ESTIMATING SUPPLY RESPONSE OF MILK PRODUCTION TO PRICE AND NON-PRICE FACTORS IN SOUTH AFRICA

by

Mateadi Thabiso Manaka

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Supervisor: Prof. A. Belete

Co-supervisor: Mrs C.L. Muchopa

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DECLARATION

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

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Miss M.T. Manaka Date

DEDICATION

I dedicate this work to my family.

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Firstly, and most importantly, I thank God almighty for providing me with the ability and opportunity to embark on this journey, and for continuously giving me strength, knowledge and wisdom to complete this project.

Secondly, I thank my Supervisors, Prof. A. Belete and Mrs Muchopa for all the support, patience and guidance that they provided me with throughout the course of my study.

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ABSTRACT

The South African dairy industry is approximately 0.5% of the global production. The production of milk contributes to exports, manufacturing, employment, food security and development of other producers of agricultural products such as maize and soya bean. Following the deregulation of the agricultural markets in 1996, the dairy industry has seen a decline in the number of producers, with Milk Producer Organisation noting that between 2008 and 2015 there has been a decline of 58%. Therefore, the decline in producers necessitates the need to understand the nature and factors that influence the remaining producers to continue producing.

This study, therefore, was undertaken to examine the supply response of milk production to price and non-price factors in South Africa using the Nerlovian Partial adjustment model. In that regard, the historical data for the period of 1996 to 2014 was used and analysed in Eviews 10 software.

The short-run and Long-run elasticities of milk production were found to be inelastic. The results of the study further indicated that milk production was responsive to changes in price of beef, technology, previous production, and temperature.

Given the study findings, thus recommendations made are that technological research and advancement, such as animal cross breeding is necessary to improve production of milk in the country. Furthermore, better price incentives such as price floors and subsidies are necessary in the industry, to encourage more milk production and reduce likelihood of farmers to switch from milk to beef, given the changes in price.

Key words: Milk production, price, non-price factors, Supply response, Nerlovian Adjustment model

TABLE OF CONTENTS

CONTENTS **PAGE**

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

DAFF	Department of Agriculture Forestry and Fisheries
MSA	Milk South Africa
MPO	Milk Producers Organisation
IDFA	International Dairy Foods Association
WWF	World Wide Fund
IMF	International Monetary Fund
FAO	Food and Agriculture Organization
ADF	Augmented Dickey-Fuller

CHAPTER ONE

INTRODUCTION

1.1 Background

According to Department of Agriculture, Forestry and Fisheries (DAFF, 2017b) the South African dairy industry is approximately 0.5% of the global milk production. Milk is critically important to a quality diet for people of all ages (Zartman & Wattiaux, 2009) in that milk and its products contain vital nutrients that are necessary for the development of the body for both the old and the young. The dairy industry is currently the third largest livestock sector in South Africa. The dairy industry is important to the economy as well as the welfare of people in a country; hence it is common throughout the world. Livestock production in South Africa contributes substantially to food security (Meissner, Scholtz, & Palmer, 2013), where milk is closely linked to crop production particularly in rural communities and non-metropolitan towns.

In 2013, the Agriculture and Horticulture Development Board (2015) states that the world cow's milk production was at 636 million tonnes and by 2016 it was 826 million tonnes (Milk Producers Organisation [MPO], 2018). The USA in 2013 was the largest producer of which it accounted for 14.4% of the world's milk production, India being second with 9.5% followed by China, Brazil, Germany, Russian Federation, France, New Zealand, Turkey and United Kingdom (Agriculture and Horticulture Development Board, 2015).

Generally, the dairy industry is mostly dominated by large-scale producers often regarded as commercial producers, medium sized and smallholder producers often regarded as the subsistence producers. In the dairy industry according to Milk South Africa (MSA, 2014), the commercial producers are linked to selling their milk produced to processors while smallholder and emerging producers are linked to the consumption of the milk produced, the selling of the milk directly to consumers and/or selling to processors. In most cases, the main purpose of most smallholder producers is for home consumption with little money being spent or earned from milk production.

Milk sources differ from one country to another, however the dairy cow is the ultimate supplier of milk but milk of other animals is of importance in other regions of the world. According to Delgado, Narrod and Tiongco (2003), India gets milk from cattle, buffaloes and goats, while according to Keteme and Tsehay (1995); Ethiopia gets milk from cows, goats, and camel. In South Africa milk is produced from goats and cows, with cow milk being the most produced. The variation in milk producing livestock amongst countries is due to how they adapt to the feed supply in the locality, management, climate conditions as well as the specific textures and flavours they bring to milk products (Zartman & Wattiaux, 2009).

Most common breeds of milk production in South Africa were identified by MSA (2014) as Holstein, Jersey, Aryshire, Guernsey, Dairy Swiss and the Swedish Red. Scholtz and Grobler (2009) further identified Afrikaner, Angus, Bonsmara, Brahman, Drakensberger, Friesian and Nguni. However, the four major breeds found in South Africa are the Holstein, Jersey, Guernsey and Ayrshire (DAFF, 2017b). The variation on which breed a producer uses depends on: what breed is used within a particular locality and is seen to be successful, the volume of milk produced by breed, feeding system used on the farm, climate of the region, availability of land and the prospective business that is to say choose a breed that will be in line with the income and profits desired.

In India, according to Delgado *et al*. (2003), the dairy industry contributes over 6 % to the GDP of the country and the industry has a market share of USD 48.5 billion for 2011 and was anticipated to reach USD 118 billion by 2017. In Nigeria, according to Mwanza (2015), in 2013 the industry was estimated to have contributed 1.7 billion in revenue to the economy. Hamid and Hossain (2014) identify the dairy industry in Bangladesh as prominent, as it accounts for 14.8%. In addition, Muia *et al*. (2011) reports that in Kenya the dairy industry contributes 3.5% of agricultural GDP, and it contributes towards the livelihoods of many smallholder farmers that is through incomes, employment and food security.

1.2 Problem statement

Milk production and consumption dates back to the early days of subsistence farming. Over the years, the concept of rearing cows for milk production has sparked interest as a viable business as producers respond to the creation of dairy preservation methods and increasing interest in trade and its contribution thereof to the social lives of local people.

Following democratic dispensation in 1994, the South African agricultural sector was deregulated and this resulted in the elimination of the agricultural marketing boards. As a result, many farmers were without any form of support from government; hence, production and marketing became competitive. According to Gertenbach (2009), Scholtz and Grobler (2009) and Singh (2013), there have been a decline in the number of milk producers in South Africa over the years. The decline in the number of producers is 30% between the years 2001 and 2007 (Scholtz & Grobler, 2009) and a further 53% between January 2008 and August 2015 (MPO, 2018).

Literature on the topic under investigation in this study over the years, suggests that information on the relationship between supply and price and non-price factors (For example: Rainfall patterns, temperature, technology, et cetera) is imperative, particularly that of developing countries because of the contribution of agriculture to the wellbeing of local people and the economy.

The decline in milk producers in South Africa therefore compels the need to understand the responsiveness of milk producers that remain in the dairy market. By identifying factors that influence milk producer's responsiveness this ensures that relevant recommendations are made to improve the participation and adjustment of production resources by the producers. Hence, this study attempts to estimate the supply response of milk production in South Africa to price and non-price factors.

1.3 Rationale of the study

Milk and milk production are important to the South African economy as they contribute towards food security directly and indirectly, that is through job creation throughout the value chain of milk, from the input sector until the marketing of milk products and it further stimulates trade. Apart from economic contribution, milk is important to the health of all if not most South Africans. According to International Dairy Foods Association (2015), milk contains nutrients such as calcium and potassium, which are required to assist in the formation of bones and the proper functioning of the human system.

The study, therefore, intends to understand how South African milk producers adjust their production resources to changes in the market, by revealing their responsiveness to changes in prices and non-price factors. This study therefore provides information that can further be used when formulating a set of policies for South African milk producers. The information in this sense, can further be used by animal technical teams to guide producers so that they can adjust their resources adequately to the changes in the market and help improve the contribution of milk production to the economy and wellbeing of people in South Africa.

1.4 Aim and objectives

1.4.1 Aim

The aim of the study is to estimate the supply response of milk production in South Africa.

1.4.2 Objectives

I. Determine the responsiveness of the supply of milk in South Africa to prices.

II. Determine the responsiveness of the supply of milk in South Africa to non-price factors such as weather conditions and technology adoption.

III. Estimate the short-run and long-run elasticities of milk production to changes in price and non-price factors.

The aim and objectives of the study are investigated using the following hypotheses.

1.5 Hypotheses

I. Supply of milk is not sensitive to prices.
II. Supply of milk is not sensitive to non-price factors.
III. There are no long-run and short-run elasticities for changes in price and non-price factors.

1.6 Organisational structure

This study is divided into five chapters, of which, chapter one is already presented. Chapter two reviews literature of the South African dairy industry and explores supply response approaches and supply response studies conducted. Chapter three presents the analytical method employed in the study by introducing the study area, defining the analytical method, and variables used in the study. Moreover, chapter four presents the results and discussions of the analysis of the study. And chapter five is the summary, conclusion and recommendations based on the results.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on milk production in South Africa, and further explores different methods and models employed in the analysis of supply responses and previous studies conducted.

2.2 South African dairy industry

Throughout the world, the dairy sector is one of the fastest growing productive sectors, in terms of volume output, sales and real commodity prices (Lokuruka, 2016). The demand for milk, according to Grobler *et al.* (2008), in developing countries is anticipated to increase by the year 2025 by 25%, this increase being attributed to increase in population, increase in incomes to spend on food products in trying to meet nutritional needs (Grobler *et al.*, 2008), urbanisation and westernisation of diets, particularly in countries like China and India (World WIldlife Fund, 2004). The MPO (2017) further predicts that the global demand for dairy will grow by 22 million tonnes per year, in which 8 million will be attributed to population growth, and the remaining 14 million due to increase in per capita consumption.

The South African dairy industry is large and intricate. Accordingly, the industry has over the years gone through structural changes with the liberalisation of the industry being at the core. Furthermore, following the dissolution of the marketing system founded under the Marketing Act no.59 of 1968 that allowed boards to control movement, pricing, product quality standards, the selling and supplying of large volume of farm production. The Marketing of Agricultural Product Act no.47 of 1996 sought to correct and stabilise the markets, to which prices in the market were left to be determined by the forces of demand and supply and further that producers sought out market on their own. However, under the Agricultural Marketing Act no.47 of 1996, the National Agricultural Marketing Council was established to monitor effects of deregulation in industries, investigate export marketing incentives and tariff investigations, to which its duties continue to date.

2.3 Value chain

There are various economic activities which exist in the marketing of dairy products (DAFF, 2017b). The dairy industry according to Van der Lee, Zijlstra, Wouters and Vugt (2014) comprises of a combination of farming systems and dairy chains. This combination of farming system and dairy chain include all the participants that are involved in primary production and the marketing of milk through a number of dairy chains that are formal and informal. The industry according to MSA (2014) employs 60 000 farm workers and further provides 40 000 people with direct jobs in the value chain that is through milk processing and the milling industry.

The value chain for this study is classified into 2 sectors as means of understanding various components vital to the industry. The sectors as shown in figure 2.1 are: the primary production sector which looks at the production of milk and inputs that are vital and used in the production. Therefore, the secondary sector looks at value adding of milk and distribution of milk to various consumers. All sectors in the value chain indicate various activities that take place within the dairy industry, which include the production and marketing. Sections 2.3.1 and 2.3.2 of the study further elaborate on the primary and secondary sectors in the South African dairy industry.

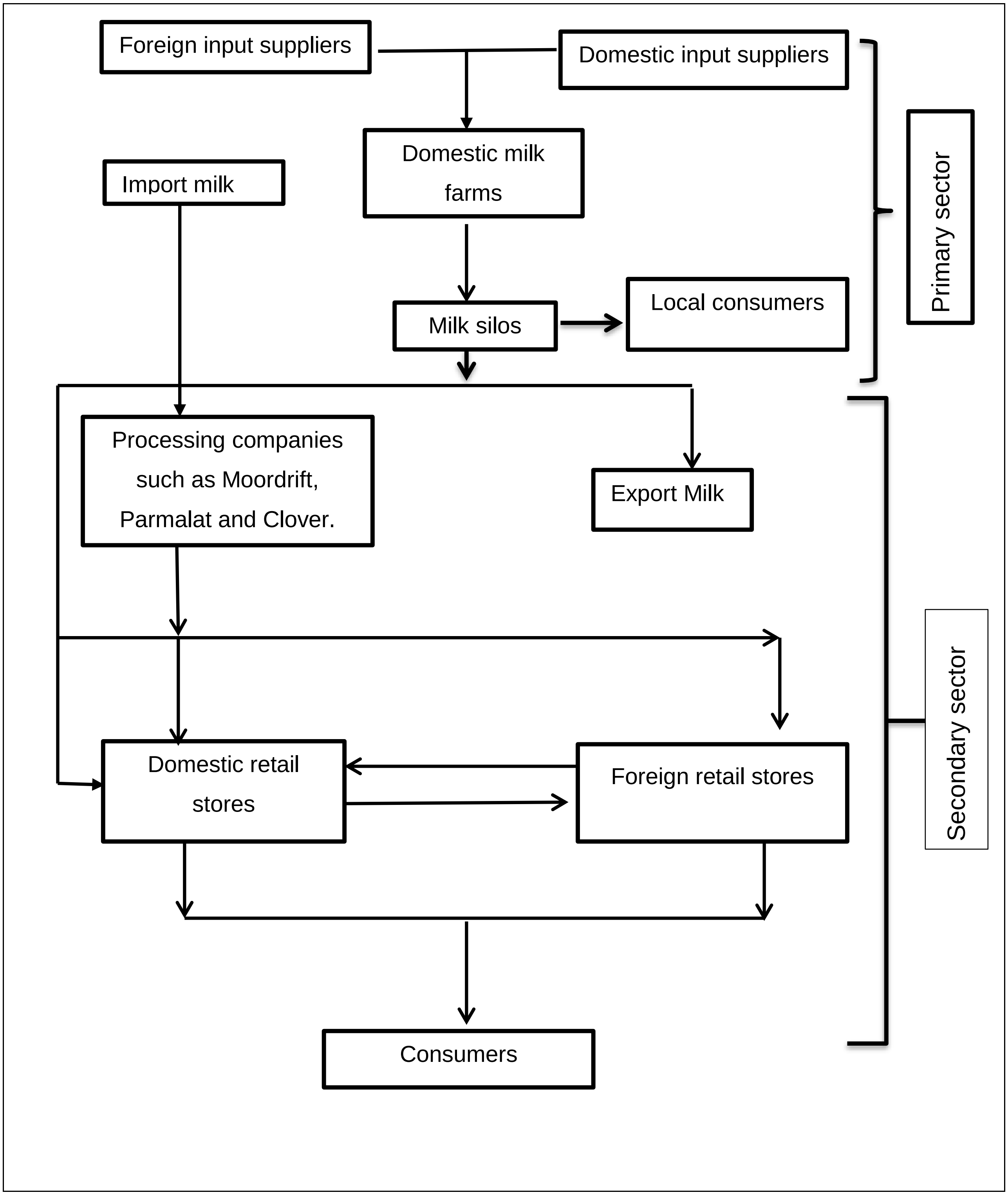

Figure 2.1 Value chain of milk.

