A QUANTITATIVE ANALYSIS OF SUPPLY RESPONSE IN THE NAMIBIAN MUTTON INDUSTRY

by

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Science in the Faculty of Engineering at Stellenbosch University

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March 2011

Declaration

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Abstract

In terms of its contribution to the agricultural economic activity in Namibia, the small stock industry is the most important sector, second only to the beef industry. This sector makes a significant contribution to the agricultural business in Namibia due to the sector's exports, its provision of employment, use of natural resources, contribution to GDP and to consumer spending as well as food security. Agricultural activities in Namibia contributed 5.5 percent to Namibia's GDP, while 70 percent of the population relies on agriculture for employment and day-to-day living.

Livestock farming in Namibia is free ranging on natural pastures and therefore produces high-quality meat that is in high demand in both the national and international markets. Small stock production in Namibia is unstable due to the high variability of weather patterns, changes in economic and social environments, unpredictable droughts as well as political and structural changes. Due to the decline in mutton production over the last years, research in the supply economics of the mutton industry in Namibia is important.

The purpose of this study is to investigate the relationships between the various price and non-price factors contributing to the supply dynamics within the mutton industry in Namibia. Two hypotheses are tested with the aid of econometric modelling techniques on monthly time series data. The Autoregressive Distributed Lag approach to co-integration was used to determine the long-run and short-run supply response elasticities towards economic and climatology factors.

Results showed a significant long-run relationship between the average Namibian mutton producer price and mutton supply. Results revealed that a one percent increase in the mutton producer price leads to a 1.97 percent increase in mutton supply. Beef producer price, a substitute product to mutton, showed a significant negative long-run effect towards mutton production whereas rainfall showed a meaningful positive long-run contribution to mutton supply. These supply shifters towards mutton production also showed significant short-run elasticities. Results further revealed that the system takes nearly two months to recover to the long-run supply equilibrium, should any disturbances occur within the supply system.

The study showed that price-related and climatological factors play a major role in the Namibian mutton production industry. Industry stakeholders and policy makers should therefore incorporate these significant relationships between supply shifters and production output into future decisions and marketing policies to secure a healthy, growing and sustainable mutton industry in Namibia.

Opsomming

In terme van bydrae tot die landboubedryf in Namibië is die kleinveebedryf die tweede belangrikste sektor, net kleiner as die land se grootveebedryf. Die sektor maak 'n betekenisvolle bydrae tot die landboubedryf in Namibië deur middel van werkskepping, die gebruik van natuurlike hulpbronne, bydrae tot Bruto Binnelandse Produk, uitvoere, verbruikersbesteding sowel as voedselsekerheid. Landbou-aktiwiteite dra by tot 5,5 persent van die Bruto Binnelandse Produk van 'n land waar meer as 70 persent van die bevolking afhanklik is van landbou om 'n bestaan te kan maak.

Veeboerdery in Namibië geskied ekstensief op natuurlike veld wat lei tot die produksie van 'n hoë kwaliteit produk, wat hoog in aanvraag is in plaaslike en internasionale markte. Kleinvee produksie in Namibië is onstabiel as gevolg van fluktuasies in weerpatrone, veranderings in ekonomiese en sosiale omgewings, onvoorspelbare droogtes asook politieke- en struktuurveranderinge. As gevolg van die huidige afname in skaapvleis produksie is navorsing in die aanbodkantekonomie van die skaapvleisbedryf belangrik in Namibië.

Die doel van hierdie studie is om die verwantskap te ondersoek tussen verskeie prys en nie-prys faktore wat bydra tot die aanboddinamika van die skaapvleisbedryf. Twee hipoteses word getoets met behulp van ekonometriese modelleringstegnieke op maandelikse tydreeksdata. 'n Outoregressiewe verspreide sloeringbenadering tot ko-integrasie is gebruik om die langtermyn en korttermyn elastisiteite tussen ekonomiese en klimaatsfaktore vir die aanbod van skaapvleis te bepaal.

Resultate dui op 'n betekenisvolle langtermyn verwantskap tussen die gemiddelde Namibiese produsente prys en skaapvleis produksie. Resultate wys daarop dat 'n een persent styging in skaapvleis produsente prys 'n 1,97 persent styging in skaapvleis aanbod het. Die beesvleis produsente prys, 'n substituut vir skaapvleis, het 'n beduidende negatiewe effek getoon oor die langtermyn op skaapvleis produksie. Reënval het 'n beduidende positiewe bydrae getoon ten opsigte van skaapvleis aanbod. Hierdie aanbodsfaktore het betekenisvolle korttermyn elastisiteite getoon. Resultate het ook getoon dat die stelsel twee maande neem om te herstel tot die langtermyn aanbodsewewig, sou daar enige drastiese veranderings in die stelsel plaasvind.

Die studie het getoon dat prysverwante en klimaatsfaktore 'n uiters prominente rol speel met betrekking tot skaapvleisproduksie in Namibië. Bedryfsaandeelhouers en politieke leiers sal hierdie betekenisvolle verwantskappe tussen produksie faktore en aanbod uitset in ag moet neem in toekomstige beplanning en bemarkingsbeleid om 'n gesonde, groeiende en volhoubare skaapvleisbedryf in Namibië te verseker.

Acknowledgements

I would like to take this opportunity to express my gratitude to the following individuals, who have contributed to this work either directly or indirectly:

- My Heavenly Father for the talents, energy and enthusiasm He has given me to participate in this study. Without His blessings, I could not have completed this study
- My parents and family for their love, encouragement and motivation during the course of this study
- My colleagues and friends for their support
- Mr Willem Boshoff for his guidance in Econometric Modelling
- Mr Willie Schutz of the Meat Board of Namibia for providing all the required data for this study and for his support
- My supervisor, Mr Nico Treurnicht, for his inputs, positive feedback, support and guidance throughout the duration of the project

"The future belongs to those who believe in the beauty of their dreams"

Eleanor Roosevelt

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Chapter One – Background and Introduction

1.1 Introduction

Agriculture in Namibia is one of the most important sectors and contributes to 5.5 percent of the Gross Domestic Product (GDP). Furthermore, approximately 70 percent of the country's population is directly or indirectly dependent on agriculture to sustain a living. Due to the harsh climate and landscape, agriculture is dominated by free ranging livestock production that produces high-quality meat for both national and international markets.

As a result of the contribution of livestock production to the country's economy, research and planning in this sector are of paramount importance for a healthy, sustainable industry. For effective planning, decision and policy makers need marketing research of supply and demand response functions and magnitudes of the behaviour of these functions towards changes in the supply and demand environment. This study will focus on the supply side of mutton production in Namibia with the aid of a supply response model that will be utilised for hypothesis testing of certain economic phenomena.

1.2 Background and Overview

Livestock in Namibia consists of cattle, sheep, goats and pigs, where cattle and sheep contribute the largest market share in terms of meat produced. As a result of various environmental effects, climatological variability and economical changes, mutton production in Namibia fluctuates. Figure 1.1 shows the total sheep marketed per annum in Namibia in the period 1992 to 2009. Stock numbers that vary from cycle to cycle suggest that many economic, biological and physical factors affect the total mutton output. Fluctuations in the trend are a growing concern for the industry and therefore supply (production) response analysis is important to develop a more comprehensive understanding of this phenomenon.

In 2003, the Small Stock Marketing Scheme was introduced in an effort to stimulate local value-adding activities within the small stock industry. However, the intended actions to promote local value-addition disturbed the existing marketing channels. Figure 1.1 shows the change since the introduction of the Small Stock Marketing Scheme in 2003, the decline in live exports and increase in local slaughtering. The initiation of the Small Stock Marketing Scheme also spawned various studies in the mutton industry due to changes in market forces that influence the behaviour of the entire value chain.

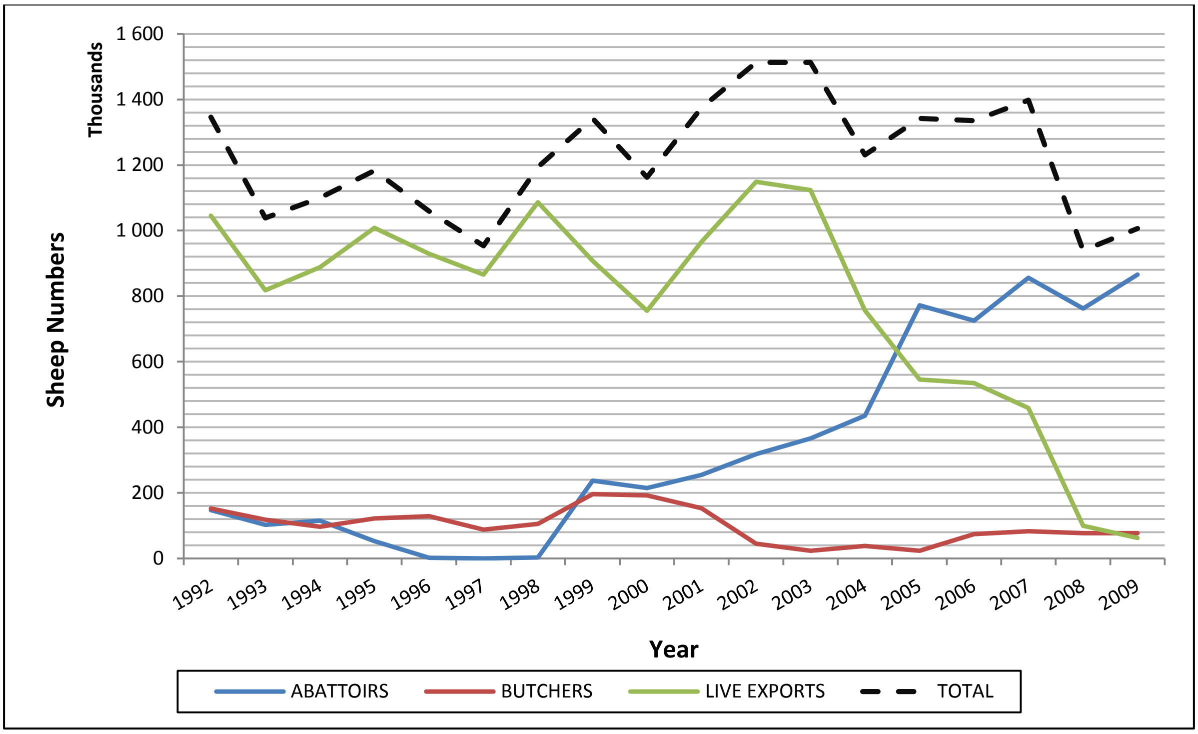

Figure 1.1: Total Sheep Marketed in Namibia 1992-2009

(Source: Meat Board of Namibia Statistics)

1.3 Research Problem and Objectives

The number of sheep marketed over the past decade displays a fluctuating, cyclic character. Various factors that contributed to these phenomena can be identified and the magnitude of their influence can be hypothesised. No research has been done on the relationship between mutton production and the factors that influence mutton production in Namibia. The purpose of this study is to contribute towards the understanding of the mutton supply industry and determine the magnitude of the supply shifters towards mutton supply.

The primary objective will be to develop a more comprehensive understanding of the mutton supply industry. The secondary objective is to determine to what extent these factors influence supply in the short-run and long-run.

Two hypotheses are tested in this study: Firstly, it is hypothesised that price-related factors play a major role in determining the supply of mutton in the industry. Secondly, it is hypothesised that climatological factors play a major role in determining the supply response in the mutton industry. These hypotheses are tested through functional relationships among statistical time series data.

1.4 Research Methodology

1.4.1 Research Classification and Reasoning

Supply response studies are aimed at developing a model that would represent the supply of a certain product or commodity. The design classification framework of the research study can be categorised in a four-dimensional framework (Mouton 2001).

Table 1.1: Research Design Classification Framework

Research Design Classification Framework	
Dimension 1	Empirical
Dimension 2	Secondary
Dimension 3	Numerical
Dimension 4	Medium Control

(Source: Mouton, 2001)

According to Mouton (2001), studies of this nature (see Table 1.1) fall into the secondary data analysis, modelling and simulation studies category. The supply response study will make use of a supply model analysing time series data, thus the specified research design framework of statistical modelling is applicable to this study. Research classification is important for the identification of advantages and limitations within each classification framework.

The classification framework for the supply response study is empirical in nature and utilises secondary (existing) numerical data. The research classification framework can further be categorised into a study using numerical data with medium control due to the use of industry recorded market time series data. The reasoning is of a more deductive nature because conclusions are drawn from hypothesis statements. Descriptive and predictive questions are answered from the hypothesis statements of this research.

1.4.2 Research Strategy

The research is done by applying existing industry data to economical supply theory. The main strength of this study is the ability to model large-scale economic phenomena by simplifying model inputs and outputs (Mouton 2001). The first step in the study is to understand supply economics for the specific industry through a literature study in order to obtain an appropriate presentable model that can be used for hypothesis analysis. Previous work carried out in the specific field will be of paramount importance from the moment the research is initiated right up to the completion of the study. Approaches to be followed for the supply study are also obtained from the literature review.

The information obtained for this study is obtained from:

1) Supply response studies done locally and in other countries on different commodities and products as well as studies on red meat supply
2) Statistical information and data obtained from governing bodies in the industry responsible for recording industry data
3) Recent industry publications and papers presented at conferences by industry experts
4) Interviews with industry experts

The second step in the research process will be to obtain reliable statistical data from the industry for the constructed model. The third step will entail the modelling of the supply function in order to generate results for hypothesis testing and validate the model through statistical specification analysis.

1.4.3 Data Collection and Analysis Method

Being a statistical research study, one of the core building blocks of this research is statistical data. Supply response studies can be differentiated from studies using cross-sectional data and studies using time series data; the latter are appropriate for this study. Time series data involve data of a specific variable, for example price, that is recorded at a certain frequency[1] over a specified time period. For accurate statistical analysis, the more data points used in the analysis, the more accurately results can be obtained (Boshoff 2010).

Due to the secondary nature of data required for this study, the data are obtained from statutory bodies in the meat industry in Namibia. The Meat Board in Namibia facilitates the marketing, processing and trade of livestock, meat and meat products, both nationally and internationally. This body is therefore a reliable source of secondary data for supply response analysis of the mutton industry. Non-meat industry-related data, such as climatological data, are obtained from the meteorological service in Namibia.

Supply response studies require various statistical tests and methods. Eviews 7.0, a statistical software package, () is used to compute the statistical tests and methods required by the chosen approach of analysis.

1.4.4 Restrictions of the Study

Supply economics is a complex phenomenon that is difficult to model correctly due to complexities and an abundance of variables that influence the system or industry. Limitations in data recording and availability restrict the model specification even more. The theoretical model for this research is restricted due to supply complexities and data constraints and may therefore display inadequacies in representing the supply of a product.

[1] Frequency refers to the number of observations within a specific time period, i.e. daily, monthly, quarterly, etc.

This study only focuses on the supply side of mutton produced in Namibia. The demand side of mutton supply is ignored, although it may have an effect on supply shifters[2] in the supply model. It is also assumed that there is a market (demand) for all the mutton produced (marketed) in Namibia, which eliminates the demand effect on supply.

1.5 Relevance of Study

The main reason for conducting research on supply response is to improve the understanding of the price mechanism and other non-price factors influencing supply. Knowledge of supply response assists farmers in their decision making regarding the allocation of resources towards business goals. It can support planners and policy makers to allocate resources and achieve production targets in long-term planning. Supply response equations can be used for forecasts based on current agricultural supply response parameters. Therefore, a thorough knowledge of the supply response of food commodities as well as implications of policies will be useful for the planning of food production against the background of a well balanced development strategy.

A research project on supply response analysis of the Namibian sheep industry will add value to the livestock industry in Namibia, because important relationships between the producers and other role players in the sheep value chain can be analysed. Stakeholders in the industry can take advantage of this analysis by incorporating these relationships into future decisions and policies. It can be concluded that in a developing country such as Namibia, research in the field of supply response on a specific food commodity is relevant to a secure, sustainable future of food supply.

1.6 Outline of Study

In the **introductory chapter,** a desktop overview of the research problem, research methodology, restrictions and relevance of the study were given. **Chapter two** is dedicated to an overview of the sheep and livestock industry in Namibia. Emphasis is placed on the value chain of the mutton production industry with the aim of providing a background on the production of mutton in Namibia for the construction of the supply model in Chapter five.

Chapter three of the thesis covers the literature review of supply response studies. It covers previous studies that have been done in this field, the approaches followed and the results that have been obtained from these studies. **Chapter four** provides a theoretical background on the approaches that can be followed to compute supply response studies. The approaches are discussed with their advantages and disadvantages.

Chapter five reconciles the approach investigated in Chapter four with the supply economics theory of the mutton industry, discussed in Chapters two and three, to obtain a representable supply

[2] Supply shifters include all the variables that influence supply (shifting the supply curve up- or downwards) i.e. price and non-price factors.

response model for hypothesis testing. The chapter is concluded with a detailed discussion of the estimation procedure regarding the ARDL 'bounds' test.

Chapter six concludes with the model outcomes, including the results on the time series properties of the variables as well as the long-run and short-run elasticities obtained from the supply response model. The results are then used for hypothesis testing from the methodology proposed in Chapter five. The results are evaluated against existing literature and conclusions are drawn. **Chapter seven** enumerates the final conclusions of the study, makes recommendations and proposes a number of topics for future research.

Chapter Two – Analysis of the Namibian Sheep Industry

2.1 Introduction

Livestock, as a sector of agribusiness, is prominent throughout Namibia and makes a significant contribution to Namibia's agricultural economy in general. The livestock sub-sector is of extreme importance to improve livelihoods in rural areas and reducing poverty. Within the Namibian small stock industry there are various stakeholders in the value chain that produce products of a high standard for both local and international markets. Stakeholders include producers, marketing agents, abattoirs, processing plants, parastatals and statutory bodies. The livestock industry, especially the sheep industry, is a well established industry in the country. Livestock farming is practised due to the harsh climate and environment and has proven itself to be a sustainable and profitable farming industry over the years of agricultural production in Namibia.

This chapter gives an overview of the livestock industry in Namibia in order to understand the role the livestock sub-sector plays in the country and the factors that affect the supply of red meat within the industry. It highlights the contribution of the livestock industry to the Gross Domestic Product. An overview of the country's natural resources is given as well as some background on the livestock composition and population in Namibia. The chapter concludes with a discussion of the mutton value chain, production and marketing within the Namibia mutton industry.

2.2 Namibian Agriculture in Perspective

Agriculture in Namibia is of paramount importance to the national economy. More specifically, agriculture is an important pillar of Namibia's formal economy as well as a fundamental source of livelihood for most of the country's population that is active in the food production sector (Agricultural Statistics Bulletin (2000-2007) 2009). Agriculture is also important in other sectors:

1. Employment creation
2. Food generation
3. Source of income
4. Primary commodity supplying several secondary economic activities
5. Its contribution to national foreign exchange earnings

As mentioned above, agriculture is a key income provider for Namibia. However, in terms of output and contribution to the growth of the national economy, the performance of agriculture within the country is not that significant. In terms of an activity's percentage contribution to Namibia's Gross Domestic Product (GDP), Agriculture and Forestry ranks seventh behind Mining and Quarrying, Manufacturing, Wholesale and Retail Trade, Government Services – Public Administration, Defence and Education, Real Estate and Business Services. Figure 2.1 shows the GDP percentage contribution by activity in the primary industries within Namibia.

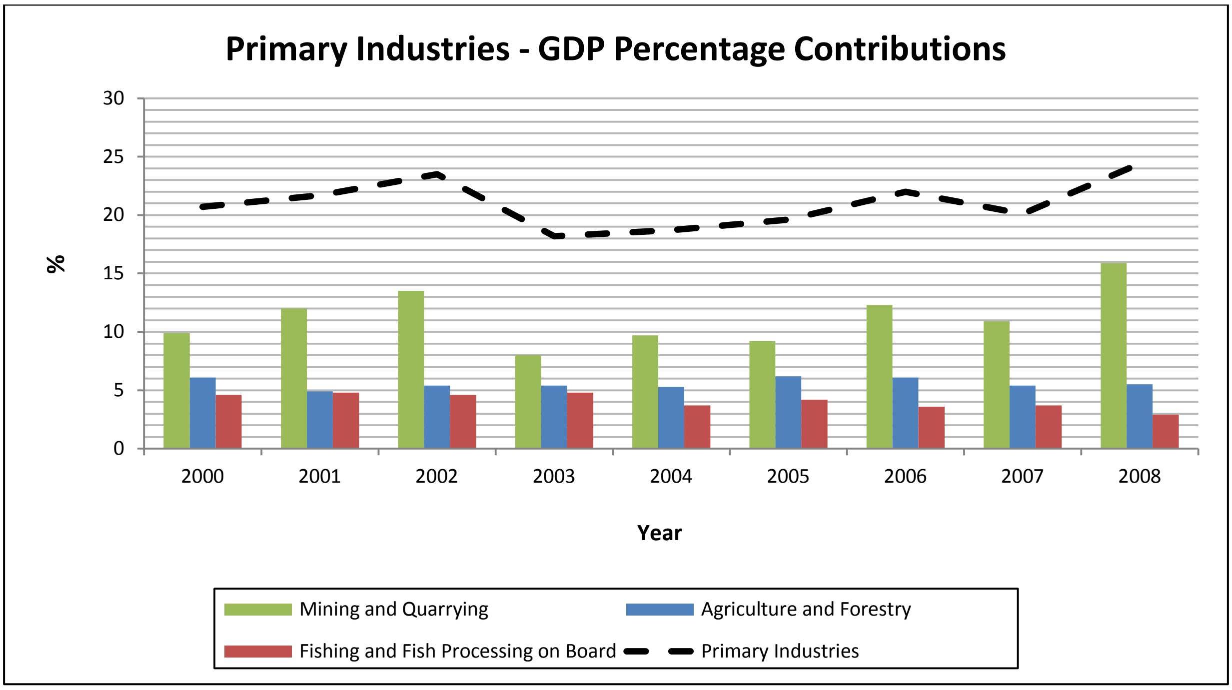

Figure 2.1: GDP Percentage Contributions by Primary Industries

(Source: Preliminary National Accounts, Namibia, 2009)

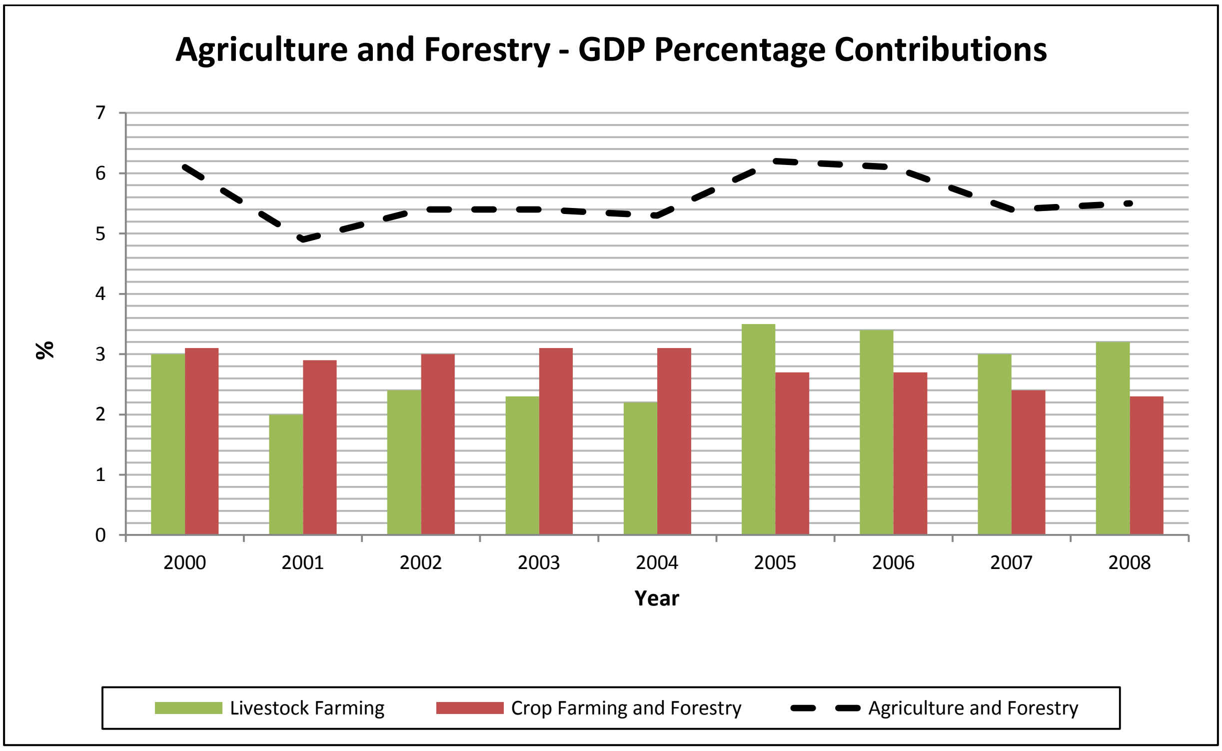

Figure 2.2: GDP Percentage Contributions by Agriculture and Forestry

(Source: Preliminary National Accounts, Namibia, 2009)

From Figure 2.1 it can be deduced that Agriculture and Forestry contributed 5.5 percent[1] (excluding meat processing) to the country's GDP and is the second highest primary industry contributor to GDP. Namibia's agricultural sector mainly consists of crop and livestock farming. The main crops grown for crop farming are: Pearl millet (Mahangu), Maize, Sorghum, Wheat, Grapes and Dates. Livestock ranching is comprised of cattle, sheep, goats and pigs in Namibia. The livestock and crop farming percentage contribution to the Agriculture sector's GDP is shown in Figure 2.2 above.

From Figure 2.2 it is clear that livestock and crop farming respectively contributes to 2.7 percent and 2.8 percent, on average, of the Agriculture and Forestry sector in Namibia over the period 2000-2008.

2.3 Namibia Natural Resources

Namibia (previously known as South-West Africa) is situated in the South-West of the continent of Africa, bordered by the Atlantic Ocean on the West, Angola and Zambia in the North, Botswana in the East and South Africa to the South. The total land area is 824 269 square kilometres and is divided into three main topographic regions: the Western coastal plain (Namib Desert), the central plateau (stretching from the North to the South) and the semi-arid Kalahari zone lying on the Eastern part of the country (Sweet 1998). Climate and geographical conditions are of paramount importance for extensive livestock farming in Namibia. For this reason it is important to elaborate on Namibia's environmental conditions in the areas where livestock farming is practised.

2.3.1 Climate

Farming in Namibia is dominated by the country's variable and harsh climate. The country has a mean annual rainfall of 250 mm, of which 83 percent is lost through evaporation, 14 percent through transpiration, 2 percent run off into rivers and 1 percent infiltrates and recharges groundwater (Sweet 1998). Based on the annual rainfall of the country, most of Namibia is considered either arid or hyper-arid. The rainfall across the country is erratic and irregular.

The Namib Desert (a strip along the West coast, approximately 100 km wide) and a 200 km strip that runs parallel with the desert, together making up 28 percent of the country's surface area, receive less than 300 mm of rainfall per year. The bulk of the country (67 percent) receives between 301 and 500 mm per annum. This area covers most of the central and northern areas as well as the Kalahari Desert in the East.

Only a small area in the North-East (3 percent) is classified as sub-humid and receives an annual rainfall of 501-700 mm (Motinga et al. 2004). Except for the extreme South that falls within the winter rainfall area, Namibia has two rainy seasons: a preliminary season from October to November and a main season from January to April (Von Bach 1990).

[1] 5.5 percent is the country's 9 years average (2000-2008) of contribution to GDP.

