Reciprocal influences of carcass classes on supply and pricing of red meat in post-Apartheid South Africa

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DECLARATION

I, Elsabe Janse van Rensburg declare that this thesis, which I hereby submit for the degree PhD (Agric) Animal Science at the University of Pretoria, is my own work and has not been submitted previously by me for a degree at this or any other tertiary institution.

SIGNATURE: _____

DATE: **2020/08/12**

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SUMMARY

The study evaluated the integrated influences of red meat carcasses and product from red meat animals on price and supply of red meat carcasses. The purpose of the study was to assess the status of the South African red meat industry over five years and in comparison, to the status during the Apartheid era. The study resolved to establish in principle the relationships between the types of red meat carcasses (beef, mutton and lamb, and pork) on the purchase price (R/kg cold carcass mass) and carcass classes over a selected period, to establish in principle the relationships between the types of red meat carcasses (beef, mutton and lamb, and pork) on products from red meat animals (wool and hide) and to determine the effect of a red meat market on red meat producers.

A great deal has changed since the Apartheid era with regards to red meat marketing and pricing. During the Apartheid era, the South African Livestock and Meat Industries Control Board (Meat Board) controlled the access of red meat to controlled areas and abattoirs. The system skewed the real picture of the supply, demand for and price of red meat. The last time a complete study of the South African red meat industry on supply and demand was completed by Du Toit in 1982, under the apartheid era. The study focused on external factors and not internal factors (carcass class) affecting supply and demand.

There is no study on the effect of a specific red meat carcass class, according to the current South African red meat classification system, on price and supply of red meat carcasses. Market research has shown that there should be an interaction between the different types of red meat carcasses, meaning for example if the supply of beef were to increase, it could have an associated decrease on demand for pork meat. The supply and demand of the different red meat carcasses affect the price per kilogram of a particular red meat type.

This study was designed to determine the effects of different meat carcass classes on each other concerning price, meat bought by the abattoirs and mass. The theory is that the different types of red meat carcasses would influence each other concerning price and number of carcasses bought by the abattoirs, the effect would be due to specific meat classes and not all the classes would be involved. It would be essential to know the effects of red meat production and price on the secondary and primary products from red meat animals. The concept is that there could be effects from some, but not all secondary and primary products from red meat animals.

Data comprising 259 sets was obtained via the Red Meat Abattoirs Association (RMAA) for the period 2013 to 2017. The data was collected from abattoirs that voluntarily sent their information to the RMAA (RMAA, 2020). This data consisted of weekly data from the abattoirs on the number of carcasses bought, average mass, average purchase price, average selling price, and minimum and maximum selling price of each carcass class (pork, beef and sheep). The following variables were used for pork, sheep and beef carcasses: the number of carcasses bought, average purchase price and average mass per carcass price. The tonnage of meat was calculated by multiplying the average purchase price with the total number of carcasses bought for the specific red meat type. Data was analysed employing SAS® (Version 9.4). Linear regression analyses were used with a 95% confidence level. For each type of red meat carcass (pork, beef and sheep) and the average purchase price as compared to the tonnage of meat and the average purchase price of carcasses (R/kg) for pork, beef and sheep carcasses and carcass class.

The influence of tonnage of pork, beef, lamb and mutton (sheep) per carcass class on the average purchase prices of pork, beef, mutton and lamb (sheep) respectively were analysed similarly. This process was followed in all the regression analyses for different explanatory variables.

The third set of regression analysis addressed the relationship between each red meat carcasses average purchase price with red meat products (feedlot hide price, veldt hide price, SA wool price, US wool price, European wool price and Australian wool price). The data was sourced from Cape Wool SA and AWEX-EMI over the review period.

The outcome of the study supported the hypothesis that carcass type and specific meat classes within carcass types were responsible for the differences in meat carcass prices. There was a differentiation in price between different meat classes, which affected the price of other classes, but some meat classes did not influence the dynamics of meat prices. The value in the analysis pointed directly to the classes that to a greater or lesser extent influenced price with an interactive effect between meat types. The analysis revealed that the influence observed was due to specific carcass classes and their specific factor (tonnage of meat, average mass, the average number of carcasses bought by abattoirs and average purchase price) and not all the carcass classes for price determination by buyers at the abattoir, processors and retailers as well as traders at the Johannesburg Stock Exchange (JSE), the different and combined influences of the different carcass classes on red meat price need to be considered.

A great deal has changed since the Apartheid era and the study of Du Toit (1982). In order to offer producers optimal prices, all factors (including carcass classes and external factors) influencing red meat prices must be taken into consideration when determining the price.

Currently, planning by red meat producers would not be influenced by the interactions of commodities and red meat, since their decision-making is not based on either carcass classes or the price of specific carcass classes. They base their decisions on the ratio between muscle and fat as well as the maximum profitability per animal based on input versus output cost. Producers are paid on a R/kg basis for carcasses and not according to the classification system. Negotiation of the price occurs before animals are brought to the abattoir according to contract or according to market information published by the JSE.

Even though this study relates to the South Africa classification system, these principles apply to other countries and their specific classification or grading system. Further studies would be required to determine the combined effect on the price and supply, as well as on-demand about the internal factors and external factors affecting them.

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LIST OF ABBREVIATIONS

AIDS	Almost ideal demand system
AWEX EMI	A series of benchmark of Australian Wool Market Indicators, Eastern Market Indicator
BC	Baconer use-category of the C carcass class
BO	Baconer use-category of the O carcass class
BP	Baconer use-category of the P carcass class
BR	Baconer use-category of the R carcass class
BS	Baconer use-category of the S carcass class
BU	Baconer use-category of the U carcass class
DFD	Dark, firm and dry meat
GDP	Gross domestic product
JSE	Johannesburg Stock Exchange
LM%	Lean Meat %
LSU	Large stock unit
NS	Not significant
OLS	Ordinary Least Squares
PC	Porker use-category of the C carcass class
PO	Porker use-category of the O carcass class
PP	Porker use-category of the P carcass class
PR	Porker use-category of the R carcass class
PS	Porker use-category of the S carcass class
PSE	Pale, Soft, Exudative meat
PU	Porker use-category of the U carcass class
Q	Quarter
R	Residuals
RMAA	Red Meat Abattoir Association
SA	South Africa
SADC	Southern African development community
SAS	Sausage carcass class
SAPPO	South African Pig producer's organisation
SD	Standard deviation
SSU	Small stock unit
US	United States of America

CHAPTER 1:
INTRODUCTION

The study evaluated the integrated influences of red meat carcasses and products from red meat animals on price and supply of red meat carcasses. The purpose of the study was to assess the status of the South African red meat industry over five years and in comparison, to the status during the Apartheid era. The study resolved to establish in principle the relationships between the types of red meat carcasses (beef, mutton and lamb, and pork) on the purchase price (R/kg cold carcass mass) and carcass classes over a selected period, to establish in principle the relationships between the types of red meat carcasses (beef, mutton and lamb, and pork) on products from red meat animals (wool and hide) and to determine the effect of a red meat market on red meat producers. The traditional commercial red meat industry of South Africa comprises of beef, sheep meat (lamb and mutton), goat meat and pork meat. Horseflesh, ostrich meat and game are other sources of red meat but are not considered part of the traditional red meat industry. For this study, red meat is defined as meat originating from pork, beef and sheep.

In 1994, the population and political dynamics of South Africa changed dramatically. The change impacted on the reordered national marketing and consumer profiles. Formerly, the country was divided into South Africa proper and homelands, of which four were independent and not considered part of South Africa (SAHO, 2020). During the Apartheid era, the South African Livestock and Meat Industries Control Board (Meat Board) controlled the access of red meat to controlled areas and abattoirs. The controlled access to markets on a quota system influenced the price of red meat sold at auction at abattoirs. The independent homeland regions were discriminated against and did not receive access to the controlled markets (South Africa, Agricultural Product Act, 1996; NAMC, 2001). The system skewed the real picture of the supply, demand for and price of red meat. After the abolishment of the Apartheid policies, radical deregulation of the controlled markets occurred.

The control boards were abolished by 1998 with the implementation of the Agricultural Product Act (Act 47 of 1996) (Hanekom, 1998). The implementation opened access to the red meat markets to the entire population. The change meant that the supply of and demand for red meat and subsequent pricing resulted from the prevailing social and economic forces of the whole population.

Aspects of the Apartheid policies have, however, remained such as the classification of persons by ethnic group. The 2011 census showed that South Africa had a population of 51,770,560 that consisted of 79% black people (African), 8% white people (Caucasian), 9% coloured people (derived from the original Koi San people, descendants of imported labour in the 18th Century from the east, mainly Java, persons of Middle Eastern origin and persons of mixed race) and 2% Asian/Indian (NAMC, 2012). Noting the population's ethnic composition becomes essential in considering the changing markets in South Africa where previously disadvantaged persons have gained access to employment and develop a more robust middle-class of consumers.

In terms of red meat sales and consumption, the developing middle class can afford red meat. This growth is driving the increase in demand for meat (Labuschagne *et al.*, 2011; Delport *et al.*, 2017). In general, in South Africa, pig meat enjoys a relatively high proportional demand. In 2013, the consumption of total meat was 40% pig meat, 33% chicken, 23% beef and 6% sheep and goat meat (Visser, 2014).

A wide range of institutions is employed to procure carcasses and deboned meat for the fresh-meat market and agro-processing. The nature of selling and buying carcasses has changed from an open market, and an auction-based system referred to by Du Toit (1982) in a study of the price elasticity between red meat sources towards contractual arrangements (Vermeulen *et al.*, 2008).

The cited study of Du Toit (1982) was carried out more than 35 years ago when South Africa was still functioning under a divisive political system. The study focused mainly on beef, and mutton and lamb (sheep) meat production, although the study also included pigs and poultry. Du Toit (1982) concluded with an ordinary least squares (OLS) regression model to estimate demand. Hancock, Nieuwoudt and Lyne (1984) published the results of a study that built on the results of Du Toit (1982), which concluded with a single and simultaneous OLS equation for demand. Loubser (1990) produced an updated version of the OLS, which was followed by the Rotterdam model (Badurally-Adam, 1998). Lately, the almost-ideal demand system (AIDS) model has been used to determine the demand for meat (Taljaard *et al.*, 2006). However, none of these formulas described the demand for meat entirely. There is no correct or final equation for a specific commodity market, so the monitoring of a commodity is an ongoing process. Without demand, production and marketing are futile exercises (Delport *et al.*, 2017). The first study in South Africa regarding the demand in the meat industry by Du Toit (1982) was, therefore based on different dynamics than the prevailing dynamics.

These studies considered meat supply, demand and price in a context of gross supply. There is no South African study on the effects of red meat carcass classes on the purchase prices of carcasses and carcass classes. This study was designed to determine the impact of different red meat carcass classes on the purchase price of red meat carcasses by abattoirs. The study of Du Toit (1982) focused on external factors, while the present research focuses on the effects of the different meat products and meat classification on each other (internal factors). The marketing system of red meat has changed since Du Toit (1982) determined the regression equation, mainly from carcasses sold at auctions to producers selling directly to abattoirs (contract sales) or meat producers owning their abattoir (Kirsten, 2003; Vermeulen *et al.*, 2008; Labuschagne *et al.*, 2011). With beef and sheep carcasses, there is an increased number of carcasses that sell on the Johannesburg stock exchange (JSE) (JSE, 2020).

No previous study was conducted on the effects of different red meat carcass classes, according to the South African classification system, on red meat prices. Market research shows that there should be an interaction between the different red meat carcasses, meaning for example if the supply of beef were to increase, it could have an associated decrease on demand for pork meat.

This study is essential for the following reasons:

- The South African classification system is not bi-directional;
- Producers, in general, do not know the classes they are producing since predicting the class in a live animal is precarious given the variation in depositing growing muscle and depositing fat that occurs. Targeting specific classes is more attainable in highly specialised pig production units using one highly selected for growth and carcass traits.
- Producers only receive a R/kg price; the determination of the demand equation for South Africa occurred in 1982; this demand equation only takes into consideration external factors, and the industry becomes a consumer-orientated system.

- The integrated influence of the different carcass classes on price needs to be taken into consideration when red meat carcass prices are established by traders and buyers, in order to provide the highest prices to producers, for the best quality meat, from a consumer perspective.

This study aimed to establish an observational relationship equation for red meat price with regards to the different red meat carcass classes of South Africa.

The objectives of the study were to:

- Assess the status of the South African red meat industry over five years and in comparison, to the status during the Apartheid era
- Establish the production level of red meat in South Africa for the period 2013 to 2017.
- Investigate the relevant relationships between the carcass class of South Africa and other products, and red meat prices and supply.
- Determine the partial coefficients for the relevant equations of red meat prices and supply.

CHAPTER 2:
LITERATURE REVIEW

2.1. Marketing of Agricultural Products Act

The 1968 Marketing Act focuses on the producers, resulting in a price gap between producers and consumers and rising food prices. The 1968 Act conflicted with the post-Apartheid government with regards to policies on efficiency, growth, food security and equality. Therefore, it was replaced by the Marketing of Agricultural Products Act, Act 47 of 1996. The objectives behind the Act 47 of 1996 are to increase market access, to promote the efficiency of marketing, to optimise export earnings and to enhance the viability of the agriculture sector (South Africa, Marketing act, 1996).

2.2. Meat marketing under the Meat Board

During Apartheid, the Meat Board controlled meat marketing to the extent that the Meat Board could exert influence or direct control over the supply of red meat to markets. The meat was sold as-is, at auction-on-the-hook, with a minimum guaranteed price. With this system, graded carcasses from the abattoir were auctioned at specific guaranteed minimum floor prices for all the meat grades, except for the lowest meat grade (Du Toit, 1982).

During the period an oversupply of red meat occurred, forcing the meat board to implement a quota-permit system. This system was initially implemented at the Witwatersrand, Pretoria and Kimberley meat markets and later at the Port Elizabeth meat market. Initially, agents could allocate 60% of abattoir quota to livestock marketers employing a quota, and the Meat Board could allocate 40% of the abattoir quota to beef marketers using a permit. This was changed in 1977 to 60% to permit and 40% to quota marketers. This was then changed in 1979 to a 100% to permit marketers at the Witwatersrand, Pretoria and Kimberley meat markets. This caused pressure on the application for permits, resulting in only 34% of beef supplied allowed, this increased to 61% at the beginning of 1980. In May 1980, the Meat Board implemented a stud price system for cattle and sheep at Witwatersrand, Pretoria and Cato Ridge areas. According to this system, the standard supply and demand would not be taken into consideration, but the Meat Board would decrease the stud price if there was a price decrease, with a maximum of 3% per day and 6% per week (Du Toit, 1982).

The changes that the Meat Board implemented received strong opposition and discontent. The minister of agriculture was approached on numerous occasions to investigate the marketing of meat for irregularities. This initially received opposition from the minister, but eventually, the minister instituted a commission to investigate the irregularities (Du Toit, 1982).

2.3. Livestock production

In 1980, 683,000 ton of beef, 194,000 ton of sheep (mutton and lamb), 89,000 ton of pork and 342,000 ton of poultry were produced in South Africa (Du Toit, 1982). These figures do not include the production from the homeland regions; therefore, it does not provide an accurate picture of production. According to Du Toit (1982), the price of beef was 37.18 c/kg at auction and 93.16 c/kg at small scale retail, sheep was 45.18 c/kg at auction and 96.06 c/kg at small scale retail, pork was 40.26 c/kg at auction, and 92.49 c/kg at small scale retail and poultry was 56.28 c/kg at small scale retail, in 1980. These prices only reflected the prices

recorded by the Meat Board. Therefore, they may not be a pure reflection of all the red meat prices in 1980.

The general trend for red meat per year per capita consumption decreased from the 1970s until the late 1990s, and subsequently, meat consumption moved sideways from the late 1990s to 2001. Between 2001 and 2006, consumption trends from beef and lamb were upwards, but downwards for pork. The per capita consumption of beef declined steadily until 2000/1, which was attributed to high red meat prices in comparison with white meat prices during the period. On the other hand, the per capita consumption of beef increased consistently from 2001/2002 until 2005/2006. The demand for meat worldwide is expected to increase. The increase in demand would be mainly in developing countries (Labuschagne *et al.,* 2011).

Poultry is the most consumed meat worldwide, followed by pork. In South Africa, the growth in demand for poultry far exceeds that of beef. The growth in demand for poultry is due to consumers perceiving poultry as being cheaper, healthier and easier to prepare than beef. Generally, beef has a better bone-to-meat ratio than chicken and has a greater demand than pork, lamb and fish (Labuschagne *et al.*, 2011).

The gross domestic product (GDP) from agriculture for the dominant world countries compared to South Africa is as follow: South Africa had a GDP of 69,058 ZAR million in December 2019, Canada with 40,058 CAD million in January 2020, Saudi Arabia with 15,493 SAR million in December 2019, Australia with 9,790 AUD million in December 2019, and Mexico with 513,178 MXN million in December 2019 (Trading-economics, 2020).

The total gross value of agricultural production, in South Africa, for 2016/17 was estimated at R273,344 million, compared to R243,057 million the previous year (an increase of 12.5%). This increase could be attributed mainly to an increase in the value of field crops and animal products. The gross values of animal products, horticultural products and field crops, were 46.5%, 27.7% and 25.8% respectively. The poultry meat industry made the most considerable contribution with 14.9%, followed by cattle and calves slaughtered with 12.5% and maize with 10.7% (Davids & Meyer, 2017).

It was estimated in 2014 that there were approximately 50,000 commercial farmers, 240,000 small-scale farmers and 3 million subsistence farmers of livestock in South Africa. In 2014, South Africa had approximately 431 abattoirs responsible for slaughtering pigs, cattle and sheep. Of these abattoirs, 40% were registered to slaughter an unlimited number of animals (DAFF, 2014a).

Traditionally, pigs were produced on small mixed farms in the Northern hemisphere on a small-scale and were fed from the residues of other farm activities (livestock and crop production). The current pig production system is highly specialised; pigs are fed a balanced diet and are kept on concrete stalled floors (Devers *et al.*, 2012).

The South African pig industry has a gross producer value of approximately R3.49 billion or 4.7% of the livestock sector, whereas the gross consumer value is estimated at R7.15 billion. There are approximately 120,000 sows in South Africa, with an estimate of 103,400 sows in the commercial section and remaining 16,000 in the communal sector (Visser, 2014).

South African commercial producers have sow units in three size categories: 50 to 150; 151 to 400; 401 to 900. An inverse relationship has occurred between increasing numbers of sows per unit and the number of farms (Visser, 2014). This inverse relationship has potentially positive and negative consequences. The larger units and a smaller number of producers could deliver more uniform types of pigs, especially considering the increasing number of breeding companies. Production targets could be narrowed, and biological and economic

efficiencies increased. The downside is a potential narrowing of the genetic base and associated variance.

The average yield per litter in 2013 was 26 to 27 piglets born per sow and 23 weaned. Top producers are weaning more than 28 piglets per sow. Compared to the previous decade, the output of pig producers increased, even though the number of sows did not increase significantly. This increase in output is due to improvement in genetics, artificial insemination, housing, nutrition, research, bio-security and health as well as management (Visser, 2014).

There are approximately 11 million cattle owned by commercial farmers and 5.69 million cattle owned by small-scale and subsistence farmers in South Africa. The gross value of beef production increased from R7.3 billion in 2004/05 to R22.7 billion in 2013/14. The average gross value of beef produced during this period amounted to R15 billion per annum. The largest share of beef production, in South Africa for 2014, was found in the Eastern Cape (24%), which was followed by KwaZulu Natal (20%), Free State (17%), North West (12%) and then Mpumalanga (10%). Over the past ten years, approximately 8.4 million tons of beef was produced (DAFF, 2014a).

South Africa is a nett importer of beef. Although in 2014, South Africa exported approximately 28000 tons of beef. These exports were mainly to other African countries, some Asia and Europe countries. From 2005 and 2014, there was a 16% increase in beef imports into South Africa. Imports, into South Africa, occur mainly from the United States of America, followed by Australia and New Zealand (DAFF, 2014a).

Sheep production is practised throughout South Africa but is mainly produced in the more arid areas of the country. There are approximately 8,000 commercial sheep farmers and 5,800 communal sheep farmers, giving approximately 24.5 million sheep in South Africa. The sheep produced in South Africa are mainly Dorper or Merino breeds (DAFF, 2014b).

The average gross production value amounted to R 4.3 billion per annum. The total gross value for the past ten years amounted to R 42.9 billion. The gross value of mutton production increased continuously from 2004 until 2013. The Eastern Cape contribute to the highest production of sheep with approximate 29%, followed by Northern Cape (25%), Free State (20%) and then Western Cape (11%). Mutton produced in South Africa is mainly consumed locally. For the period 2004 to 2013, mutton consumption peaked in 2007 (169 million kilograms) and then in 2013 (152 million kilograms) (DAFF, 2014b).

South Africa is a nett importer of mutton, with an average of approximately 16.3 million kilograms per annum. However, South Africa exported approximately 413,145 kg of mutton to the Southern African development community (SADC). South Africa mainly imports from Australia and New Zealand, the largest producers of mutton in the world (DAFF, 2014b).

2.4. International and national changes in the markets

The agro-food system has rapidly evolved worldwide in the last few decades with marketing and quality control, shifting from product control to process control, thereby shifting competition in the agro-food system. Concurrently, there have been substantial changes in the features of food demand and consumption moving away from the mass consumption model towards an increasing qualitative differentiation of products and demand (Van Zyl *et al.*, 2013). Globally there is a shift in the consumption of red meat and red meat products. This shift is also taking place in South Africa (Visser, 2004; Van Zyl *et al.*, 2013; Labuschagne *et al.*, 2011).

According to Visser (2004), the agricultural product market became a more consumer-orientated market and not producer-orientated at the turn of the millennium (2000). However,

the momentum of change among consumers was still in the beginning stages in 2000. Sixteen years later, the shift in consumer profiles and expendable income is continuing to spread among the South African population. There is much vying for the increasing expendable income base by marketers of commodities, which include motor vehicles, insurance brokers, the entertainment industry and the food industry (Visser, 2004; Labuschagne *et al.*, 2011). This shift to the consumer is due to the consumer being empowered by more better knowledge and the consumers' need for change (Labuschagne *et al.*, 2011; Van Zyl *et al.*, 2013). The movement towards addressing consumer demand for food products with more advanced quality attributes has led to increasingly complex food qualification processes and a proliferation of standards (Van Zyl *et al.*, 2013).

The increasing world population and growing middle class in developing economies are causing an increase in the consumption of meat. This opens opportunities for the meat industries to produce more meat products. The demand also means more efficiency and more market-specific products (Alemu & Ogundeji, 2010; Devers *et al.*, 2012; Olson, 2013; Van Zyl *et al.*, 2013; Sharaunga *et al.*, 2014; Delport *et al.*, 2017). This increase in meat demand is due to changing diets and a general increase in the standard of living (allowing more people to afford meat) (Devers *et al.*, 2012). According to Van Milgen *et al.*, (2012), improved management, nutrition, and genetic potential of animals are putting these animals into better carcass classification groups. This also means that as with broilers, the range in variation becomes narrower. Consumer, supply chain and network analysis are critical to finding an optimal solution that is sustainable enough to meet the changing environment. The South African beef industry is challenged by the increasing complexity and demand brought about by globalisation, increased volumes and competition, the shortage of skilled staff and pressures to meet changing consumer needs (Labuschagne *et al.*, 2011).

The six most crucial worldwide consumer trends are convenience, versatility, environmental and ethical issues, and value for money, health consciousness and simplicity. One of these trends is a general worldwide increase in consumer concern regarding health, diets and safety. Internationally, this relates to issues such as traceability, animal welfare, diseases and production processes, sustainable agricultural practices and natural, organically produced meat (Labuschagne *et al.*, 2011; Van Zyl *et al.*, 2013). Most South African consumers are less concerned about meat safety and animal welfare (Labuschagne *et al.*, 2011).

2.5. South African consumer

In South Africa, the portion of the population falling in the middle class is increasing, causing an increase in people able to afford meat. This increase is driving the rise in demand for meat (Labuschagne *et al.*, 2011; Delport *et al.*, 2017). Engel's Law states, "*As the income rises, the share of the budget spent on food tends to decline*". Whereas Bennett's Law states, "*As income rises, consumers reallocate their food budget away from starchy staples, such as rice and maize that are inexpensive sources of calories, towards higher-cost sources of calories such as fruit, vegetables and animal products*" (Akinleye & Rahji, 2007). Meaning that the middle-income class consumers would buy meat based on price, purchasing the meat product that has the lowest price per kilogram.

In a study of the South African pork value chain, Davids *et al.*, (2013) found that fundamental drivers of pork consumption were both economic and non-economic. Quoting Oyewumi & Jooste (2006), "*it was highlighted that South African consumers prefer value-added pork products as opposed to fresh meat with an average of 58% across ethnic groups.*

The African and White populations had > 70% preference". This reflects the division of around 45% of pigs produced being sold for the fresh meat market and approximately 55% being sold for the processed market. However, the parameters in the analysis of partial effects by Oyewumi & Jooste (2006) included responses of households to changes in pork quality. The analysis revealed that quality assurance and value-adding led to a much greater probability of pork consumption by households.

In general, in South Africa, pig meat enjoys a relatively high proportional demand. In 2013, the consumption of total meat was 40% pig meat, 33% chicken, 23% beef and 6% sheep and goat meat (Visser, 2014).

It must be noted that the South African population is not uniform in preferences for red meat or red meat types. A significant number of South Africans do not eat pork due to cultural prohibitions, which include persons of the Muslim and Jewish faith that constitute 1.9% and 0.2% of the religious affiliations, respectively, and sectors within the Christian community that constitutes 86% of the religious affiliations (Statistics South Africa, 2015), such as the Zion Christian Church with a membership of >4 million and other faith-based groups. A broad cluster of Eastern religions such as Hindu has high preferences for sheep and pork, while beef is not entertained. These preferences could influence demand and price, but it was not the objective of the study to differentiate the demands for the types of red meat along with cultural identities. The analysis considers the demand for and pricing of red meat in South Africa undifferentiated by cultural practices.

Considering the Davids *et al.* (2013) report's conclusions, together with these results, a comprehensive set of conclusions are: "*The numbers of primary producers outnumber the abattoirs and processors and as a result have limited bargaining power related to prices. The production and abattoir situations often lead to a lack of trust in the price formation mechanism*". Demand for pork products is expected to grow in the long term. Average weather conditions (as opposed to abnormal weather that affects the yield and prices of feed resources) should result in decreased feed costs, providing improved conditions for pork production. If increased demand is to be met by increased domestic production rather than imports, significant investment would be required across the value chain in order to provide possible export opportunities for parts of the carcass that are less popular in South Africa.

Greater coordination providing surety of a market as well as transparency regarding price formation would have a significant role in ensuring that the required investment occurs at the primary producer level. Competitiveness is constrained by factors that include national infrastructure, the political climate, the costs and regulations related to labour, productivity by labour and the cost of administered prices such as fuel and electricity. An economic and social upward mobile group of consumers could have a significant impact on the consumption of pork in gross terms, concerning niche markets (Davids *et al.*, 2013).

There is no doubt that investment would be required in order to increase production levels and improve the efficiency of the value-chain in the long term; however, this is more likely to materialise in a macro environment that supports the efficient functioning of the South African pork value chain. It is noticeable that the report of Davids *et al.* (2013) made no mention of classification of carcasses as an element in the fresh or processed industries, or that carcass classification might influence the price of carcasses. It made one reference to classification in that processors procure whole carcasses and not primal cuts and that the margins that were calculated were only for the Class BP (BP pork class) carcasses.

Increasingly educated classes of consumers with increasing expendable income would emphasise quality, which should be easily communicated to them, as is done in the motorcar and other commodity industries. The procurement of meat, poultry and eggs appear to favour

vertical integration (and some cases own production), medium to long-term contracts and long-term "informal" supply arrangements with selected groups of farmers are employed. With the increasing commercialisation of agricultural and food systems worldwide, the food industry is increasingly being dominated by supermarkets and agro-industry, while small traders and neighbourhood stores are declining. This trend is due to the increasing urbanisation of the world population, large-scale innovation in biology and information technology as well as strong consumer demand for high-quality food products (Vermeulen *et al.*, 2008).

The South African beef supply chain combines a lean and agile supply chain. Lean relates to the way beef is produced and delivered to the retailer. This includes the producer, feedlot, the abattoir and the wholesaler, and links with the price sensitivity of consumers and competition with other meat types. The lean part of the supply chain also enables traceability and the naturally produced beef required by consumers. The partners in a successful, competitive beef supply chain are highly dependent on each other. Businesses have to select the right supply chain configuration carefully to produce the optimal consumer value (Labuschagne *et al.*, 2011; Van Zyl *et al.*, 2013).

2.6. South African supply chain and price transmission of red meat

In a study done on the price transmission in South Africa, it was concluded that it is unidirectional, running from producer to retailer, but not *vice versa* (Alemu & Ogundeji, 2010).

Soji & Muchenje (2017) did a literature review on the validity of the current red meat classification system of South Africa. They found that although the classification system is of good design, the system is only used by meat traders and does impact the consumer. They also found that the classification system does not reflect the demand of the consumer.

A wide range of institutions are employed to procure raw commodities (including various meats) for South African agro-processing sector, and companies are increasingly moving away from open market sources as supply from raw commodities and towards contractual arrangements (Vermeulen *et al.*, 2008).

Marketing practices of pork have changed from an auction system at abattoirs under the auspices of the Abattoir Corporation, which was influential in the price determination. However, since ABAKOR went out of business, many abattoirs were forced to close. Now auctions only occur in Port Elizabeth and Cape Town, but these are not enough to be used as price indicators. Some producers still make use of the open market (Casey & Du Toit, 2015), which makes it essential to note the apparent relationship between pig carcass classes and prices shown in Table 2.1.

Table 2.1: Typical spread of pork carcasses by class and the associated auction price

Mass Class	Class	Number	C/kg
Weaner		15	868
Class P			
V	P	1	943
W	P	10	1014.5
X	P	82	1056.4
Y	P	115	1144.3
Z	P	99	1089.7
Total Class P		307	1098.3
Class O			
V	O	5	968
W	O	65	99
X	O	179	1043.5
Y	O	66	1084
Z	O	80	1026.1
Total Class O		395	1038.5
Class R			
V	R	1	899
W	R	43	968
X	R	95	1008
Y	R	44	1057.4
Z	R	20	955
Total Class R		203	1004.5
Class C			
V	C	2	911
W	C	18	837
X	C	31	958
Y	C	6	975.2
Z	C	2	801
Total Class C		59	946.4
Class U			
V	U	0	0
W	U	2	860
X	U	4	844
Y	U	0	0
Z	U	0	0
Total Class U		6	849.3
Class S			
V	S	0	0
W	S	1	737
X	S	0	0
Y	S	3	749
Z	S	0	0
Total Class S		4	746
Sausager		17	668.3
Pork Total		1006	1033.4

(as modified from DAFF (2014b)

There are five mass classes for pork carcasses auctioned: V, W, X, Y, Z, where the industry designates V and W as a Porker because they are lighter in weight (e.g. < 60 kg), and X, Y and Z are the heavier carcasses and are designated as Baconer (e.g. 60 to 90 kg) (NDA, 2020). It must be noted that the use-categories designated Porker and Baconer are not

official designations as published in the Marketing of Agricultural Products Act (Act 47 of 1996). These are, however, essential categories in the marketing of classed pork carcasses. Kirsten (2003) found that the majority of pork sold in South Africa is through contracts.

Traditionally, beef is sold fresh to the consumer through various types of retail outlets. However, the consumers' need for convenience could lead to market share erosion as a result of ready-to-eat and heat-and-eat meals (Labuschagne *et al.*, 2011). According to Kirsten (2003), the beef industry supply is becoming increasingly more vertical, due to an increasing number of feedlots owning their abattoirs as well as the rising number of abattoirs selling directly to the consumer. According to the same author, there is also a shift of abattoirs to buy live animals directly from the farmers, instead of at auctions. Up to now, beef producers were in no position to manipulate the market in any way, due to typical production cycle as well as the fact that producers have to contend with extreme climate occurrences and the biological nature of the system. With the implementation of the trade of beef on the Johannesburg stock exchange (JSE), prices could be agreed ahead of time. The effect is more stable (less elastic) beef prices. Mutton and lamb recently also started to trade on the JSE (JSE, 2020).

According to Davids *et al.* (2013), the pig production system does not allow pigs to stay longer at the farm than market age. Therefore, the price that is presented is the price the farmer/producer must accept. Whereas with cattle and sheep, the farmer could hold back the animals until the market price is more favourable for the farmer/producer. According to the same authors the constraints are experienced in the pork value chain due to the following factors; national infrastructure, political climate, cost and regulations of labour, labour productivity, administration cost, and building cost.

Meat production has a natural production cycle, and a farm could only profitably sustain a certain number of animals. In production, whether extensive production of the veld or via a feedlot, a critical point is reached where the animal costs the producer more than what the producer could sell the animal for. Therefore producers would sell their animals before they reach this point (Penson *et al.*, 2002). Another aspect that producers take into consideration when determining the point to sell the animals is the ratio between muscle mass and fat mass. Muscle weighs more than fat, and since animals are sold on a R/kg bases, the producer would look at the optimum ratio between muscle and fat to obtain the maximum price (R/kg). This point would differ depending on the maturity type of the animal (Lawrence & Fowler, 2002). Where possible, beef producers monitor feed intake, and rates of gain since the gain in muscle is more efficient than fat gain aiming to market an animal at the optimum stage of mass gain and feed conversion.

2.7. Factors affecting supply and demand for red meat

It is important to understand the factors influencing supply and demand in order to determine the price of agricultural products accurately. Understanding the factors that influence agricultural prices is fundamental for sustained growth and the rest of the economy (Asfaha & Jooste, 2007).

The demand for basic commodities tends to be stable and generally are more responsive to changes in income and taste than changes in price. In this situation, a small shift in supply or demand conditions could have a major impact on market prices. The demand for most raw agricultural commodities is steady throughout the year. Demand estimation is important for informed decision making by industry stakeholders and policymakers (Lusk & Tonsor, 2016). The factors that affect the supply of a product include the production system, the efficiency of production, and feed costs (Stotts, 2013; Schulz 2013; Lusk & Tonsor, 2016).

The factors affecting the demand of a product has to do with the consumer and include factors like the healthiness of the product, the budget of the consumer, the income of the consumer, economic growth, and urbanisation (Davids *et al.*, 2013; McCarthy *et al.*, 2003, 2004; Hahn, 2004 Zotte, 2002; Van Zyl *et al.*, 2013).

Culture and religion also play a role in the demand of meat, because some cultures and religions do not eat specific meat products or eat specific meat products only at certain times of the year (Ackerman & Tellis, 2001; Van Zyl *et al.*, 2013). According to Stotts (2013), the demand for one meat product would influence the demand for the other meat products. As noted, the South African population has diverse red meat consuming profile.

Commodity prices, in general, are considered to have high volatility; this volatility increases the risk of paying higher prices for a specific commodity. For various reasons, commodity prices, and in particular agricultural prices, are subject to significant fluctuations in both domestic and international markets (Geyser & Cutts, 2007; Jordaan & Grové, 2007; Ayankoya *et al.*, 2016).

Global trends and prices also play a role in the price of products including meat prices in South Africa (Alemu & Ogundeji, 2010; Davids *et al.*, 2013), as well as bans on meat from and to other countries would influence the price (Stotts, 2013). Any restrictions on the movement of meat between countries would influence the price (Stotts, 2013). Restrictions may be due to limited trade agreements and/or the risks associated with translocating diseases. A ban of a specific meat product to a country would cause a surplus in the country of origin and an export ban from a country would cause a surplus of that product in the export country thereby causing a price decrease in the country with the surplus. According to McCarthy *et al.* (2004) and McCarthy *et al.* (2003), the disease status of the country would influence the price of meat because this would impact the import and export of the meat. This statement is supported by Verbeke & Ward (2001), who stated that disease status could have a negative influence on local meat prices.

