ECONOMETRIC ANALYSIS OF SUPPLY RESPONSE AMONG BEEF FARMERS IN BOTSWANA

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ABSTRACT

The cattle (especially beef) industry in Botswana has traditionally played an important role in the country's economy, with significant contributions to Gross Domestic Product (GDP), exports, and employment, as well as playing an important role in social and cultural spheres. Agriculture contributes about 2.3 % of GDP, out of which 70% - 80% is attributable to cattle production. By 2004, beef exports amounted to P284m, approximately 1.7% of total exports of P16.2 billion. In recent years, however, there have been signs of decline and stagnation, especially in the beef export subsector, with adverse implications for the viability of cattle farming in the country, and more generally for rural livelihoods. Botswana's beef subsector has not fulfilled its potential as a contributor to economic growth and development, especially in the rural areas. The BMC has never been able to meet its quota of 19 000 tonnes of beef to the European Union (EU), despite being cushioned by the Continuo agreement against price competition from more efficient beef producers like Brazil.

With the above background, the study was undertaken to examine the supply response of beef farmers in Botswana to various economic (e.g. prices) and non-economic [e.g. rainfall, technology and inventory (cattle population)] factors. This study used historical data on Botswana's beef subsector for the period 1993 to 2005, and Nerlove's partial adjustment model was used for the empirical analysis of the data.

The results of the study revealed that Botswana beef farmers respond positively to price incentives and time trend (proxy for technology), and negatively to all other variables. Elasticities of supply showed that cattle supply is elastic with respect to variations in producer price and almost unit elastic to changes in cattle inventory. However, the response to shocks in other variables included in the model was inelastic. Short run price elasticity of supply is 1.511 whereas long run price elasticity is 10.57, a clear sign that pricing can be employed as a strategy to enhance beef production in Botswana. The speed of adjustment however, was relatively very low at 14% per period. This slow adjustment perhaps tells us that Botswana farmers, who are predominantly subsistence

farmers, may not be having enough capacity (in terms of resources and technology) to immediately increase production when economic environment improves in their favour.

Based on the results it is recommended that price increase be adopted as a strategy for improving cattle supply. Extension services need to be strengthened with a view of promoting cattle farming as a commercial activity. Current technology of using communal grazing and indigenous breeds need to be improved. It is also recommended that studies be conducted to determine the suitability of technology that is at the disposal of the farmers. Lastly Botswana government needs to come up with a strategy by which farmers can change from their attitude of oxen production to weaner production.

ACKNOWLEDGEMENT

DEDICATION

I dedicate this piece of work to the memory of my late mother Kearoma Alice Gosalamang, how I wish she could have lived a little longer to witness my success. May God bless her soul!

DECLARATION

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

Signature----------------------------   Date-------------------------------------

Dikgang Stephen Gosalamang

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BEDIA   Botswana Enterprise Development and Investment Authority

BIDPA   Botswana Institute of Development and Policy Analysis

BMC   Botswana Meat Commission

CBPP   Contagious Bovine Pleuropneumonia

CIA   Central Intelligence Agency

CPI   Consumer Price Index

CSO   Central Statistics Office

EU   European Union

FMD   Foot and Mouth Disease

GDP   Gross Domestic Product

NDP   National Development Plan

SACU   Southern African Customs Union

CHAPTER 1: INTRODUCTION

1.1 Background

Agriculture remains the critical source of livelihood for most people in Botswana. The Botswana government, through its National Development Plan 9 (NDP9), underpins the importance of boosting agricultural yields and productivity in order to expand incomes and create sustainable jobs. In 2003/04, agriculture contributed 2.3% of the GDP, out of which about 70% - 80% was attributable to cattle production (BEDIA, 2007). By 2004, beef exports amounted to P284m, approximately 1.7% of total exports of P16.2 billion (Jefferis, 2005). Notwithstanding this contribution, cattle production remains an important factor in the rural economy as a source of income, employment and investment opportunities. It also has strong linkages with the rest of the economy as a supplier of inputs for meat processing, leather and other industries.
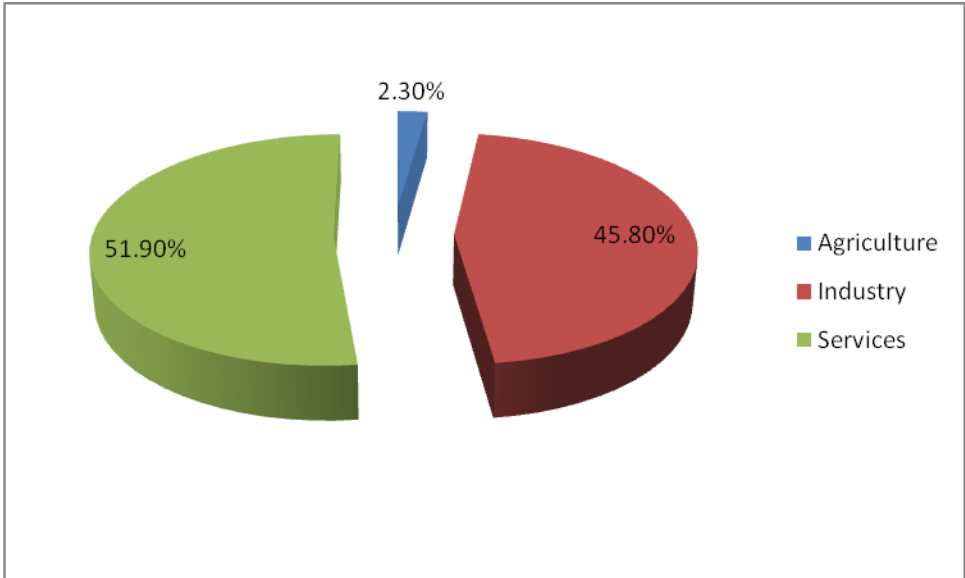
Figure 1.1: Sectoral Contributions to Botswana's GDP

Data Source: CIA World Factbook (2010).

Beef is Botswana's only agricultural export to the European Union (EU), and the EU is Botswana's most important market. The industry benefits greatly from Continuo preferences which give the country significant competitive advantage over other exporters of beef to the EU (Meyn, 2007). According to Meyn (2007), the country is not a globally competitive beef exporter; currently it is only able to supply markets that have both a high protection degree and a high price level. Both criteria apply to the EU market and the EU's recent offer of duty and quota free market access has further contributed to its attractiveness as export destination.

The cattle population in Botswana has fluctuated between 2.5 and 3 million (BEDIA, 2007). Despite this seemingly high number of cattle, the off take rate, especially to the Botswana Meat Commission (BMC) which is undoubtedly the chief buyer of beef cattle in Botswana, had been declining over the years. The low off take rate had been attributed mainly to low producer prices. This resulted in excess capacity at the BMC and a huge supply deficit to the EU. Cattle in Botswana are kept under two production systems that is, the traditional (communal) and commercial systems. Currently, the traditional system accounts for approximately 80% of the national cattle population, while the commercial system accounts for only 20% (BEDIA, 2007).

The Botswana Meat Commission (BMC), a government parastatal, has a monopoly over the export of beef products. It also sells beef products directly to retailers in the local market. BMC currently operates three abattoirs in Lobatse (800 cattle/day capacity) and Francistown (350 cattle/day capacity) with a combined capacity to slaughter over 300,000 cattle per annum and the third one at Maun. The Lobatse and Francistown abattoirs slaughter cattle for export market while the Maun one is responsible for the domestic market. This emanates from the fact that the Maun region is prone to foot and mouth (FMD) outbreaks. The Maun abattoir has been closed indefinitely since the outbreak of the Contagious Bovine Pleuropneumonia disease in the region in 1995. The Government of Botswana is however, currently reviewing BMC's export monopoly to identify opportunities for liberalization of this sector. The Ministry of Agriculture has put plans to restructure and thereby streamline the BMC in what the Agriculture Hub Coordinator has called 'restructuring' of the business. According to the

coordinator of the Agricultural Hub in Botswana, plans are underway to open up competition in the beef export industry. This resolution was arrived at after the ministry had undertaken extensive consultations with stakeholders. According to Meat Trade News Daily (2010), in the past BMC operated erratically, making profits one year and at times running huge deficits. With the restructuring it is envisaged that BMC will also be able to pay out the best prices to local farmers. Previously farmers were sceptical about selling their beasts to the commission complaining of low prices but since 2008 the situation has improved.

Recent proposals for restructuring the cattle and beef industry in Botswana aimed at restoring the competitiveness of the sector have included proposals to raise prices to export parity levels. Besides restoring profitability to cattle producers and providing a Market-related price signal, the expectation is that higher prices will contribute to restoring the viability of the beef and cattle sector by stimulating increased production through improved productivity and higher off take, and thereby addressing the low throughput problem that has bedevilled BMC in particular. The 40% average producer price increase announced by BMC in early 2006, while still below export parity levels, is aimed at partially addressing this problem (Jefferis, 2007).

1.2 Problem statement

Botswana's cattle and beef sector has performed poorly in recent years and has not fulfilled its potential as a contributor to economic growth and development, especially in the rural areas. The BMC has never been able to meet its quota of 19 000 tonnes of beef to the European Union (EU),despite being cushioned by the Continuo agreement against price competition from more efficient beef producers like Brazil. Recent proposals for restructuring the industry and improving its competitiveness have included a recommendation to raise prices to match those in the region, in the expectation that farmers would respond positively to this price incentive by raising productivity and production levels. The effectiveness of such a proposal depends on the responsiveness of farmers to price incentives. Available literature also suggests that non economic -

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factors such as cattle numbers (inventory), rainfall and technology have a great influence on the supply of cattle for slaughter. Therefore it would be of great interest to find out how responsive are Botswana farmers to variations in these factors? Hence an endeavour by the study to determine the responsiveness of beef farmers to shocks in these economic and non economic factors.

1.3 Motivation of the study

Cattle production plays a very important role in the economy of the rural poor in Botswana. It serves as source of protein (meat and milk), social prestige, income and security and is very useful in social functions such as weddings, funerals and paying lobola. The study is intended at helping to commercialize beef production, by revealing the responsiveness of beef farmers to variations in both economic and non-economic factors. Knowledge of the supply response will aid individual producers to make informed decisions to adjust production to projected prices. The study will also help the government in formulating suitable set of policies to promote economic development of the rural poor.

1.4 Aim and objectives

1.4.1 Aim

The study is undertaken to examine the supply response of beef farmers in Botswana to various economic (prices) and non-economic [e.g. rainfall, technology and inventory (cattle population)] factors.

1.4.2 Objectives

i) To determine the responsiveness of beef farmers in Botswana to price incentives.

ii) To examine the responsiveness of beef farmers to non-economic factors such as rainfall, technology and cattle inventory.

1.5 Hypotheses

Hypothesis 1: It is hypothesized in this study that planned supply of beef is not affected by price incentives.

Hypothesis 2: It is also hypothesized that planned supply of beef is not affected by non-economic factors such as rainfall, technology and cattle inventory.

1.6 Organizational Structure

Since the aim of this study was to examine the supply response of beef farmers in Botswana to various economic and non-economic factors, the remainder of this study is structured as follows: Chapter two presents the literature reviewed in the study: Chapter three describes the study area and the methodological processes followed during the collection and analysis of the data: Chapter four presents the results and discussion of the study; and Chapter five focuses on the summary, conclusions and recommendations of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter covers literature that is related to the topic of study. The literature focuses on items such as beef market in Botswana, the use of econometric models in analyzing economic problems, agricultural supply response and the work done in relation to the research problem.

2.2 The beef market in Botswana

According to Stevens and Kennan (2005), the Botswana beef export industry is in crisis. The recent financial difficulties of the BMC have been exacerbated by temporary factors; notably the recurrent drought and the outbreak of FMD resulting in all probability from cross-border contamination. But while there may well be a cyclical upturn, these cycles are occurring around a deteriorating trend. There is no reason to suppose that without fundamental change on the supply side this trend will be reversed. The authors postulate that the underlying trend arises because European Union beef prices have not increased in real terms for three or four decades and are unlikely to do so in future. In order to cope with the inevitable increase in costs incurred outside Botswana and the effects of rapid growth within Botswana, the beef sector would have needed continuous efficiency gains. There is no evidence that these have occurred. Consequently, margins have been squeezed. A trade that was once profitable is now marginal. With little scope to increase real export returns the future of the industry now depends upon fundamental supply-side change.