Figure 2.3 shows the annual rainfall distribution across Namibia. Namibia's variable climate results in the ecosystems it supports, displaying unpredictable behaviour.. Therefore the structure of ecosystems and the resulting levels of production yields vary significantly from year to year. Livestock farming in this context requires a high level of skill to ensure responsiveness to environmental conditions (Motinga et al. 2004).

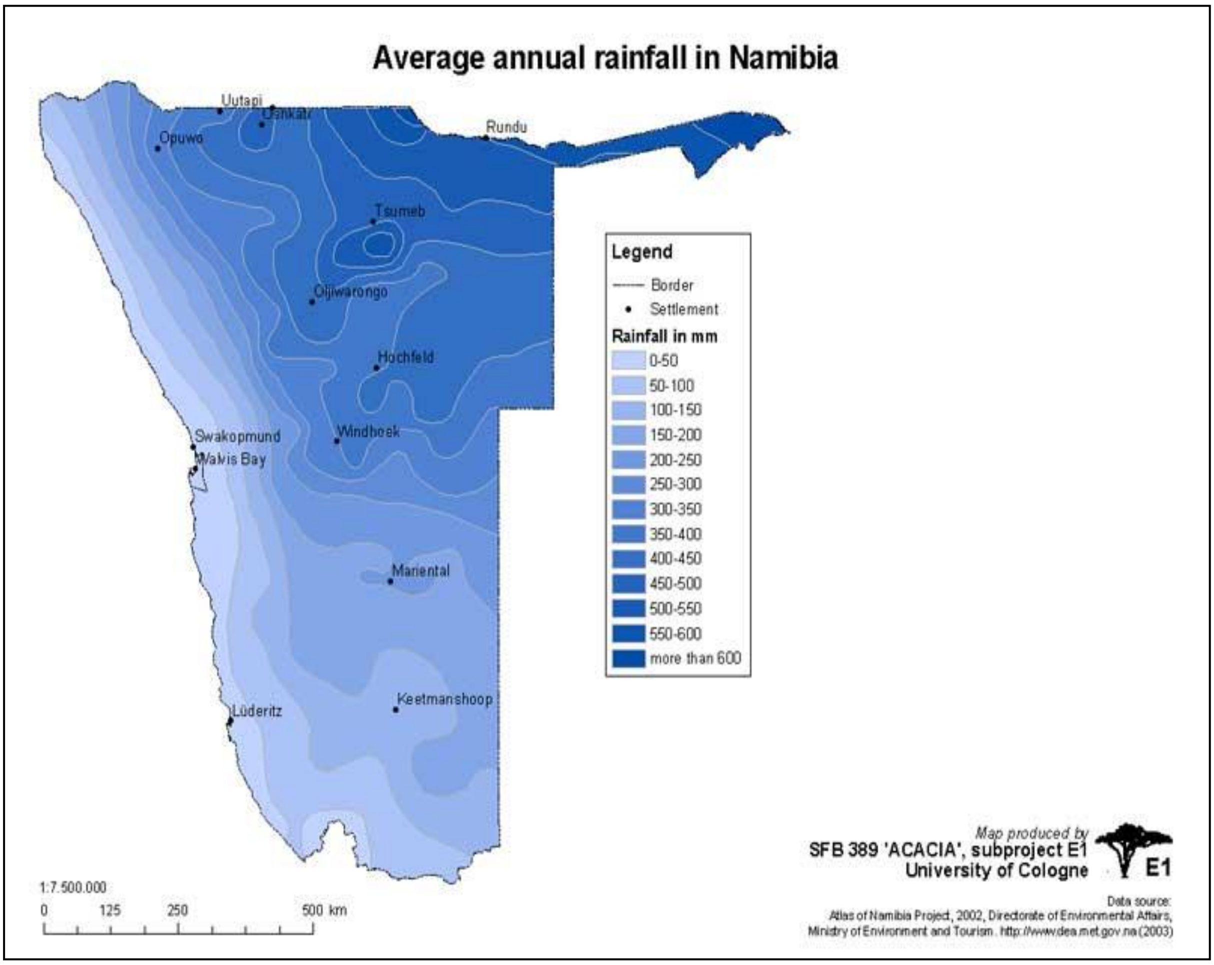

Figure 2.3: Average Annual Rainfall Distribution in Namibia

(Source: Atlas of Namibia Project, 2002, Directorate of Environment Affairs, Ministry of Environment and Tourism. www.dea.met.gov.na)

2.3.2 Vegetation

Namibia's agricultural natural resources are sensitive and react drastically to climate conditions and agricultural misuse. The open Southern areas of the country with marginal rainfall are used extensively for small stock and to a lesser extent for beef production. In contrast, the central and northern parts are dominated by beef production (Von Bach 1990). Due to the scarcity of water, fodder production for livestock farming is limited. Therefore extensive free-range farming practices are prevalent for livestock production.

The estimated carrying capacity for livestock on natural vegetation is presented in Figure 2.4. Carrying capacity is measured in kilogram of live mass that can be sustained by one hectare of natural vegetation. From Figure 2.4 it is clear that the carrying capacity is higher for areas receiving more rainfall per annum. This figure also explains the reason for which small stock farming dominates the Southern parts of Namibia, while large stock dominates the northern parts.

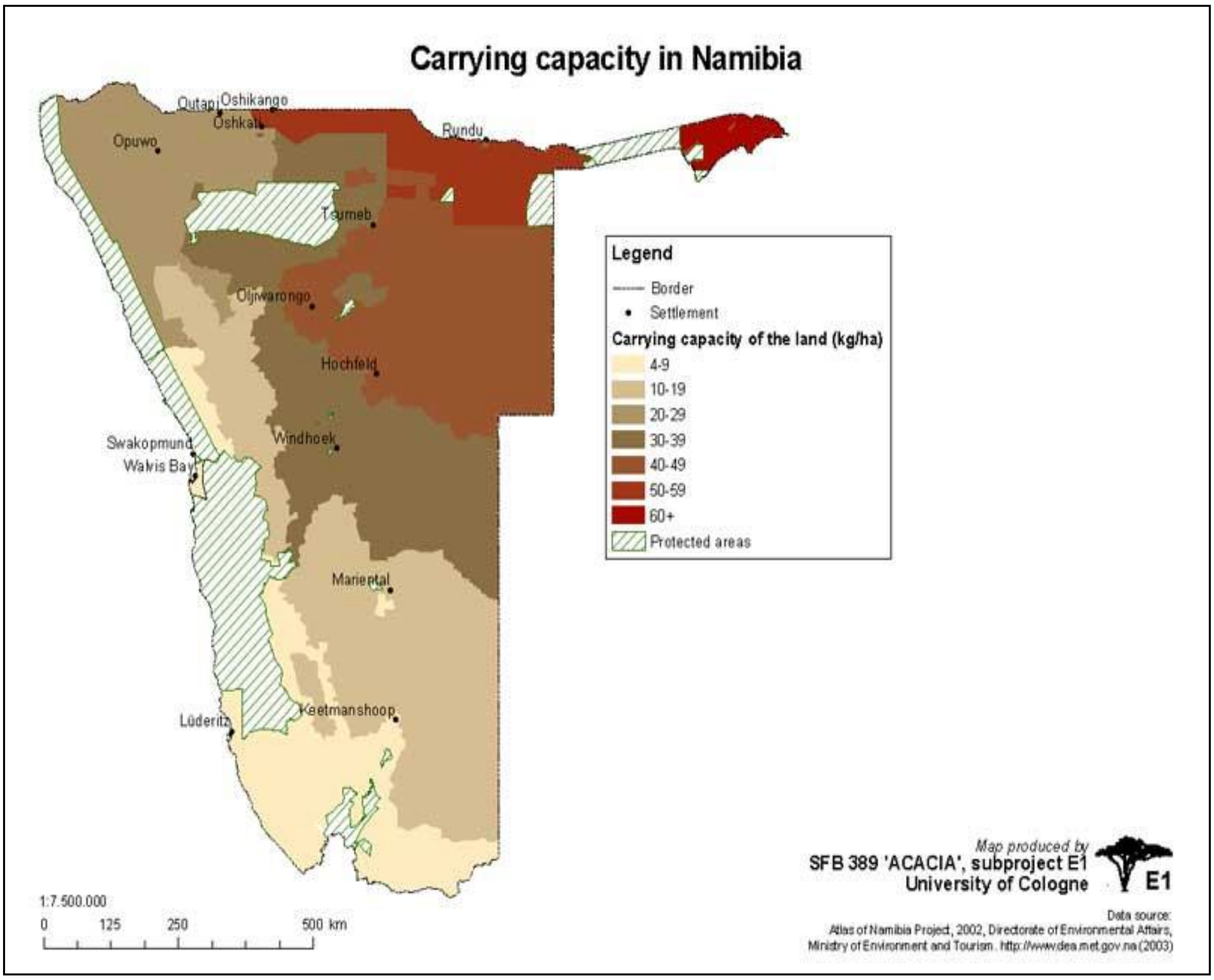

Figure 2.4: Livestock Carrying Capacity in Namibia

(Source: Atlas of Namibia Project, 2002, Directorate of Environment Affairs, Ministry of Environment and Tourism. www.dea.met.gov.na)

2.4 Meat and Livestock Industry in Namibia

Red meat is an important commodity for Namibia's agricultural trade. Due to the agricultural production climate, livestock farming dominates the agricultural sector. The contribution of livestock production to agriculture and forestry GDP can be further grouped into various categories, as presented in Figure 2.5.

From Figure 2.5 it is clear that cattle, sheep and goats dominate the livestock sector in terms of contribution to GDP.

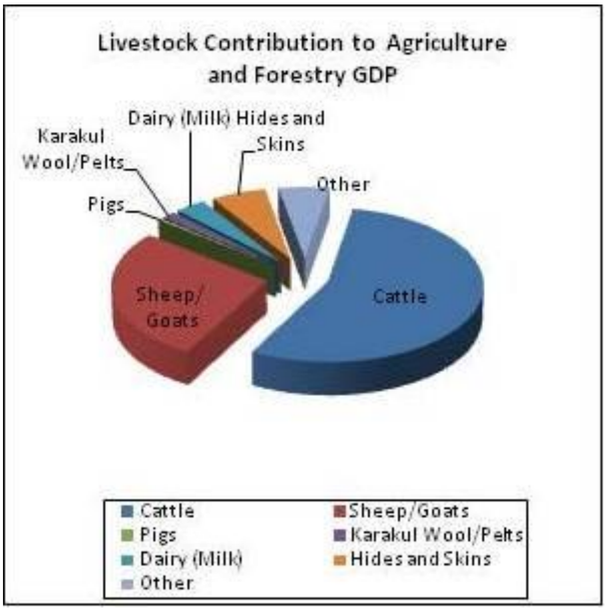

Figure 2.5: Livestock GDP Contribution to Agriculture and Forestry

(Source: Agricultural Statistics Bulletin (2000-2007), 2009)

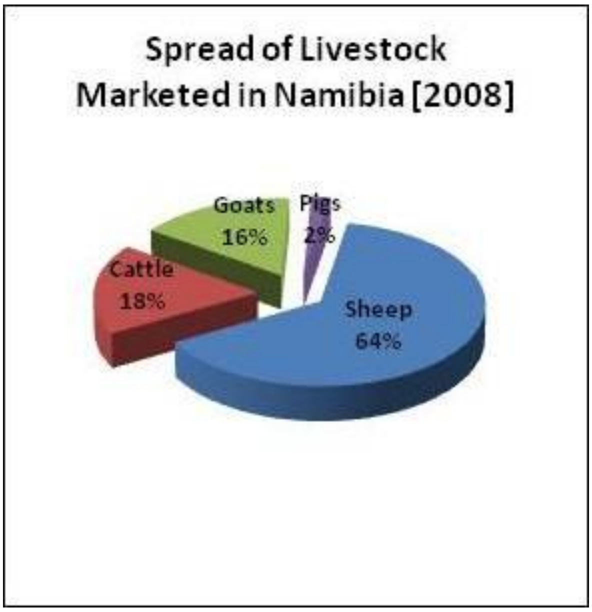

Figure 2.6: Spread of Livestock in Namibia

(Source: Schutz, 2009)

In terms of value addition – the downstream processing of agricultural products – the sector's contribution to the economy is small but significant. Meat processing contributes only 0.36 percent (see Table 2.1) to total GDP as compared to 1.65 percent from the processing of fish on shore (Preliminary National Accounts, Namibia 2009).

Table 2.1: Value Addition Activities' Contribution to GDP

Agriculture Value addition Industry	Average [2000-2007]
Meat Processing	0.36%
Dairy (milk)	2.28%
Hides and Skins	4.05%

(Source: Agricultural Statistics Bulletin (2000-2007), 2009)

As mentioned previously, livestock farming in Namibia consists of cattle, sheep, goats and pigs. Livestock marketed per head in 2008 is presented in Figure 2.6 according to the monthly statistics of the Meat Board of Namibia. From Figure 2.6 it is clear that in terms of number of head marketed, sheep is the leading livestock industry, although in terms of contribution to GDP cattle has the largest share. One can conclude that sheep farming is important in Namibia due to its contribution to the country's GDP and livestock industry.

2.5 The Sheep Industry in Namibia

The global trade in live sheep, lamb and mutton is dominated by Australia and New Zealand. The United Kingdom and Ireland are the next largest exporters, although they are involved principally in the inter-European Union trade. Outside the European Union the largest markets for Namibian lamb and mutton are Japan, South Africa, the Middle East and North America. In terms of meat production, lamb and mutton represent only 3-4 percent of global meat production. There are 45 countries in the world with sheep populations over 5 million head, accounting for over 90% of the global sheep population. However this population represents wool sheep, hair sheep and prime lamb flocks (Motinga et al. 2004).

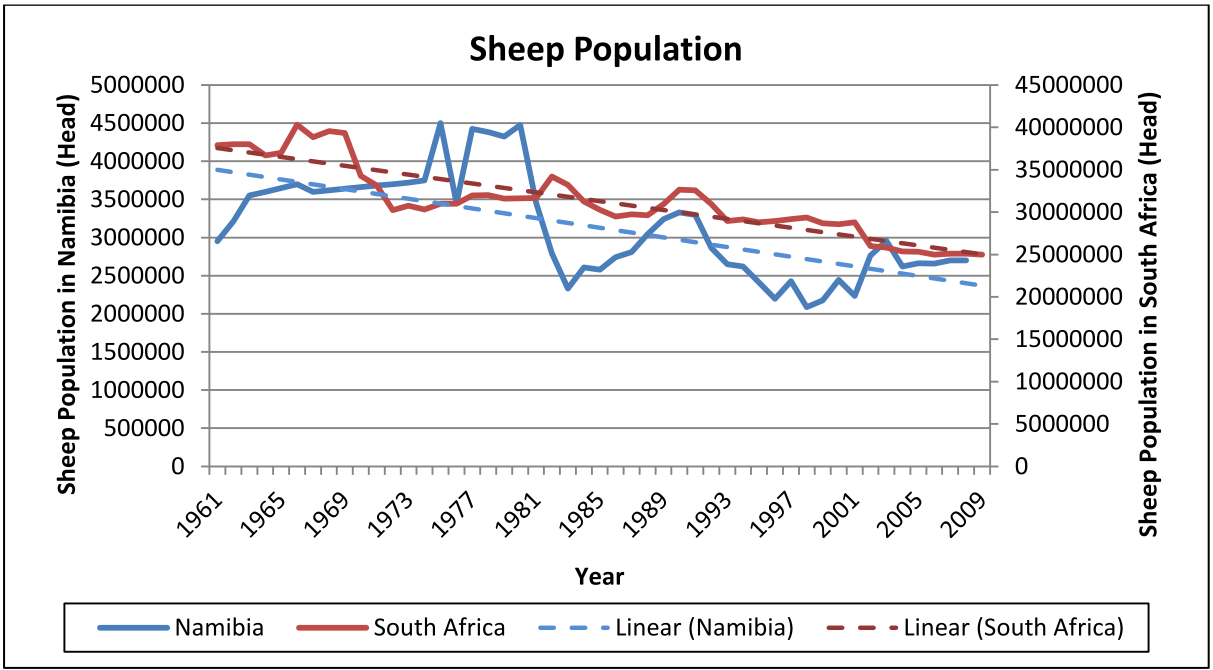

Figure 2.7: Sheep Population: Namibia vs South Africa

(Source: Food and Agricultural Organization of the United Nations – www.faostat.fao.org)

Namibia is ranked third in Eastern and Southern Africa in sheep production after South Africa and Tanzania (Kauika, Tutalife & Montinga 2006). Namibia is a surplus producer of mutton and lamb and has been exporting live sheep and mutton mainly to South Africa, long before Namibia became independent from South Africa in 1990 (Taljaard et al. 2009). Figure 2.7 shows the sheep population within Namibia and South Africa, obtained from the Food and Agricultural Organization of the United Nations, over the period 1961-2009. A long-term decline is visible in the sheep population in Namibia. The steep decline in sheep numbers in the early 1980s can be attributed to the collapse of the Karakul industry, whereas the long-term decline can be assigned to the decline in red meat demand in local and export markets, such as South Africa (see Figure B.7 in Annexure B).

The South African sheep population also shows a decline over the same time period (see Figure 2.7). One of the main reasons for this occurrence is the steep decline in red meat consumption per capita in South Africa compared to the consumption per capita of white meat (see Figure B.7 in Annexure B). It is clear from the data above that the sheep industry is under pressure due to shifts and changes in the consumer demand for red meat. This section further gives a background of the sheep industry within Namibia regarding the value chain, sheep production and marketing in Namibia.

2.5.1 The Value Chain

The Namibian sheep value chain is structured around four main components, namely on-farm production, primary processing (slaughtering), secondary processing (de-boning) and marketing (wholesale and retail).

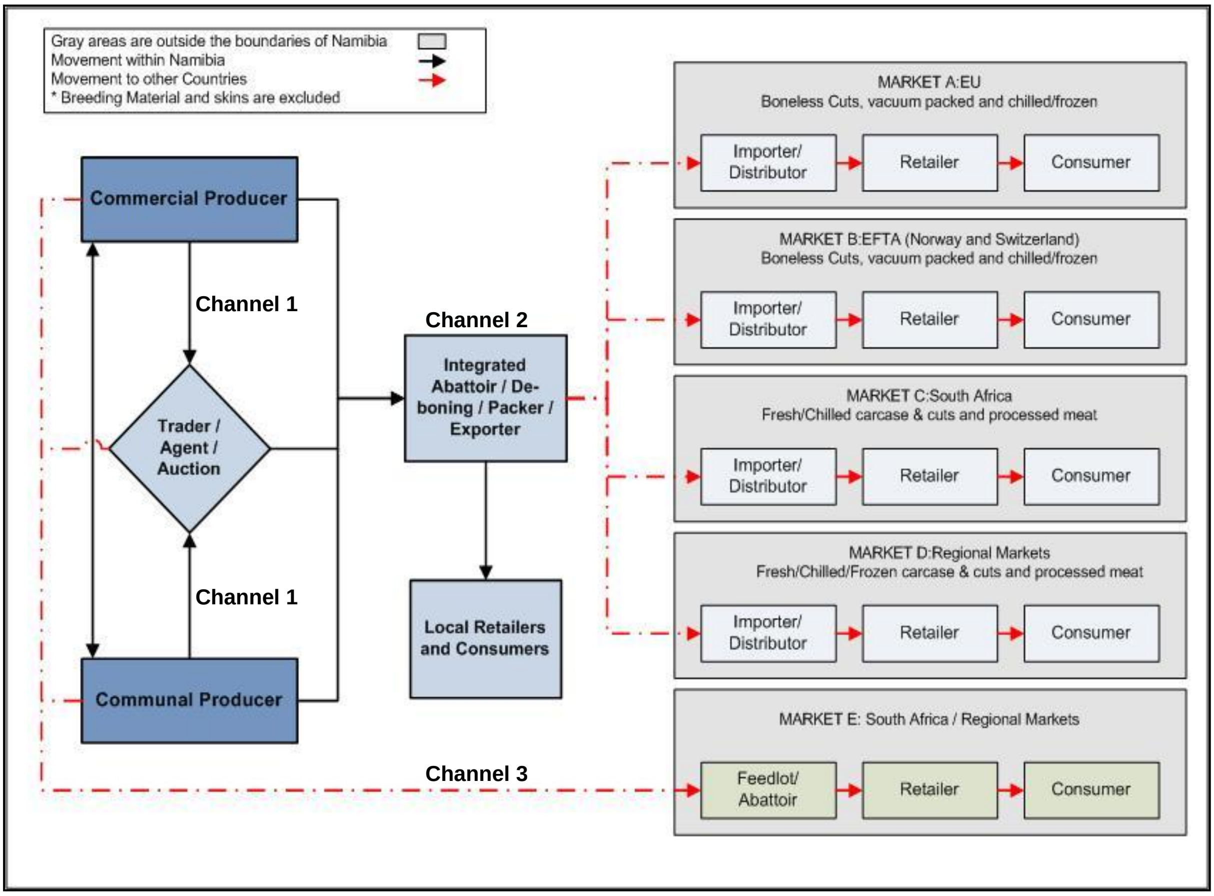

Figure 2.8: Sheep Value Chain Map in Namibia

(Source: Adapted from Schutz, 2009)

From the value chain map in Figure 2.8 it is clear that various value chains, markets and linkages between the various role players exist within the sheep industry in Namibia. The on-farm production as well as the marketing through the various marketing channels to local and other various export markets are discussed in Sections 2.5.2 and 2.5.3.

2.5.2 Production

The primary aim of the sheep production system is to improve the sheep with the goal of optimum production of quality mutton. In most of the Southern African countries there are two systems of livestock farming, namely commercial and communal farming.

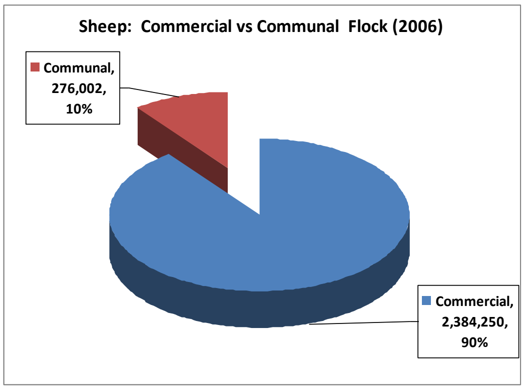

Figure 2.9: Communal Versus Commercial Farming Systems in Namibia

(Source: Schutz, 2009)

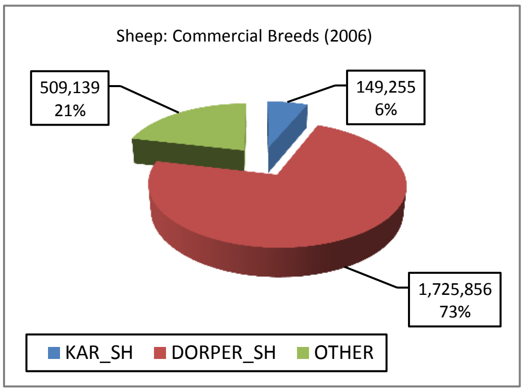

Figure 2.10: Commercial Breed Distribution in Namibia

(Source: Schutz, 2009)

Commercial farms occupy 52 percent of the total farming land in Namibia and is divided into 6 337 farms (1992 data) with an average size of 5 700 hectares, whereas communal areas occupy the balance of the total farming area (Sweet 1998). For commercial farming, livestock is grazed on fenced grazing land where range conservation and herd improvement measures are taken. These herds gain higher technical efficiencies than those achieved by communal farming. In the communal farming system, livestock is farmed on unfenced grazing land. This system is characterised by over-grazing, low off-take rates and low technical efficiency measures in terms of lambing and mortality rates (Von Bach, Van Reenen & Kirsten 1998). The proportion of commercial and communal farming systems in terms of sheep farming within Namibia is presented in Figure 2.9. According to Von Bach (1990), the most important traits contributing to economic production of livestock under Namibia's tough ranching conditions are: pre-weaning growth rate, post-weaning growth rate, feed conversion ratio (efficiency of feed use), carcass composition and quality, reproductive ability and a low mortality rate. For successful sheep production the quality of management, veld and animals are of paramount importance.

Sheep production is a biologically based dynamic process. Consequently, it causes cyclic trends in the number of sheep produced. The fact that population numbers fluctuate between cycles suggests that there are many economic, biological and physical factors affecting these cycles. The lag between the time a producer decides to expand his/her herd and the time that sheep production resulting from that decision reaches the consumer is a contributing factor to the cycle. According to Von Bach (1990), economic conditions, weather and other random events can drastically influence a given production cycle both in terms of timing and amplitude.

The most popular sheep breeds farmed within Namibia are Dorper, Karakul, Damara, Van Rooy, Blackhead Persian, Mutton Merino and various cross breeds (Motinga et al. 2004). In Figure 2.10 the commercial breed distribution in Namibia is shown. Dorper sheep amount to 73 percent and Karakul sheep 6 percent of the total, whereas 21 percent of the national flock consist of other breeds. Dorper is primarily a mutton sheep with excellent carcass quality. Lambs grow rapidly to attain a high weaning weight and can reach a live weight of 36 kg at the age of four months. This ensures a high quality carcass of approximately 16 kg. A full grown lamb has a good fat distribution that generally receives an A2-A3 grading (see Section 2.5.3). This breed is also well adapted to a variety of climatic and grazing conditions and reacts favourably to intensive feeding conditions. The Dorper breed has a favourable reproduction rate with a long breeding season and good mothering qualities. A lambing percentage of 150 percent is achievable with optimum feeding conditions (Motinga et al. 2004).

Feeding is the most important environmental factor and has a large influence on production and reproduction in any production system. Although the fat tail breeds like Damara, Van Rooy and Persian are better adapted than Dorper for mutton production throughout most regions of Namibia, Dorper sheep are a better choice in terms of carcass mass and quality.

Sheep production operations differ according to climatic regions, management skills and available infrastructure. Intensification of sheep production by improved management practices rather than an expansion in sheep numbers can meet the demand for future animal production. Higher production by increasing the lambing percentage, lowering the mortality rate and increasing the actual weight produced can be achieved by farming with the appropriate breeds and through good production practices (Von Bach 1990).