Source: Own creation (2018).

2.3.1 Primary sector

The primary sector as indicated in figure 2.1 includes producers in respective areas, cattle breeds that are used in the production, feed, medication, equipment, labour and research on ways to improve the production. In this regard, the primary sector is the most vital sector in the industry to which Gertenbach (2009) indicates that it requires the highest demand on advanced technology and skilled and trained workers to ensure that cows acquire required nutrition to produce optimal amount of quality milk.

There are three types of farmers identified in South Africa: the commercial, emerging and small-scale farmers. Gertenbach (2009) identifies 6 areas in South Africa where milk is produced, namely; Kwa-Zulu Natal (KZN), Southern Cape, Western Cape (WC), Central Highveld and Free State, Central Eastern Cape and Southern Eastern Cape. Notably, in figure 2.2 below, milk production in South Africa is mostly concentrated along the coastal areas making them contribute about 83% to the total milk production in the country (DAFF, 2017b). Therefore, Western Cape, Eastern Cape (EC) and KwaZulu-Natal are the largest producers (Lassen, 2012).

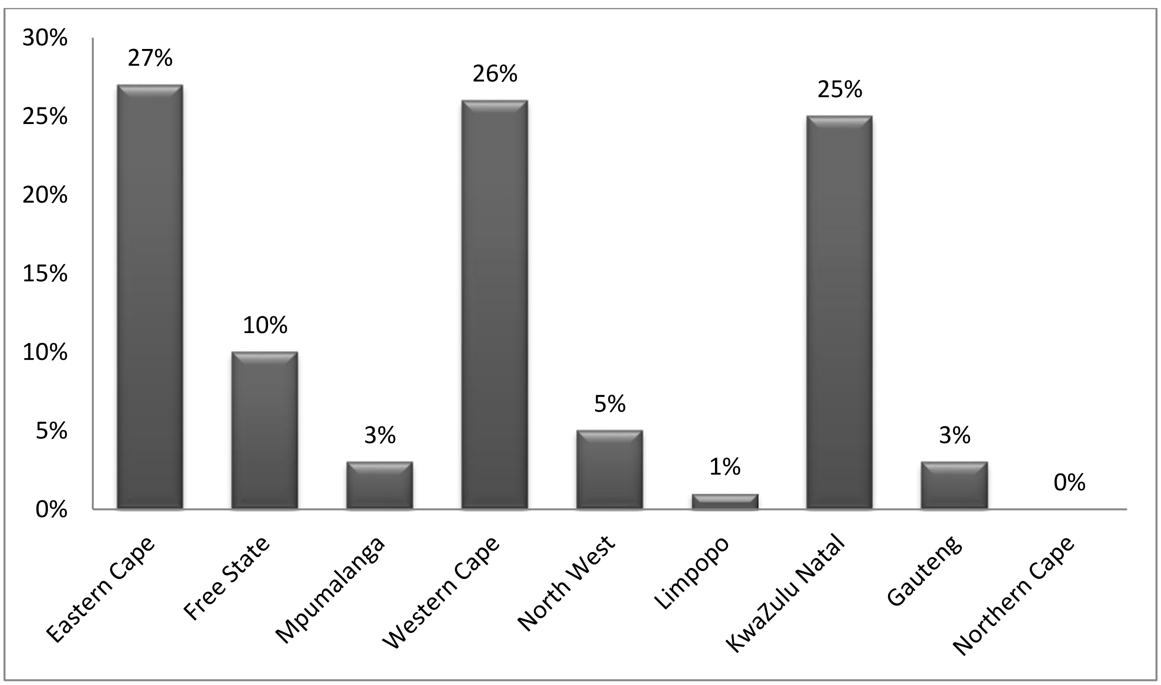

Figure 2.2: Percentage of production per province

Source: MPO (2017)

The number of milk producers in South Africa has decreased by 58%, thus, from 3 551 in January 2009 to 1 503 in June 2017 (MPO, 2017). However, regardless of the decline in milk producers, there has been 22% increase in the amount of milk produced (2 587 000 t in 2009 to 3 158 000 t in 2016). The changes in number of producers over the years are observed in figure 2.3 below.

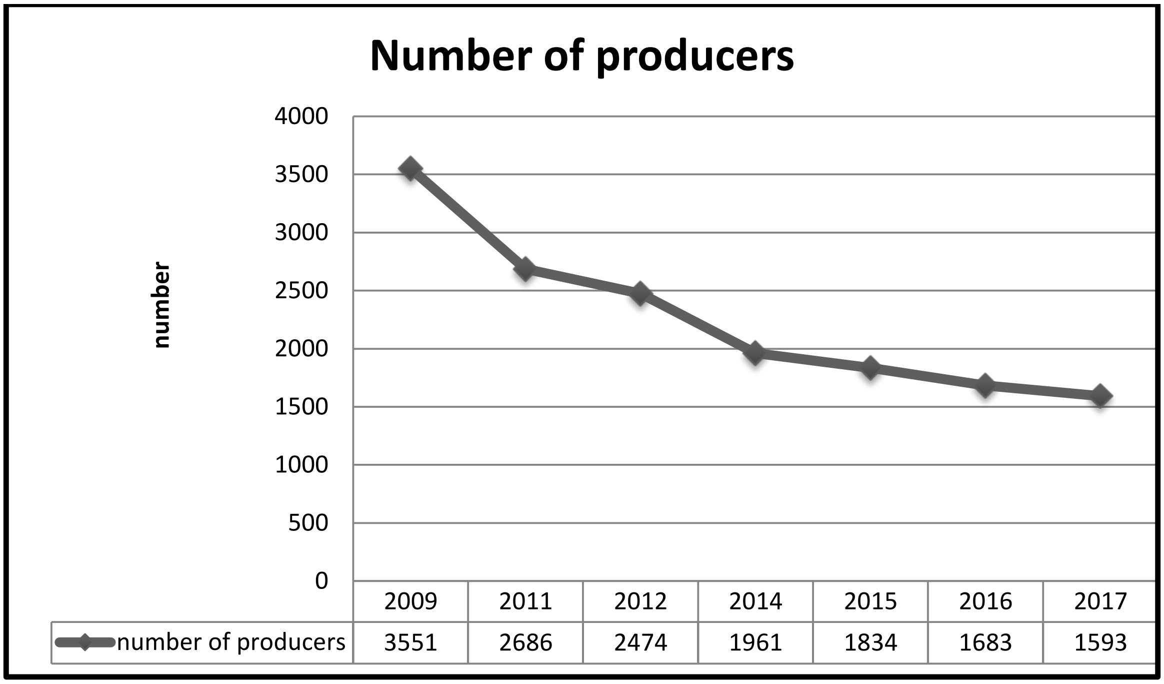

Figure 2.3 Number of producers from 2009 to 2017

Source: MPO (2017)

Table 2.1 below shows the number of producers per province in South Africa from January 2009 to January 2017. In addition, table 2.1 table shows that the decline in number of producers which can also be seen throughout the provinces, both coastal and inland provinces. Some of the biggest changes can be seen with a decline in the North West Province, where there were 540 producers in 2009, but by 2017 there were 165 producers left. Moreover, Gauteng also reports to having a declined from 217 producers in 2009 to 98 producers in 2017. Furthermore, Mpumalanga Province has also seen a decline from 286 producers in 2009 to 87 producers in 2017. However, some provinces though they show a decline, the decline has however been slow: for example, the decline in producers in the Eastern Cape, 283 producers in 2012 and 264 producers in 2014; 262 producers in 2015 and 251 producers in 2016. Therefore, the decline is different from that observed in the Free State, where in 2012 there were 535 producers, in 2014 there were 389 producers, in 2015 there were 328 producers, and by 2016 there were 280 producers; a magnitude change of 146, 61 and 48 producers throughout the years for Free State and a change of 19, 2, and 11 producers for the Eastern Cape.

Furthermore, table 2.1 below shows that the Western Cape, Eastern Cape and Kwa-Zulu Natal Provinces have the highest number of producers. The Western Cape continues to have the highest number of producers in South Africa. Limpopo Province, Gauteng and the Northern Cape however, have the lowest number of producers.

Table 2.1 Number of producers per province from 2009 to 2017

Province	Jan 2009	Jan 2011	Jan 2012	Jan 2014	Jan 2015	Jan 2016	Jan 2017
Western cape	795	683	647	529	533	502	481
Eastern cape	387	314	283	264	262	251	244
Northern Cape	37	28	21	25	14	14	7
Kwa-Zulu Natal	373	323	322	281	267	253	247
Free State	884	601	535	389	328	280	249
North West	540	386	352	233	222	181	165
Gauteng	217	127	126	109	100	97	98
Mpumalanga	286	201	164	117	94	93	87
Limpopo	32	23	24	14	14	12	15

Source: MPO (2018)

In the 1980s, it was found that a producer in South Africa only needed 85 cows to be profitable (Gertenbach, 2009). However, MSA (2014) later indicated that a farmer needs at least about 100 cows to survive and be profitable. South Africa is one of the countries with larger dairy farms with a higher average number of cows. In light of this, table 2.2 below shows average herd sizes of ten countries.

Table 2.2 Average herd size in 2016 for selected countries

Country	Average herd size
Saudi Arabia	6 924
New Zealand	419
South Africa	354
Australia	283
Czech Republic	207
US	203
Denmark	185
Israel	171
Argentina	168
United Kingdom	143

Source: MPO (2018)

The average herd in 2016 was found to be 354 with EC, KZN and WC with the biggest herd (MPO, 2017), thus, a great improvement from the 2011/2 herd which was found to be 300 cows (Lassen, 2012). Therefore, table 2.3 below shows the average herd sizes in South African provinces.

Table 2.3: Average number of cows per producer per province in 2016

Province	Average herd
Western Cape	244
Eastern Cape	584
Northern Cape	168
KwaZulu Natal	433
Free State	173
North West	105
Gauteng	127
Mpumalanga	149
Limpopo	191

Source: MPO (2017)

According to International Dairy Federation (2013) and DAFF (2017b), the number of dairy farms in a country greatly depends on the farming system the farmers utilize. Farming systems used in SA are based on weather conditions, geographical location of farm, and seasons. Three types of farming systems were identified by Lassen (2012), namely; Grass based system, Total Mixed Ration (TMR) and the mixed system. Of the three systems, Eastern Cape was found to employ the grass-based system, where cows are kept out door to graze on pasture that is irrigated and grass-clover mixture, this system is similar to one that is used in New Zealand and Ireland. Therefore, the TMR is used by most producers in the Western Cape, and is similar to that used by European producers. The TMR system according to Milk SA is a practice of weighing and blending all feedstuff into a complete ration that provides adequate nourishment to meet the needs of cows, each bite contains the required level of nutrients needed by the cow. Lastly, producers in provinces that are in the middle of the country are found to use the mixed system, where cows graze and the TMR is adopted in the winter season.

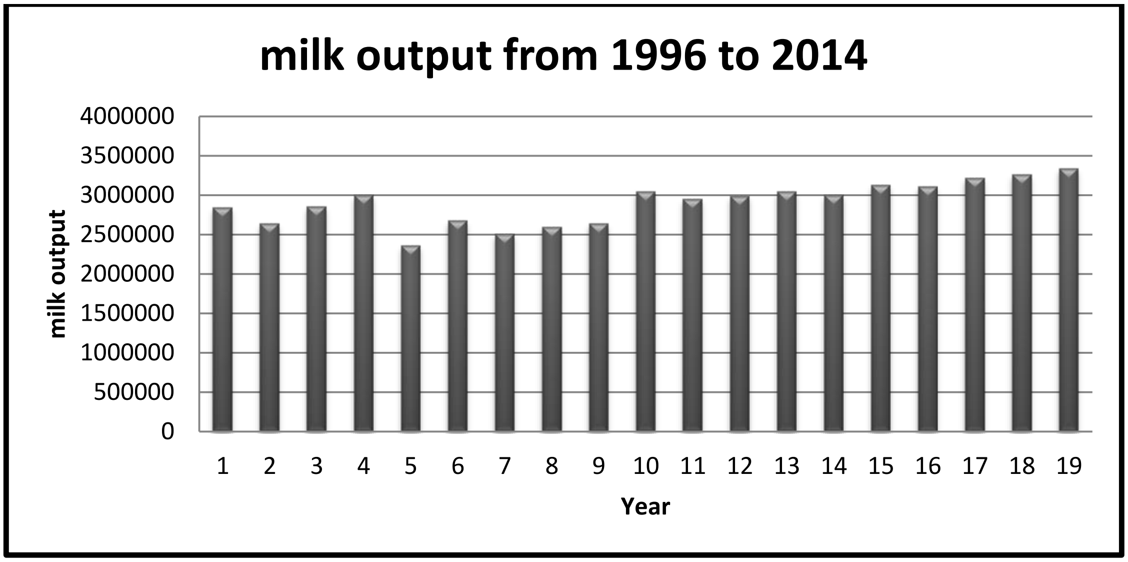

Figure 2.4 Milk output from 1996 to 2014

Source: FAOSTAT

The amount of milk produced throughout the years is indicated in figure 2.4 above. Milk output varies from one years to the next, from figure 2.4 above, the lowest milk production was in year 5 that is in the year 2000 and the highest in year 19, which is in 2014.