2.3 Econometric models

Quantities traded and prices realized in agricultural commodity markets, whether national or international, reflect a complex of interrelationships between economic, technical, biological and institutional factors. Quantitative models of markets, which capture the key features of their workings, represent one approach to dealing with this complexity. The use of such models or information derived from them is now common

place for many of those involved in analyzing current market developments, predicting future developments, devising policy interventions, and actually buying and selling. World markets and, at least in the case of the industrialized countries, national markets, for almost every agricultural commodity have been modelled, some more than once (Hallam, 1990).

The nature and functioning of agricultural commodity markets can be highly complex, more so than the markets for many industrial products. Production is influenced by biological and climatic factors, such as diseases and pests, droughts and frosts which can be controlled only imperfectly if at all. Production cycles can be very long particularly for perennial crops and beef cattle which may take several years. National markets may involve complex marketing chains, with the product passing through many hands between the producer and the consumer, and with each marketing stage exerting its influence on prices received and paid throughout the chain. Agricultural commodity markets (national or international) are subject to a wide range of official interventions aimed at modifying the free market solutions for prices and quantities. In national markets throughout the world, government intervene directly or indirectly in the process producing distortions in agricultural prices such that they may differ substantially from those that would be realized in the free market. The prices and quantities realized on agricultural commodity markets are therefore the product of a series of complex dynamic interactions between prices, quantities traded and a wide range of exogenous factors (Hallam, 1990).

A number of econometric models have been used to study supply response of agricultural products. These include among others, the partial adjustment model by Nerlove (1956), which seeks to explain the lags inherent in farmers' response to changes in prices, the adaptive expectations model by Cagan (1956) which suggests that, because of the delays inherent in the production process, production and marketing decisions must be based upon expectations regarding the future values of relevant variables. For example; a variable of interest say supply, may be based upon expected price. There is also the Nerlove supply response model which combines the

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two models above. The last and most recent models are the co-integration and error correction techniques. Each of the above mentioned models has its own advantages and disadvantages, so the onus is usually on the researcher to choose the one which suits his situation best.

2.4 Time series models

Time series models are of special interest in econometrics because they are often used for forecasting (Halcoussis, 2005). The models use the past to predict the future. Available historical data are used to make the best guess about the future. A time series variable can be thought of as an econometric time travel, because the variable measures the same thing, but at different points in time (Halcoussis, 2005). Unlike in cross sectional data where variables are observed at a particular point in time, observations for time series data are made through time. Time series models take note of the fact that it takes time for the impact of an independent variable to show up on the dependent variable. The influence of the independent variable is spread out or distributed across several time periods, hence the distributed lagged models. A distributed lag model is a model in which the independent variable(s) appear in a regression with different time lags (Halcoussis, 2005). Predicting the future is no crystal ball, no matter how good one is at econometrics, thus econometric forecasts are far from perfect. Time series econometricians usually encounter a number of problems; 1) the fact that variables can influence one another with a time lag. 2) variables are often non stationary i.e. they tend to depict a particular trend over time, usually a rising trend, and 3) when measuring economic variables using monetary values, price fluctuations tend to distort the data.

2.4.1 Stationarity of the data

A time series variable is called stationary if it does not have an upward or downward trend over time. For a series to be stationary, its mean, variance and autocorrelation pattern must remain the same over time (Halcoussis, 2005). A time series variable that does not meet these criteria and exhibits a trend over time is called nonstationary. A

nonstationary variable causes misleading results. It will seem as if the regression has much better goodness of fit than it really does, and the nonstationary variable will seem to have a greater impact in the regression than it really does. When a regression has a very strong goodness of fit and significant t-statistic because of a trend or other fact not accounted for in the model, it is often referred to as a spurious regression or correlation (Halcoussis, 2005). This anomaly can be rectified by the use of a method known as differencing, which attempts to de-trend the data to control autocorrelation and achieve stationarity by subtracting each datum in a series from its predecessor (North Carolina State University, 2010). The following tests may be performed to test for stationarity: Durbin-Watson, Dickey- Fuller, Augmented Dickey-Fuller and root examination for univariate time series.

2.4.2 Autocorrelation

Autocorrelation also called serial correlation occurs when observed errors follow a pattern so that they are correlated (Halcoussis, 2005; Ashenfelter, Levine and Zimmerman, 2003). The most common type of autocorrelation, first-order autocorrelation, is present when observed error tends to be influenced by the observed error that immediately precedes it in the previous time period (Halcoussis, 2005). According to Kennedy (2008), whenever a lagged value of the dependent variable appears as a regressor in an estimating relationship, we have a case of autoregression. He went on to suggest that, the lagged dependent variable cannot be independent of the entire disturbance term because the dependent variable is in part determined by the disturbance term. He argues that the lagged dependent variable is correlated to all its past disturbances; however, it is not correlated to the current or the future disturbances.

2.4.3 Multicollinearity

Ordinary Least Squares (OLS) assumes that no independent variable is a linear function of another. Slope estimates in an OLS regression give the average change in Y for a unit change in X holding all other independent variables constant. If one independent variable is a linear function of another, then when one changes value so does the other (Halcoussis, 2005). This condition is known as multicollinearity.

Independent variables that exhibit multicollinearity contain similar information and tend to move together, and the OLS procedure finds it difficult to estimate their slope coefficients (Halcoussis, 2005). Economics tells us that many factors in different markets and different parts of the economy affect each other, so most regressions always display some degree of multicollinearity (Halcoussis, 2005). According to available literature the most common methods of measuring multicollinearity are; the use of the correlation coefficient which should not exceed 0.8 and the variance inflation factor which should not have a coefficient value exceeding 4.

2.4.4 Price fluctuations

Time series variables that are measured in monetary terms, such as income, gross domestic product, tax revenues and price will have larger values over time due to inflation. This affects regression results in a misleading way. An independent variable may seem to have a statistically significant coefficient while in actual fact it is not. The independent and dependent variables may seem to be related, while in actual fact they are both increasing because of inflation (Halcoussis, 2005).

Economists are interested in tracking the valve of goods and services consumed independent of any price movements. This enables them to make sensible comparisons across time periods even as prices move. Data unadjusted for price fluctuations over time, distort the measurement of economic variables measured in the dollar value (Federal Reserve Bank of Dallas, 2010). In effect, $1 today is worth less than $1 say ten years ago. The relative value of different goods over time can be obscured by changes in the value or purchasing power of the dollar (Goodwin, 1994). Removing the price effect from the data gives researchers a clearer picture of what is really happening to sales levels relative to any time period. The object is to remove any part of the variable's change that is attributable to price movements, arriving at a real or inflation adjusted indicator (Federal Reserve Bank of Dallas, 2010).To effectively use prices in the econometric analysis of time series data, one needs to transform a series into real terms (or deflate nominal data series into real values). The consumer price index (CPI) is commonly used to correct prices for changes in the value of the dollar, making year to year comparisons feasible.

2.5 Agricultural supply response

The agricultural sector in developing countries is normally neglected because economic growth is thought to be synonymous with industrialization. This anomaly was justified by the belief that industry is a dynamic sector, while agriculture is static and unresponsive to incentives. This belief led to the taxing of agriculture by turning domestic terms of trade against the sector. The consideration that agriculture is unresponsive implied that resources generated in agriculture could be transferred to other sectors of the economy without significantly affecting agricultural growth (Alemu, Oosthuizen and van Schalkwyk, 2003).

The concern of supply response analysis is the response of domestic agricultural production to changes in output and input prices, which may be policy-induced. The focus may be aggregate agricultural output and its responsiveness to changes in agriculture's terms of trade (output-input price ratios or agriculture's barter terms of trade) where analysis of overall agricultural growth is the primary objective. Alternatively, the focus may be on individual products to allow exploration of the effects of price movements on the commodity composition of agricultural output, or to consider certain products of particular quantitative importance on their own right e.g. beef production. Yields per unit area or per animal are of interest as well as the scale of production reflected in areas planted and harvested (Hallam, 1990).

A lot of work has been done on estimating the supply response of agriculture with the general finding that its response is inelastic (Bond 1983, Chibber 1989 and McKay, Morrissey and Vaillant 1999). However, there has been controversy as to whether aggregate agricultural supply is really not responsive. Schiff and Montenegro (1997) argued that aggregate agricultural supply response to prices is in fact high but that there are other constraints such as financing that hinder this response such that a low elasticity is found. Other writers also assert that aggregate agricultural supply is highly responsive but that low elasticities have been observed because of factor prices adjusting in parallel to output prices. A lot of methodological questions have also been raised on the previously used models and the estimation techniques applied. These

questions range from the reliability of the estimates for forecasting supply response to the validity of the estimates. For instance, the major criticism of time series estimates of aggregate agricultural supply response has been that estimates are drawn for a given price regime hence they mainly reflect short run variations in prices. Given that agriculture heavily relies on a fixed input, land, it is unlikely that aggregate agricultural supply will respond to short run fluctuations hence time series estimates are biased downwards (Muchampondwa, 2008).

According to Jefferies (2007), questions have been raised about how responsive Botswana cattle producers are to price, and whether there would in fact be a positive supply response to higher prices. Doubts about supply response are generally framed in terms of the dominance of traditional cattle producers farming on communal land, whom it is sometimes argued, do not view cattle rearing as a commercial activity, and only sell cattle to meet a money income target. von Bach, van Renen and Kirstein (1998) argued that communal farmers consider their cattle as a store of wealth (i.e. cattle are viewed more as an investment commodity than a consumption commodity), and they only sell to meet their cash needs. Increased prices therefore allowed farmers to meet their cash needs by selling fewer cattle. This effect would be reinforced by the traditional status of cattle as a determinant of social status. Countering this is the argument that many traditional cattle producers are poor, and their need for higher incomes would give them an incentive to sell more cattle (which is now a more lucrative activity). Responses to cattle price changes can be divided into investment demand and consumption demand. A higher price may result in higher investment demand, in anticipation of even higher prices in future, or if more utility is derived from a higher stock of cattle than from greater income, in which case cattle supply would fall. By contrast, higher consumption demand would result in increased supplies to benefit immediately from higher prices.

In many communal areas it was found that beef supply is only determined by cattle numbers (van Renen, 1997). Prompt payments were also found to be very important in encouraging farmers to sell their cattle. The herders' willingness to sell was found to be affected more by the promptness of payments rather than the price they received. According to von Bach, van Renen and Kirstein (1998), limited access to high priced

market by small farmers indicated that the problem with low off-take rates does not lie with price responsiveness but rather with market. In commercial areas both rainfall and cattle numbers were found to be major determinants of beef supply.

2.6 Supply price elasticity

Supply price elasticities are derived from a rule that defines the relationship between a set of prices and output. In supply relationships, it is normally accepted that producers who try to maximize profits will increase (decrease) the supply of a commodity in response to an increase (decrease) in the price of that commodity subject to a given technology. The technology available to the producers determines the physical response of output to the use of a set of inputs; this is what economists refer to as a production function. Producers use changes in both output and input prices to determine the expected profitability of a particular production activity. Supply price elasticities refer to the percentage change in output arising from a percentage change in prices and are obtained from supply functions (Rodriguez, 1986).

According to Rodriguez (1986), cattle slaughter relationships present differing situations in the short-run, an increase in the price of beef may reduce the number of cattle slaughtered. This implies that the marketable output of beef will be lower in comparison to a situation where prices did not increase, that is, the short-run price elasticity of beef supply estimated from a given slaughter function will be negative. Disregarding the on-farm consumption effect, this situation could arise from two possible reasons. First, when beef prices increase, commercial producers will decide to build up their herd inventory by retaining the most productive animals and will increase the herd size in anticipation of still higher prices in the future. They will increase their herd size up to the point where the marginal cost of an additional input is equal to the marginal return of an additional livestock output. Secondly, subsistence oriented farmers will sell less of the now higher-priced animals to meet a target cash demand. Roudriguez, (1986) went on to suggest that, in a commercial production setting, withholding animals from the slaughter market due to increased prices will induce beef prices to increase even more because, other things being equal, of the decrease in beef supply. When those animals

which were held back reach the appropriate slaughter age and/or weight, producers will have to sell these animals. This would mean that increased slaughter levels will depress beef prices. Lower prices will further induce producers to sell as much as possible in anticipation of even lower prices in the future. This is usually referred to as the cattle cycle in commercial beef production. Part of the reason of why beef supply responses are said to be negative in the short-run and positive in the long-run is explained by the cattle cycle phenomena.