Globally, there has been a marked increase in food prices. This is attributed to several factors, namely rising energy prices, subsidised biofuels production, income growth, population growth, globalisation, urbanisation, land and water constraints, underinvestment in rural infrastructure and agricultural innovation, lack of access to inputs, and water disruptions. This situation is also accurate in South Africa (Alemu & Ogundeji, 2010). According to Green *et al.* (2013), changes in global food prices would have a greater effect on food consumption in lower-income countries and poorer households within a country. In poorer income countries and households, a decrease in demand for the product would occur when global food prices increase. The current Covid-19 pandemic could also affect food prices that will materialise later in 2020 as the consequences on world trade, local production, and on-demand due to decreased household incomes caused by limited or lost employment. Future studies will report on this.

The supply of agricultural commodities within a given crop year or production cycle is seasonal by nature. Crops are abundant at harvest, and supply falls during the remainder of the market year. Animal production, though more continuous, is also predisposed to the production cycle due to animal birth rates and feeding schedules. Whereas the demand for these products is constant throughout the year, the contrast between supply and demand of agricultural commodities could give rise to seasonal cycles of low prices at production peaks, followed by higher prices as stock is drawn down (Geyser & Cutts, 2007; Monk *et al.*, 2010).

Livestock production faces numerous challenges that place constraints on the ability of agriculture to sustain growth and prosperity. Some of the factors that influence this include rising and volatile input costs, the potential for severe equity drain, and broader economic

influences (Geyser & Cutts, 2007; Monk *et al.*, 2010; Schulz, 2013). According to Schulz (2013), if a recession occurs, all prices fall drastically, then take approximately two years to reach a new high. Monthly supply, demand and price variations reflect phenomena often not isolated in annual or quarterly time series analysis. Regular monthly demand fluctuations, income and population changes, and the slaughter supply per packer workday were found to affect cattle and pig prices (Hayenga *et al.*, 1970).

An extensive survey in Europe (Dransfield *et al.*, 2005) revealed an interesting aspect of consumer profiles. Although the results apply to the European population, cognisance could be taken of the profiling that shows definite consumer differentiation by nationality or culture. South Africa is in a dynamic transformation phase with economic class migration and an expanding middle class, especially among the African population. The abstract of the research is presented: Reactions of consumers to the appearance and taste of pork with and without information concerning outdoor production of pigs were tested in France, Denmark, Sweden and the UK. Consumers in all four countries focussed on colour and fatness rather than marbling and drip to make their choice. Almost half of the British and Danish preferred the paler and the French the darker pork. Most people preferred the leaner pork. When information was provided in the form of labels, the vast majority of consumers preferred the pork labelled as originating from their own country as opposed to 'imported' and that labelled as pork from pigs' raised outside' as opposed to 'inside'. There was no difference in the taste of grilled pork from indoor and outdoor production systems, but pork labelled 'home-produced' or 'outdoor' were more appreciated. Consumers' willingness to pay varied widely and was higher for those consumers who found more of the characteristics they sought. Consumers offered about 5% more for 'home country' and 'raised outside' labels (Dransfield *et al.*, 2005; Van Zyl *et al.*, 2013). The deductions are that the profile of the meat market is changing internationally and in South Africa. The red meat industry is continually expanding with a high preference for value-added products. Pricing of carcasses appears to be a dilemma while the expectation is that scientific-technical advances would improve production efficiency. However, this must be linked to more specific consumer profiling in South Africa.

South Africa is considered as an upper-middle-class country, despite an extreme degree of inequality in the distribution of income, assets and opportunity (Pauw, 2007). South African agricultural production is switching away from field crops to meat as diets change (Labuschagne *et al.*, 2011). The South African consumer market is characterised by socio-economic and cultural diversity, food expenditure patterns, behaviour and preferences differ significantly between the various sub-groups. The low-income socio sub-group has a very limited understanding of the red meat classification system, whereas the middle and wealthy sub-group check for the classification marks (Vermeulen *et al.,* 2015). According to Vermeulen *et al.* (2015), consumers are not concerned with the red meat classification system; consumers check quality, fattiness, tenderness, juiciness, taste, smell and appearance. The main focus of purchases is on safety, appearance, price and eating quality.

Meat quality influences consumer satisfaction and, as previously mentioned, there has been a shift towards consumer-oriented markets. Therefore, there is a need to look at factors affecting meat quality. These factors include:

- the pH of the meat anti-, pre- and post mortem
- electrical stimulation
- the stress of animal anti- and pre-mortem
- fatness
- type of fat and location

- period of maturing
- tenderness
- juiciness (Muchenje *et al.*, 2009a; Frylinck *et al.*, 2012)

Quality is a multifaceted concept that consumers cannot evaluate as a whole. Therefore, consumers use indicators of quality to make a judgement about the product quality attributes. Consumers are faced with a buying decision; they have an idea of the specific product attribute they desire. Consumers would value similar products differently based on slight differences in product attributes (Van Zyl *et al.,* 2013). Quality attributes could be categorised as search, experience and credence attributes. Search attributes could be identified immediately and could thus be verified at the time of the purchase; this may include product colour, meat cut and packaging material. Experience attributes could only be identified during or after consumption and may include tenderness, taste and product convenience. Credence attributes cannot be objectively evaluated before, during or after consuming the product, this may consist of hormone-free or nutritional claims (generally certified by a reputable third party) (Van Zyl *et al.,* 2013). Quality parameters for pork include the colour of the muscle of young and older pigs, colour and texture of the fat, fat distribution over the carcass and between the fat depots and tenderness/toughness/residue due to collagen characteristics of young and older animals. Post mortem glycolysis indicated by the pH is an indicator of pale soft exudative meat (PSE) and dark, firm and dry meat (DFD) and post mortem water-binding capacity.

Backfat needs to be of specific quality for processing. Good quality fat must be firm and white, whereas poor quality fat is soft. Soft fat may result in insufficient drying, an oily appearance, rancidity development and separation between muscle and adipose tissue on the cutting of processed meat (Hugo & Roodt, 2007). During processing, poor quality fat causes problems such as excessive dehydration (Peloso *et al.*, 2010) and salt being poorly absorbed resulting in crusting and anomalous fermentation or putrefaction phenomena (Boschetti *et al.*, 2013). Due to research in human nutrition, the meat industry is pressured to produce meat that contains more polyunsaturated fatty acids. The polyunsaturated fatty acids are the reason why pork meat became softer over the years. Pigs respond better to changes in dietary ingredients that promote polyunsaturated fatty acids than do ruminants (Raes *et al.*, 2004).

Sheard *et al.* (2000) looked at the effect of the higher polyunsaturated fatty acids on the shelf life of pork meat as well as the effect of lipid oxidation on the flavour of the meat. They observed no significant impact on flavour nor shelf life. Heavier carcasses are mainly used for processing, whereas lighter carcasses are mainly used for fresh meat processing (Peloso *et al.,* 2010). In the South African context, porker carcasses are mostly used for fresh meat production, whereas baconer and sausage carcasses are used for processed meat. A significant relationship seems to exist between the quality of carcass fat and the classes in terms of the South African PORCUS system. A relationship of this nature indicates that quality parameters could be coupled into the classification system, which at present are not included (Hugo & Roodt, 2015). However, none of the meat quality attributes are communicated directly to the consumer through the carcass classification system other than in beef and sheep carcasses where age-related carcass classes imply tenderness. Such carcass classes imply tenderness because other factors including pre-slaughter stress of the animal or post-slaughter cold shortening of muscle fibres could have detrimental effects on tenderness.

The common phrase is "*consumers want a good quality carcass*". The misnomer of the phrase is that it essentially means meat quality. Consumers have little or no interest in a

carcass, but solely in the cut or joint presented in the meat market (supermarket or butchery). Written jargon, scientific or non-scientific equates carcass quality to meat quality. In contrast, the two terms are mutually exclusive unless bonded as in the case of beef, mutton and lamb carcasses. In those species, the link is to a physiological age through the number of teeth, or in the USDA system, the ossification of the vertebrae.

Meat quality generally refers to tenderness and juiciness (Li *et al.*, 2008; Muchenje *et al.*, 2009b; Zhao *et al.*, 2013; Lomiwes *et al.*, 2014). Tenderness is the most important factor in determining consumer satisfaction (Jeleníková *et al.*, 2008). This statement must be apparent because the consumer profile is not generic, as is often depicted in scientific articles. Meat quality is consumer profile dependent. Many factors work together to produce the final meat quality, which ranges from management and handling on the farm and at the abattoir, to the genetics and gender of the animal. Starting on the farm, the growing environment, the management of the animals on the farm, the nutrition on the farm and human handling on the farm would all contribute to the final tenderness. The transport of the animal to the abattoir influences the tenderness, due to the stress experienced by the animals during transport (Du Toit & Oguttu, 2013).

Pre-slaughter handling of live animals and post-slaughter handling of the carcasses have important consequences on meat quality. Pre-slaughter handling of animals includes loading, transport, handling at the holding pens, moving along the chutes and rendering unconscious either by the captive bolt (completely not recommended), electrical stunning or by asphyxiation with CO_2, which could cause stress reactivity that could manifest in either DFD meat or PSE meat. Exhaustive stress causes a drop-in glycogen concentration in the muscles resulting in an unacceptable high ultimate pH resulting in DFD meat. Post-mortem handing involves too rapid chilling of carcasses causing cold shortening and toughening of pre-rigour mortis muscle. This situation does not easily arise in South African pig carcasses, because the skin is not removed, thereby exposing the muscle to the cold (Du Toit & Oguttu, 2013). PSE and DFD are linked to the ultimate pH and both conditions, which are deviations in meat quality, are highly unacceptable to consumers and processors.

Market research shows that there should be an interaction between the different red meat carcasses, meaning for example if the supply of beef were to increase, it could have an associated decrease on demand for pork meat. The supply and demand of the different red meat carcasses affect the price per kilogram of the red meat.

Commodity prices, in general, are highly volatile; this volatility increases the risk of paying higher prices for a specific commodity. For various reasons, commodity prices, specifically agricultural prices, have significant fluctuations in both domestic and international markets. The markets for agricultural products, where supply and demand are inelastic, are characterised by large changes in prices. Agricultural prices are structurally prone to fluctuations because of short-run inelasticity of supply and demand for the products. Production of agricultural commodities is fixed in the short-run and is highly dependent on growing conditions on the farm, which could vary greatly from year to year. This in return, could create periods of under or oversupply of the commodity. The supply of agricultural commodities within a given crop year or production cycle is seasonal. Crops are abundant at harvest, and supply falls during the remainder of the year. Animal production, though more continuous, is also predisposed to production cycles due to animal birth rates and feeding schedules (Geyser & Cutts, 2007; Jordaan & Grové, 2007; Monk *et al.*, 2010). The rate of price increase is not proportional to the rate of increase in money supply (Asfaha & Jooste, 2007).

2.8. The elasticity of price and demand

Price elasticity is the degree to which demand for a good or service varies with its price. Typically, sales increase with a drop in prices and a decrease with rising prices. As a general rule, appliances, cars, confectionary and other non-essentials show elasticity of demand. In contrast, most necessities (food, medicine, essential clothing) show inelasticity of demand (do not sell significantly more or less with price changes (BusinessDictionary, 2020)).

Over time the price elasticity for demand changes and develops. This is due to personal and external factors that include relative price, the income and expendable income of the consumer, health trends, food safety, product characteristics, new competing products, a shift in consumer demography and lifestyle (Tomek & Cochrane, 1962; Lusk & Tonsor, 2016). Lusk & Tonsor (2016) studied the demand price elasticity due to unprecedented high beef and pork prices. This price increase was due to a drought that increased the feed prices as well as due to unexpected animal disease occurrence and growing global demand. The authors showed that the price elasticity is non-linear and that the level of income of the consumer influences the elasticity. The elasticity of demand is more inelastic with the higher income consumer than the low-income consumer. The authors also found that as the price of beef and pork increase, so does the inelasticity of the elasticity of demand.

There is no correct or final demand relationship for the specific commodity market, and thus the monitoring of a particular commodity is an on-going process. Without demand, production and marketing are futile exercises (Delport *et al.,* 2017). The first study in South Africa regarding the demand in the meat industry was done by Du Toit (1982), in which he concluded with the following formulas for beef and sheep demand:

Abt = - 212.12 + 7213.89 $\frac{Ab_{t-1}}{TVP_{t-1}}$ + 11.530 Pbt-5 – 0.4795 I where;
Abt: Arrivals of cattle for slaughter in controlled areas, in thousands
$\frac{Ab_{t-1}}{TVP_{t-1}}$: The supply of cattle to the controlled markets in the previous year in relation to the total number of cattle on white farms in the same year
Pbt-5: The weighted average real auction price of all grades of beef in the previous year, c / kg
I: Imports of cattle and cattle carcasses from adjacent areas in thousands

Ast = - 148.87 – 47.1818 Pst-1 + 84.6045 Pst-4 + 48.4491 Pst-3 – 1.4820 Rt-1 + 4.978 I + 249.2099 T where;
Ast: Arrival of sheep for slaughter in controlled areas, in thousands
Pst-1: The weighted average real auction price of all grades of beef in the previous year, c / kg, Pst-3 is where time was delayed by three years and Pst-4 time was delayed by four years.
Rt-1: Average yearly rainfall, measured at Bloemfontein. Middelburg and Kimberley
I: Import of sheep and sheep carcasses from adjacent areas in thousands
T: Time

The above study focused on external factors, whereas this study focuses on the effect of the different meat products on each other (internal factors). The marketing system of red meat has changed since Du Toit (1982) determined the equation. At the stage the equation was determined, carcasses were sold via auction. This changed to more producers selling

directly to the abattoir (contract sales) or owning their abattoir (Kirsten, 2003; Labuschagne *et al.*, 2011; Vermeulen, Kirsten & Sartorius, 2008). With beef and mutton carcasses, there is an increased number that is being sold on the JSE (JSE, 2020).

In general, agricultural products react with a low elasticity to change in demand, though this could differ with other products. If the elasticity of a product is higher than -0.3, the consumer tends to substitute that product of a higher frequency with other similar products (Bielik & Šajbidorová, 2009). According to Gallet (2010), there is a relatively high variation in the elasticity of meat products, with fish having the highest elasticity and lamb the lowest elasticity.

The demand for basic commodities tends to be stable and generally is more responsive to changes in income and taste, than changes in price. In this situation, a small shift in supply or demand conditions could have a major impact on market prices. The demand for most raw agricultural commodities is steady throughout the year. The contrast between supply and demand for agricultural commodities could give rise to seasonal prices at production peaks, followed by higher prices as stocks are being depleted. Agricultural commodities are relatively price-inelastic, meaning quantities demanded and supplied changes proportionally less than price (Geyser & Cutts, 2007; Monk *et al.*, 2010).

A meat meta-analysis from data across the world was done on the price elasticity of meat. It was concluded that the elasticity of demand for beef, lamb and fish tend to be more elastic compared to that of poultry. The elasticity of meat products is particularly sensitive to the specification of demand chosen estimation method and publication characteristics (Gallet, 2010). Agricultural commodities are relatively price-inelastic, meaning quantities demanded and supplied change proportionally less than price (Geyser & Cutts, 2007; Monk *et al.*, 2010).

According to Davids *et al.* (2013), the elasticity of demand for pork is inelastic, meaning that the price does not fluctuate a great deal compared to the other meat products. According to Tomek & Cochrane (1962), beef, pork, and other meat products' prices are inelastic. In the short-term, livestock and meat prices, vary more than the cost of production, processing and marketing. Dynamic adjustments drive monthly changes in livestock and meat prices. It takes time for prices to adjust and tend to adjust. These adjustments are more rapid when adjusting increasing than decreasing (Mckenzie & Holt, 2002; Hahn, 2004; Mabaya *et al.*, 2010). Although in the short-term there are dramatic price adjustments, in the long-term the price adjustments are less dramatic, meaning in general agricultural products are inelastic in the short-term, but elastic in the long-term (Chambers & Just, 1981; Geyser & Cutts, 2007; Monk *et al.*, 2010).

2.9. Economic values in meat production

Economic value is defined as "*The worth of a good or service as determined by people's preferences and the trade-offs they choose to make given their scarce resources or the value the market places on an item*". Economic value is represented by the maximum amount a consumer is willing to pay for an item in a free market economy or the amount of time an individual would sacrifice waiting to obtain government-rationed goods in a socialist economy. In contrast, the market value represents the minimum amount a consumer would pay (Casey & Du Toit, 2015).

Dube *et al.* (2013) determined the economic value for different characteristics in pigs for improving genetic selection. The economic values are as seen in Table 2.2.

Table 2.2: Economic values for pork production

Characteristic	Economic value
Number of pigs born alive	61.26
21-day litter size	38.02
21-day litter weight	210.15
Average daily gain	33.34
Feed conversion ratio	-21.81
Age at slaughter	-68.18
Dressing percentage	5.78
Lean content	4.69
Backfat thickness	-1.48

(Dube *et al.,* 2013)

As the feed price increased, the economic value for number born alive, 21-day litter size, dressing percentage and lean content decreased. The dressing percentage and lean content increased as the marketing price for carcass increased, while the economic value for backfat thickness is not sensitive to change in price (Dube *et al.,* 2013).

Most economically essential carcass traits are not affected by season, but by gender. Backfat thickness and age at slaughter increased with increased total feed intake. Castrates produced high carcass yields at a lower quality than females (Dube *et al.*, 2011).

Table 2.3 represents the economic values for sheep production in R/SSU (rand per small stock unit). From this table, it could be observed that body weight, clean fleece weight, lambs born, and fibre diameter play a large role in the production system of sheep, and staple length, staple strength, wool quality and body condition play a smaller role.

Table 2.3: Economic values for sheep in R/SSU* (Van Graan *et al.*, 2014)

Characteristic	Economic value
Bodyweight	16.03
Clean fleece weight	58.91
Lambs born per 100 ewes mated	23.48
Fibre diameter	-5.56
Staple length	0,42
Staple strength	0.26
Wool quality	0.33
Body condition	1.21

*SSU: small stock unit (Van Graan *et al.*, 2014)

Table 2.4 represents the economic values for cattle dairy production system in R/LSU (rand per large stock unit). From this table, it could be observed that the amount of milk produced only plays a small role in the production of milk, and somatic cell score plays a large role.

Table 2.4: Economic values for cattle dairy production system in R/LSU*

Characteristic	Economic value
Milk fat (kg)	1.21
Milk protein (kg)	7.62
Milk (L)	0.28
Longevity (days)	1.15
Live weight (kg)	-7.49
Calving interval (days)	-4.19
Somatic cell score	-433.87

*LSU: Large stock unit (Banga *et al.*, 2011)

Table 2.5 represents the economic values for the beef production system. From this table, it could observe that the number of calves weaned plays a significant role in the production system, and weight and feed intake does not play a large role.

Table 2.5: Economic values for a beef production system (Kluyts *et al.*, 2003)

Characteristic	Economic value
Calves weaned	198.45
Carcass weight – Steers – Heifers – Cows	 0.486 0.160 0.013
Feed intake – Steers – Heifers – Cows	 -0.012 -0.012 -0.033

(Kluyts *et al.*, 2003)

2.10. South African red meat classification system

Pork classes

Pork carcass classes are determined by physiological stage or condition (sucking pig, sausage pig, rough), mass (≤20kg, 20.1 to ≤100kg), LM% (unspecified, ≥70% down to ≤61%) and fat thickness at the P2 position (unspecified, ≥1mm to ≤31mm) and designated “Sucking pig”, “Class P”, “Class O”, “Class R”, “Class C”, “Class U”, “Class S”, “Sausage pig” and “Rough” (SAMIC, 2020).

Sucking pigs are pigs weighing less than 20.1kg carcass weight, and sausage pigs weigh more than 100kg. If a pig carcass weight is between 20 and 100 kg, the carcass is classified according to the codes P, O, R, C, U and S. A pig carcass is classified as Rough. Suppose the carcass of specific conformation shows conspicuously poor breeding characteristics on appearance, such as it is emaciated. In that case, the skin appears visibly thick or rough, or the fat appears excessively oily. These descriptions are not very defined and leave it up to the judgement of the person doing the classification (SAMIC, 2020). Table 2.6 summarises by class the current South African classification system for pig carcasses.

Table 2.6: South African classification system for pork carcasses

Class	LM%	Fat thickness (mm)
Suckling pig	Not specified	Not specified
P	70 +	1 but not >12
O	68 but not >69	12 but not >17
R	66 but not >67	17 but not >22
C	64 but not >65	22 but not >27
U	62 but not >63	27 but not >32
S	61 and less	More than 32
Sausage pig	Not specified	Not specified
Rough	Not specified	Not specified

(SAMIC, 2020)

According to the regulation on classification and marketing of meat, the LM% of pork carcasses is calculated after fat thickness, and muscle thickness has been measured (except with the Intrascope). With the Intrascope, only the fat thickness is measured between the 2nd and 3rd ribs, 45 mm from the midline of the carcass in a hanging position. According to the same regulation, the conformation of pork is divided into five classes: 1 - very flat; 2 - flat; 3 - medium; 4 - round and 5 - very round. This conformation class is roller-marked in green on one side of the carcass (SAMIC, 2020).

The regulation on the classification and marketing of meat states that there are three damage classes each with its own colour stamp, the stamp is indicated near the damaged area. The classes and marks are as follows: 1 - slightly damaged (brown stamp); 2 - moderate damage (red stamp); 3 - severe damage (black stamp). If a carcass shows signs of masculinity, it is stamped with an MD in black on each side (SAMIC, 2020). Table 2.7 shows the roller mark information of the different pork classes.

Table 2.7: Roller mark of the different pork carcass classes in the South African classification system for pork carcass

Class	Mark	Colour	Position on carcass
Sucking pig	S	Purple	On forehead
P	P	Purple	On each side
O	O	Purple	On each side
R	R	Purple	On each side
C	C	Purple	On each side
U	U	Purple	On each side
S	S	Purple	On each side
Sausage pig	W	Purple	On each side
Rough	RU	Black	On each side

(SAMIC, 2020)

Although not indicated in the Act or its Regulations, the industry introduced mass classes in addition to the legislated classes. It seems the mass classes are not standardised. Pork is generally divided into two main categories, namely porker and baconer, where a porker is approximately 60kg and a baconer up to 90kg. Subdivision categories are a porker (<60kg), a light baconer (60-80kg), a heavy baconer (81-90kg), and a sausage pig (>90kg) (Eskort, 2020).

Beef, mutton and lamb classes

The beef, mutton and lamb carcass classes are based on physiological age and fatness of the animal. The number of erupted permanent incisors determines the physiological age of the animals. The carcasses are then further divided into conformation, damage (if applicable) and gender (where applicable) classes. There are four age classes, six fatness classes, five conformation classes and three damage classes in the classification system (SAMIC, 2020). Table 2.8 represents the beef, mutton and lamb classification system.

Table 2.8: Beef, lamb and mutton classification system

Age	**Class**
0 Teeth	A
1-2 Teeth	AB
3-6 Teeth	B
More than 6 Teeth	C
Fatness	**Class**
No Fat	0
Very lean	1
Lean	2
Medium	3
Fat	4
Slightly overfat	5
Excessively overfat	6
Conformation	**Class**
Very flat	1
Flat	2
Medium	3
Round	4
Very round	5
Damage	**Class**
Slight	1
Moderate	2
Severe	3
Sex	
The carcasses of a ram or a bull as well as castrated animals showing signs of late castration of the AB, B and C age classes, are identified and marked MD in black on each side	

(SAMIC, 2020)

Table 2.9 is a representation of the roller marking of the beef, mutton and lamb carcasses. The regulation on the classification and marketing of meat states that there are three damage classes each with its own colour stamp, the stamp is indicated near the damaged area. If a carcass shows signs of masculinity, it is stamped with an MD in black on each side (SAMIC, 2020)

Table 2.9: The roller mark according to the red meat classification system for beef, mutton and lamb

TRAIT	MARK	WHERE ON THE CARCASE
Age (A, AB, B, C)		One mark on each quarter of beef carcase.
Fatness* (0 to 6)	Eg. Class 3 	Only one mark on the carcase for lamb, sheep and goat carcasses.
Conformation (1 to 5)	Eg. Class 3 	One mark on each side of beef carcasses. No mark for lamb, sheep and goat carcasses.
Damage** (1 to 3)	<1> <2> <3>	Taking into account the area of damage, one mark on each side for beef carcasses. Only one mark on the carcase for lamb, sheep and goat carcasses.
Sex		One mark on each side of beef carcasses. Only one mark on the carcase for lamb, sheep and goat carcasses.

* In case of a sheep carcass with a fat tail, a double impression of the mark

** Damage, if it occurs, is indicated on a scale of one to three for the areas concern, with is B (buttock), L (loin) and F (forequarter) (SAMIC, 2020)

CHAPTER 3:
MATERIALS AND METHODS

3.1. Materials

Data comprising 259 sets was obtained via the Red Meat Abattoirs Association (RMAA) for the period 2013 to 2017. The data was collected from abattoirs that voluntarily sent their information to the RMAA (RMAA, 2020). This data consisted of weekly data from the abattoirs on the number of carcasses bought, average mass, average purchase price, average selling price, and minimum and maximum selling price of each carcass class (pork, beef and sheep). The following variables were used for pork, sheep and beef carcasses: the number of carcasses bought, average purchase price and average mass per carcass price. The tonnage of meat was calculated by multiplying the average purchase price with the total number of carcasses bought for the specific red meat type.

Since the number of abattoirs that supplied data over the period 2013 to 2017 fluctuated, the observed values, for example, the average mass of carcasses bought, also varied. Calculating moving averages for the various time series did not present smoother trends. Hence the weekly data was summarised by computing averages across every four non-overlapping weeks. This resulted in 65 observations per variable.

Data were also collected for hide prices from the feedlot, hide prices from veldt cattle, wool prices as well as bales of wool. The wool data, comprising of 161 sets, were obtained from Cape Wools South Africa (Capewools, 2020). The carcass data, including hide prices, are available from RMAA (RMAA, 2020).

For the purpose of the study, the carcass classification system, according to South Africa regulations was used for beef and sheep. With pork, the carcass classes according to the regulations as well as the use-categories within class what the industry unofficially uses were used. For pork in the text, the Baconer use-category is indicated as B and Porker use-category as P at the beginning of the acronym.

AWEX maintains a series of benchmark Australian Wool Market Indicators. These are based on fixed baskets of wool types, calculated each sale day and released via a series of subscription reports. The Indicators are economic expressions relating to the current and previous levels of the wool market. Some AWEX Indicators are used as the basis for derivative wool market trading. The primary Wool Market Indicator is the AWEX Eastern Market Indicator (AWEX-EMI), with support by three Regional Market Indicators (RMI-North, South and West). A series of sub Indicators known as Micron Price Guides (MPG's) are also published for each regional sale day. All Indicators are expressed in Australian cents per clean kilogram (AWEX, 2020).

No significant differences are indicated in the text as NS and standard deviations as SD.

3.2. Data used

The following tables show the data used for the statistical analysis (Table 3.1 to 3.6).

Table 3.1: The total number of red meat carcasses bought by abattoirs (2013 to 2017)

	Quarter	Pork	Beef	Sheep	Total
2013	**1**	91625	76113	335194	502932
	2	81643	79095	334446	495184
	3	92812	84025	159198	336035
	4	79047	91922	87299	258268
	All	345127	331155	916137	1592419
2014	**1**	85264	85240	133877	304381
	2	93134	87012	152110	332256
	3	97345	81889	120505	299739
	4	82636	87967	153909	324512
	All	358379	342108	560401	1260888
2015	**1**	89680	74707	96104	260491
	2	95585	73635	94048	263268
	3	89135	134570	164777	388482
	4	101478	193501	289260	584239
	All	375818	563098	776373	1715289
2016	**1**	120031	190127	219122	529280
	2	119353	220248	240891	580492
	3	141022	222954	208480	572456
	4	126524	207387	192432	526344
	All	506930	840716	860926	2208572
2017	**1**	173451	196680	208863	578994
	2	147293	177586	201910	526789
	3	145530	193622	192983	532135
	4	153938	215440	226812	596190
	All	620212	783328	830568	2234108
2013 – 2017	**All**	2206466	2860405	3944405	9011276
	%	24.49	31.74	43.77	100

(Modified from RMAA, 2020)

Table 3.2: The total number of pork carcass classes bought by abattoirs per quarter (2013 to 2017)

	Quarter	BP	BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC
2013	**1**	44016	28235	4028	152	17	707	1590	11300	1510	50	20
	2	39474	27559	2497	151	31	509	1849	8945	542	59	27
	3	44125	31148	5014	409	35	500	1335	8859	1132	206	49
	4	38713	27440	3993	229	62	488	870	6624	408	121	99
	All	166328	114382	15532	941	145	2204	5644	35728	3592	436	195
2014	**1**	41285	29709	5492	208	41	450	1276	6113	540	108	42
	2	39306	31565	7420	760	73	318	2287	10761	522	97	25
	3	41289	37107	8207	815	91	532	2585	6052	624	29	14
	4	39264	30338	5204	476	67	277	1814	4571	471	110	44
	All	161144	128719	26323	2259	272	1577	7962	27497	2157	344	125
2015	**1**	48749	25422	4579	317	61	526	1269	8146	371	129	111
	2	49143	28589	4320	404	104	276	3035	9058	535	60	61
	3	45369	31548	4411	381	60	305	2528	4192	209	72	60
	4	54479	29962	3280	315	69	157	2737	8699	1504	200	76
	All	152371	129342	43727	5447	615	1019	7346	28431	6602	598	320
2016	**1**	66914	28365	3426	378	64	46	3199	14792	2273	505	68
	2	65999	30854	3673	295	138	55	4534	12021	1495	237	52
	3	75642	26548	3173	366	77	20	8880	24389	1684	201	42
	4	68981	29937	3903	422	97	29	5534	15779	1518	254	71
	All	277536	115704	14175	1461	376	150	22147	66981	6970	1197	233
2017	**1**	91334	34592	3212	325	77	123	6457	34112	2843	317	59
	2	78572	27577	2782	278	53	93	6723	28872	1842	353	148
	3	81609	24806	2570	369	96	70	10068	24051	1507	300	84
	4	85759	29125	2715	374	90	82	9137	24749	1482	310	115
	All	337274	116100	11279	1346	316	368	32385	111784	7674	1280	406
2013 – 2017	**All**	1094653	604247	111036	11454	1724	5318	75484	270421	26995	3855	1279
	%	49.61	27.39	5.03	0.52	0.08	0.24	3.42	12.26	1.22	0.17	0.06

(Modified from RMAA, 2020)

Table 3.3: The total number of beef carcass classes bought by abattoirs per class (2013 to 2017)

	Quarter	A2	A3	AB2	AB3	B2	B3	C2	C3
2013	**1**	49606	8737	3226	710	2244	424	9073	2093
	2	49804	10131	3229	825	2570	593	9595	2348
	3	55831	8962	3272	758	2633	612	9542	2415
	4	64918	9150	3473	828	2585	412	8610	1946
	All	220159	36980	13200	3121	10032	2041	36820	8802
2014	**1**	57082	7902	3868	729	2963	436	10016	2244
	2	52879	11902	3430	805	3446	644	11334	2572
	3	55174	9363	3036	534	2758	383	9170	1471
	4	59373	11345	2676	362	3026	434	8966	1785
	All	224508	40512	13010	2430	12193	1897	39486	8072
2015	**1**	48331	9586	2674	492	2988	779	7807	2050
	2	49056	10305	2806	508	2431	471	6414	1644
	3	97036	14708	4922	828	3868	694	10064	2450
	4	145377	17781	6491	1002	4468	612	15086	2684
	All	331899	134708	26679	6924	10715	5730	30001	16442
2016	**1**	131088	20488	6513	1218	5189	740	20484	4407
	2	139856	24730	8570	1600	7541	1500	28313	8138
	3	152231	22304	6594	1386	6681	1315	24943	7500
	4	143767	21155	6712	1201	6012	1102	21620	5819
	All	566942	88677	28389	5405	25423	4657	95360	25864
2017	**1**	141313	15716	6566	1104	4571	951	20481	5978
	2	115659	16509	7972	1600	5723	1294	22260	6569
	3	131455	14441	9360	1763	7129	2032	19535	7907
	4	151920	16959	12419	2252	7747	2020	16242	5881
	All	540347	63625	36317	6719	25170	6297	78518	26335
2013 – 2017	**All**	1883855	364502	117595	24599	83533	20622	280185	85515
	%	65.86	12.74	4.11	0.86	2.92	0.72	9.80	2.99

(Modified from RMAA, 2020)

Table 3.4: The total number of sheep carcass classes bought by abattoirs per class (2013 to 2017)

	Quarter	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3
2013	1	2849	19946	205987	39418	11229	3440	5898	5192	710	4626	733	29496	5670
	2	1924	14831	206763	47650	9494	2383	4662	4936	661	6094	966	28648	5434
	3	923	6306	98478	23595	5588	1594	2623	3179	574	2857	749	9737	2995
	4	610	4664	55312	12071	1363	484	714	1386	236	1329	254	7071	1805
	All	6306	45747	566540	122734	27674	7901	13897	14693	2181	14906	2702	74952	15904
2014	1	1654	6710	92836	12798	1971	480	965	1920	296	2032	330	9989	1896
	2	1570	6503	99726	21107	4053	881	1923	1392	242	1380	427	10287	2619
	3	3257	8539	84441	10411	1128	195	513	1877	216	2262	425	6349	892
	4	5633	15148	99835	14069	1386	123	630	2117	275	2405	338	10563	1387
	All	12114	36900	376838	58385	8538	1679	4031	7306	1029	8079	1520	37188	6794
2015	1	2687	7913	64550	8990	667	167	310	1446	120	1100	201	6891	1062
	2	1798	5372	65589	7509	739	101	488	1609	106	1399	357	7128	1853
	3	2429	10063	106307	21677	4449	1174	1865	2227	690	2168	539	8803	2386
	4	4688	19716	181424	39244	8443	2224	2821	4528	1059	2827	926	16877	4483
	All	143743	35430	321626	162050	31526	6941	4793	9448	3512	6016	3652	31435	16201
2016	1	3145	13799	141281	27428	4745	955	1325	3438	655	2426	478	15608	3839
	2	1977	9803	157036	33731	6142	1347	1985	2746	671	3139	753	16635	4926
	3	3034	11662	137424	26649	5450	1414	2278	2464	601	3376	960	9766	3402
	4	3565	12867	126895	23659	4098	950	1184	2525	625	2246	669	9961	3188
	All	11721	48131	562636	111467	20435	4666	6772	11173	2552	11187	2860	51970	15355
2017	1	3026	19703	132783	23664	4206	855	1427	2327	663	2574	737	13408	3602
	2	3188	15227	134528	20641	3690	740	1096	2236	422	2641	796	13096	3609
	3	3018	13548	128220	17913	3587	754	782	3472	494	4125	938	12799	3333
	4	1888	12189	151863	26862	4928	743	777	2815	619	4017	1007	15198	2902
	All	11120	60667	547394	89080	16411	3092	4082	10850	2198	13357	3478	54501	13446
2013 – 2017	All	185004	226875	2375034	543716	104584	24279	33575	53470	11472	53545	14212	250046	67700
	%	4.69	5.75	60.23	13.79	2.65	0.62	0.85	1.36	0.29	1.36	0.36	6.34	1.72

(Modified from RMAA, 2020)

Table 3.5: The average number of hides as well as the average price of hide from feedlot and veldt animals (2013 to 2017)

	Quarter	Number of hides	Feedlot (R/kg) (mean ± SD)	Veldt (R/kg) (mean ± SD)
2013	**1**	76113	11.91 ± 0.58	11.88 ± 0.75
	2	79095	13.71 ± 0.28	13.74 ± 0.32
	3	84025	14.63 ± 0.46	14.56 ± 0.40
	4	91922	15.92 ± 0.39	15.85 ± 0.48
	All	331155	14.00 ± 1.53	13.97 ± 1.53
2014	**1**	85240	17.21 ± 0.64	17.12 ± 0.55
	2	87012	18.84 ± 0.11	18.66 ± 0.18
	3	81889	18.49 ± 0.16	18.31 ± 0.18
	4	87967	18.73 ± 0.12	18.61 ± 0.16
	All	342108	18.32 ± 4.18	18.17 ± 4.14
2015	**1**	74707	18.24 ± 0.10	18.20 ± 0.13
	2	73635	18.31 ± 0.13	18.20 ± 0.18
	3	134570	15.45 ± 1.83	15.18 ± 1.85
	4	193501	13.02 ± 0.63	12.95 ± 0.69
	All	563098	16.52 ± 2.54	16.20 ± 2.41
2016	**1**	190127	13.67 ± 0.53	13.58 ± 0.53
	2	220248	14.91 ± 0.44	14.82 ± 0.45
	3	222954	15.44 ± 0.09	15.40 ± 0.11
	4	207387	15.83 ± 0.20	15.72 ± 0.17
	All	840716	14.96 ± 3.35	14.88 ± 3.34
2017	**1**	173451	15.64 ± 0.33	15.60 ± 0.34
	2	147293	15.46 ± 0.12	15.41 ± 0.17
	3	145530	14.48 ± 0.65	14.52 ± 0.61
	4	153938	12.50 ± 0.22	12.65 ± 0.35
	All	620212	14.52 ± 1.31	14.47 ± 1.26
2013 – 2017	**All**	2206466	15.62 ± 2.15	15.55 ± 2.12