2.3.2 Secondary sector

The South African secondary dairy industry comprises of few large dairy processors that operate nationally, whereby, others operate in more than one region while others operate in specific areas (MPO, 2017) and others sell their milk to retailers and consumers (commonly known as producer-distributors) (MPO, 2016). Moreover, there are other larger major multinational dairy companies that are active participants in the South African dairy market, these include; Nestle from Switzerland and Danone from France.

The dairy industry, according to MPO (2017), is divided into 63% liquid and 37% concentrated products, a 3% change from that identified by DAFF in 2015, where 60% was liquid and 40% concentrate products. In this regard, liquid products include; Pasteurised milk, UHT (long life milk), yoghurt, maas and buttermilk, and flavoured milk and the concentrated products include; hard and semi-cheese, milk powder, butter, whey powder, buttermilk powder, condensed milk and other cheese.

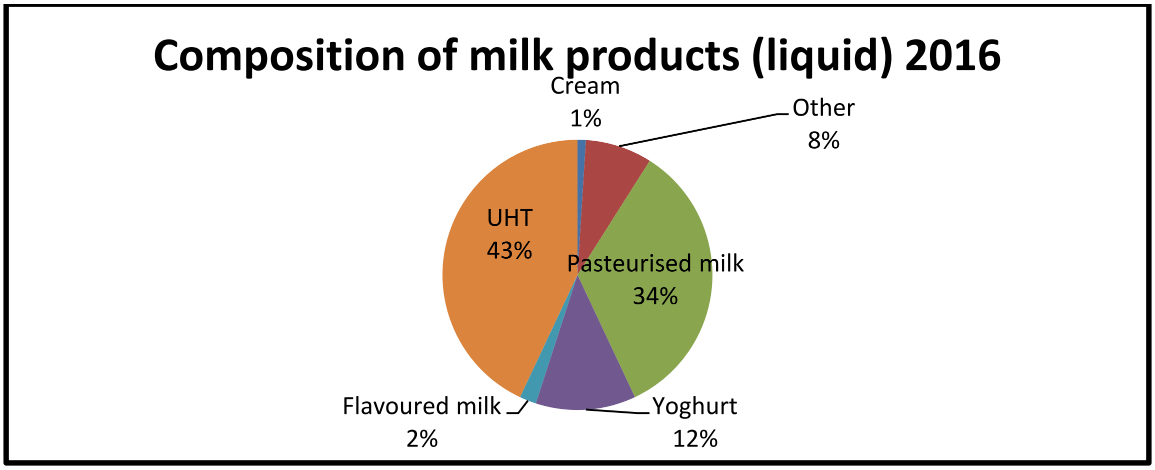

Figure 2.5 Composition of milk products (Liquid) 2016

Source: DAFF (2017b).

Figure 2.5 above indicates that in South Africa, of 63% of milk that is used in the production of liquid products, most goes to the production of UHT, Pasteurised milk and yoghurt, with each being, 43%, 34% and 12% respectively.

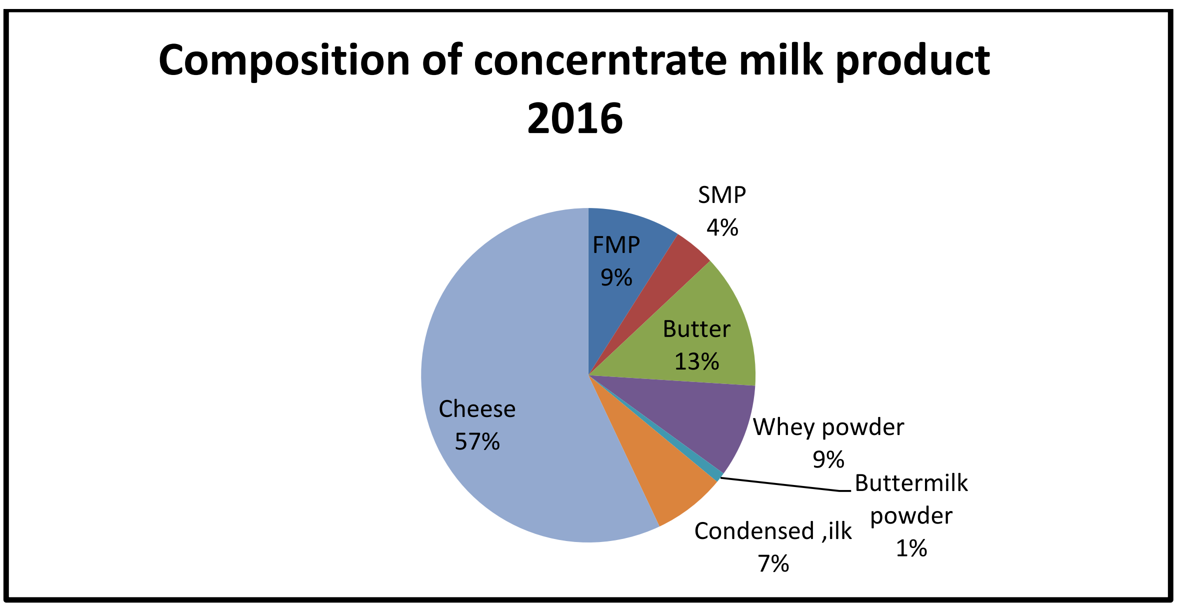

Figure 2.6 Composition of concentrate milk products 2016

Source: DAFF (2017b).

Figure 2.6 shows that of the 37% of concentrate milk products produced, 57% of it goes to the production of cheese and 13 % to butter.

According to Harcourt (2011), in 1996 there were 113 firms in South Africa that were involved in the processing of milk products, however Lassen in a 2012 study found that there were 168 processors, with 5 found to be dominating the sector. In this regard, 98 % of the milk that is produced in the country is sold to formal markets where it is mostly processed into liquid milk, that is; UHT and pasteurised milk (Lassen, 2012). This however, is contrary to what was found in 2016 by MPO. According to MPO (2016) 96% of milk is sold to formal markets and only 2% is sold to informal markets and the other 2% unaccounted for, and this is only for farmers registered with the organisation.

In comparison to some countries in the world, table 2.4 below shows the amount of milk produced by top ten countries in the world in 2015, with the amount of milk marketed and the marketed percentage to formal markets. In addition, the table indicates that India in 2015 was the largest producer of milk, yet interestingly only 17% of the milk that was produced was sold in formal markets. Moreover, in comparison to the top 10 countries, South Africa only produced 3.1 million tons of milk, and 97% of the milk reported is sold to formal markets. Therefore, the differences in the magnitude of milk produced in the top 10 countries and South Africa shows that there is still a long way to go for the South African dairy sector to be able to compete with international markets. In this regard, the difference between the last country and South Africa is 12.5 million tons of milk; however the production, the 97% indicates availability of market for milk produced in South Africa.

Table 2.4 Percentage of milk production to market 2015

Country	Milk produced in million tons	Milk to market in million tons	Percentage of total production to market
1. India	164.5	28.0	17%
2. USA	90.2	89.8	100%
3. Pakistan	45.9	1.4	3%
4. Brazil	34.7	24.4	70%
5. Germany	33.4	32.1	96%
6. China	31.8	28.5	90%
7. Russian Federation	28.5	18.6	65%
8. France	25.6	25.1	98%
9. New Zealand	24.6	24.6	100%
10. Turkey	15.7	8.2	52%
South Africa	3.2	3.1	97%

Source: (Coetzee, 2016)

Table 2.4 shows that USA and New Zealand were the only countries that sold 100% of the milk produced to formal markets. According to DAFF (2017b) milk is cheaply produced in New Zealand than any other country, hence allowing for producers to be able to sell off some of their milk not only to local markets, but to other international markets, hence making their milk price attractive. In the United States on the other hand, producers are offered subsidies, producers are paid guaranteed floor price for dairy products and furthermore, they are granted subsidies too to bridge the gap between domestic prices and world market prices (DAFF, 2017b). In the European

Union, producers are offered subsidies on inputs, hence this allows for lower prices of milk and hence the upper hand in the market as observed by the 96% and 98% of marketed milk by Germany and France respectively.

Most of milk and milk products produced in South Africa are exported to Southern African Development Community countries in which, Botswana (41%), Mozambique (13%) and Namibia (12%) are the highest importers. However, South Africa imports plenty of milk and milk products on average according to DAFF (2017b), which observed that the country in the past 10 years has imported 45 347 tons valued at R1.2 Billion.

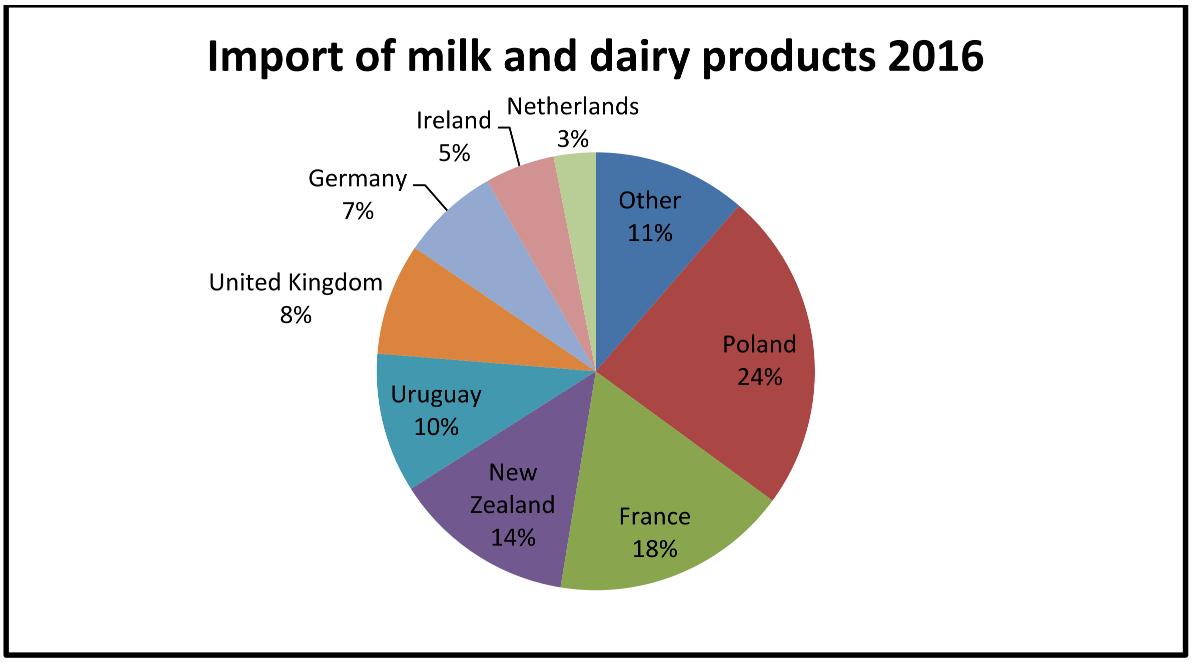

Figure 2.7 Import of milk and dairy products

Source: DAFF (2017b)

Figure 2.7 shows some of the countries that South Africa imports milk and milk products from. In this regard, Poland supplies 24% of milk and milk products, France supplies 18%, New Zealand supplies 14% and Uruguay supplies 10%.

2.4. Supply responses

A supply response is a tool that is used to evaluate the effectiveness of price policies and to assist producers in the allocation of resources (Gosalamang, Belete, Hlongwane, & Masuku, 2012). Therefore, supply response studies are useful particularly for evaluating production policies and incentives (Van Wyk & Treurnicht, 2012). This is because, supply response explains the change in behaviour of producers regarding their production, consumption and exchange decisions for a product or group of products, brought forth by changes in economic incentives (Ajetomobi, 2010).

2.4.1 Supply response techniques

Over the years, there are various approaches that have been used to analyse the supply response of agricultural commodities (Elterich & Masud, 1980). Tripathi (2008) identifies two types of studies that exist; firstly, studies conducted on an individual commodity level, which show the changes in the composition of agricultural output to changes in the relative price of a particular commodity. Secondly, there are other studies conducted on an aggregate output level. In addition, they show a change in total agricultural output due to change in the relative price of agricultural commodities compared with industrial goods.

On the analysis level of the supply responses however, there are two approaches that can be used to analyse the supply response of a commodity or of a group of commodities. Shoko, Chaminuka and Belete (2016), Tripathi (2008) and van Wyk and Treurnicht (2012) have classified these approaches into two; firstly, the indirect structural approach also regarded as the linear programming approach (Van Wyk & Treurnicht, 2012). This approach, therefore, involves the derivation of the input demand function and the supply function from the available data on information related to production and an individual’s behaviour.

Furthermore, a linear production model is created which reflects or represents the typical production system of a specified product or various products. The objective function is usually specified as that related to profit maximisation. Therefore, the advantage of using this particular approach is that it is capable of handling complex multi-relationship at farm level in a production system. Accordingly, this involves the recognition of all the effects of supply on production price, input price and technological and physical restrictions. Furthermore, the disadvantages of this approach are: it fails to take into account the partial adjustment in production and the mechanism used by farmers in forming expectation. This approach further requires extensive, detailed information on all the input prices.

Secondly, there is the direct approach, also regarded as the econometric models. This approach to supply response is based on the notion that production in agriculture is not instantaneous, and is dependent on post-investment decisions and expectation, that is to say, the production in any period or season is affected by past decisions. In this approach therefore, the supply response is directly estimated by including partial adjustment and expectation formation.

The Nerlovian model is the early version of model to be used to capture agricultural supply to price incentives. Although, this model has been widely used it is often criticised for its inability to distinguish between short-run and long-run elasticities. However, Mythili (2006) used it and argues that it allows for one to determine short-run and long-run elasticities also that it gives flexibility to introduce non-price shift variables in the model. And the model however, uses integrated (non-stationary) series that poses the danger of spurious regression analysis.