According to Ison (2000), factors determining price elasticity include among others; a) the existence of spare capacity, even if price increases a firm may not be able to increase supply if it does not have surplus capacity. The firm may be operating at full capacity so that in the short run supply may be perfectly inelastic. But if the firm has spare capacity it will respond by increasing output. b) Mobility of the factors of production. If the firm can easily reallocate its resources such as labour, land and productive capacity, from one type of production to another then the supply for that product will tend to be more elastic. c) Time period; it will take time for a firm to adjust to change in price, so supply is likely to be more elastic in the long run, because it is possible for the firm to expand its productive capacity.

2.7 A Summary of work done on the research problem

Ndzinge, Marsh and Greer (1984) when analysing cattle supply response in Botswana, contrary to expectations, found a very high short-term price elasticity of 3.76, but no long-term price response. A study by Rodriguez (1985) on cattle supply response in Zimbabwe provided some comparative data on southern African countries, and found short run price elasticities of 0.3, -1.1 and -0.6 for Botswana, Swaziland and Zimbabwe respectively. The long run price elasticties were 2.6 for Botswana, 0 for Swaziland and 2.6 for Zimbabwe. These results show relatively low short-run elasticities with some negative values, but higher long-term elasticities, with very similar figures for Botswana and Zimbabwe. This would imply that cattle supply would increase more than proportionately in the long-run, e.g., a 40% price increase would in the long-run increase supply by over 100%. Another study carried out by Fidzani (1993) that

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analyzed the differing price responsiveness of small, medium and large cattle herders in Botswana, supports the argument that cattle farmers respond positively to price incentives, with average supply elasticity across all groups of farmers of 0.6531. Furthermore, small scale farmers had higher supply elasticity than those with medium-sized herds.

von Bach, van Renen and Kirsten (1998) analyzed supply response in all SACU member countries. Unlike in the previous studies, this one did not find any response of cattle supply to prices in Botswana (only rainfall and herd size were significant determinants of cattle supply). Similar results were found in the other SACU countries. BIDPA (2006) analyzed the factors determining the supply of cattle to BMC. The results indicated similar pattern to that of Rodriguez (1985), with negative short-term price elasticity but positive medium-term price elasticity. However, the elasticity results are somewhat low, with cumulative elasticity for cattle of 0.3. Nevertheless, the study concludes that as BMC prices have fallen over time (in real terms); this is one of the factors that has caused cattle sales to BMC to fall, and that it is possible for BMC to stimulate cattle marketing by increasing producer prices at a rate that is higher than the inflation rate. The magnitude of the elasticity coefficient would, however, indicate that a substantial price increase would be necessary to induce a significant increase in cattle supplies to the BMC, and that the price increase to date should not be expected to lead to a dramatic increase in cattle supplies to BMC.

Rodriguez, (1986) when comparing the short-run response of Zimbabwe's commercial cattle sector to beef price changes with other countries reported a wide diversity, for example, for a 10% rise in beef prices, producers in Brazil reduced slaughter levels by 1.1 to 5.6%; Argentina by 6.7 to 9.6%; and Colombia by 0.58 to 12%. In Zimbabwe the short-run price elasticity of beef ranged from -0.49 to -0.61 which in other words means that if producer price increases the by 10%, the number of cattle supplied for slaughter will decrease by approximately 5 to 6%.

Easter and Paris (1983) found that the US beef import policy generating a 10 per cent beef price fall could reduce Australian beef supply by 3.5 per cent and grazing industry

net revenue by 8.4 per cent, despite some switching from beef production to other enterprises. They attributed this to the heavy reliance of the Australian beef export on the U.S import market.

Seleka (2001) when estimating the short-run supply of sheep and goats in Botswana found that elasticity estimates indicate that a 1% increase (decrease) in rainfall at year t leads to a 0.53% rise (fall) in goat marketing in year t+1, and that a 1% rise (fall) in goat population (inventory) leads to a 0.15% rise (fall) in goat sales. The sheep equation reveals that a 1% increase (decrease) in sheep inventory results in a 1.23% rise (fall) in the number of sheep marketed, and suggests that rainfall has no impact on sheep sales. It is argued that the inelastic response of goat sales to changes in goat inventory reinforces the general view that livestock in Botswana are treated as a store of wealth, rather than as primarily a commercial activity for generating cash incomes. This tendency seems to be reduced in the case of sheep, where an elastic response of sales to changes in sheep inventory is observed. Producer prices were found to have no impact on small ruminant sale. The lack of responsiveness of supply to prices may be revealing the existence of inadequate access by most producers to organized markets for small ruminants. It is further argued that without promoting the development of such markets, other developmental efforts, particularly those geared at improving farm-level productivity will yield no positive outcomes, as farmers lack the cash incentive to invest in improved management and husbandry practices.

Muchampondwa (2008) when estimating aggregate agricultural supply response in Zimbabwe found a long-run price elasticity of 0.18 confirming the findings in the literature that aggregate agricultural supply response to price is inelastic. This result means that the agricultural price policy in developing countries is rather a blunt instrument for effecting growth in aggregate agricultural supply. He argued that the provision of non-price incentives must play a key role in reviving the agricultural sector in Zimbabwe. It is also suggested that the low price elasticity could also be attributable to the presence of hysteresis in the agricultural sector in which case the aggregate agricultural supply response can only be stimulated through technical progress and

mechanization of agriculture rather than by just price reforms. Given the significance of the rainfall variable, other policies such as irrigation investment are also likely to have a direct effect on aggregate agricultural supply. In fact, a package of changes may bring about better response from farmers than a price change alone.

Past studies in Africa provide a mixed result about the reaction of subsistence cattle producers to beef price adjustments. Quantitative estimates by Doran, Low and Kemp (1979) and Rodriguez (1985) showed that cattle numbers in communal areas in Swaziland and Zimbabwe respectively, will increase further as a result of beef price increases. One reason for the rise in herd inventories was that the increase in the price of beef resulted in a higher cash value per animal unit, as a result, the subsistence oriented livestock producers sold fewer animals to meet their minimum money transaction demand. Khalifa and Simpson (1972) indicated a decline in animal inventories in Sudan as a result of increases in the price of beef. This can be attributed to the income effects of the larger cash generated in selling higher priced animals. As the nomadic producer increases his cash income, his other demand for money (e.g. speculative motive in the form of gold ornament purchases) comes into play.

Rezitis and Stavropoulos (2009) when examining the supply response of the Greek beef market and the possible effect of the European Union's Common Agricultural Policy (CAP) on the Greek beef sector during the period 1993-2005 found that price volatility and feed price are important risk factors in the supply response function, while the negative asymmetric price volatility that was detected implies that producers have a weak market position. Furthermore, the empirical findings confirm that the annual premium paid by the EU to beef producers had a positive impact on the production level and also, the change of the EU price support regime, after 2006, is having negative effects on beef production level in Greece.

In conclusion, it could be said that the subsistence farmers would respond negatively to prices in terms of increasing marketed supplies. According to Jefferies (2007), the technical aspects of data analysis in this field are complex, and the data are poor,

especially with respect to the supply of cattle to entities other than the BMC (in case of Botswana), making firm conclusions somewhat difficult to reach. There is also a wide range of estimates over the magnitude of the response by different researchers, which suggests a need for continued research on the topic (Jefferies, 2007). From literature above it could be seen that short-run price elasticity for beef farmers in Botswana ranged from negative short-run elasticity through zero to positive 3.76, whereas long-run price elasticity ranged between zero and 2.6.

CHAPTER 3: METHODOLOGY

3.1 Description of study area

The study was conducted in Botswana- a landlocked country situated north west of the republic of South Africa. The country is bordered by Namibia in the west, Zambia in the north and Zimbabwe in the east. The capital city of Botswana is Gaborone which is situated in the south east of the country some 600km from Polokwane. Botswana Meat commission (the chief buyer of beef cattle) has three abattoirs for cattle slaughter and meat processing.
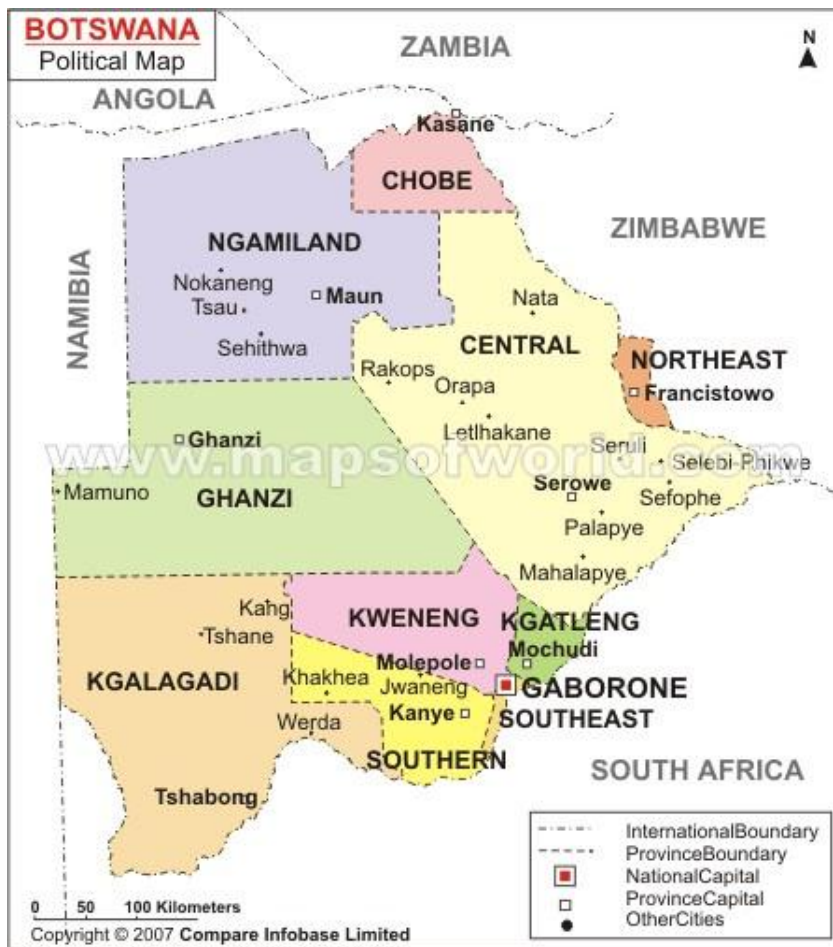

Figure 3.1: Map of Botswana

Source: Compare Infobase Limited (2010).

The main abattoir is in Lobatse, a small town 70 km south of the capital city Gaborone, the second one is in the city of Francistown some 400km north of Gaborone and the third one is in Maun about 1000km from the capital city in the north west. There are also numerous butcheries which slaughter cattle solely for the domestic market.

The study area has been chosen primarily because livestock production, especially beef cattle, has been the backbone of the rural livelihood in Botswana for a very long time now. Agriculture has been the main employer for the rural communities and beef the sole agricultural export. Unfortunately much has not been achieved in improving the economy of the rural poor. Thus the researcher has seen it fit to explore ways in which the rural communities in Botswana can change from subsistence agriculture to commercial agriculture as strategy towards rural development and food security.

3.2 Data collection

Historical time series data for the period 1993 to 2005 was used in this study. The data on domestic producer prices were obtained from the Botswana Meat Commission (BMC) (1994; 2006); the main buyer of beef animals and the sole exporter of beef and beef products. Data on annual precipitation were obtained from the department of meteorological services in the Ministry of Environment, Wildlife and Tourism (MoEWT) (2010). Data on the price of chicken, the main competitor of beef could not be found due to poor record keeping by the concerned departments. Data on chicken output were obtained from the poultry unit in the Ministry of Agriculture (MoA) (2010). Data on cattle inventory (population) and annual throughput (number cattle sold yearly) were obtained from the Agricultural statistics unit of the Ministry of Agriculture (2010). Data on annual inflation rate as measured by Consumer Price Index (CPI) were obtained from Central Statistics Office (CSO) in the Ministry of Finance and Development Planning (MoFDP) (2010).