(Modified from RMAA, 2020)

Table 3.6: The average number of wool sold as well as the average wool price (2013 to 2017)

	Quarter	SA c/kg (mean ± SD)	US c/kg (mean ± SD)	Euro c/kg (mean ± SD)	AWEX EMI (mean ± SD)	# bales SA (mean ± SD)
2013	**1**	11234.50 ± 198.41	1260.50 ± 25.83	954.40 ± 11.85	1110.10 ± 21.54	10986 ± 3472
	2	10398.00 ± 407.07	1123.00 ± 13.31	859.83 ± 11.84	1015.83 ± 30.93	9384 ± 3648
	3	11040.20 ± 524.55	1103.60 ± 56.93	828.00 ± 45.00	1083.00 ± 45.86	9328 ± 3551
	4	11467.64 ± 217.86	1136.45 ± 22.73	836.36 ± 17.30	1006.64 ± 334.11	10375 ± 2450
	All	11127.44 ± 487.80	1167.56 ± 70.58	876.34 ± 58.17	1052.63 ± 196.97	10217 ± 3110
2014	**1**	11579.40 ± 344.96	1066.80 ± 24.29	779.60 ± 21.81	1089.10 ± 35.34	10391 ± 3359
	2	11108.00 ± 505.88	1058.80 ± 47.81	766.80 ± 32.68	1017.40 ± 24.59	8142 ± 2602
	3	11380.80 ± 145.19	1047.20 ± 9.98	803.20 ± 9.55	1016.20 ± 9.96	9945 ± 3273
	4	11197.18 ± 249.77	1007.27 ± 20.98	802.00 ± 12.18	1042.36 ± 10.37	9737 ± 2182
	All	11335.71 ± 3198.45	1041.23 ± 294.61	789.29 ± 222.21	1049.19 ± 285.13	9724 ± 3290
2015	**1**	11067.20 ± 141.33	948.10 ± 14.81	838.30 ± 17.27	1079.30 ± 17.33	10092 ± 3147
	2	12607.83 ± 1075.12	1047.00 ± 85.55	956.00 ± 62.50	1214.33 ± 85.38	8218 ± 2163
	3	12919.00 ± 569.69	983.43 ± 79.64	879.71 ± 69.81	1275.57 ± 47.50	7191 ± 2260
	4	13095.00 ± 704.93	941.18 ± 25.66	858.82 ± 45.60	1224.82 ± 26.54	9991 ± 1914
	All	12235.70 ± 1135.71	3427.91 ± 4911.60	895.59 ± 78.75	1109.12 ± 142.10	7914 ± 4094
2016	**1**	15636.82 ± 331.47	983.45 ± 20.93	892.55 ± 14.95	1266.55 ± 23.47	9697 ± 3139
	2	15463.00 ± 608.60	1030.83 ± 4.54	910.00 ± 7.07	1264.83 ± 28.42	8306 ± 2068
	3	14873.67 ± 445.35	1080.00 ± 12.12	963.67 ± 6.03	1297.33 ± 12.01	7143 ± 539
	4	15068.00 ± 457.15	1087.33 ± 15.72	1000.00 ± 28.95	1321.67 ± 29.23	11006 ± 2504
	All	15345.38 ± 4439.21	1035.48 ± 862.96	936.86 ± 275.71	1286.48 ± 369.13	9551 ± 3257
2017	**1**	14856.17 ± 4202.88	1214.08 ± 46.44	1137.83 ± 42.01	1467.75 ± 52.47	9438 ± 2781
	2	15988.86 ± 504.34	1208.14 ± 22.97	1102.71 ± 40.43	1488.14 ± 33.60	8923 ± 2763
	3	17769.33 ± 385.75	1345.50 ± 26.99	1135.17 ± 29.26	1549.83 ± 30.41	8816 ± 3232
	4	18748.90 ± 673.11	1356.50 ± 24.65	1155.00 ± 23.69	1622.00 ± 61.07	10705 ± 1988
	All	16694.31 ± 2939.74	1276.11 ± 78.22	1135.26 ± 38.33	1529.97 ± 80.62	9590 ± 2646
2013 – 2017	**All**	13401.24 ± 2707.79	1101.45 ± 128.26	926.32 ± 128.89	1227.00 ± 210.13	9637 ± 2783

(modified from Capewools, 2020)

3.3. Analysis of data

Data were analysed employing SAS® (Version 9.4). Pearson's R correlations were performed for red meat carcass type, the carcass classes within and between type, hide prices and wool (c/kg). Each red meat carcass type (pork, beef and sheep) was compared in terms of tonnage of meat, the average number of carcasses bought by abattoirs, the average mass of carcasses bought by abattoirs (kg), and the average purchase price of carcasses bought by abattoirs (R/kg) of pork, beef and sheep. The average red meat carcass purchase prices

were then compared in terms of the tonnage of meat, the average number of carcasses bought by abattoirs, average mass of carcasses bought by abattoirs (kg), and the average purchase price of carcasses bought by abattoirs (R/kg) of each carcass class. A 95% confidence level was set for the correlations.

Correlations were also calculated for the tonnage of meat, the average number of carcasses bought by abattoirs, the average mass of carcasses bought by abattoirs (kg), and the average purchase price of carcasses bought by abattoirs (R/kg) for pork, beef and sheep carcasses compared to red meat products (feedlot hide price, veldt hide price, SA wool price, US wool price, European wool price and Australian wool price). A 95% confidence level was set for the correlations.

The following model was used for the correlation:

$P_{x,y} = \text{cov}(x,y)/ \sigma_x \sigma_y$;

where;

- $P_{x,y}$ is the correlation coefficient
- cov(x,y) the two variables compared
- $\sigma_{x,}$ σ_y are the standard deviations of the variables.

Linear regressions were determined with a 95% confidence level. For each type of red meat carcass (pork, beef and sheep) and the average purchase price as compared to the tonnage of meat and the average purchase price of carcasses (R/kg) for pork, beef and sheep carcasses and carcass class.

The multivariate linear regression model for each of the variables was as follows:

$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} \ldots \beta_p x_{ip}$ for p = 1, 2, …, n;

where;

- yi is the dependent variable
- xip the independent variable
- β1, β2, … βp the applicable partial regression coefficient of the variable
- β0 the intercept.

Because of the small sample size (n=65), the regression models were performed on one or two explanatory variables at a time. For example, a regression analysis was performed on the average purchase price of pork (dependent variable) and tonnage (explanatory variable) of pork per carcass class to determine which carcass classes affected the average purchase price of pork. Similar regression models were fitted with the tonnage of beef and mutton and lamb (sheep) as explanatory variables and the average purchase price of pork as the dependent variable. The tonnage of carcass classes that showed significant parameter estimates according to these three regression models was then combined in one regression model with the average purchase price of pork as the dependent variable. The tonnage of the carcass classes with the highest p-values associated with its parameter estimates was then systematically removed from the regression model until the model included only explanatory variables with parameter estimates significant at the 5% level.

The influence of tonnage of pork, beef, lamb and mutton (sheep) per carcass class on the average purchase prices of pork, beef, mutton and lamb (sheep) respectively were analysed similarly. This process was followed in all the regression analyses for different explanatory variables.

The third set of regression analysis addressed the relationship between each red meat carcasses average purchase price with red meat products (feedlot hide price, veldt hide price,

SA wool price, US wool price, European wool price and Australian wool price). The data was sourced at Cape Wool SA and AWEX-EMI over the review period.

Ethical approval reference EC160519-31 was granted for the use of internal and external datasets in research with the RMAA and South African Pork Producer Organisation (SAPPO) as respondents.

CHAPTER 4:
RESULTS AND DISCUSSION: RED MEAT CARCASSES BOUGHT BY ABATTOIRS

Internationally and nationally, the consumption and production of meat are increasing. The general trend for red meat per year per capita consumption decreased from the 1970s until the late 1990s, and subsequently, meat consumption moved sideways from the late 1990s to 2001. Between 2001 and 2006, consumption trends from beef and lamb were upwards, but downwards for pork. The per capita consumption of beef declined steadily until 2000/1, which is largely attributed to high red meat prices in comparison with white meat prices during the period. On the other hand, the per capita consumption of beef increased consistently from 2001/2002 until 2005/2006. The demand for meat worldwide is expected to increase. The increase in demand would mainly increase in developing countries (Labuschagne *et al.*, 2011).

4.1. The tonnage of red meat bought by abattoirs during the period 2013 to 2017

Table 4.1, Figure 4.1 and Figure 4.2 demonstrate the tonnage of red meat carcasses bought by abattoirs in the period 2013 to 2017, as expected, during this period the beef carcass had the highest average tonnage of meat bought by abattoirs (2,877.86 ± 1321) followed by pork carcasses (669.54 ± 497) then the lowest tonnage of red meat bought by abattoirs was sheep carcasses (320.91 ± 142). This was due to the differences in demand of the different red meat carcasses and their respective mass (Labuschagne *et al.* 2011). With the mass of the carcasses playing the main role in the different tonnages, as discussed later, beef carcasses were the heaviest and sheep carcasses the lightest. The coefficient of variation for pork carcasses (74%) was the highest followed by beef (46%), and the lowest coefficient of variance occurred with sheep carcasses (44%). The coefficient of variance for pork carcass was mainly due to a sudden increase of pork carcasses bought by the abattoirs in the first quarter of 2017, more pork carcasses were sold to the abattoir as a result of a high purchase price during the quarter.

Table 4.1: The tonnage of meat from the different red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	Pork (mean ± SD)	Beef (mean ± SD)	Sheep (mean ± SD)
2013	**1**	537.35 ± 57.19	1595.94 ± 265.73	539.27 ± 149.73
	2	472.14 ± 114.80	1678.71 ± 247.27	538.18 ± 136.96
	3	540.38 ± 61.25	1819.01 ± 327.43	265.76 ± 33.96
	4	494.08 ± 50.60	2104.86 ± 340.57	163.53 ± 54.51
	All	511.32 ± 79.23	1793.65 ± 346.24	380.86 ± 196.35
2014	**1**	494.12 ± 81.98	1751.66 ± 204.56	214.06 ± 81.78
	2	530.05 ± 106.18	1763.37 ± 160.03	249.15 ± 73.79
	3	561.35 ± 44.32	1681.14 ± 341.65	214.15 ± 126.81
	4	480.20 ± 54.57	1813.97 ± 202.01	265.51 ± 49.55
	All	516.43 ± 80.13	1752.53 ± 235.01	235.72 ± 87.90
2015	**1**	522.35 ± 42.99	1496.86 ± 310.09	161.39 ± 45.92
	2	544.33 ± 26.62	1487.98 ± 283.05	155.95 ± 19.55
	3	502.83 ± 45.20	2808.77 ± 730.07	267.87 ± 39.38
	4	581.56 ± 90.23	3997.25 ± 648.24	468.68 ± 213.76
	All	537.77 ± 62.20	2447.72 ± 1173.15	263.47 ± 167.46
2016	**1**	690.03 ± 211.89	3907.85 ± 570.93	357.26 ± 58.97
	2	672.14 ± 146.43	4565.10 ± 453.67	400.83 ± 96.64
	3	793.48 ± 122.27	4673.65 ± 727.29	368.92 ± 94.06
	4	713.85 ± 74.16	4310.54 ± 143.67	326.42 ± 52.59
	All	717.37 ± 150.38	4364.29 ± 585.62	363.36 ± 80.44
2017	**1**	1682.73 ± 1878.55	3992.24 ± 588.08	352.68 ± 74.40
	2	881.02 ± 219.89	3494.38 ± 805.57	353.24 ± 62.49
	3	824.43 ± 68.86	4023.68 ± 479.81	341.78 ± 49.61
	4	858.89 ± 195.74	4530.73 ± 1119.37	401.38 ± 81.97
	All	1061.77 ± 991.62	4010.26 ± 848.57	362.27 ± 70.16
2013 – 2017	**All**	669.54 ± 496.73	2877.86 ± 1320.99	320.91 ± 142.62

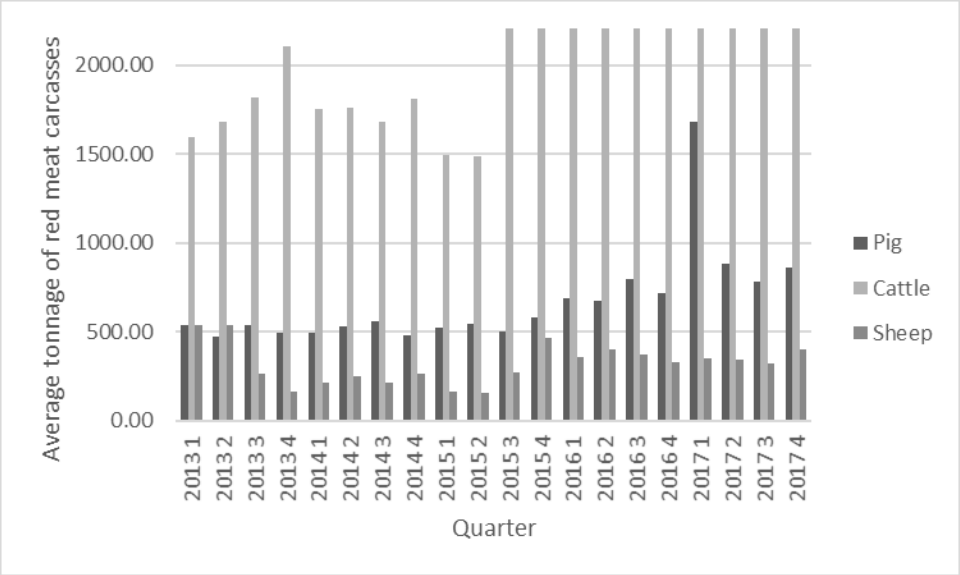

Figure 4.1: The average tonnage of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

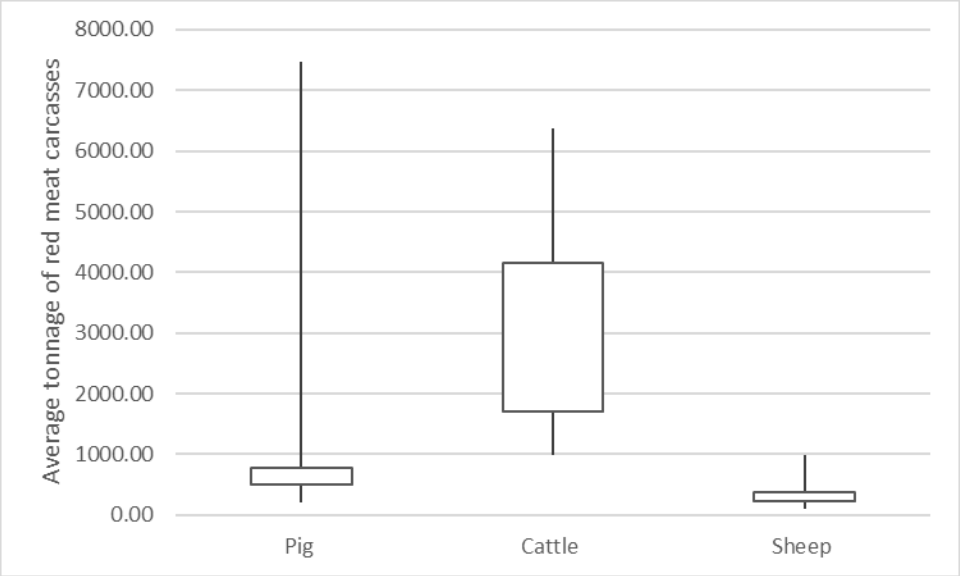

Figure 4.2: The average tonnage of red meat carcasses bought by abattoirs for the period 2013 to 2017

Table 4.2, Figure 4.3 and Figure 4.4 illustrate the tonnage of different pork carcass classes bought by abattoirs in the period 2013 to 2017. During this period BP pork class had the highest average tonnage of meat bought by abattoirs (327.13 ± 108.2), and PC pork class had the lowest tonnage of meat bought by abattoirs (0.24 ± 0.3). As with the different red meat carcasses, the supply of pork carcass class would affect the tonnage, and the different masses also play a role. In this case, the supply of the specific carcass class plays a larger role than the mass of the carcasses (as discussed later).

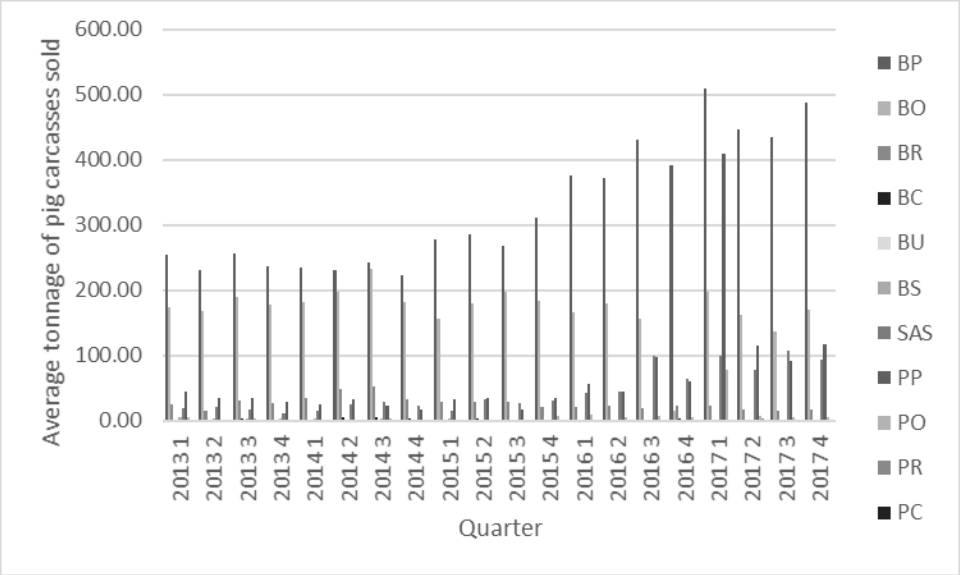

Figure 4.3: The average tonnage of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

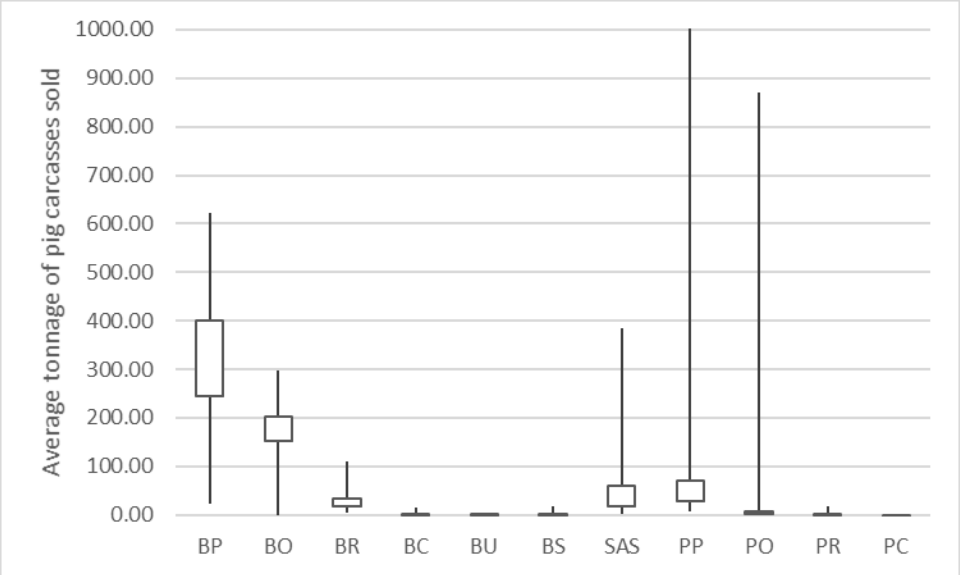

Figure 4.4: The average tonnage of pork carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.2: The average tonnage of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	BP (mean ± SD)	BO (mean ± SD)	BR (mean ± SD)	BC (mean ± SD)	BU (mean ± SD)	BS (mean ± SD)	SAS (mean ± SD)	PP (mean ± SD)	PO (mean ± SD)	PR (mean ± SD)	PC (mean ± SD)
2013	1	254.49 ± 30.05	173.02 ± 22.91	25.27 ± 11.11	0.95 ± 0.79	0.10 ± 0.04	5.46 ± 4.99	19.08 ± 6.32	44.27 ± 9.44	6.12 ± 4.84	0.18 ± 0.16	0.07 ± 0.03
	2	231.55 ± 82.27	169.00 ± 20.54	15.78 ± 3.67	0.93 ± 0.62	0.19 ± 0.08	3.51 ± 1.95	20.64 ± 8.70	34.96 ± 6.85	2.08 ± 1.84	0.22 ± 0.13	0.10 ± 0.10
	3	256.62 ± 46.79	190.13 ± 32.70	31.34 ± 24.47	2.58 ± 4.10	0.21 ± 0.21	3.42 ± 1.67	16.00 ± 4.41	35.17 ± 8.47	4.18 ± 4.30	0.77 ± 0.80	0.18 ± 0.10
	4	237.23 ± 19.17	178.70 ± 25.16	26.28 ± 7.25	1.50 ± 1.08	0.39 ± 0.43	3.61 ± 2.32	11.64 ± 6.62	27.81 ± 6.76	1.62 ± 0.82	0.47 ± 0.29	0.41 ± 0.31
	All	245.12 ± 50.67	177.70 ± 26.25	24.64 ± 14.86	1.49 ± 2.24	0.22 ± 0.25	4.01 ± 3.08	16.94 ± 7.33	35.71 ± 9.70	3.54 ± 3.78	0.41 ± 0.49	0.19 ± 0.21
2014	1	234.58 ± 41.24	181.07 ± 32.15	35.04 ± 8.52	1.27 ± 0.53	0.23 ± 0.11	3.10 ± 2.42	15.57 ± 8.56	24.06 ± 5.38	2.00 ± 1.13	0.39 ± 0.31	0.14 ± 0.07
	2	230.57 ± 33.93	197.02 ± 21.69	48.25 ± 11.98	4.58 ± 2.04	0.41 ± 0.36	1.94 ± 2.20	25.54 ± 9.70	33.13 ± 22.34	1.98 ± 1.14	0.36 ± 0.26	0.09 ± 0.02
	3	243.60 ± 21.19	233.05 ± 21.55	52.84 ± 12.17	4.66 ± 2.65	0.56 ± 0.88	3.66 ± 4.30	28.33 ± 11.61	23.48 ± 4.21	2.39 ± 1.54	0.11 ± 0.18	0.05 ± 0.02
	4	223.80 ± 18.23	181.73 ± 35.31	32.54 ± 10.32	2.67 ± 1.87	0.40 ± 0.33	1.92 ± 2.55	22.70 ± 7.77	17.65 ± 4.75	1.82 ± 1.36	0.42 ± 0.65	0.15 ± 0.29
	All	233.14 ± 30.12	198.22 ± 34.79	42.17 ± 13.63	3.29 ± 2.36	0.40 ± 0.51	2.65 ± 3.00	23.03 ± 10.41	24.58 ± 12.84	2.05 ± 1.28	0.32 ± 0.40	0.11 ± 0.15
2015	1	277.62 ± 24.91	156.42 ± 28.37	29.25 ± 9.92	1.87 ± 0.99	0.35 ± 0.28	3.58 ± 3.46	15.65 ± 6.46	31.99 ± 7.02	1.45 ± 0.56	0.46 ± 0.36	0.40 ± 0.58
	2	286.60 ± 19.13	179.29 ± 14.01	27.95 ± 5.33	2.34 ± 0.43	0.57 ± 0.23	1.87 ± 1.80	33.38 ± 7.62	35.34 ± 6.10	2.07 ± 0.59	0.21 ± 0.19	0.23 ± 0.62
	3	268.51 ± 28.63	197.95 ± 28.13	27.94 ± 6.25	2.08 ± 1.20	0.35 ± 0.21	2.05 ± 2.43	26.88 ± 6.44	16.11 ± 9.59	0.82 ± 0.57	0.27 ± 0.15	0.21 ± 0.19
	4	311.84 ± 52.01	183.18 ± 43.91	20.81 ± 7.94	1.78 ± 0.83	0.40 ± 0.33	1.12 ± 1.57	31.13 ± 7.89	35.23 ± 27.28	6.67 ± 9.70	0.88 ± 1.69	0.33 ± 0.58
	All	292.02 ± 36.44	196.85 ± 33.18	68.99 ± 8.07	8.48 ± 0.91	0.85 ± 0.28	1.73 ± 2.52	20.55 ± 9.77	32.36 ± 16.78	6.57 ± 5.27	0.59 ± 0.88	0.31 ± 0.51
2016	1	376.26 ± 102.00	166.42 ± 80.91	19.95 ± 10.33	2.21 ± 1.17	0.37 ± 0.22	0.26 ± 0.18	42.41 ± 23.02	56.26 ± 9.40	8.74 ± 5.40	1.86 ± 2.66	0.27 ± 0.35
	2	372.72 ± 77.67	180.36 ± 58.02	22.78 ± 9.79	1.73 ± 0.42	0.82 ± 1.21	0.32 ± 0.37	44.63 ± 20.26	44.47 ± 9.81	5.38 ± 2.57	1.03 ± 0.79	0.18 ± 0.19
	3	431.27 ± 53.31	155.74 ± 54.00	18.63 ± 7.35	2.14 ± 1.79	0.44 ± 0.26	0.12 ± 0.14	98.79 ± 32.02	97.65 ± 30.99	6.46 ± 3.79	0.74 ± 0.30	0.16 ± 0.10
	4	392.52 ± 35.23	14.42 ± 4.34	23.57 ± 0.44	2.40 ± 0.04	0.55 ± 0.14	0.18 ± 0.04	63.46 ± 10.27	61.03 ± 18.82	5.91 ± 0.46	1.03 ± 0.08	0.26 ± 0.02
	All	393.19 ± 73.33	129.24 ± 87.07	21.23 ± 8.03	2.12 ± 1.08	0.55 ± 0.64	0.22 ± 0.23	62.32 ± 31.74	64.85 ± 27.49	6.62 ± 3.68	1.16 ± 1.42	0.21 ± 0.21
2017	1	508.88 ± 50.99	197.66 ± 25.57	22.16 ± 12.83	1.82 ± 0.92	0.42 ± 0.2	0.73 ± 1.08	99.93 ± 92.55	408.6 ± 964.3	78.78 ± 237.67	1.2 ± 0.87	0.22 ± 0.12
	2	445.97 ± 62.48	162.3 ± 21.44	16.13 ± 3.42	1.55 ± 0.91	0.3 ± 0.23	0.58 ± 0.36	78.2 ± 21.91	114.98 ± 13.27	7.11 ± 1.58	2.59 ± 4.55	0.54 ± 0.61
	3	435.52 ± 119.33	137.05 ± 39.73	14.65 ± 6.08	2.13 ± 0.58	0.57 ± 0.33	0.47 ± 0.37	106.38 ± 44.87	91.22 ± 31.09	5.64 ± 1.98	1.4 ± 1.05	0.35 ± 0.12
	4	488.47 ± 90.67	170.65 ± 52.25	16.31 ± 6.98	2.17 ± 0.83	0.52 ± 0.42	0.49 ± 0.38	93.95 ± 35.26	117.64 ± 86.68	5.62 ± 2.88	1.17 ± 0.61	0.43 ± 0.31
	All	476.47 ± 67.09	169.11 ± 36.77	17.48 ± 8.17	1.92 ± 0.83	0.45 ± 0.32	0.57 ± 0.62	95.06 ± 54.32	185.45 ± 487.54	24.4 ± 119.57	1.53 ± 2.36	0.39 ± 0.36
2013 – 2017	All	327.13 ± 108.24	170.67 ± 53.67	26.41 ± 13.8	2.17 ± 1.72	0.41 ± 0.44	1.91 ± 2.62	44.93 ± 41.46	68.18 ± 225.62	7.9 ± 53.94	0.78 ± 1.4	0.24 ± 0.33

Table 4.3, Figure 4.5 and Figure 4.6 show the tonnage of beef carcass classes bought by abattoirs in the period 2013 to 2017. During this period the A2 beef carcass class had the highest average tonnage of meat bought by abattoirs (1,889.22 ± 927.08), and the B3 beef carcass class had the lowest tonnage of meat bought by abattoirs (19.11 ± 13.79). As with the different pork carcass classes, the supply of the beef carcass class would affect the tonnage, and the different masses play a role. The supply for a specific carcass class played a more substantial part than the mass of the carcass classes (as discussed later).

Table 4.3: The average tonnage of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A2 (mean ± SD)	A3 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	987.52 ± 190.30	186.11 ± 43.64	63.87 ± 18.35	16.12 ± 6.92	42.25 ± 13.97	9.80 ± 5.41	175.91 ± 49.12	46.62 ± 15.50
	2	1000.39 ± 149.35	218.00 ± 38.63	65.73 ± 18.62	19.22 ± 6.96	50.69 ± 12.46	13.57 ± 3.55	187.15 ± 34.99	53.78 ± 13.26
	3	1131.27 ± 194.95	196.50 ± 34.61	70.02 ± 20.89	18.04 ± 9.10	54.37 ± 12.36	13.66 ± 6.19	187.60 ± 47.99	56.15 ± 14.90
	4	1376.12 ± 300.72	209.65 ± 65.90	76.95 ± 14.43	20.59 ± 5.40	54.74 ± 13.58	10.23 ± 4.57	185.51 ± 36.64	49.47 ± 24.69
	All	1118.88 ± 259.07	202.43 ± 47.03	68.99 ± 18.43	18.45 ± 7.22	50.43 ± 13.69	11.85 ± 5.22	184.01 ± 41.77	51.55 ± 17.36
2014	1	1130.26 ± 168.88	162.13 ± 36.54	75.68 ± 13.03	16.53 ± 9.81	54.89 ± 12.39	9.84 ± 5.23	189.25 ± 54.19	48.93 ± 22.35
	2	1038.68 ± 124.78	242.78 ± 43.91	65.48 ± 19.48	18.07 ± 4.28	64.35 ± 11.21	13.97 ± 3.60	212.41 ± 19.71	55.64 ± 13.23
	3	1088.26 ± 343.73	182.37 ± 40.75	59.64 ± 19.23	12.15 ± 6.01	51.59 ± 11.14	8.48 ± 4.04	176.26 ± 40.10	32.97 ± 9.72
	4	1178.33 ± 145.98	231.73 ± 38.75	51.74 ± 6.55	7.72 ± 2.82	56.96 ± 6.36	9.78 ± 4.89	172.88 ± 19.64	40.77 ± 8.67
	All	1108.88 ± 214.24	204.75 ± 51.54	63.13 ± 17.44	13.62 ± 7.34	56.95 ± 11.26	10.52 ± 4.83	187.70 ± 38.69	44.58 ± 16.51
2015	1	950.49 ± 271.94	194.76 ± 43.62	48.93 ± 14.52	10.80 ± 11.88	56.47 ± 32.76	17.18 ± 16.89	148.15 ± 62.96	43.00 ± 34.04
	2	951.13 ± 199.02	206.70 ± 37.08	52.31 ± 19.42	11.02 ± 2.41	46.07 ± 15.25	9.82 ± 8.54	123.32 ± 32.12	36.28 ± 10.33
	3	1881.37 ± 488.47	302.48 ± 81.32	100.02 ± 30.82	18.48 ± 6.45	77.09 ± 24.80	15.63 ± 4.99	195.13 ± 84.71	54.54 ± 20.03
	4	2869.87 ± 561.43	365.81 ± 85.54	131.02 ± 26.64	21.99 ± 6.22	85.46 ± 19.66	13.54 ± 4.33	292.71 ± 71.86	60.22 ± 16.37
	All	1204.30 ± 893.89	662.16 ± 95.47	133.69 ± 41.55	35.96 ± 8.79	51.62 ± 28.20	29.41 ± 10.12	144.95 ± 91.40	83.66 ± 23.35
2016	1	2636.02 ± 417.49	436.51 ± 145.06	129.79 ± 30.11	26.64 ± 10.05	96.95 ± 24.14	16.00 ± 5.34	391.59 ± 67.99	95.46 ± 27.33
	2	2809.96 ± 282.44	529.67 ± 70.78	169.23 ± 37.19	35.79 ± 6.47	148.24 ± 27.84	32.79 ± 8.75	540.85 ± 99.30	175.32 ± 33.48
	3	3045.44 ± 440.94	473.33 ± 261.04	135.36 ± 24.59	31.18 ± 6.42	133.78 ± 37.13	29.69 ± 8.88	484.56 ± 91.15	162.21 ± 27.78
	4	2842.72 ± 121.01	438.55 ± 35.29	131.91 ± 6.85	25.91 ± 0.78	123.14 ± 2.18	23.73 ± 2.05	451.55 ± 11.11	125.59 ± 15.66
	All	2833.54 ± 361.29	469.51 ± 154.61	141.57 ± 30.92	29.88 ± 7.71	125.53 ± 31.68	25.55 ± 9.28	467.14 ± 91.49	139.64 ± 41.00
2017	1	2817.95 ± 458.56	338.12 ± 61.58	127.62 ± 36.63	23.40 ± 6.46	85.94 ± 23.10	19.81 ± 6.59	393.92 ± 85.21	126.99 ± 37.59
	2	2255.49 ± 660.18	326.68 ± 89.59	155.56 ± 48.83	33.21 ± 9.20	106.77 ± 24.56	24.91 ± 4.75	398.35 ± 76.73	134.01 ± 34.29
	3	2497.12 ± 693.78	282.40 ± 77.08	179.32 ± 49.47	35.86 ± 13.51	133.63 ± 45.18	41.92 ± 20.49	371.18 ± 96.50	167.81 ± 55.27
	4	3083.53 ± 832.60	370.40 ± 92.71	256.68 ± 74.55	49.42 ± 18.68	155.16 ± 55.36	44.56 ± 20.93	325.63 ± 99.03	127.90 ± 40.56
	All	2706.80 ± 670.47	335.57 ± 78.58	182.36 ± 69.05	35.96 ± 15.14	122.06 ± 44.61	33.45 ± 17.82	380.65 ± 83.91	141.14 ± 42.21
2013 – 2017	All	1889.22 ± 927.08	296.30 ± 136.60	107.98 ± 61.42	22.71 ± 13.01	84.38 ± 43.40	19.11 ± 13.79	282.24 ± 140.02	85.21 ± 54.41

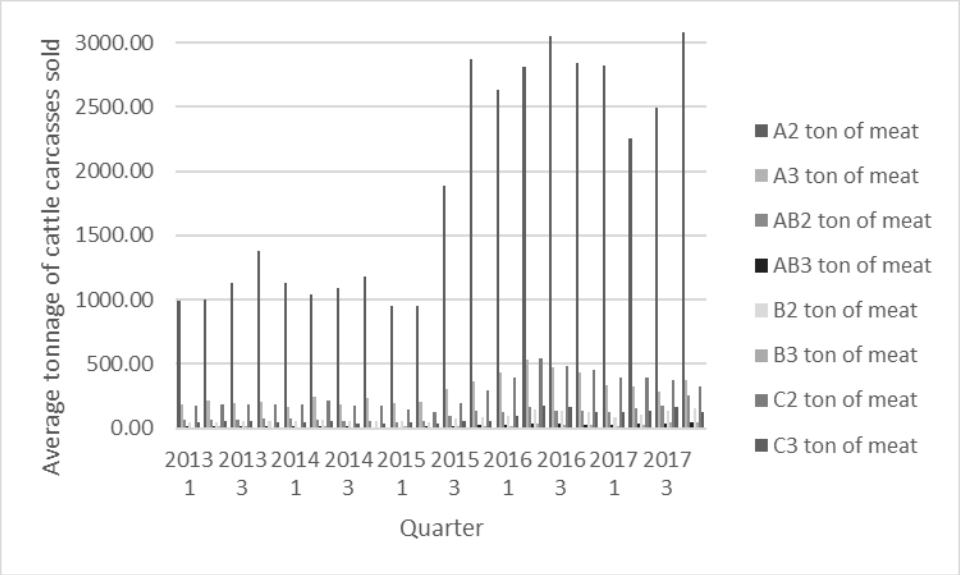

Figure 4.5: The average tonnage of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

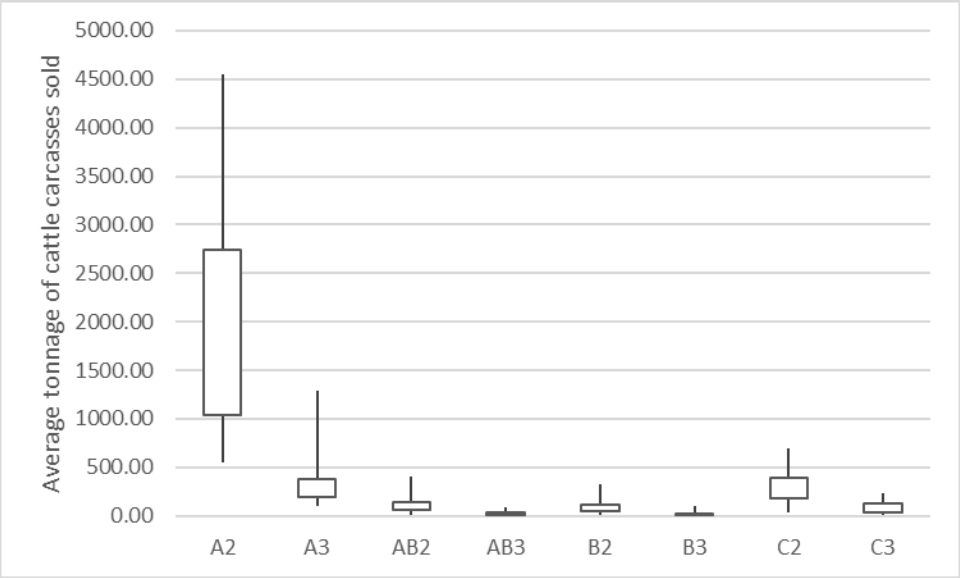

Figure 4.6: The average tonnage of beef carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.4, Figure 4.7 and Figure 4.8 illustrate the tonnage of sheep carcass classes bought by abattoirs in the period 2013 to 2017. During this period the A2 sheep carcass class had the highest average tonnage of meat bought by abattoirs (187.18 ± 81.1), and the AB3 sheep carcass class had the lowest tonnage of meat bought by abattoirs (0.92 ± 0.7). As with the different beef and pork carcass classes, the supply of the sheep carcass class would affect the tonnage, and the different masses play a role. The supply for a specific carcass class plays a larger role than the mass of the carcasses (as discussed later).