With the disadvantages of the Nerlovian indicated, the Error Correction and Co-integration analysis models were used to make corrections of identified errors where; The Error Correction Model (ECM) is an approach used to analyse non-stationary time series data that are known to be co-integrated, it assumes co-movement of variables in the long-run.

The co-integration analysis however, involves various techniques, it is used mostly when solving for statistical problems that are related to non-stationary data series that could lead to spurious results.

The Autoregressive Distributed Lag (ARDL) is one technique in co-integration, which tests for the existence of non-spurious long-run relationships between economic variables. The advantages of using this technique, therefore, is that this particular model can distinguish between long-run and short-run elasticities and it does not impose the restrictive assumption that all the variables in the study are to be integrated to the same order. The model further allows for the inclusion of different variables that have different optimal number of lags.

2.4.2 Previous studies

Various methods are used to estimate supply responses of various products. The different supply responses can be seen in terms of their methodology, time periods, geographical regions and locations. This section will explore supply response studies on various crops, livestock and livestock products.

Schimmelpfennig, Thirtle and van Zyl (1996) used the error correction model in the estimation of supply response summer-rain grain, for which in the study Sorghum and Maize were the two dominating crops. The study was carried out for the period between 1956 and 1993. Consequently, there are variables that were found to significantly influence the supply of maize, which are; the price of maize, price of Sorghum and Sunflower, and the price of complementary intermediate input prices. In addition, variables that were found to influence the supply environment of maize were rainfall, farmer education and cooperative extension. However, Sorghum was found to be a secondary crop as it is influenced by the changes in the variables affecting maize. The size of the area which Sorghum is planted on depends on intermediate input prices and rainfall. Furthermore, the study found that most policies formulated in South Africa are mainly focused on the production of maize.

Supply response for maize alone was estimated by Shoko *et al.* (2016) for South Africa. The study was carried out for data ranging from 1980 to 2012. In this regard, the area under cultivation for the time period was used as the dependent variable. The results indicated that non-price incentives such as rainfall and technology have more effect on maize supply than price incentives as observed by Schimmelpfennig *et al.* (1996). Therefore, the differences in results found by Shoko *et al.* (2016) and Schimmelpfennig *et al.* (1996) can be due to the presence of maize marketing board as per the Marketing Act no.59 of 1968. Furthermore, Shoko *et al.* (2016) found the short-run price elasticity to be 0.24 and the long-run price elasticity to be 0.36, this indicating that producers are less sensitive to change in prices.

In the case of Mississippi, Levins (1982) used a polynomial lag model to estimate the supply response of milk to which is said to offer theoretical possibility of approximating the expected pattern of lagged variables. In the analysis, therefore, it is identified that non-price factors that determined production were: production costs and technological changes and it is further indicated that short-run production changes can be made by culling herds and/ or alternating feed practices. In the long-run, production increases are said to require changes in herd sizes.

Ayinde, Bessler and Oni (2017) estimate the supply response and price risk on rice using co-integration models and the vector autoregressive distributed lag model. The study was for the period 1970 to 2011, and variables used were: producer price, hectarage in the year, quantity imported in year and rainfall. The results of the study therefore indicate that, there is a negative relation between producer price and output, and also for imports and output, however, a positive relation is found between hectarage and output.

Kibara, George and Gerald (2016) use the error correction model in estimating supply response for livestock products together with the polynomial distributed lag model to determine the long-run and short-run responses. In this regard, the results obtained from the analysis indicate that changes in the price of livestock products, rate of national inflation in macro-economic environment, drought and the amount of rainfall received play an important role in the responses of farmers. Moreover, inflation is a key macroeconomic variable that affects production systems and hence a continuous increase in inflation would negatively impact the supply of livestock and livestock products. The study further found that producers adjust quite early, probably as soon as they gain the slightest indication that the market signal would be permanent.

Gosalamang *et al.* (2012) in the case of Botswana uses the Nerlovian partial adjustment model which postulated that the supply adjusts by some constant fraction of the difference between previous and the desired supply, however, Mbaga and Coyle (2003) in the case of Alberta uses the autoregressive distributed lag model. Furthermore, Beef farmers in the research by Gosalamang *et al.* (2012) are found to be responsive to both economic and non-economic factors. Moreover, it is indicated that farmers respond negatively to rainfall, increase in number of cattle, previous year supply and chicken output. Cattle in Botswana for most farmers is regarded or seen as investment rather than a commercial enterprise similar to that found by Mbaga and Coyle (2003) who consider the importance of the beef cow as both a capital and consumption good, even though they focus more on uncertainty because farmers are generally considered to be risk averse and are prone to price uncertainty and risk aversion which Gosalamang *et al.* (2012) had not considered. Famers have been found to respond positively to technological advancement even though response was found to be inelastic Gosalamang e*t al.* (2012).

Yu, Lui and You (2011) also used the Nerlovian approach on maize. The study was interested in directly estimating farmers' output reaction to policy investments. In this regard, focus was made on acreage and yield response of wheat and rapeseed for winter and maize, cotton and non-rapeseed for summer. Accordingly, the results of the research indicate that maize acreage is significantly influenced by the price of maize, cotton and oil crops. Grain yield on the other hand, showed no evidence of responsiveness to market prices. Moreover, yield elasticities of cash crops (cotton and rapeseed) were negative, this suggesting that price incentives alone are not enough to bring farmers interest in cash crops.

Furthermore, supply response for Macadamia nuts in Zimbabwe is estimated by Mazuruse, Mhuru, Muvingi, Gwarimbo and Chiusunga (2018) using monthly data from 2009 to 2016. In light of this, yield is used as a depended variable, and accompanying independent variables are lagged values of price of Macadamia nuts, rainfall, fertilizer, chemical, fuel and labour, and yield. The results of the study, therefore, suggest that response for Macadamia nuts in Zimbabwe is inelastic, both in the long-run and short-run.

Elterich and Masud (1980) and Bryant, Outlaw and Anderson (2007) researched aggregate milk supply response in Delaware and on Milk income loss contract program (MILCP) respectively. Both studies employ two equations in which number of cows and milk production per cow are a function of lagged price of milk, technology and input prices, although Bryant *et al.* (2007) include a dummy for the utilization of the MILCP and Elterich and Masud (1980) include the price of beef. In this, both studies found that milk prices have a positive effect, however adjustments differed. In study conducted by Bryant *et al.* (2007) therefore it is established that the adjustment period was 10.5 years, however, Elterich and Masud (1980) find it to be 1- 2 years this being attributed to that farmers in the locality are few, have large herds and are more specialised. The short-run elasticity was 2 and the long-run was 2.8 (Elterich & Masud, 1980). However, for Bryant *et al.* (2007), the results are that MILCP is found to be somewhat self-defeating as the program would lower market prices of dairy products that otherwise prevail, and hence that in the long-run leading to the removal of other dairy products particularly in times of low prices.

Raghunathan (2014) analyses the impact of milk supply response to Marginal Protection Plan (MPP)-Dairy in the United States of America. The MPP-Dairy programme provides farmers a cash payment if the national margin (that is, milk price minus feed cost) drops below a selected level for a period of 2 months. In this regard, the stochastic dynamic optimisation programme is used to analyse monthly average daily information from 2000 to 2009. Moreover, in his regard, farms used in the study are divided into 3 groups; small, medium and large, based on milk production per farm. The study includes the use of Milk Income Loss Contract (MILC). The results therefore, indicate that both the MILC and MPP-Dairy reduce milk responsiveness; the MPP-Dairy was further found to have less distortionary effect on the aggregate milk supply. Furthermore, payment period of MPP-Dairy is considered to be highly important as it allows for producers to reinvest payments into the farm, and hence this increasing the supply of milk, and therefore, impacting the price and of milk and increasing the volatility.

Hoehl and Hess (2018) conducted a study on the supply response for milk in seven German states. The time period of their study is from 1961 to 1983, this is for the period before the dairy quota was imposed. Furthermore, the supply response analysis was also done for the period 1984 to 2015, a period during which the dairy quota was effective. For the study, the seven states where separated to Northern German states and the Southern German states. The Global Vector Autoregressive (GVAR) model is used to estimate supply response. The results of the study, in this regard, suggest that after the initiation of the policy, the increase in prices particularly in North-western Germany resulted in investment, hence affecting the capacity and supply in the long-run. In Southern Germany however, it shows that production was less responsive to output expansion.

Nerlovian Partial adjustment lagged model is used by Wasim (2005) in a study on milk production of Pakistan for 31 years starting 1971-72 to 2002-03. In this regard, the variables that were used in the study were relative price, credit availability and lagged milk production, of which all were found to be important. Results of the analysis therefore, indicate that milk producers in Pakistan take more time to adjust in the long-run than in the short-run.

Tripathi (2008) however, conducted a study on India using the aggregated approach in examining supply response for India, and further investigates the difference in supply response among highly agricultural, medium agricultural and low agricultural based states. The response in this regard, is found to be inelastic to which reasons are attributed to lack of integrated farming approaches, lack of research and extension network, restrictions on trade and processing and public expenditure on rural infrastructure; this therefore, can be construed to relate and explain findings of Wasim (2005).

Furthermore, in the analysis of milk supply response in Swaziland by Sukati, Masuku and Rugambisa (2017), monthly data from the year 2010-2014 is used. The dependent variable selected for the study is milk marketed per month, and the independent variables are lagged variable of milk, real average monthly marketed milk, real average monthly producer price, and average import of milk powder, average monthly Swazi milk powder prices and the average monthly rainfall. Upon analysis therefore, it is found that milk powder output and milk powder price are significant in determining the milk supply response in the long-run, to which the elasticities are found to be -0.58 and -0.92

respectively however the short-run where -0.211 and 0.702 respectively. It is further found that milk producers respond very slowly to the desired output.

A bigger approach to supply response analysis is conducted by Bhattachrya, Rath, and Dash (2016) in the case of BRIC countries, for the period 1992 to 2010 using panel data. To analyse, two models such as that adopted by Sukati *et al.* (2017), Elterich and Masud (1980), and Bryant *et al*. (2007) are used where number of milking animals and total milk yield are used as dependent variables. In this regard, results of the analysis indicate that there is a strong positive response of milk price to number of animals and yield; however, the reaction to number of animals is greater than that of yield. Furthermore, a strong association is found between price of substitute chicken meat and milk supply.

2.5 Chapter summary

In summation, data from various time periods, different methodologies and different supply response scenarios are considered by different researchers. Furthermore, supply responses were generally found to be low, this indicating that farmers adjustments to changes are not instantaneous but rather can be seen over a period of time. Moreover, the adjustment periods can be attributed to how fast the farmers can adjust their resources to accommodate the change, such as how fast they can acquire land and financial resources. In addition, variables mostly considered include price of commodity in question, inputs used in production, price of competing commodity and other non-price factors such as rainfall, extension services, research, and Technology.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents a brief background of the study area, data collection and elaboration of the model and variables used in the study.

3.2 Study area

Figure 3.1 Map of South Africa

Source: (Cimairamon, 2012)

South Africa, as can be seen on figure 3.1 above, is located on the Southern tip of the African continent and it covers an area of 1 219 090 square kilometres (Statistics South Africa, 1996) in which it has 9 provinces. Gauteng Province is the smallest and the Northern Cape is the largest of all the provinces. South Africa is home to 55.7 million people according to Statistics South Africa’s 2016 population census.

Furthermore, South Africa has 11 officially recognised languages of which most are indigenous to the country. The country is bordered by countries, Namibia, Botswana, Zimbabwe, and Mozambique. Within the country, two independent kingdoms are found, which are; Lesotho and Swazi-Land. The country has the Indian Ocean on the eastern side and the Atlantic Ocean on the west. In addition, the country has a variety of economic activities that take place in the country, ranging from agriculture, mining, construction, real estate et cetera.

3.3 Data collection and analysis

Time series data was used for the estimation of the supply response. Annual data from the year 1996 to 2014 was used; this follows the changes in South African agricultural marketing policies. The use of data prior to 1996 would not be inclusive as results might be biased towards a specific group and not the country as a whole; hence the data from 1996 to 2014 was used.

Table 3.1 Table of Variables and sources

Analytical software	Eviews 10
VARIABLES	
Dependent variable	
Milk output (Ton)	Food and Agriculture Organisation Statistics (FAOSTAT).
Independent variable	**Source**
Rainfall (mm)	World Bank database
Temperatures (°C)	
Beef prices (R/Kg)	Department of Agriculture, forestry and Fisheries (DAFF) Abstract 2016
Milk prices (R/Litre)	
Feed costs represented by maize price (R/Ton)	
Number of cows (Head)	Food and Agriculture Organisation Statistics (FAOSTAT)
Annual inflation rate measured using Producer Price Index (PPI)	DAFF Abstract 2016

This study used the longitudinal study design in which according to Bless, Higson-Smith and Sithole (2013) this particular study design is concerned with data collection spread over time, as is for this study, given that time series data for South Africa for the past 19 years was used. This study design further assists in deducing the sensitivity of milk producers and current state of the dairy industry in South Africa. Table 3.1 above highlights the time series variables that were used for the study and their sources.

3.4 Analytical technique

The Nerlovian Partial adjustment model is used in the analysis of the study because it has widely been used in analysing supply responses for agricultural products for years dating back to 1958. In addition, the model is regarded as an adjustment model because, according to economic theory, producers adjust output (Q_t) to the desired or optimum level (${Q^*}_t$). Partial adjustment supply response model, therefore, according to Gosalamang *et al.* (2012), is dynamic in nature because the path of the dependent variable is explained by its previous values and the lagged values of the independent variables, it is also heterogeneous by commodity structure, and it is econometrically estimated by the ordinary least squares method.