It is evident from Table 3.1 that, for the thirteen years under study, cattle population has been fluctuating at around 2.3 million. There hasn't been any significant increase in cattle population except in 2002 where the population went slightly above 3 million. The 3.06 million cattle in 2002 could be attributed to the good rains in the years 2000 and

2001, whereas the 1.82 million in 1993 could be due to the 1992 drought. This stagnation in cattle population could be attributable to the fact that most farmers use communal areas for grazing. The use of communal grazing areas means that the stocking rate is not controlled and quite often the carrying capacity of these areas is exceeded, resulting in overstocking and reduced cattle productivity. The traditional sector is usually characterised by low productivity, in the form of low calving rates, low off-take rates, and high death rates compared to the commercial sector. Calving rates in the traditional sector average around 50%, compared to 60%-80% in the commercial sector, while off-take rates of 7% to10% occurred in the traditional sector compared to 15% to 20% in the commercial sector (Jefferis, 2005). Moreover, much of the grazing land is taken by the rapidly growing villages and towns, as well as game reserves and national parks; these squeeze the grazing land even further.

Table 3.1: Time series data on Botswana's livestock sector

Year	Cattle Population in millions	Deflated producer prices in (P/ kg)	Average annual rainfall in 100mm	Number of cattle sold per year in 100 thousands	Annual chicken output in 1000 tons	Annual inflation rate(CPI)
1993	1.82	4.17	3.76	2.31	6.16	14.4
1994	2.3	4.55	3.15	2.06	4.61	10.6
1995	2.53	4.62	4.13	2.26	7.85	10.5
1996	2.25	4.23	5.02	1.01	7.72	10.1
1997	2.21	4.17	5.08	2.43	11.85	8.9
1998	2.34	4.78	4.5	2.1	15.46	6.5
1999	2.58	4.65	3.59	2.66	17.22	7.8
2000	2.1	4.52	6.67	2.14	27.95	8.5
2001	2.47	4.45	5.51	1.81	32.5	6.6
2002	3.06	4.62	2.9	2.08	38.96	8.0
2003	2.02	4.7	3.04	2.42	57.3	9.2
2004	2.15	4.52	5.04	1.84	64.32	7.0
2005	2.07	4.35	3.87	1.62	40	8.6
Mean	2.3	4.49	4.33	2.06	25.53	9.0

Source: Cattle population, chicken output and Annual Sales: MoA (2010). Prices: BMC (1994;2006). Rainfall: MoEWT (2010). CPI: MoFDP (2010).

Tourism comes second (after mining) as a foreign exchange earner, as a result the Botswana government seems to be biased towards improving wildlife reserves at the expense of beef farming. Frequent outbreaks of some economically important diseases such as the Contagious Bovine Pleuropneumonia (CBPP) in 1995 and foot and mouth disease (quite often) together with the adopted method of control of eradicating all the cattle in the affected areas have made sure that the cattle population remains stagnant. These diseases are said to be economically important because once there is an outbreak the export of beef products is suspended until the situation is under control. Evidence is the indefinite closure of the Maun abattoir in 1996 due to the outbreak of the CBPP, and the subsequent slaughter of all cattle in the Ngamiland region. These suspensions usually result in loss of business for the beef sector. Erratic rainfall and recurrent droughts are also responsible for this stagnation, as they usually lead to many deaths.
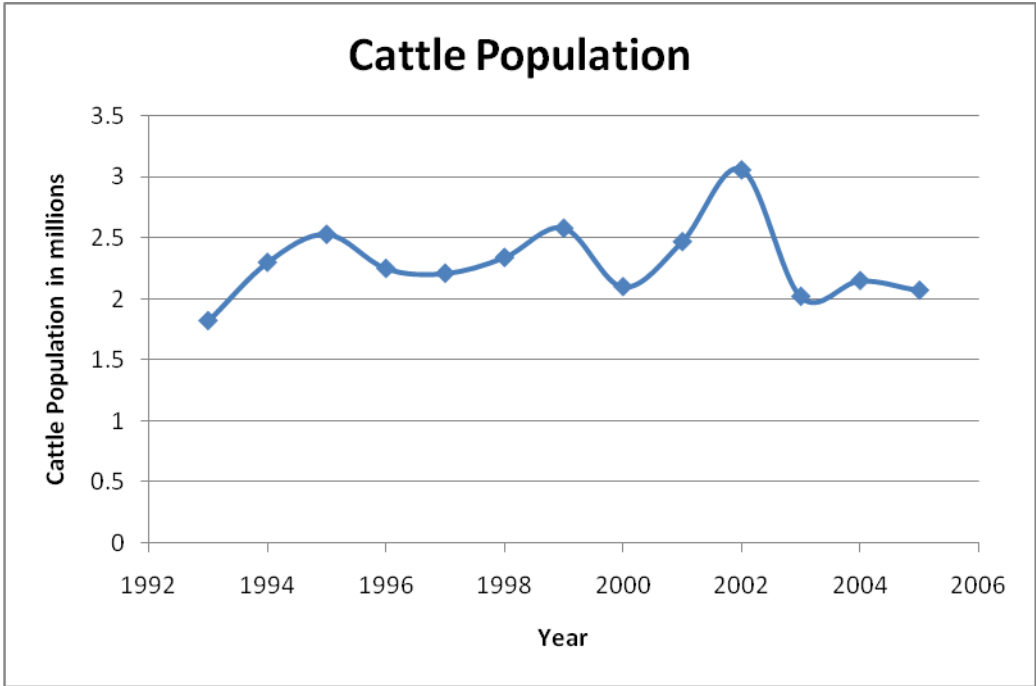

Figure 3.2: Cattle Population

Data Source: MoA (2010).

Between 1993 and 2005 beef producer prices have not been increasing significantly, at least in real terms. The prices have revolved around P4.49 per kilogram, despite the escalating inflation rate which averaged 9% per year. These sluggish price increases coupled with high inflation rate squeezed the profit margins for the beef sector and reduced the comparative advantage of the sector to other sectors of the economy in the country. As a result beef production became an unattractive business activity, as the future prospects appeared very bleak. The poor producer prices have also been blamed for the erratic performance of the Botswana meat commission, as farmers were not willing to sell their animals so cheaply. It is hoped that the envisaged de-regulation of the export market will open up competition and lead to improved efficiencies, as well as better prices to the farmers.

According to BMC (2002) the poor producer prices prevailed because of depressed beef prices in the major markets coupled with the strengthening of the Pula against the major currencies, resulting in squeezed profit margins. Jefferis (2005) asserts that, the beef and cattle sector is probably the most heavily protected economic activity in Botswana, in that, apart from BMC's beef exports, international trade in beef and cattle is prohibited. As a result, the normal forces of competition that result from trade are largely absent, thus reducing competitive pressures on the industry, particularly the beef producing sector to be efficient. The poor domestic producer prices are blamed on the inefficient operation of the BMC which it is argued is as a result of bestowing the monopoly of international trade on the organization.

Botswana is predominantly a dry country, precipitation levels are very low averaging approximately 433 mm per year in the thirteen years under study. These low rainfall levels adversely affect beef cattle productivity and render cattle production a very risky endeavour, more so that most farmers rely on natural pastures and surface water. This is because conditions always point towards a looming drought. The drastic decline of cattle numbers between 2002 (3.06 million) and 2003 (2.02 million) is clear evidence of the effect of rainfall on cattle population, as rainfall amount was only 290mm in the year 2002, suggesting that 2003 was a drought year.
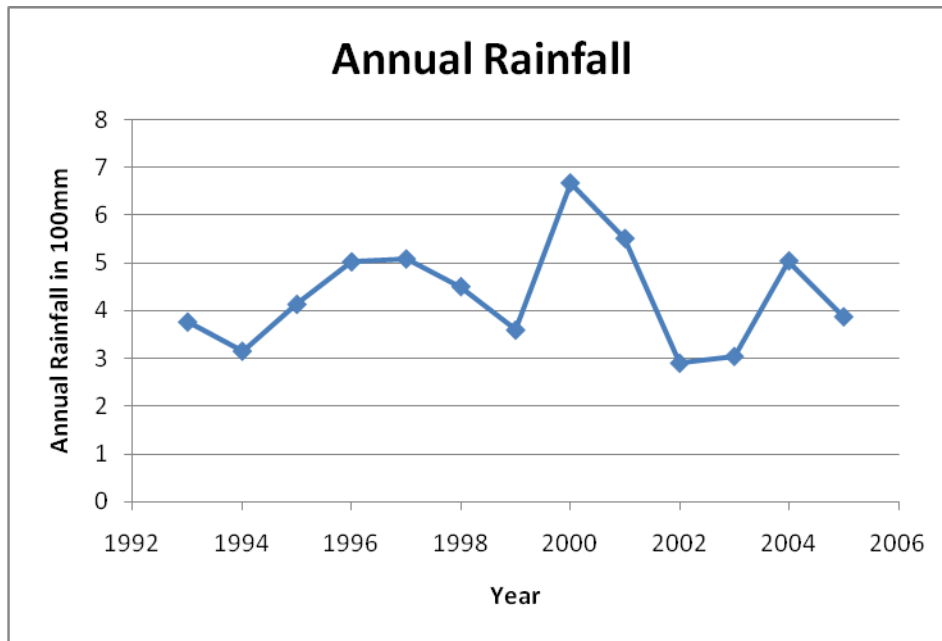
Figure 3.3: Showing Annual Rainfall

Data Source: MoEWT (2010).

The number of cattle sold for slaughter has not been increasing in the thirteen years under study; the mean number of cattle sold per year is 206000, with the lowest off-take rate being 101000 in 1996, following the massive destruction of all cattle in the Ngamiland district after the 1995 outbreak of the CBPP, and the highest being 266000 in 1999. BMC (1995/96) attributes the low supply in 1996 to the fact that farmers held back their stock in view of selling to the government during the restocking exercise of the Ngamiland district. The off-take trend shows that cattle sales revolved around 200 000 cattle per year which is far below the BMC' slaughter capacity of 300 000 cattle in a year. This static cattle supply has been blamed on the problems faced by subsistence farmers such as, having to get permits from the Police and veterinary services, the newly introduced bolus (computerized cattle identification system) and lack of transport to market, especially to BMC. According BMC (2007), the traditional sector holds 70% of the national herd and has an estimated off-take rate of 12-13%. In an effort to enhance the off-take rate the BMC has opened procurement offices in the rural areas, perhaps to reduce transport costs to farmers.
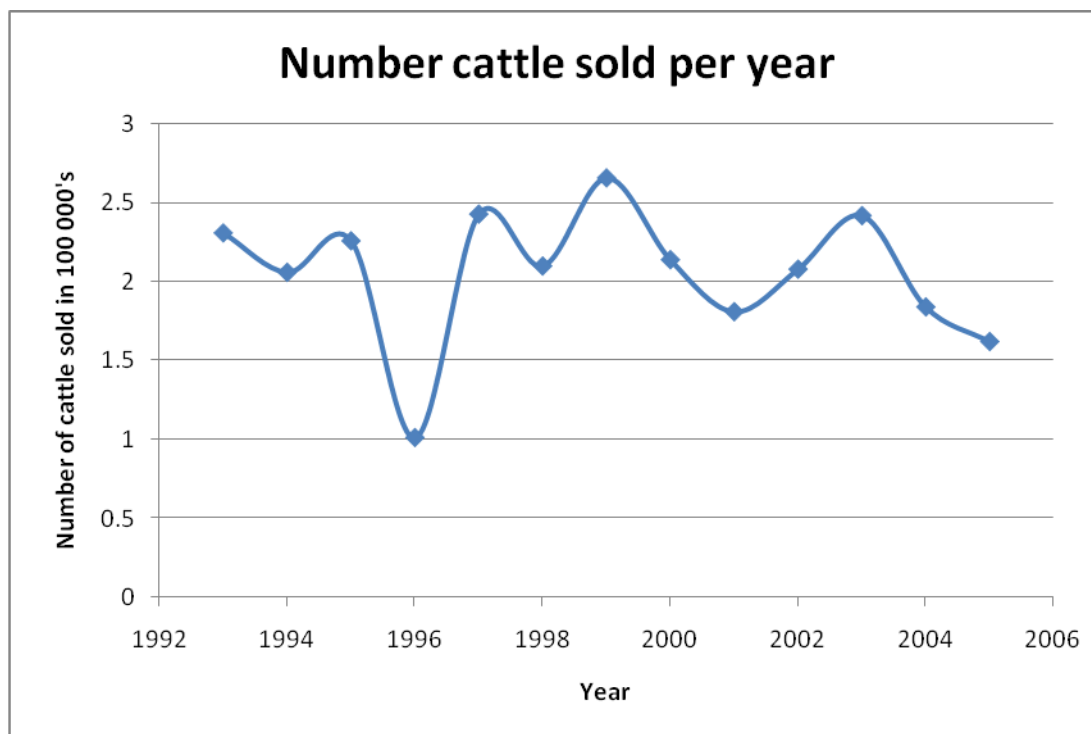
Figure 3.4: Showing Number of Cattle Sold Per Year.