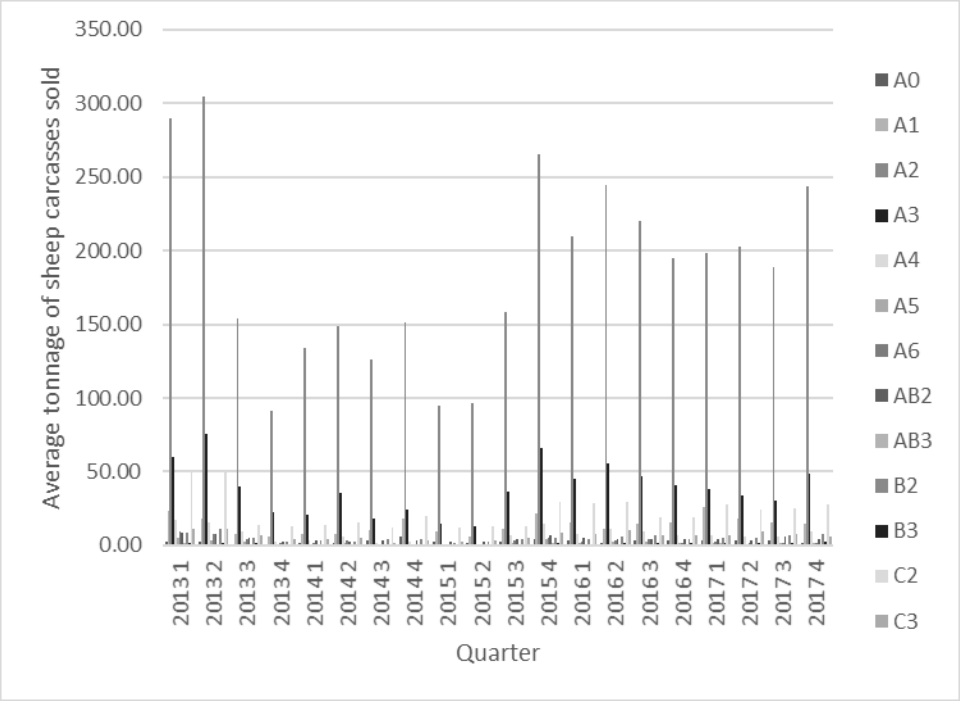

Figure 4.7: The average tonnage of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

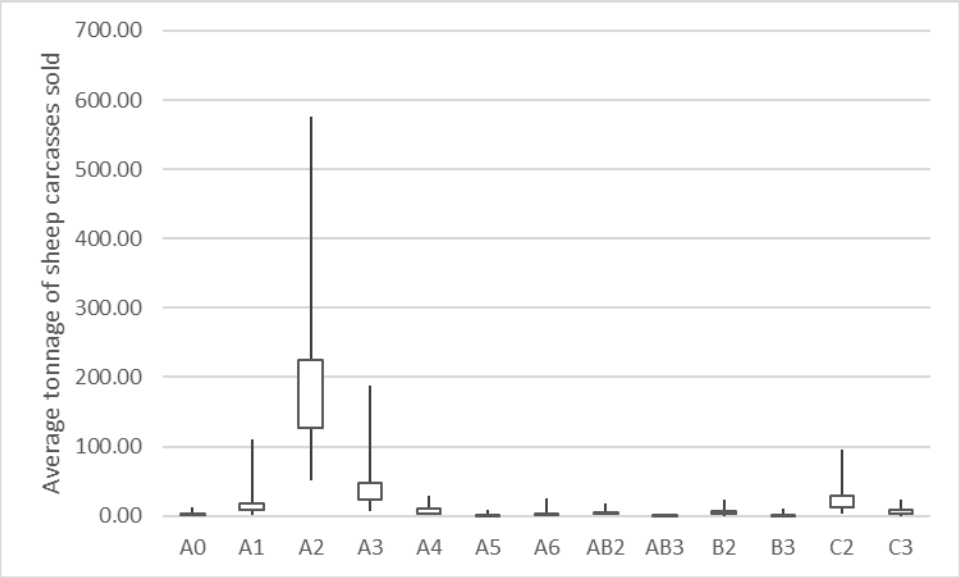

Figure 4.8: The average tonnage of sheep carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.4: The average tonnage of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A0 (mean ± SD)	A1 (mean ± SD)	A2 (mean ± SD)	A3 (mean ± SD)	A4 (mean ± SD)	A5 (mean ± SD)	A6 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	2.91 ± 1.30	23.64 ± 8.08	289.52 ± 84.25	59.80 ± 20.08	17.25 ± 6.30	5.30 ± 2.28	9.05 ± 4.61	8.75 ± 4.66	1.30 ± 0.71	8.36 ± 3.67	1.52 ± 0.99	51.51 ± 16.31	11.29 ± 4.37
	2	2.08 ± 1.34	17.86 ± 8.95	304.41 ± 65.67	75.88 ± 38.73	15.30 ± 5.20	3.74 ± 1.97	7.47 ± 5.80	7.64 ± 3.56	1.17 ± 0.65	10.96 ± 5.84	1.91 ± 0.85	49.11 ± 16.44	10.85 ± 3.30
	3	1.03 ± 0.85	7.52 ± 1.99	153.67 ± 18.26	40.24 ± 9.94	9.52 ± 3.33	2.70 ± 1.15	4.48 ± 1.93	5.27 ± 2.94	1.14 ± 0.67	5.19 ± 2.75	1.54 ± 1.34	13.65 ± 7.46	6.47 ± 2.39
	4	0.65 ± 0.28	6.01 ± 1.66	91.52 ± 42.63	22.72 ± 9.30	2.66 ± 1.77	0.93 ± 0.75	1.34 ± 1.14	2.65 ± 1.29	0.53 ± 0.44	2.67 ± 1.35	0.61 ± 0.47	13.19 ± 3.32	4.30 ± 1.35
	All	1.69 ± 1.35	13.91 ± 9.52	212.10 ± 106.63	50.19 ± 30.03	11.35 ± 7.17	3.21 ± 2.27	5.67 ± 4.80	6.14 ± 4.02	1.04 ± 0.68	6.88 ± 4.85	1.41 ± 1.06	32.23 ± 22.18	8.31 ± 4.20
2014	1	1.71 ± 0.68	7.72 ± 3.19	134.24 ± 55.77	20.51 ± 10.27	3.21 ± 2.28	0.73 ± 0.69	1.50 ± 1.61	3.13 ± 1.89	0.54 ± 0.31	3.56 ± 4.29	0.68 ± 0.36	14.24 ± 4.07	3.83 ± 1.48
	2	1.64 ± 0.83	7.97 ± 2.45	149.14 ± 55.41	35.26 ± 8.98	6.36 ± 3.09	1.39 ± 0.71	3.03 ± 2.26	2.23 ± 0.99	0.47 ± 0.17	2.57 ± 1.33	0.92 ± 0.41	15.28 ± 3.54	5.38 ± 2.72
	3	3.39 ± 2.60	10.41 ± 8.49	125.95 ± 76.32	18.60 ± 7.11	1.94 ± 0.78	0.33 ± 0.24	0.84 ± 0.58	3.32 ± 1.91	0.44 ± 0.28	4.44 ± 3.82	0.99 ± 0.60	12.27 ± 7.62	2.03 ± 1.06
	4	5.97 ± 3.02	18.32 ± 8.27	151.46 ± 35.26	23.87 ± 4.68	2.38 ± 0.93	0.21 ± 0.16	1.06 ± 0.41	3.55 ± 1.27	0.54 ± 0.26	4.31 ± 3.61	0.75 ± 0.42	20.15 ± 7.79	3.07 ± 1.16
	All	3.18 ± 2.68	11.11 ± 7.46	140.20 ± 56.84	24.56 ± 10.17	3.47 ± 2.62	0.67 ± 0.68	1.61 ± 1.63	3.06 ± 1.60	0.50 ± 0.26	3.72 ± 3.44	0.84 ± 0.46	15.49 ± 6.59	3.58 ± 2.09
2015	1	2.68 ± 1.66	9.40 ± 4.35	94.60 ± 30.44	14.93 ± 6.24	1.08 ± 0.63	0.25 ± 0.44	0.58 ± 0.89	2.27 ± 1.19	0.23 ± 0.11	2.01 ± 1.24	0.43 ± 0.24	12.46 ± 6.91	2.17 ± 1.24
	2	1.83 ± 0.60	6.30 ± 1.55	96.32 ± 13.84	12.72 ± 2.81	1.15 ± 0.34	0.17 ± 0.09	0.72 ± 0.43	2.57 ± 1.40	0.21 ± 0.12	2.58 ± 1.34	0.77 ± 0.52	12.78 ± 3.12	3.75 ± 1.81
	3	2.41 ± 0.61	11.55 ± 2.33	158.03 ± 30.58	36.11 ± 7.68	7.25 ± 2.15	1.92 ± 1.13	3.01 ± 1.84	4.01 ± 1.86	1.21 ± 0.53	3.93 ± 1.72	1.10 ± 0.39	13.01 ± 4.79	4.87 ± 1.49
	4	4.46 ± 1.88	22.02 ± 12.01	265.23 ± 119.92	65.74 ± 31.36	14.62 ± 8.58	3.94 ± 2.54	4.81 ± 2.81	6.58 ± 3.45	1.80 ± 0.94	5.09 ± 5.24	1.95 ± 2.20	29.49 ± 14.04	8.98 ± 3.32
	All	90.02 ± 1.62	10.03 ± 8.70	116.92 ± 93.66	62.85 ± 26.83	13.24 ± 7.07	2.90 ± 2.07	2.01 ± 2.45	3.61 ± 2.71	1.56 ± 0.86	2.72 ± 3.07	1.77 ± 1.26	13.96 ± 10.91	6.98 ± 3.28
2016	1	3.07 ± 1.88	15.49 ± 5.23	209.48 ± 42.84	45.01 ± 9.96	8.09 ± 2.92	1.65 ± 0.90	2.14 ± 1.17	5.29 ± 1.89	1.12 ± 0.54	4.12 ± 1.72	0.98 ± 0.41	28.36 ± 12.45	7.79 ± 4.00
	2	2.06 ± 0.96	11.56 ± 4.67	244.17 ± 59.99	55.80 ± 17.79	11.10 ± 3.37	2.31 ± 1.02	3.20 ± 1.49	4.32 ± 1.57	1.16 ± 0.51	5.61 ± 3.98	1.50 ± 0.75	29.26 ± 8.08	10.18 ± 4.37
	3	3.31 ± 1.54	15.06 ± 6.04	220.57 ± 52.08	47.29 ± 15.19	9.85 ± 4.49	2.50 ± 1.52	3.83 ± 4.21	4.23 ± 1.63	1.17 ± 0.44	6.55 ± 2.19	2.06 ± 1.23	18.99 ± 6.64	7.27 ± 3.72
	4	3.61 ± 0.21	15.30 ± 4.21	194.88 ± 26.12	40.68 ± 6.05	7.19 ± 1.88	1.68 ± 0.85	1.97 ± 1.28	4.07 ± 1.01	1.14 ± 0.15	4.17 ± 1.34	1.44 ± 0.28	18.70 ± 4.41	6.70 ± 1.20
	All	3.01 ± 1.40	14.35 ± 5.20	217.28 ± 49.07	47.20 ± 13.84	9.06 ± 3.55	2.03 ± 1.14	2.78 ± 2.45	4.48 ± 1.58	1.15 ± 0.42	5.11 ± 2.65	1.50 ± 0.84	23.83 ± 9.60	7.98 ± 3.69
2017	1	3.26 ± 1.27	25.80 ± 25.98	198.05 ± 43.29	38.20 ± 8.57	6.88 ± 2.40	1.38 ± 0.67	2.25 ± 1.62	4.13 ± 2.19	1.23 ± 1.03	4.89 ± 3.31	1.50 ± 1.28	27.59 ± 21.85	7.25 ± 3.40
	2	3.43 ± 1.59	18.17 ± 5.06	202.70 ± 39.32	33.95 ± 10.55	6.06 ± 2.30	1.12 ± 0.56	1.58 ± 0.85	3.56 ± 1.83	0.70 ± 0.41	5.32 ± 2.73	1.69 ± 1.22	23.91 ± 7.12	9.17 ± 5.32
	3	3.25 ± 1.22	15.89 ± 5.92	189.09 ± 52.63	30.30 ± 9.15	6.29 ± 2.45	1.38 ± 0.67	1.36 ± 0.85	5.61 ± 2.48	0.92 ± 0.94	7.09 ± 3.71	1.74 ± 0.56	24.92 ± 13.13	7.54 ± 2.13
	4	2.00 ± 1.03	15.01 ± 7.07	243.92 ± 49.86	48.73 ± 13.26	9.55 ± 2.96	1.47 ± 0.58	1.46 ± 0.94	4.67 ± 1.94	1.20 ± 0.93	7.33 ± 4.42	2.11 ± 2.71	27.89 ± 7.81	6.18 ± 2.31
	All	3.04 ± 1.39	19.12 ± 14.16	213.26 ± 45.15	38.40 ± 11.77	7.35 ± 2.78	1.37 ± 0.63	1.71 ± 1.16	4.55 ± 2.17	1.04 ± 0.86	6.20 ± 3.62	1.76 ± 1.61	26.52 ± 23.00	7.65 ± 3.61
2013 – 2017	All	2.76 ± 1.83	14.16 ± 9.80	187.18 ± 81.06	38.50 ± 22.18	7.44 ± 5.69	1.77 ± 1.73	2.80 ± 3.14	4.41 ± 2.75	0.92 ± 0.70	5.05 ± 3.82	1.31 ± 1.15	22.96 ± 14.78	6.48 ± 3.91

4.2. Total number of red meat carcasses bought by abattoirs during the period 2013 to 2017

The following figures are representations of the total number of carcasses bought by abattoirs of pork, beef and sheep carcasses during the period 2013 to 2017. Figure 4.9 and Figure 4.10 is a presentation of the total number of carcasses bought by abattoirs per red meat type for the period 2013 to 2017. During this period pork (24%) was the least bought by abattoirs carcass type, beef carcasses (32%) was the second-lowest bought by abattoirs, and sheep carcasses (44%) had the highest quantity bought by abattoirs. In 2013 a drought started in South Africa (Ngoepe, 2015; Joubert, 2016; United Nations Food and Agricultural Organisation (FAO), 2016), and due to this event, a large number of sheep was bought by abattoirs initially at the start of the drought. Comparing the different animals and production systems, sheep have the highest vulnerability to the drought, followed by beef and then pork (Schulz, 2013; Stotts, 2013; Maree & Casey, 1993).

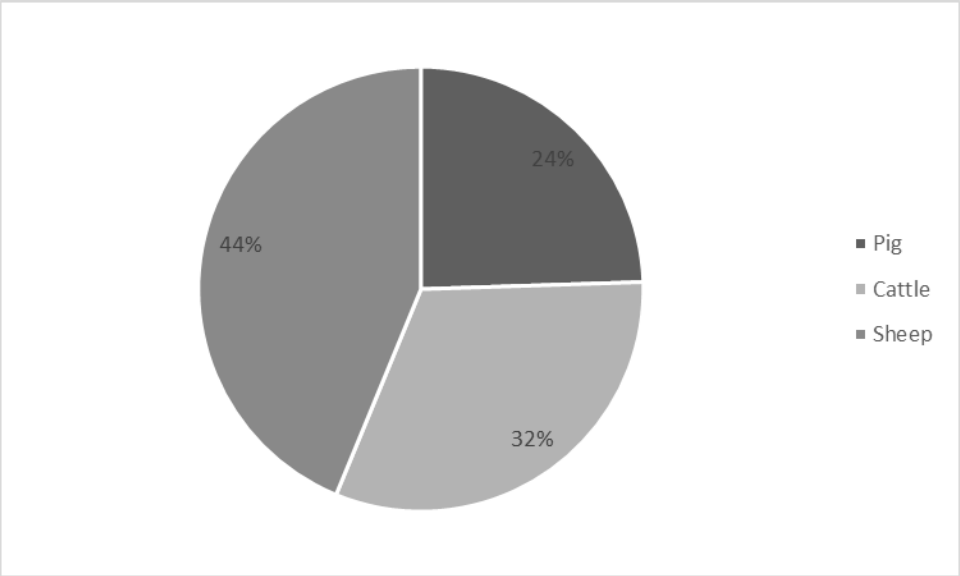

Figure 4.9: The percentage of red meat carcasses bought by abattoirs for the period 2013 to 2017

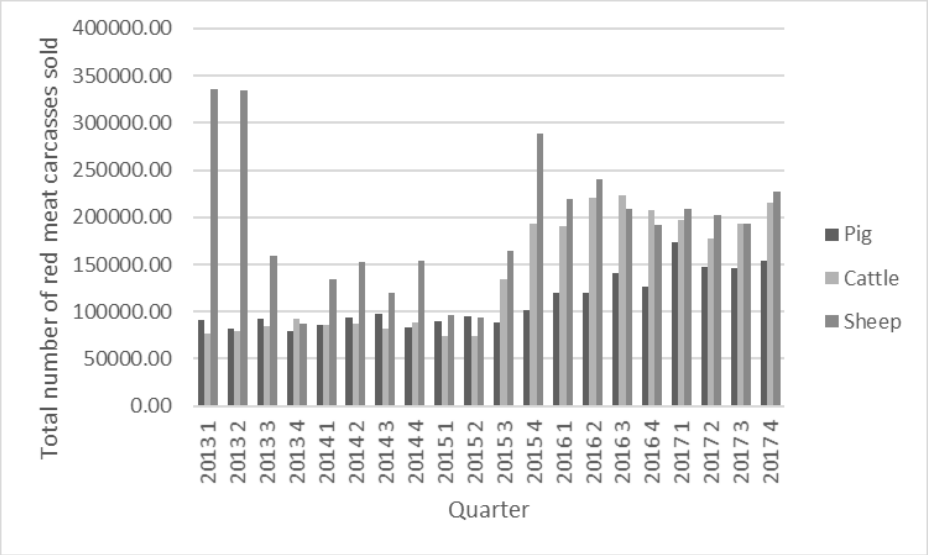

Figure 4.10: The total number of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

Compared to the other red meat carcasses, pork carcasses fluctuated less with the quarter, and sheep carcasses varied the most. The more substantial fluctuation of sheep was due to the effect of the drought that started in 2013 and ended middle 2018 (Ngoepe, 2015; Joubert, 2016; United Nations Food and Agricultural Organisation (FAO), 2016). Pork production is in a controlled environment whereas sheep and cattle production are not in a controlled environment and are easier affected by the drought (Schulz, 2013; Stotts, 2013; Lusk & Tonsor, 2016). There were initially large numbers of sheep bought by abattoirs, after which the numbers stabilised due to farmers responding to the drought and decreasing the stocking rates in the affected areas. Following that, another large number was bought by abattoirs. The fluctuation was due to the higher vulnerability of sheep, than in comparison with cattle to the drought conditions (Schulz, 2013; Stotts, 2013; Lusk & Tonsor, 2016).

Figure 4.11 shows the percentage of pork carcass classes bought by abattoirs per quarter from the period 2013 to 2017. During this period, there were no PS and PU pork classes as well as suckling pigs bought by abattoirs. The BP pork class comprised 49.61% of numbers of carcasses bought by abattoirs followed by the BO pork class (27.39%), PP pork class (12.26%) and BR pork class (5.03%). This was an indication that producers were focusing mainly on producing the bigger leaner carcasses.

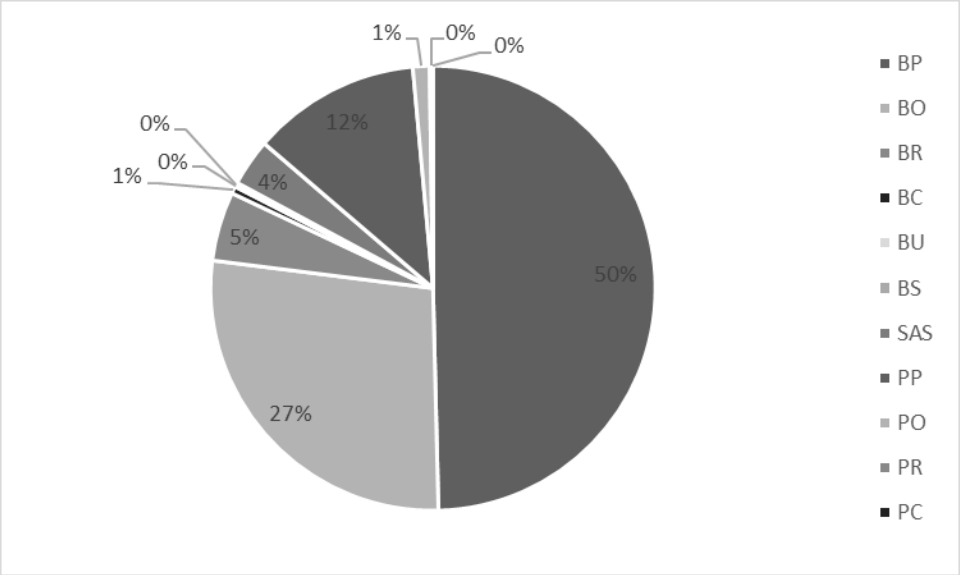

Figure 4.11: The percentage of pork carcass classes bought by abattoirs for the period 2013 to 2017

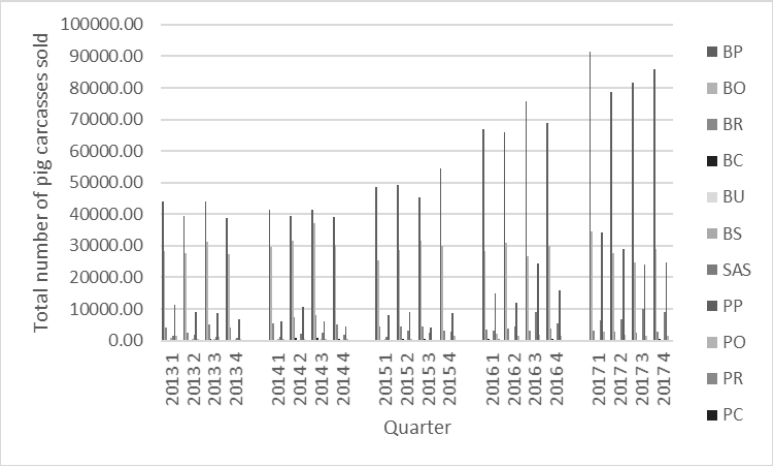

Figure 4.12: The number of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

Figure 4.12 provides a graphical representation of the total number of pork carcass classes bought by abattoirs per quarter from the period 2013 to 2017. As expected, the number of pork carcasses bought by abattoirs per year increased yearly, with quarterly fluctuations. An analysis of variance (ANOVA) indicated that all classes differed significantly from each other with regard to the number of pork carcasses bought by abattoirs during the period 2013 to 2017.

Figure 4.13 illustrates the total number of pork carcasses bought by abattoirs per quarter for the period 2013 to 2017. An overall increase in the total number of carcasses bought by abattoirs occurred with quarterly fluctuations. The variation relates to the nature of the pork production system.

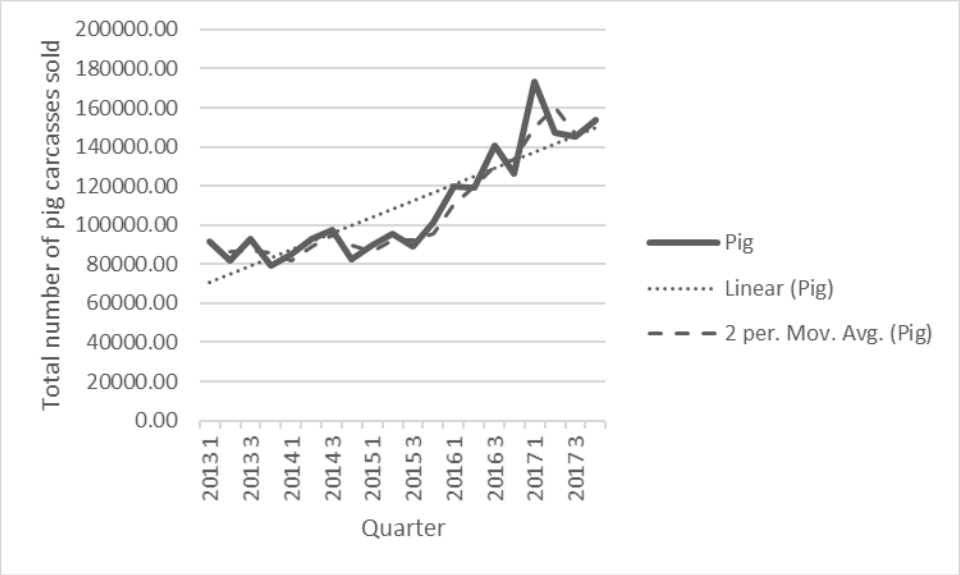

Figure 4.13: The trend of total pork carcasses bought by abattoirs per quarter for the period 2013 to 2017

Figure 4.14 demonstrates the percentage of beef carcass classes bought by abattoirs in the period 2013 to 2017 and Figure 4.15 is a graphical representation of the total number of beef carcass classes bought by abattoirs per quarter for the same period. The A2 carcass class (1,883,855) was the main class bought by abattoirs followed by the A3 (364,502) and C2 (280,185) classes, whereas the B3 carcass class (20,622) was the class that was the least bought by abattoirs.

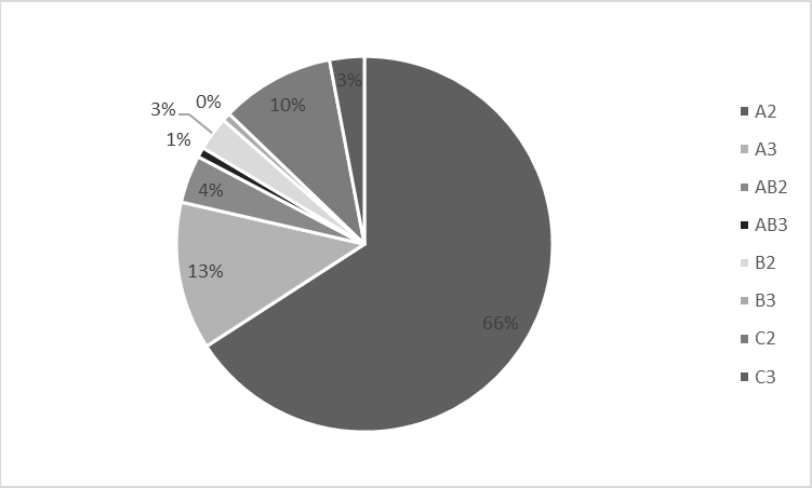

Figure 4.14: The percentage of beef carcass classes bought by abattoirs for the period 2013 to 2017

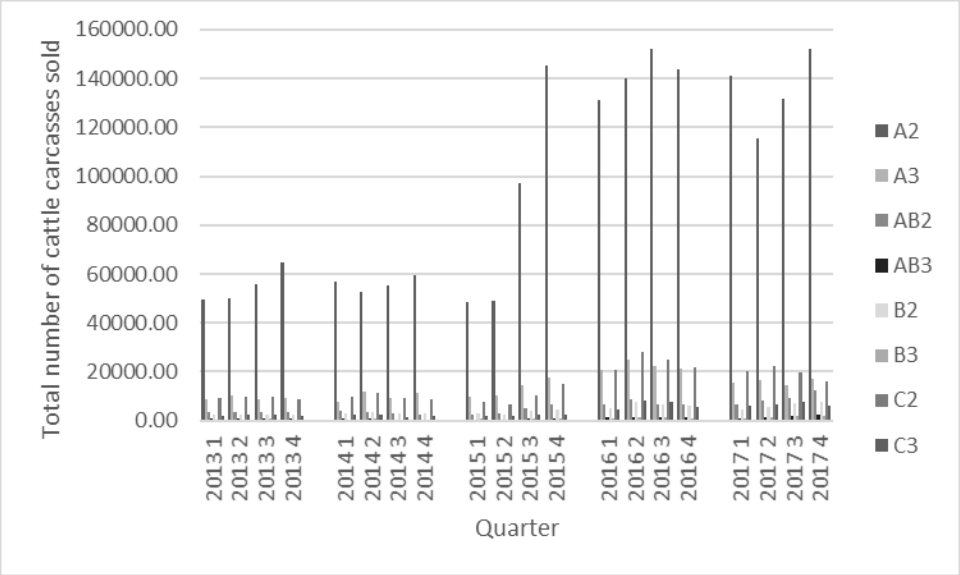

Figure 4.15: The total number of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

Figure 4.16 illustrates the total number of sheep carcass classes bought by abattoirs and Figure 4.17 provides a graphical representation of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017. The A2 carcass class (2,375,034) was the main class bought, followed by the A3 class (543,716), and the AB3 carcass class (11,472) was the least bought.

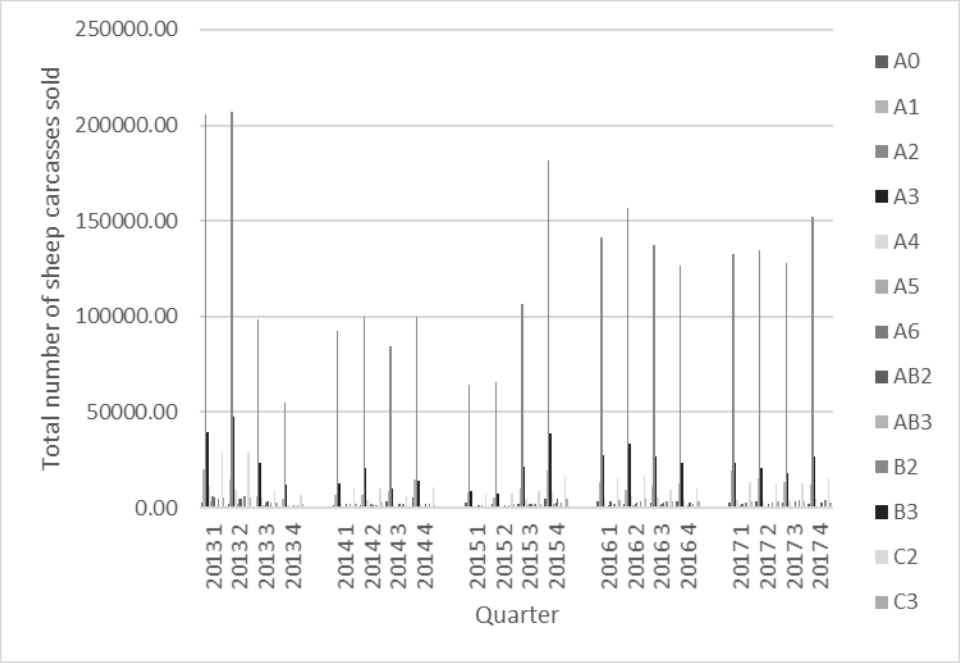

Figure 4.16: The total number of sheep carcass class per quarter for the period 2013 to 2017

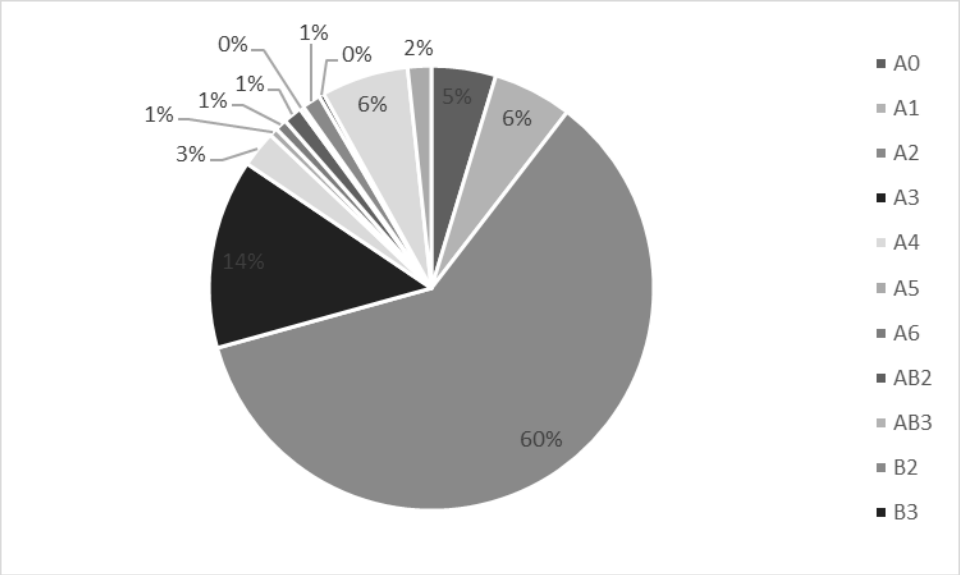

Figure 4.17: The percentage of sheep carcass class bought by abattoirs for the period 2013 to 2017

4.3. The average number of red meat carcasses bought by abattoirs during the period 2013 to 2017

Table 4.5, Figure 4.18 and Figure 4.19 show the average number of red meat carcasses bought by abattoirs per species for the period 2013 to 2017. As earlier stated, the number of sheep carcasses bought by abattoirs fluctuated the most, compared to beef and pork carcasses. The differences in fluctuation were due to differences in production between the species as well as the effect of the susceptibility to the impact of the drought by the red meat types.