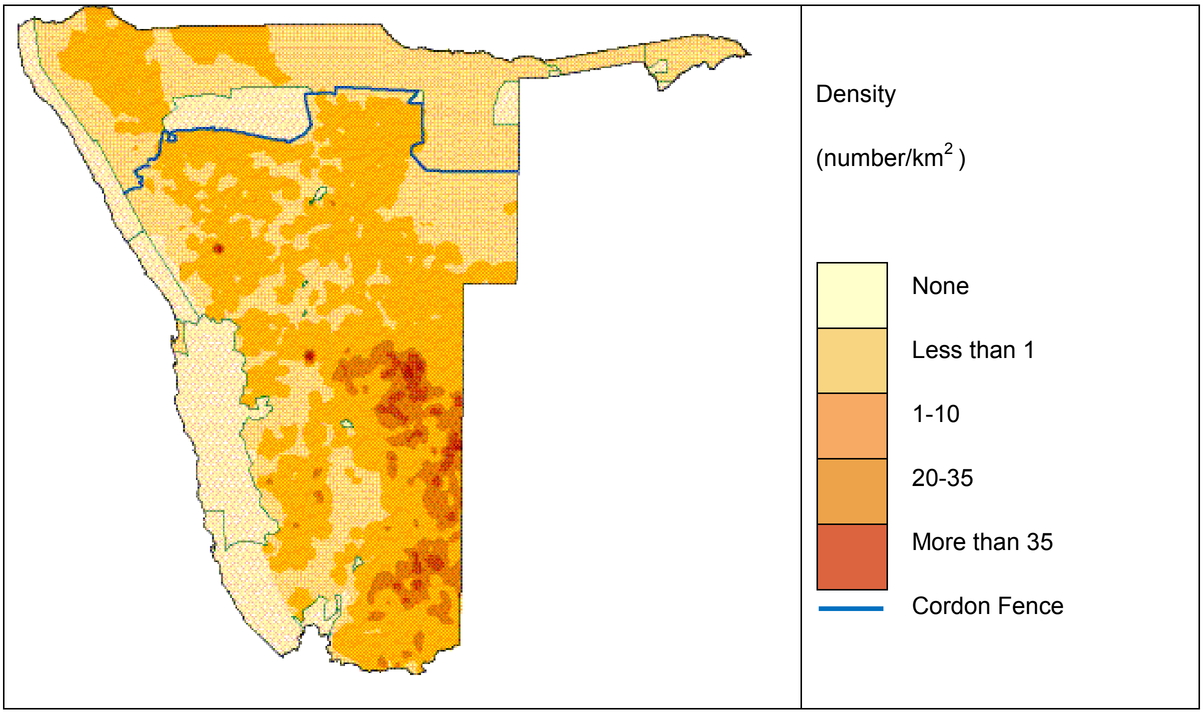

Figure 2.11: Lamb and Mutton Prodcing Sheep Density in Namibia

(Source: Motinga *et al.* (2004), *Atlas of Namibia Project, 2002, Directorate of Environment Affairs, Ministry of Environment and Tourism.* *www.dea.met.gov.na)*

The climatic regions discussed in Section 2.3 influence the sheep population because of their particular landscape, carrying capacity and rainfall. Figure 2.11 shows the lamb and mutton production density (units/km^2) within Namibia. The population density of sheep is the greatest in the

Southern and South-Eastern parts of the country due to better adaptability to the dryer areas (than cattle) and to fit the type of vegetation found in these areas.

Figure 2.12 shows the sheep population within Namibia over the last 16 years, categorised in communal and commercial farming systems. It is clear from Figure 2.12 that the total sheep population fluctuates around the 2.6 million mark. It is also clear that there is a long-term decline in sheep numbers from 1990–2006 (this occurrence is also reflected in Figure 2.7). This decline is due to farmers diversifying into other livestock production industries as well as game for hunting. The ratio between Commercial and Communal farming systems remained approximately the same over the time period shown in Figure 2.12.

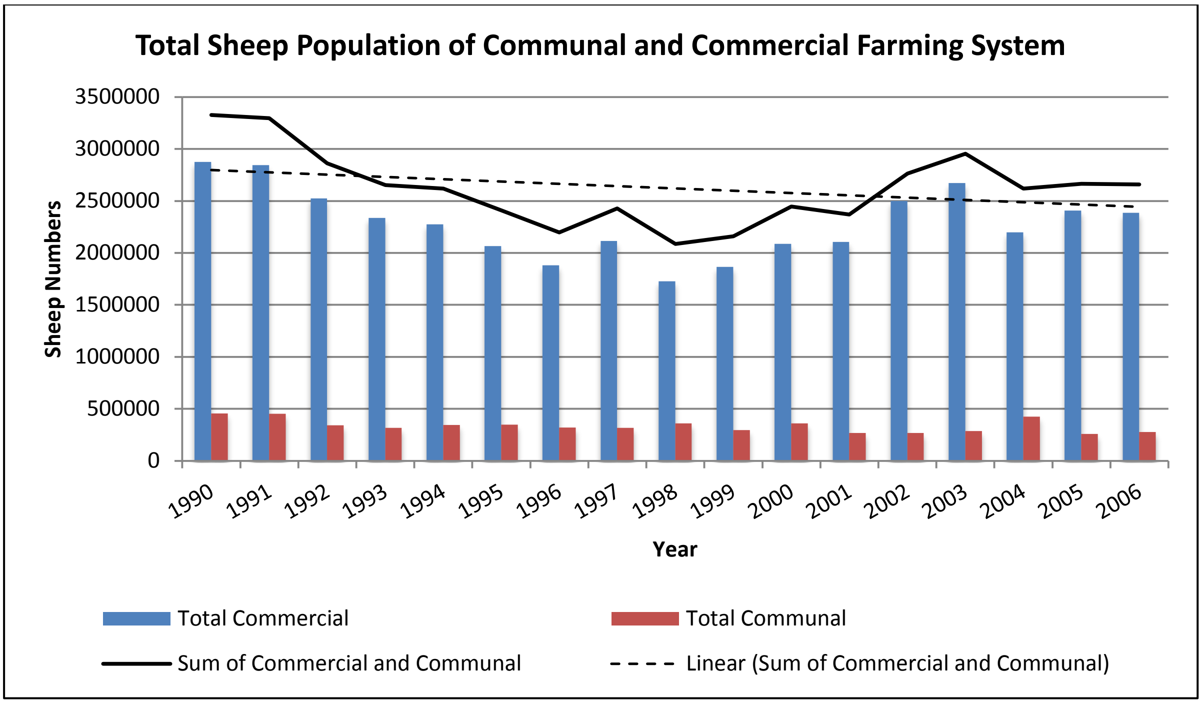

Figure 2.12: Total Sheep Population in Namibia

(Source: Meat board of Namibia, Compiled from the Veterinary Census: Ministry of Agriculture)

Feedlots are not viable or competitive within Namibia due to the scarcity and unreliability of feed (grain) production and the high transport cost. Sheep are transported over long distances to meat processing plants and other markets. The extended transport distances have a negative influence on quality because of bruising and stress.

2.5.3 Marketing

Namibia is an excess producer of mutton and therefore a net exporter of mutton[2] (Kauika, Tutalife & Montinga 2006). Most of the mutton yield is exported to South Africa with some limited marketing to Botswana. Figure 2.13 shows the sheep marketed over the last two decades within the various

[2] Namibia imports 1.85 percent of the total mutton exports and is mainly imported to the copper and diamond mines located near the South African border (Schutz 2009).

marketing channels in the Namibian sheep industry. On average, Namibia markets 1.2 million head of sheep per annum through the various marketing channels within the value chain (see Figure 2.13). Since the introduction of the Scheme in 2003, a steep decline can be observed in the marketing of live sheep in Namibia (see Figure 2.13). The Scheme went through various stages (refer to Table 2.3) where the most recent version is a flexible *ad valorem*[3] levy of 15–30% of the price paid to the producer on all the sheep being exported. The decline in sheep marketed since 2003 (see Figure 2.13) can be partly attributed to producers diversifying to game, cattle and karakul farming – all perceived to be more profitable farming options (Schutz 2009).

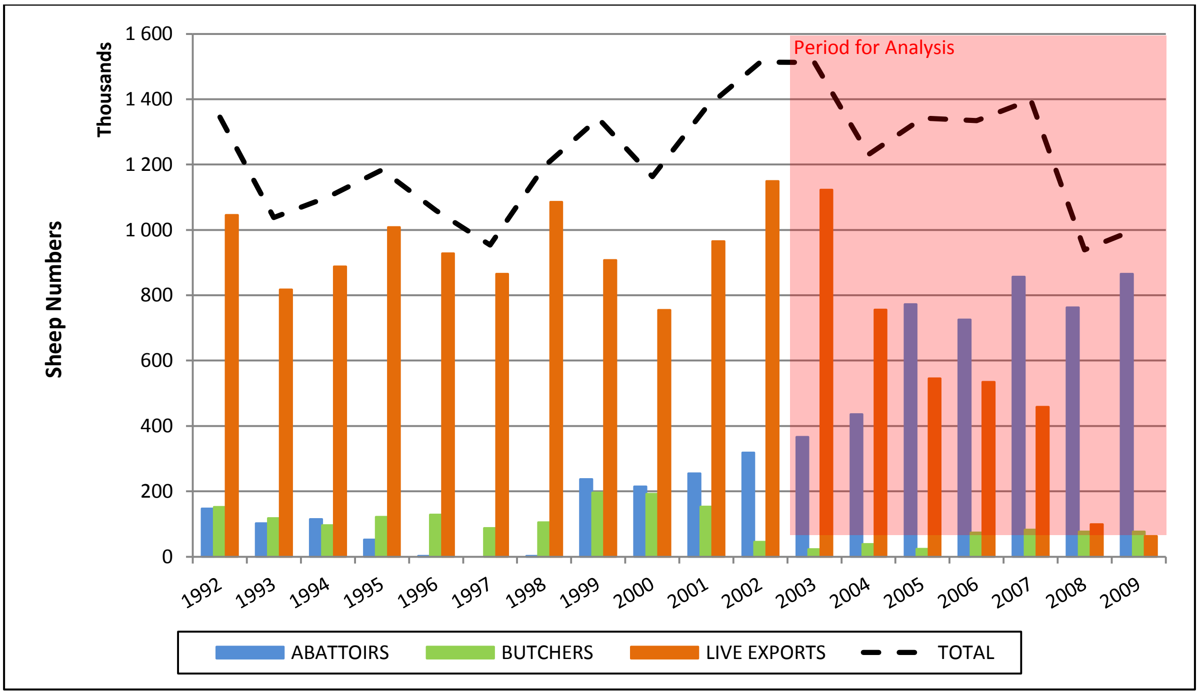

Figure 2.13: Marketing of Sheep in Namibia

(Source: Meat board of Namibia)

From the sheep value chain presented in Figure 2.7 it is clear that three marketing channels exist within the Namibian sheep industry from the perspective of the producer. Traditionally, domestic marketing by producers takes place through auctions held by intermediary agencies. Live sheep exported to predominantly export markets decreased since 2003, whereas local slaughtering has increased at local abattoirs (see Figure 2.13).

Mutton is a perishable product, and is relatively high in value. For a product like this, marketing functions such as quality control, hygienic standards, storing and packaging play an important role in slaughtering plants and processing facilities. There are four approved mutton export abattoirs within Namibia, and two of them have also been approved by the European Union. These abattoirs with their locations and slaughtering capacities are presented in Table 2.2. A further 40 smaller abattoirs are spread across the country. Throughput has nearly doubled since the onset of the Scheme (Schutz

[3] *Ad valorem*: in proportion to the estimated value of the goods taxed.

2009). Producers market the sheep directly to the abattoirs or through auction agents. The remaining marketing channels are live exports to South African abattoirs or feedlots (see Figure 2.8).

Sheep marketing is also rather seasonal and depends on the rainfall cycle and the festive season in South Africa, as South Africa is Namibia's largest market. The peak marketing season is from March to May, while December is traditionally a high-value market that takes advantage of the South African festive season. Seasonality, however, has an impact on profitability in abattoirs due to the variation in throughput during the year (Schutz 2009).

Table 2.2: Approved Mutton Export Abattoirs Slaughter Capacities

Approved Export Abattoir	NAMCO-Windhoek	FARMERS MEAT MARKET-Mariental	BRUKARROS MEAT PROCESSORS-Keetmanshoop	NAMIBIA NATURAL MEAT PRODUCERS-Aranos	TOTAL
Slaughter Capacity (units/day)	1450	1200	1600	1200	5450
% of Total Capacity	26.6	22	29.4	22	100

(Source: Schutz, 2009)

Producers are remunerated according to carcass weight and grade. A well-established mutton carcass grading system is used, whereby the mutton carcass is classed according to age and condition. The classification of A, AB, B and C are an indication of age, where grades 0-6 indicate the fatness and quality of mutton. Grades A2 and A3 are the most preferred grades by the consumer and therefore receives the highest price. The grade distribution relating to Dorper sheep slaughtered locally indicates that 83 percent (See Figure B.2 in Annexure B) of the slaughtered sheep at local abattoirs are comprised of Grade A (PWC 2007).

The domestic market for sheep is limited due to the relatively small consumer population. Therefore most of the annual mutton yield is exported to various export markets. Roughly 300 tonnes of mutton and vacuum-packed boneless cuts (chilled/frozen) are exported to the European Union, Norway and Switzerland. Except for live sheep exports (see Figure 2.13), 14 000 tonnes of fresh/chilled sheep carcasses and processed meat are exported to South Africa and other neighbouring countries (see Figure B.6, Annexure B).

Mutton producer prices have predominantly moved upwards over the last seven years. Figure 2.14 shows the average real producer price for the various livestock industries. Producer prices of substitute livestock industries show a marginal increase in producer price with the producer price of beef showing the most visible increase compared to sheep and goats. This phenomenon in the long term would lead to a decrease in mutton supply due to producers converting to alternative livestock industries. When comparing the average Namibian producer price with the average South African producer price it is clear that there is an economic wedge between international and domestic prices (see Figure B.5 in Annexure B). Schutz (2009), in a study commissioned by the Meat Board of

Namibia in 2007, states that the primary producer is negatively affected by the Scheme, because the average Namibian producer price is manipulated.

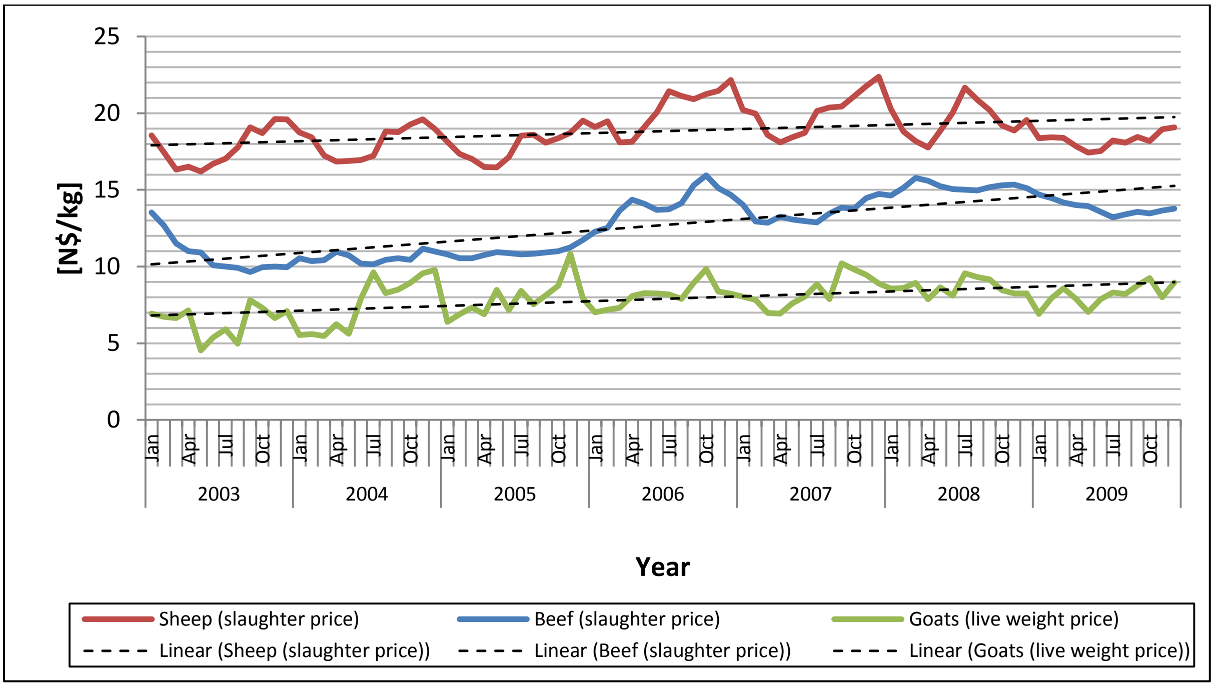

Figure 2.14: Average Namibian Real Producer Price

(Source: Meat Board of Namibia Monthly Statistics)

The Meat Board, established through the Meat Industry Act (Act no. 12 of 1981), aims to facilitate the marketing, processing and trade of livestock, meat and meat products both nationally and internationally. The Meat Board plays a facilitating role and aims to provide supportive and co-ordinating services for long-term sustainability, and competitiveness for the country's livestock and meat industry (Motinga et al. 2004). The Meat Board is directed by farmer representatives and covers operational costs by means of slaughter and export levies.

2.5.4 Small Stock Marketing Scheme

In 2003 the Small Stock Marketing Scheme ('the Scheme") was introduced by the Namibian government to promote industrial development and job-creation by introducing value addition to available raw materials in the mining and agricultural sector (as these sectors are the largest contributors to GDP in the Primary Industries; see Figure 2.1). The main aim of Namibia's industrial policy as contained in the White Paper on Industrial Development is to transform Namibia's economy from being a producer of primary products and exporter of raw materials to one that converts its raw materials and exports into finished manufactured goods. The Scheme appears to be a mechanism for the implementation of the overall value-addition strategy for the country. It intends to provide producers, processors and exporters with a framework to fully utilise the available slaughtering and tanning capacity within Namibia (Kauika, Tutalife & Montinga 2006).

At the initiation of the Scheme the apparent point of departure was that if value addition activities are increased, the utilisation of the factors of production would also increase. This implies improvement of value addition in all facets (PWC 2007).

1. Employment Creation: Since labour is defined as a factor of production, an increase in value addition could be achieved through increase in the use of labour.
2. Capacity Utilisation: Capacity refers to the land and capital goods of abattoirs and other Namibian manufacturers. If local output is increased in terms of the number of stock being slaughtered in Namibia, the capacity of Namibian abattoirs and tanners should be utilised to a greater extent
3. Income Generation: The concept of value addition is based on income generation as the value added to products equals more income to the production stakeholders.
4. Foreign Exchange Earnings: Given the fact the value of exported products (value-added products) of small stock should be higher than the value of non value-added products (live exports), the potential for foreign exchange earnings should also be higher (only if a higher price is achieved for the value-added products).

The Scheme envisaged a pro rata increase in the local slaughtering of small stock to almost a 100% utilisation of available slaughtering capacity by the end of 2007. Since the introduction of the Scheme, various marketing strategies have been applied and tested in order to reach the final goal of 100% local slaughtering and tanning. The Scheme has been subjected to the following marketing strategies since introduction:

Table 2.3: Export Strategies for the Scheme

Reference	Legislation	Start of Period	End of Period	Export Ratio[4]
1:1 Period	Notice 129 of Government Gazette 3214 1 June 2004	1 July 2004	28 February 2005	1:1
2:1 Period	Notice 1of Government Gazette 3365 3 January 2005	1 March 2005	31 August 2006	2:1
6:1 Period	Notice 94 of Government Gazette 3658 1 July 2006	1 September 2006	1 April 2007	6:1
3:1 Period	Notice 73 of the government Gazette 3819 2 April 2007	2 April 2007	14 May 2007	3:1
20% Period	Statement by Meat Board of Namibia	15 May 2007	14 June 2007	

[4] For example, a 6:1 export ratio means that six sheep must be marketed to local abattoirs before one sheep can be exported live to export markets.

Second 3:1 Period	Statement by Meat Board of Namibia	15 June 2007	15 July 2007	3:1
6:1 Period	Statement by Meat Board of Namibia	16 July 2007	1 July 2009	6:1
Value Addition Incentive Levy	Media Release from Cabinet's Chambers	30 June 2010	To date	15-30% *ad valorem* export levy

(Source: PWC (2007) and Namibian Government Gazette)

Table 2.3 presents the various export strategies since the introduction of the Scheme. The various export restrictions forced producers to use only some of the available marketing channels within the sheep value chain (see Section 2.5.1) leading to oligopsony where the number of buyers is small compared to the number of sellers (namely the primary producers).

As producers have very little bargaining power, lower producer prices result in a loss of income for sheep producers. Producers tend to diversify into other farming practices like game farming, cattle farming, goat farming and karakul faming (Schutz 2009). This diversification leads to a decrease in mutton production that will lead to a shortage of sheep and could effectively mean that some of the current active abattoirs could close down in the near future, as well as a loss of labour opportunities on farm level. These results are in conflict with the government's aim of creating employment and stimulating local value addition activities.

With the initiation of the Scheme, Namibia has laid down export restrictions, made effective through a quota on the export of live sheep and a restriction in the form of an export permit system. A study administered under the auspices of the National Agricultural Marketing Council (NAMC) investigated the acceptability of the Scheme with Namibia's commitments under the rules of the World Trade Organisation (WTO), the Southern African Development Community (SADC) Protocol of Trade and the Southern African Customs Union (SACU) Agreement.

According to the NAMC the following findings can be drawn from the investigation (Taljaard et al. 2009):

- In terms of the WTO rules, the quantitative export restrictions imposed on live sheep and the export licence scheme for sheep is a violation of Articles XI and XX of the General Agreement on Tariffs and Trade (GATT)
- In terms of the SADC Protocol of Trade, an export duty on small livestock is contrary to provisions of Article 5(1) of the Trade Protocol
- Quantitative export restrictions on small livestock is contradictory to Article 8(1) of the SADC Trade Protocol
- In terms of the SACU Agreement, Namibia contravenes the objectives of the SACU Agreement (provisions of Article 18) by establishing export restrictions of live sheep exports in the form of export duties, quotas and permits

From the points made above it can be concluded that Namibia's Small Stock Marketing Scheme does not fully align with the objectives and agreements of the WTO rules, the SADC Protocol on Trade and the SACU Agreement and the issues raised are of growing concern to the livestock industry as regards its trade with other member countries in the near future.

2.5.5 General

Namibia's Northern regions are separated by a cordon fence[5] from the rest of Namibia, preventing uncontrolled displacement of animals from these areas into the rest of the country. Such movements could pose a serious threat to the livestock industry in view of export market requirements and health regulations (Von Bach 1990).

The mandate of the Directorate of Veterinary Services (DVS) is to maintain and improve the health of the country's livestock in order to ensure safe and orderly access of Namibian livestock products to local and foreign markets. The DVS's main functions are the monitoring of the health of the national herd and the control of export abattoirs. The DVS also maintains and monitors the cordon fence that is important for the zoning of health status areas as required for international marketing of livestock (Motinga et al. 2004).

2.6 Conclusion

This chapter highlights the fundamental importance of the sheep industry within Namibia's economy, as well as the contribution of livestock production and value adding activities to the Agriculture and Forestry GDP. It is clear from this chapter that, as a result of Namibia's harsh climate and landscape, the country's agricultural production is dominated by livestock farming. Mutton production is the second most important sector, being a smaller contributor to GDP than the beef industry. Since the introduction of the Small Stock Marketing Scheme, a decline in the amount of mutton produced can be observed and this is a growing concern for industry stakeholders. It is clear that the Scheme disturbed the marketing practices within the industry.

It can be concluded from this chapter that Namibia's production conditions are challenging. There has also been a decline in sheep population numbers over the last four decades in both Namibia and South Africa. As this phenomenon is a growing concern for the industry, research in this sector is important to secure a sustainable future for mutton production. Supply response studies are therefore an important tool to highlight the crucial factors contributing to mutton production within Namibia and determine to what extent these factors influence mutton production.

[5] Veterinary Cordon Fence – 1 251 km double stock-proof cordon fence maintained and patrolled by veterinary officials in an effort to contain Foot-and-Mouth Disease North of the cordon fence (Motinga et al. 2004). Refer to the blue line in Figure 2.11, which represents the cordon fence.

Chapter Three – Supply Analysis Literature Review

3.1 Introduction

Supply response studies have been carried out across the world by various researchers in order to understand more about the supply (production) of commodities and the factors that influence supply. This chapter outlines a cross section of previous work that has been done in the field of supply response analysis. A variety of approaches and techniques were utilised for studies done on a range of commodities. The aim of this chapter is to highlight the different approaches, techniques, supply models and results obtained from previous work conducted in this field.

3.2 Supply Economics

Supply response indicates the output response to change in price and non-price factors. The concept of supply response is dynamic and different from the supply function that is a static concept (Tripathi 2008). The response relation is a general concept that shows the change in quantity supplied with changes in supply shifters, i.e. price and non-price factors.

The supply curve of a product such as mutton is a schedule indicating the quantities producers are willing to supply (produce) at a given price, time and locality assuming that all other factors influencing supply, such as technology or production costs, remain the same *ceteris paribus*. The slope of the supply curve is determined by the time it takes producers to adjust to changes. According to the law of supply, if the price of a product increases the supply should also increase. Supply response studies are performed in order to reveal the relationship between inputs and outputs. However, as with any model generating outputs from inputs, limitations and problems exist. Typical problems that occur in supply response studies are (Von Bach 1990):

- Uncertainty in expectations
- Technological changes
- Measurement of the influence of weather

Proper model design is important for supply response analysis. It is of paramount importance that it should be based on accurate data. The development of these models provides good support to human judgement (management) in marketing, planning, control and policy. According to Von Bach (1990), supply response studies for agricultural commodities and products can be differentiated into the following categories:

1. Studies of the supply of individual commodities based on time series data
2. Studies based on budgeting techniques or linear programming models using typical farms or regions as units of analysis

3. Studies of aggregate supply including both the development of theoretical concepts and the estimation of the response of total farm output to changes in product and factor prices

Most studies of supply response, of either aggregate or individual commodities, are based on times series data and either use the Nerlove (1956) partial adjustment model for single commodities or the method developed by Griliches (1960) for aggregate supply response (Mckay, Morrissey & Vaillant 1999). For the purpose of this paper the supply of a single commodity is considered for the analysis of supply response for the Namibian mutton industry.

According to Huq & Arshad (2010), supply response is also a tool that is used to evaluate the effectiveness of price policies and enables producers to allocate their resources. Supply response studies are useful for evaluating production policies and incentives. Earlier studies in the field of supply response were done in order to understand the price mechanism. However, except for price, there are various other non-price factors that influence supply, such as weather, technology, etc. Supply response studies are also useful for making forecasts for a product within a production environment.

3.3 Previous Work done in this Field

Several research studies undertaken worldwide have been done in the field of supply response. Recent studies increasingly focused on developing countries in Africa, such as Ghana, Zimbabwe, Botswana, Namibia, South Africa and Egypt. Earlier studies on supply response predominantly focused on one commodity, where price responsiveness towards supply was the major factor evaluated within the researched studies. More recent studies used improved quantitative methods, as explained in the next section.

Von Bach & Van Zyl (1990) researched the supply response of beef in sixteen homogeneous ecological areas in Namibia by using multiple regression techniques on biological and economic time series data. The approach to their study was based on the fundamentals of the work done by Nerlove (1958). The independent variables used in their study include total cattle stock, total cattle exported, total Namibia beef carcasses, average Namibian beef producer price, real average beef producer price, income per carcass, real income per carcass and the South African average beef producer price with various time lags[1]. The dependent variable of the supply model for their analysis was total beef marketed within Namibia, South of the cordon fence. The results obtained from their study showed that producers' price of beef does not significantly affect production. They found that environmental factors and cattle demographics (population numbers) played a major role in the amount of cattle produced (marketed) per annum. However, Ogundeji, Jooste & Oyewumi (2011) raised questions about Von Bach's results due to possible multi-collinearity among the independent variables.

[1] Time-lagged variables: due to the dynamic nature of production (a producer's decision in any one year will evidently affect his possible actions in succeeding years (Court 1967)), variables influencing supply included in the supply model are lagged by a number of time periods according to the nature of production; for example, last year's herd population numbers have an influence on this year's supply.

Seleka (2001) researched the short-run supply of small-ruminants (including sheep and goats) in Botswana. Seleka (2001) used pooled data for six agricultural regions found in Botswana. The independent variables used for the research included unit price of animals sold, total number of livestock in the agricultural region and the lagged annual rainfall in the agricultural region. The dependent variable for the supply model is the number of animals marketed within each region. Results obtained from the research showed that a one percent increase in sheep inventory results in a 1.23 percent rise in the number of sheep marketed where rainfall showed no significant impact on sheep sales. The research also found that producer prices have no impact on small ruminant sales. However, for goat production, a one percent increase in rainfall leads to a 0.53 percent rise in goats marketed the following year.