Data Source: MoA (2010).

Some economic comentators have attributed the low beef cattle supply to poor producer prices especially by the BMC. According to Goodwin (1994), if costs of production are just barely being covered, then there will be no funds to plough back into the business for purposes of expansion. Thus, the dollar votes that consumers cast in the form of prices are the determing factor in what products are to be available and in what quantities.

Chicken output has improved tremendously in the thirteen years under study. It increased from 6160 tons in 1993 to 64320 tons in 2004. Chicken output declined significantly in 2005 due mainly to outbreak of avian influenza in ostriches in Zimbabwe and the Republic of South Africa which resulted in imports of broiler chicks being banned from the two countries (Moreki, 2010). The rapid growth in chicken output perhaps tells us that in the past the chicken market had not been fully exploited resulting in supply deficit which was met by imports from South Africa. Because of the shortage in chicken supply, the farm gate prices for chicken were more competitive

when compared to beef prices, as a result more and more people ventured into chicken production at the expense of beef production hence the static cattle supply.
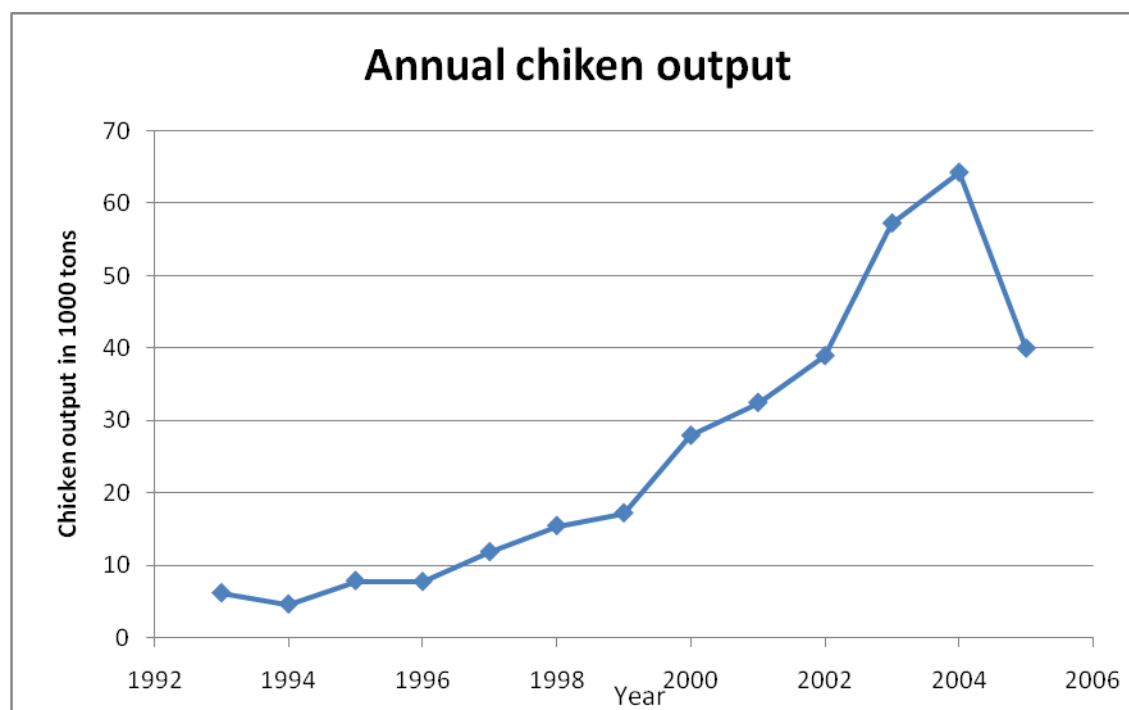
Figure 3.5: Showing Annual Chicken Output.

Data Source: MoA (2010).

3.3 Analytical technique

3.3.1 The Nerlove's partial adjustment model

This econometric model suitable for the analysis of agricultural supply response based on time series data has been developed by Nerlove (1956). Of all the econometric models used to estimate agricultural supply response, the Nerlovian partial adjustment model is considered one of the most influential and successful, judged by the number of studies, which utilize this approach (Braulke, 1982). One survey lists application of the model to more than 500 agricultural commodities including both crops and animals.

According to McKay *et al.* (1999), the Nerlovian model allows explaining dynamic optimization behaviour of farmers, their decisions and their reactions to moving targets. The Nerlove Supply Response (NSR) model is a partial adjustment supply response

model, dynamic by nature [A method is dynamic if the path of the dependent variable is explained by its previous values and the lagged values of the independent variables (Gujarati,1995)], heterogeneous by commodity structure, and econometrically estimated by (ordinary least squares) method. According to Leaver (2004), the Nerlovian model is an autoregressive model because it includes lagged values of the dependent variable (output) among its explanatory variables. It is an adjustment model, because, according to the assumption you would see in equation (1), producers adjust output S_t to the desired or optimum level, S_t^*. The economic unit to which S_t^* refers to, may not always be able or willing to make the transition to the desired level instantaneously; thus, if S_t^* is a desired number of livestock, this optimal level may not be attained instantaneously, but gradually over a sequence of time periods. This happens because of costs of adjustments, technical delays, technological constraints, institutional limitations, biological factors or habit persistence movements from the current level of supply or demand to new equilibrium levels consequent upon changes in economic or technical conditions. Hence, the observable level of the variable may reflect a partial adjustment of the economic unit from current to optimal levels (Kennedy, 2008; Dhrymes, 1981). The partial adjustment model describes the change in a variable say supply from one period to the next as some portion (δ) of the difference between the current level S_t and the desired level S_t^* (Kennedy, 2008; Seay, Pitts and Kamery, 2004; Hallam, 1990). Seay *et al.* (2004) postulated that at any particular time period t, only a fixed fraction of the desired adjustment is accomplished. The partial adjustment model may be depicted as follows:

$$S_t - S_{t-1} = \delta (S_t^* - S_{t-1}) \qquad \delta \in [0, 1] \qquad (1)$$

Or

$$S_t = (1 - \delta) S_{t-1} + \delta S_t^*$$

Where: S_t: is output (number of cattle sold for slaughter) at time t.

S_{t-1}: is output at time $t-1$

S_t^*: desired output level

δ: is the coefficient of adjustment

In other words, the change in output between the current and previous periods is only a proportion of the difference between the optimum level and the last year's output (Seay *et al.*, 2004; Hallam, 1990). δ is the adjustment coefficient, which lies between zero and one. The restriction placed on the parameter δ in equation (1) is both intuitive, and theoretically sound. If δ = 1, it implies that producers are able to fully adjust to supply and demand shocks in one period and $S_t^* = S_t$. If δ = 0, it implies that there is no adjustment $S_t = S_{t-1}$. An estimate of δ close to one implies almost immediate adjustment; a low δ implies a very slow adjustment to changes in exogenous variables (Hallam, 1990 and Griliches, 1959). The desired supply is unobservable and must be expressed as a function of variables which can be observed, for example,

$$S_t^* = \alpha + \beta_1 P_{t-1} + \beta_2 Z_{t-1} + U_t \qquad (2)$$

S_t^*: is the planned (desired supply) at time t.

α: is a constant (i.e planned supply without the influence of price, the Z vector and the error term)

P_{t-1} = price lagged by one period.

β_1 and β_2 are the parameters of price and the Z vector respectively.

Z_{t-1}: the impact of other factors included in the model also lagged by one period.

U_t: represents the impact of other factors not included in the model (error term).

The Z vector was included into the Nerlove partial adjustment model, as the impact of other factors, such as labour, technology, price for comparative product, etc., which could be also important: The Z vector is lagged by one period because it is believed desired supply at time t is a result of the Z vector that occurred in the previous period.

Combining this equation with the partial adjustment model gives the equation

$$S_t = \alpha\delta + (1-\delta) S_{t-1} + \delta\beta_1 P_{t-1} + \delta\beta_2 Z_{t-1} + U_t, \qquad (3)$$

which can be estimated since it involves only observable variables. An estimate of the adjustment parameter, δ, can be obtained by taking one minus the estimated coefficient on the lagged dependent variable 1-(1- δ) (Hallam, 1990). The short-run price effect is measured by the estimated coefficient on price which is equal to δβ. Dividing this by the

estimated adjustment coefficient gives an estimate of the long run price effect, β, when supply would have fully adjusted to new equilibrium (Hallam, 1990., Pindyck and Rubinfeld, 1998).

3.3.2 Specification of variables

Most of the independent variables included in the empirical model were chosen based on the economic theory and available literature on past studies. Some variables were however, included based on hypothesized relationship between the dependent and independent variables. Micro-economic theory suggests that the determinant of the supply of a given product is its own price, i.e. here the domestic price of beef. Goodwin (1994) asserts that, any time a farmer plants a crop, some anticipation or forecast of the price that is likely to be received at harvest have implicitly been included as a dimension of the decision making process. Cobweb models stipulate that expectations are based on lagged prices by only one time period. The Nerlove's adaptive expectation model on the other hand postulates that in agricultural markets, expected prices are based on a weighted sum of past prices, in which weights decline as one goes back in time.

Economic theory further suggests that major shifters for beef production and supply are the prices of competing outputs (substitutes) and the prices of inputs. For the beef sector in Botswana, the major competing product is poultry in particular chicken. A large share of costs of variable inputs for livestock is determined by the costs of feed. In the case of Botswana livestock feeds, drugs and vaccines are highly subsidized by the Government and are sold to farmers through the Livestock Advisory centres in the Ministry of Agriculture. Despite all these subsidies, cattle farmers in Botswana are not used to feeding their livestock, probably because the majority of them keep cattle for subsistence purposes. Only a few commercial producers benefit from these subsidies. Botswana is predominantly a desert characterized by poor soils and sporadic droughts (resulting from low rainfall) and therefore precipitation level is one important variable that should not be omitted. This is because it determines the amount of herbage available for grazing by livestock, as well as the water supply especially surface water. In addition, a number of other factors, such as the amount of production factors (labour, land and capital) employed in agriculture as a whole and in beef production in particular,

as well as the underlying prices for these factors play an important role. Lastly, in an open economy, imports and/or exports will influence the domestic price of beef and hence its production. In the case of Botswana, exports of beef are very important as it (beef) ranks second after minerals, particularly diamonds. The imports of beef on the other hand are very insignificant; in fact Botswana imports only processed beef products, mostly from the neighbouring South Africa. In this study, the dependent variable will be the number of livestock sold for slaughter (S_t). Thus, the structural model can be summarized as follows:

$$S_t= f (Pb, C, Pf, PE, AW, TE, I, R) \qquad (4)$$

The independent variables would be as follows:

Pb = producer price of beef.

C = Chicken output (proxy for chicken price)

Pf = price of feed.

AW = labour force (in P/hr)

TE = time trend (proxy for technology).

I= inventory (population) of beef cattle.

R =rainfall (included because we are dealing with grazing animals).