The Nerlovian partial adjustment model is used in this study because milk producers, like other agricultural producers rely on prices of the past year to formulate their production for the current year. Therefore, for assuming that the desired production is linearly related to the price of milk a typical specification comes up as:

$${Q^*}_t = a + bP_{t-1} + U_t \qquad (1)$$

Where ${Q^*}_t$ is the desired or long-run production and P_{t-1} is the lagged price of milk. Since the desired production ${Q^*}_t$ is an unobserved variable, the Nerlovian formulation suggests that it can be specified as follows;

$$Q_t - Q_{t-1} = \beta({Q^*}_t - Q_{t-1}) \text{ Where } 0<\beta<1 \qquad (2)$$

This hence suggesting that the current supply is:

$$Q_t = Q_{t-1} + \beta({Q^*}_t - Q_{t-1}) \qquad (3)$$

The β represents the coefficient of adjustment, which accounts for the forces which cause the difference between the short-run and long-run supply price elasticities. It further indicates how fast the milk producers are adjusting themselves to their expectation. If β is close to zero, therefore, it would imply that the producers adjust slowly to economic changes, if the value of β is close to 1 it implies that the milk producers are quickly adjusting to the changing levels of economic factors almost instantaneously. And accordingly, when adjustment is 1 it implies that adjustment is perfect (Wasim, 2005).

The reduced equation will hence be:

$$Q_t = A + BP_{t-1} + CQ_{t-1} + V_T \qquad (4)$$

Similarly: $$Q_t = a\beta + b\beta P_{t-1} + c\beta Q_{t-1} + \beta U_t \qquad (5)$$

3.4.1 Variable selection

The variables used in the study are based on economic theory and various studies that have been conducted in the area of supply response for agricultural products. Micro economic theory suggests that, supply of products is influenced by a number of shifters. Major shifters of supply are; resources prices, technology, the price of other product, expected future prices, taxes and subsidies and number of suppliers (Carbaugh, 2011). The dependent variable for this study is the output or yield; this is the amount of milk that is produced in the country yearly.

Furthermore, explanatory variables selected for this research are based on economic theory, intuition as well as from other studies conducted on the supply response for milk. Economic theory postulates that one of the main determinants of supply is the price of the product. In addition, economic theory further indicates that there is a positive relationship between prices of the product and output, in this case milk and the quantity supplied, the relationship is such that farmers respond equally to a rise and fall in prices. This relationship is based on the assumption that farmers always want to maximise their profits, hence higher prices mean higher returns for them. In this study therefore, milk prices from the past year are used, as farmers usually base their production on past prices, this phenomenon is usually explained by the Cobb-Webb where increase in prices leads to increased quantities.

Price of inputs is regarded as another variable that influences the supply; hence in this study feed costs are used as a representation. According to MPO (2017) internationally, the prices of maize and soybean are used as a proxy for feed prices. In this study, the price of maize will be used. MSA regards maize as one of the most common silage crop in South Africa. This is because, maize's nutritional value when compared to other grains is found to have a higher metabolisable energy density, higher starch, and ferments at a slower rate per hour in the rumen, and a lower crude protein, hence considered the best crop to use for milk production (Little, 2016).

Furthermore, price of a competing commodity is also a vital variable that affects the supply of milk; in this study the price of beef is used. The selection of price of beef as variable is that, if the price of beef increases, production of milk is likely to decline; this is because milk farmers may cull some of the cows. The culling of cows, thus, increases the number of cattle slaughtered for meat and when this happens, it leads to a decrease in number of cattle used for milk production. Furthermore, some of the resources that are used in the rearing of milk cattle can be used for rearing beef cattle, particularly in cases where pasture areas and feedlots are used.

Moreover, rainfall patterns influence the amount of milk produced as it is linked to the amount of feeds that the cows are able to eat or have access to and also hinders prices, particularly world prices for milk. Similarly, it influences whether a producer wants to switch from one commodity to another, especially during drought seasons. Hence, in this study annual rainfall is used as a variable.

The annual average temperatures are used in the study because temperature influences the amount of milk that cows produce. In addition, temperatures affect the feed intake of cows, and consequently this affects the reproductive potential which ultimately affects the production and quality of milk (it affects various components such as fat (%), solid-non-fat, Protein, casein and lactose content) (Pragna, et al., 2017).

The number of cattle available for milking is an important factor as it positively affects the output. The more milk cattle a producer has, the more milk he/she is likely to produce.

According to Askari and Cummings (1977), the time trend can be used as a proxy to detect time related effects on overall output such as advancement in technology. Gosalamang *et al.* (2012), Shoko *et al.* (2016), Elterich and Masud (1980) and Bryant *et al.* (2007) use the time trend as a proxy for technology, for this study the time trend too is used as a proxy for change in technology.

3.4.2 Model specification

The structural partial adjustment model for the study:

$$Q_t = f(P_m, W, P_S, N_P, P_i, P_e)$$

The hypothesized estimated equation:

$$Q_t = a\beta + b\beta P_{m_{t-1}} - c\beta W_{t-1} - d\beta P_s + e\beta N_P + f\beta P_{i_{t-1}} + (1-\beta)Q_{t-1} + \beta U_t \qquad (5)$$

In this regard, literature suggests that the estimated equation be transformed into log form. According to Shoko *et al*. (2016), Wasim (2005) and van Wyk and Treurnicht (2012) transforming data to log form and using the log model provides estimates of short-run and Long-run supply elasticities directly. The Log form further ensures that errors are normally distributed (Shoko *et al*., 2016), and yields consistent, better results, with respect to signs, values and level of significance of the regression coefficients (Wasim, 2005). Therefore, the hypothesised model transformed into log form:

$$lnQ_t = ln\, a\beta + ln\, b\beta P_{m_{t-1}} - ln\, c\beta W_{t-1} - ln\, d\beta P_s + ln\, e\beta N_P + ln\, f\beta P_{i_{t-1}} + (1-\beta)lnQ_{t-1} + ln\, \beta U_t \qquad (6)$$

Where: $\boldsymbol{Q_t}$ - is the milk output in year t, $\boldsymbol{P_m}$ - Is the average price of milk in year t, **W** - Is rainfall in mm in year t, $\boldsymbol{P_S}$ – Is the average price of beef meat in year t, $\boldsymbol{N_P}$ -Is the number of cattle available for milking in year t, $\boldsymbol{P_i}$ -Is the average price of inputs (in this case maize) in year t, $\mathbf{Q_{t-1}}$ -Is milk output lagged by 1 year and β - Is the coefficient of adjustment.

3.5 Price fluctuations

When working with prices in analysis, firstly the influence of inflation is to be taken into consideration. Generally, inflation is regarded as the rise in general level of prices of goods and services in an economy over a period of time (Food and Agriculture Organisation [FAO], 2010).

The influence of inflation can be observed through deflating the prices. Real prices are used in the analysis where the values are obtained through formula:

$$\text{real price} = \frac{\text{nominal value}}{\text{price index}}$$

Therefore, where Nominal Value refers to prices that have not been adjusted for inflation, the prices are equal to the money that is paid for a unit of good or service in the market (Famine Early Warning Systems Network, 2009).

Real value on the other hand, refers to the value of economic variables adjusted for price movements. Price index refers to a measure of price movement, i.e. inflation (or deflation), and it could be in the form of Consumer Price Index (CPI), Producer Price Index (PPI). Personal Consumption Expenditure index (PCE) or the Gross Domestic Product (GDP) deflator (Gosalamang *et al.,* 2012).

In this study therefore, the PPI is used as a price index to deflate prices. PPI measures the rate of change in the price of goods and services bought and sold by producer (International Monetary Fund, 2004).

In light of this, table 3.2 below, shows the conversion of nominal price of milk. For this study according to DAFF Abstract of Agricultural Statistics 2017, the nominal price of milk is the average unit price that is paid by purchasers of milk to producers, i.e. average unit price received by producers. Price received by farmers according to FAO (2018)**,** refers to the national average price of individual commodities comprising of all grades, kinds, and varieties received by farmer in the nearest market. These prices are determined at the farm gate or first-point-of-sale transaction when farmers participate in their capacity as sellers of their own products.

Furthermore, the conversion of nominal prices to real prices enables analysis of inflation particularly as it relates to purchasing power of the currency. According to (Goodwin, 1994), $1 today is worth less than $1, say, ten years ago. The relative value of different goods over time therefore, can be obscured by changes in the value or purchasing power of the dollar, hence by deflating the prices it allows for the movement to be observed.

Table 3.2 Nominal prices versus real prices of milk.

Year	Nominal Price (Rands/Litre)	Producer indices	Deflator	Real prices (Rands/Litre)
1996	1.035	33.5	0.335	3.09
1997	1.3	43.1	0.431	3.02
1998	1.176	40.5	0.405	2.90
1999	1.161	38.4	0.384	3.02
2000	1.329	43.6	0.436	3.05
2001	1.498	49.5	0.495	3.03
2002	1.835	59.3	0.593	3.09
2003	1.996	67.3	0.673	2.97
2004	1.949	64.9	0.649	3.00
2005	1.82	60.7	0.607	3.00
2006	1.939	63.6	0.636	3.05
2007	2.735	85.2	0.852	3.21
2008	3.031	104.1	1.041	2.91
2009	3.052	101.5	1.015	3.01
2010	2.94	100	1	2.94
2011	2.992	98.2	0.982	3.05
2012	3.485	115.6	1.156	3.01
2013	3.82	121.5	1.215	3.14
2014	4.313	142.9	1.429	3.02

Source: DAFF (2017a), Base year = 2010

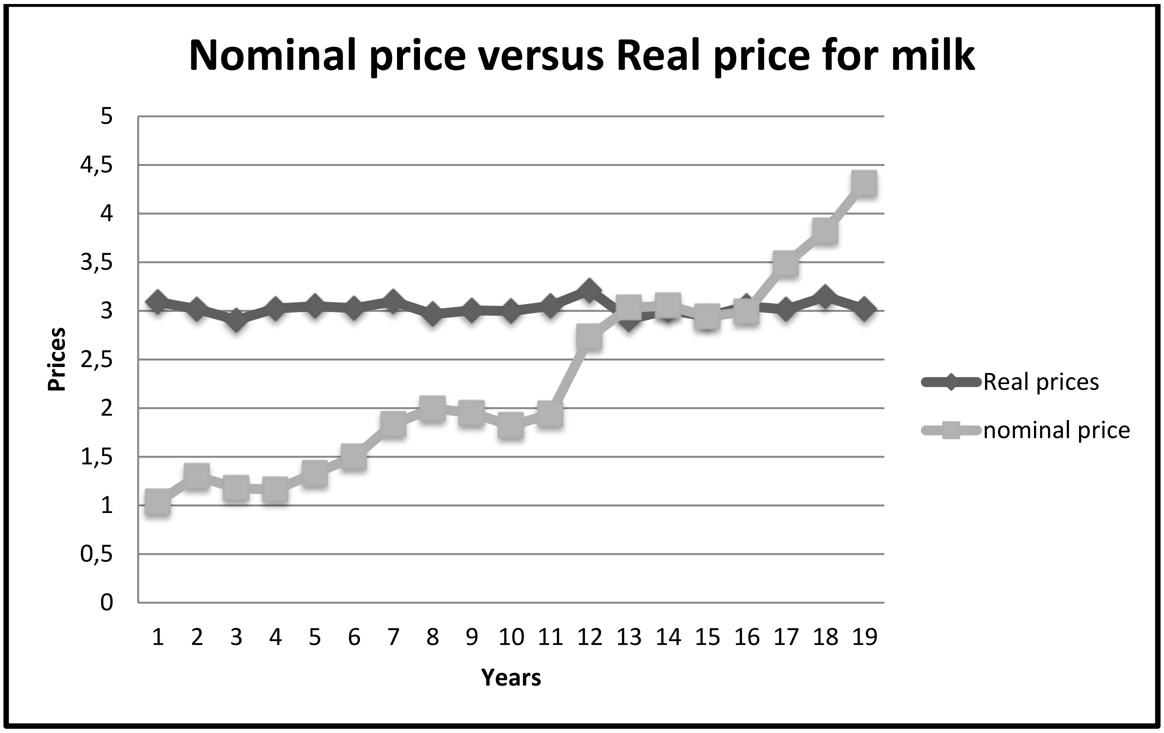

Figure 3.2 Nominal Price versus Real Price for milk

Source: Own creation.

The effect and important consideration of inflation can be observed in figure 3.2 for the 19 years, starting 1996 to 2014. Gradually on the graph, the nominal price of milk can be seen to increasing however, after taking into consideration the effect of inflation (real prices) it can be observed that the real prices of milk have not been increasing as such.

3.6 Stationarity

To ensure that the above approach is correct, unit root test for stationarity was carried out. A variable is regarded as being stationary when they do not have an upward or downward trend over time. The purpose of performing the unit root test, thus, is to verify that variables are stationary in levels in order to determine the order of integration of variables (Van Wyk & Treurnicht, 2012). By doing the unit root test it ensures that regression results are not spurious and that the regression model is stable (Shoko *et al*., 2016).

Various methods are used to test for stationarity. A graphical view of the data can be used to which Sukati *et al.* (2017) suggest it allows for one to capture errors and structural disruptions or drifts that contain unit root tests. The correlogram and the Ljung-Box (LB) statistic can also be used, where the spikes and the Q-statistic and Probability values are observed respectively.

Furthermore, the Augmented Dickey-Fuller (ADF) test is commonly carried out with it being used by Van Wyk and Treurnicht (2012), Gosalamang *et al.* (2012), Shoko *et al*. (2016) and Sukati *et al*. (2017). To which the null hypothesis (H_0) is data is not stationary and the alternative hypothesis (H_a) Data is stationary, are tested.

3.7 Autocorrelation

Autocorrelation, also called serial correlation, occurs when observed errors follow a pattern so that they are correlated (Gosalamang *et al.*, 2012). Serial Correlation occur when model is incorrectly specified, this can be attributed to omission of variables, incorrect functional form and incorrectly transformed data (Sukati *et al*., 2017).

To test for any correlation, the Breusch-Godfrey (BG) test is used. When using the BG test the null hypothesis (H_0) is such that there is no serial correlation in the residuals, and the alternative hypothesis (H_a) is such that there is serial correlation in the residuals. The decision rule for the test in this regard, is that if the P-value of the Obs* R-square is less than 5 % (0.05), the null hypothesis stating that there is no serial correlation is rejected and the alternative stating that there is serial correlation is accepted.