Lubbe (1992) researched price stabilisation policies to beef producers in South Africa. Multiple regression analysis with distributed lag models was used to analyse producer supply response flexibilities to rainfall and price cycle variation. Results showed that adjustment of supply depends both on price and rainfall parameters. Supply responded negatively to a one-year lag in the price cycle and the current rainfall cycle level. Conversely positive supply cycle response was obtained with a five-year lag in prices and a two-year lag in rainfall.

Abbot and Ahmed (1999) analysed the impact of change in price and non-price factors on the supply response of the South African wool industry. Abbot and Ahmed (1999) made use of a distributed lag model where the independent variables include the average price of wool, average price of beef, average price of maize, average index of farm costs and the average price of mutton. The production of wool was used as a dependent variable in the supply model. The model was computed using Ordinary Least Squares with time lags of up to five years for the independent variables over a time period from 1972/73 to 1994/95. Results obtained showed a significant relationship between beef price and wool production, where no significant relationship was found between the supply of wool and the average level of farm costs. Significant negative relationships were obtained between wool production, maize and mutton prices. Wool production was found to respond slowly to a change in wool prices. This inelastic behaviour of price towards wool production is similar to the results of work done by other researchers, according to Abbot and Ahmed (1999).

Phororo (1996) investigated the factors wool producers in Lesotho consider in their decisions regarding wool production. Phororo (1996) hypothesised a wool supply model where the decision variables (independent variables) included wool production that lagged one year, deflated wool export prices that lagged one year, deflated mohair export prices that lagged one year, as well as the rainfall index in Lesotho. The output variable (dependent variable) for the model is the wool produced in Lesotho. Ordinary Least Squares[2] were used to compute the relationships among the variables for the time period 1973/74 to 1987/88. The estimated results showed that lagged wool production and lagged wool producer price are important factors in explaining the current wool production. The negative wool production elasticities imply that a one percent increase in wool price will lead to a

[2] Ordinary Least Squares – is a quantitative method used for estimating unknown parameters in a regression model (Winston 2004).

decrease in wool production, resulting in a backward sloping supply curve[3]. The rainfall variable did not prove to be significant in explaining current wool production.

Court (1967) analysed the supply response of New Zealand sheep farmers towards the price of mutton, price of wool and price of lamb[4], while Reynolds and Gardiner (1980) investigated the supply response in the Australian sheep industry. Relationships between product price and production output on wool, mutton and lamb as well as seasonal conditions were analysed. Previous researchers have observed zero or negative elasticities of production output with respect to price. Reynolds and Gardiner (1980) found empirical evidence that short-run supply elasticities may be zero or negative.

Whipple and Menkhaus (1989) constructed a dynamic supply model for the U.S. sheep industry in order to investigate the relationship between sheep supply, lamb price and wool price. The results obtained by Whipple and Menkhaus (1989) showed that supply is positively related to lamb price in the short run and long run, although the short-run lamb price elasticity of supply is inelastic. Results also showed that sheep supply has a positive elastic response towards wool price. Akinboade (1999) investigated the influence of producer price and capital/labour ratio on the production of livestock and sorghum in Botswana.

The most recent research on the modelling of beef supply response in South Africa was conducted by Ogundeji *et al.* (2011). With the aid of an Error Correction Model (ECM) the supply response of beef production in South Africa could be investigated. The independent variables in their supply model were rainfall, real producers' price of beef, lamb, pork, chicken, yellow maize, imports and cattle population that represented the climatic, economic, trade and demographic factors. The production variables were modelled respectively to cattle marketed for slaughtering (dependent variable). Results showed that beef producers in South Africa respond to these production variables in the long run. However, in the short run, results showed beef marketed is only responsive to climatic factors and beef imports. Results also showed that the supply model short-run adjustment speed of cattle marketed to the long-run equilibrium position is 63 percent of the proportion of disequilibrium. The result is that 63 percent of disequilibrium from the long run in the cattle marketed is corrected each year.

Over the last decade various studies have been conducted in Africa on several commodities with new approaches towards supply response. These studies include the analysis conducted by Schimmelpfennig, Thirtle & van Zyl (1996); Mckay, Morrissey & Vaillant (1999) and Ocran & Biekpe (2008). According to Mose, Burger & Kuvyenhoven (2007) numerous supply response studies that have been conducted on various commodities showed low short-run price elasticities, where the long-run price elasticities have been found to be higher than the short-run elasticities.

[3] Backward sloping supply curve (Backward-bending supply curve): a common theorem in supply economics according to which, if the price of a product increases, the supply of that product will also increase. However, in production dynamics, it is possible that the price of a product increases while the supply of that product decreases because producers retain their stock in response to price increases with the expectation of increased future income outweighing present income. This phenomenon is referred to as the Backward sloping supply curve, where supply decreases as the price of the product increases.

[4] Lamb – meat of sheep (mutton) younger than one year

3.4 Conclusion

Several research studies have been conducted in the field of supply response analysis on agricultural commodities. Supply response studies have also been done in the red meat industry in various countries across the world, including countries in Southern Africa. Although various studies have been conducted in the red meat industry in Southern Africa, only a limited number of studies have focused on supply response of mutton.

The following concluding remarks can be drawn from the literature described above:

- Firstly, most of the studies have used variants of the same methodology originally introduced by Nerlove in the original form or with modification
- Supply models are based on the theoretical framework of product supply
- All the studies included economic variables as production factors in the supply models, such as the price of the product and the prices of substitute products
- Studies included climate variables as production variable – rainfall in particular
- Dependent variable of the supply model is product supplied, produced or marketed
- Long-run and short-run supply elasticities are low (inelastic) for most of the studies
- Previous studies have also shown that non-price factors are of the same order of importance as price factors in supply response

It is clear that different results have been obtained from the various studies. The reason for this phenomenon is that each study has its own limitations, restrictions, scope of study and approaches[5].

[5] The approaches followed for conducting supply response studies are discussed in Chapter four.

Chapter Four – Basic Framework and Approaches in Estimation

4.1 Introduction

Broadly speaking, two approaches can be followed to measure agricultural supply response to price and other non-price factors: 1) Programming and 2) Econometrics (Colman 1983). The econometric approach can further be subdivided into three categories. Because of substantial scepticism regarding the results from econometric analysis, this study will place considerable emphasis on gaining an understanding of the methodology used to derive the results. This will provide some indication of the confidence that can be placed in econometric estimates. This chapter provides a theoretical background of the available approaches that can be utilised in supply response studies.

4.2 Programming

4.2.1 Linear programming

Programming models, usually linear programming, involve the creation of a linear production model that represents the typical production system of a specific, or various products. An objective function is usually specified as it relates to stakeholder benefit, where complex adjustments are simulated as they would take place in an agricultural production environment in response to internal and external changes. Other objective functions in linear programming models, such as risk minimisation, can also be defined and simulated according to production goals. By solving the model with various sets of data, assuming the profit is maximised, the supply-price relationship can be established for a specific product.

The advantage of this approach is that linear programming is capable of handling complex multi-relationships on farm level in a production system. The complex multi-relationships involve recognition of all the effects on supply due to change in product prices, input prices as well as the incorporation of technological and physical restrictions on farm level. However, the data requirements are extensive, the collection of data at farm level is costly and the development of such models requires extensive time to be developed (Thomson & Buckwell 1979). Given the fact that these studies focus mainly on supply response on farm level, they lack a more comprehensive perspective on the industry supply response. The assumption that farmers maximise their profits may lead to the overestimation of supply that is not always true in practice. Due to the restricted availability of data and the resource-intensive nature of this technique, this approach is not widely used among researchers when supply response studies are conducted.

4.3 Econometrics

Econometrics developed out of a desire to further understand economic phenomena and grew to its position of being the approach of choice for the expression of neoclassical economics. Statistical data proved to be valuable in establishing economic regularities, presenting economic arguments and performing measurement of economic variables (Townsend 1997). At the start disproportionate trust was placed in the quantitative techniques; however, after initial optimism of the quantitative revolution, disillusionment and scepticism became common. According to Townsend (1997) the scepticism centred on the methodology adopted in formulating these econometric models. Although various econometric approaches exist for analysis of supply response functions, only three of the most widely used approaches are discussed in this paper. These approaches are Directly Estimated Partial Models, Error Correction Models and the Autoregressive Distributed Lag Bounds test approach.

4.3.1 Direct Reduced Form Approach

The first approach is directly estimated partial supply models that involve the direct estimation of single commodity supply functions from time series data. Production in agriculture is not instantaneous and is dependent on post investment decisions and expectations, resulting in the situation where production in any period or season is affected by past decisions. The level of supply is a function of current economic conditions, at the time decisions were made as well as the expectation about future conditions (Colman 1983). The majority of older researched supply response studies fall in this category.

The partial adjustment model used by Nerlove (1958) is an earlier version of an econometric approach used in measuring agricultural supply response for a single commodity. Nerlove's partial adjustment model is used to capture agricultural supply response to price incentives. The general static supply function can be mathematically presented as:

$$Y_t = c + \beta P_{t-1} + \gamma T + \vartheta_t \qquad (4.1)$$

Where, Y_t → expected long-run equilibrium output level at time *t*

c → constant term

β → long-run supply response (rate of change)

P_{t-1} → output price at time *t-1*

γ → coefficient of linear deterministic time trend T

ϑ_t → error term

The dynamic adjustment of the supply response equation is based on Nerlove's hypothesis that each year farmers revise the output level they expect to prevail in the coming year in proportion to the error they made in predicting the output level of this period.

This is presented as:

$$Y_t^* - Y_{t-1}^* = \lambda(Y_t - Y_{t-1}^*) \quad where\ 0 > \lambda > 1 \tag{4.2}$$

Where Y_t^* → expected output level at time t

λ → coefficient of expectation about price or elasticity if variables are in logarithm

By substituting equation 4.1 in equation 4.2:

$$Y_t^* = \lambda c + \lambda\beta P_{t-1} + (1-\lambda)Y_{t-1}^* + \lambda\gamma T + \lambda\vartheta_t \tag{4.3}$$

where $\lambda\beta$ captures the short-run price elasticity of supply. Nerlove states that if producers have static expectations and if supply depends on expected normal prices or prices of the preceding year, then the coefficient of expectation λ is equal to one in equation 4.2. In such a case producers do not immediately adjust their production decisions to changes in prices observed in period t, such that:

$$Y_t = Y_t^* = c + \beta P_{t-1} \tag{4.4}$$

If λ is less than 1, the fluctuation in expected output level is less than the fluctuation in the observed output level, such that the actual change in output level in the periods *t* or *t-1* is only a small part of the change required to achieve the expected output level. In this case the only condition for observing significant differences between short-run and long-run elasticities are the initiation of non-static assumptions (Abou-Talb & El Begawy 2008; Olubode-Awosola, Oyewumi & Jooste 2006).

According to Abou-Talb *et al.* (2008) the previous studies that are based on the Nerlovian partial adjustment model have found low values or even zero long-run price elasticities of agricultural supply. This method assumes that the difference between current and long-run planned outputs is eliminated, i.e. it assumes that farmers are not forward-looking in their production decisions. This method also lacks the capacity to measure the effect of non-price factors influencing supply.

According to Abou-Talb *et al.* (2008) and Alemu, Oosthuizen and Van Schalkwyk (2003) the weaknesses of the Nerlovian partial adjustment model can be summarised as follows:

1. It does not distinguish between short-run and long-run elasticities
2. The model's use of integrated (nonstationary) series poses the danger of spurious regression results
3. The assumption that production adjusts to a fixed target of supply, towards which actual supply adjusts, is considered unrealistic under dynamic conditions

It can be concluded that the partial adjustment model was used as a framework by many previous studies on supply response analysis but due to its limitations and the improvement of methods the partial adjustment model has been superseded by further developments such that it is no longer a model of choice for a study of supply response on agricultural output.

4.3.2 Error Correction Model

Empirical dynamics of supply can also be described by Error Correction Models (ECM). The ECM form of dynamic specification has been used by various authors in macroeconomic modelling since its appearance in the Davidson, Hendry, Srba and Yeo (DHSY) consumption function of 1978 (Hallam & Zanoli 1993). The ECM offers a means of reincorporating levels of variables alongside their differences and hence of modelling long-run and short-run relationships between integrated series. Furthermore, economic time series data contain trends over time[1], although regression analysis shows significant results with high R^2, the results may be spurious. ECM and co-integration analysis are used to overcome the problem of spurious regression (Tripathi 2008).

Due to the limitations of the partial adjustment model, the ECM is favoured above the Nerlove method. The ECM overcomes the restrictive dynamic specification and captures the forward-looking behaviour of producers optimising their production in dynamic situations (Abou-Talb & El Begawy 2008). The ECM approach is used to analyse non-stationary[2] time series data that are known to be co-integrated. This method also assumes co-movement of the variables in the long-run. The general form of the ECM method is;

$$\Delta Y_t = c + \sum_k \alpha_k \Delta Y_{t-n} - \lambda\left(Y_{t-1} - \sum_j \beta_j X_{jt-n}\right) + \gamma T + \vartheta_t \qquad (4.5)$$

Where, Δ → deference operator such that $\Delta Y_t = Y_t - Y_{t-1}$

α_j → short-run supply elasticity with respect to factor k

β_j → long-run supply elasticity with respect to the factor j

$Y_t's$ are assumed to be co-integrated time series variables (including other explanatory variables X_{t-n}).

Co-integration analysis can be carried out with the Johansen or Engle-Granger test approach. The Engle-Granger approach is briefly discussed in the section to follow.

[1] However, trends in time series data, for example price data, may be caused by a number of factors, including inflation. The presence of significant trends in deflated and deseasonalised data therefore implies that there are other factors as well that contribute to the trends in the time series data. These trends have to be removed due to the assumption that time series data is stationary (Gujarati 2006).

[2] Various tests are available for the testing of the presence of a unit root, for example Augmented Dicky-Fuller test (refer to equation 4.6). If the test confirms the presence of a unit root, the data need to be differenced to make it stationary. The number of times the series needs to be differenced indicates its order of integration of the series.

Engle-Granger approach to co-integration analysis

The latest supply response studies of co-integration analysis have been widely adopted by researchers (Huq & Arshad 2010). The Engle-Granger test for co-integration involves estimating a static Ordinary Least Squares (OLS) model where all variables enter in levels[3]. The OLS model usually shows a high R^2 with a low Durbin-Watson statistic that indicates significant evidence of serial correlation in the residual (Gujarati 2006). To test for the co-integration of the series, the residual is expected to be stationary, i.e. to have a unit root[4]. In the spurious OLS regression, the t-statistic cannot be used to test hypotheses, because the variables are not stationary in levels.

The Augmented Dicky-Fuller (ADF) regression of the form

$$\Delta\vartheta_t = \delta_0\vartheta_t + \sum_{i=i}^{k} \delta_i \Delta\vartheta_{t-k} \tag{4.6}$$

is fitted to test for stationarity of the residual ϑ_t in equation 4.1. If there is evidence of a unit root the residual is non-stationary. K in equation 4.6 is an arbitrarily chosen lag period until the residual is found stationary when δ_i is significantly different from zero. Then β in equation 4.5, that is the parameter estimate of long-run supply elasticity, may be interpreted as the co-integration parameter from the linear combination of the series. However, error correction representation may result from this co-integration. The error is subsequently corrected by using the residual ϑ_t to estimate an ECM of the form:

$$\Delta Y_t = c + \alpha\Delta X_{t-n} + \lambda\vartheta_t \tag{4.7}$$

Olubode-Awosola *et al.* (2006) criticise the Engle-Granger approach because the estimate of the co-integration parameter from the statistic regression equation 4.1 could be subjected to small sample bias. They argue that this can be eliminated by estimating the ECM in dynamic form by replacing residual ϑ_t with the lagged variables $(Y_{t-1} - X_{t-1})$ and X_{t-1} resulting in the following unrestricted regression:

$$\Delta Y_t = c + \alpha_{t-n}\Delta X_{t-n} + \lambda_{1n}(Y_{t-n} - \beta X_{t-n}) + \lambda_{2n}X_{t-n} \tag{4.8}$$

Where, α is the short run elasticity of supply

λ_2 is the dynamic adjustment of supply

λ_1 is the coefficient of the error/equilibrium correction term of the co-integration equation that presents the period to adjust to the long-run equilibrium. In addition to this, λ_1 must be negative and significantly

[3] Time series data in levels refer to the data in their original form.

[4] Unit root: as mentioned, time series data could contain trends over time that make the series non-stationary (refer to footnote 1 in the current chapter). If a time series is non-stationary, implying that it contains trends, the series has a unit root. Thus, by conducting a unit root test, the existence of trends within the time series data is tested.

different from zero. Being negative implies that, if there is a deviation from the current and long-run levels, there would be adjustment back to the long-run equilibrium in subsequent periods to eliminate the disequilibrium.

If β is significant, the ECM captures the speculative behaviour of producers, otherwise the ECM is reduced to the Nerlove partial adjustment model. It should be noted that while static co-integration regression predicts the level of supply, the error correction predicts the changes so that the variation in the supply is necessarily higher. The new, corrected co-integration parameter estimate (long-run elasticity) β^* is computed as:

$$\beta^* = 1 - \frac{\lambda 2n}{\lambda 1n} \ or \ \frac{\lambda 2n}{\lambda 1n} \text{ if the fraction is negative} \qquad (9)$$

Due to the property of time series data to generate spurious regression results, co-integrated techniques received much attention to solve the statistical models associated with time series data. The ECM is one of the first approaches used to solve this problem. As mentioned, the ECM requires prior tests on the properties of the included variables in the model, in other words estimation of long-run co-integration relationships when variables are non-stationary.

4.3.3 The ARDL Bounds Test Approach

Co-integration techniques received much attention as they solve the statistical problems associated with non-stationary data series leading to spurious regression results. Various co-integration approaches are available, however all of them are associated with some limitations and assumptions. The Autoregressive Distributed Lag (ARDL) approach to co-integration, developed by Persaran, Shin and Smith (2001), tests for the existence of a non-spurious long-run relationship between economic and non-economic variables. Unlike other co-integration techniques, the ARDL model does not impose restrictive assumptions that all the variables in the study must be integrated of the same order. This implies that the ARDL approach can be applied regardless of whether the underlying variables are stationary, non-stationary or mutually integrated (Odhiambo 2009). Another difficulty that the ARDL approach avoids is the decision regarding the number of endogenous and exogenous variables to be included in the supply model, as well as the time lags applicable to each variable. The ARDL approach makes it possible to include different variables having different optimal numbers of lags within the supply model (Ogazi 2009).

Due to these problems, researchers propose the direct estimation of the long-run parameters using unrestricted error correction models (UECM) specified with the inclusion of dynamics (Olokoyo, Osabuohien & Salami 2009). The dynamic nature of production and market equilibrium makes it necessary to take into account the dynamics arising both from dependent and independent variables. By including all the identified variables for a selected unrestricted dynamic supply model with the appropriate time lags for each variable, the supply model transforms into an Autoregressive Distributed Lag Model. The bounds testing approach to the level relationship, together with the ARDL modelling approach to co-integration analysis developed by Persaran *et al.* (2001) involves Ordinary Least Square estimation of an ECM of the following;

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta Y_{t-1} + \sum_{i=1}^{q-1} \beta_i \Delta X_{t-i} + e_t \quad (4.10)$$

Where, Δ is the first difference operator

α_0 is the constant

Y_t is the dependent variable

X_t is the independent variable

e_t is the error term

p and q are the maximum lag orders

α_i is the long-run relationship (elasticities) among the variables

β_i is the short-run relationship among the variables

The existence of a long-run level relationship in an ECM framework between the dependent variable Y_t and the independent variable X_t can be tested when it is not known whether the underlying independent variable is stationary, non-stationary or mutually co-integrated with the ARDL approach.

The ARDL approach to co-integration analysis is divided into two stages:

The first stage involves the estimation of the ECM to compute the F-statistic [Wald-test] that is used for testing joint significance of the coefficients of the lagged level independent variables $(\alpha_1, \alpha_2, \dots \alpha_i)$ in the model. The significance of the F-statistic is determined using critical values developed by Persaran *et al.* (2001). These are bounds containing a band of critical values with upper and lower limits for different significance levels. If the F-statistic lies above the upper bound for a specific significance level, a non-spurious long-run relationship exists among the variables in the ARDL model. If the F-statistic lies below the lower bound critical value, there is no long-run relationship among the variables in the ARDL model (Getnet, Verbeke & Viaene 2005).

If the long-run relationship is confirmed with the Wald test among the variables, the second stage of the ARDL approach can be conducted. The second stage involves estimation of the long-run and short-run elasticities of the ARDL model. This approach is used to test for the presence of long-run relationships between supply output and factors (variables) influencing supply. After the long-run relationship is confirmed among the variables, Ordinary Least Square (OLS) regression is utilised to estimate the long-run and short-run elasticity coefficients of supply.

4.4 Conclusion

From this chapter it is clear that various approaches exist for conducting supply response studies. Linear programming and Econometrics are the most widely used approaches when supply response studies are conducted. Due to the extensive data requirement of linear programming it was not considered as an approach for this study. However, most of the supply response studies follow the econometric approach to analyse the relationship between economic variables. Initial work in this field, during which supply response on commodities was analysed, employed the directly estimated partial supply model that is based on work done by Nerlove (1956). Due to the limitations of the partial supply model and the properties of time series data leading to spurious regression results, the ECM became a more appropriate approach to supply response studies.

Co-integration analysis of integrated time series data within an ECM framework was developed by Engle and Granger (1987). The econometric approach of Engle *et al.* (1987) introduced the capability to compute a more non-spurious supply response analysis among co-integrated variables in an ECM supply response model. Various other econometric approaches to co-integration are available for supply response studies. The ARDL bounds testing approach to co-integration proposed by Persaran *et al.* (2001) overcomes a significant number of limitations of previous co-integration approaches. Hence, it is considered the most appropriate econometric approach to be followed in this study.

Chapter Five – Empirical Framework for Supply Analysis

5.1 Introduction

The methodology and approach (ARDL bounds testing approach) discussed in Chapter four are used as a framework for the mutton supply response analysis. This section covers the framework and specification of the supply model for mutton production in Namibia, as well as the variables that should be included in the supply model in order to align the model with the model hypothesised in theory. The estimation procedure used in order to compute the analysis is discussed in detail throughout this chapter.

5.2 Supply Model

5.2.1 The Supply Model

In the initial work done on supply of agricultural commodities, price was the only production variable to be included for analysis within the supply model. The main reason for including price as the only production (independent) variable in supply response analysis is because output price increases profit and an increase in profit provides an incentive for producers to produce more of a specific product. Profit is a function of input prices, output prices and volume. The change in input and output prices will increase or decrease the profit on a specific product. According to Panagiotou (2005) and Thiele (2002), there are other factors besides output and input prices that influence agricultural production. Rural infrastructure, human capital, technology and agroclimatic conditions are factors to be considered together with the price of a specific product, the prices of substitutes for the specific product and prices of complements to the specific product when constructing a model of supply.

Rural infrastructure includes roads to marketing facilities; marketing facilities; farm infrastructure, including fencing, water facilities and animal handling facilities; abattoirs; cold storage distribution centres; extension services; veterinary services and communication networks. All of these factors should be considered when constructing a supply model as they should have a positive effect on production.

Research and development and other technological factors are also expected to have a positive influence on agricultural supply. Due to agriculture’s dependence on natural resources, agroclimatic factors, such as rainfall, are likely to be the most decisive in agricultural supply (Tripathi 2008). Due to the qualitative nature of some of these data, only some of these factors can be included in the supply model.

According to Olubode-Awosola *et al.*(2006) other factors such as public investment and credit facilities should be taken into account when estimating supply response. Akinboade (1999) hypothesised that price incentives, economy-wide capital-labour ratio and technology influence agricultural supply.

Abbot and Ahmed (1999) researched the response of wool supply towards wool price and other alternative agricultural product prices, e.g. price of beef, mutton and grain crops.

Various factors stated by theory influencing supply can be included in the supply model; however, theory and practice do not correlate well under certain circumstances. Muchapondwa (2008) states that the theory of supply of a free market enterprise assumes instantaneous reaction between inputs and outputs, and this assumption is not always true in practice. According to Muchapondwa (2008), his statement is motivated by the following reasons:

1. The agricultural sector is characterised by biological lags between input application and output production. The biological nature of production periods and climate seasons leads to time lags in the production process that can change expectations and production objectives during the course of the production process.
2. For agricultural enterprises, there may be technological and institutional factors that prevent production decisions from being fully realised during any period, e.g. the Scheme that puts restrictions on the export marketing channels for producers.
3. There is an assumption that perfect knowledge and foresight is not valid for the majority of agricultural enterprises as well as the characterised high imperfections in price and other information.
4. The risk and uncertainty faced by agricultural enterprises is much higher than the risk and uncertainty faced by non-agricultural enterprises. In other words, producers (farmers) might have the objective to give preference to minimising risk and maintaining food security rather than maximising profit.

Therefore modifications and extensions might be required to model the realistic production processes of agricultural enterprises in this particular case, namely mutton production. To conclude, various studies have been done on supply response analysis with various supply factors playing an important role in model specification and selection.

5.2.2 Model Specification and Selection of Variables

The model specification and selection of variables influencing supply are the foundation of the supply response study. The aim is to start with a hypothesised general unrestricted model for supply including the dynamical specification suggested by theory. Through the course of study the aim will be to reduce the model size through testing various linear and non-linear restrictions. This will ultimately merge the model into a specific model addressing the requirements and constraints of the application, namely the mutton industry of Namibia.

Model specification is an important step in order to correctly model the phenomenon under study – the supply response of mutton. Model specification errors occur when, instead of estimating the correct model, another model is estimated. According to Gujarati (2006) the major specification errors encountered by researchers are:

1. Omission of relevant variables (under-fitting the model)
2. Inclusion of unnecessary variables (over-fitting the model)
3. Adoption of the wrong functional form
4. Errors in the measurement

The first specification error committed by researchers is the omission of relevant variables (under-fitting). Typical factors influencing supply that were not included in the model used in this study are described by Panagiotou (2005) and Thiele (2002). These factors include rural infrastructure, human capital, technology and agroclimatic conditions. However, the qualitative nature of some of these factors and the unavailability of data for these factors explain their omission.

The second potential error of specification is the inclusion of non-relevant (unnecessary) variables in the model. The third specification error is the adoption of the wrong functional form. In this case, the Log-Linear model was used to compute supply response. The reason for this is that the computed coefficients of the independent variables measure the elasticity of the dependent variable respective to the independent variable, keeping the other factors constant, where the linear model only measures the rate of change (slope) and not the elasticity. In the log-linear model not all variables need to be in logarithmic form. Some variables may be in the linear form as well.

The last potential specification error mentioned by Gujarati (2006) is errors in measurement. These errors include guess estimates, extrapolating, interpolating and round-off errors. The data used in this study have been modified for inflation. The inflation modified data were then transformed to their natural logarithms in order to compute elasticities. Therefore, errors in the measurement were limited to a minimum in this study.

According to Sarmiento and Allen (1998) more plausible results on computed supply response elasticities and tests of theory are possible under three conditions:

1. The model used in the analysis is based on a previously published model and therefore can reproduce a prior result
2. The model used cannot be rejected based on diagnostic specification error tests
3. The model contains robust estimates and conclusions

Variables that have been used in the various livestock supply response models (functions) are competitive grazers (production substitutes), weather (rainfall), calving/lambing percentages, condition of pastures, livestock population, producer prices, feed prices, livestock marketed (Von Bach 1990). The output factor (dependent variable) of the model may vary according to the scope of study. For a livestock supply response model a typical output variable is the quantity of livestock marketed over a specific time period or the quantity produced.