PE= export price

After some substitution in equation (1) and considering the specific variables of the vector Z in equation (4), we obtain the final estimation equation (5), as follows

$$S_t = \alpha\delta + \delta\beta_1 Pb_{t-1} + \delta\beta_2 C_{t-1} + \delta\beta_3 R_{t-1} + \delta\beta_4 TE_{t-1} + \delta\beta_5 I_{t-1} + (1-\delta) S_{t-1} + \delta U_t \quad (5)$$

The price of feed represents the costs of the major variable input for beef production, but in this case it would not be included because farmers mostly use natural pastures on communal land. The time variable shall represent the level of technology used in beef production. Another variable, which is expected to have a negative influence on beef production, is the price of chicken, but because of lack of records it has not been

included in the model. Chicken is the major competing product with beef in Botswana, that is, in terms of consumption and resources, thus chicken output (as a proxy for the price of chicken) has been included in the model. Finally, the Nerlovian adjustment process (i.e. the level of beef production and the speed of adjustment) will heavily depend on the available stock of labour and capital employed in the beef sector. The agricultural labour force in Botswana is such that farmers use family labour as most of them are subsistent farmers. Since the farmers use traditional method of farming they employ very little amount of capital if any and again records on this factor may not be available. The land factor in Botswana cannot be included in the model because the majority of farmers who are traditional farmers, use communal land which is free of charge, whereas commercial farmers use their own private (free hold) farms. One factor that may affect agricultural supply either positively or negatively is structural breaks related to policy changes or natural calamities. In Botswana there hasn't been any significant policy change which may have affected the beef market, probably with the envisaged liberalization of the export market, there would be need in future to consider policy changes. With regard to natural disasters or calamities, the most common one is drought, but since it results from low rainfall, and rainfall has been included in the model it would not be considered. The export price variable has been excluded from the model because BMC is the sole exporter of beef and beef products, so it has no direct influence on farmers' production decisions. Again the export price signal is indirectly reflected in the domestic price.

3.4 Deflating nominal prices

The first step was to remove the effect of price fluctuations by deflating nominal producer prices of beef into real values. The consumer price index was used as it is believed farmers are affected by input prices in raising their livestock. The deflated prices are shown in the table below, and the following simple formula was used to deflate nominal data series to real values:

$$\frac{\text{Nominal Value}}{\text{Price Index (Decimal Form)}} = \text{Real Value}$$

Where; Nominal value refers to the value of an economic variable in terms of the price level at the time of measurement (unadjusted for price movements). Real value on the other hand refers to the value of economic variables adjusted for price movements. Price index is a measure of price movement i.e. inflation (or deflation). It could be in the form of Consumer Price Index (CPI), Producer Price Index (PPI). Personal Consumption Expenditure index (PCE) or the Gross Domestic Product (GDP) deflator.

Table 3.2: Deflated beef prices with 1995 as base year

Year	Nominal Beef Prices(P/Kg)	Consumer Price Index(CPI)	Price index (1995 as base year)	Deflator	Real Beef Prices(P/Kg)
1993	3.52	114.4	84	0.84	4.17
1994	4.2	125	92	0.92	4.55
1995	4.62	135.5	100	1	4.62
1996	4.54	145.6	107	1.07	4.23
1997	4.75	154.5	114	1.14	4.17
1998	5.68	161	119	1.19	4.78
1999	5.79	168.8	125	1.25	4.65
2000	5.91	177.3	131	1.31	4.52
2001	6.04	183.9	136	1.36	4.45
2002	6.55	191.9	142	1.42	4.62
2003	6.97	201.1	148	1.48	4.7
2004	6.94	208.1	154	1.54	4.52
2005	6.95	216.7	160	1.6	4.35
Mean	5.57	167.98	124	1.24	4.49

Data source: Nominal Beef Prices; BMC (1994;2006). CPI: MoFDP (2010).

While nominal figures show increasing producer prices over the years, real prices depict otherwise. Nominal prices have increased by P3.45 between 1993 and 2003, whereas in real values the difference between the lowest and the highest value is a paltry P0.61. In real terms prices have been fluctuating around P4.49, in effect there has not been any significant increase in producer prices. This sluggish price increase has been singled out as the main cause of the decline in beef cattle supply, especially to the Botswana Meat Commission, which exacerbated the supply deficit to the European Union. Unless the government of Botswana intervenes in this pricing calamity, the beef

industry is likely to close shop, as production costs will soon exceed returns. The price increases are illustrated in Figure 3.6 below;
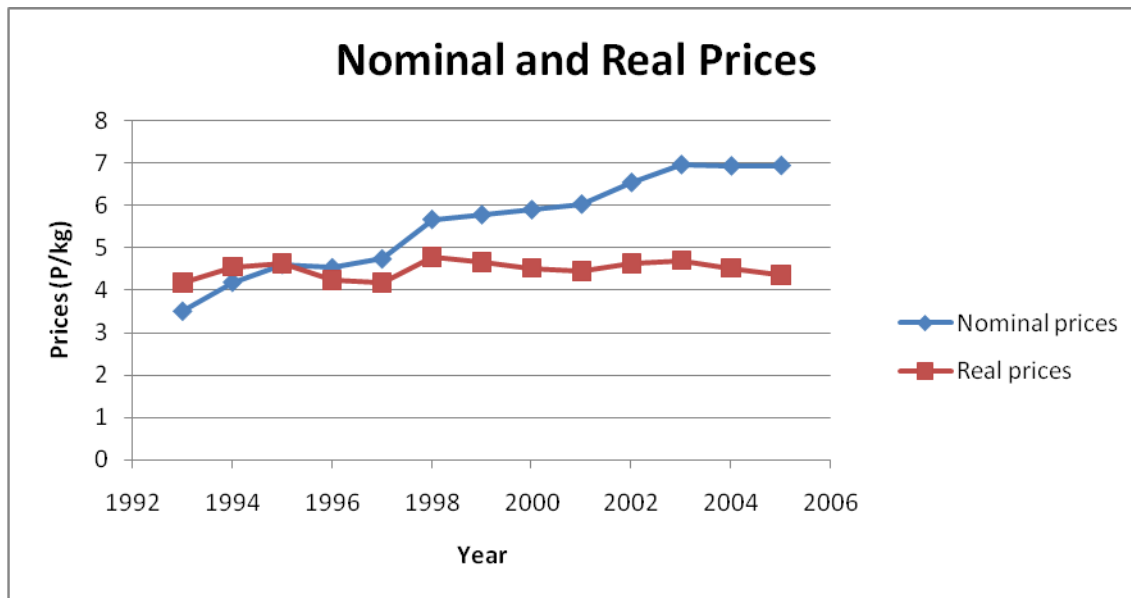
Figure 3.6: Nominal Beef Prices Against Real Prices

Data source: BMC (2010).

3.5 Testing for unit root nonstationarity

A time series variable is stationary if it does not have an upward or downward trend over time. Economists normally focus on one type of nonstationarity, that is, the unit root nonstationarity (Koop, 2009). Where $Y_t = \alpha + \Phi Y_{t-1} + e_t$. If $\Phi = 1$ then Y has a unit root and it is nostationary. If $|\Phi| < 1$ then Y is stationary. If Y has a unit root the value of Φ will not decrease as the lag length increases, and will also have a long memory, as a result will exhibit a trend, especially if α is nonzero (Koop, 2009). Koop (2009) also states that if Y has a unit root, then ΔY will be stationary, hence a series with unit root are often referred to as differenced stationary series. If $\alpha = 0$ and $\Phi = 1$ the new value of Y differs from the preceding value by the error term, and in this case Y is called random walk because the values of Y over time will consist of random changes, since the error term is random (Halcoussis,2005; Koop, 2009). If Y is non stationary it does not move back and forth around a constant mean, it drifts away over time. For Y to be stationary

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the value of Φ must lie between -1 and 1 (Halcoussis, 2009). The most common unit root test is the Dickey-Fuller test, which was developed by statisticians Dickey and Fuller.

3.5.1 The Dickey- Fuller test

It assumes the form $Y_t - Y_{t-1} = B_0 + B_1 Y_{t-1} + e_t$. The dependent variable is the difference between the current and the preceding values of Y and the explanatory variable is Y lagged one period. After running the above regression one tests for the null hypothesis of the form $H_0: B_1 \geq 0$ versus the alternative hypothesis of $H_1: B_1 < 0$. This is a one sided test. If B_1 is equal or greater than zero then Y is nonstationary and H_o is accepted. If the Dickey-Fuller test rejects the null hypothesis, then we can assume that Y is stationary (Halcoussis, 2005). The critical value for the Dickey-Fuller test at 1% error level is -3.75 whereas the calculated (t-statistic) value is -3.975 which is greater in absolute terms. The null hypothesis $H_0: B_1 \geq 0$ is rejected. Then we can now assume that Y is stationary. We are 99% (using the t-statistics) confident that B_1 is not equal or greater than zero. See equation 6 below;

$$\Delta Y = 2.578 - 1.259 Y_{t-1} + e_t \qquad (6)$$

$$(0.675)^a \ (0.317)^a$$

$$[3.818]^b \ [-3.975]^b$$

$$R^2 = 0.574$$

F- Statistic = 15.797

This test is equivalent to testing for the hypothesis $H_o: \Phi = 1$ against the alternative hypothesis $H_1: \Phi < 1$ in the autoregressive equation $Y_t = \alpha + \Phi Y_{t-1} + e_t$ in 3.5 above.

_____

[a]: figures in the parentheses are standard errors.

[b]: figures in brackets are the t-statistics.

The other alternative $\Phi > 1$ is not considered because that will make the model explosive, which is unlikely in economic time series (Ramanathan, 2002). So accepting alternative hypothesis H_1: $B_1 < 0$ is equivalent to accepting H_1: $\Phi < 1$ which signifies no evidence of unit root nonstationarity since $\Phi = B_1 - 1$.

3.6 Limitation of the study

Data in Botswana are sporadically kept, records are difficult to find, and statistics for various years are missing, perhaps because surveys were not conducted. The quality of the data kept is also suspect. So, lack of records has forced the researcher to reduce the sample size from the intended 20 years to 13 years.

CHAPTER 4: EMPIRICAL RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the results of the study. In order to evaluate the results of the regression analysis, both economic and econometric criteria were followed; Economic criteria mainly concerned the sign of the coefficients of the explanatory variables, i.e. whether they conform to economic theory or not. Econometric criteria on the other hand involved evaluating the statistical reliability of the coefficients using some statistical tests. When a regression analysis involves a small sample size, the most convenient way of checking the extent of reliability of the individual coefficients based on the standard error is the so-called t-statistic (Antonova and Zeller, 2007).The t-statistic greater than the critical t-value at 1% and 2% levels of significance will be considered highly significant, and 5% level significant and 10% fairly significant. The decision to reject a null hypothesis does not mean that the variable is somehow uninformative, but rather that the probability of making a type I error (rejecting the null of zero when we shouldn't) is slightly higher than we would otherwise like. Again the so-called insignificance is a statement about precision in estimation and not about causality. Significance is a statistical term that tells how sure we are that a difference or relationship exists (Walonick, 2010). So there is absolutely no reason to drop variables whose coefficients are somehow deemed insignificant. Other important criteria would be to investigate the presence of autocorrelation and multicollinearity.

4.2 Regression Analysis

Econometricians use regression analysis to make quantitative estimates of economic relationships. Regression analysis is a statistical technique that attempts to explain movements in one variable, the dependent variable, as a function of movements in a set of other variables, the independent or explanatory variables (Studenmund, 2006). The analysis helps to predict both the direction and magnitude of change in the dependent variable that is due to change in the independent variable(s). The computer package SPSS, was used to estimate the coefficients of the model by the ordinary least squares method. The linear regression function was used for analysis and interpretation of

results. Several combinations of the independent variables were tried and the best results are presented in Table 4.1.

Table 4.1: Regression results with deflated prices

Variable	Coefficient	Std. Error (SE)	t-statistic	VIF	Sig.
Constant	-0.157	2.2	-0.071		0.946
Price	1.511***	0.429	3.519	1.523	0.017
Lagged rainfall (Lr)	-0.288***	0.089	-3.227	2.471	0.023
Lagged time (Lt)	0.295***	0.092	3.198	26.197	0.024
Lagged chicken output (Lc)	-0.053***	0.016	-3.378	23.557	0.02
Lagged Inventory (Li)	-0.955**	0.355	-2.689	3.03	0.043
Lagged sales (Ls)	-0.857****	0.192	-4.457	1.54	0.007

Dependent variable: cattle sold for slaughter

****, ***, **: Significance at 1%, 2% and 5% respectively.

F-statistic = 6.603

Adjusted R- Squared: = 0.753

Durbin-Watson statistic: = 2.577

Durbin- h statistic: = - 1.021

4.2.1 Coefficients

In simple or multiple linear regression, the size of the coefficient for each independent variable gives us the size of the effect that variable is having on the dependent variable, and the sign on the coefficient (positive or negative) gives us the direction of the effect. In regression with a single independent variable, the coefficient tells us how much the dependent variable is expected to increase (if the coefficient is positive) or decrease (if the coefficient is negative) when that independent variable increases by one unit. In a regression with multiple independent variables, the coefficient tells us how much the dependent variable is expected to increase or decrease when that independent variable

increases by one, holding all the other independent variables constant (Princeton University, 2007).