Table 4.5: The average number of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	Pork (mean ± SD)	Beef (mean ± SD)	Sheep (mean ± SD)
2013	**1**	641 ± 56	732 ± 120	1983 ± 539
	2	571 ± 137	761 ± 104	1979 ± 541
	3	649 ± 72	808 ± 130	942 ± 113
	4	599 ± 58	958 ± 158	560 ± 189
	All	615 ± 91	578 ± 152	1382 ± 742
2014	**1**	596 ± 97	820 ± 107	792 ± 322
	2	651 ± 145	837 ± 72	900 ± 300
	3	681 ± 54	787 ± 154	713 ± 422
	4	578 ± 64	846 ± 100	911 ± 190
	All	627 ± 103	822 ± 111	829 ± 320
2015	**1**	627 ± 53	718 ± 157	569 ± 152
	2	668 ± 35	708 ± 131	556 ± 77
	3	623 ± 54	1294 ± 327	975 ± 143
	4	710 ± 105	1861 ± 312	1712 ± 790
	All	657 ± 74	1145 ± 538	953 ± 619
2016	**1**	839 ± 249	1828 ± 272	1297 ± 245
	2	859 ± 161	2118 ± 205	1425 ± 325
	3	1045 ± 149	2144 ± 327	1234 ± 341
	4	712 ± 89	1994 ± 60	1139 ± 176
	All	861 ± 186	2021 ± 263	1274 ± 291
2017	**1**	685 ± 108	769 ± 159	1314 ± 424
	2	575 ± 86	809 ± 161	1268 ± 321
	3	540 ± 96	830 ± 135	1212 ± 225
	4	576 ± 185	870 ± 244	1428 ± 376
	All	1084 ± 216	1883 ± 455	1227 ± 351
2013 – 2017	**All**	951 ± 446	1434 ± 867	2021 ± 1232

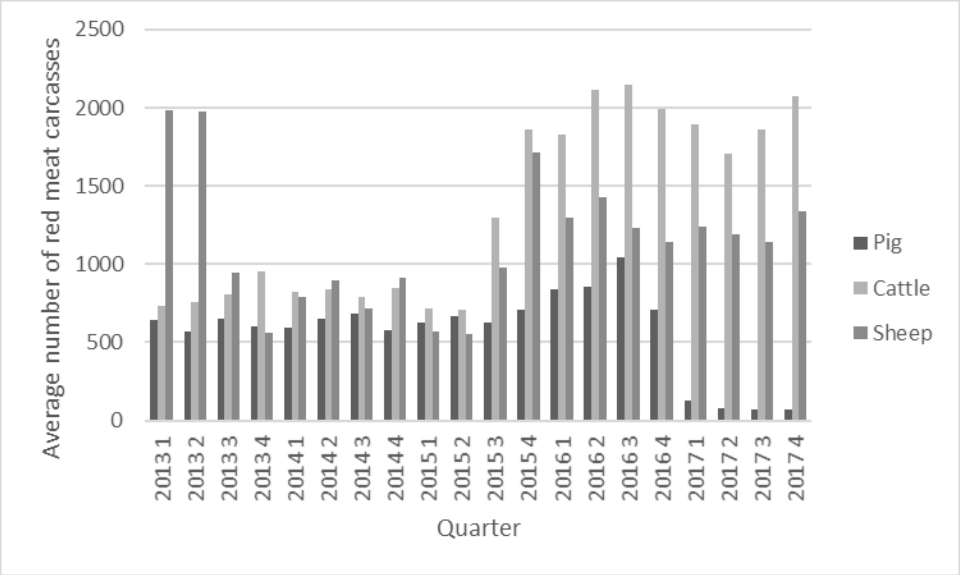

Figure 4.18: The average number of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

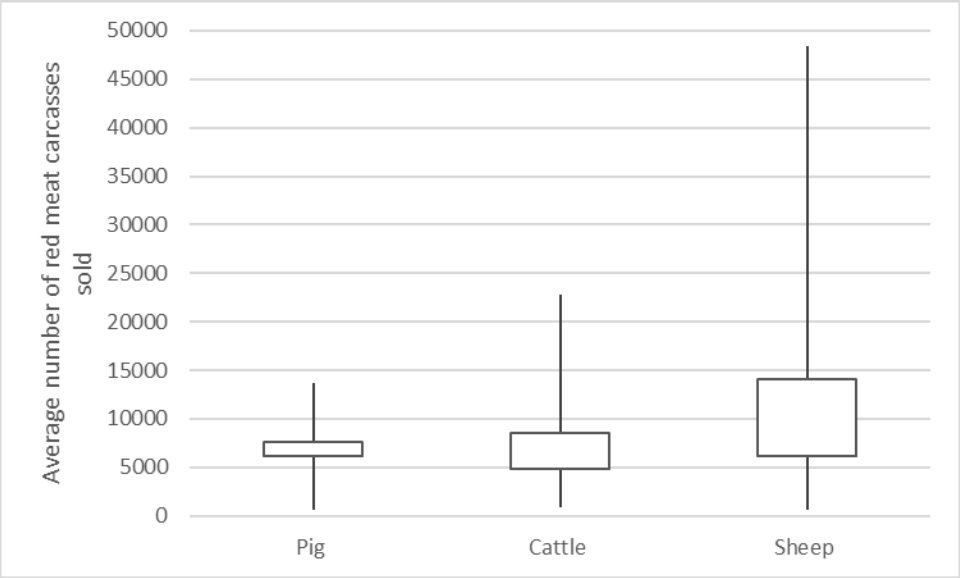

Figure 4.19: The average number of red meat carcasses bought by abattoirs for the period 2013 to 2017

Table 4.6, Figure 4.20 and Figure 4.21 are representations of the average number of pork carcass classes bought by abattoirs for the period 2013 to 2017. The BP pork class (4,402 ± 1,499) was the main class bought followed by the BO pork class (2,280 ± 503) and PP pork class (1,051 ± 755). The difference in the average number was due to the differences in the supply for the different carcass classes (Labuschagne *et al.*, 2011; Delport *et al.*, 2017), resulting from producers producing towards specific carcass classes. The PP pork carcass class was used in the fresh meat market, whereas BP pork class and BO carcass classes were used for processing (Labuschagne *et al.*, 2011; Delport *et al.*, 2017).

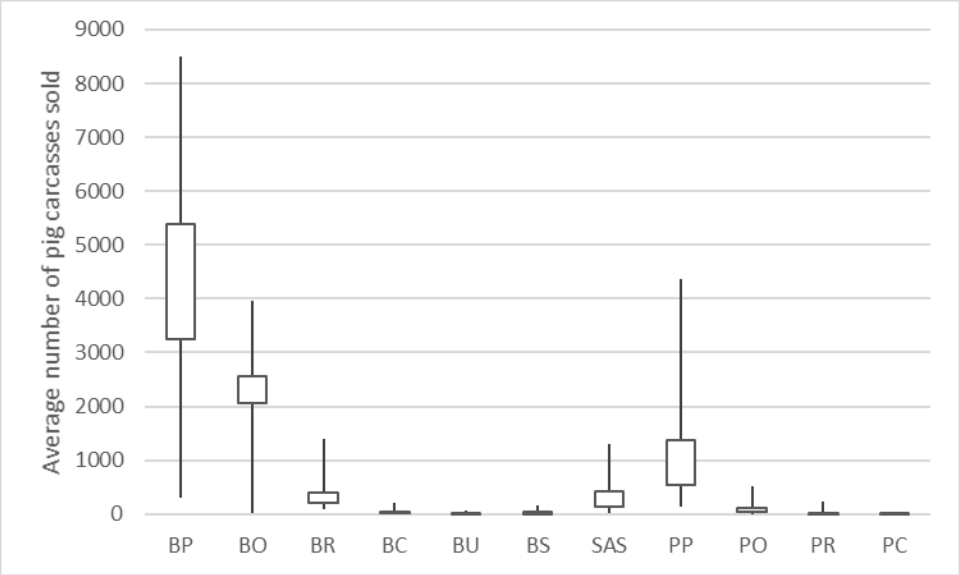

Figure 4.20: The average number of pork carcass classes bought by abattoirs for the period 2013 to 2017

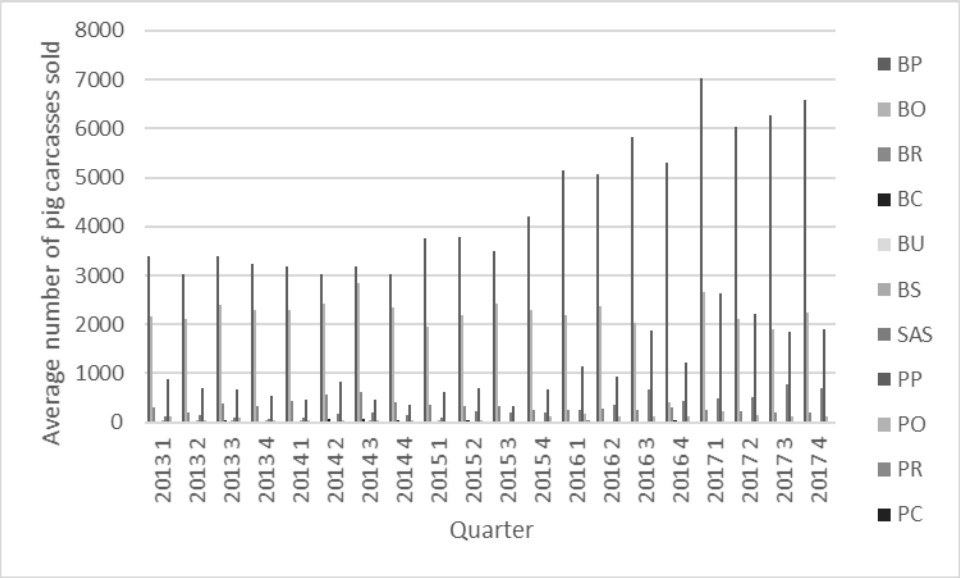

Figure 4.21: The average number of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

Table 4.6: The average number of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	BP (mean ± SD)	BO (mean ± SD)	BR (mean ± SD)	BC (mean ± SD)	BU (mean ± SD)	BS (mean ± SD)	PP (mean ± SD)	PO (mean ± SD)	PR (mean ± SD)	PC (mean ± SD)	SAS (mean ± SD)
2013	1	3386 ± 385	2172 ± 283	310 ± 133	12 ± 9	1 ±0	54 ± 42	869 ± 176	116 ± 90	4 ± 4	2 ± 1	122 ± 39
	2	3036 ± 1087	2120 ± 283	192 ± 46	12 ± 8	2 ±1	39 ± 22	688 ± 140	42 ± 35	5 ± 3	2 ± 2	142 ± 57
	3	3394 ± 598	2396 ± 415	386 ± 311	31 ± 50	3 ± 2	38 ± 19	681 ± 158	87 ± 91	16 ± 16	4 ± 2	103 ± 27
	4	3226 ± 265	2287 ± 310	333 ± 92	19 ± 14	5 ± 6	41 ± 26	552 ± 131	34 ± 18	10 ± 6	8 ± 6	73 ± 40
	All	3261 ± 665	2243 ± 336	305 ± 187	18 ± 27	3 ±3	43 ± 28	701 ± 186	70 ± 74	9 ± 10	4 ± 4	111 ± 48
2014	1	3176 ± 546	2285 ± 404	422 ± 101	16 ± 7	3 ± 2	35 ± 27	470 ± 106	42 ± 23	8 ± 7	3 ± 2	98 ± 52
	2	3024 ± 453	2428 ± 282	571 ± 143	58 ± 27	6 ± 5	24 ± 27	828 ± 1066	40 ± 23	7 ± 5	2 ± 0	176 ± 68
	3	3176 ± 273	2854 ± 257	631 ± 152	63 ± 36	7 ± 10	41 ± 48	466 ± 96	48 ± 31	2 ± 4	1 ± 0	199 ± 85
	4	3020 ± 250	2334 ± 443	400 ± 126	37 ± 29	5 ± 4	21 ± 28	352 ± 87	36 ± 27	8 ± 12	3 ± 7	140 ± 48
	All	3099 ± 396	2475 ± 413	506 ± 162	43 ± 32	5 ± 6	30 ± 33	529 ± 554	41 ± 26	7 ± 8	2 ± 3	153 ± 74
2015	1	3750 ± 353	1956 ± 351	352 ± 118	24 ± 14	5 ± 4	40 ± 39	627 ± 136	29 ± 11	10 ± 8	9 ± 13	98 ± 41
	2	3780 ± 274	2199 ± 162	332 ± 61	31 ± 6	8 ± 3	21 ± 20	697 ± 116	41 ± 11	5 ± 4	5 ± 12	233 ± 59
	3	3490 ± 372	2427 ± 359	339 ± 67	29 ± 18	5 ± 3	23 ± 27	322 ± 190	16 ± 11	6 ± 3	5 ± 4	194 ± 45
	4	4191± 696	2305 ± 517	252 ± 91	24 ± 13	5 ± 5	12 ± 17	669 ± 481	116 ± 150	15 ± 25	6 ± 9	211 ± 46
	All	3803 ± 507	2487 ± 399	841 ± 94	105 ± 13	12 ± 4	20 ± 28	547 ± 306	127 ± 83	12 ± 14	6 ± 10	141 ± 70
2016	1	5147 ± 1409	2182 ± 1109	264 ± 138	29 ± 16	5 ± 3	4 ± 3	1138 ± 196	175 ± 112	39 ± 57	5 ± 6	246 ± 106
	2	5077 ± 942	2373 ± 682	2883 ± 95	23 ± 5	11 ± 15	5 ± 5	925 ± 216	115 ± 56	18 ± 12	5 ± 4	349 ± 139
	3	5819 ± 706	2042 ± 710	244 ± 97	28 ± 24	6 ± 3	3 ± 2	1876 ± 563	130 ± 81	15 ± 7	4 ± 2	683 ± 231
	4	5306 ± 487	400 ± 717	300 ± 5	32 ± 1	7 ± 2	2 ± 1	1214 ± 349	117 ± 10	20 ± 1	5 ± 0	426 ± 58
	All	5337 ± 967	1749 ± 1127	273 ± 96	28 ± 14	7 ± 8	3 ± 3	1288 ± 502	134 ± 76	23 ± 30	5 ± 4	426 ± 217
2017	1	2661 ± 335	247 ± 34	25 ± 10	6 ± 2	9 ± 13	497 ± 229	2624 ± 353	219 ± 77	24 ± 15	5 ± 2	1223 ± 121
	2	2121 ± 263	214 ± 46	21 ± 12	4 ± 3	7 ± 5	517 ± 174	2221 ± 272	142 ± 39	27 ± 6	11 ± 10	1038 ± 117
	3	1908 ± 281	198 ± 67	28 ± 7	7 ± 5	5 ± 4	774 ± 210	1850 ± 359	116 ± 28	23 ± 9	6 ± 2	1018 ± 79
	4	2240 ± 695	209 ± 86	29 ± 11	8 ± 6	7 ± 5	703 ± 245	1904 ± 671	114 ± 56	24 ± 12	9 ± 7	1092 ± 246
	All	6486 ± 934	2233 ± 502	217 ± 63	26 ± 11	6 ± 4	7 ± 8	623 ± 242	2150 ± 529	148 ± 67	25 ± 11	8 ± 7
2013 – 2017	All	4402 ± 1499	2280 ± 503	324 ± 161	29 ± 23	5 ± 5	22 ± 28	300 ± 248	1051 ± 755	89 ± 81	14 ± 18	5 ± 6

Table 4.7, Figure 4.22 and Figure 4.23 show the average number of beef carcass classes bought by abattoirs in the period 2013 to 2017. The difference observed was also due to the difference in supply for the different carcass classes and producers producing towards the carcass class with the highest R/kg price. The A2 beef carcass class (7,304 ± 3,522) had the highest average amount of carcasses bought by abattoirs, whereas the B3 carcass class (67 ± 48) was the least.

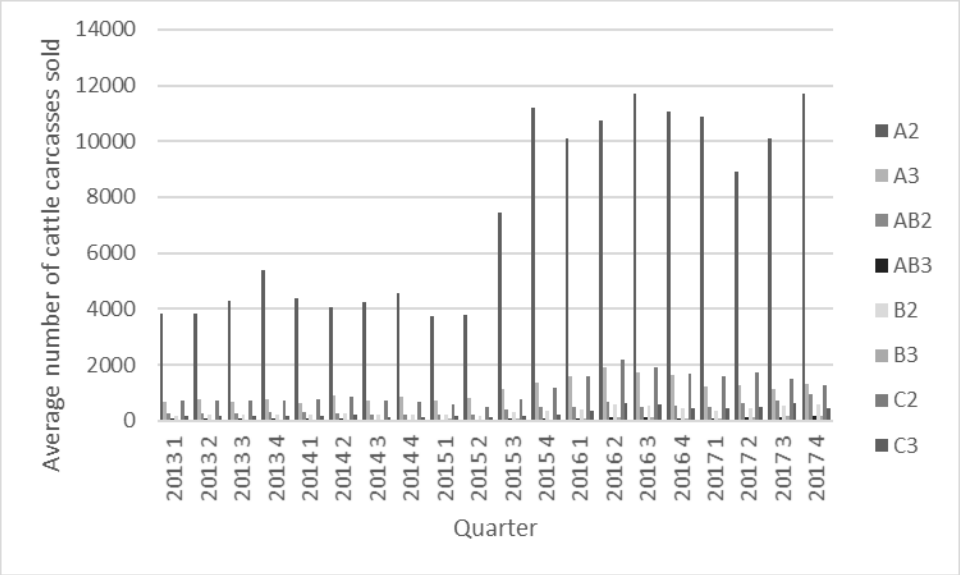

Figure 4.22: The average number of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

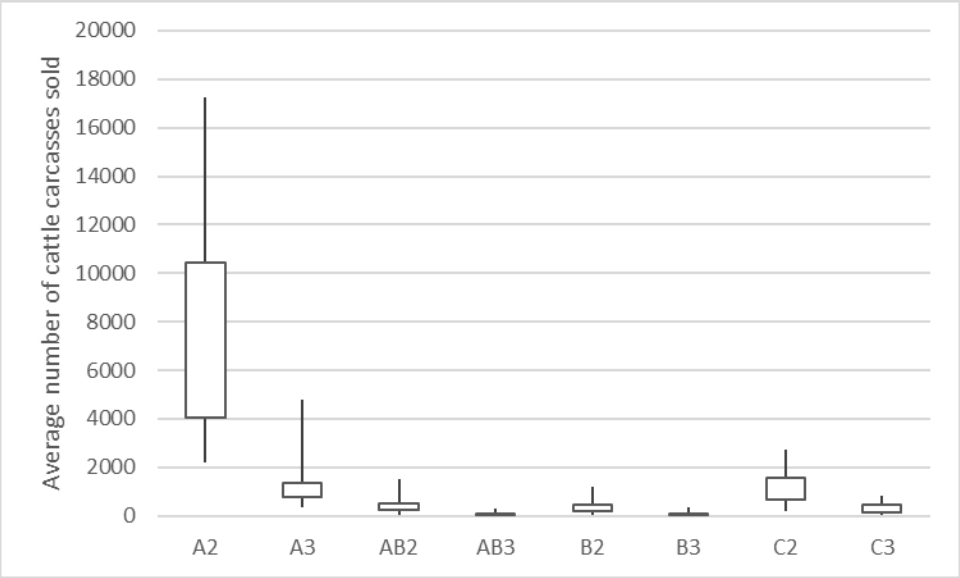

Figure 4.23: The average number of beef carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.7: The average number of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A2 (mean ± SD)	A3 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	3816 ± 718	672 ± 155	248 ± 71	55 ± 23	173 ± 56	33 ± 17	698 ± 203	161 ± 54
	2	3831 ± 548	779 ± 132	248 ± 60	63 ± 21	198 ± 43	46 ± 11	738 ± 140	181 ± 43
	3	4295 ± 695	689 ± 114	252 ± 69	58 ± 26	203 ± 36	47 ± 22	734 ± 194	186 ± 50
	4	5410 ± 1178	763 ± 243	289 ± 48	69 ± 17	215 ± 48	34 ± 13	718 ± 134	162 ± 79
	All	4317 ± 1015	725 ± 168	259 ± 63	61 ± 22	197 ± 48	40 ± 17	722 ± 167	173 ± 57
2014	1	4391 ± 591	608 ± 138	298 ± 50	56 ± 31	228 ± 54	34 ± 17	770 ± 226	173 ± 84
	2	4068 ± 504	916 ± 157	264 ± 80	62 ± 11	265 ± 47	50 ± 12	872 ± 83	198 ± 47
	3	4244 ± 1217	720 ± 170	234 ± 73	41 ± 20	212 ± 47	29 ± 13	705 ± 147	113 ± 35
	4	4567 ± 568	873 ± 179	206 ± 27	28 ± 11	233 ± 25	33 ± 19	690 ± 78	137 ± 32
	All	4317 ± 775	779 ± 200	250 ± 69	47 ± 24	234 ± 47	36 ± 17	759 ± 159	155 ± 62
2015	1	3718 ± 1003	737 ± 170	206 ± 66	38 ± 41	230 ± 115	60 ± 56	601 ± 246	158 ± 128
	2	3774 ± 800	793 ± 150	216 ± 79	39 ± 8	187 ± 64	36 ± 33	493 ± 127	126 ± 35
	3	7464 ± 1887	1131 ± 300	379 ± 111	64 ± 21	298 ± 98	53 ± 17	774 ± 342	188 ± 70
	4	11183 ± 2190	1368 ± 310	499 ± 97	77 ± 23	344 ± 79	47 ± 15	1160 ± 289	206 ± 56
	All	4824 ± 3471	2591 ± 351	513 ± 151	133 ± 30	206 ± 107	110 ± 34	577 ± 362	316 ± 84
2016	1	10084 ± 1544	1576± 531	501 ± 144	94 ± 35	399 ± 99	57 ± 18	1576 ± 282	339 ± 109
	2	10758 ± 1119	1902 ± 253	659 ± 142	123 ± 21	580 ± 104	115 ± 31	2178 ± 400	626 ± 118
	3	11710 ± 1685	1716 ± 970	507 ± 88	107 ± 20	514 ± 131	101 ± 29	1919 ± 357	577 ± 102
	4	11059 ± 480	1627 ± 140	516 ± 29	92 ± 2	462 ± 16	85 ± 7	1663 ± 64	448 ± 55
	All	10903 ± 1388	1705 ± 568	546 ± 119	104 ± 25	489 ± 116	90 ± 30	1834 ± 379	497 ± 149
2017	1	1209 ± 223	505 ± 146	85 ± 22	352 ± 96	73 ± 22	1575 ± 355	460 ± 139	1891 ± 269
	2	1270 ± 279	613 ± 151	123 ± 29	440 ± 84	100 ± 22	1712 ± 277	505 ± 112	1708 ± 337
	3	1111 ± 199	720 ± 109	136 ± 38	548 ± 116	156 ± 63	1503 ± 169	608 ± 148	1862 ± 238
	4	1305 ± 324	955 ± 277	173 ± 63	596 ± 196	155 ± 69	1249 ± 375	452 ± 138	2072 ± 512
	All	10391 ± 2373	1224 ± 264	698 ± 244	129 ± 51	484 ± 159	121 ± 60	1510 ± 341	506 ± 145
2013 – 2017	All	7304 ± 3522	1089 ± 492	416 ± 229	79 ± 45	334 ± 164	67 ± 48	1118 ± 552	301 ± 196

Table 4.8, Figure 4.24 and Figure 4.25 represent the average number of sheep carcass classes bought by abattoirs in the period 2013 to 2017. As with pork and beef carcasses, the supply for the specific carcass class was the main driver for the differences in the percentages bought by abattoirs. The main class bought by abattoirs was the A2 sheep carcass class (9,542 ± 4,259), whereas the least bought class was AB3 sheep carcass class (38 ± 30).

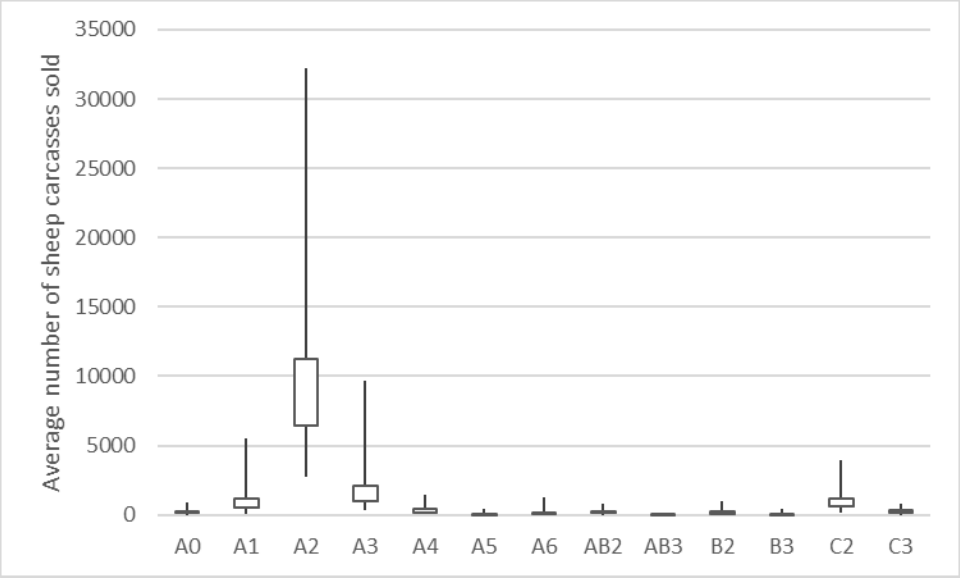

Figure 4.24: The average number of sheep carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.8: The average number of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A0 (mean ± SD)	A1 (mean ± SD)	A2 (mean ± SD)	A3 (mean ± SD)	A4 (mean ± SD)	A5 (mean ± SD)	A6 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	219 ± 102	1534 ± 513	15845 ± 4534	3032 ± 1007	864 ± 320	265 ± 118	454 ± 233	399 ± 206	55 ± 30	356 ± 163	56 ± 37	2269 ± 682	436 ± 178
	2	148 ± 89	1141 ± 570	15905 ± 3836	3665 ± 2024	730 ± 260	183 ± 103	359 ± 296	380 ± 183	51 ± 28	469 ± 240	74 ± 31	2204 ± 684	418 ± 135
	3	71 ± 52	485 ± 133	7575 ± 942	1815 ± 429	430 ± 147	123 ± 54	202 ± 87	245 ± 136	44 ± 26	220 ± 119	58 ± 52	749 ± 249	230 ± 80
	4	51 ± 21	389 ± 100	4609 ± 1950	1006 ± 390	114 ± 79	40 ± 32	60 ± 48	116 ± 58	20 ± 16	111 ± 58	21 ± 16	589 ± 134	150 ± 42
	All	124 ± 98	897 ± 612	11109 ± 5892	2407 ± 1543	543 ± 362	155 ± 116	272 ± 243	288 ± 191	43 ± 28	292 ± 207	53 ± 40	1470 ± 933	312 ± 170
2014	1	127 ± 51	516 ± 215	7141 ± 2943	984 ± 512	152 ± 115	37 ± 36	74 ± 81	148 ± 85	23 ± 13	156 ± 196	25 ± 13	768 ± 327	146 ± 63
	2	121 ± 58	500 ± 141	7671 ± 2854	1624 ± 438	312 ± 152	68 ± 36	148 ± 109	107 ± 55	19 ± 7	106 ± 51	33 ± 14	791 ± 318	201 ± 114
	3	251 ± 202	657 ± 555	6495 ± 4025	801 ± 298	87 ± 36	15 ± 11	39 ± 28	144 ± 89	17 ± 11	174 ± 145	33 ± 19	488 ± 287	69 ± 34
	4	433 ± 205	1165 ± 492	7680 ± 1347	1082 ± 264	107 ± 35	9 ± 7	48 ± 20	163 ± 61	21 ± 11	185 ± 167	26 ± 15	813 ± 314	107 ± 41
	All	233 ± 193	710 ± 468	7247 ± 2904	1123 ± 489	164 ± 131	32 ± 34	78 ± 80	141 ± 75	20 ± 11	155 ± 149	29 ± 15	715 ± 330	131 ± 84
2015	1	207 ± 132	609 ± 278	4965 ± 1588	692 ± 293	51 ± 32	13 ± 24	24 ± 28	111 ± 62	9 ± 4	85 ± 52	15 ± 9	530 ± 300	82 ± 49
	2	138 ± 41	413 ± 102	5045 ± 751	578 ± 112	57 ± 16	8 ± 4	38 ± 22	124 ± 66	8 ± 5	108 ± 56	27 ± 21	548 ± 137	143 ± 69
	3	187 ± 43	774 ± 145	8177 ± 1459	1667 ± 353	342 ± 105	90 ± 54	143 ± 85	171 ± 57	53 ± 24	167 ± 78	41 ± 16	677 ± 223	184 ± 56
	4	361 ± 153	1517 ± 836	13956 ± 6732	3019 ± 1430	649 ± 353	171 ± 96	217 ± 115	348 ± 194	81 ± 43	217 ± 216	71 ± 74	1298 ± 579	345 ± 133
	All	500 ± 132	681 ± 606	6185 ± 5051	3116 ± 1230	606 ± 306	133 ± 87	92 ± 107	182 ± 144	68 ± 39	116 ± 128	70 ± 44	605 ± 465	312 ± 128
2016	1	242 ± 154	1061 ± 358	10868 ± 2276	2110 ± 464	365 ± 121	73 ± 38	102 ± 60	264 ± 95	50 ± 25	187 ± 81	37 ± 17	1201 ± 526	295 ± 162
	2	152 ± 66	754 ± 299	12080 ± 2915	2595 ± 863	472 ± 124	104 ± 50	153 ± 75	211 ± 83	52 ± 23	241 ± 177	58 ± 29	1280 ± 361	379 ± 112
	3	233 ± 103	897 ± 357	10571 ± 2696	2050 ± 722	419 ± 205	109 ± 69	175 ± 203	190 ± 78	46 ± 18	260 ± 91	74 ± 47	751 ± 269	262 ± 141
	4	274 ± 16	990 ± 248	9761 ± 1255	1820 ± 267	315 ± 82	73 ± 38	91 ± 60	194 ± 51	48 ± 6	173 ± 50	51 ± 10	766 ± 161	245 ± 39
	All	225 ± 106	926 ± 330	10820 ± 2451	2144 ± 668	393 ± 148	90 ± 52	130 ± 118	215 ± 82	49 ± 19	215 ± 113	55 ± 31	999 ± 423	295 ± 130
2017	1	1516 ± 1252	10214 ± 2413	1820 ± 427	324 ± 123	66 ± 34	110 ± 83	179 ± 97	51 ± 42	198 ± 134	57 ± 51	1031 ± 467	277 ± 132	1237 ± 260
	2	1171 ± 348	10348 ± 2254	1588 ± 505	284 ± 122	57 ± 33	84 ± 49	172 ± 83	32 ± 20	203 ± 102	61 ± 51	1007 ± 291	278 ± 69	1195 ± 246
	3	1042 ± 301	9863 ± 1304	1378 ± 288	276 ± 92	58 ± 27	60 ± 36	267 ± 105	38 ± 40	317 ± 155	72 ± 34	985 ± 342	256 ± 49	1142 ± 150
	4	938 ± 424	11682 ± 2561	2066 ± 586	379 ± 113	57 ± 23	60 ± 42	217 ± 94	48 ± 35	309 ± 193	77 ± 101	1169 ± 333	223 ± 85	1336 ± 295
	All	214 ± 89	1167 ± 714	10527 ± 2235	1713 ± 520	316 ± 117	59 ± 29	79 ± 58	209 ± 100	42 ± 35	257 ± 156	67 ± 63	1048 ± 361	259 ± 89
2013 – 2017	All	204 ± 135	905 ± 578	9542 ± 4259	1773 ± 1076	337 ± 265	81 ± 82	132 ± 154	208 ± 134	38 ± 30	212 ± 163	49 ± 44	997 ± 605	237 ± 141

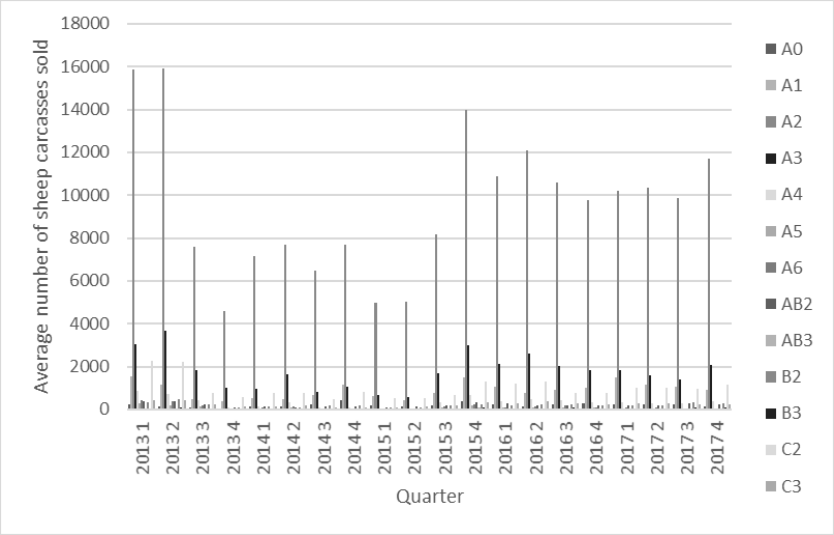

Figure 4.25: The average number of sheep carcass classes per quarter bought by abattoirs for the period 2013 to 2017

The results of this study showed that there were significant influences between the different carcass classes of the various red meat species on each other for price and the number of carcasses bought by abattoirs. Labuschagne *et al.* (2011) confirm that different meat types compete. Different meat types, therefore, influence the prices of each other. They do not only compete with other meat types but with other protein sources as well (Labuschagne *et al.* 2011). On the other hand, due to several of the prediction intervals that overlap in a meta-analysis study by Gallet (2010), they could not say that price elasticity across all meat types was significant.

There was a seasonal effect on the sale of different classes. Geyser & Cutts (2007), Jordaan & Grové (2007) and Monk *et al.* (2010) explained that seasonality was due to production cycles and harvest time. At harvest, crops are abundant and prices of commodity low, as the supply fall increase the price of the commodity. With animal production, at peak production, the prices for the commodities are low and increase as the supply decreases. As expected, over the period (2013 to 2017) there was an increase in the number of carcasses bought by abattoirs as well as the price of these carcasses. There was no change in the mass of the classes for the period studied.

Sheep were the main carcasses bought by abattoirs in South Africa, followed by beef and lastly by pork. As the number of beef carcasses increased, the number of pork carcasses decreased and *vice versa*. Compared to the other red meat carcasses, pork carcass numbers fluctuated less over the quarter, and sheep carcasses numbers varied the most. The drought that South Africa had been experiencing since 2013 may explain the more considerable fluctuation in the mutton and lamb carcasses because the production of sheep is more susceptible to the influence of the drought compared to cattle and pigs (Ngoepe, 2015; Joubert, 2016; United Nations Food and Agricultural Organisation (FAO), 2016).

There were no PS and PU pork classes as well as suckling pigs bought by abattoirs during the period. This indicated a shift towards the production of bigger leaner carcasses. According to Davids *et al.* (2013), 7% of all meat bought by abattoirs in 2011 was from pork meat.

The number of pork carcasses bought by abattoirs fluctuated quarterly, which was unexpected. The pork production system is supposed to deliver a constant amount of pigs

throughout the year. An analysis of variance (ANOVA) indicated that all classes differ significantly from each other concerning the number of pork carcasses bought by abattoirs.

The results showed that there was an overall increase in the total number of carcasses bought by abattoirs for the period 2013 to 2017. It also shows that there were quarterly fluctuations in the sale of pork carcasses. This quarterly fluctuation was probably due to the influence of other carcasses bought by abattoirs like mutton, lamb, and beef. As earlier stated, it would appear that the number of sheep carcasses obtained by abattoirs fluctuates the most, compared to beef and pork carcasses.