Recent work done by Ogundeji *et al.* (2011) showed input factors that should be considered for a typical livestock supply response model.

1. Economic Factors: In the case of Namibia, real producer price of sheep and substitute products, such as cattle and goats. The real producer prices of crops such as maize as a feed input, hence a support factor to livestock production.
2. Climatic Factors: Rainfall
3. Demographic Factors: Sheep population and population of substitute livestock
4. Trading Factors: Imports and exports of livestock

Von Bach *et al.* (1998) also included social factors in their supply response analysis, such as land rights and distribution of population.

Selection of variables suggested by theory and estimates of elasticities can be misleading under specification errors in the model, therefore more attention is given to misspecification tests (refer to Section 5.3.5) on the model residuals, and problems are resolved by the modification of the specification rather than using different variables in the supply model. This approach is based on the work done by Sarmiento and Allen (1998).

5.2.3 Empirical Model for Sheep Supply

The model used for this study is based on economic theory to select the variables influencing mutton supply and previous work done in this field of the livestock industry. However, as mentioned earlier, it is not always possible to estimate a model suggested by theory, because it is not always possible to include all the variables initiated by theory due to the non-availability[1] (due to an insufficient number of data points for selected variables) of data and quantification problems. In practice it is difficult, for example, to measure agricultural extension services. Considering the previous comment, the following model for mutton supply in Namibia was hypothesised. The supply model for sheep supply is based on livestock models used by Von Bach (1990), Abbot *et al.* (1999) and Ogundeji *et al.* (2011). However, most of these studies focus on beef supply in the Southern African environment.

Due to the similarities that exist between beef and mutton supply, the models used by these research studies were used as a framework for constructing a mutton supply model for this study. In order to compute the long-run and short-run elasticities of supply and to test relationships hypothesised by theory, the following model was hypothesised for mutton production in Namibia with the variables in their natural logarithm,[2] as indicated in equation 5.1:

$$lnY_t = \beta_0 + \beta_1 lnY_{t-n} + \beta_2 lnNP_{t-n} + \beta_3 lnPB_{t-n} + \beta_4 \, ln\,RF_{t-n} + e_t \quad (5.1)$$

[1] For accurate econometric results, more than 40 data points are required (Boshoff 2010). Due to an insufficient number of data points with annual data on selected variables, monthly data was used to exceed 40 points within the selected variables. Due to inappropriate data frequencies some variables were omitted from the supply model.

[2] Refer to functional form in Section 5.2.2.

Where,

lnY_t – the dependent variable of the mutton supply model. Mutton marketed per month is measured in sheep units. Mutton marketed includes the total number of sheep that have been traded through the available marketing channels, as discussed in Chapter two. This includes sheep marketed to local export abattoirs, local livestock auctions and export markets in South Africa. Sheep units produced (population numbers) could also have been used as a dependent variable in the supply model, but due to an insufficient data frequency (only annual data-leading to insufficient number of data points for analysis) on the sheep demographics of Namibia, sheep demographics were not considered as a dependent variable in the supply model.

lnY_{t-n} – a lag variable of mutton marketed is also included as an independent variable in the model leading to a general Autoregressive Distributed Lag Model (see Section 4.3). The reason for this inclusion is to start with the least restricted general model. It can also be hypothesised that last month's supply affects this month's mutton supply due to changes in stock numbers.

$lnNP_{t-n}$ – the real average monthly Namibian producer price (average sheep slaughter price, N$/kg across the four export abattoirs in Namibia). This variable is seen as an economic factor influencing supply. As in the law of supply, price plays an important role in product supply. As the sheep producer price rises, sheep supply would rise from a production perspective. The importance of this variable in the model cannot be underestimated. According to Seleka (2001), a positive sign in producer price would imply that sheep are viewed as a consumption commodity, and that a rise in prices causes producers to sell immediately in response to higher prices. On the other hand, a negative sign would imply that sheep are viewed as capital assests, the tendency to hold inventory (or to sell less) in response to a rise in current prices, in anticipation of higher future prices leading to the backward-bending supply curve.

The slaughter price is the average price among the carcass classification grades A2, B2 and C2. However the Namibian slaughter price only represents one marketing channel available to producers. Auction prices and South African slaughter prices could also have been included, as producers react to these indicators. Due to a high correlation between these prices, only one price representative is selected for the supply response model. Furthermore, most of the sheep are marketed through the local export abattoirs due to the introduction of the Small Stock Marketing Scheme (refer to increase in local slaughtering, see Figure 2.13). Therefore it is appropriate to include the average producer (slaughter) price offered by the local export abattoirs in the model.

$lnPB_{t-n}$ – the real average monthly Namibian producer price for beef (average beef slaughter price, N$/kg), included as an economic factor that functions as a substitute for mutton in the red meat market. The beef producer price is hypothesised to influence the mutton supply negatively as it acts as a substitute to mutton supply. The increase of beef prices would have a negative effect on mutton supply due to the fact that farmers would decrease their sheep flocks and rather convert to a higher proportion ofbeef production system. The average beef price was computed over the beef carcass classification grades A2, AB2, B2 and C2. Another mutton substitute is goat meat. As the price of goats increases it is hypothesised that producers tend to produce more goats and this has a negative effect on mutton supply. Due to the fact that goat production is more favoured in the Northern communal areas of Namibia, beef was included as a substitute to mutton as part of the supply model.

$lnRF_{t-n}$ – the average monthly rainfall, measured in millimetres per month, across Namibia and is included as a climatic factor influencing supply. Rainfall is included as a weather variable and is used as an indicator for the condition of Namibia's natural feed resources. High correlation exists between rainfall and condition of grazing, therefore rainfall can be included as a presentable independent variable representing climate (Von Bach 1990). The flock size of the sheep for an enterprise depends on grazing conditions. As the monthly rainfall increases, a production unit would increase its herd size that will lead to higher production. Therefore rainfall has a positive effect on mutton supply.

e_t – is the error term in the model

β – is the unknown population parameters to be estimated

t – represents the time period

n – represents the time lags in the model

Supply in many agricultural commodities reflects the *cobweb phenomenon*, where supply reacts to price and other factors with a lag of one time period or more due to the time it takes for supply decisions to become implemented decisions (Gujarati 2006). Due to the biological lags between input application and output production, as discussed in Section 5.2, time lags are included in the model. The lags in this sheep supply model are specified as the maximum to be expected in the light of the technical nature of sheep production.

Due to the introduction of the Small Stock Marketing Scheme in June 2004, marketing patterns were disrupted, as discussed in Chapter two, and this disruption has influenced the mutton marketed per annum. Therefore a structural break is appropriate to eliminate the effect of the scheme. However, no visible effect[3] of unnatural supply shocks exists in the mutton supply in the short-run or long-run (see Figure A.1) and therefore no structural break was included in the model.

Factors influencing supply that were not included in the mutton supply model (equation 5.1) are demographic factors, such as sheep population. The sheep population census is done on an annual basis by the Directorate of Veterinary Services in Namibia which makes this supply factor inappropriate due to a lack of monthly frequency data. In spite of the periodic collection of data, the census data are only available up to 2006, therefore sheep population was not considered as a demographic factor influencing supply.

[3] No visual effect – Refer to Figure A.1 in Annexure A. Since the introduction of the Scheme on 1 July 2004, no observable change (dramatic change in the trend) in mutton marketed is visible, therefore a structural break was neglected.

Technology is a factor of production having an influence on supply. However, the data set that is used in this analysis covers a seven-year period, which is a relatively short period as regards a change in technology in an extensive mutton production environment. Therefore technology was omitted from the mutton supply model as an independent variable.

Input costs for production are a factor to be considered for the supply of a product. In a mutton production environment, typical direct production costs will include: costs of feeds, costs of licks and veterinary and medicine costs. According to Schutz (2009) the direct production costs of a primary mutton producer's cost structure amount to 10% of the total revenue. As this factor is relatively small in an extensive production environment, it is clear that the direct production cost has a small effect on the producer's decision making regarding production. Therefore costs of production were not considered in the mutton supply model.

Trade data relating to meat imports and exports also influence supply. Namibia is an excess producer of mutton and therefore a net exporter of mutton. Therefore the mutton marketed is well correlated with mutton exported to export markets. Due to statistical problems that may arise due to multi-collinearity, the sheep exported could not be included as a trade variable influencing supply.

From equation 5.1 an Unrestricted Error Correction Model type of ARDL model can be expressed as:

$$\Delta LY_t = \alpha_0 + \alpha_1 LY_{t-1} + \alpha_2 LNP_{t-1} + \alpha_3 LPB_{t-1} + \alpha_4 LRF_{t-1} + \sum_{i=1}^{m} \beta_0 \, \Delta LY_{t-i} + \sum_{i=0}^{m} \beta_1 \, \Delta \, LNP_{t-i} + \sum_{i=0}^{m} \beta_2 \, \Delta LPB_{t-i} + \sum_{i=0}^{m} \beta_3 \Delta LRF_{t-i} + e_t \qquad (5.2)$$

Where, α_j for j = 0 is the constant

α_j for j = 1 to 4 shows the long-run dynamics of the supply model

β_j for j = 1 to 3 represent the short-run dynamics of the supply model

Δ is the first difference term

e_t is the white noise disturbance term (error term)

Neither the theory nor generic research provides a basis for specifying the lag lengths on distributed lag models. In this ARDL it is sensible to start at a maximum lag length of 12 months. The motivation behind 12 months is based on the fact that the maximum lag length appropriate for the supply dynamics of sheep production is 12 months, due to rainfall seasons within the extensive production system of livestock in Namibia.

5.3 Estimation Procedure

All the estimations were performed using the standard version of Eviews 7.0 (Econometric software) that is generally used for econometric and statistical analysis.

5.3.1 Test for Seasonality

In order to compute supply elasticities, various tests are computed beforehand to eliminate spurious regression results and unstable models. The time series data of the selected variables first have to undergo analytical statistical tests before they can be used to compute short-run and long-run elasticities. The first test on the data is the test for seasonality in the data. The motive behind the test is the fact that quarterly or monthly frequency data exhibit seasonal patterns. It is utilised to remove the seasonal component of time series data (deseasonalisation), so that the regression can concentrate on the other attributes of the time series data. Several methods exist, suitable for removing the seasonal component of time series data. The most common method is the use of dummy variables also known as the *method of dummy variables* (Gujarati 2006) (refer to Section 6.3).

Dummy variables are included in the model to represent the 11 months of the year, with the 12th month used as a reference month, and can be expressed as:

$$Y_t = \beta_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 D_3 + \beta_5 D_4 + \beta_6 D_5 + \beta_7 D_6 + \beta_8 D_7 + \beta_9 D_8 + \beta_{10} D_9 + \beta_{11} D_{10} + \beta_{12} D_{11} + u_t \tag{5.3}$$

Where,

Y_t is the mutton marketed in time t

D_i are the dummies for January to November, taking a value of 1 for the relevant month and 0 for the rest of the months. December is used as the reference month.

It is important that only 11 dummy variables are included in the model in order to avoid the dummy variable trap[4] (Gujarati 2006). The test for seasonality is repeated for all the variables that are included in the mutton supply model. If the regression model in equation 5.3 shows significant results, seasonality may exist in the data and therefore the data of the appropriate variable should be adjusted for seasonality.

5.3.2 Unit Root Test for Stationarity

The second test on time series data is the test for the presence of a unit root by estimating an Augmented Dickey Fuller (ADF) equation with a deterministic trend and with a constant in the equation, as discussed in Section 4.3.2. The equation can be mathematically presented as:

$$\Delta LY_t = \beta_0 + \beta_1 T + \beta_2 LY_{t-1} + e_t \tag{5.4}$$

Where,

Δ is the first difference of mutton supply ($\Delta Y_t = (Y_t - Y_{t-1})$), T is the trend variable and β_0 is a constant. Y_{t-1} is the one-period lagged variable of the dependent variable Y_t. The null hypothesis

[4] Dummy variable trap: the dummy variable trap is avoided by including only eleven dummy variables for twelve months of the year. This is to avoid the situation of perfect collinearity among the variables, i.e. a situation where there would be an exact linear relationship among the variables in the model (Gujarati 2006).

states that coefficient β_2 of (Y_{t-1}) is zero. This is another way of expressing that the series is non-stationary. This is also called the *unit root hypothesis* (Gujarati 2006) [If the absolute computed t value of the coefficient β_2 is larger than the critical t values computed by the ADF test then we can reject the unit root hypothesis and we conclude that the time series is stationary.]

The reason for performing the unit root test is to verify that the variables are stationary in levels in order to determine the order of integration of the variables. If there are non-stationary variables the unit root test is repeated for the variables in the first differences[5] also with a deterministic trend and constant term in the equation. The number of times the series needs to be differenced indicates its order of integration, therefore variables that are stationary in levels are integrated of order zero I(0), and variables that need to be differenced once to make them stationary is integrated of order one I(1). The unit root test is important to determine the order of integration of the variables that are included in the mutton supply response model.

5.3.3 ARDL Bounds Test

The ARDL model (equation 5.2) is transformed into a more specific model by a step-by-step elimination of insignificant lags and variables from the general model. As mentioned in Section 4.3.3, the ARDL method involves the examination of the existence of long-run relationship among all the variables in the supply model. The second stage can only be initiated once a long-run relationship between the variables has been determined by the Wald-Coefficient test [F-test]. Here the joint significance is evaluated by testing the null hypothesis of no co-integration: all the lagged level variables are set to zero or against the alternative hypothesis that the coefficients of all the lagged variables in the model are not equal to zero (Hoque & Yusop 2010). Considering the mutton supply model in equation 5.2 the null and alternative hypotheses are:

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$$

$$H_A: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$$

The estimated F-statistic is checked for the null hypothesis and whether all long-run coefficients are jointly equal to zero. At the significance levels of 1%, 5% and 10% the calculated F-statistic is compared to the respective case of bound critical values tabulated by Persaran *et al.* (2001). The tables developed by Persaran *et al.* (2001) present the critical values for five different cases to show whether the model contains a trend and/or an intercept. These critical values contain upper and lower bounds for the estimated F-statistic, covering all the classification variables into I(1), I(0) and mutually integrated.

If the estimated F-statistic is larger than the upper bound of the critical value, then the null hypothesis of no co-integration is rejected and a long-run relationship exists among the variables (variables are co-integrated). If the estimated F-statistic is smaller than the lower bound of the critical value, the null hypothesis of no co-integration is accepted and no long-run relationship exists among the lagged level

[5] First difference – $\Delta Y_t = (Y_t - Y_{t-1})$.

coefficients. However, if the estimated F-value falls between the upper and lower bounds, the long-run relationship is considered inconclusive.

The order of integration among the variables is important for any conclusion. If the variables are integrated of the order zero I(0), the variables are tested for a long-run relationship according to the lower bound of the critical values and if the variables are integrated of the order I(1), the estimated F-statistic is compared to the upper bound critical value (Hoque & Yusop 2010).

5.3.4 Misspecification Analysis

According to Sarmiento *et al.* (1998) previous studies lack tests for model performance to diagnose whether test of theory or elasticity estimates are subjected to different types of specification errors. Only a few studies on supply response go beyond the Durbin-Watson test in reporting the performance of their model specification.

As mentioned previously in Section 5.2.2, misspecification tests must be employed in order to test for the validity of the supply model. These parameter tests are shown at the bottom of the tables in Chapter six where the parameter estimates and diagnostics statistics are presented. These diagnostic statistics include tests for heteroscedasticity, serial correlation, stability of long-run coefficients, and the Jarque-Bera normality test of the residuals. The Durbin-Watson statistic is also checked for autocorrelation.

To test for regression model specification, the test developed by Ramsey, called the RESET (regression error specification test), is utilised. The test is executed by testing the relevance of adding the square of the predicted values to the original model (Susanto, Rosson & Henneberry 2008). The F-test is computed; if the F-test is statistically significant at the chosen level of significance it can be concluded that the initial model was misspecified. Unfortunately, the RESET does not advise on the misspecified variables in the model. Therefore various models are computed to test various combinations of variables and time lags influencing mutton supply in order to eliminate misspecification errors.

The quantity R^2 is defined as the coefficient of determination and is most commonly used to measure the goodness of fit of the regression line, or the elasticities computed in the supply model. R^2 measures the proportion or the percentage of the total variation in the dependent variable explained by the estimated regression model (Gujarati 2006). However, if models are compared where the number of independent variables may vary between the models, the degrees of freedom[6] should also be taken into account when comparing these models. Therefore the Adjusted R^2 is used when models are compared where the number of independent variables differs between the models.

[6] Degrees of freedom refer to the differences between the total number of data points and the number of independent variables included in the model. The degrees of freedom should always be positive.

5.4 Data Source

The data required for the supply response analysis were obtained from the Meat Board of Namibia. The data are published on a monthly basis by the Meat Board through industry feedback reports. Livestock marketed as well as livestock producer prices were obtained from the monthly published reports. The rainfall figures were obtained from the Meteorological Service of Namibia. Data of three weather stations (Grootfontein, Windhoek, Keetmanshoop) were used to calculate the country's monthly average that was used in the model. The locations of these stations are indicated in Figure 5.1.

The Namibian producer price data were deflated to real price data by dividing the monthly nominal prices of the selected price variables by the monthly Consumer Price Index[7] (CPI) obtained from the *Central Bureau of Statistics* in Namibia. The response analysis time span covers January 2003 – December 2009. This period was selected for analysis, because of the availability of data sets for all the variables included in the model.

Figure 5.1: Selected Weather Stations in Namibia

(Source: www.climate-zone.com)

5.5 Conclusion

In Chapter five the mutton supply response model was constructed. Several supply response studies have been reported in literature. Work done by Von Bach (1990), Abbot *et al.*(1999) and Ogundeji *et*

[7] Researchers tend to use the Consumer Price Index, rather than the Producer Price Index, to deflate price related factors in supply response analysis.

al. (2011) was used as a framework for the supply model for this study. Literature suggests that a range of variables should be included in the supply response model. However, before considering a model, three aspects should be considered: 1) The scope of study (final outcome); 2) Data availability of the variables to be included in the model and 3) The factors influencing supply, suggested by theory. Therefore, a compromise between theory, scope of study and data availability needs to be found in order to obtain the best representable model for the supply response study.

Considering these factors, the mutton supply response model for the Namibian industry was hypothesised. Monthly mutton marketed represents the dependent variable in the model, where the average real Namibian mutton producer price, real Namibian beef producer price and monthly rainfall were included as factors (independent variables) influencing supply.

A review of the methodology used in the estimation of the elasticities is provided as well as the data to be used in the study. Emphasis is placed on model specification tests in order to ensure that the hypothesised model is statistically significant. Specification tests include the test for serial correlation, heteroscedasticity, model stability, test for normality in the model residuals and model specification. Satisfactory results on the specification tests ensure reliable results from the supply model and are therefore an important part of the study.

Chapter Six – Results and Discussions

6.1 Introduction

The empirical work of the mutton supply response analysis is covered in Chapter six. This work incorporates the hypothesised model, estimation procedure and data described in Chapter five as well as the approach discussed in Chapter four in order to obtain the required model elasticities. The data for the model are first examined for seasonality, after which they are tested for stationarity. These pre-tests are required to determine the statistical properties of the variables before they are entered into the ECM model. The Wald test is subsequently applied in order to determine whether there is a long-run relationship among the variables in the specified model. Long-run and short-run elasticities are obtained from the model and are interpreted according to the theory and previous work done in the field. The chapter concludes with a final discussion of the results obtained.

6.2 Descriptive Statistics

Table 6.1 shows the statistical properties of the data used in the mutton supply function. The mean, standard deviation, maximum and minimum of the variables of the model are presented for the specified time frame. On average, 86 654 sheep units are marketed per month with an average standard deviation of 26 442 units. The average Namibian mutton producer price is N$18.83/kg with a standard deviation of N$1.46/kg. The average beef producer price is N$12.70/kg with a standard deviation of N$1.90/kg. The average monthly rainfall is 33.42 mm with a standard deviation of 46.12 mm per month. Table 6.2 shows the natural logarithmic statistical properties of the variables of the mutton supply model. Figure 6.1 shows the variables in their natural logarithm form.

Table 6.1: Statistical Properties of the Original Data

Original Data				
	Yt [units]	**NPt [N$/kg]**	**PBt [N$/kg]**	**RFt [mm]**
Mean	*86654*	*18.83*	*12.70*	*33.42*
STD Deviation	*26422*	*1.46*	*1.90*	*46.12*
Maximum	*160815*	*22.37*	*15.95*	*244.03*
Minimum	*33879*	*16.19*	*9.65*	*0.00*

Table 6.2: Statistical Properties of the Natural Logarithm of the Original Data

LN(Seasonal Adjusted Data)				
	LN(YXt)	**LN(NPt)**	**LN(PBt)**	**LN(RFXt)**
Mean	*11.32*	*2.93*	*2.53*	*2.28*
STD Deviation	*0.19*	*0.08*	*0.15*	*0.62*
Maximum	*11.67*	*3.11*	*2.77*	*4.13*
Minimum	*10.61*	*2.78*	*2.27*	*0.90*

The graphical presentation of the time series data used in the supply model including mutton supply, mutton producer price, beef producer price and monthly rainfall can be seen in Figures A.1 to A.3.

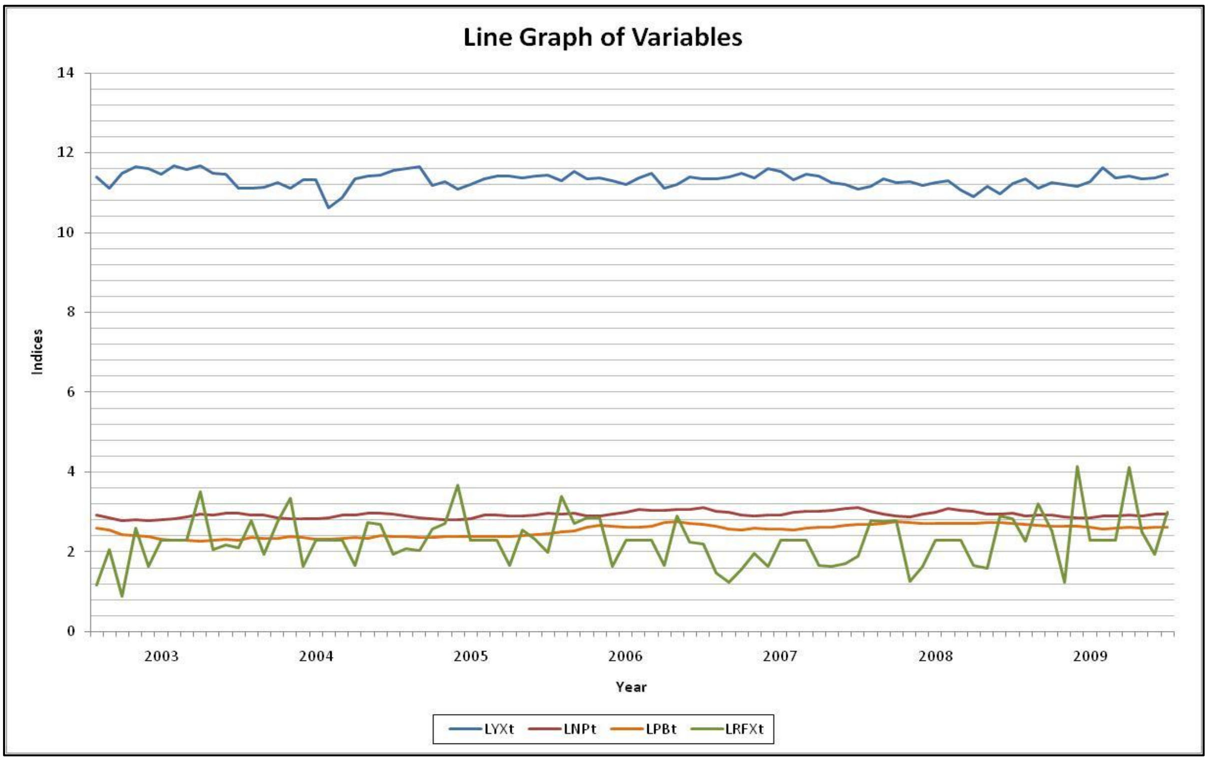

Figure 6.1: Graphical Presentation of Natural Logarithms of Data

6.3 Test for Seasonality

Table 6.3 shows the regression results obtained from the test for seasonality for all the variables of the mutton supply model. According to the goodness of fit (R^2) and the significance of the regression coefficients, Sheep Marketed $[Y_t]$ and Monthly Rainfall $[RF_t]$ are the most likely to contain seasonal factors. These results correlate well with what was expected due to the fact that supply is influenced by rainfall.

Table 6.3: Results of Seasonality Tests for Model Variables

	YT		NPT		PBT		RFT	
Variables	*Coefficient*	*t-statistic*	*Coefficient*	*t-statistic*	*Coefficient*	*t-statistic*	*Coefficient*	*t-statistic*
C	11.35	146.76***	2.95	120.55***	2.55	41.65***	4.39	17.53***
D1	0.12	1.14	-0.03	-0.77	-0.02	-0.24	0.00	0.01
D2	0.28	2.55**	-0.07	-2.16**	-0.02	-0.23	-0.40	-1.12
D3	0.31	2.79***	-0.09	-2.65**	-0.01	-0.10	-1.02	-2.89***
D4	0.26	2.36**	-0.08	-2.30**	-0.02	-0.22	-3.74	-10.56***
D5	0.22	1.99*	-0.05	-1.44	-0.05	-0.57	-4.39	-12.40***
D6	-0.21	-1.97*	0.00	0.08	-0.06	-0.66	-4.39	-12.40***
D7	-0.30	-2.77**	0.02	0.44	-0.04	-0.47	-4.39	-12.40***
D8	-0.36	-3.30***	0.02	0.54	-0.02	-0.27	-3.78	-10.67***

D9	-0.32	-2.96***	0.02	0.56	-0.01	-0.16	-1.40	-3.96***
D10	-0.31	-2.79***	0.04	1.17	0.00	0.01	-0.71	-2.02*
D11	-0.05	-0.44	0.06	1.63	0.00	0.02	-1.07	-3.03***
R^2	0.64		0.38		0.02		0.89	
DW-Stat	0.95		0.21		0.04		1.86	

*** Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level, * significantly different from 0 at 10% level.

For the remainder of the analysis, the two variables Sheep Marketed and Monthly Rainfall are seasonally adjusted. The deseasonalisation of the data by the method of dummy variables is used to eliminate the seasonal component. A residual series (difference between estimated value of the dependent variable and the actual value of the dependent variable) of the regression obtained in Table 6.3 is generated for sheep marketed and rainfall. The residual series is added to the mean value of the original series of Sheep Marketed and Monthly Rainfall. The new deseasonalised series of Sheep Marketed and Monthly Rainfall are shown in Figures 6.2 and 6.3.