4.3 The F-statistic

The p-value for the F-statistic in our regression is 0.028 or (P0,03), so we are 97% confident that at least one of the slopes is significantly different from zero. The null hypothesis that says all the slopes are equal to zero is rejected.

4.4 The R^2

The coefficient of determination (adj. R^2) measures the goodness of fit of the regression line, or how best the model fits the data. The adjusted R^2 measures the portion of the movement in the dependent variable that can be explained by the regression model, thus the larger the R^2 the better the model fits the data (Halcoussis, 2005; Koop, 2009). If the R^2 is close to 1, then the regression explains most of the movement in the dependent variable. Our regression results give an adjusted R^2 of 0.753. This means that 75% of the dependent variable (number of cattle sold) can be predicted based on the changes in the values of the explanatory variables.

4.5 Autocorrelation test

The Durbin-Watson test is used to test for first order autocorrelation. The first order correlation assumes that the current value of the error term is a function of the previous value of the error term, that is, $\epsilon_t = \dot{\rho}\epsilon_{t-1} + u_t$. When the parameter ($\dot{\rho}$) of the first order correlation case is zero (reflecting no autocorrelation), the d-statistic is approximately 2.0. The further away the d-statistic is from 2.0, the less confident one can be that there is no autocorrelation (Kennedy, 2008). The magnitude of the parameter ($\dot{\rho}$) indicates the strength of the serial correlation in an equation. If $\dot{\rho}$ is equal to zero then there is no autocorrelation because $\epsilon = u$, a classical error term. As $\dot{\rho}$ approaches 1 in absolute value, the value of the previous error term becomes important in determining the current

value of the error term, and a high degree of autocorrelation exists (Studenmund, 2006). It is unreasonable for $\dot{\rho}$ to be greater than 1 in absolute value because it implies that the error term has a tendency to continually increase or explode over time. The sign of the parameter $\dot{\rho}$ indicates the nature of serial correlation; a positive sign indicates positive serial correlation whereas a negative sign indicates negative serial correlation. The Durbin-Watson test is biased towards not finding autocorrelated errors whenever a lagged dependent variable appears as one of the regressors (Belete, 1995; Halcoussis, 2005; Kennedy, 2008). Since in this particular model the lagged dependent variable is used as a regressor, the Durbin-Watson statistic is likely to be biased, instead the Durbin-h statistic has been used to try and avert this problem. The Durbin h-statistic tests for first order autocorrelation in models with a lagged dependent variable as an explanatory variable. The formula for the Durbin h-statistic relies in part on the original Durbin-Watson statistic and it is as follows:

$$h = (1 - D.W/2) \sqrt{n/1 - n[SE(\lambda)]^2}. \qquad (7)$$

Where D.W is the original Durbin-Watson statistic from the regression results, n is the sample size and SE (λ) is the standard error of the estimate of λ. The symbol λ represent the coefficient of the lagged dependent variable. The decision rule for a two sided test at 5% error level is; if the Durbin h-statistic is greater than 1.96, reject the null hypothesis of no autocorrelation. There is evidence of autocorrelation. If the Durbin h-statistic is equal or less than 1.96, do not reject the null hypothesis of no autocorrelation; assume that autocorrelation is a problem (Halcoussis, 2005). According to Halcoussis (2005), if the Durbin-Watson statistic is 2, the Durbin h-statistic is zero and test indicate no evidence of autocorrelation. The closer to 2 the Durbin-Watson statistic is, the less likely we are to reject the null hypothesis of no autocorrelation, keeping the other parts of the h-statistic the same. In our model;

$$h = (1 - 2.577/2) \sqrt{13/1 - 13(0.192)^2} = -1.021. \quad (8)$$

The Durbin h-statistic is less than 1.96. Thus; the null hypothesis of no autocorrelation is accepted. This means there is no evidence of serious autocorrelation in the residuals. If

we use the t-statistic to test for the hypothesis H_o: $\dot{\rho} = 0$ against the alternative H_1: $\dot{\rho} < 1$, still we are obliged to accept the null hypothesis of no autocorrelation since the critical value at 5% error level for a one- tailed test is 1.943, which is greater than the calculated value of -1.021 that is, in absolute terms.

4.6 Multicollinearity test

To investigate multicollinearity the Variance Inflation Factor (VIF) was used .Variance Inflation Factor is a measure of multicollinearity based upon regressing one of the independent variables on all of the remaining independent variables (Halcoussis, 2005). It is believed that a VIF greater than 4 indicates a serious multicollinearity problem. One point to note is that if the R^2 from regressing one independent variable on other independent variables is greater than 0.75 the VIF will be greater than 4. From the results it could be seen that there is an element of multicollinearity between time trend; VIF = 26.197, and Chicken output; VIF =23.557. This result perhaps suggests that chicken output is influenced by time trend. The result is not surprising because from the data it is evident that chicken output has been growing over time. The remedies of multicollinearity include the following: 1) Leave the model alone, 2) eliminate an independent variable, 3) redesign the model and 4) increase the sample size. According to Halcoussis (2005), if the t-statistics are high enough so that the coefficients are still statistically significant, this could be a signal that multicollinearity is not a serious problem and it is best to leave the model alone. Chicken output and time trend are both significant at 2% error level, so there is no need to temper with them.

4.7 Standard error of estimates

The estimated standard error SE (B) measures whether the different slope estimates vary a little or a lot. A larger standard error means the slope estimate moves around a lot and a small SE means the slope estimate moves less (Halcoussis, 2005). We can have more confidence in the slope when the standard error is small. The standard error of the estimate for regression measures the amount of variability in the points around

the regression line. It is the standard deviation of the data points as they are distributed around the regression line. The standard error of the estimate can be used to develop confidence intervals around a prediction (Walonick, 2010). From the results of our regression the standard errors are quite small (except for the constant), therefore we can be confident that the values of our slopes are stable and would not change a lot when the regression is performed repeatedly.

4.8 The t- test

The t-test is the most common test used in econometrics. This test helps us asses the chances of a slope's true value being zero (Halcoussis, 2005). The t- test allows us to conduct a separate hypothesis test on each slope estimate (including the intercept). A one sided or two sided test may be used. The t-statistic is the slope divided by the standard error of estimates. Therefore the further away the slope (B) is from zero the higher the t-statistic, and the likelihood of rejecting the null hypothesis ($H_{o:}$ B = 0). Likewise the smaller the standard error of estimates, the larger the t-statistic, and the more likely the null hypothesis will be rejected. The absolute value of the t-statistic is what is important. A t-statistic far from zero in either the negative or positive direction increases the chance of the null hypothesis being rejected. Critical values and decision rules help to decide whether the null hypothesis should be rejected or not. The critical value which marks the beginning of the rejection region is found in a t- table. To get the critical value one needs to choose the level of significance say 5%, and the degrees of freedom obtained by n-k-1.The decision rule on the other hand tells us to reject the null hypothesis if the actual t-statistic from the regression results is further from zero than the critical value (Halcoussis, 2005).

In our model the degrees of freedom is 6 and critical value at 1% error level is 3.707, at 2% error level it is 3.143 and at 5% error level the critical value is 2.447. From our regression results; lagged cattle sales is significant at 1% level of significance. Current price, lagged chicken output, lagged rainfall and time trend are all significant at 2% level of significance. Lagged cattle population (inventory) on the other hand is significant at 5% error level. This means that we are 99% confident that the slope of lagged cattle

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sales is further from zero, 98% confident that the slopes of current price, lagged chicken output, lagged rainfall and time trend are further from zero and 95% confident that the slope of lagged cattle population is further from zero. In short we are now confident that all the independent variables included in the model are significant predictors of cattle supply, at most 5% error level. The critical values used above are for a two sided t-test. According to Halcoussis (2005), in a two sided test, the null hypothesis is rejected if the true value of B (slope) is significantly different from zero on either side, negative or positive.

4.9 The partial adjustment model

$S_t = -1.157 - 0.857S_{t-1} + 1.511Pb - 0.053C_{t-1} - 0.288R_{t-1} + 0.295TE_{t-1} - 0.955I_{t-1}$ (9)

   (2.200) (0.192)   (0.429)   (0.016)   (0.089)   (0.092)   (0.355)

   Adjusted R^2 = 0.75

From equation (9) it can be said that farmers in Botswana take into consideration current price as opposed to previous year (t-1) price when making marketing decisions. This scenario is contrary to available economic theory, Cobweb models stipulate that expectations are based on lagged prices by only one time period. The Nerlove's adaptive expectation model on the other hand suggests that in agricultural markets, expected prices are based on a weighted sum of past prices, in which weights decline as one goes back in time. This perhaps suggests that only information from past prices is taken into account when making production decisions. Some economic commentators argue that price in the previous period(s) affects the decision to increase or decrease inventory whereas current price directly influence cattle supply. Price lagged by one period, when included in our model gives a very weird result.

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*Values in the parenthesis are standard errors.

The coefficient of lagged price is neither significant nor economically plausible as it gives a negative sign. The law of supply tells us that supply will increase when own price increases, but the negative coefficient of lagged price seems to suggest otherwise. Even the explanatory power (adjusted R^2) of the model is drastically reduced. The unexpected result probably suggests that, rearing cattle in Botswana is rather a cultural activity than a business activity, farmers do not necessarily plan to sell, they sell only when conditions are good, and therefore they have nothing to do with price in the period t-1. The positive relationship between current prices and the number of cattle sold is an economically acceptable response. It is economically expected that supply would increase as prices increase. The result from the regression indicates that in the short run, a unit change in current prices would lead to a 1.5 unit increase in cattle supply. This result shows that farmers in Botswana would sell more cattle when producer prices are increased. The magnitude of the short run elasticity shows that farmers are highly responsive to changes in prices. This positive short run elasticity is in line with what was found by Ndzinge, *et al* (1984) and Rodriguez (1985) and contrary to BIDPA (2006). Quite strangely when the cattle population increases the number of cattle sold seems to decline. A 1% increase in cattle population would lead to a 0.96% decline in the number of cattle sold. When rounded to one decimal place the coefficient of cattle population would give us a unitary relationship, that is, a 1% increase in cattle population would result in a 1% decrease in the number of cattle sold. This could be due to the fact that traditional farmers in Botswana view cattle as a store of wealth rather than a commercial activity. They derive more satisfaction from the cattle numbers than the money they make from them. Cattle numbers in rural communities are a source of social prestige i.e the more cattle one has the more he is respected by the society, and the less likely he will be willing to sell.

When rainfall increases by 10% the number of cattle sold decrease by 2.9% and vice versa, this negative relationship between rainfall and the number of cattle sold was unexpected. This is because high levels of precipitation are known to improve cattle conditions as both grazing and water would be in abundance, thus increasing chances of fetching better prices. But in Botswana this result is not surprising at all; here we are dealing with subsistence farmers who subsist on both crops and animals. More rainfall

means improved harvest to the farmer and reduced requirements for money. Cattle are usually sold to meet monetary requirements such as food, but when food is plenty there is no need to sell more cattle. Again when cattle are in good conditions they fetch better prices, to a subsistence farmer this means fewer cattle will be sold to meet monetary requirements. The negative relationship between rainfall and cattle sales reflects that farmers would sell more cattle during the period of low rainfall; this is quite intuitive because Botswana is a semi arid country with erratic rainfall, resulting in sporadic droughts. So, during the times of low rainfall farmers would sell more cattle to avoid huge losses during the drought period. This trend was confirmed by BMC (2007) when it observed that good rains sometimes have an inverse relationship with supply and that drought affected cattle sales positively as farmers would off-load their cattle to escape drought. Lastly crop harvest is very poor when rainfall is poor and the monetary requirements are high.