Furthermore, according to Wasim (2005), a model cannot be tested for autocorrelation using the DW d-tests since the model includes a lagged dependent variable in the set of regressors. Therefore, it is suggested that the Lagrange Multiplier Test, also known as the Durbin h-statistic, be used to test for first order autocorrelation. The h-statistic is hence defined as:

$$h = 1 - \frac{1}{2}\mathrm{DW}\sqrt{\frac{N}{1 - N[\mathrm{Var}(Q_{t-1})]}}$$

Where DW is the Durbin Watson statistic, N is the number of observations and $Var(Q_{t-1})$ is the square of the standard error of the estimated parameter of the lagged dependent variable.

3.8 Normality

One of the main assumptions of classical normal linear regression is that the residuals are normally distributed. To test for normality therefore, the Jarque-Bera statistic is used. The hypotheses that are tested such that: H_0: Residuals are normally distributed and H_a: The residuals are not normally distributed. The decision rule in this case is such that if the P-value of Jarque-Bera statistic is less than 5% (0.05) then, the null hypothesis that states that the residuals are normally distributed is rejected and the alternative that states that the residuals are not normally distributed is accepted.

3.9 Ethical Clearance

Ethical clearance is not required for this study, as no humans or animals were involved in the study.

3.10 Chapter summary

This chapter outlined and gave an overview of the study area, data collection, analytical technique and the variables of the study. Lastly, the chapter outlined the diagnostic tests carried out for the study.

CHAPTER FOUR

EMPIRICAL RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the results of the study are discussed. The properties of the data are explored, through mean, minimum, maximum and standard deviation of the original series and their natural logarithm. The regression analysis of the study uses the independent variables identified in chapter three and are interpreted. Furthermore, various diagnostic tests are done to ensure that the specified regression results are reliable; starting with the stationarity test to test whether the variables used in the analysis are stationary or not, for this the ADF test is used. Furthermore, to test Normality, the Jarque-Bera test is used; the Breusch-Godfrey LM test is used to test for serial correlation and the CUSUM test is then used to test the stability of the model. And lastly, from the specified regression model the short-run and Long run elasticities are determined.

4.2 Descriptive statistics

The statistical properties of the data used in the analysis are shown below in table 4.1. On average the amount of milk produced is 2 902 911 tons a year with standard deviation (Std. Dev) of 270 621.80 tons. On Average, the real producer price for milk is R3.03/ Litre with the minimum price being R2.90/Litre and standard deviation of R0.074/Litre. The average price of beef is R22.48/kg with a standard deviation of R0.944/kg. Minimum annual temperatures are 18.23ºC and maximum annual temperatures being 19.45ºC.

Table 4.1 Statistical properties of original data

Variable description	Variable name	Minimum	Maximum	Mean	Std. Dev.
Real milk price (R/Litre)	Pm	2.90	3.21	3.03	0.074
Milk output (t)	Qt	2 360 000	3 337 018	2 902 911	270 621.80
Number of milk cows (Head)	Np	98 000	1 000 000	836 736.8	201 378.8
Real beef prices (R/ Kg)	Ps	22.48	25.51	23.82	0.944
Real Maize Prices (R/T)	Pi	557.15	1 681.619	1 079.546	360.402
Rainfall (mm)	W	30.28	50.49	36.67	5.73
Temperature (C)	T	18.23	19.45	18.88	0.296

The series is transformed into their natural log form, this is done to ensure that the errors are normally distributed and table 4.2 below shows the statistical properties of the series in their natural logarithm form.

Table 4.2 Statistical properties of log data

Variable	Variable name	Min.	Max.	Mean	Std. Dev.
Real milk price (R/Litre)	LnPm	0.463	0.507	0.481	0.011
Milk output (t)	LnQt	6.373	6.523	6.461	0.041
Number of milk cows (Head)	LnNp	4.991	6.000	5.891	0.223
Real beef prices (R/ Kg)	Ps	1.352	1.407	1.377	0.017
Real Maize Prices (R/T)	Pi	2.746	3.226	3.010	0.149
Rainfall (mm)	W	3.41	3.92	3.68	0.14
Temperature (C)	T	2.90	2.97	2.94	0.015

4.3 Stationarity test

This study adopts the Augmented Dickey-Fuller (ADF) unit root test to test for stationarity of the data. Therefore, table 4.3 shows the ADF unit root test results at level and table 4.4 shows the ADF unit root test results at first difference. Variables tested in this regard, are in their natural logarithm (Log) form and the tested hypotheses are such that:

H_0: Data is not stationary

$H_{a:}$ Data is stationary.

The decision rule is such that if P-value is less than 0.05 then series is stationary and further if the absolute value of the ADF statistic is greater than the t-statistic critical value at 5% then series is stationary. The implication is such that, null hypothesis (H_0) is rejected if P-value is less than 0.05 and the ADF test statistic is greater than critical values, in that case the alternative hypothesis (H_a) is accepted.

Table 4.3 ADF unit root test results at level.

Variable	ADF stat	Critical value (5%)	Probability	Verdict
LnPm	4.1739	3.0810	0.0067	Stationary
lnQt	0.636912	3.052165	0.8373	Not stationary
LnNp	4.180734	3.040391	0.0052	Stationary
LnPs	3.048537	3.040391	0.0492	Not stationary
LnPi	3.065150	3.040391	0.0477	Not stationary
LnW	3.204251	3.040391	0.0366	Stationary
LnT	3.200852	3.040391	0.0368	Stationary

At level, the price of milk, number of milk cows, rainfall and temperature are all stationary, also regarded as being integrated to order 0; i.e. I(0). However, these variables; milk output, price of feed and price of beef are not stationary. Therefore, they will be tested for stationarity at first difference; i.e. integrated to order 1, I(1).

Table 4.4 ADF unit root test results at first difference.

Variable	ADF stat	Critical value	Probability	Verdict
LnQt	6.916007	3.052169	0.0000	Stationary
LnPi	4.792952	3.098896	0.0025	Stationary
LnPs	5.959632	3.052169	0.0002	Stationary

The variables: milk output, price of feed and price of beef are tested for stationarity at first difference. Where the hypotheses are:

Ho: Data is not stationery at first difference and

Ha: Data is stationary at first difference.

Decision rule: Reject the null hypothesis when the absolute value of the ADF stat is greater than the critical value (at 5%) and accept the alternative hypothesis. Furthermore, the null hypothesis should be reject if the probability value is greater than 0.05.

Therefore, Table 4.4 above shows ADF test results for variables that were found to be non-stationary at level as represented in table 4.3. The results on Table 4.4 hence represent results for variables at first difference, or integrated to order 1. From table 4.4 it can be seen that the P-values for the variables are less than 0.05 or (5%), and the critical values are less than the ADF stat values. Therefore given the decision rule, the null hypothesis can be rejected and the alternative hypothesis accepted, meaning that the variables are stationary at first difference or integrated to order 1.

4.3 Supply response regression

Upon running multiple regressions analysis, various combinations of variables were tested and the model selected was based looking at the size of coefficient of determination (Adjusted R^2), the size of the F-statistic, Durbin Watson (DW) statistic, standard errors of estimates (SEE), t-statistics of coefficients and various model diagnostics that are done to test the model as specified in chapter 4, section 4.6 to 4.8. In this regard, for the model to be of good fit, the Adjusted R^2 should be higher in the selected model than other models, the Durbin Watson should be 2, Prob. F-statistic should be less than 0.05 and be accompanied by a high F-statistic.

The best model for this study is represented by the regression in Table 4.5. Table 4.5 shows the supply response regression for output as specified in chapter 3, section 3.4.2.

Furthermore, the software Eviews 10 was used in the estimation of the supply response. The estimated supply equation of milk production has an Adjusted R^2 of 0.80, which means that 80% of the production variation is because of the explanatory variables used in the model.

The Durbin Watson statistic value indicates whether there is autocorrelation in the residuals of time series regression or not. The closer to 2 the value of the Durbin Watson statistic is; it can be considered that there is no autocorrelation. For this study, the DW statistic is 2.33 and hence, can be concluded that there is no autocorrelation.

The F- statistic of the model indicates the joint significance of independent variables in explaining the dependent variable, the higher the better. For this study, the F-statistic is 8.95. The accompanying P-value of F-statistic indicates the significance of the model, the smaller the value the better, and for this study the P-value of F-statistic is 0.002.

Table 4.5 Regression results for Supply response

Dependent variable :Ln Qt				
Explanatory variables	Coefficient (short-run)	SEE	t-statistic	P-value
c	18.008	4.758	3.785	0.0053*
lnQ_{t-1}	0.343	0.215	1.597	0.1490***
$LnPm_{t-1}$	-0.719	0.583	-1.310	0.2264
$LnNp_{t-1}$	-0.032	0.024	-1.308	0.2272
$LnPs_{t-1}$	-0.795	0.304	-2.609	0.0312**
LnPst	0.736	0.364	2.025	0.0774**
LnPi	0.0006	0.041	0.016	0.9877
LnW	0.036	0.081	0.448	0.6659
LnT	-2.452	0.806	-3.041	0.0160**
trend	0.014	0.003	4.149	0.0032*
(*) 1%.(**) 5%, (***) 10% significance level Adjusted R^2 = 0.80 F-Statistic= 8.95 Durbin Watson = 2.33 Durbin h-Statistic= -1.708				

Table 4.5 above shows results for the regression to which, Trend (Proxy for technology), Constant, lagged production, lagged price of beef, current price of beef and lagged temperature are found to be significant at 1%, 5% and 10% significance level.

The Short-run elasticities for the study are given by the estimated coefficients of the regression analysis. In this regard, the short-run elasticities indicate the responsiveness of producer output (in this case milk output) over a period of time in which some of the resources used in production can be altered and at least one of the resources cannot be altered.

The long-run elasticities are determined using formula:

$$\text{long}-\text{run elasticity} = \frac{\text{short}-\text{run elasticities}}{\text{coefficient of adjustment}}$$

Where: The coefficient of adjustment is determined by 1 minus the short-run coefficient of the lagged dependent variable. For the study, the coefficient of adjustment is 0.657, obtained from 1- 0.343 (which is the coefficient of the lagged milk output (LnQt-1) from the model). Table 4.6 below represents the long-run elasticities for the study variables. The long-run elasticities indicate the responsiveness of producers in a period of time in which producers can vary all resources as means of altering the output, and for new producers to enter the market.

Table 4.6 Long-run elasticities

Variable	lnQ_{t-1}	$LnPm_{t-1}$	$LnNp_{t-1}$	$LnPs_{t-1}$	LnPst	LnPi	LnW	LnT	trend
Long-run elasticity	0.52	-1.089	-0.05	0.009	-1.12	-1.20	-3.72	0.06	0.02

4.4 The Partial Adjustment model

$$\begin{aligned} \text{lnQt} = 18.008 + 0.343\text{lnQ}_{t-1} - 0.719\text{lnPm}_{t-1} - 0.032\text{lnNp}_{t-1} - 0.795\text{lnPs}_{t-1} + 0.736\text{lnPs}_{t} \\ + 0.0006\text{lnPi} + 0.036\text{lnW} - 2.452\text{lnT} + 0.014\text{Trend} \qquad (7) \end{aligned}$$

From equation 7 above, Lagged milk production (LnQ_{t-1}) indicates a positive relationship, this implies that yield from 1 period will be followed by increase in yield in the next period. This, therefore, agrees with the behavior attributed to producers, where past production experiences form production expectation. The coefficient is 0.353, which is significant at 10 percent level. The results suggest that adjustment for lagged milk production is low, similar results were observed by Wasim (2005) with 0.876 and Grad and Mansour (2008) with 0.62. The elasticities of lagged production indicate that supply is inelastic both in the short-run and long-run with values being 0.353 and 0.52 respectively, these results being different from those found by Grad and Mansour

(2008), to which in the long-run it becomes elastic. The elasticity in this study is low, and there is only a change of 0.167 between the long-run and short-run elasticities.

Furthermore, the trend variable is used as a proxy for technology. In this regard, the trend variable shows a positive relationship to production. The results of trend variable indicate that a change in technology causes a shift in milk production by magnitude of 0.014 a year. The variable is significant at 1 percent level. This suggests that production increases over time as a result of producers adopting new technologies to improve production, this validates statement made by Gertenbach (2009) to which technology is regarded as an important avenue for farmers to try and improve profitability of their farming enterprise. In the long-run, the elasticity is 0.02, a change of 0.006 from the short-run, this indicating a low adjustment. The producer low adjustment could be attributed to significant decline in research in dairy farming as stated by Gertenbach (2009). Another likely cause for the low adjustment has to do with the availability of funds to which producers can use to purchase new technology; this can be in a form of new feeding rations, improved milk breed cow and milking equipment. And furthermore the availability of land and knowhow of adopting new technology could be the cause of the slow adjustment. The findings of this study support those presented by Shoko *et al.* (2016), Gosalamang *et al*. (2012) and Elterich and Masud (1980).

Moreover, lagged beef price was found to be significant just as that found by Grad and Mansour (2008) however, they found the coefficient to be positive. In this analysis, it was found to be negative. Therefore, the negative coefficient with respect to milk output indicates that price of beef in the past period has an influence on current milk production; this is due to the reduced number of milk animals associated with good beef prices. Therefore, it can then be ascertained that due to price changes in substitute product, producers are likely to switch from producing one commodity to producing another. In this case, they move from milk production to beef production. This however, can be linked to the coefficient of current beef price which show a positive relationship to output, indicating that instead of hastily moving to producing beef production, producers hold on to their livestock with hopes of better prices and increase in livestock.

The elasticities show that current price of beef is inelastic in the short-run but however elastic in the long-run; this means that in the long-run producers can change their resources such that they move from rearing cows for milk but for beef production. The long-run and short-run elasticities were 1.12 and 0.736 respectively.