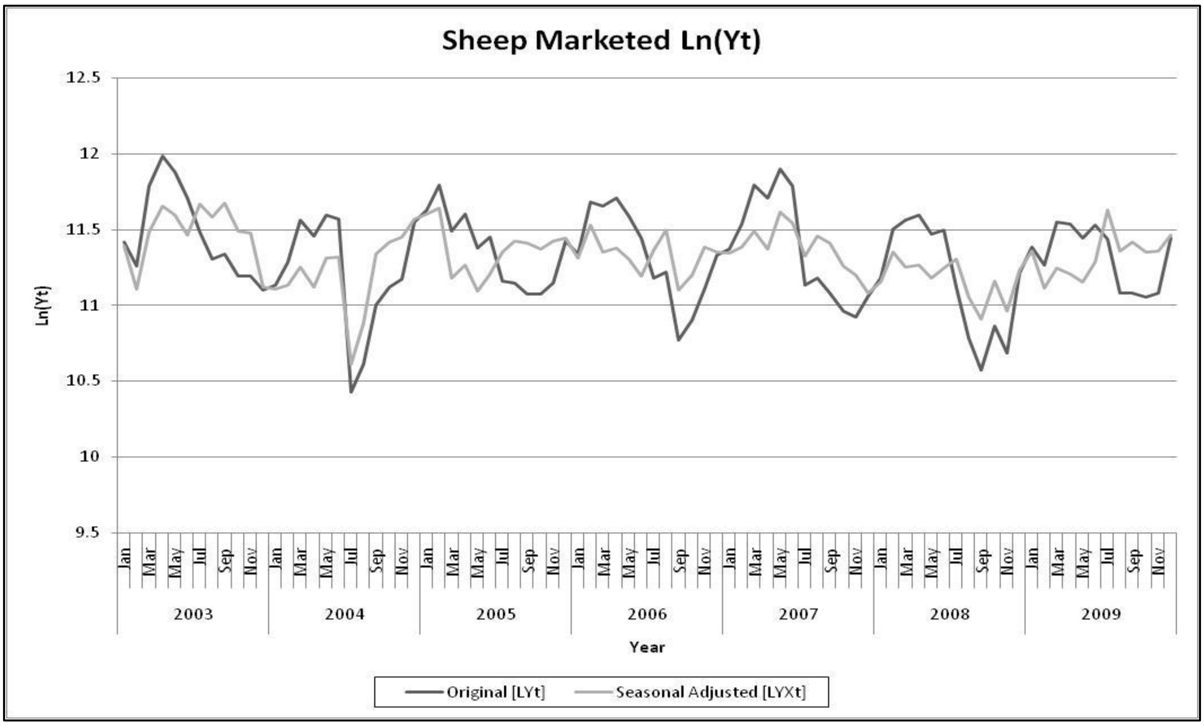

Figure 6.2: Seasonally Adjusted Trend of Sheep Marketed

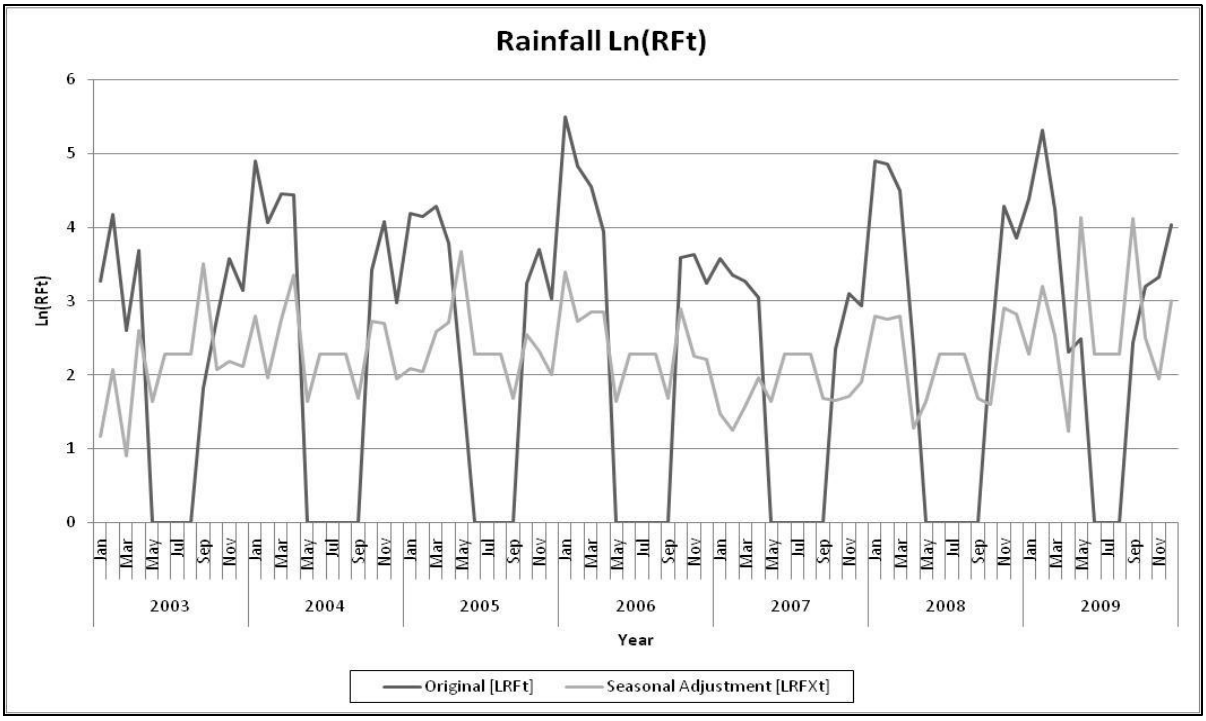

Figure 6.3: Seasonally Adjusted Trend of Rainfall

6.4 Test for Stationarity

In this section the stationarity properties of the supply model variables are determined. The ARDL approach followed in this study avoids the pre-testing requirement on the time series properties. However the stationarity properties are needed to test for a long-run relationship among the specified variables in the Engle-Granger and Johansen approaches to co-integration. The Wald test incorporates the long-run relationship among variables (whether variables are nonstationary, stationary or mutually co-integrated); therefore the unit root test is not applicable in the ARDL approach. However, it is still essential to complement the estimation process with a unit root test in order to be sure that the variables to be included in the analysis are integrated of higher order, i.e. I(2) according to Olokoyo *et al*. (2009).

Table 6.4: Results of the Unit Root Tests

In Levels					First Differences		
Variables	**No Intercept**		**Intercept**		**Variables**	**Intercept**	
	ADF	***Inference***	***ADF***	***Inference***		***ADF***	***Inference***
LYt	-0.02	Accept H_0	-5.00***	Reject H_0	**ΔLYt**	-9.28***	Reject H_0
LNPt	0.14	Accept H_0	-3.60***	Reject H_0	**ΔLNPt**	-6.91***	Reject H_0
LPBt	0.20	Accept H_0	-1.38	Accept H_0	**ΔLPBt**	-6.19***	Reject H_0
LRFt	0.31	Accept H_0	-8.72***	Reject H_0	**ΔLRFt**	-7.08***	Reject H_0

*** Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level, * significantly different from 0 at 10% level. (Ho: There is a unit root)

The results of the unit root test conducted for the specified variables of the mutton supply model are presented in Table 6.4. The unit root tests conducted use the Augmented Dicky-Fuller (ADF) test in both scenarios, 1) with intercept without trend, and 2) no intercept without trend (see Figure 6.1). As mentioned in Section 5.3.2, the null hypothesis for the unit root test is the test for the presence of a unit root (time series is non-stationary).

It is apparent from Table 6.4 that mutton supply (LYt), Average Real Mutton Producer Price (LNPt) and Monthly Rainfall (LRFt) are stationary in levels with an intercept. The null hypothesis of non-stationary (presence of a unit root) was accepted for Average Real Beef Producer Price (LPBt) in levels. The Average Real Beef Producer Price was differenced once to make it stationary, resulting in the Average Real Namibian Beef Producer Price to be integrated of order one, I(1) where the other variables are integrated of order zero, I(0). The stationarity properties of mutton marketed, average real beef producer price and monthly rainfall agree with results obtained from Ogundeji *et al.* (2011), while the same results were found for average real producer for sheep in a study conducted by (Rezitis & Stavropoulos 2009).

We can conclude that none of the variables in the mutton supply function is integrated of an order higher than one I(1). With the stationarity properties of the data known, the next step of the supply response analysis can be initiated using the ARDL approach.

6.5 Estimated ARDL Model for Mutton Supply

In order to analyse the supply response of mutton towards various price and non-price factors, a UECM version of the ARDL model was obtained in equation 5.2. According to Tang (2003) a mean UECM is desirable in order to confirm the explanatory variables to be included in the model. The general model was tested downward sequentially to arrive at a more specific model for mutton supply. In the selection of the specific model, all the first differenced variables that have relatively small t-values (less than one) were dropped sequentially. Various lagged variables of the general model were dropped due to low t-values leading to insignificant results. The more specific model is estimated and reported in Table 6.5. The results include the regression coefficients with their significance levels. Ordinary Least Square regression was used to compute the results obtained in Table 6.5.

Table 6.5: Estimated ARDL Model Based on the Mutton Supply Function

Model [ΔLYX_t]		
Variables	***Coefficient***	***t-statistic***
C	3.618**	2.287
$DLNP_t$	-0.749	-1.408
$DLNP_{t-2}$	-1.210**	-2.489
$DLNP_{t-4}$	-1.723*	-3.204
$DLNP_{t-10}$	-1.246*	-2.757
$DLNP_{t-12}$	0.779***	1.754
$DLPB_{t-1}$	1.275***	1.969
$DLPB_{t-4}$	-1.861*	-2.940

$DLPB_{t-11}$	1.216**	2.425
$DLRFX_{t}$	-0.050***	-1.817
$DLRFX_{t-1}$	-0.157*	-2.771
$DLRFX_{t-2}$	-0.106**	-2.327
$DLRFX_{t-3}$	-0.103*	-3.030
D407	-0.649*	-4.736
LYX_{t-1}	-0.516*	-5.705
LNP_{t-1}	1.020**	2.335
LPB_{t-1}	-0.440*	-2.914
$LRFX_{t-1}$	0.153**	2.176
R^2	0.67	
R^2 Adjusted	0.56	
Durbin-Watson	2.26	
F-stat	6.27	
P-value	0.00	

*** Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level, * significantly different from 0 at 10% level. Due to the time lags in the model, the adjusted sample period is Feb 2004 – Dec 2009.

The magnitude of the adjusted coefficient of determination (R^2 adjusted) and the F-statistic shows the supply model's goodness of fit. Based on the volume of the adjusted coefficient of determination, the explanatory variables explain 56 percent of the variation in the dependent variable. The residual plot for the mutton supply model in Table 6.5 can be seen in Figure B.1 (see Annexure B), where the difference between the *actual* and *fitted* data is presented.

Table 6.6: Diagnostic Tests for ARDL Model

Diagnostic Tests			
Test of Normality			
Jarque-Bera		0.182	
Serial Correlation LM Test: Breusch-Godfrey			
F-statistic	*1st Order*	2.106	[0.152]
	2nd Order	1.437	[0.247]
	3rd Order	0.946	[0.425]
Heteroskedasticity: ARCH			
F-statistic	*1st Order*	0.388	[0.535]
	2nd Order	0.175	[0.840]
	3rd Order	0.121	[0.947]
Specification: Ramsey RESET			
F-statistic		0.377	

Diagnostic tests are based on F-statistics, and figures in [ ] represent the probability-values

Misspecification in the regression is possible and therefore it is important to test the assumptions of the statistical model. According to Hendry and Nielsen (2007) various tests are available to test misspecifications in regression models. These tests include tests for normality, heteroscedasticity and the regression specification error test (RESET) that was introduced by Ramsey in 1969 (Hendry *et al.* 2007). Therefore the validity of the specific mutton supply model is confirmed by utilising relevant diagnostic tests. The tests included the Jarque-Bera test for normality, the Breusch-Godfrey test for serial correlation, the ARCH test for heteroscedasticity, the Ramsey RESET test for model specification and the CUSUM and CUSUM of Squares test for model stability.

The Jarque-Bera statistic confirmed the normality behaviour of the residuals of the estimated mutton supply model (See Table 6.6). The Breusch-Godfrey LM test statistic rejects the first, second and third order serial correlation in the mutton supply model. The ARCH tests verify that residuals are homoscedastic in the supply model. The Ramsey RESET test shows no evidence of functional form misspecification in the rejection of the hypothesis of misspecification.

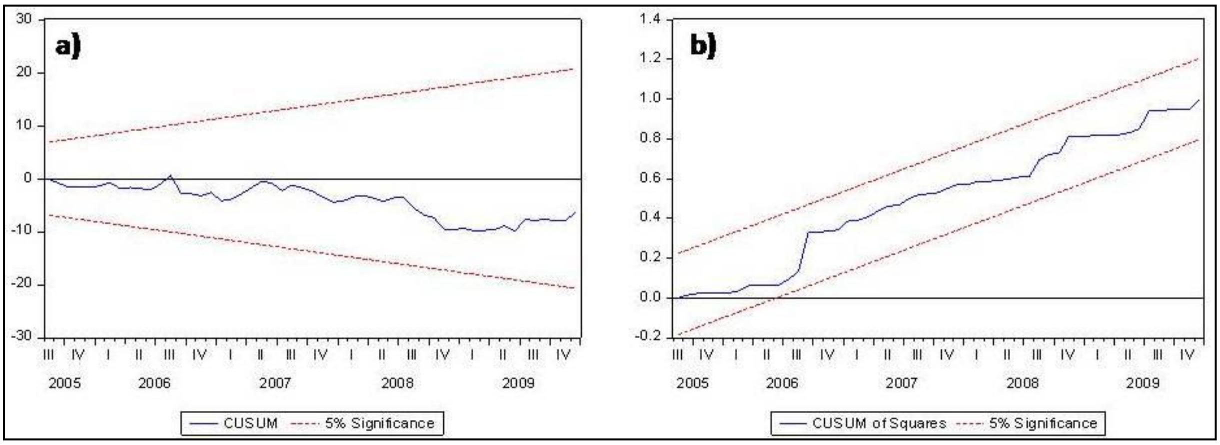

Figure 6.4: a) Results of the CUSUM Test and b) Results of the CUSUM of Squares Test

The cumulative sum (CUSUM) and CUSUM of squares tests validate the stability within the model parameters over the adjusted sample period of the mutton supply model. Figures 6.4 (a) and 6.4 (b) show the CUSUM test and CUSUM of squares test for stability at a 5% significance level. According to Ogazi (2009) the null hypothesis (which means that the regression equation is correctly specified) cannot be rejected if the plot of these CUSUM and CUSUM of squares statistics remains within the critical bound of the 5% significance level. Therefore as the plots of the CUSUM and CUSUM of squares remain within the 5% significance bounds it can be concluded that the statistics confirm the stability of the long-run coefficients in the model.

6.6 Results on ARDL Bounds Test

Once the ECM is specified and estimated, the next step is to test for the joint null hypothesis of no long-run level relationship. As mentioned in Section 5.3.3, the presence of a long-run relationship among the variables is tested with the aid of the Wald 'Bounds' test. The results obtained from the 'Bounds' test is presented in Table 6.7.

Table 6.7: Wald Bounds Test for Co-integration of the ARDL Mutton Supply Function

Wald Test (F-test)	
Computed F-statistic ***Null Hypothesis : no co-integration***	10.21
(H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$)	
Critical Value Bounds at 1% level[a]	
Lower Bounds, *I(0)*	4.29
Upper Bounds, *I(1)*	5.61

[a]Values from (Persaran, Shin & Smith 2001), p300, Table CI(iii): unrestricted intercept and no trend (three regressors, k=3)

The computed F-statistics for the mutton supply model in Table 6.7, based on the Wald test, is 10.21. This result clearly exceeds the lower bound value I(0) of 4.29 at a 1% significance level. Thus the null hypothesis of no co-integration is rejected for the supply model and a non-spurious long-run relationship is confirmed among the monthly mutton marketed, real Namibian mutton producer price, real Namibian beef producer price and monthly rainfall for mutton supply in Namibia. This result implies that these variables move together and so cannot move 'too far away' from each other independently (Hoque & Yusop 2010). From this result we can conclude that any disequilibrium among the variables in the supply model is a short-run phenomenon.

6.7 Short-Run and Long-Run Elasticities

The long-run elasticities of the production variables included in the mutton supply model, influencing supply, are calculated from the computed coefficients of the respective lag level independent variables (LNP_{t-1}, LPB_{t-1}, $LRFX_{t-1}$), divided by the coefficient of the lag level dependent variable (LYX_{t-1}) of the specific ECM mutton supply model in Table 6.5. The results are multiplied with a negative sign to obtain the long-run supply elasticities of the various variables on mutton supply.

In explaining the long-run elasticities of equation 5.2, Table 6.8 shows the elasticities obtained from the analysis. All the long-run variables contain the expected signs and are statistically significant. The average real Namibian mutton price elasticity of supply is elastic with the expected positive sign. This means that, if the average real Namibian mutton producer price increases by one percent, the mutton marketed will increase by 1.97 percent in the long run. Related to this factor, there is a positive relationship between the mutton producer price and the number of sheep marketed, i.e. the mutton producer's decision to market sheep for slaughter is positively influenced by price in the long run.

Similar long-run price elasticities of mutton supply were found in work done by Rezitis and Stavropoulos (2009) on the Greek mutton industry. Rezitis *et al.* (2009) found a long-run price elasticity of supply of 1.79 for the Greek sheep industry.

Table 6.8 Long-Run Elasticities for ARDL Mutton Supply Function

Long-Run Elasticities	
Variable	***Dependent Variable LYXT(-1)***
	Long-run
LNPT(-1)	1.97**
LPBT(-1)	-0.85*
LRFXT(-1)	0.29**

*** Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level, * significantly different from 0 at 10% level

The average real Namibian beef producer price elasticity of supply is inelastic with a negative sign. In practical terms the explanation is that when the beef price increases, mutton supply decreases in the long run, since beef is a substitute for mutton in the production environment. The reason for this behaviour is that producers will start to reduce the mutton production as beef production is more profitable as the beef price increases. The average real Namibian beef producer price elasticity of supply is -0.85. If the beef price increases by one percent the mutton (sheep) marketed will decrease by 0.85 percent.

In Chapter one it was stated that there is a need for this study, due to the lack of other similar studies in this field. The further effect of this situation is that there is a complete lack of similar studies for comparative purposes. However, the long-run price elasticity of substitute products can be compared to those of Ogundeji *et al.* (2011), who researched supply response of beef in South Africa. Their research obtained a substitute product price elasticity of supply of -0.31. This is less than the results obtained in this study, the difference between these elasticities can be assigned to the fact that their work incorporated the price of various substitute products[1] and not only one product (i.e. beef) as in this case.

The long-run rainfall elasticity of supply is inelastic and has a positive sign. As expected, the positive sign of rainfall has a positive effect on mutton supply in the long-run: as rainfall increases, mutton supply will increase. The long-run rainfall elasticity is 0.29, which translates to the fact that when rainfall increases by one percent the mutton supply increases by 0.29 percent in the long-run. Long-run elasticity for rainfall obtained from Ogundeji *et al.* (2011) is -0.25 compared to this study of 0.29. The magnitude for these studies is the same, but the elasticities' signs are opposites. Ogundeji *et al.* (2011) state that the negative influence of rainfall on supply appears when there is sufficient rainfall; the producers will tend to market less of their livestock in order to rebuild the stock depleted during a preceding drought period. However, sufficient rainfall could also motivate producers to market their stock, as sufficient rain leads to good grazing conditions that accelerate finishing of the stock to market readiness.

[1] Ogundeji et al. (2011) included a weighted average price of mutton, pork and chicken as a substitute price for beef. Pork and chicken producer prices were not considered for this model, as pork and chicken are to a lesser extent a substitute product for mutton in Namibia.

The short-run elasticities are represented by the coefficients of the respective first differenced variables. When there is more than one coefficient for a particular variable in the short run (coefficients of the differenced variables in equation 5.2), they are added and their joint significance is tested using the Wald test.

Table 6.9: Short-Run Elasticities for ARDL Mutton Supply Function

Short-Run Elasticities	
Variable	***Dependent Variable ΔLYXT***
	Short-run
ΔLNPT	-4.14*
ΔLPBT	0.63*
ΔLRFXT	-0.41*

*** Significantly different from 0 at 1% level, ** significantly different from 0 at 5% level, * significantly different from 0 at 10% level

Table 6.9 shows the short-run elasticities for the mutton supply function. The significance of the lagged coefficients were tested with the Wald test. Results of the short-run elasticities showed that the average real Namibian mutton producer price is elastic and has a significant negative effect on the mutton supply. This leads to the backward-bending supply curve discussed in Section 3.3. In practical terms it means that producers retain their livestock in response to price increases in the short run, with the expectation of increased future income outweighing present income. The real Namibian beef producer price is inelastic and has a positive effect on mutton supply in the short run. Realistically this means that producers marketed sheep in response to beef producer price increase in the short run, in order to expand their cattle stock, as it becomes more profitable due to the beef producer price increase.

The rainfall short-run elasticity of supply is inelastic but negative. This result was also found by Ogundeji *et al.* (2011). The short-run negative effect indicates that good rainfall results in lower throughput (marketing of sheep) for slaughtering, probably due to the expectation that rainfall will result in better grazing conditions and hence producers would hold back stock.

It is difficult to determine short-run elasticities due to the uncertainty in various factors influencing production. However, the significance of these short-run coefficients at the 10 percent confidence interval gives good support to the long-run relationships. This implies the presence of significant short-run dynamics behind the long-run relationships (Getnet, Verbeke & Viaene 2005).

The error correction term (coefficient of LYX_{t-1}) is statistically significant and implies that there is adjustment back to the long-run (equilibrium) position once there is disturbance in the short-run due to shocks. The significance of the error term in the mutton supply function is another indicator for the presence of a long-run relationship among the variables included in the mutton supply model. The magnitude of the error correction term indicates the speed of adjustment back to the equilibrium position once the system is in disequilibrium. The error correction coefficient of -0.51 indicates that 51 percent of the previous month's deviation from long-run equilibrium is corrected in the current month. This means that a deviation from this month's equilibrium will take approximately two months to regain its position of equilibrium.

6.8 Conclusion

Chapter six details the empirical analysis results obtained from the monthly data from 2003–2009. The seasonality and time series properties of the data were first analysed according to the relatively new econometric technique of co-integration analysis, namely the ARDL approach. Mutton marketed and monthly rainfalls were adjusted according to seasonal effects. Unit root tests showed that the mutton marketed, average real Namibian mutton producer price and monthly rainfall are stationary in levels, whereas the average real Namibian beef producer price is stationary at first differences. Therefore none of the variables was integrated of an order higher than one, and the variable could be used in the UECM.

Ordinary least squares regression was utilised to compute the final model. From UECM a more specific ECM was obtained through the elimination of non-significant variables in the ECM model. The Wald test for joint significance among the included variables of the mutton supply model was computed and evaluated against the upper and lower bound values specified by Persaran *et al.* (2001). Co-integration among the variables was confirmed by the Wald test, supporting the existence of a long-run relationship among the variables in the model.

After co-integration was confirmed, long-run and short-run elasticities were computed for mutton supply. Significant long-run results were obtained from the model, showing that the real Namibian mutton producer price influences mutton supply positively in the long-run, where the price of the substitute product, real Namibian beef producer price, showed a negative effect on mutton supply as expected. Monthly rainfall showed a positive influence on mutton supply in the long-run.

Short-run elasticities showed significant results for real Namibian mutton producer price, real Namibian beef producer price and rainfall. The error correction term of the mutton supply model showed the expected significant negative sign, meaning that should there occur any disturbances within the mutton supply system (due to significant short-run changes or shocks to included variables), it will take two months for the mutton supply system to recover to the long-run supply equilibrium position.

Results obtained from the analysis are as expected for the long-run and short-run elasticities. The results also correspond well with those obtained in the literature on similar studies on supply response analysis.

Chapter 7 – Conclusion and Recommendations

Supply response studies are important to understand the supply mechanics and supply relationships between input application and output production. Supply response studies serve as the fundamental building blocks for efficient supply of a product. In Namibia, where more than 70 percent of the population is dependent on agriculture to sustain a living, the agricultural sector contributes to 5.5 percent of the country's national Gross Domestic Product. Livestock Farming is an established agricultural industry in Namibia and contributes to 2.7 percent of the national Gross Domestic Product that defines this as a major sector in Namibia.

The aim of this study was to evaluate economic supply theory with the aid of a supply response model within the mutton industry of Namibia. Two hypotheses were tested in this study: first it was hypothesised that price related factors have a major contributing role in determining the supply of mutton in Namibia and second, it was hypothesised that climatological factors play a major role in mutton supply in Namibia. Production variables for the supply model obtained from literature, able to evaluate the stated hypotheses, were identified and selected according to data availability.

Various approaches for econometric modelling of supply response studies are available. The Autoregressive Distributed Lag 'Bounds' test approach was selected as the most appropriate approach for conducting the statistical analysis of time series data for the supply response model. This approach was selected based on the fact that it can distinguish between long-run and short-run supply elasticities as well as the fact that the ARDL approach does not impose restrictive assumptions on the variables included in the model.

The time series properties were first determined for the selected variables with the aid of statistical software. The ARDL approach to co-integration analysis was completed in two stages in order to generate the required relationships between dependent and independent variables within the supply model. The first stage involved the estimation of an unrestricted error correction model that included the dynamic nature of production. Through the elimination of insignificant variables from the model, a more specific error correction model was obtained. The second stage entailed the Wald test that was used to confirm the existence of long-run relationship among the variables in the supply model. Model specification tests were used to validate the model and the results obtained from the analysis. Therefore, with the aid of an appropriate approach, statistical software and data, non-spurious results were obtained for analysis of the mutton industry in Namibia.

Results showed that the producer price of mutton is a primary supply shifter for mutton supply in Namibia. An increase in the average Namibian producer price affects mutton supply positively in the long-run and negatively in the short run. Results also showed that the producer price of substitute products (beef) has a negative effect on mutton supply in the long run and a positive effect in the short run in Namibia. Therefore, it can be concluded that the hypothesis, which stated that price related factors influence supply, has been validated by this study. The supply response outcome also showed that climatological factors, such as rainfall, have a significant effect on mutton produced in Namibia. An increase in rainfall has a positive influence on mutton produced in the long run, but negative in the short run. Thus the hypothesis which stated that climatological factors play a major role in mutton production in Namibia has also been validated by this study. The long-run elasticities have the opposite effect on mutton supply compared the short-run elasticities. This behaviour can be assigned to the fact that producers' production goals for the long term and the short term are different. These results agree with findings of other similar studies that have been conducted in this field.

Results revealed that the error correction term indicates the speed of adjustment back to the equilibrium position once the system is in disequilibrium. The error correction coefficient shows that 51 percent of the previous month's deviation from long-run equilibrium is corrected in the current month. This means that a deviation from this month's equilibrium will take approximately two months to regain its equilibrium. This is a valid measure of the system's responsiveness towards change in the factors influencing the supply of mutton.

A supply response analysis of the mutton industry in Namibia showed the relevant importance of supply shifters towards production output. The decline in sheep production in Namibia is a growing concern for industry stakeholders. The effect of the Scheme on total mutton production is debatable at this stage, however production of mutton shows a decline since the initiation of the Scheme. In future policy making regarding marketing policies, relationships between producer price related factors and production output can be used as a guideline for policy makers. The strong relationship between production output and producer price should make policy makers aware of the sensitivity of these factors to structural changes.

The influence of climatological factors on production should make industry stakeholders and policy makers aware of the effect of drought on mutton production and the country's economy. The optimum production goal, from a free-range farming perspective, is the conservation of the natural resources to prevent over-grazing. From a production perspective, it is clear that producers react drastically to producer prices of mutton, and to a lesser extent to the producer price of beef. Climate also plays an important part in the producers' decision making regarding the production of mutton as one would expect in a drought prone country such as Namibia.

It is anticipated that the supply response model can still be refined by including other factors that influence the supply of mutton in Namibia. These factors include cost factors, such as feed costs (grain prices) and other input costs for mutton production. The relationships between these cost factors and output could also assist policy makers in determining grant allocation criteria for emerging farmers.