The time variable which was used as proxy for technology showed a positive relationship with the number of cattle sold. This was expected because technological advancement is expected to increase both production level and efficiency. From the regression results a 10% increase in technology would lead to a 3% increase in the number of cattle sold. The magnitude of the response is however, not satisfactory, as it seems to suggest that technology does not have much influence on cattle supply. This small coefficient of time trend could be attributed to the fact that, here we are dealing with small scale farmers who use mostly traditional technology such as communal grazing, natural breeding and indigenous breeds. The low parameter of time may perhaps suggest that the available technology is not fully utilized; the adoption rate of new technology may be so low to the extent that it does not have much impact on cattle supply. This could be due to the fact that the Botswana beef farmers who are predominantly traditional are somewhat conservative and as such are resisting change. The other reason could be that the available technology is not suited to the subsistence farmers, probably in terms of complexity and affordability. It should also be noted that technology comes at a cost, and not many farmers would be ready to invest their meagre resources in new technology. The other argument may be that the extension service might not be having enough capacity (in terms of resources) to ensure effective

technological transfer, especially that most of the farmers are deep in the rural areas. This scenario calls for the government to assess the available technology to check if it suits the traditional farmers in terms of complexity and affordability. The government also needs to strengthen its extension services (perhaps the farmers are just sceptical and resisting change, so they need to be educated on the new technology).

There is a negative relationship between previous and present year supply, when the previous year supply or sales increase by 10% current year supply declines by 8.6%. This behaviour could also be attributed to the subsistence nature of traditional farmers. If they sold more cattle the previous year, they are likely to need less money this year to meet their basic needs. BMC (2007) postulates that the negative relationship between current and previous year supply is due to the fact that farmers take some time to re-build their herds following high off-take rate the previous year.

The last variable is lagged chicken output, which is the main competitor of beef. The negative relationship between chicken output and cattle supply is quite normal, as we expect demand for beef to go down when chicken prices decline, since chicken is a perfect substitute for beef. A 10% increase in chicken output led to a 0.5% decrease in the number of cattle sold. The small coefficient for chicken output perhaps suggests that, although domestic demand for beef would decline, the export market would still be available to absorb the shock. When the supply of the competing commodity (chicken) is increased, (either by increasing the number of sellers or by increasing the quantity produced by the present sellers) this will cause a right ward shift of the supply curve, thereby creating a temporary surplus, which will in turn exert a downward pressure on price. The resultant price will eliminate the surplus and increase the equilibrium quantity. Therefore increasing chicken output would signify reducing chicken prices.

The coefficient of adjustment; that is, the speed at which farmers adjust from the previous output (supply) to the desired equilibrium, is 0.143. An estimate of the adjustment parameter (δ) can be obtained by taking one minus the estimated coefficient on the lagged dependent variable 1-(1- δ) (Hallam, 1990). In our case the adjustment parameter (δ) 0.143, has been obtained by subtracting the absolute value of (1- δ) or 0.857 from 1. According to Hallam (1990), a coefficient of adjustment close to zero

implies a slow adjustment to changes in exogenous variables. Therefore the adjustment coefficient of this magnitude implies that beef farmers in Botswana adjust slowly to changes in both economic and technical factors. This means that farmers eliminate about 14% of the difference between the previous and the desired supply in one period, in this case a year. This low adjustment coefficient perhaps tells us that when producer price increases farmers cannot immediately switch from other sectors of the economy to cattle farming; perhaps because unlike manufacturing the time lag between the decision to produce and marketing is quite long, so this may discourage more farmers from venturing into the beef business.

Cattle farming is an expensive and difficult undertaking, and requires extensive experience, so switching from other agricultural sectors such as poultry farming and crop production may not be very easy. And again when compared to other agricultural enterprises the time lag involved in beef production is quite extensive. According to Jefferis (2005), Botswana beef cattle subsector is based on an oxen production system, as opposed to the more modern weaner production system, and this contributes significantly to this slow rate of adjustment. The latter has higher productivity as well as reduced costs and environmental damage. The fact that it takes a lot of resources (both financial and otherwise) to raise cattle to market weight, may also cause us to believe that the subsistence farmers run out of capacity to adjust production accordingly. The biological nature of cattle also dictates that not all that are willing to adjust to the new equilibrium will achieve it immediately. High mortality rate and low calving percentage that characterise the traditional sector would always ensure slow adjustment to the new equilibrium level. Frequent outbreaks of diseases such as foot and mouth makes venturing into cattle farming a risky endeavour and makes it difficult for farmers to immediately switch to the business when economic environment improves. Also there might as well be some institutional and technological challenges encountered by the farmers in the production of their livestock. Lack of financial muscle by traditional farmers, means that they cannot acquire the necessary inputs to adjust production at the right time. This is compounded by the fact that subsistence farmers in Botswana normally find it very difficult to access credit to enhance their production. Until recently much has not been done by financial institutions (commercial banks) and the

government to assist farmers with funds to improve their production. The only remedy to this problem is to improve access to credit by small farmers, perhaps by setting up an agricultural bank or making arrangements with the existing commercial banks.

Low level of technology combined with low adoption rate by the farmers might be the main culprits in this low coefficient of adjustment. Farmers in Botswana mostly use traditional technology, where cattle graze on communal areas and have to travel long distances to get both food and water, this would normally result in poor productivity of the beef animals. The natural pastures in the semi-arid Botswana are known to be deficient in some nutrients which could promote rapid growth and above all the pastures are normally overstocked leading to overgrazing and poor conditions of the animals. A good example is phosphorus deficiency which normally results in cattle suffering from a condition known as aphosphorosis. To improve the productivity of the rangelands the Botswana Government will have to seriously consider restructuring the traditional system in view of doing away with communal grazing. Traditional farmers mainly raise the indigenous Tswana breed which is known for its poor traits such as poor growth rate and low level fertility. So if farmers are to improve the speed of adjustment, they will have to improve their breeding stock so as to enhance the aforementioned traits.

Psychological inertia is one other factor that could have contributed to this low speed of adjustment. Cattle production is a risky undertaking and farmers are risk averters by nature, so, many of them are likely to be reluctant to immediately respond to changes in both economic and technical environment, especially in a country where there are no institutions offering agricultural insurance. Recurrent drought and frequent diseases outbreaks have made the situation even worse. Perhaps the government will have to find a way of proving security to cattle farmers, to minimize the risk involved. Lastly one may also suspect that since famers respond negatively to increases in some of the factors there might as well be some interactive effect resulting in the slow adjustment.

4.10 Supply Elasticities

Elasticity is the measurement of the percentage change in one variable that results from a 1% change in another variable. Elasticities allow economists to quantify the differences among markets without standardizing the units of measurement. When an elasticity is small (between 0 and 1 in absolute value), we call the relationship that it describes inelastic, and when it is large (greater than 1 in absolute value), we call the relationship that it describes elastic. Unit (or unitary) elastic on the other hand is when elasticity is equal to 1. Price elasticity of supply tells us how sensitive is the quantity supplied to a change in the price of the good. Inelastic supply means that the quantity supplied is not very sensitive to price variations (Abowd, 1998).

Short run supply elasticities were given by the estimated coefficient $\delta\beta$ on the explanatory variables, whereas long run elasticities, β^s were obtained by dividing the short run elasticities $\delta\beta$ by δ (Hallam, 1990; Pindyck and Rubinfed, 1998). Elasticities for the variables were as follows;

Table 4.2: Supply Elasticities

Variable	Short run elasticities	Long run elasticities
Price	1.511	10.57
Chicken Output	-0.053	-0.37
Rainfall	-0.288	-0.201
Time	0.295	2.06
Inventory	-0.955	-6.68
Lagged Sales	-0.857	-5.99

Source: own presentation.

Based on the analysis of the elasticities, price elasticity of supply in the short run is very high at 1.511 and this means that a 1% increase in the producer price of beef would lead to a 1.5% increase in cattle supply, that is, when other independent variables are held constant at their sample mean. Since the value of the coefficient of elasticity is greater than unity, it could be said that in the short run beef cattle supply is highly elastic to variations in producer prices. The long-run price elasticity is even greater at 10.57.

This implies that, in the long run when most or all of the factors that influence supply have changed, the beef farmers in Botswana are even more responsive to producer prices. This elastic response to price shocks is contrary to what Muchampondwa (2008) found in Zimbabwe, and what BIDPA (2006) found in Botswana. In Botswana cattle supply seems to be insensitive to variations in the following factors; rainfall, chicken output, time, cattle population and lagged cattle sales, in the short run, and sensitive to all factors except chicken in the long run, as elasticities are now greater than unity. The elastic long run responses to variations in these factors is however, not surprising as in the long run famers have more time to work on these changes including increasing their productive capacity.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter focuses on the summary, conclusions and recommendations all based on the findings of this study.

5.1 Summary

This study was aimed at examining the supply response of beef farmers in Botswana to various economic and non economic factors. The study used historical time series data from livestock sector in the Republic of Botswana. The data were obtained from a number of government departments in the country. Due to unavailability of records a small sample size (of thirteen observations) was used in the study. It is perhaps important to note that the small sample size together with poor quality of the time series data could somehow dent the reliability of the results of the study.

The method used in the empirical analysis of this work is the partial adjustment model developed by Nerlove (1956). The model postulates that supply adjust by some constant fraction of the difference between the previous and the desired supply.

The findings of the study indicate that indeed farmers in Botswana do respond to variations in both economic and non-economic factors. The findings revealed that farmers respond positively to price incentives and time trend but negatively to shocks in other variables.

5.2 Conclusion

The primary objective of this study was to determine whether beef farmers in Botswana do respond to price incentives. Indeed they do. The elasticity coefficient of price indicates that a unit increase in price will result in more than a unit increase in cattle sales. This result perhaps implies that cattle supply in Botswana is elastic to variations in cattle producer prices. This is a good observation since we can now recommend price increase as a way of improving beef cattle supply since farmers respond positively to price changes, more so that the response is elastic. On the other hand elasticity estimates of chicken output, rainfall, cattle inventory, time trend and lagged sales were

found to be less than unitary, an indication that cattle supply is inelastic to these factors. In the long run cattle supply is elastic to all the factors except chicken output.

From this empirical analysis, it is evident that Botswana farmers take into account all variables included in the model when deciding on the sale of their cattle. One other important point to note is that all of the variables except beef price and time trend are inversely correlated with cattle sales. This simply implies that when the variables increase cattle sales decrease. It is also worth noting that although farmers would respond positively to price increase, they can only cover 14% of the desired level of output or supply in a year. This means that, they would take approximately seven years to reach the new equilibrium (which is also shifting as time passes by). This slow rate of adjustment could be attributed to the fact that farmers do not make use of modern technology such as artificial feeds and improved breeds with fast growth rates.

Based on the results of this study we can now reject both hypothesis 1 and 2, and conclude that indeed Botswana beef farmers are responsive to both economic and non-economic factors. Although in the short run the response is only elastic to price shocks and inelastic to changes in all other factors.

5.3 Recommendations

The recommendations discussed below are based on the findings of the study.

The results revealed that price elasticity of supply is more than unitary and that the estimated coefficient of price is positive, therefore price increase can be recommended as a strategy for enhancing cattle supply.

The results also revealed that farmers respond negatively to rainfall, increased cattle numbers, previous year supply and chicken output. This could be due to the fact that farmers in Botswana view cattle rearing more as an investment activity than a commercial activity; they just sell to meet their basic needs. The only remedy to this problem could be educating the farmers to change their mindset towards commercialising beef farming; of course it will have to be supplemented with skills provision.

The study showed that farmers in Botswana respond positively to technological advancement although the response is inelastic. This perhaps tells us that the available new technology is not suitable to the extent that farmers do not fully utilize it, perhaps because it is either too complex or too expensive, or both. It is therefore recommended that studies be conducted to determine the suitability of the technology, in terms of affordability, complexity and magnitude. The extension services could also be strengthened to improve the rate of technology transfer. Farmers need to be educated on modern farming systems such as controlled grazing, weaner production, artificial insemination and the use of high performance breeds.

The results also depicted a very slow rate of adjustment which could be attributed to shortage of resources, especially funds, and poor technology. These problems may be addressed by improving supporting institutions such as setting up an agricultural bank so that farmers could have access to subsidized credit. Insurance institutions should also consider including cattle production as this will reduce the risk involved and encourage those who are risk averters to act.

Finally, because data in Botswana are sporadically kept and are difficult to find, the estimates were made from a very small sample, so they could be unreliable, it is recommended therefore that the government of Botswana should strengthen its record keeping in the farming sector to enable researchers to have access to adequate and reliable data.

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