Furthermore, temperature coefficient shows that there is a negative relationship between milk production and temperature. The coefficient indicates that changes in temperatures change the amount of milk that is produced, and this is greatly related to the biological nature of milk cows, to which increase in temperature leads to animal stress consequently reducing the capacity of animal to produce milk. Furthermore, the short-run elasticity is 2.45 which indicate that it is elastic, meaning that output is highly responsive to changes in temperature; this therefore, means that when temperatures change in the short-run producers do not have enough time to adjust resources to combat cows from producing little milk than usual. However, in the long-run the elasticity is 0.06, this indicates that it is inelastic, which means that over time milk producers can adjust their resources in such a way that they can minimize the influence of temperature on milk output. Therefore, the likely cause of a long-run elasticity that is inelastic could be due to the adoption of new management system that producers can adopt particularly for producers in the coastal regions where milk cows are left to graze in the fields, hence being exposed to the changes in temperature.

Moreover, the price of milk was found to not be significant and with a negative coefficient similar to that obtained by Gosalamang *et al*. (2012). This, therefore, is unusual for economic theory, as the theory suggests that producers are profit driven and production decision is influenced by price of commodity. The results, however, suggest that the relationship between milk output and milk price is inverse, indicating that price is not a driving force for producers, and hence their production is not influenced by the price of milk. Furthermore, the likely cause for the negative relationship could be due to the fact that the South African dairy industry operates in a free market system, where milk prices are determined by the forces of demand and supply.

In addition, rainfall, however insignificant, shows a positive relationship with respect to output, these results supporting those found Sukati *et al.* (2017) and Van Wyk and Treurnicht (2012) where, increase in rainfall result in increase in output. This positive relation indicates that increase in rainfall will lead to increase in output, this particularly related to the availability of grazing pasture for the animals and consequently influencing their production capabilities. The positive relationship not only applies for the grazing land but for other feed that can be used to feed the milk cows such as maize, better rainfall implies that better harvests are realized by producers and hence that leads to lower prices for the feed and hence making them more accessible for the milk producers for their livestock for feed.

4.4 Diagnostic tests results

It is possible to have estimated the regression, however, it can suffer from misspecification, therefore, and it is of paramount importance that diagnostic tests be undertaken. For this regression the Wald test for coefficient significance, Jarque-Bera test, Breusch-Godfrey test and CUSUM and CUSUM of squares test for stability tests are conducted. In this regard, table 4.7 below shows diagnostic tests that are carried out in the study.

Table 4.7 Diagnostic tests

Test	Test method
Model specification	Wald test
Normal distribution	Jarque-Bera test
Serial Correlation	Breusch- Godfrey LM test
Model Stability	CUSUM and CUSUM of squares test

4.4.1 Wald test

This test is undertaken as a way of validating the importance of variables added to the model that were however found to be insignificant. Hypotheses tested were:

H_0: Coefficient=0 (indicating that variables are not relevant)

H_a: Coefficient ≠ 0 (indicating that variables are relevant).

The decision rule: The null hypothesis that indicates that variables are not relevant is rejected if the P-value of the F-test statistic is less than 0.05 or 5% and hence, the alternative hypothesis that indicates that the variables are relevant is accepted.

In this regard, the results for the test were: F-statistic = 0.5673 and the P-value = 0.6864. Given the decision guideline, the null hypothesis in this case is rejected as the p-value if greater than 0.05 and hence, suggesting that the variables are relevant to the model, even though they are insignificant.

4.4.2 Jaque-Bera test

This test tests the normality of data using that the Jarque-Bera statistic.

H_0: The residuals are normally distributed.

H_a: The residuals are not normally distributed.

The decision rule: If P-value of the Jarque-Bera is less than 0.05 (5%) we reject the null hypothesis that the residuals are normally distributed and accept the alternative that states that they are not normally distributed.

The test results of the study are that the Jarque-Bera test statistic is 1.513 and the respective P-value is 0.469 which is greater than 0.05, hence it can be said that the residuals are normally distributed and hence null hypothesis is accepted.

4.4.3 Breusch-Godfrey LM test

The Breusch-Godfrey test is used to test for serial correlation. For the study, the hypotheses are such that;

H_0: There is no correlation between residuals.

H_a: There is correlation between residuals.

The decision rule: The null hypothesis which states that there is no correlation between residuals is rejected if the P-value of the Obs*R-squared is less than 0.05 (5%), and the alternative hypothesis that states that there is correlation between the residuals is accepted.

For this study, therefore, the P-value of Obs*R-squared is 0.293, which is greater than 0.05, hence the null hypothesis that states that there is no serial correlation is accepted and the alternative hypothesis that states that there is serial correlation is rejected. Furthermore, the Durbin Watson for the study is 2.33, and the Durbin Watson h-statistic for this model is -1.708, which indicates that there is no autocorrelation.

4.4.3 Stability test

The CUSUM and CUSUM of squares tests validate the stability within the model parameters over the adjusted time period. Stability at 5% significance level results are observed on figure 4.1 and 4.2 which represent the CUSUM test results and CUSUM of squares test results respectively.

The hypotheses tested are:

H_0: The regression equation is correctly specified

H_a: The regression equation is not correctly specified.

The decision rule for the test: The null hypothesis that states that the regression equation is correctly specified is accepted if the plot of the CUSUM and CUSUM of squares statistic remain within the critical bounds of the 5% significance level and the alternative hypothesis that states that the regression is not correctly specified is rejected.

For this study, figure 4.1 and 4.2; indicate the CUSUM and CUSUM of squares respectively. The CUSUM plot for both CUSUM and CUSUM of squares statistic remain with the critical bounds of the 5% significance, hence it can be concluded by accepting the null hypothesis that the regression equation is correctly specified.

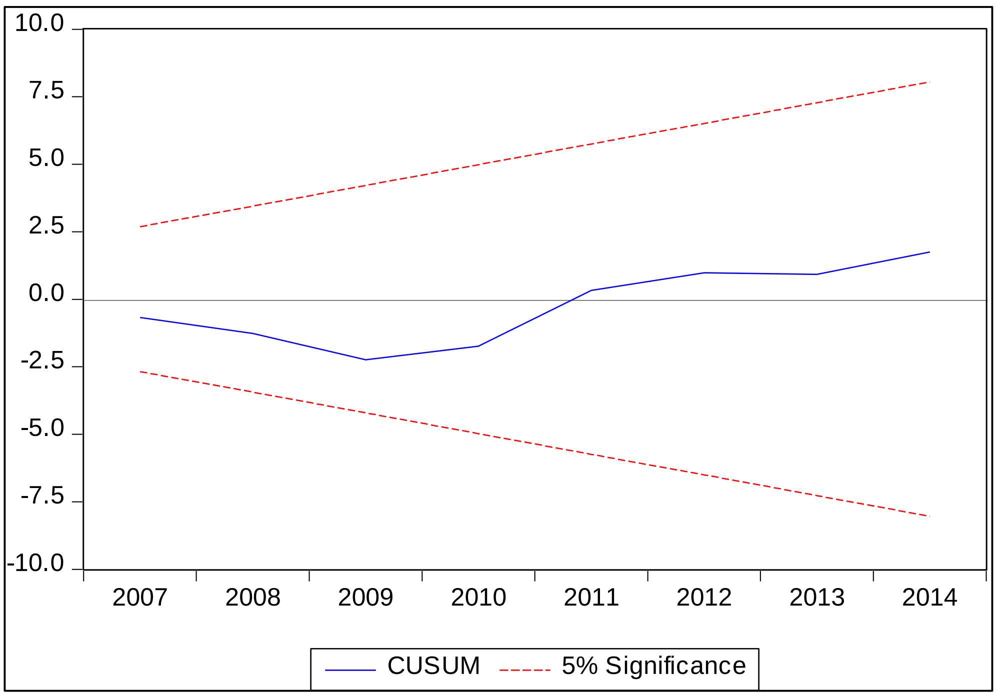

Figure 4.1 CUSUM test results.

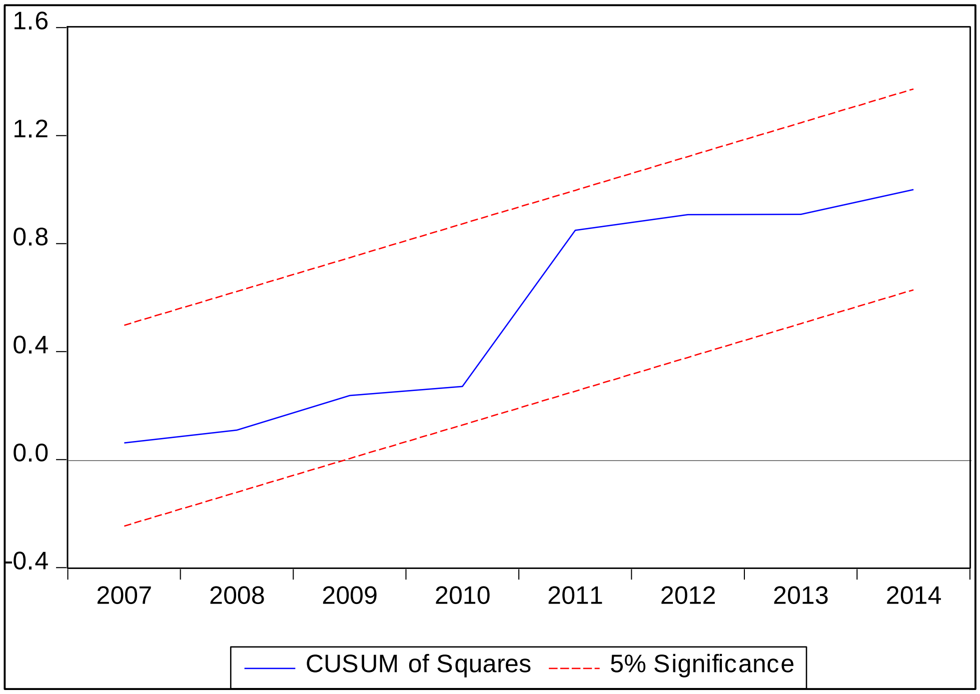

Figure 4.2 CUSUM of squares test results.

4.5 Chapter summary

This chapter detailed the empirical analysis of the study for the period from 1996 to 2014. The long-run and short-run elasticities were obtained. Furthermore, the diagnostic tests performed indicate that there is no autocorrelation, residuals are normally distributed and that the model is stable and well specified.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter focuses on the summary, conclusion and recommendation of the study based on the regression findings.

5.2 Summary

The aim of the study was to estimate the supply response of milk production in South Africa to price and non-price factors; and the objectives were to determine the responsiveness of milk production to price and non-price factors and further estimate the long-run and short-run elasticities. In light of this, the study estimated the supply response using the Nerlovian Partial Adjustment model with Eviews 10 software. Moreover, annual historical data for the period 1996 to 2014 was used in the analysis to test the hypotheses that milk supply is not affected by price and non-price factors.

To ensure the good quality of the model used, data were made stationary and various diagnostic tests for the estimated model were conducted. The Jarque-Bera test was used to test for normality, the Breusch-Godfrey LM test was used to test for serial correlation and the CUSUM test and the CUSUM test of squares was used to test for the stability of the model.

The estimated supply response model indicates that milk production in South Africa responds to price and non-price factors; hence the hypotheses stated in chapter 1 were rejected. In addition, milk production was found to respond to price of beef, last period production, technology and temperature.

5.3 Conclusion

The hypotheses in the study were rejected, this is seen through the variables that were significant in the study, to which, price and non-price factors were observed to have influence on the production of milk.

The estimated short-run and long-run elasticity values indicate a rigid supply; most of the short-run elasticities are inelastic however only long-run elasticities that are elastic are for lagged price of milk, lagged price of beef and temperature. The study therefore, highlighted that output is responsive to changes in technology, meaning that any technological development in milk production improves the output of milk.

5.4 Recommendations

The following recommendations are made based on the findings of the study.

The findings of the study show that the responsiveness of milk production is slow in the long-run and short-run. Production was found to respond to price of substitute product (in this study, price of beef), temperatures, technology and previous production output.

Therefore, based on the results, price of milk was found to not be significant and this indicate that price of milk alone is not good enough incentive for producers to produce milk. However, it was found that milk production responded to changes in the price of beef. Moreover, better price mechanisms should be developed by policy makers, for government to enforce, such as the establishment of fixed floor price as it is done by the European Union countries and the United States of America. The establishment of price floors can give producers in the country an upper hand to compete in the international supply market of milk. Furthermore, the establishment of price floors will encourage producers of milk to not switch between commodities and plan production well to their advantage. More people will be encouraged to participate in the industry by the above market prices and hence in the long-run contributing to the development of local economies as well as strengthening domestic milk market.

The effect of temperature in this regard, can be coupled with technological investment to reduce the effect of temperature on production and improve technological aspect. This can be done through research into finding breeds that are less susceptible to changes in temperature. Furthermore, investments by milk producers should be made into intensive farming, where instead of cows going out to graze, they are kept in an area where temperature can be modified to fit the animals.

It was further identified that the number of milk producers in South Africa has over the years been declining; therefore, new initiatives need to be put in place to encourage new entries into the market. More investment is needed, particularly in areas of information dissemination by government, especially regarding how to rear and care for milk cows particularly in areas such as the Free State, where producers can easily access maize for feeding. The introduction of subsidies by government could also be another means of attracting new producers, particularly if the subsidy put more support on newly entering producers and producers with smaller herd sizes. Given the removal of the marketing boards that assisted farmers in acquiring markets for their milk, market cooperatives can be encouraged in the industry. Allowing cooperatives helps producers to find avenues to sell their produce and further allow for them to share information on how to manage and improve their businesses and also help them attract and obtain buyers for their milk.

Furthermore, forms of government insurance for producers could be another way of encouraging producers to not switch between commodities, especially during drought seasons. Most producers are afraid of losing their profits, hence they selling off some of the cattle for beef, particularly if the price of beef if more favorable than that of milk. In addition, funding programmes can also be initiated, where they are not only looking at provision of financial capital or livestock for producers. However, Funding programmes initiated for training of producers to adapt and adopt new skill which will assist them in improving their livestock and livestock management. Furthermore newly entering producer can also be capacitated in the management of business and livestock rearing. Most importantly, youth participation and capacitation in the production of milk will greatly assist the industry; this is through encouraging longevity of the industry by investing in the younger generation and encouraging the adoption of new farming methods and encourages more research development to the industry.