Supply forecasting remains a relatively fallow area in this field of study. Forecasting for the mutton industry at this stage is important due to its declining trend in sheep marketed over the past number of years. Supply forecasts are useful for analysing current scenarios in order to make informed decisions for future planning. Therefore, investigating the current situation of mutton supply in Namibia, it is recommended to use forecasts to evaluate the Small Stock Marketing Scheme against its current intended goals.

To conclude, the present marketing and production framework in the Namibian mutton industry displays clear warning signs to industry stakeholders due to the decline in sheep produced over the past seven years. Therefore, relationships between marketing and production are important for a sustainable future for the mutton industry. Considering that Namibia is a country where agriculture, especially livestock farming, is of primary importance and where a high-value product is produced, favoured by local and international markets, research in this field of study is required to secure a sustainable livelihood and economy for the people of Namibia.

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ANNEXURE A: Graphical Presentation of Data for Supply Response Analysis

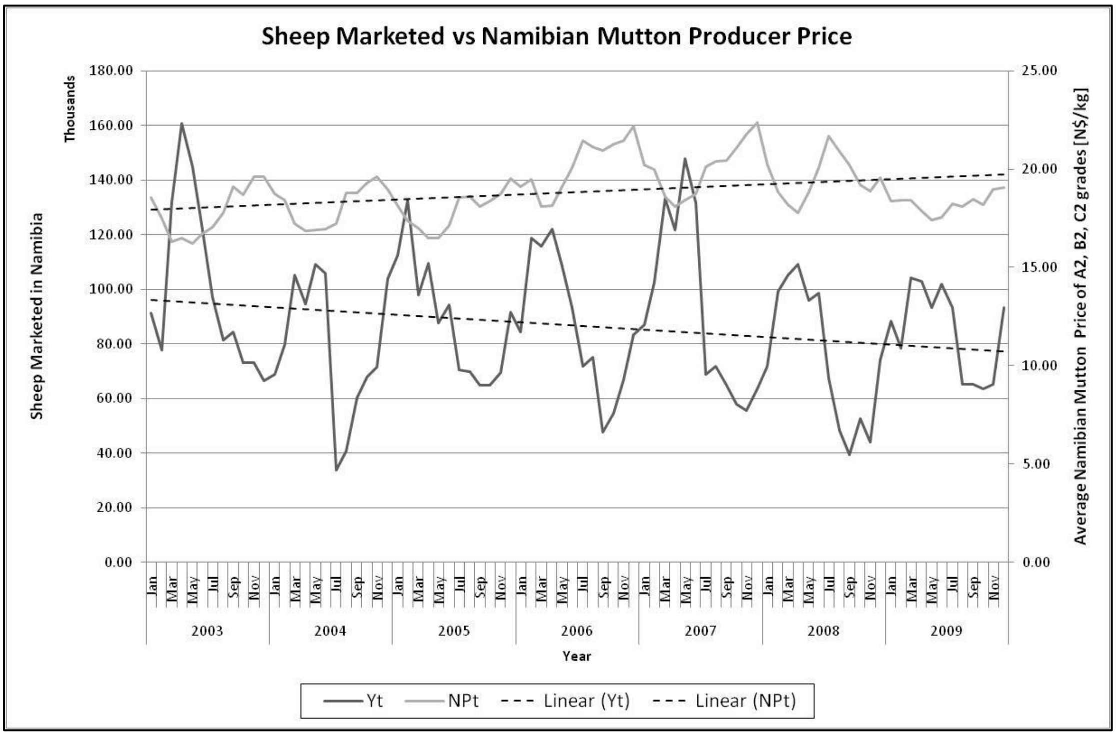

Figure A.1: Graphical Presentation of Sheep Marketed vs Mutton Producer Price

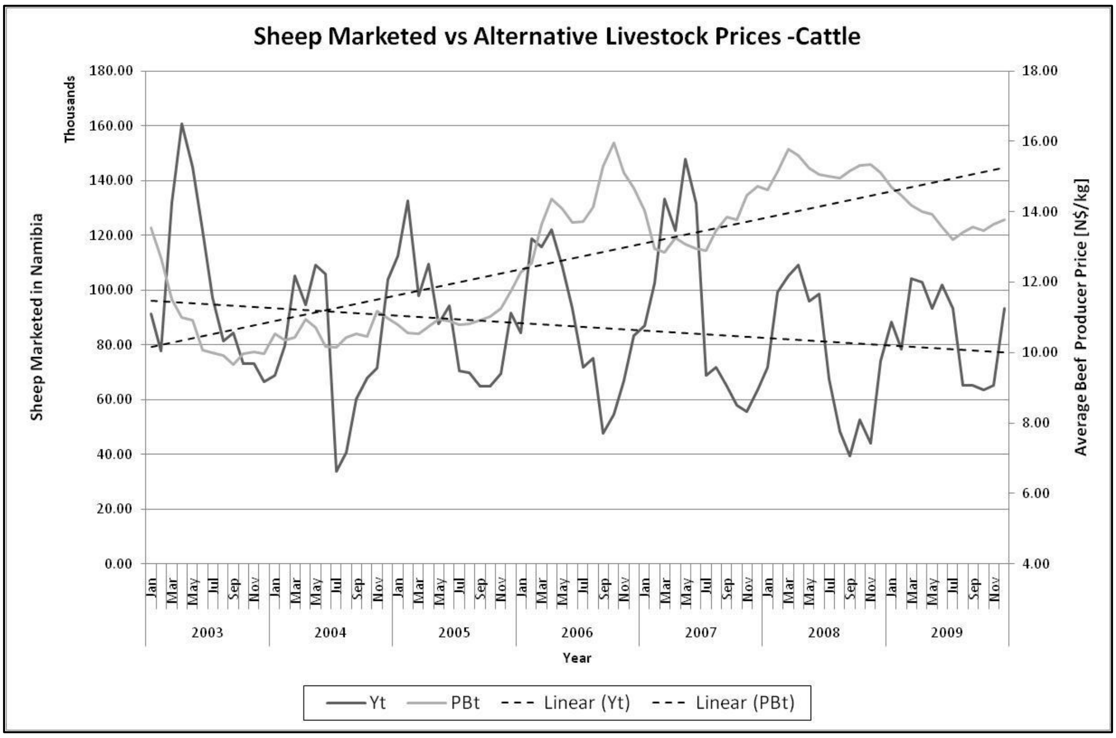

Figure A.2: Graphical Presentation of Sheep Marketed vs Beef Producer Price

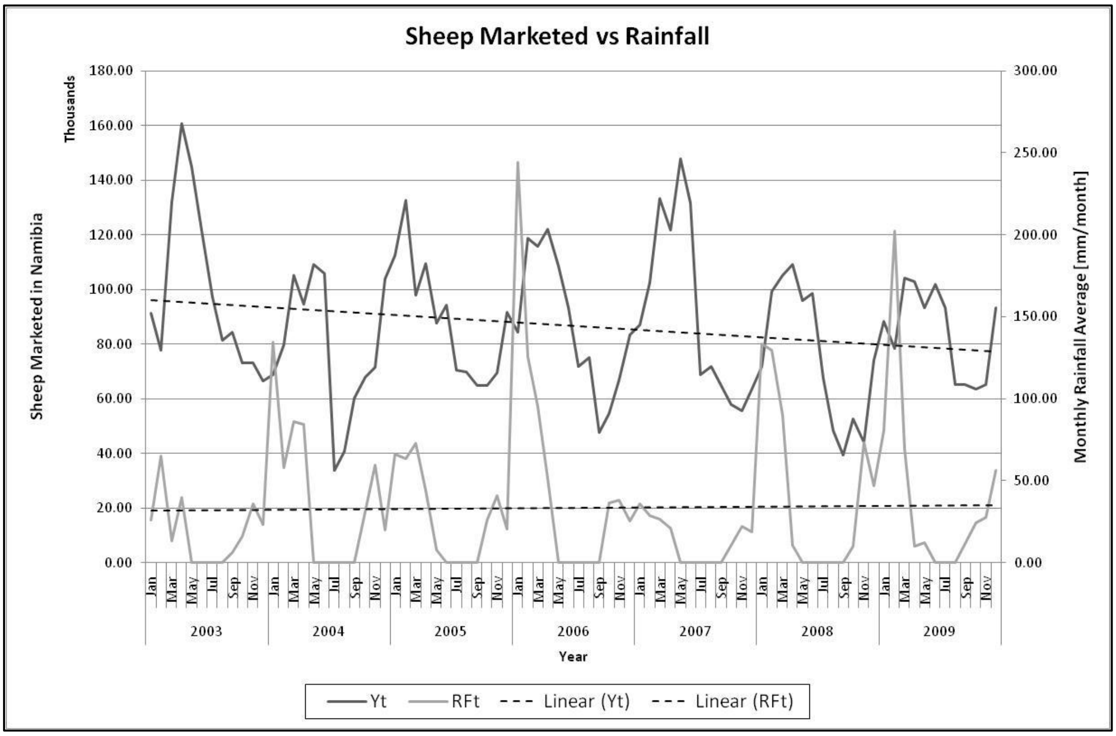

Figure A.3: Graphical Presentation of Sheep Marketed vs Monthly Rainfall

ANNEXURE B: Residual Plots of Model, Grade distribution Chart, Price Graphs, Meat Trade and Consumption per Capita

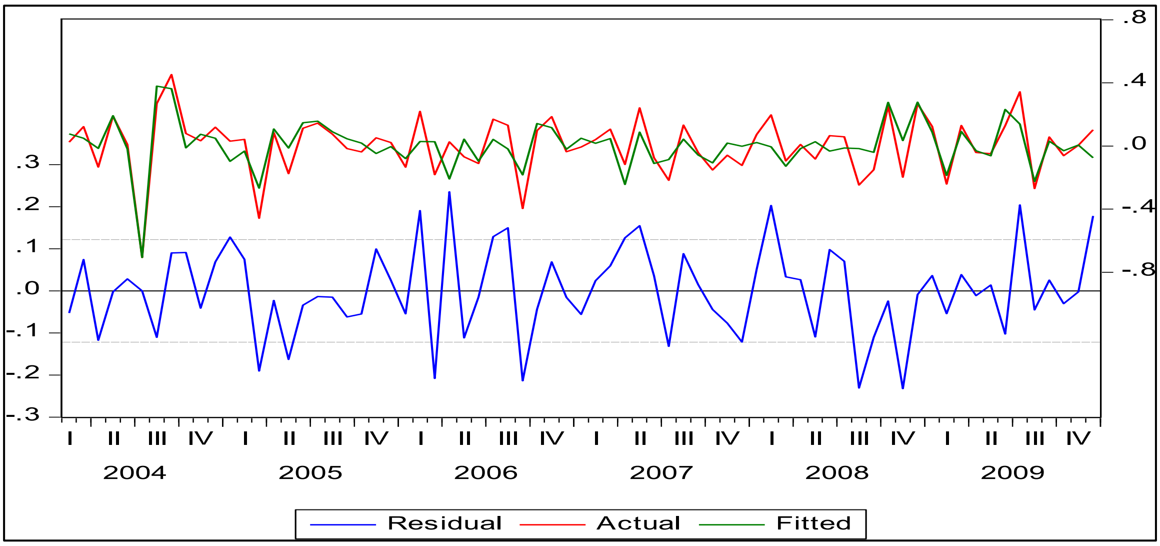

Figure B.1: Residual Plot, Actual vs Fitted Data of the Mutton Supply Model

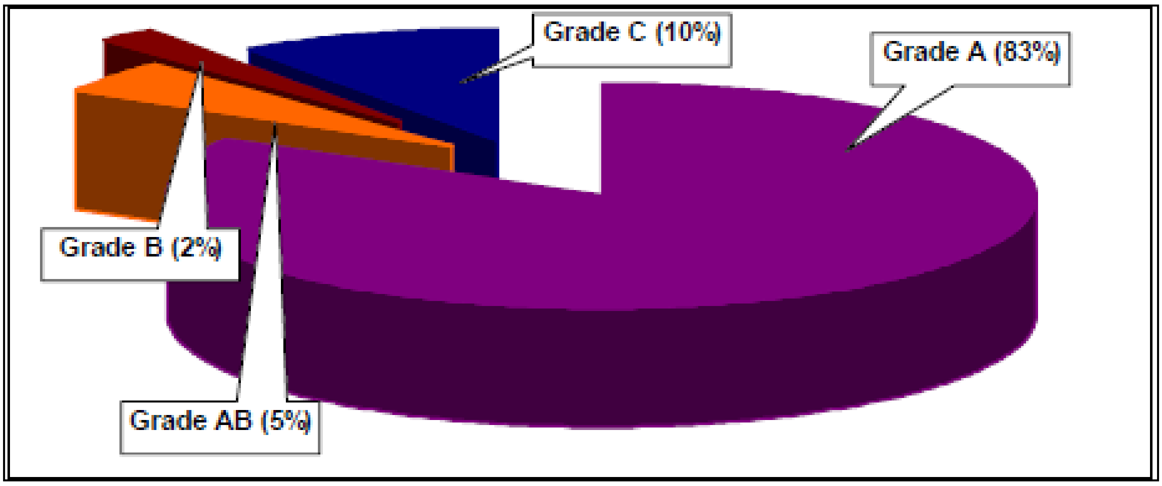

Figure B.2: Carcass Grade Distribution at Namibian Export Abattoirs [2004-2007]

(Source: PWC 2007)

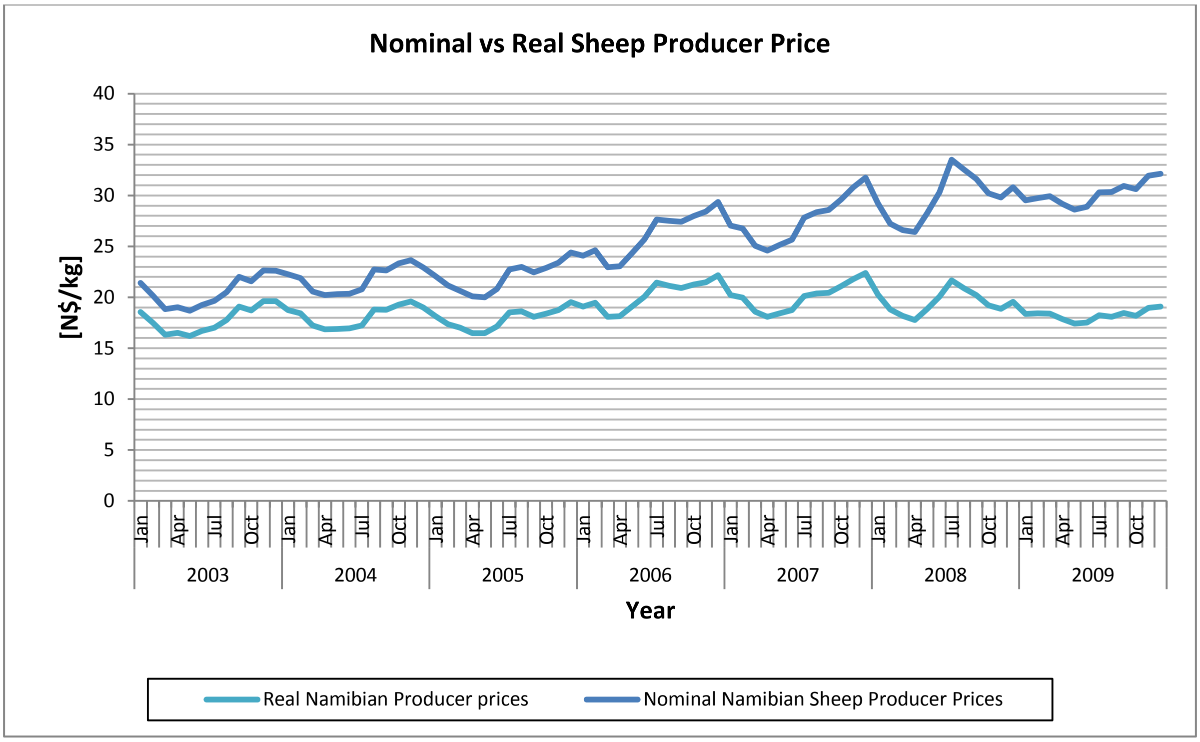

Figure B.3 Real vs Nominal Sheep Prices

(Source: Meat Board of Namibia Statistics)

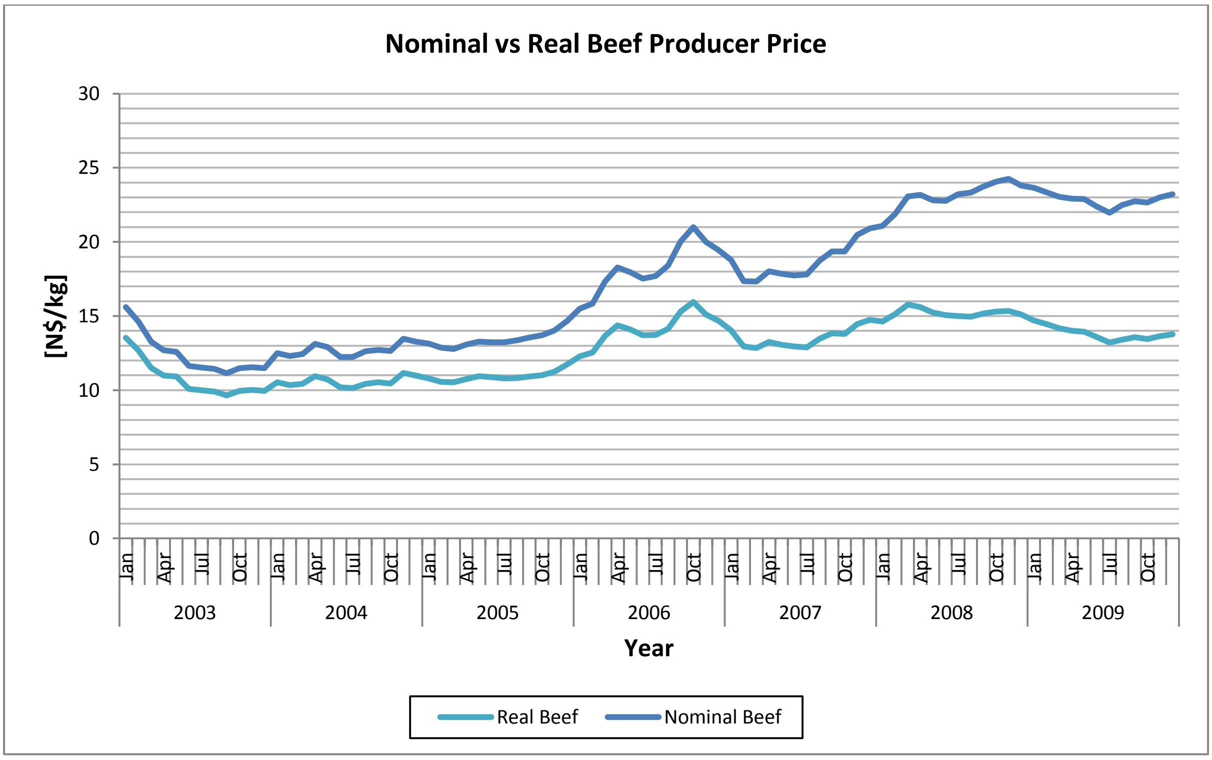

Figure B.4: Real vs Nominal Beef Prices

(Source: Meat Board of Namibia Statistics)

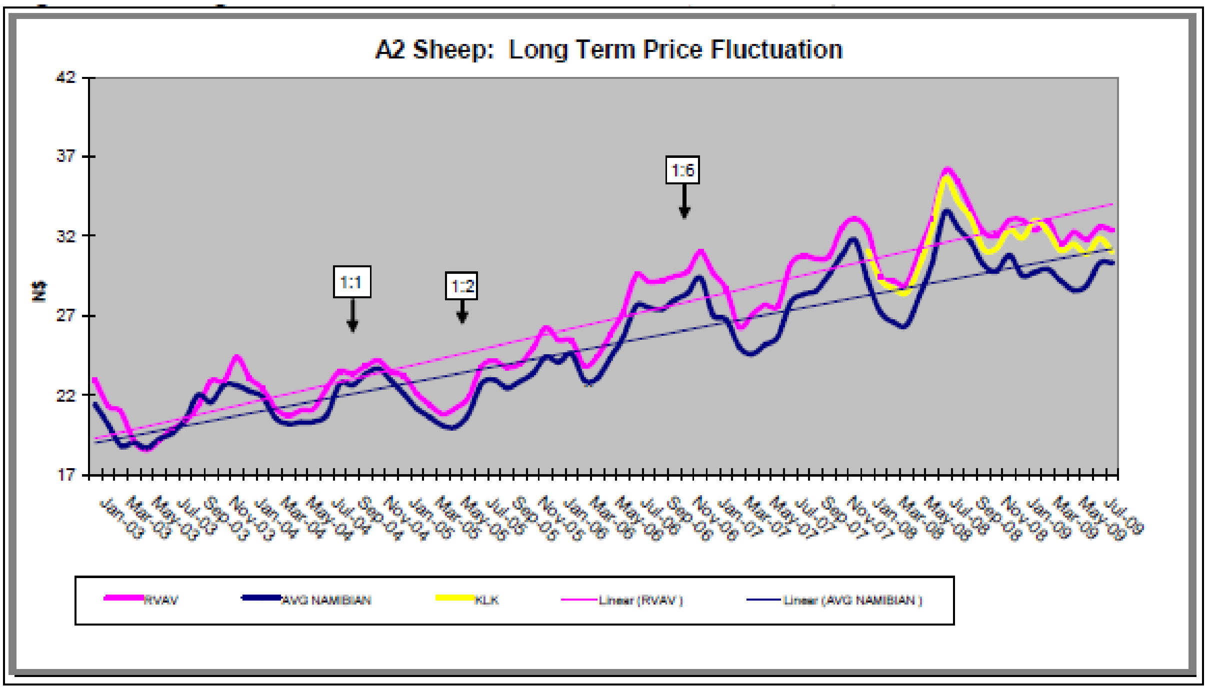

Figure B.5: Namibian Producer Price Compared to the South African Producer Price for A2 Sheep

(Source: Schutz, Dec 2009)

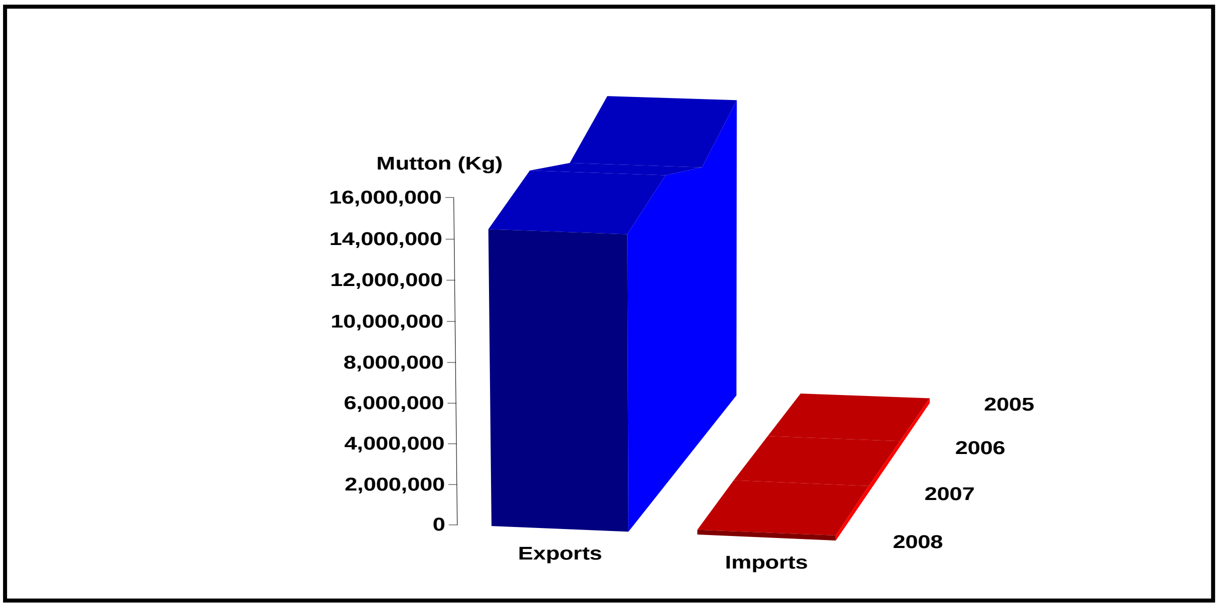

Figure B.6: Meat Trade - Mutton Exports vs Imports

(Source: Schutz 2009)

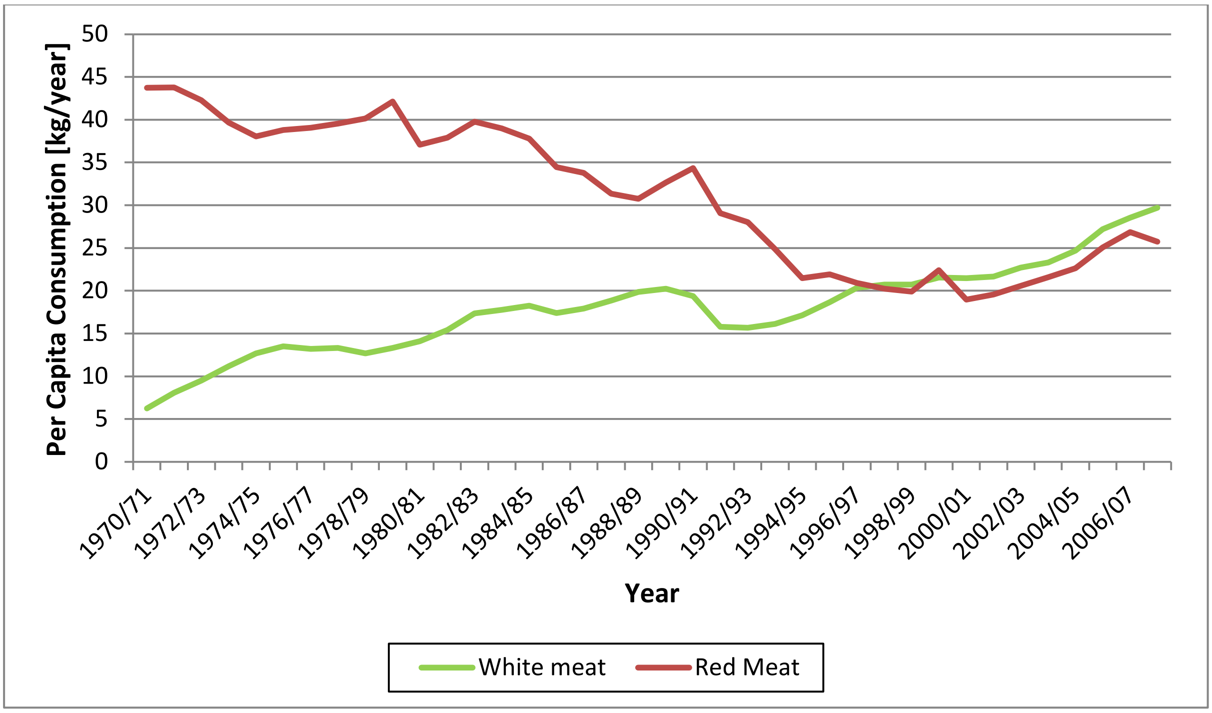

Figure B.7: White- and Red Meat Consumption per Capita in South Africa

(Source: Abstract of Agricultural Statistics 2009)

ANNEXURE C: SAIIE 2010 Conference Article

SUPPLY RESPONSE ANALYSIS OF THE NAMIBIAN MUTTON INDUSTRY: A METHODOLOGY OVERVIEW

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ABSTRACT

In terms of contribution to the agricultural economic activity in Namibia, the small stock industry is the second most important sector being smaller than only the beef industry. This sector makes a significant contribution to the agricultural sector in Namibia due to the sector's provision of employment, use of natural resources, contribution to GDP, exports and the contribution to consumer spending as well as food security. Agricultural activities in Namibia contributed 5.7% to Namibia's GDP while 70% of the population relies on agriculture for employment and day to day living.