4.4. The average mass of red meat carcass bought by abattoirs during the period 2013 to 2017

Table 4.9, Figure 4.26 and Figure 4.27 represent the average mass of red meat carcasses bought by abattoirs in the period 2013 to 2017. As expected, beef carcasses (268.73 ± 9.0) were the heaviest, followed by pork (77.13 ± 31.2) and then sheep (21.96 ± 1.3). The difference in tonnage observed earlier was mainly due to this difference in mass.

Table 4.9: The average mass of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	Pork	Beef	Sheep
2013	**1**	76.15 ± 30.64	272.58 ± 23.36	20.89 ± 3.90
	2	75.13 ± 26.86	275.61 ± 22.22	21.04 ± 3.54
	3	75.69 ± 29.88	280.65 ± 21.58	21.69 ± 4.35
	4	74.99 ± 31.01	275.01 ± 22.26	22.50 ± 4.59
	All	75.50 ± 29.54	277.03 ± 22.39	21.51 ± 4.14
2014	**1**	75.31 ± 29.98	267.71 ± 24.71	21.01 ± 4.23
	2	74.25 ± 27.45	263.41 ± 22.52	21.56 ± 4.39
	3	75.00 ± 26.90	266.67 ± 23.10	23.12 ± 4.92
	4	75.51 ± 31.67	268.30 ± 22.56	22.56 ± 4.65
	All	75.02 ± 28.99	266.52 ± 23.23	22.06 ± 4.62
2015	**1**	75.74 ± 30.73	261.18 ± 24.17	21.75 ± 4.68
	2	74.05 ± 26.86	262.48 ± 20.11	21.60 ± 4.59
	3	73.33 ± 25.70	270.77 ± 17.76	21.14 ± 4.16
	4	74.47 ± 28.37	268.78 ± 18.19	21.09 ± 4.14
	All	74.40 ± 27.92	265.80 ± 20.55	21.39 ± 4.40
2016	**1**	74.69 ± 6.00	280.79 ± 50.00	21.31 ± 1.00
	2	72.92 ± 8.20	269.41 ± 4.79	21.59 ± 0.76
	3	73.12 ± 1.76	272.43 ± 4.58	23.15 ± 0.79
	4	73.27 ± 0.20	274.03 ± 14.88	22.04 ± 0.11
	All	73.51 ± 5.13	274.16 ± 25.72	22.02 ± 1.11
2017	**1**	73.68 ± 1.92	263.69 ± 3.19	22.01 ± 1.43
	2	77.26 ± 12.39	255.02 ± 20.79	23.04 ± 3.23
	3	73.65 ± 2.64	270.41 ± 3.53	23.03 ± 1.72
	4	72.61 ± 2.20	273.40 ± 3.50	23.09 ± 0.62
	All	87.14 ± 69.06	265.63 ± 12.68	22.79 ± 1.98
2013 – 2017	**All**	77.13 ± 31.24	268.73 ± 8.96	21.96 ± 1.32

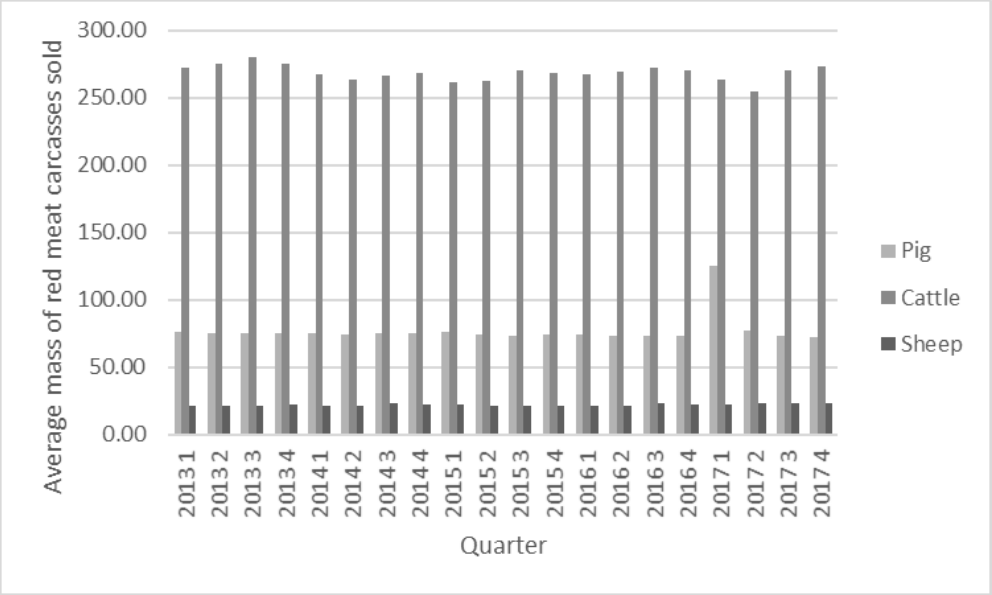

Figure 4.26: The average mass of red meat carcasses bought by abattoirs per quarter for the period 2013 to 2017

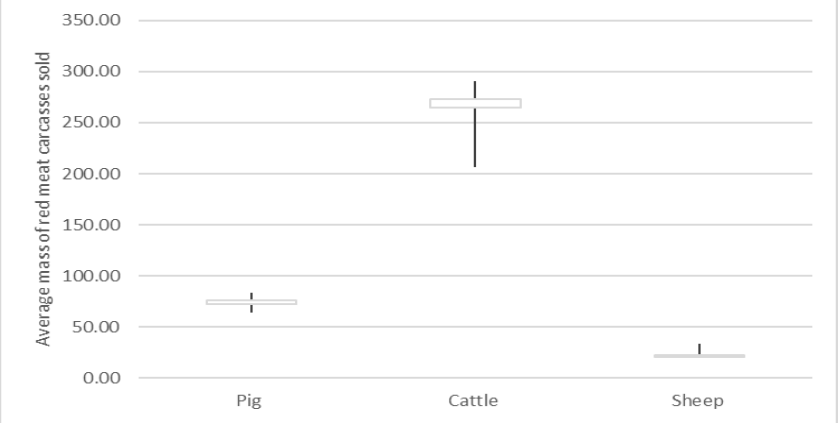

Figure 4.27: The average mass of red meat carcasses bought by abattoirs for the period 2013 to 2017

Table 4.10, Figure 4.28 and Figure 4.29 demonstrate the mean and SD of the mass of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017. During this period, sausage pigs were the heaviest carcasses (147.38 ± 20.9) and PC pork class the lightest (48.43 ± 4.8). For the Baconer class, BS pork class (83.60 ± 11.0) produced the heaviest carcasses and BP pork class the lightest carcasses (74.15 ± 4.4). For the Porker class, PR pork class was the heaviest (52.68 ± 43.5) and the PC pork class the lightest (48.43 ± 4.8). According to an ANOVA test, the differences in mass between the Baconer classes as well as between the Porker classes were NS. There were significant differences between Baconers, Porkers and Sausage pigs. Comparing these results with the tonnage (as earlier discussed), the tonnage of pork carcass classes was not due to the differences in mass.

Table 4.10: The average mass for pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	BP (mean ± SD)	BO (mean ± SD)	BR (mean ± SD)	BC (mean ± SD)	BU (mean ± SD)	BS (mean ± SD)	PP (mean ± SD)	PO (mean ± SD)	PR (mean ± SD)	PC (mean ± SD)	SAS (mean ± SD)
2013	1	75.15 ± 1.78	79.65 ± 0.89	81.27 ± 1.45	79.17 ± 5.11	78.13 ± 11.85	91.70 ± 24.27	155.32 ± 8.08	50.86 ± 1.07	51.59 ± 2.13	45.77 ± 2.82	49.07 ± 4.33
	2	76.30 ± 0.98	79.88 ± 2.20	82.31 ± 1.10	81.68 ± 3.89	77.58 ± 6.56	86.45 ± 7.09	143.24 ± 16.18	50.89 ± 1.10	48.75 ± 3.10	50.37 ± 6.51	48.95 ± 3.50
	3	75.51 ± 0.79	79.37 ± 0.90	81.94 ± 1.21	82.04 ± 2.23	74.79 ± 10.99	88.48 ± 1.57	155.42 ± 6.34	51.55 ± 1.00	48.66 ± 1.64	47.48 ± 4.99	47.31 ± 6.57
	4	67.89 ± 0.82	72.10 ± 0.92	73.11 ± 4.27	72.16 ± 3.17	69.56 ± 10.07	81.05 ± 3.35	147.16 ± 12.05	46.36 ± 1.73	44.40 ± 2.78	42.20 ± 4.97	45.45 ± 3.23
	All	75.15 ± 1.51	79.28 ± 1.48	81.22 ± 2.56	80.31 ± 4.00	76.49 ± 9.87	88.63 ± 12.66	153.23 ± 12.55	50.89 ± 1.30	49.30 ± 2.76	47.36 ± 5.21	48.63 ± 4.55
2014	1	73.79 ± 1.49	79.21 ± 1.03	82.85 ± 1.21	79.50 ± 4.68	73.34 ± 3.50	89.01 ± 1.89	155.93 ± 9.13	51.16 ± 1.69	48.04 ± 3.73	48.03 ± 3.36	47.52 ± 7.25
	2	76.31 ± 1.05	81.20 ± 1.11	84.56 ± 0.99	79.52 ± 4.99	71.72 ± 10.09	80.98 ± 11.07	145.52 ± 10.16	48.82 ± 7.48	49.21 ± 2.21	49.70 ± 4.21	49.18 ± 3.02
	3	76.70 ± 1.39	81.65 ± 1.41	83.88 ± 1.70	75.37 ± 5.83	76.95 ± 11.48	85.79 ± 6.03	144.26 ± 13.02	50.75 ± 2.11	49.80 ± 2.16	49.48 ± 4.91	50.35 ± 1.03
	4	74.11 ± 1.05	77.70 ± 2.27	80.70 ± 3.55	76.88 ± 6.76	74.72 ± 14.05	87.88 ± 4.50	162.73 ± 5.85	49.95 ± 1.84	50.40 ± 2.18	49.21 ± 4.92	46.30 ± 3.04
	All	75.23 ± 1.79	79.94 ± 2.19	83.00 ± 2.53	77.82 ± 5.74	74.18 ± 10.40	85.92 ± 7.26	152.11 ± 12.29	50.17 ± 4.06	49.36 ± 2.72	49.10 ± 4.31	48.34 ± 4.40
2015	1	74.07 ± 1.31	79.97 ± 0.75	82.91 ± 1.18	77.62 ± 4.35	75.03 ± 8.32	87.34 ± 3.69	159.85 ± 8.30	51.03 ± 1.27	50.77 ± 2.22	46.98 ± 1.73	47.63 ± 2.90
	2	75.85 ± 0.87	81.51 ± 0.88	84.02 ± 0.92	75.48 ± 2.89	71.47 ± 2.52	86.73 ± 4.11	144.02 ± 8.83	50.68 ± 0.85	50.00 ± 1.47	45.81 ± 1.54	49.01 ± 1.56
	3	76.95 ± 0.89	81.65 ± 0.81	82.15 ± 6.47	72.52 ± 5.39	76.16 ± 11.07	83.37 ± 7.73	138.13 ± 9.47	49.67 ± 2.58	51.78 ± 2.20	48.01 ± 3.92	46.27 ± 2.48
	4	74.40 ± 1.51	79.16 ± 2.37	81.55 ± 3.46	75.19 ± 4.45	75.12 ± 8.53	86.49 ± 26.84	146.46 ± 10.72	51.31 ± 3.77	52.82 ± 5.83	48.42 ± 7.94	48.26 ± 7.03
	All	74.77 ± 1.63	79.4 ± 1.71	82.53 ± 3.75	77.61 ± 4.61	73.53 ± 8.18	84.18 ± 13.90	133.43± 12.13	72.79 ± 2.42	50.81 ± 3.38	48.25 ± 4.55	48.22 ± 4.08
2016	1	73.13 ± 0.85	77.11 ± 9.00	75.84 ± 1.13	75.81 ± 2.26	75.81 ± 6.11	75.83 ± 7.80	171.34 ± 67.55	49.52 ± 1.15	50.38 ± 1.54	48.62 ± 2.32	48.18 ± 4.27
	2	73.17 ± 3.50	75.32 ± 4.57	78.98 ± 8.30	75.93 ± 1.87	75.81 ± 4.49	59.15 ± 2.23	135.89 ± 16.69	48.22 ± 1.33	47.26 ± 1.89	67.75 ± 79.96	36.63 ± 3.83
	3	74.10 ± 0.63	76.17 ± 0.89	76.43 ± 1.32	76.29 ± 2.20	68.85 ± 4.14	49.59 ± 9.04	145.36 ± 7.27	51.67 ± 2.03	50.51 ± 2.41	48.40 ± 3.05	41.99 ± 3.11
	4	73.98 ± 0.13	71.56 ± 0.10	78.52 ± 0.61	73.98 ± 0.28	74.71 ± 1.45	78.80 ± 1.52	148.73 ± 2.67	50.12 ± 0.59	50.63 ± 0.52	52.49 ± 2.40	46.85 ± 0.38
	All	73.60 ± 1.83	76.51 ± 5.04	77.44 ± 4.34	75.50 ± 2.00	75.24 ± 4.29	77.81 ± 5.92	150.33 ± 36.41	49.89 ± 1.83	49.69 ± 2.20	54.31 ± 39.66	47.03 ± 3.88
2017	1	72.46 ± 1.02	74.26 ± 0.75	75.87 ± 1.10	75.68 ± 1.62	74.38 ± 3.15	78.79 ± 7.29	152.99 ± 13.76	52.56 ± 0.78	51.98 ± 1.09	49.57 ± 2.41	49.78 ± 2.67
	2	68.13 ± 19.32	71.35 ± 20.82	70.25 ± 19.97	68.97 ± 19.51	70.34 ± 20.85	78.95 ± 21.05	136.70 ± 35.86	49.26 ± 13.97	48.75 ± 13.75	52.96 ± 135.83	46.62 ± 13.23
	3	70.11 ± 14.63	72.14 ± 14.80	73.10 ± 15.31	70.63 ± 14.82	71.34 ± 14.81	79.57 ± 18.23	129.02 ± 29.65	50.02 ± 10.47	49.54 ± 10.38	55.69 ± 23.20	47.42 ± 10.35
	4	74.10 ± 0.62	76.30 ± 0.66	77.86 ± 3.36	75.62 ± 2.30	76.56 ± 5.17	79.98 ± 9.58	134.08 ± 17.16	58.64 ± 26.55	49.00 ± 1.51	48.33 ± 2.66	49.37 ± 4.26
	All	74.15 ± 4.44	77.78 ± 5.44	79.36 ± 5.90	76.23 ± 5.83	75.01 ± 8.31	83.60 ± 11.04	147.38 ± 20.91	51.58 ± 8.70	50.26 ± 3.80	52.68 ± 43.47	48.43 ± 4.83
2013 – 2017	All	74.15 ± 4.44	77.78 ± 5.44	79.36 ± 5.90	76.23 ± 5.83	75.01 ± 8.31	83.60 ± 11.04	147.38 ± 20.91	51.58 ± 8.70	50.26 ± 3.80	52.68 ± 43.47	48.43 ± 4.83

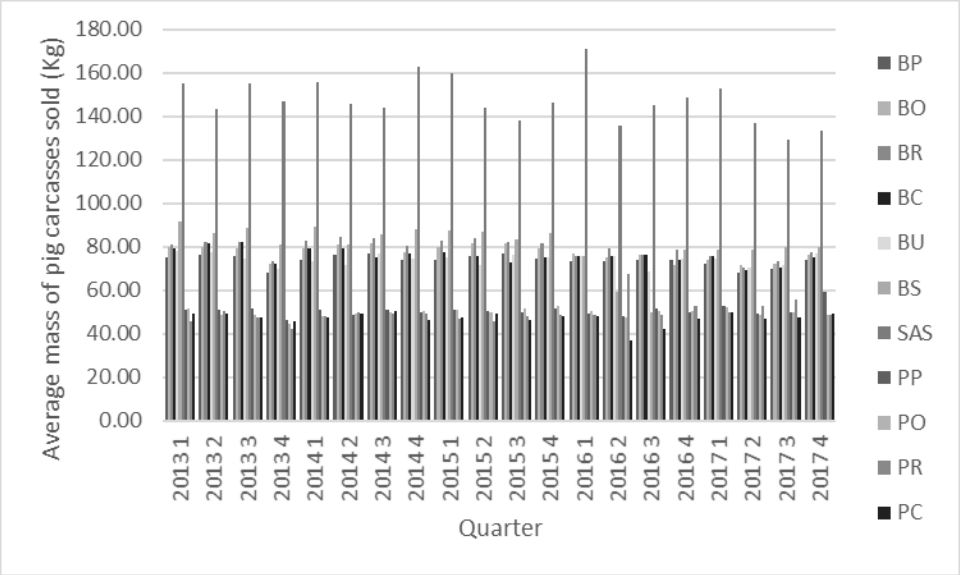

Figure 4.28: The average mass of pork carcass classes bought by abattoirs per quarter for the period 2013 to 2017

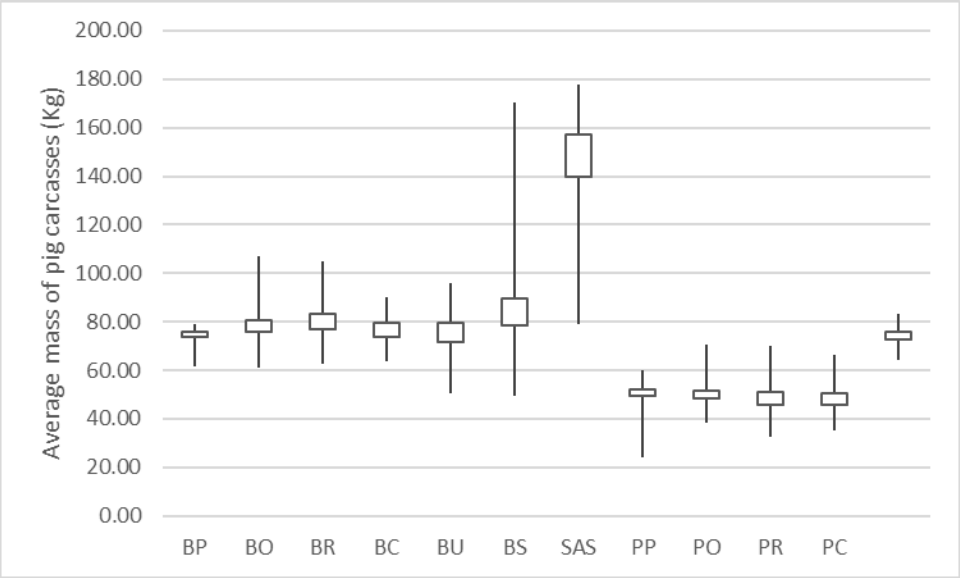

Figure 4.29: The average mass of pork carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.11, Figure 4.30 and Figure 4.31 illustrate the mean and SD of beef carcass classes bought by abattoirs in the period 2013 to 2017. Carcass classes C3 (287.04 ± 13.7) and AB3 (287.20 ± 17.1) were the heaviest carcasses, followed by B3 (285.49 ± 19.6). Comparing these results with the tonnage (discussed earlier), the tonnage of beef carcass classes was not due to the differences in mass.

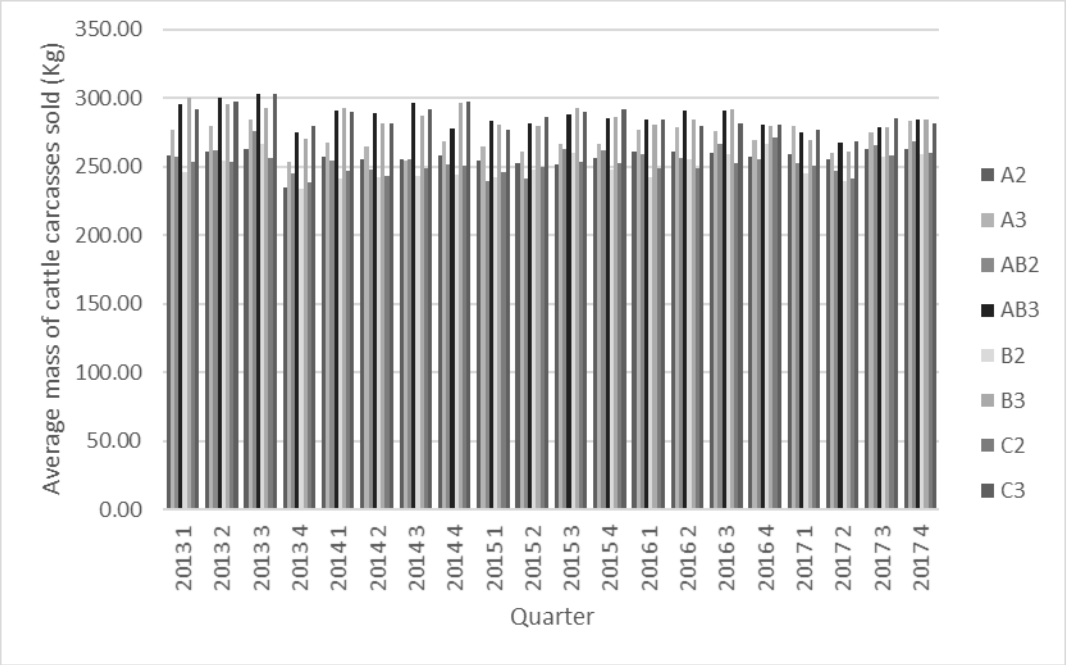

Figure 4.30: The average mass of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

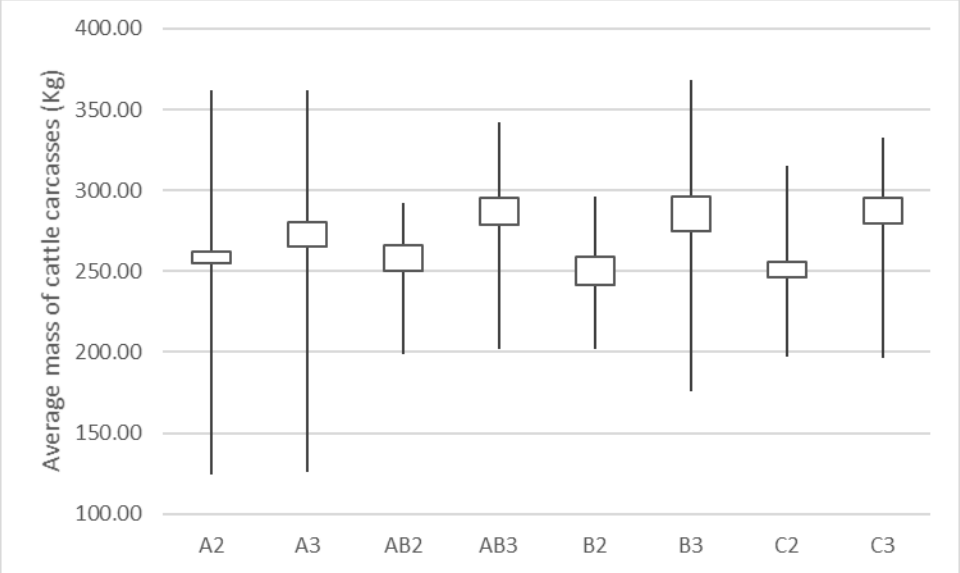

Figure 4.31: The average mass of beef carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.11: The average mass of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A2 (mean ± SD)	A3 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	258.61 ± 4.25	276.61 ± 5.98	257.33 ± 9.86	296.06 ± 16.16	246.39 ± 17.91	300.08 ± 19.15	253.80 ± 8.60	291.78 ± 9.48
	2	260.98 ± 5.75	279.49 ± 5.41	262.47 ± 13.75	300.39 ± 19.63	254.90 ± 15.57	295.71 ± 17.23	253.78 ± 3.41	297.17 ± 5.18
	3	263.00 ± 5.41	284.41 ± 6.01	276.32 ± 10.83	303.07 ± 19.66	266.54 ± 14.76	292.88 ± 24.90	256.16 ± 4.77	302.79 ± 9.54
	4	234.89 ± 3.65	253.93 ± 7.45	244.87 ± 10.27	275.16 ± 15.08	233.72 ± 11.50	270.51 ± 21.60	238.25 ± 6.65	279.53 ± 7.75
	All	259.36 ± 5.68	278.97 ± 7.02	265.35 ± 13.04	299.43 ± 17.46	255.30 ± 16.47	295.48 ± 20.48	255.41 ± 6.24	298.56 ± 9.19
2014	1	257.14 ± 11.04	267.21 ± 7.34	254.51 ± 12.71	290.89 ± 10.51	241.80 ± 9.90	292.75 ± 29.97	247.16 ± 10.25	290.23 ± 19.63
	2	255.52 ± 7.83	264.96 ± 6.19	247.75 ± 8.08	289.37 ± 34.66	242.87 ± 6.41	281.53 ± 14.05	243.76 ± 4.92	281.54 ± 8.36
	3	255.32 ± 7.74	254.19 ± 9.16	255.44 ± 16.28	297.07 ± 17.55	243.52 ± 7.25	286.88 ± 11.96	249.11 ± 9.15	291.85 ± 9.66
	4	258.03 ± 3.27	268.72 ± 28.38	251.60 ± 5.66	278.37 ± 8.11	244.64 ± 2.92	296.36 ± 11.27	250.65 ± 1.65	297.99 ± 6.17
	All	256.50 ± 7.81	263.77 ± 16.24	252.32 ± 11.51	288.93 ± 21.05	243.21 ± 6.94	289.38 ± 18.81	247.67 ± 7.58	290.41 ± 13.16
2015	1	254.65 ± 9.58	265.02 ± 13.57	240.04 ± 13.93	283.35 ± 11.45	242.22 ± 17.30	280.73 ± 33.25	245.97 ± 19.23	277.44 ± 14.76
	2	252.26 ± 7.82	261.18 ± 5.98	241.86 ± 7.27	281.69 ± 12.94	248.02 ± 17.69	279.39 ± 20.43	249.54 ± 7.50	285.91 ± 8.88
	3	251.49 ± 4.57	267.07 ± 4.41	263.11 ± 8.23	287.82 ± 13.05	259.79 ± 7.75	293.27 ± 6.87	253.57 ± 7.52	290.01 ± 8.22
	4	256.66 ± 4.14	267.01 ± 14.21	261.85 ± 6.62	285.76 ± 11.00	248.39 ± 7.86	286.48 ± 13.55	252.53 ± 3.71	291.52 ± 5.94
	All	209.23 ± 7.01	261.18 ± 10.47	252.70 ± 14.25	278.48 ± 12.01	256.61 ± 14.63	276.60 ± 21.05	260.33 ± 11.21	277.11 ± 11.16
2016	1	261.23 ± 2.05	277.21 ± 3.59	258.90 ± 6.05	269.45 ± 52.90	261.67 ± 68.13	263.76 ± 66.96	369.33 ± 433.48	284.75 ± 19.04
	2	261.31 ± 3.80	278.44 ± 2.80	256.54 ± 7.92	290.63 ± 10.63	255.20 ± 14.69	284.63 ± 13.41	248.53 ± 4.94	279.97 ± 4.93
	3	260.08 ± 3.00	276.36 ± 5.33	266.44 ± 4.75	291.25 ± 9.89	258.94 ± 8.56	292.24 ± 12.97	252.42 ± 2.95	281.73 ± 11.75
	4	257.06 ± 0.23	269.66 ± 2.14	255.54 ± 1.23	280.54 ± 2.52	297.29 ± 119.89	279.87 ± 1.44	271.74 ± 8.18	280.54 ± 0.63
	All	259.92 ± 3.09	275.42 ± 4.95	259.35 ± 6.90	282.97 ± 28.11	268.27 ± 69.52	280.12 ± 35.33	285.51 ± 216.11	281.75 ± 11.27
2017	1	259.09 ± 3.80	279.91 ± 5.82	252.76 ± 6.20	275.09 ± 11.13	245.35 ± 10.74	269.15 ± 9.32	250.79 ± 6.09	277.41 ± 6.86
	2	255.79 ± 49.08	259.76 ± 42.74	247.07 ± 22.78	267.60 ± 24.09	239.19 ± 13.78	260.89 ± 27.94	241.28 ± 14.08	268.55 ± 22.46
	3	263.10 ± 2.49	274.88 ± 7.73	265.81 ± 5.16	278.74 ± 7.10	257.15 ± 6.17	279.09 ± 9.41	258.62 ± 4.96	285.87 ± 6.08
	4	263.40 ± 4.75	283.80 ± 3.76	268.70 ± 3.80	284.78 ± 8.59	259.24 ± 7.63	284.69 ± 8.65	260.54 ± 17.37	282.04 ± 7.81
	All	260.35 ± 24.23	274.59 ± 23.24	258.59 ± 14.92	276.55 ± 15.31	250.23 ± 12.83	273.45 ± 18.10	252.81 ± 13.82	278.47 ± 13.98
2013 – 2017	All	257.97 ± 12.34	271.53 ± 15.21	257.43 ± 13.34	287.20 ± 17.06	250.83 ± 13.88	285.49 ± 19.55	252.32 ± 10.69	287.04 ± 13.72

Table 4.12, Figure 4.32 and Figure 4.33 show the average mass of sheep carcass classes bought by abattoirs in the period 2013 to 2017. Carcass class B3 (27.45 ± 2.4) was the heaviest followed by C3 (27.13 ± 2.1). The carcass class A0 (13.51 ± 1.1) was the lightest as expected. Comparing these results with the tonnage (discussed earlier), the tonnage of sheep carcass classes was not due to the differences in mass.

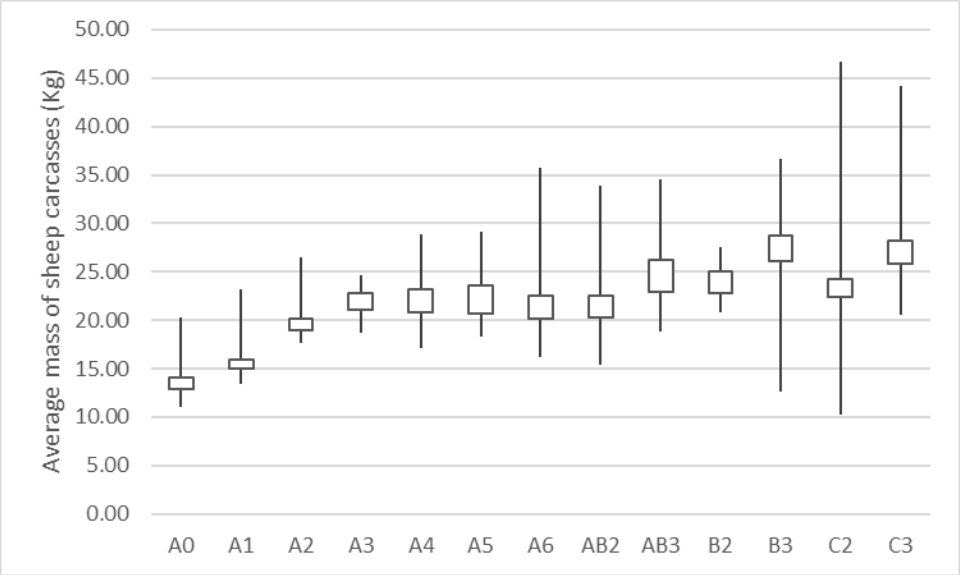

Figure 4.32: The average mass of sheep carcass classes for the period 2013 to 2017

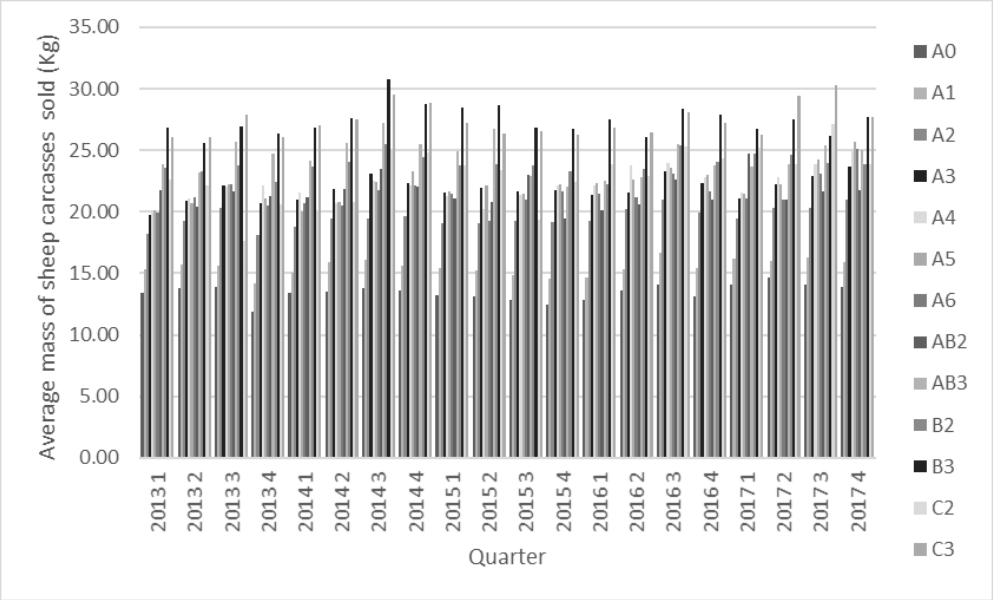

Figure 4.33: The average mass of sheep carcass classes per quarter for the period 2013 to 2017