5.5 Further areas of study

This study was conducted using annual historical time series data. therefore, it is important in the future to conduct studies referring to a smaller geographical area, (such as looking at farmers inland and farmers on coastal areas), different time periods and during periods of different institutional changes in the country (for example, before and after market deregulation). By conducting studies on different locations, in this way, it will give an understanding of whether producers, regardless of location, have similar influencing factors or not. Similarly, studying responses post market deregulation could shed light into the influence milk boards have on production, and what non-price factors influence production when marketing was left to the government.

REFERENCES

Agriculture and Horticulture Development Board. (2015). *World milk production.* Retrieved July 2016, 2016, from AHDB: http://dairy.ahdb.org.uk/market-information/supply-production/milk-production/world-milk

Ajetomobi, J. O. (2010). Supply response, risk and institutional change in Nigerian Agriculture. AERC research paper 197. Nairobi: African Economic Research Consortium. Retrieved November 01, 2018, from http://www.aercafrica.org/document/RP197,pdf

Askari, H., & Cummings , J. T. (1977). Estimating agricultural upply response with Nerlovian model: A survey. *International Economic Review, 18*(2), 25-92.

Ayinde, O. E., Bessler, D. A., & Oni, F. E. (2017). Analysis of supply response and price risk on production in Nigeria. *Journal of Agribusiness and Rural Development, 1*(43), 17-24.

Bhattacharya, P., Rath, B. N., & Dash, A. K. (2016). Supply response of milk production: Analysis and implication for BRICS countries. *Applied Econometrics and International Development, 16*(1), 179-198. Retrieved June 17, 2018, from http://www.usc.es/economet/journals1/aeid/aeid16114.pdf

Bless, C., Higson-Smith, C., & Sithole, S. L. (2013). *Fundamentals of Social research methods: An african perpective* (5th ed.). South Africa: Juta and Company.

Bryant, H. L., Outlaw, J. L., & Anderson, D. (2007). Aggregate milk supply response to the milk income loss contract program. *Journal of Agribusiness, 25*(1), 133-146.

Carbaugh, R. J. (2011). *Contemporary Economics: An application approach* (6 ed.). New York: M.E Sharpe Inc.

Cimairamon. *South African Map.* Retrieved November 08, 2018, from http://www.maps-africa.blogspot.com/2012/05/south-africa-maps-pictures

Coetzee, K. (2016). *The international competitiveness of the South African primary dairy sector, 2015.* MilkSA. Retrieved November 04, 2018, from http://www.milksa.co.za/reports

Delgado, C. L., Narrod, C. A., & Tiongco, M. M. (2003). *Policy, Technical, and Environmental determinants and implications of the scaling-up of livestock production in four fast-growing developing countries; A synthesis.* Retrieved April 07, 2016, from FAO: http://fao.org/wairdocs/lead/x6170e/x6170e2x.htm

Department of Agriculture, Forestry and Fisheries (DAFF). (2017b). *A profile of the South African Dairy Market value chain.* Retrieved June 14, 2018, from NDA: http://www.nda.za

Department of Agriculture, Foresty and Fisheries (DAFF). (2017a). Abstract of Agricultural Statistics. Retrieved February 14, 2018, from http://www.daff.gov.za

Elterich, G. J., & Masud, S. (1980). Milk response in Delaware. *Journal of the Northeastern Agricultural Economics Council, 9*(1), 41-45.

Famine Early Warning Systems Network. (2009, May). *Adjusting prices for inflation and creating price indices, FEWS NET market guide no,3.* Retrieved September 10, 2018, from FEWS NET: http://fews.net

Food and Agriculture Organisation (FAO). (2018). *Concepts on price data.* Retrieved September 10, 2018, from FAO: http://www.fao.org/economic

Food and Agriculture Organisation [FAO]. (2010). *Markets and price monitoring training manual*. Retrieved September 10, 2018, from FAO: http://www.fao.org/economic

Gertenbach, W. (2009). *Dairy farming in SA: Where to now?* Western Cape Department of Agriculture: Institute For Animal prodution. Retrieved from http://www.fao.org

Goodwin, W. J. (1994). *Agricultural Price analysis and forecasting.* USA: John Wiley and Sons Inc. .

Gosalamang, D. S., Belete, A., Hlongwane, J. J., & Masuku, M. (2012). Supply response of beef in Botswana: A Nerlovian partial adjustment model approach. *African Journal of Agricultural Research, 7*(33), 4383-4389.

Grad , S., & Mansour, F. (2008). Analysis of supply response for selected food groups in Syria. (pp. 3-33). Damascus, Syria: National Agriculture Policy Center (NAPC), Ministry of Agriculture and Agrian Reform.

Grobler, S. M., Scholtz, M. M., Bester, J., Mamabolo, J. M., & Ramsay, K. A. (2008). Dairy production systems in the emerging and communal sectors of South Africa: Results from a structured survey. *Applied Animal Husbandry and Rural Development, 1*, 25-30.

Hamid , M. A., & Hossain, K. M. (2014). Role of private sector in the development of dairy industry in Bangladesh. *Livestock Research and Rural Development, 26*(179). Retrieved July 22, 2016, from http://www.lrrd.cipav.org/lrrd26/10/hami26179.htm

Harcourt, D. A. (2011). *The South African food processing industry.* Retrieved December 13, 2017, from http://www.digivi.co.za/blog/wp-content/The-SA-Food-Processing-Industry-copy.pdf

Hoehl, S., & Hess, S. (2018). Estimating German milk supply response using Global Vector Autoregressive Model. *German Association of Agricultural Economists (GEWISOLA) 58th Annual Conference.* Kiel, Germany. Retrieved from http://www.ageconserch.umn.edu/record/275844

International Dairy Federation. (2013). *Economic importance of dairying: February 2013 IDF factsheet.* International Dairy Federation. Retrieved June 02, 2017, from http://www.fil-IDF.org

International Dairy Foods Association. (2015). *Industry Facts: The importance of milk in the diet*. Retrieved March 06, 2017, from http://www.idfa.org/resource-center/industry-facts

International Monetary Fund. (2004). *Producer Price Index Manual: Theory and Practice.* Retrieved September 05, 2018, from IMF: http://imf.org

Keteme, H., & Tsehay, R. (1995). Dairy production system in Ethiopia; Strategies for market orientation of small-scale milk producers and their organisations. Proceesings of a workshop held at Morogoro Hotel Tanzania.

Kibara, M. J., George, R., & Gerald, M. (2016). Estimating supply response of livestock products: The case of Kajido District. *Economics, 5*(1), 8-16.

Lassen, B. J. (2012). *Dairy production in South Africa-Impression: Agribenchmark country report 2012/11.* Retrieved June 15, 2018, from http://www.agribenchmark.org

Levins, R. A. (1982). Price specification in milk supply response analysis. *Journal of Agricultural Economics, 64*(2), 286-288. Retrieved September 05, 2018, from http://academic.oop.com/ajae/article

Little, S. (2016). *Feeding maize grain to dairy cows fact sheet: Jan 2016.* Dairy Australia. Retrieved September 08, 2018, from http://www.dairyaustralia.com.au

Lokuruka, M. I. (2016). Overview of dairy processing and marketing in East African dairy value chains: Opportunities and challenges. *African Journal of Food Science, 10*(11), 254-262.

Mazuruse, P., Mhuru, D., Muvingi, J., Gwarimbo, W., & Chiusunga, D. (2018). Estimating the supply response to price and non-price factors of macadamia nuts in Zimbabwe: The case of Chipinge's Makandi Estates. *International Journal of Interdisciplinary Research and Innovations, 6*(2), 189-208.

Mbaga, M., & Coyle, B. T. (2003). Beef supply response under uncertainity: An Autoregressive Distributed lag model. *Journal of Agricultural and Resource Economics, 28*(3), 519-539.

Meissner, H. H., Scholtz, M. M., & Palmer, A. R. (2013). Sustainanility of the South African Livestock Sector towards 2050 Part1: Worth and impact of the sector. *South African Journal of Animal cience, 43*(3), 282-297.

Milk Producers Organisation (MPO). (2016, May). *Lactodata, 19*(1). Retrieved June 18, 2018, from http://www.milksa.co.za

Milk Producers Organisation (MPO). (2017, November). *Lactodata, 20*(2). Retrieved December 16, 2017, from http://www.milksa.co.za

Milk Producers Organisation (MPO). (2018, May). *Lactodata, 21*(1). Retrieved November 04, 2018

Milk South Africa (MSA). (2014). *Milk SA guide to dairy farming in South Africa.* Retrieved April 10, 2014, from MilkSA: http://www.milksa.org

Muia, J. M., Kariuki, J. N., Mbugua, P. N., Gachuiri, C. K., Lukibisi, L. B., Ayako, W. O., & Ngunjiri, W. V. (2011). Smallholder dairy production in high altitude Nyadarua Milkshed in Kenya: Status, Challanges and opportunities. *Livestock Research for Rural Development, 23*(5). Retrieved June 16, 2017, from http://lrrd.org/lrrd23/5/muia23108.htm

Mwanza, K. (2015, July 09). Nigeria's dairy industry chocked by nations heavy oil dependence. *AFKinsider*. Retrieved July 07, 2016, from http://afkinsider.com/99662/nigerias-dairy-industry-chocked-by-nations-heavy-oil-dependence

Mythili, G. (2006). Supply response of Indian farmers: Pre and Post Reform. Mumbai: Indira Gandhi Institute of Development Research.

Pragna, P., Archana, P. R., Aleena, J., Veerasamy, S., Govindan, K., Madiajagan, B., . . . Bhatta, R. (2017). Heat stress and dairy cow: Impact on both milk yield and composition. *International Journal of Dairy Science, 12*(1), 1-11.

Raghunathan, U. (2014). The impact on the milk supply responseto MPP-Dairy. *Journal of Agribusiness, 32*(2), 207-222.

Schimmelpfennig, D., Thirtle, C., & Van Zyl, J. (1996). Crop level supply response in South African Agriculture: An error correction approach. *Agrikon, 35*(3), 114-122.

Scholtz, M. M., & Grobler, S. M. (2009). A systems approach to the South African dairy industry. *South African Journal of Animal Sciences, 39*(1), 116-120.

Shoko, R. R., Chaminuka, P., & Belete, A. (2016). Estimting supply response in South Africa: A Nerlovian partial adjustment approach. *Agricultural Economics Research, Policy and Practice in Southern Africa, 55*(3), 237-253.

Singh, S. (2013, September 30). Are small dairy farmers becoming extinct? *Cover*. Retrieved April 2016, 2016, from http://www.cover.co.za/short-term-insurance/are-small-dairy-farmers-becoming-extinct

Statistics South Africa. (1996). *The people of South Africa Population census 1996: census brief, 3rd Edition, July 1999.* Statistics South Africa.

Sukati, M. C., Masuku, M. B., & Ragambisa, J. T. (2017). Supply response of milk producers to economic and non-economic factors in Swaziland. *Journal of Agricultural Studies, 5*(4), 14-34.

Tripathi, A. (2008). Estimating Agricultural supply response by co-integration approach. Retrieved August 2017, 2017, from works.bepress.com/amanathi_tripathi/4/

Van der Lee, J., Zijlstra, J., Wouters, A. P., & Van Vugt, S. M. (2014). *Milking to potential: Strategic framework for Dairy sector development in Emerging Economies.* Center for Development Innovation and Livestock Research. Wageningen: Wageningen UR (University and Research Centre).

Van Wyk , & Treurnicht, N. F. (2012). A quantitative analyis of supply response in the Namibian mutton industry. *South African Journal of Industrial Engineering, 23*(1), 202-215.

Wasim, M. P. (2005). Milk production in Pakistan. *The Lehore Journal of Economics, 10*(1), 105-122.

World WIldlife Fund. (2004). *Dairy.* Retrieved April 06, 2016, from WWF: www.worldwildlife.org/industries/dairy

Yu, B., Lui, F., & You, L. (2011). Dynamic agricultural response under economic transformation: A case study of Henan, China. *American Journal of Agricultural Economics, 94*(2), 370-379. doi:10.1093/ajae/aa114

Zartman, D. L., & Wattiaux, M. A. (2009). Dairy industry. In *Agricultural Science* (Vol. 1, pp. 138-156). EOLSS Publications. Retrieved July 07, 2016, from http://www.eolss.net/sample-chapters/c10/e5-24-03-01.pdf

APPENDIX

Appendix 1: Time Series Data.

Year	Mprice	Bprice	out	num	Fprice	Temp	Rain
1996	3.089552	23.32102	2840000	820000	806.4516	17.36575	48.05104
1997	3.016241	22.48219	2638000	790000	745.0276	17.72247	40.97503
1998	2.903704	22.73988	2851000	790000	972.1377	18.16153	41.07663
1999	3.023438	23.66949	2996000	760000	723.5788	18.55299	36.33349
2000	3.048165	22.51882	2360000	990000	1136.424	17.22945	50.48696
2001	3.026263	25.5102	2670000	990000	1462.647	17.90678	45.30557
2002	3.094435	24.75775	2507000	850000	624.8802	17.94218	34.67748
2003	2.965825	24.1	2591000	790000	670.0306	18.26983	30.28418
2004	3.003082	23.5459	2640000	770000	557.151	18.44405	39.56362
2005	2.998353	25.34154	3044000	820000	1650.052	18.2088	32.68332
2006	3.048742	25.48603	2950000	800000	1681.619	18.09161	49.0016
2007	3.210094	24.2181	2988000	790000	1170.192	18.31813	34.22057
2008	2.911623	23.76717	3042000	98000	906.5111	18.40717	35.7892
2009	3.006897	22.85258	2997000	1000000	907.3777	18.35863	40.23483
2010	2.94	24.316	3123000	1000000	1636.14	18.71144	38.86583
2011	3.046843	23.37993	3107000	970000	1446.495	18.1244	46.02198
2012	3.014706	23.05925	3214000	930000	1079.258	18.21972	38.71022
2013	3.144033	23.87765	3260291	990000	1157.728	18.35143	35.05265
2014	3.018195	23.68559	3337018	950000	1177.681	18.48281	40.12895