}$	-6.371 (0.0000)***	-3.750	-3.000	-2.630	I(1)
Realpricecoton$_{t-1}$	-6.841 (0.0000)***	-3.750	-3.000	-2.630	I(1)

Source Own Computations

Appendix E: Supply response of maize ECM

Short run ECM estimates using ECM				Long run estimates using ECM		
Dmaizeouput	**Coefficient.**	**T**	**P>t**	**Coefficient.**	**t**	**P>t**
DLmaizeouput	-0.800034*	-2.15	0.068			
Darea	4.515136**	3.76	0.007	0.7655	1.13	0.281
DESAP	-988.1903	-1.44	0.193	-141.6587	-0.77	0.455
Dfertilizer use	0.0097001	1.11	0.302	-.0102188**	-2.56	0.026
DLreal price cotton	0.4339481	0.53	0.611	.8376609*	1.98	0.073
DLreal SAFEX price	2.145948	0.37	0.724	.0789688	0.03	0.974
DLreal maize price	1.345021	0.77	0.464	.600001	0.77	0.460
DLrainfall	4.615037**	3.42	0.011	.2746534	0.72	0.489
DLconsumption	3.624863	0.86	0.420	.8681813	0.40	0.697
Drealcredit	-0.060805*	-2.07	0.077	.0026787	0.15	0.880
Dconsumption	9.594614*	2.29	0.056	1.339556	0.78	0.450
DLR&E	-137.0477	-1.65	0.142	-64.58208	-1.52	0.157
Timetrend	-52.60154	-0.39	0.708			
Timetrend2	3.729958	0.98	0.358			
ECT	-.4083795	-0.80	0.449			
Cons	79.73289	0.10	0.924	31.46832	133.8523	0.24
F(15, 7)	5.32				4.01	
Prob > F	0.01				0.04	
R-squared	0.92				0.81	
Adjasted R-squared	0.75				0.61	
Durbin-Watson(16,23)	1.7				1.9	

Source Own Computations

Appendix F Maize Production

Growing Season	Harvest Year	COMMUNAL			COMMERCIAL			NATIONAL		
		Production (mt)	**Area (Ha)**	**Yield (kg/ha)**	**Production (mt)**	**Area (Ha)**	**Yield (kg/ha)**	**Production (mt)**	**Area (Ha)**	**Yield (kg/ha)**
1979/80	1980	600,000	900,000	667	910,700	277,700	3,279	1,510,700	1,177,700	1,283
1980/81	1981	1,000,000	1,000,000	1,000	1,833,400	363,400	5,045	2,833,400	1,363,400	2,078
1981/82	1982	595,000	1,100,000	541	1,213,400	316,400	3,835	1,808,400	1,416,400	1,277
1982/83	1983	285,000	1,050,000	271	624,800	283,900	2,201	909,800	1,333,900	682
1883/84	1984	670,000	1,136,000	590	678,500	224,600	3,021	1,348,500	1,360,600	991
1984/85	1985	1,558,000	1,018,000	1,530	1,153,000	238,000	4,845	2,711,000	1,256,000	2,158
1985/86	1986	1,348,000	1,074,000	1,255	1,064,000	240,000	4,433	2,412,000	1,314,000	1,836
1986/87	1987	1,064,000	627,700	1,695	466,000	147,100	3,168	1,530,000	774,800	1,975
1987/88	1988	1,609,300	1,149,500	1,400	643,800	150,000	4,292	2,253,100	1,299,500	1,734
1988/89	1989	1,188,200	1,030,000	1,154	743,000	168,300	4,415	1,931,200	1,198,300	1,612
1989/90	1990	1,262,300	971,000	1,300	731,500	178,800	4,091	1,993,800	1,149,800	1,734
1990/91	1991	1,019,300	926,200	1,101	566,500	175,000	3,237	1,585,800	1,101,200	1,440
1991/92	1992	115,200	728,000	158	245,800	153,000	1,607	361,000	881,000	410
1992/93	1993	1,133,600	1,040,000	1,090	878,250	198,000	4,436	2,011,850	1,238,000	1,625
1993/94	1994	1,313,600	1,169,200	1,124	1,012,400	232,000	4,364	2,326,000	1,401,200	1,660
1994/95	1995	399,400	1,209,200	330	440,200	188,700	2,333	839,600	1,397,900	601
1995/96	1996	1,687,000	1,330,000	1,268	922,000	205,000	4,498	2,609,000	1,535,000	1,700
1996/97	1997	1,453,000	1,483,000	980	738,370	157,100	4,700	2,191,370	1,640,100	1,336
1997/98	1998	727,550	1,057,000	688	690,480	166,800	4,140	1,418,030	1,223,800	1,159
1998/99	1999	845,300	1,262,000	670	674,260	184,400	3,657	1,519,560	1,446,400	1,051
1999/00	2000	938,709	1,212,540	774	680,942	160,577	4,241	1,619,651	1,373,117	1,180
2000/01	2001	993,940	1,084,100	917	532,388	155,888	3,415	1,526,328	1,239,988	1,231
2001/02	2002	310638	1,199,021	259	294,120	128,833	2,283	604,758	1,327,854	455
2002/03	2003	817,446	1,225,791	667	241,340	126,577	1,907	1,058,786	1,352,368	783
2003/04	2004	1,505,970	1,400,800	1,075	180,181	93,010	1,937	1,686,151	1,493,810	1,129
2005/06	2005	837,304	1,659,424	505	78,062	70,443	1,108	915,366	1,729,867	529
2005/06	2006	1,385,957	1,650,158	840	98,882	62,841	1,574	1,484,839	1,712,999	867
2006/07	2007	1080624	1390132	777	80986	55683	1,454	952,600	1,445,800	659

Source MAMID, 2007