Table 4.12: The average mass of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A0 (mean ± SD)	A1 (mean ± SD)	A2 (mean ± SD)	A3 (mean ± SD)	A4 (mean ± SD)	A5 (mean ± SD)	A6 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	13.38 ± 0.58	15.36 ± 0.62	18.25 ± 0.34	19.72 ± 0.43	19.99 ± 0.47	20.16 ± 0.57	19.92 ± 0.93	21.73 ± 1.70	23.83 ± 1.51	23.58 ± 2.23	26.86 ± 1.62	22.64 ± 1.26	26.10 ± 1.18
	2	13.83 ± 1.01	15.69 ± 0.28	19.26 ± 0.75	20.93 ± 1.33	21.10 ± 1.69	20.74 ± 0.95	21.18 ± 1.12	20.45 ± 1.34	23.23 ± 1.96	23.24 ± 1.16	25.61 ± 1.88	22.14 ± 1.55	26.09 ± 0.73
	3	13.92 ± 1.89	15.57 ± 0.75	20.30 ± 0.60	22.13 ± 0.93	22.09 ± 0.94	22.23 ± 1.09	22.21 ± 0.70	21.66 ± 0.92	25.74 ± 1.61	23.73 ± 1.17	26.89 ± 1.52	17.65 ± 5.27	27.92 ± 1.20
	4	11.85 ± 0.86	14.21 ± 0.46	18.13 ± 0.80	20.67 ± 1.15	22.13 ± 1.62	21.11 ± 1.82	20.47 ± 2.55	21.26 ± 1.25	24.69 ± 1.11	22.45 ± 1.21	26.35 ± 1.10	20.57 ± 1.71	26.11 ± 1.98
	All	13.50 ± 1.23	15.50 ± 0.56	19.36 ± 0.98	21.27 ± 1.45	21.75 ± 1.91	21.47 ± 1.58	21.36 ± 1.72	21.69 ± 1.58	24.85 ± 2.09	23.71 ± 1.52	26.95 ± 1.84	21.16 ± 3.55	27.07 ± 1.64
2014	1	13.42 ± 0.90	14.99 ± 0.55	18.78 ± 0.47	20.97 ± 1.18	21.52 ± 1.82	20.04 ± 1.34	20.70 ± 1.37	21.17 ± 0.88	24.15 ± 2.05	23.65 ± 1.34	26.82 ± 1.33	19.91 ± 4.61	27.03 ± 2.62
	2	13.50 ± 0.81	15.95 ± 2.22	19.46 ± 0.37	21.84 ± 0.87	20.66 ± 0.96	20.82 ± 0.96	20.55 ± 1.01	21.82 ± 2.35	25.61 ± 3.24	24.10 ± 1.19	27.63 ± 2.18	20.77 ± 4.30	27.56 ± 1.84
	3	13.75 ± 0.61	16.05 ± 1.55	19.46 ± 0.31	23.10 ± 0.80	22.50 ± 1.94	22.47 ± 1.68	21.77 ± 1.76	23.52 ± 2.23	27.20 ± 2.95	25.53 ± 1.23	30.77 ± 2.05	24.94 ± 1.03	29.51 ± 1.57
	4	13.62 ± 0.58	15.61 ± 0.46	19.67 ± 2.18	22.30 ± 1.35	22.15 ± 2.45	23.31 ± 2.71	22.17 ± 4.11	22.09 ± 1.52	25.53 ± 1.67	24.42 ± 1.71	28.76 ± 1.37	24.81 ± 0.83	28.83 ± 1.60
	All	13.57 ± 0.73	15.65 ± 1.42	19.34 ± 1.16	22.05 ± 1.30	21.71 ± 1.95	21.66 ± 2.18	21.30 ± 2.42	22.15 ± 1.99	25.62 ± 2.71	24.43 ± 1.51	28.49 ± 2.28	22.61 ± 3.89	28.23 ± 2.14
2015	1	13.21 ± 0.84	15.39 ± 0.60	19.05 ± 0.31	21.53 ± 1.28	21.24 ± 1.80	21.61 ± 2.92	21.44 ± 4.72	21.08 ± 2.35	24.94 ± 2.72	23.77 ± 1.68	28.50 ± 3.65	23.73 ± 1.28	27.24 ± 2.42
	2	13.12 ± 0.83	15.23 ± 0.41	19.11 ± 0.39	21.97 ± 0.92	20.18 ± 1.91	22.11 ± 2.38	19.24 ± 1.35	20.82 ± 1.55	26.77 ± 2.97	23.84 ± 1.50	28.63 ± 3.57	23.37 ± 0.59	26.39 ± 0.89
	3	12.87 ± 0.99	14.90 ± 0.84	19.29 ± 0.41	21.66 ± 0.50	21.33 ± 0.86	21.47 ± 1.09	20.95 ± 1.20	22.96 ± 3.76	22.91 ± 0.82	23.77 ± 0.78	26.87 ± 0.95	19.33 ± 3.72	26.52 ± 1.02
	4	12.43 ± 0.72	14.60 ± 0.70	19.15 ± 0.61	21.76 ± 0.65	22.12 ± 1.48	22.20 ± 2.50	21.66 ± 2.22	19.43 ± 1.66	22.08 ± 1.12	23.31 ± 1.21	26.73 ± 1.77	22.46 ± 2.50	26.25 ± 1.18
	All	77.38 ± 0.88	14.52 ± 0.71	18.05 ± 0.44	21.14 ± 0.88	21.30 ± 1.67	21.81 ± 2.28	20.95 ± 2.85	20.57 ± 2.73	24.19 ± 2.77	23.46 ± 1.32	26.90 ± 2.81	24.11 ± 2.87	24.81 ± 1.51
2016	1	12.83 ± 0.86	14.62 ± 0.59	19.30 ± 0.53	21.35 ± 0.84	22.10 ± 1.40	22.37 ± 2.08	21.45 ± 2.18	20.08 ± 0.85	22.50 ± 0.98	22.25 ± 0.89	27.52 ± 5.23	23.86 ± 4.88	26.84 ± 4.65
	2	13.58 ± 1.21	15.35 ± 0.87	20.19 ± 0.70	21.60 ± 0.57	23.74 ± 5.84	22.66 ± 1.19	21.15 ± 1.35	20.62 ± 1.07	22.85 ± 1.87	23.46 ± 1.14	26.09 ± 1.38	22.90 ± 0.69	26.48 ± 5.45
	3	14.10 ± 0.78	16.71 ± 0.57	20.96 ± 0.61	23.29 ± 0.86	23.93 ± 1.45	23.55 ± 1.26	23.05 ± 2.56	22.62 ± 1.32	25.49 ± 2.05	25.37 ± 1.34	28.38 ± 1.28	25.34 ± 0.88	28.08 ± 1.02
	4	13.16 ± 0.02	15.41 ± 0.23	19.96 ± 0.08	22.35 ± 0.05	22.79 ± 0.05	22.97 ± 0.09	21.62 ± 0.06	21.00 ± 0.21	23.73 ± 0.16	24.02 ± 0.47	27.89 ± 0.04	24.33 ± 0.41	27.25 ± 0.37
	All	13.42 ± 0.95	15.52 ± 0.96	20.10 ± 0.79	22.15 ± 1.00	23.14 ± 3.09	22.89 ± 1.39	21.82 ± 1.91	21.08 ± 1.33	23.64 ± 1.85	23.77 ± 1.50	27.47 ± 2.83	24.11 ± 2.59	27.16 ± 3.57
2017	1	14.06 ± 1.46	16.23 ± 1.22	19.48 ± 0.71	21.06 ± 0.86	21.52 ± 1.35	21.46 ± 1.24	21.06 ± 1.38	20.88 ± 1.23	23.64 ± 2.10	24.68 ± 1.69	26.70 ± 1.66	25.21 ± 6.54	26.27 ± 1.33
	2	13.74 ± 3.99	14.90 ± 4.02	18.95 ± 5.30	20.63 ± 5.77	21.02 ± 5.78	20.75 ± 5.85	19.29 ± 5.35	19.43 ± 5.45	22.15 ± 6.05	22.96 ± 6.22	25.54 ± 7.10	22.63 ± 4.68	24.41 ± 6.72
	3	13.21 ± 2.73	15.39 ± 3.29	19.15 ± 4.01	21.53 ± 4.57	22.76 ± 4.95	22.93 ± 5.21	22.18 ± 5.09	20.43 ± 4.44	24.12 ± 5.59	22.57 ± 4.80	24.79 ± 6.62	22.59 ± 5.39	25.60 ± 5.88
	4	13.97 ± 1.10	15.97 ± 1.11	20.94 ± 0.65	23.63 ± 0.63	24.96 ± 1.06	25.48 ± 1.92	24.74 ± 2.86	21.82 ± 1.13	25.01 ± 1.98	24.08 ± 1.51	27.80 ± 2.33	24.03 ± 0.75	27.85 ± 0.93
	All	14.16 ± 1.37	16.10 ± 0.94	20.28 ± 0.81	22.45 ± 1.22	23.33 ± 1.74	23.44 ± 2.31	22.56 ± 2.57	22.26 ± 7.00	24.49 ± 2.15	24.29 ± 1.39	27.03 ± 2.79	25.02 ± 6.09	30.93 ± 20.59
2013 – 2017	All	13.51 ± 1.12	15.56 ± 1.02	19.65 ± 0.98	21.93 ± 1.24	22.16 ± 1.89	22.27 ± 2.11	21.57 ± 2.39	21.46 ± 1.90	24.55 ± 2.42	23.97 ± 1.47	27.45 ± 2.37	22.81 ± 3.30	27.13 ± 2.11

4.5. The average purchase price of red meat carcass bought by abattoirs during the period 2013 to 2017

Commodity prices, in general, are highly volatile; this volatility increases the risk of paying higher prices for a specific commodity. For various reasons, commodity prices, specifically agricultural prices, have significant fluctuations in both domestic and international markets. The market for agricultural products, where supply and demand are inelastic, is characterised by substantial changes in price. Agricultural prices are structurally prone to fluctuations because of short-term inelasticity of supply and demand for the products. Production of agricultural commodities is fixed in the short-term and is highly dependent on production conditions on the farm, which could vary significantly from year to year. This in return, could create periods of under-supply or over-supply. The supply of agricultural

commodities within a given crop year or production cycle is seasonal. Crops are abundant at harvest, and supply falls during the remainder of the year. Animal production, though more continues, is also predisposed to production cycles due to animal birth rates and feeding schedules (Geyser & Cutts, 2007; Jordaan & Grové, 2007; Monk *et al.*, 2010).

Table 4.13, Figure 4.34 and Figure 4.35 represent the average purchase price of red meat carcasses in the period 2013 to 2017. During this period, sheep carcasses (47.24 ± 9.1) cost the most, followed by beef (32.64 ± 6.5) and then pork (21.04 ± 3.0). There were quarterly influences on the average purchase price of red meat bought by abattoirs and purchase price increased yearly. The difference between the prices of different red meat was mainly due to the differences in the cost of production per animal (Maree & Casey, 1993). Stotts (2013) indicated that beef carcasses prices are higher than pork carcasses prices.

According to Davids *et al.* (2013), the pig production systems do not allow pigs to stay at the farm longer than market age. Therefore, the price that is offered is the price the farmer/producer must accept. Whereas with cattle and sheep, the farmer could hold the animals back until the market price is better for the farmer/producer. According to the same authors, the constraints that are experienced in the pork value chain are due to the following factors: national infrastructure, political climate, costs and regulations of labour, labour productivity, administration costs, and building costs. According to Lusk & Tonsor (2016), low beef and pork prices are incentivising producers to hold back breeding stock until the price increases. According to the same authors, the price of pork would start decreasing before that of beef, due to a shorter production cycle of pigs. Global trends and prices also play a role in the price of products including meat prices in South Africa (Davids *et al.*, 2013) as well as bans on meats from and to other countries that would influence the price (Stotts 2013). A prohibition of a specific meat product to a country would cause a surplus in the country of origin and an export ban from a country would also cause a surplus of that product in the export country, therefore creating a price decrease in the country with the surplus. According to McCarthy *et al.*, (2003) and McCarthy *et al.*, (2004), the disease status of the country would influence the price of meat, because this would influence the import and export of the meat. This statement is supported by Verbeke & Ward (2001), who stated that disease status could have a negative influence on meat prices.

According to Green *et al.* (2013), changes in global food prices would have a more significant effect on food consumption in lower-income countries and poorer households within a country. In poorer income countries and households, a decrease in demand for the product would occur when global food prices increase.

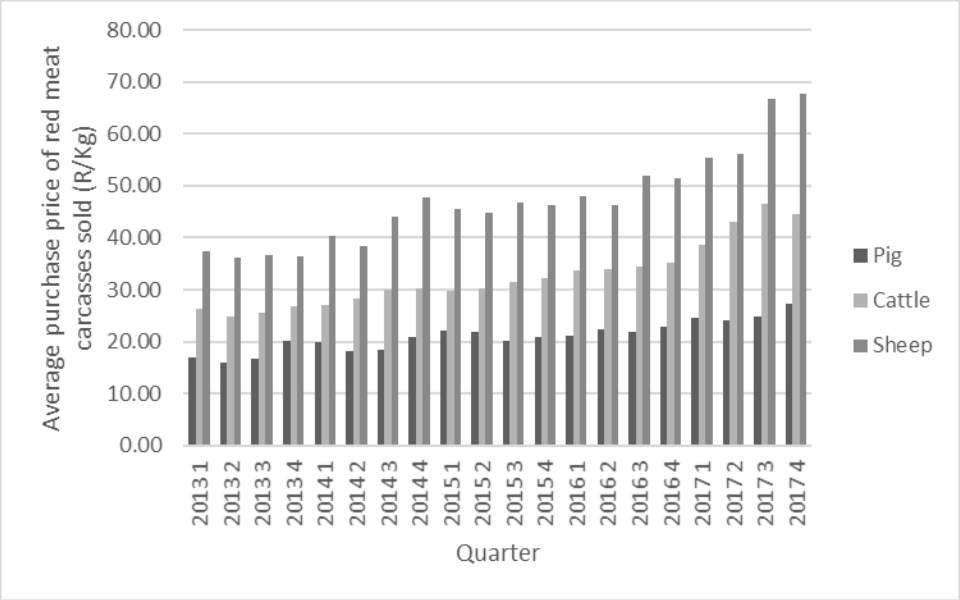

Figure 4.34: The average purchase prices of red meat carcasses by abattoir per quarter for the period 2013 to 2017

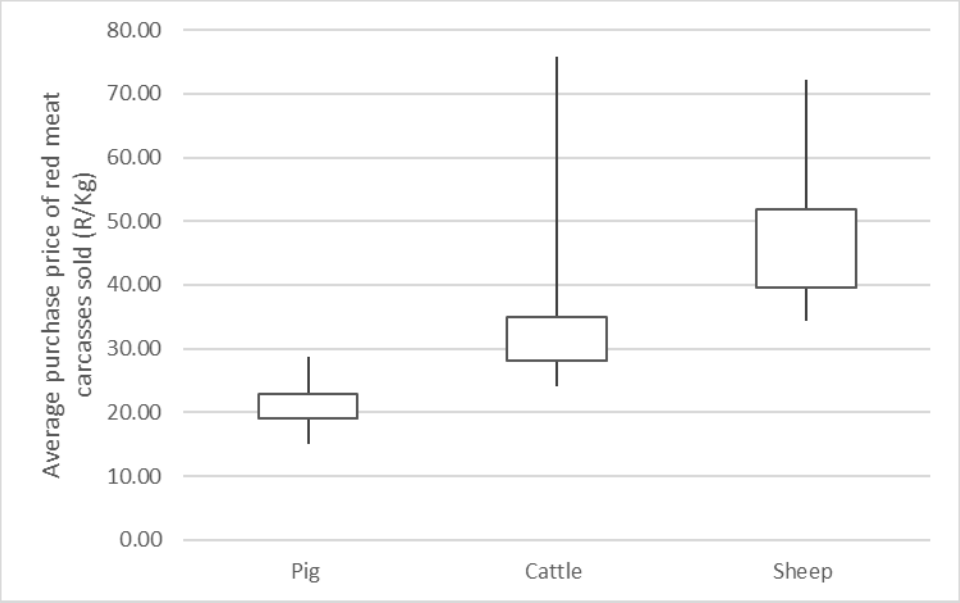

Figure 4.35: The average purchase prices of red meat carcasses by abattoirs for the period 2013 to 2017

Table 4.13: The average purchase price of carcasses by abattoir per quarter for the period 2013 to 2017

	Quarter	Pork (mean ± SD)	Beef (mean ± SD)	Sheep (mean ± SD)
2013	**1**	16.86 ± 1.08	26.40 ± 1.41	37.41 ± 1.49
	2	15.90 ± 0.35	24.82 ± 0.39	36.25 ± 0.71
	3	16.73 ± 0.68	25.62 ± 0.72	36.66 ± 0.76
	4	20.11 ± 0.73	26.89 ± 0.41	36.32 ± 1.29
	All	17.35 ± 1.75	25.53 ± 1.14	36.67 ± 1.17
2014	**1**	19.82 ± 0.87	26.95 ± 0.86	40.29 ± 1.19
	2	18.22 ± 0.92	28.23 ± 0.64	38.25 ± 1.27
	3	18.28 ± 0.59	29.97 ± 1.09	44.07 ± 1.35
	4	20.93 ± 1.22	30.13 ± 0.55	47.67 ± 2.10
	All	19.31 ± 1.45	28.82 ± 1.54	42.57 ± 3.93
2015	**1**	22.15 ± 0.45	29.72 ± 0.72	45.52 ± 2.34
	2	21.84 ± 0.53	30.31 ± 0.25	44.69 ± 1.19
	3	20.16 ± 0.68	31.46 ± 0.61	46.86 ± 1.46
	4	20.85 ± 0.68	32.28 ± 0.63	46.26 ± 1.19
	All	21.25 ± 0.98	30.68 ± 1.15	45.65 ± 1.77
2016	**1**	21.16 ± 0.50	33.61 ± 1.38	47.91 ± 2.34
	2	22.25 ± 2.06	33.82 ± 0.39	46.23 ± 1.61
	3	21.80 ± 0.57	34.47 ± 0.47	52.00 ± 1.89
	4	22.86 ± 0.34	54.62 ± 0.28	51.55 ± 0.53
	All	22.02 ± 1.26	39.13 ± 0.98	49.42 ± 2.97
2017	**1**	24.60 ± 0.85	38.59 ± 1.59	55.45 ± 1.96
	2	24.07 ± 0.56	42.96 ± 0.94	56.07 ± 3.86
	3	24.76 ± 0.79	46.44 ± 8.84	66.75 ± 2.06
	4	27.22 ± 0.80	44.42 ± 1.20	67.75 ± 2.72
	All	25.16 ± 1.43	43.10 ± 5.29	61.50 ± 6.40
2013 – 2017	**All**	21.04 ± 2.98	32.64 ± 6.46	47.24 ± 9.09

The average purchase price of pork carcass class bought by abattoirs per quarter for the period 2013 to 2017 appears in Table 4.14, Figure 4.36 and Figure 4.37. On average, the PP pork class (24.15 ± 3.5) had the highest purchase price (R/kg) followed by the PO pork class (23.83 ± 3.6), BP (22.95 ± 3.1) and BO (22.94 ± 3.1) pork classes, whereas Sausage pigs (16.01 ± 2.5) and BS Pork class (17.54 ± 3.6) had the lowest. The ANOVA test indicated that all the purchase prices differed significantly from each other. Figure 4.38 is a graphical representation of the average purchase price of pork carcass classes bought by abattoirs for the period 2013 to 2017. Each year during the first and second quarters, the purchase price decreased and increased during the third and fourth quarters. It increased overall from 2013 to 2017. The differences in the prices were mainly due to the differences in demand for the different carcass classes (Labuschagne *et al.,* 2011; Delport *et al.*, 2017).

Table 4.14: The average purchase price of pork carcass class by abattoir per quarter for the period 2013 to 2017

	Quarter	BP (mean ± SD)	BO (mean ± SD)	BR (mean ± SD)	BC (mean ± SD)	BU (mean ± SD)	BS (mean ± SD)	SAS (mean ± SD)	PP (mean ± SD)	PO (mean ± SD)	PR (mean ± SD)	PC (mean ± SD)
2013	1	18.40 ± 1.22	18.80 ± 1.12	18.30 ± 1.10	17.38 ± 1.50	16.00 ± 2.77	13.11 ± 1.64	12.59 ± 0.93	19.55 ± 1.27	19.28 ± 1.47	18.53 ± 1.42	13.49 ± 1.89
	2	17.69 ± 0.25	17.73 ± 0.13	17.01 ± 0.11	15.24 ± 1.19	13.98 ± 0.77	12.58 ± 0.64	11.78 ± 0.55	18.72 ± 0.28	18.29 ± 0.50	16.72 ± 0.79	15.14 ± 2.40
	3	18.50 ± 0.74	18.47 ± 0.78	17.88 ± 0.82	16.30 ± 1.12	15.12 ± 1.91	13.66 ± 1.09	12.43 ± 0.61	19.51 ± 1.17	18.97 ± 0.84	17.66 ± 0.89	15.58 ± 2.08
	4	20.40 ± 0.74	20.04 ± 0.72	19.52 ± 0.71	18.04 ± 0.97	17.92 ± 0.97	16.05 ± 0.97	13.42 ± 0.67	20.71 ± 1.56	21.07 ± 0.99	19.50 ± 1.39	17.53 ± 2.44
	All	19.12 ± 1.88	19.13 ± 1.68	18.54 ± 1.71	17.07 ± 1.97	16.06 ± 2.67	14.12 ± 2.17	12.80 ± 1.23	20.01 ± 1.80	19.78 ± 2.00	18.46 ± 1.98	15.74 ± 2.92
2014	1	22.01 ± 0.44	21.83 ± 0.27	21.17 ± 0.25	20.21 ± 0.45	17.91 ± 2.33	15.60 ± 1.83	14.67 ± 0.55	21.70 ± 0.42	22.38 ± 1.29	20.95 ± 2.17	19.57 ± 2.36
	2	20.73 ± 0.69	20.89 ± 0.55	20.22 ± 0.76	18.93 ± 1.41	15.51 ± 2.93	13.85 ± 0.84	14.19 ± 0.44	21.36 ± 0.39	20.48 ± 0.76	17.95 ± 2.82	16.35 ± 3.17
	3	19.76 ± 0.94	19.72 ± 0.87	18.97 ± 0.55	19.49 ± 1.22	16.55 ± 1.61	14.81 ± 1.12	14.24 ± 0.62	21.56 ± 0.63	20.76 ± 1.35	18.64 ± 1.71	16.58 ± 0.28
	4	23.33 ± 0.93	22.95 ± 1.19	21.69 ± 1.28	20.95 ± 1.63	20.28 ± 1.20	17.62 ± 1.21	17.01 ± 0.95	24.72 ± 1.27	24.58 ± 1.27	19.27 ± 3.75	17.82 ± 1.24
	All	21.46 ± 1.55	21.35 ± 1.43	20.51 ± 1.30	19.90 ± 1.44	17.56 ± 2.74	15.47 ± 1.88	15.03 ± 1.34	22.33 ± 1.58	22.05 ± 2.01	19.20 ± 2.87	17.58 ± 2.39
2015	1	24.15 ± 0.62	23.56 ± 0.12	22.49 ± 0.26	21.36 ± 1.06	20.49 ± 0.75	18.36 ± 1.12	17.12 ± 0.61	25.77 ± 0.56	25.24 ± 0.83	23.34 ± 1.02	21.79 ± 2.03
	2	23.53 ± 0.37	23.49 ± 0.34	22.48 ± 0.25	21.07 ± 0.70	19.55 ± 0.61	17.38 ± 0.64	17.11 ± 0.73	25.34 ± 0.28	24.49 ± 0.49	23.18 ± 2.27	22.60 ± 3.46
	3	21.37 ± 0.54	21.40 ± 0.52	20.49 ± 0.47	20.66 ± 1.32	18.63 ± 1.37	15.58 ± 1.10	15.75 ± 0.25	23.29 ± 1.17	22.01 ± 1.09	21.50 ± 1.17	21.12 ± 1.96
	4	22.25 ± 0.64	22.15 ± 0.71	20.87 ± 0.52	20.16 ± 0.88	19.87 ± 1.08	17.68 ± 2.05	16.30 ± 0.47	23.63 ± 1.07	23.46 ± 0.74	22.45 ± 1.01	20.54 ± 1.94
	All	23.31 ± 1.22	22.64 ± 1.03	21.81 ± 1.00	20.77 ± 1.09	20.14 ± 1.19	18.01 ± 1.66	16.53 ± 0.79	22.62 ± 1.36	24.12 ± 1.46	22.75 ± 1.60	21.61 ± 2.49
2016	1	23.29 ± 0.60	23.47 ± 0.57	22.28 ± 1.05	20.40 ± 0.67	17.74 ± 2.16	18.59 ± 3.52	15.45 ± 1.13	24.31 ± 0.73	24.26 ± 0.80	22.18 ± 2.12	20.79 ± 2.11
	2	23.95 ± 0.44	23.93 ± 0.57	23.28 ± 0.82	20.24 ± 0.71	18.77 ± 2.68	13.81 ± 3.00	15.88 ± 1.59	26.83 ± 6.54	26.89 ± 6.75	25.30 ± 5.86	17.35 ± 2.99
	3	23.53 ± 0.20	23.56 ± 0.28	22.91 ± 0.35	20.36 ± 0.38	18.42 ± 1.21	11.72 ± 2.53	15.85 ± 0.79	24.68 ± 0.29	24.35 ± 0.84	22.73 ± 2.02	18.26 ± 3.29
	4	24.69 ± 0.12	24.69 ± 0.15	23.62 ± 0.13	21.70 ± 0.48	19.80 ± 2.05	19.90 ± 1.08	17.20 ± 0.40	26.62 ± 0.33	26.17 ± 0.38	24.46 ± 0.22	22.58 ± 0.80
	All	23.87 ± 0.66	23.91 ± 0.64	23.02 ± 0.84	20.68 ± 0.82	19.05 ± 2.23	18.92 ± 2.69	16.09 ± 1.23	25.61 ± 3.40	25.42 ± 3.52	23.67 ± 3.43	21.39 ± 2.49
2017	1	26.88 ± 0.29	27.26 ± 0.28	26.29 ± 0.39	23.64 ± 1.71	21.55 ± 1.90	21.68 ± 3.01	17.78 ± 0.58	27.94 ± 1.02	28.28 ± 0.89	25.72 ± 1.79	23.47 ± 4.12
	2	26.35 ± 0.15	26.70 ± 0.24	25.90 ± 0.38	22.86 ± 1.46	22.10 ± 2.22	22.35 ± 2.21	19.39 ± 2.35	26.34 ± 0.23	26.14 ± 0.62	24.24 ± 1.50	22.24 ± 2.17
	3	27.06 ± 0.70	27.07 ± 0.55	25.97 ± 0.95	24.25 ± 1.00	22.39 ± 2.12	21.60 ± 2.12	19.81 ± 0.56	27.52 ± 1.52	27.19 ± 1.69	25.80 ± 1.27	23.71 ± 2.47
	4	29.38 ± 0.44	29.33 ± 0.51	27.86 ± 0.69	26.06 ± 1.64	24.87 ± 2.67	23.27 ± 2.25	20.96 ± 1.13	31.03 ± 0.63	30.52 ± 1.28	28.2 ± 2.02	27.30 ± 3.01
	All	27.42 ± 1.25	27.59 ± 1.11	26.50 ± 1.02	24.20 ± 1.86	22.70 ± 2.51	22.20 ± 2.45	19.49 ± 1.76	28.21 ± 1.99	28.03 ± 2.01	26.00 ± 2.18	24.19 ± 3.49
2013 – 2017	All	22.95 ± 3.07	22.94 ± 3.07	22.04 ± 2.93	20.54 ± 2.72	18.98 ± 3.21	17.54 ± 3.58	16.01 ± 2.53	24.15 ± 3.52	23.83 ± 3.63	22.00 ± 3.75	20.06 ± 4.11

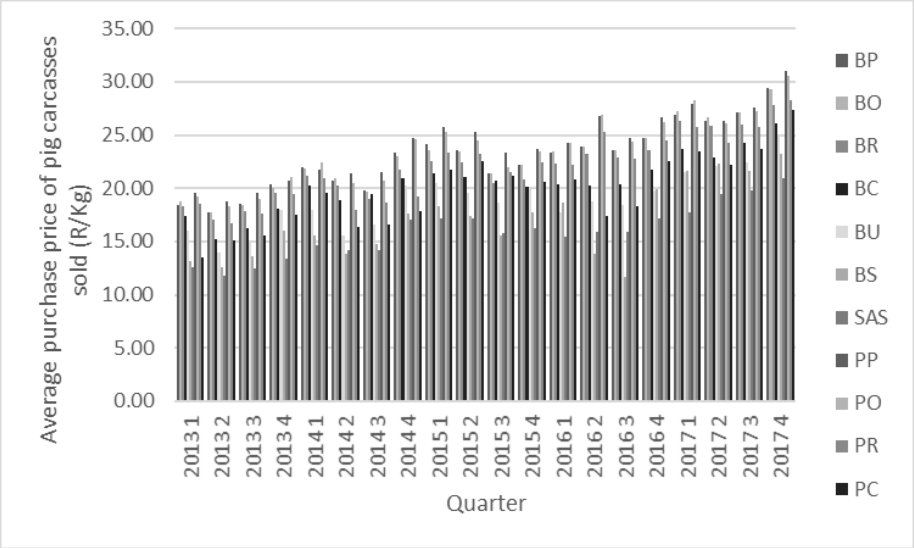

Figure 4.36: The average purchase price of pork carcass class by abattoir per quarter for the period 2013 to 2017

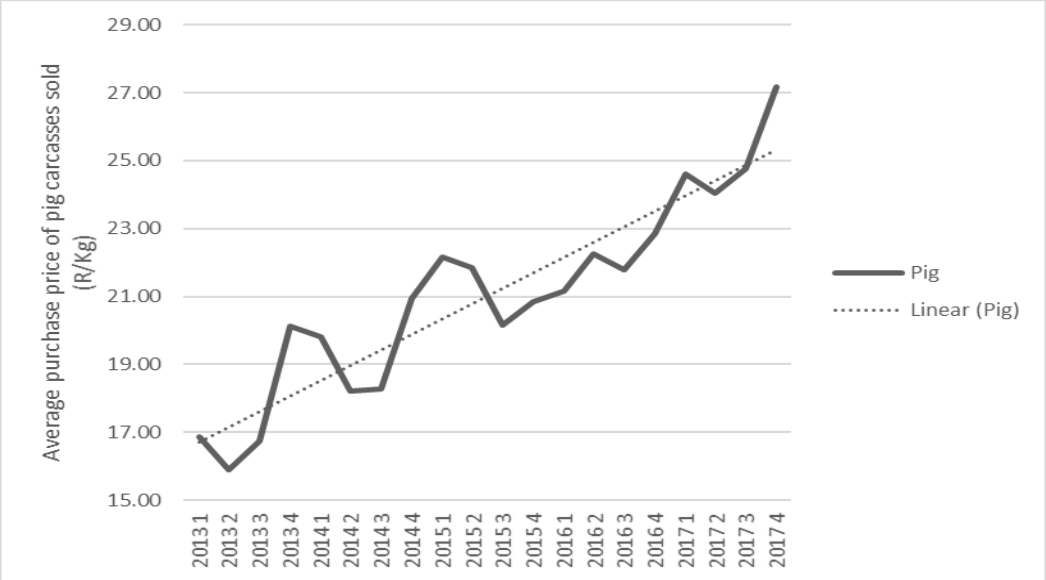

Figure 4.37: The trend of the average purchase price of pork carcasses by abattoir per quarter for the period 2013 to 2017

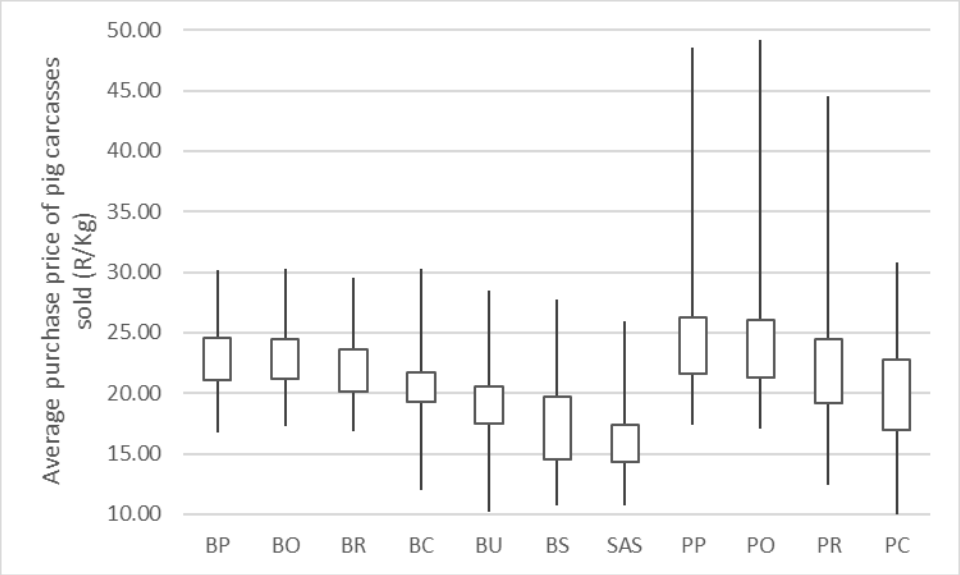

Figure 4.38: The average purchase price of pork carcass class by abattoir for the period 2013 to 2017

Table 4.15, Figure 4.39 and Figure 4.40 show the average purchase price of beef carcass classes bought by abattoirs in the period 2013 to 2017. The A3 (36.10 ± 5.9) and A2 (36.01 ± 5.9) classes had the highest average purchase price, whereas the C2 (28.88 ± 6.1) and C3 (30.09 ± 17.5) classes had the lowest average purchase prices. The differences in the prices were mainly due to the differences in demand for the different carcass classes (Labuschagne *et al.*, 2011; Delport *et al.*, 2017).

Table 4.15: The average purchase price of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A2 (mean ± SD)	A3 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	29.73 ± 1.26	29.71 ± 1.18	27.62 ± 1.23	27.83 ± 0.96	24.80 ± 1.37	25.50 ± 1.51	22.92 ± 2.12	23.11 ± 2.00
	2	27.93 ± 0.34	27.83 ± 0.51	26.05 ± 0.31	26.22 ± 0.65	23.73 ± 0.85	23.54 ± 0.51	21.56 ± 0.92	21.71 ± 0.85
	3	28.67 ± 0.75	28.67 ± 0.85	26.81 ± 0.74	26.63 ± 1.04	24.52 ± 0.53	24.05 ± 1.04	22.80 ± 0.67	22.86 ± 0.97
	4	27.47 ± 0.35	27.42 ± 0.49	25.88 ± 0.34	25.92 ± 0.48	23.86 ± 0.80	23.91 ± 0.68	21.92 ± 0.89	22.21 ± 0.68
	All	29.01 ± 1.08	28.96 ± 1.12	27.11 ± 1.06	27.17 ± 1.12	24.70 ± 1.19	24.72 ± 1.39	22.74 ± 1.48	22.91 ± 1.47
2014	1	30.66 ± 1.46	31.00 ± 1.27	28.16 ± 1.02	28.74 ± 1.15	25.31 ± 1.22	24.99 ± 1.67	23.21 ± 1.09	23.56 ± 1.24
	2	33.48 ± 0.90	33.92 ± 0.90	29.98 ± 0.67	30.81 ± 0.69	26.28 ± 1.04	26.28 ± 1.50	22.56 ± 0.55	22.54 ± 1.14
	3	33.72 ± 1.12	33.99 ± 1.18	30.90 ± 1.32	31.81 ± 0.93	28.77 ± 0.98	28.89 ± 1.01	25.89 ± 1.77	25.78 ± 1.88
	4	33.52 ± 0.43	33.93 ± 0.44	31.03 ± 0.73	31.51 ± 1.06	27.95 ± 0.52	28.36 ± 0.91	27.05 ± 0.36	27.65 ± 2.76
	All	32.85 ± 1.63	33.21 ± 1.62	30.02 ± 1.49	30.72 ± 1.54	27.08 ± 1.67	27.13 ± 2.03	24.68 ± 2.15	24.89 ± 2.70
2015	1	33.48 ± 0.34	33.86 ± 0.39	30.57 ± 0.58	31.08 ± 0.39	27.75 ± 1.02	28.12 ± 2.46	26.31 ± 1.40	26.55 ± 1.63
	2	34.09 ± 0.35	34.33 ± 0.29	31.37 ± 0.62	32.03 ± 0.31	28.27 ± 1.42	28.75 ± 0.92	26.57 ± 0.61	27.08 ± 0.63
	3	34.34 ± 0.59	34.50 ± 0.56	32.69 ± 0.79	32.84 ± 0.87	30.22 ± 0.72	30.32 ± 0.62	28.16 ± 0.77	28.59 ± 0.59
	4	35.28 ± 0.57	35.47 ± 0.62	33.83 ± 0.81	33.86 ± 1.25	30.88 ± 0.46	30.85 ± 0.91	28.94 ± 0.58	29.17 ± 0.88
	All	30.75 ± 0.80	34.50 ± 0.75	32.57 ± 1.43	32.42 ± 1.29	29.93 ± 1.62	29.49 ± 1.78	28.03 ± 1.41	27.74 ± 1.47
2016	1	37.33 ± 1.63	36.30 ± 3.72	35.44 ± 1.45	35.61 ± 1.12	32.11 ± 1.26	32.30 ± 1.21	29.72 ± 1.55	30.06 ± 1.36
	2	38.39 ± 0.51	38.30 ± 0.33	36.14 ± 0.47	36.45 ± 0.58	32.04 ± 0.65	32.22 ± 0.98	28.38 ± 0.72	28.63 ± 0.52
	3	37.81 ± 0.88	37.98 ± 0.23	36.19 ± 0.40	35.81 ± 0.60	33.03 ± 0.48	32.82 ± 0.60	31.00 ± 1.02	31.15 ± 1.06
	4	38.93 ± 0.40	38.91 ± 0.37	36.93 ± 0.35	37.06 ± 0.41	188.51 ± 46.98	33.67 ± 0.28	31.29 ± 0.38	31.62 ± 0.40
	All	38.12 ± 1.13	37.87 ± 2.07	36.17 ± 0.95	36.23 ± 0.91	71.42 ± 71.97	32.76 ± 1.01	30.09 ± 1.52	30.36 ± 1.47
2017	1	42.09 ± 2.05	42.26 ± 2.15	40.21 ± 1.99	40.40 ± 1.94	36.76 ± 1.42	36.22 ± 1.37	35.36 ± 1.25	35.39 ± 1.41
	2	47.51 ± 0.72	47.50 ± 0.57	45.35 ± 0.94	45.53 ± 0.92	40.21 ± 1.49	40.56 ± 2.03	38.35 ± 1.26	38.63 ± 1.25
	3	46.60 ± 0.37	46.65 ± 0.45	45.52 ± 0.40	45.48 ± 0.46	42.76 ± 0.62	42.56 ± 0.54	41.28 ± 0.34	60.69 ± 69.77
	4	46.43 ± 1.30	46.70 ± 1.22	45.71 ± 1.23	45.31 ± 1.14	43.38 ± 1.15	43.14 ± 1.14	42.15 ± 1.18	42.55 ± 1.53
	All	45.66 ± 2.46	45.78 ± 2.42	44.20 ± 2.64	44.18 ± 2.51	40.78 ± 2.89	40.62 ± 3.05	39.29 ± 2.89	44.32 ± 35.28
2013 – 2017	All	36.01 ± 5.86	36.10 ± 5.88	33.95 ± 6.15	34.18 ± 6.01	30.92 ± 5.88	30.97 ± 5.86	28.88 ± 6.11	30.09 ± 17.50

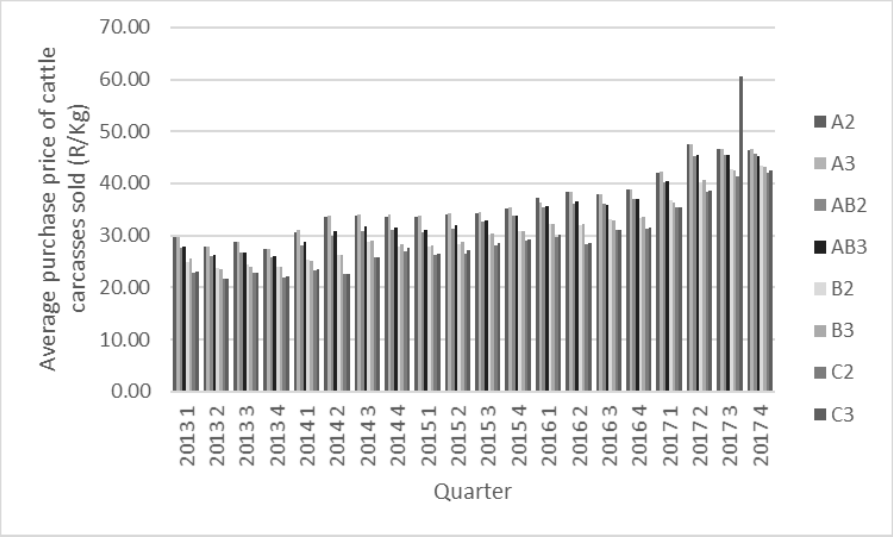

Figure 4.39: The average purchase price of beef carcass classes bought by abattoirs per quarter for the period 2013 to 2017

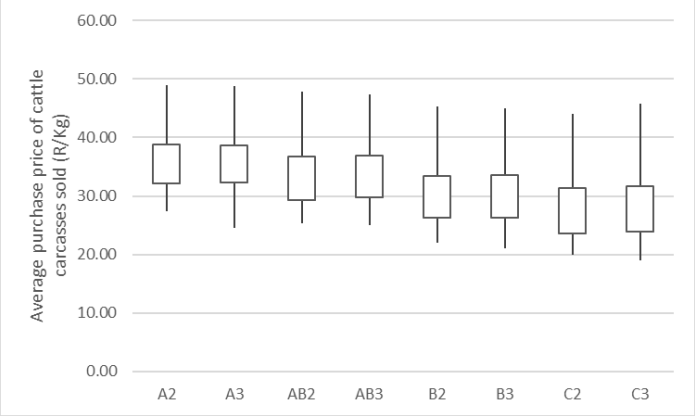

Figure 4.40: The average purchase price of beef carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.16, Figure 4.33 and Figure 4.34 show the average purchase price of sheep carcass classes bought by abattoirs in the period 2013 to 2017. The highest price was for the A3 (55.72 ± 10.8) and A2 (55.09 ± 10.7) classes, whereas the lowest price was for the C3 class (41.10 ± 8.4). The differences in the prices were mainly due to the differences in demand for the different carcass classes (Labuschagne *et al.*, 2011; Delport *et al.*, 2017).