Livestock in Namibia is free ranging on natural pastures and therefore produces high quality meat that is in high demand in national and international markets. Small stock production in Namibia is unstable due to high variability weather patterns, changes in economic and social environments, unpredictable droughts as well as political and structural changes.

This study investigates the relationship between the various factors contributing to supply dynamics. Previous work in this field that is discussed in this paper includes econometric modelling of various agricultural commodities in USA, Australia, and New Zealand. Similar research on supply response and supply chain dynamics in Southern African countries, such as Zimbabwe, Botswana, Namibia and South Africa is included as background to the investigation.

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1. INTRODUCTION

Meat consumption plays an important role in the daily food consumption patterns of the consumer and is therefore seen as a primary product of the Namibian agriculture economy. Because of the demand for red meat and the geography in Namibia, livestock industry is the major contributor to Namibia's Gross Domestic Product.
Namibia is located in the South Western part of Africa with arid and semi-arid bio-resource regions and a population of 2.2 million people. Agriculture contributes 5.7% to the Namibian GDP while 70% of the population is dependent on agriculture to sustain a living. Because of Namibia's variable and harsh climate agricultural production is dominated by livestock farming, in contrast to a small area of approximate 1% that is suited available for horticulture and crop production (Schutz 2009).

Livestock production consists of cattle, sheep, goats and pigs. Rainfall and vegetation determines the distribution of these livestock types through the various geographical regions of Namibia. Figure C.1 shows the relative proportion of livestock marketed in Namibia.

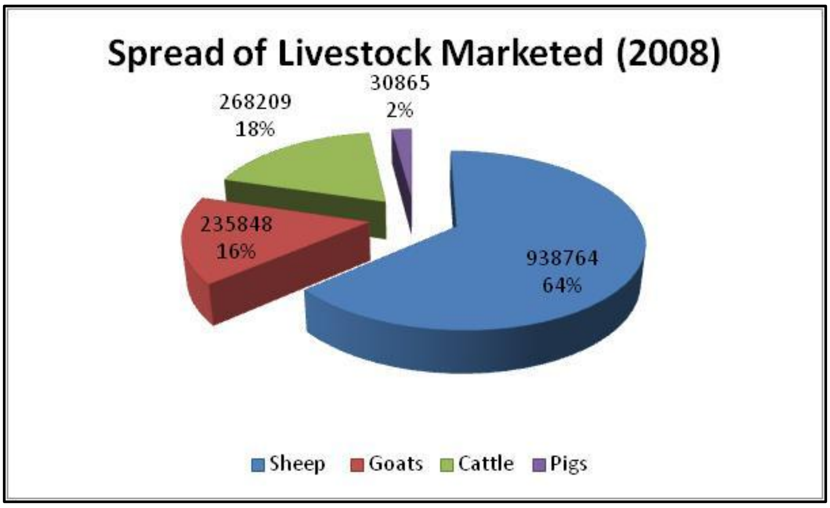

Figure C.1: Livestock Marketed (Source: Meat Board of Namibia Monthly Stats, 2008

The production sector consists of commercial and communal farmers where the latter predominantly practice subsistence farming. In figure C.2 the small stock population is summarized as provided by the Meat Board of Namibia.

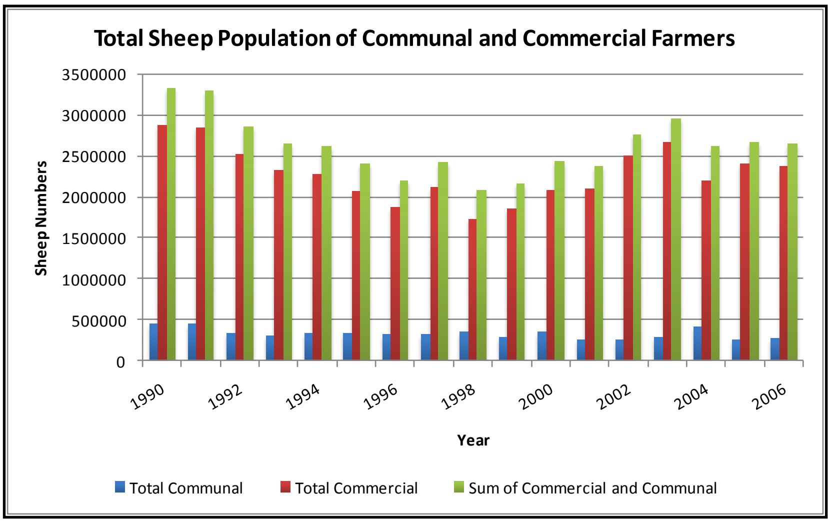

Figure C.2: Sheep Population from 1990-2006 (Source: Meat Board of Namibia Monthly Stats, 2008)

Namibia exports 85% of the annual produce to South Africa. Deboned high quality value added cuts are also exported to Norway (Schutz 2009). Since 2003 the Namibian government introduced the Small Stock

Marketing Scheme that established export restrictions for live animals. Since the Small Stock Marketing Scheme was introduced, live exports decreased while the export of slaughtered carcasses of sheep increased (refer Figure C.3).

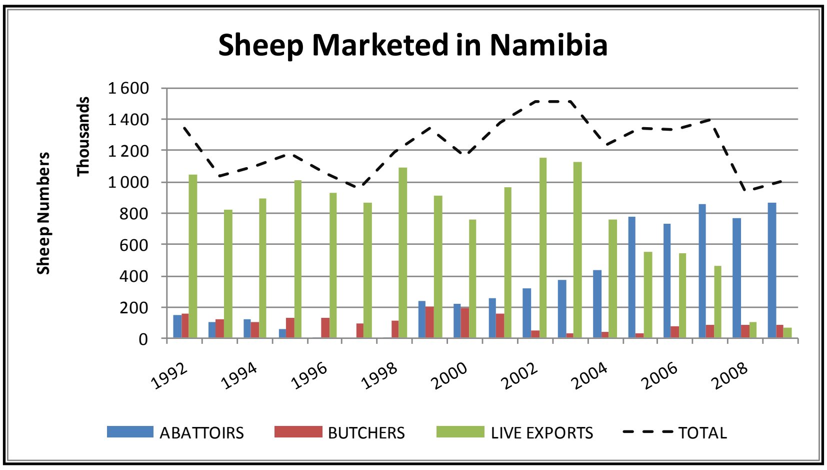

Figure C.3: Total Sheep Marketed 1990-2009 (Source: Meat Board of Namibia Monthly Stats, 2009)

Sheep production is a biological process. This introduces cyclical movements in the number of stock produced and marketed per annum. The fact that stock numbers vary from cycle to cycle suggests that there are many economic, biological and physical (weather) factors affecting the cycles. The time lag between the producer who decides to expand its flock and production resulting from that decision contributes to the cyclic nature of production. Economic and weather conditions as well as other random effects can influence a given cycle both in terms of timing and amplitude (Von Bach 1990). Management and expectations are also factors contributing to the variabilityof instability of production cycles. Due to variability in supply, the purpose of conducting a supply response study is to analyse the factors that influence the total agricultural output supply, in this case marketed sheep.

The remainder of the paper is constructed as follows: section two gives a brief background on supply response where section three describes the approaches followed for these studies, whilst section four discusses the previous work done is this field and a model for supply response is presented in section five. The relevance of this study to stakeholders is examined in the last section of this paper.

2. BACKGROUND TO SUPPLY RESPONSE

The supply curve of a product such as mutton is a schedule indicating the quantities producers are willing to supply at a given price, time and locality. The slope of the supply curve is determined by the time it takes producers to adjust to changes. According to the law of supply, if the price of a product increases the supply should also increase. Supply response studies are performed in order to reveal the relationship between inputs and outputs. However as any model generating outputs from inputs, limitations and problems exist, typical problems that occur in supply response studies are:

•Uncertainty in expectations
•Flexibility of fixed factors
•Problem of technological changes
•Measurement of the influence of weather

Proper model design is important for supply response analysis. It is of paramount importance that it should be based on accurate data. The development of these models provides good support to human judgement (management) in marketing, planning, control and policy. According to Sartoruis Von Bach (Von Bach 1990), supply response studies for agricultural commodities and products can be differentiated into the following categories:

1. Studies of the supply of individual commodities based on time series data

2. Studies based on budgeting techniques or linear programming models using typical farms or regions as units of analysis

3. Studies of aggregate supply including both the development of theoretical concepts and the estimation of the response of total farm output to changes in product and factor prices

Most studies of supply response, aggregate or individual crop, are based on times series data and either use the Nerlove (Nerlove 1956) partial adjustment model for single commodities or the method developed by Griliches (Griliches 1960) for aggregate supply response (Mckay, Morrissey & Vaillant 1999). For the purpose of this paper the first study on supply of a single commodity is considered for the analysis of supply response for the Namibian sheep industry.

3. APPROACHES TO MEASURE SUPPLY RESPONSE ANALYSIS

To measure agricultural output supply responses to price and other contributing factors broadly two approaches can be followed; 1) Programming 2) Econometrics (Colman 1983). The econometric approach can further be subdivided into 2 categories. As there has been considerable scepticism regarding the generated results from econometric analysis a greater understanding of the methodology used to derive the results will provide some indication of the confidence that can be placed in econometric estimates.

3.1 Programming:

Programming Models, usually ***linear programming***, involves the creation of a linear production model that represents the typical production system of a specific product or various products. An objective function is usually specified related to profit maximization. Other objectives such as risk minimization can also be defined.

By solving the model with various sets of data, assuming the profit is maximised, the supply-price relationship can be established for a specific product. The advantages of this approach are that linear programming is capable of handling complex multi-relationships on farm level in a production system. The complex multi-relationships involve recognition of all the effects of supply of product prices, input prices, technological and physical restrictions. However, the data requirements are extensive and the collection of data at farm level is costly and the development of such models require some extensive time to be developed (Thomson & Buckwell 1979). The assumption that farmers maximise their profits may lead to the overestimation of supply that is not always true in practice. Due to the restricted data availability and resources, this approach is not widely used among researchers when supply response studies are conducted.

3.2 Econometrics:

Econometrics was developed out of a desire to further understanding of economic phenomena and was used as being the nature of extension and expression of neoclassical economics. Statistical data proved to be valuable in establishing economic regularities, in presenting economic arguments and performing measurement of economic variables **(Townsend 1997)**. At the start disproportionate trust was placed in the quantitative techniques, however after initial optimism of the quantitative revolution some disillusionment and scepticism became common. According to Townsend **(Townsend 1997)** scepticism pivots around thus methodology adopted in formulating these econometric models. Although various econometric approaches exist for analysis of supply response functions, only two of most widely used approaches are discussed in this paper. These approaches include Directly Estimated Partial Models and Error Correction Models, and are briefly discussed below.

3.2.1 Directly Estimated Partial Supply Models

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

The partial adjustment model, used by Nerlove (Nerlove 1958), is an earlier version of an econometric approach used in measuring agricultural supply response for a single commodity. Nerlove's partial adjustment model is used to capture agricultural supply response to price incentives. The general static supply function can be mathematically presented as;

$$Y_t = c + \beta P_{t-1} + \gamma T + \vartheta_t \quad (1)$$

Where Y_t → expected long-run equilibrium output level at time t,
c → constant term
β → long-run supply response
P_{t-1} → output price at time *t-1*
γ → coefficient of linear deterministic time trend T
ϑ_t → independently normally distributed error

The dynamic adjustment supply response equation is based on Nerlove's hypothesis that "each year farmers revise the output level they expect to prevail in the coming year in proportion to the error they made in predicting the output level of this period".

This is presented as;

$$Y_t^* - Y_{t-1}^* = \lambda(Y_t - Y_{t-1}^*) \quad where\ 0 > \lambda > 1 \quad (2)$$

Where Y_t^* → expected output level at time t,
λ → coefficient of expectation about price or elasticity if variables are in logarithm

By substituting equation (1) in equation (2);

$$Y_t^* = \lambda c + \lambda\beta P_{t-1} + (1-\lambda)Y_{t-1}^* + \lambda\gamma T + \lambda\vartheta_t \quad (3)$$

where $\lambda\beta$ captures the short-run price elasticity of supply. Nerlove states that if producers have static expectations and if supply depends on expected normal prices or prices of the preceding year, than the coefficient of expectation, λ is equal to one in equation (2). In such a case producers do not immediately adjust their production decisions to changes in prices observed in period t, such that;

$$Y_t = Y_t^* = c + \beta P_{t-1} \quad (4)$$

If λ is less than 1, the fluctuation in expected output level is less than the fluctuation in the observed output level such that the actual change in output level in the periods *t* or *t-1* is only a small part of the change required to achieve the expected output level. In this case the only condition for observing significant differences between short and long-run elasticity's is the initiation non-static assumptions (Abou-Talb & El Begawy 2008), (Olubode-Awosola, Oyewumi & Jooste 2006).

According to Abou-Talb et al. (Abou-Talb & El Begawy 2008) the previous studies that are based on the Nerlovian partial adjustment model have found low values or even zero long-run price elasticity of agricultural supply. This method assumes that difference between current and long-run planned outputs is eliminated i.e. it assumes that farmers are not forward looking in their production decisions.

This method also lacks the capacity to measure the effect of non-price factors such as rural infrastructure and credit.

According to Abou-Talb et al. (Abou-Talb & El Begawy 2008) and Alemu et al. (Alemu, Oosthuizen & van Schalkwyk 2003) the Nerlovian partial adjustment model is considered weak for the following reasons:

1. The inability to distinguish between short-run and long-run elasticities
2. The model use integrated series which poses the danger of spurious regression
3. The assumption that production adjusts to a fixed target of supply, towards which actual supply adjusts, is considered unrealistic under dynamic conditions
4. The empirical evidence that Error Correction Models (refer Section 3.2.2) describe the dynamics of supply better that the Partial Adjustment Models

In can be concluded that the partial adjustment model was used as a framework by many previous studies on supply response analysis but due to its limitations and the improvement of methods the partial adjustment model is less appropriate for the study of supply response on agricultural output.

3.2.2 Error Correction Models

Empirical dynamics of supply can also be described by Error Correction Models (ECM). The ECM form of dynamic specification has been used by various authors in macroeconomic modelling since its appearance in the Davidson, Hendry, Srba and Yeo (DHSY) consumption function of 1978 (Hallam & Zanoli 1993). The ECM offers a means of reincorporating levels of variables alongside their differences and hence of modelling long-run and short-run relationships between integrated series. In addition to this, economic time series data contain trends overtime, although regression analysis shows significant results with high R^2, the results may be spurious. ECM and co-integration analysis is used to overcome the problem of spurious regression (Tripathi 2008).

Due to the limitations of the partial adjustment model, the ECM is favoured above the Nerlove method. The ECM overcome the restrictive dynamic specification and captures the forward-looking behaviour of producers optimizing their production in dynamic situations (Abou-Talb & El Begawy 2008). The ECM approach is used to analyse non-stationary time series data that are know to be co-integrated. This method also assumes co-movement of the variables in the long-run. The general form of the ECM method is;

$$\Delta Y_t = c + \sum_k \alpha_k \Delta Y_{t-n} - \lambda\left(Y_{t-1} - \sum_j \beta_j X_{jt-n}\right) + \gamma T + \vartheta_t \tag{5}$$

Where, Δ $\rightarrow$ deference operator such that $\Delta Y_t = Y_t - Y_{t-1}$
α_j $\rightarrow$ short run supply elasticity
β_j $\rightarrow$ long run supply elasticity

Y_s are assumed to be co-integrated time series variables (including previous supply levels of Y_{t-n} and other explanatory variables X_{t-n}).

Co-integration analysis can be carried out with the Johansen or Engle-Granger test approach.

Engle-Granger approach to co-integration analysis

The Engle-Granger test for co-integration involves estimating a static Ordinary Least Squares (OLS) model where all variables enter at levels. The OLS model usually shows a high R^2 with a low Durbin-Watson statistic that indicates significant evidence of serial correlation in the residual. To test for the co-integration of the series, the residual is expected to be stationary i.e. having a unit root. In the spurious OLS regression the t-statistic can not be used to test hypothesis, because the variables are not stationary in levels.

The Augmented Dicky-Fuller (ADF) regression of the form;

$$\Delta\vartheta_t = \delta_0 \vartheta_t + \sum_{i=i}^{k} \delta_i \Delta\vartheta_{t-k} \tag{6}$$

is fitted to test for stationarity of the residual ϑ_t in equation (1). If there is an evidence of a unit root the residual is stationary. I addition to this there is proof of co-integration of the time series in equation (5). K in equation (6) is arbitrarily chosen lagged period until the residual is found stationary when δ_i is significantly different from zero. Then β in equation (5), that is the parameter estimate of long-run supply elasticity, may be interpreted as the co-integration parameter from the linear combination of the series. However, error correction representation may result from this co-integration. The error is subsequently corrected by using the residual ϑ_t to estimate an ECM of the form;

$$\Delta Y_t = c + \alpha \Delta X_{t-n} - \lambda \vartheta_t \tag{7}$$

However some researchers criticise the Engle-Granger approach because the estimate of the co-integrating parameter from the statistic regression equation (1) could be subjected to small sample bias. They argue that this can be overcome by estimating the ECM in dynamic form by replacing residual ϑ_t with the lagged variables $(Y_{t-1} - X_{t-1})$ and X_{t-1} resulting in the following unrestricted regression;

$$\Delta Y_t = c + \alpha_{t-n} \Delta X_{t-n} + \lambda_{1n}(Y_{t-n} - \beta X_{t-n}) + \lambda_{2n} X_{t-n} \tag{8}$$

where, α is the short run elasticity of supply
λ_2 is dynamic adjustment of supply

λ_1 is the coefficient of the error/equilibrium correction term of the co-integration equation, that presents the period to adjust to the long-run equilibrium. λ_1 must be negative and significantly different from zero. Being negative implies that if there is a deviation from the current and long-run levels, there would be adjustment back to the long-run equilibrium in subsequent periods to eliminate the disequilibrium.

If β is significant, the ECM captures the speculative behaviour of producers, otherwise the ECM reduces to the Nerlove partial adjustment model. It should be noted that while static co-integration regression predicts the level of supply, the error correction predicts the changes so that the variation in the supply is necessarily higher. The new, corrected co-integration parameter estimate (long-run elasticity), β^*, is computed as;

$$\beta^* = 1 - \frac{\lambda 2n}{\lambda 1n} \ or \ \frac{\lambda 2n}{\lambda 1n} \text{ if the fraction is negative} \quad (9)$$

The Engle-Granger approach to co-integration is suited to bivariate relationship (Olubode-Awosola, Oyewumi & Jooste 2006).

Johansen Approach to Co-integration Analysis

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

$$\Delta Y_t = c + \sum_j \alpha_j \Delta Y_{t-1} + \delta D_t + \gamma T + \lambda \varepsilon_{t-1} + \vartheta_t \quad (10)$$

where, $\varepsilon_{t-1} = lnY_{t-1} - \sum_j \beta_j Y_{jt-1}$ (error/equilibrium correction term)

D_t → vector of stationary exogenous variables

δ → vector of parameters of exogenous variables

λ → coefficient of error correction term ε_{t-1}

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

When the co-integrating rank r is equal to 1, the Johansen single equation dynamic modelling and the Engle-Granger approach are both valid. When r equals 1, the normalisation restriction for the parameters produces a unique estimate of what the economic theory suggests. However, when there is more than one co-integrating equation the Johansen approach to co-integrating analysis is preferred to the Engle-Granger approach (Olubode-Awosola, Oyewumi & Jooste 2006).

4. PREVIOUS WORK DONE ON SUPPLY RESPONSE ANALYSIS

Several research studies undertaken worldwide have been done in the field of supply response. Recent studies increasingly focussed on developing countries in Africa such as Ghana, Zimbabwe, Botswana, Namibia, South Africa and Egypt. Earlier studies on supply response predominantly focus on one commodity, where price responsiveness is the mayor factor of influencing supply. More recent studies used improved quantitative methods as explained in the previous section.

Whipple et al. (Whipple & Menkhaus 1989) developed a dynamic model for the U.S. sheep industry to examine the supply response of sheep products, including lamb, mutton and wool. The approach followed was based on dynamic modelling where the producer's objective is to maximise profits. Reynolds et al. (Reynolds & Gardiner 1980) analysed the Australian sheep industry to construct a model of supply that is believed to be faced by the producers in Australia. Relationships of quantities produced between the output of lamb, mutton and wool and changes in inventory levels were hypothesised as describing the producer's response to prices and seasonal changes. Court (Court 1967) investigated the New Zealand sheep industry in order to obtain numerical estimates for economic influences on New Zealand wool, mutton and lamb supply.

Sartoruis von Bach et al (Von Bach, van Zyl & Vink 1992), analysed the influence of prices and access to markets on the cattle population in certain regions of Namibia, where communal farming dominates.

The approach to their study was based on the fundamentals of the work done by Nerlove (Nerlove 1958). Abbott and Ahmed (Abbot & Ahmed 1999) analysed the effect of supply response of wool production towards price changes in South Africa.Over the last decade various studies have been conducted in Africa on several commodities with new approaches towards supply response. These studies include the analysis conducted by Schimmelpfennig et al (Schimmelpfennig, Thirtle & van Zyl 1996), Mckay et al. (Mckay, Morrissey & Vaillant 1999), Ocran et al. (Ocran & Biekpe 2008). Akinboade (Akinboade 1999), investigated the influence of producer price and capital/labour ratio on the production of livestock and sorghum in Botswana.

After reviewing most of these studies in the field of supply response analysis on various commodities a few conclusions can be drawn. Firstly most of the studies have used the same methodology by Nerlove in the original form or with modification. These studies mostly have reported low supply response elasticities. Previous studies have also shown that non-price factors are of the same order of importance than price factors in supply response.

5. EMPIRICAL METHODOLOGY FOR SUPPLY RESPONSE MODELLING

For a supply response analysis, investigating the relationship between inputs and outputs, a model is required that includes these inputs and outputs.

Agricultural supply depends on both output and input prices. The fundamental result from free market theory is that output price is the most important determinant of supply (Muchapondwa 2008). If the output prices increase the profit increase and that motivates producers to produce more. Similarly, an increase in input prices leads to increase in production costs that depress supply. However there are several other factors affecting agricultural production. These factors include; lack of infrastructure, human capital, technology and agroclimatic conditions (Thiele 2002). Infrastructure includes accessibility of roads, market facilities, farmer access to credit, agro extension services, availability of good breeding stock, pesticides, communication and transport facilities have an affect on the agricultural output through the effect on productivity and cost of production. Other factor including education, research and extension services have a positive effect on production by increasing production and reducing costs (Tripathi 2008).

According to Muchapondwa (Muchapondwa 2008), differences arise between theory and practice when constructing a supply response model. Theory assumes that there is an instantaneous response between inputs and outputs, and this is not experienced in agriculture in practice. Firstly the agricultural sector is characterised by biological lags between input application and output production. Secondly for an agricultural production unit the technical rules implied by the production function are a variable that may change during the course of the production process. Thirdly for an agricultural production unit, technological and institutional factors may exist that prevent optimal decision making in the production process. Fourthly, perfect knowledge and foresight is not valid in the majority of agricultural firms during the production process. The last factor mentioned by Muchapondwa (Muchapondwa 2008) is that in agriculture, risk and uncertainty is faced by agricultural production units at a higher level than other standard non-agricultural firms or production units. This concludes that the result from production behaviour in practice may differ from the logical theoretical behaviour.

A supply response model of Namibian sheep was hypothesised and constructed according to work completed by previous researchers. As mentioned earlier, in developing countries data availability may restrict the comprehensiveness of the model. The total supply response model presented in equation (11) is based on a marketed cattle production model constructed by Sartoruis von Bach (Von Bach 1990);

$$Z_t = f(X_t, X_{t-1}, M_{t-1}, M_{t-2}, E_{t-1}, E_{t-2}, CA_{t-1}, CA_{t-2}, NP_t, NP_{t-1}, NPR_{t-1}, NI_t, NI_{t-1}, NRI_t, NRI_{t-1}, T_t, T_{t-1}, RP_t, RP_{t-1}) \quad (11)$$

Z_t = Total head count of sheep marketed, including all sheep marketed by the producer, i.e. live sheep marketed to export markets, local butchers, export abattoirs etc.

$X_{t,t-1,t-2}$ = Total sheep stock, lagged one year, lagged two years. Sheep stock is influenced by external factors, rainfall, sheep numbers of the previous year etc.

$M_{t-1,t-2}$ = Total sheep marketed, lagged one year, lagged two years

$E_{t-1,t-2}$ = Total sheep exported, lagged one year, lagged two years

$CA_{t-1,t-2}$ = Total carcasses slaughtered, lagged one year, lagged two years

$NP_{t,t-1,}$ = Namibian average sheep producer price, lagged one year

$NRP_{t,t-1}$ = Namibian real producer price, lagged one year

$CM_{t,t-1}$ = Mean carcass mass, lagged one year, lagged two years (this variable is used to calculate the Income *NI*)

$NI_{t,t-1}$ = Namibian Income per carcass, lagged one year, lagged two years

$NRI_{t,t-1}$ = Real Namibian incomer per carcass, lagged one year, lagged two years

$T_{t,t-1}$ = Time, lagged one year,

$RP_{t,t-1}$ = RSA average sheep producer price, lagged one year, lagged two years

Time lags were used due to the biological lags between input application and output production, where the inclusion of the time trend, *T* is intended to identify the influence of non measurable monotonic time related factors on overall output, including advances in agro-technology, infrastructural facilities designed to increase the production and finally to incorporate fluctuations in natural elements (Akinboade 1999).

Other factors influencing production output included by other researchers that was not included into this Sartoruis van Bach (Von Bach 1990) study is capital to labour ratios (Akinboade 1999), prices of substitutional farming enterprises with competing outputs like cattle, goats or game and feed prices (including the price of maize) (Abbot & Ahmed 1999).

The livestock industry in Namibia is an established commercialised agricultural sector with the necessary infrastructure, marketing systems and extension services in place for optimal production. The elimination of factors that influence the production of livestock in this regard is therefore ignored by Sartoruis von Bach.

Due to the fact that most producers in Namibia, market both sheep and cattle through the same marketing systems, and where the environmental conditions remain the same for both livestock enterprises, the cattle supply response model of Sartoruis von Bach (Von Bach 1990) can be used as the fundamental framework for the sheep production supply model. Although some differences may exist in the marketing due to the Small Stock Marketing System, the marketing channels remain the same.

6. CONCLUSION: USEFULLNESS OF SUPPLY RESPONSE MODELLING TO INDUSTRY STAKEHOLDERS

The main reason for conducting research on supply response is to improve the understanding of the price mechanism. The knowledge of supply response greatly assists farmers in their decision making regarding the allocation of resources towards business goals. It can support planners and policy makers to allocate resources and achieve production targets in long term planning. Supply response equations can be used for forecasts based on current agricultural supply response parameters. Therefore, a thorough knowledge of the supply response of food commodities as well as implications of policies will be useful for planning food production against the background of a well balanced development strategy.

A research project on supply response analysis of the Namibian sheep industry will add value to the livestock industry in Namibia due to the fact that important relationships between the producers and other role players in the sheep value chain can be analysed. Stakeholders in the industry can take advantage of this analysis by incorporating these relationships into future decisions and policies.

It can be concluded that in a developing country such as Namibia, research on the field of supply response on a specific food commodity is relevant to a secure sustainable future of food security.

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