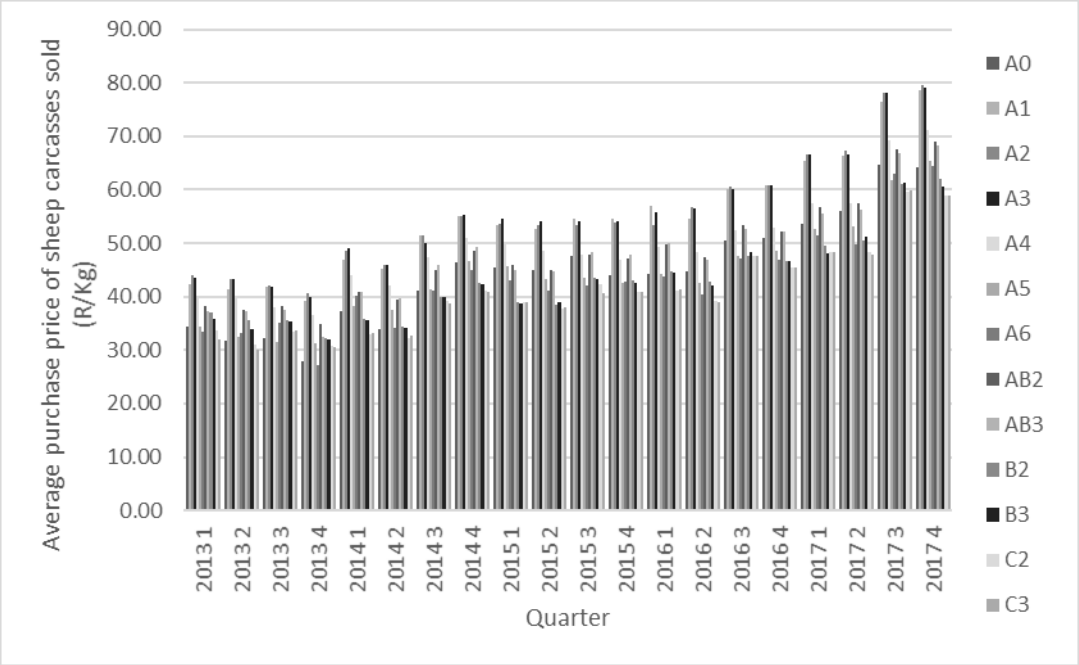

Figure 4.41: The average purchase price of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

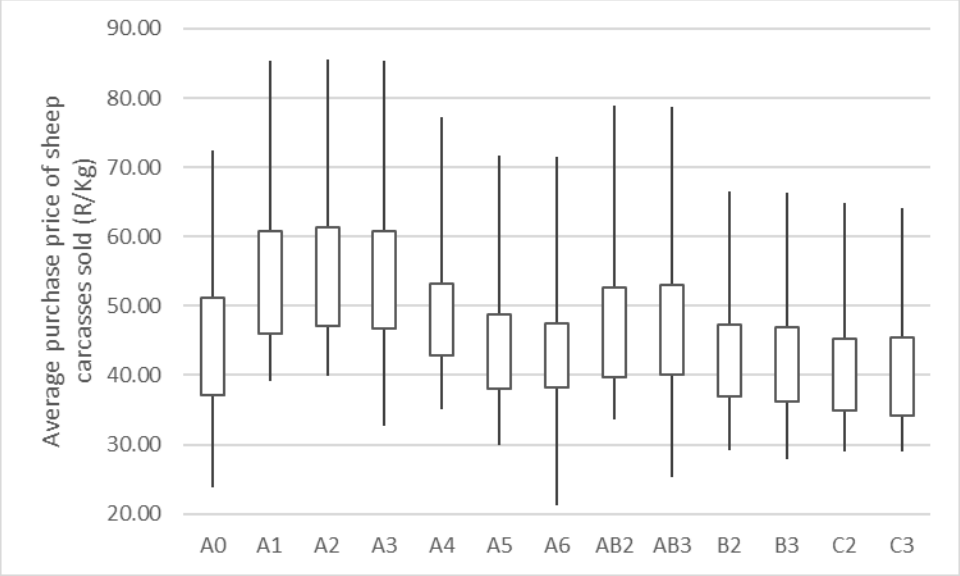

Figure 4.42: The average purchase price of sheep carcass classes bought by abattoirs for the period 2013 to 2017

Table 4.16: The average purchase price of sheep carcass classes bought by abattoirs per quarter for the period 2013 to 2017

	Quarter	A0 (mean ± SD)	A1 (mean ± SD)	A2 (mean ± SD)	A3 (mean ± SD)	A4 (mean ± SD)	A5 (mean ± SD)	A6 (mean ± SD)	AB2 (mean ± SD)	AB3 (mean ± SD)	B2 (mean ± SD)	B3 (mean ± SD)	C2 (mean ± SD)	C3 (mean ± SD)
2013	1	34.47 ± 1.97	42.39 ± 2.35	43.95 ± 2.07	43.57 ± 1.88	39.99 ± 2.24	34.38 ± 2.51	33.33 ± 1.64	38.31 ± 1.27	37.29 ± 1.13	37.14 ± 1.92	35.81 ± 1.82	33.67 ± 2.48	31.97 ± 1.80
	2	31.66 ± 2.03	41.46 ± 1.01	43.27 ± 0.99	43.41 ± 1.14	40.25 ± 1.47	32.52 ± 1.29	33.09 ± 2.71	37.44 ± 0.68	37.38 ± 0.94	35.61 ±.06	34.03 ± 2.06	31.02 ± 1.99	30.10 ± 0.58
	3	32.35 ± 3.32	41.87 ± 0.86	42.03 ± 1.70	41.84 ± 2.12	37.92 ± 1.41	31.58 ± 0.64	35.08 ± 5.28	38.36 ± 0.83	37.54 ± 1.13	35.49 ± 1.64	35.38 ± 1.66	33.52 ± 1.24	33.63 ± 1.22
	4	27.90 ± 3.22	39.15 ± 1.72	40.56 ± 1.72	39.87 ± 0.79	36.68 ± 2.87	31.39 ± 3.51	27.25 ± 2.64	34.93 ± 0.96	32.51 ± 3.17	32.31 ± 1.33	31.97 ± 1.24	30.79 ± 1.73	30.51 ± 2.52
	All	32.21 ± 3.03	42.03 ± 1.60	43.28 ± 1.80	43.00 ± 1.69	39.47 ± 2.21	33.10 ± 2.46	32.82 ± 3.83	37.99 ± 1.00	36.89 ± 1.98	35.83 ± 1.90	34.97 ± 1.81	32.88 ± 2.16	32.17 ± 2.12
2014	1	37.36 ± 2.38	46.82 ± 1.96	48.53 ± 1.23	49.11 ± 1.26	43.92 ± 1.88	38.21 ± 1.45	40.15 ± 2.12	40.99 ± 1.81	40.83 ± 2.48	35.91 ± 2.21	35.66 ± 2.36	33.01 ± 1.25	33.22 ± 1.01
	2	33.99 ± 2.95	45.13 ± 1.19	45.97 ± 1.94	45.88 ± 1.63	42.00 ± 1.42	37.53 ± 1.51	34.21 ± 7.42	39.39 ± 1.43	39.78 ± 3.11	34.32 ± 1.58	34.26 ± 1.93	32.22 ± 1.57	32.60 ± 1.29
	3	41.05 ± 2.77	51.40 ± 1.46	51.41 ± 1.17	50.14 ± 3.10	47.45 ± 1.82	41.44 ± 2.98	41.13 ± 2.57	44.86 ± 1.45	46.06 ± 2.54	40.04 ± 1.05	39.97 ± 1.21	39.33 ± 1.64	38.62 ± 1.77
	4	46.54 ± 3.67	55.01 ± 2.28	55.15 ± 2.03	55.26 ± 1.91	51.08 ± 2.70	46.75 ± 2.73	45.07 ± 2.89	48.55 ± 1.99	49.24 ± 3.19	42.55 ± 3.54	42.41 ± 3.51	41.05 ± 2.01	40.99 ± 2.02
	All	39.74 ± 5.52	49.59 ± 4.28	50.27 ± 3.80	50.10 ± 3.96	46.11 ± 4.01	40.98 ± 4.29	40.14 ± 5.74	43.45 ± 3.95	43.98 ± 4.78	38.21 ± 3.98	38.08 ± 4.04	36.40 ± 4.20	36.36 ± 3.90
2015	1	45.46 ± 3.06	53.29 ± 2.24	53.71 ± 2.22	54.69 ± 2.37	49.67 ± 2.71	45.63 ± 3.62	43.14 ± 3.29	45.90 ± 4.20	44.90 ± 4.76	38.95 ± 3.20	38.63 ± 3.84	38.89 ± 2.70	38.86 ± 3.63
	2	45.07 ± 2.00	52.58 ± 1.82	53.43 ± 1.22	54.15 ± 1.37	48.68 ± 2.11	43.19 ± 2.68	41.15 ± 6.06	44.92 ± 3.68	44.64 ± 6.24	38.42 ± 1.06	38.98 ± 1.89	37.68 ± 0.97	38.11 ± 1.06
	3	47.60 ± 2.53	54.54 ± 2.33	53.33 ± 4.02	54.05 ± 3.70	47.80 ± 1.69	43.47 ± 2.12	42.19 ± 2.24	47.95 ± 4.02	48.32 ± 2.79	43.51 ± 1.97	43.23 ± 1.83	42.42 ± 2.54	40.71 ± 2.13
	4	43.92 ± 2.66	54.54 ± 1.64	53.96 ± 3.01	54.19 ± 3.00	46.88 ± 3.58	42.68 ± 3.27	42.83 ± 3.59	47.17 ± 1.11	47.83 ± 1.32	43.08 ± 0.71	42.46 ± 0.87	40.80 ± 1.43	40.99 ± 1.27
	All	41.48 ± 2.85	52.00 ± 2.14	53.91 ± 2.74	54.09 ± 2.68	48.82 ± 2.75	44.83 ± 3.11	42.65 ± 4.00	45.05 ± 3.58	46.33 ± 4.42	42.19 ± 3.03	40.90 ± 3.09	40.15 ± 2.70	40.09 ± 2.52
2016	1	44.27 ± 2.77	56.93 ± 3.32	53.47 ± 3.31	55.85 ± 7.31	49.30 ± 3.31	44.16 ± 3.61	43.70 ± 3.36	49.77 ± 3.04	49.97 ± 2.88	44.82 ± 3.25	44.43 ± 2.89	41.19 ± 2.87	41.33 ± 2.67
	2	44.67 ± 2.24	54.62 ± 1.49	56.69 ± 1.27	56.40 ± 1.51	48.42 ± 1.79	42.56 ± 2.20	40.32 ± 1.90	47.34 ± 1.90	46.84 ± 2.32	42.85 ± 2.28	42.13 ± 2.05	39.10 ± 2.12	39.03 ± 2.32
	3	50.55 ± 1.92	60.11 ± 1.48	60.53 ± 2.26	60.23 ± 2.32	52.3 ± 1.35	47.60 ± 2.46	47.08 ± 2.98	53.41 ± 2.22	52.71 ± 3.21	47.72 ± 3.09	48.29 ± 2.70	47.72 ± 2.43	47.71 ± 2.22
	4	50.96 ± 1.04	60.76 ± 0.69	60.88 ± 0.77	60.78 ± 0.46	52.80 ± 0.52	48.50 ± 0.57	46.83 ± 0.29	52.25 ± 1.37	52.28 ± 1.65	46.65 ± 0.56	46.56 ± 0.39	45.40 ± 0.70	45.44 ± 0.49
	All	47.61 ± 3.77	58.10 ± 3.16	59.03 ± 2.71	58.32 ± 4.40	50.73 ± 2.74	45.70 ± 3.43	44.48 ± 3.65	50.69 ± 3.19	50.45 ± 3.44	45.51 ± 3.09	45.35 ± 3.18	43.35 ± 4.03	43.38 ± 3.99
2017	1	53.72 ± 4.38	65.44 ± 2.58	66.61 ± 2.45	66.70 ± 2.43	57.46 ± 2.64	52.70 ± 2.42	51.47 ± 2.78	56.64 ± 2.84	55.58 ± 4.04	49.63 ± 2.05	48.19 ± 2.33	48.38 ± 3.17	48.29 ± 3.13
	2	56.12 ± 5.43	66.48 ± 4.77	67.3 ± 3.56	66.64 ± 3.19	57.57 ± 2.83	53.09 ± 3.93	49.88 ± 5.95	57.37 ± 5.25	56.29 ± 4.53	50.58 ± 3.56	51.22 ± 4.56	48.38 ± 3.39	47.96 ± 3.19
	3	64.67 ± 7.38	76.35 ± 2.07	78.07 ± 1.36	78.14 ± 1.27	69.27 ± 2.37	61.86 ± 3.3	63.03 ± 3.61	67.52 ± 2.78	66.89 ± 3.03	60.97 ± 6.47	61.40 ± 2.10	59.69 ± 2.70	59.87 ± 2.65
	4	64.14 ± 5.06	78.73 ± 3.54	79.62 ± 3.73	79.11 ± 4.08	71.27 ± 3.85	65.38 ± 3.8	64.54 ± 3.87	69.10 ± 4.35	68.34 ± 4.68	62.06 ± 3.52	60.62 ± 3.53	58.86 ± 2.98	58.97 ± 2.72
	All	59.66 ± 7.35	71.75 ± 6.78	72.90 ± 6.67	72.65 ± 6.68	63.90 ± 7.09	58.26 ± 6.47	57.23 ± 7.82	62.66 ± 6.9	61.77 ± 7.15	55.81 ± 7.08	55.36 ± 6.63	53.83 ± 6.26	53.77 ± 6.38
2013 - 2017	All	45.00 ± 10.27	55.09 ± 10.68	55.85 ± 10.71	55.72 ± 10.75	49.73 ± 9.03	44.40 ± 9.17	43.44 ± 9.51	48.29 ± 9.29	47.95 ± 9.44	43.30 ± 8.20	42.95 ± 8.18	41.31 ± 8.27	41.10 ± 8.39

4.6. The average price and number of hides and wool sold during the period 2013 to 2017

Figure 4.43 represents the average hide price of feedlot and veldt cattle for the period 2013 to 2017. During this period, hide prices increased from beginning 2013 to the second quarter of 2014. The prices then decreased until the end of 2015, followed by an increase. This increase-decrease cycle was due to the drought that had started in 2013 and only ended in 2018 (Ngoepe, 2015; Joubert, 2016; United Nations Food and Agricultural Organisation (FAO), 2016). The price increased due to a lack of good quality supplied.

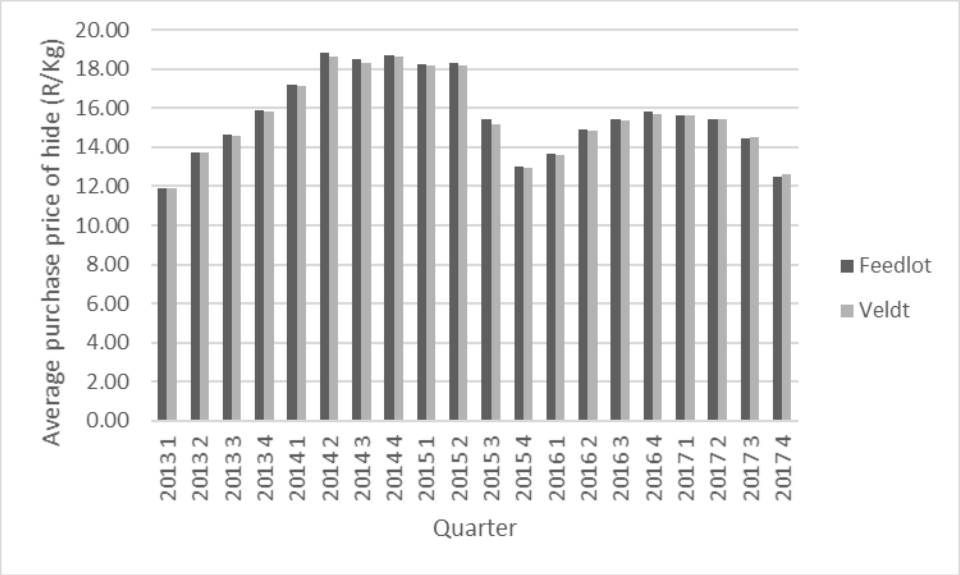

Figure 4.43: The average price of feedlot and veldt hide per quarter for the period 2013 to 2017

AWEX maintains a series of benchmark Australian Wool Market Indicators. These are based on fixed baskets of wool types, calculated each sale day and released via a series of subscription reports. The Indicators are economic expressions relating to the current and previous levels of the wool market. Some AWEX Indicators are used as the basis for derivative wool market trading. The primary Wool Market Indicator is the AWEX Eastern Market Indicator (AWEX-EMI), with support by three Regional Market Indicators (RMI-North, South and West). A series of sub indicators known as Micron Price Guides (MPG's) are also published for each regional sale day. All Indicators are expressed in Australian cents per clean kilogram (AWEX, 2020).

Figure 4.44 represents the average wool price for the period 2013 to 2017. As expected, there were seasonal fluctuations in wool prices, with an increase over time. This has to do with the production cycle of wool since sheep are only shorn during a certain period of the year, that increases supply and a decrease in prices during the shearing season, followed by a decrease in supply and a price increase (Maree & Casey, 1993; Labuschagne *et al.*, 2011).

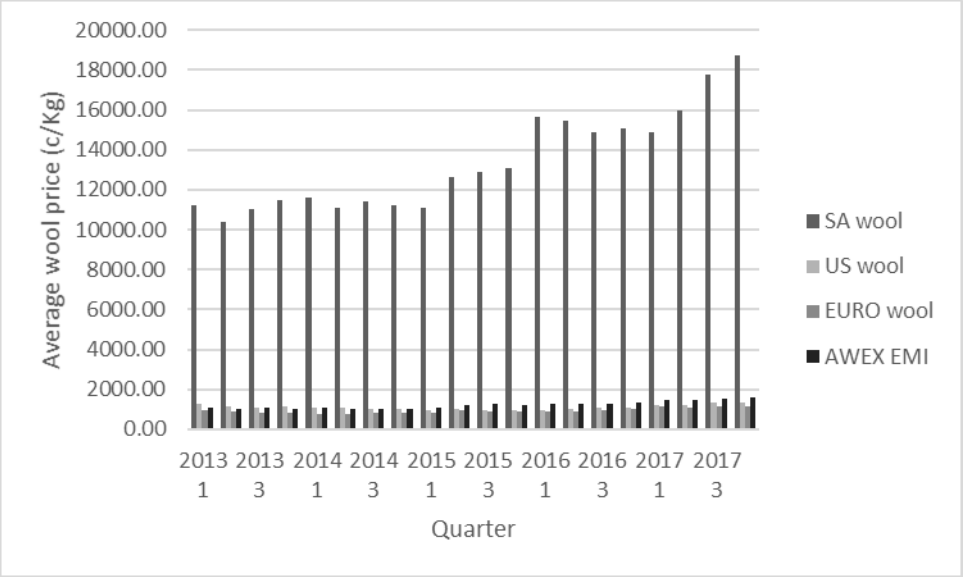

Figure 4.44: The average wool price per quarter for the period 2013 to 2017

CHAPTER 5:
RESULTS AND DISCUSSION: CORRELATIONS

Statistical analyses were done to determine the relationships between the different carcass classes of sheep, beef and pork concerning the number of carcasses bought by abattoirs as well as the weekly average purchase prices of carcass expressed in R/kg (significant level of 0.005).

5.1. The relationships between different red meat carcass classes during the period 2013 to 2017

The relationships between the purchase price and the number of carcasses bought by abattoirs with regards to the different carcass classes were both positive and negative (Table 5.1, Table 5.2 and Table 5.3). In general, a negative correlation occurred between the number of sheep carcass classes and the purchase price of pork, beef and sheep carcass classes. Meaning as the number of sheep carcass class increased the purchase price of the other red meat carcasses bought by the abattoir decreased. The resultant relationship was due to a large number of sheep carcasses bought by abattoirs at the beginning of the drought in 2013 (Ngoepe, 2015; Joubert, 2016; United Nations Food and Agricultural Organisation (FAO), 2016). The increased supply, therefore, resulted in drastically exceeding a threshold value.

In general, the number of pork and beef carcasses was positively correlated with the purchase price, meaning that if the number increased, so did the purchase price. The correlation result was due to the number of carcasses not exceeding the threshold value that would have resulted in a decreased purchase price. The BS pork class was the only carcass class that had a negative correlation with the purchase price. BS pork class carcasses were heavy and fat carcasses that have low demand. Still, there was a relatively large supply of these carcasses, resulting in a negative impact on the purchase price.

Table 5.1: The Pearson R correlation coefficients ($P_{x,y}$) for the relationship between the purchase price of red meat (pork, beef, and mutton and lamb) carcass classes and number of pork carcass classes over the period 2013 to 2017

Number of carcasses – Pork classes	Purchase price – Pork class											
	BP	BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All
BP	0.5	0.5	0.5	0.3	NS	0.5	0.3	0.5	0.5	0.5	0.3	0.5
BU	0.3	0.3	0.3	0.3	NS	NS	0.3	0.2	0.2	NS	NS	0.3
BS	-0.4	-0.4	-0.3	-0.2	NS	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3
SAS	0.4	0.4	0.4	0.2	NS	0.3	0.3	0.3	0.3	0.3	0.3	0.4
PP	0.2	0.3	0.3	NS	NS	0.3	NS	NS	NS	0.2	NS	0.2
PO	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PR	NS	0.2	0.2	NS	NS	0.3	NS	0.2	0.2	0.3	NS	0.2
PC	0.2	0.2	0.2	0.2	NS	0.2	NS	0.2	0.2	NS	NS	0.2
All	0.4	0.4	0.4	0.2	NS	0.4	0.2	0.4	0.3	0.4	0.1	0.4

Number of carcasses – Pork classes	Purchase price – Beef class								
	A2	A3	AB2	AB3	B2	B3	C2	C3	All
BP	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.6	0.7
BU	0.3	0.3	0.3	0.3	0.3	0.3	NS	NS	0.3
BS	-0.5	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.5
SAS	0.6	0.6	0.7	0.6	0.7	0.6	0.6	0.6	0.7
PP	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.4
PO	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
PR	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2
PC	NS	NS	NS	NS	NS	NS	NS	NS	NS
All	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Number of carcasses – Pork classes	Purchase price – Sheep class													
	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
BP	0.5	0.6	0.7	0.6	0.5	0.5	0.4	0.6	0.5	0.6	0.6	0.6	0.6	0.6
BU	0.2	0.3	0.3	0.2	0.2	0.2	NS	0.2	NS	0.2	0.2	0.2	0.2	0.2
BS	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.4
SAS	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.6	0.5	0.6	0.6	0.6	0.6	0.6
PP	0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.3	0.3	0.4	0.4	0.3	0.4	0.3
PO	NS	0.2	0.3	NS	NS	NS	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2
PR	NS	0.2	0.2	0.2	NS	NS	NS	0.2	NS	0.2	0.2	0.2	0.2	0.2
PC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
All	0.4	0.5	0.6	0.5	0.4	0.4	0.3	0.5	0.4	0.6	0.5	0.5	0.6	0.5

Table 5.2: The Pearson R correlation coefficients ($P_{x,y}$) for the relationship between the purchase price of red meat (pork, beef, and mutton and lamb) carcass classes and number of beef carcass classes over the period 2013 to 2017

		Purchase price																																		
		Pork class												Beef class									Sheep class													
		BP	BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Number of carcasses	Beef classes																																			
	A2	0.5	0.5	0.5	0.3	0.3	0.5	0.4	0.5	0.4	0.5	0.4	0.5	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.8	0.6	0.7	0.7	0.6	0.5	0.5	0.5	0.7	0.6	0.7	0.7	0.7	0.7	0.7
	A3	0.4	0.5	0.5	0.3	0.2	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.7	0.5	0.6	0.6	0.5	0.5	0.4	0.4	0.6	0.5	0.6	0.6	0.5	0.6	0.6
	AB2	0.4	0.4	0.5	0.2	NS	0.3	0.2	0.4	0.4	0.4	0.3	0.4	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.6	0.7	0.4	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.4	0.6	0.5	0.5	0.5	0.5
	AB3	0.2	0.3	0.3	NS	NS	0.2	NS	0.2	0.2	0.3	NS	0.2	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.5	NS	0.3	0.3	0.2	NS	NS	NS	0.3	0.2	0.4	0.3	0.3	0.3	0.3
	B2	0.5	0.5	0.5	0.3	0.2	0.4	0.3	0.5	0.5	0.4	0.3	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.7	0.5	0.6	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.6	0.5	0.5	0.5	0.5
	B3	0.3	0.4	0.4	NS	NS	0.3	0.2	0.4	0.3	0.4	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
	C2	0.4	0.5	0.5	NS	NS	0.4	0.2	0.4	0.4	0.4	0.2	0.4	0.7	0.6	0.7	0.7	0.7	0.6	0.6	0.6	0.7	0.4	0.5	0.6	0.5	0.4	0.4	0.3	0.5	0.4	0.6	0.5	0.5	0.5	0.5
	C3	0.4	0.4	0.5	NS	NS	0.4	0.2	0.4	0.4	0.4	0.2	0.4	0.6	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.6	0.4	0.5	0.5	0.5	0.4	0.3	0.3	0.5	0.4	0.5	0.5	0.5	0.5	0.5
	All	0.5	0.5	0.5	0.3	0.3	0.5	0.4	0.5	0.5	0.5	0.4	0.5	0.8	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.5	0.7	0.7	0.6	0.5	0.5	0.4	0.7	0.6	0.7	0.7	0.6	0.7	0.6

Table 5.3: The Pearson R correlation coefficients ($P_{x,y}$) for the relationship between the purchase price of red meat (pork, beef, and mutton and lamb) carcass classes and number of sheep carcasses classes over the period 2013 to 2017

Purchase price		Number of carcasses: Sheep classes													
		A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Pork class	BP	0.2	NS	-0.3	-0.3	-0.4	-0.4	-0.5	-0.3	NS	-0.3	NS	-0.4	-0.2	-0.3
	BO	0.2	NS	-0.2	-0.3	-0.4	-0.4	-0.4	-0.3	NS	-0.3	NS	-0.4	NS	-0.3
	BR	NS	NS	-0.2	-0.3	-0.4	-0.4	-0.4	-0.3	NS	-0.3	NS	-0.3	NS	-0.3
	BC	0.3	NS	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4	NS	-0.4	-0.2	-0.5	-0.4	-0.4
	BU	0.2	NS	-0.3	-0.3	-0.3	-0.3	-0.4	-0.2	NS	-0.3	NS	-0.4	-0.3	-0.3
	BS	0.3	NS	NS	NS	-0.3	-0.3	-0.4	-0.2	NS	-0.3	NS	-0.3	NS	NS
	SAS	0.3	NS	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	NS	-0.3	-0.2	-0.4	-0.3	-0.3
	PP	0.2	NS	NS	-0.2	-0.3	-0.3	-0.4	-0.2	NS	-0.3	NS	-0.3	NS	-0.2
	PO	NS	NS	NS	-0.2	-0.3	-0.3	-0.4	-0.2	NS	-0.3	NS	-0.3	-0.2	-0.2
	PR	NS	NS	NS	NS	NS	NS	-0.2	NS	NS	NS	NS	-0.2	NS	NS
	PC	NS	NS	-0.2	-0.2	-0.3	-0.3	-0.3	NS	NS	-0.2	NS	-0.3	NS	-0.2
	All	0.2	NS	-0.2	-0.3	-0.4	-0.4	-0.5	-0.3	NS	-0.3	NS	-0.4	-0.2	-0.3
Beef class	A2	0.3	NS	NS	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.2	NS	NS
	A3	0.3	NS	NS	NS	NS	-0.2	-0.3	-0.2	NS	-0.2	NS	-0.2	NS	NS
	AB2	0.3	NS	NS	NS	NS	NS	-0.2	NS	0.2	-0.2	NS	NS	NS	NS
	AB3	0.3	NS	NS	NS	NS	NS	-0.2	NS	NS	NS	NS	-0.2	NS	NS
	B2	0.3	NS	NS	NS	NS	NS	-0.2	NS	0.2	NS	NS	-0.2	NS	NS
	B3	0.3	NS	NS	NS	NS	NS	-0.2	NS	NS	NS	NS	-0.2	NS	NS
	C2	0.3	NS	NS	NS	NS	NS	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	C3	0.3	NS	NS	NS	NS	NS	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	All	0.3	NS	NS	NS	NS	NS	-0.3	NS	NS	NS	NS	-0.2	NS	NS
Sheep class	A0	0.4	NS	NS	NS	-0.2	-0.2	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	A1	0.4	NS	NS	NS	-0.2	-0.3	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	A2	0.4	NS	NS	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.2	NS	NS
	A3	0.4	NS	NS	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	A4	0.4	NS	NS	-0.2	-0.3	-0.3	-0.4	NS	NS	NS	NS	-0.3	-0.2	NS
	A5	0.4	NS	NS	-0.2	-0.3	-0.3	-0.3	-0.2	NS	-0.2	NS	-0.4	-0.2	NS
	A6	0.4	NS	NS	NS	NS	-0.3	-0.3	NS	NS	NS	NS	-0.2	NS	NS
	AB2	0.4	NS	NS	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	AB3	0.4	NS	NS	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.2	NS	NS
	B2	0.5	0.3	0.1	NS	NS	NS	NS	NS	0.2	NS	NS	NS	NS	NS
	B3	0.5	0.2	0.1	NS	NS	NS	NS	NS	0.2	NS	NS	NS	NS	NS
	C2	0.4	NS	-0.04	NS	NS	NS	-0.2	NS	NS	NS	NS	-0.3	NS	NS
	C3	0.4	NS	-0.1	NS	NS	-0.2	-0.3	NS	NS	NS	NS	-0.3	NS	NS
	All	0.5	NS	-0.04	NS	-0.2	-0.2	-0.3	NS	NS	NS	NS	-0.3	NS	NS

Tables 5.4 to 5.6 demonstrate Pearson's R coefficients ($P_{x,y}$) from the relationship between carcass classes for purchase price for the period 2013 to 2017. The positive correlation between all the carcass classes of all the red meat species' average purchase prices was significant. Meaning that if one carcass class's purchase price increased the other carcass classes, purchase prices followed the increase and *vice versa*.

Table 5.4: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship between the purchase prices of the different red meat carcass classes compared to purchase price of pork carcass classes for the period 2013 to 2017

		Pork class												Beef class								Sheep class											
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All		A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Pork class	BP	0.98	0.97	0.82	0.70	0.79	0.85	0.78	0.79	0.66	0.68	0.93		0.75	0.74	0.73	0.74	0.69	0.71	0.72	0.72	0.75	0.71	0.77	0.78	0.76	0.74	0.75	0.59	0.69	0.62	0.56	0.59	0.60	0.67	0.74
	BO		0.98	0.82	0.69	0.79	0.84	0.78	0.78	0.66	0.68	0.92		0.79	0.78	0.77	0.78	0.72	0.73	0.74	0.74	0.78	0.72	0.78	0.79	0.77	0.75	0.75	0.60	0.71	0.64	0.59	0.62	0.62	0.68	0.75
	BR			0.80	0.66	0.78	0.79	0.77	0.77	0.68	0.67	0.91		0.78	0.78	0.76	0.76	0.71	0.72	0.72	0.71	0.76	0.68	0.75	0.77	0.74	0.72	0.71	0.55	0.68	0.60	0.57	0.60	0.59	0.66	0.72
	BC				0.70	0.64	0.80	0.69	0.68	0.60	0.64	0.83		0.64	0.64	0.60	0.62	0.59	0.62	0.62	0.62	0.64	0.67	0.68	0.66	0.64	0.67	0.68	0.53	0.63	0.59	0.49	0.54	0.57	0.61	0.67
	BU					0.67	0.70	0.61	0.63	0.56	0.54	0.77		0.44	0.44	0.46	0.46	0.46	0.48	0.54	0.55	0.49	0.53	0.55	0.53	0.56	0.53	0.54	0.41	0.50	0.44	0.43	0.45	0.49	0.50	0.53
	BS						0.65	0.66	0.67	0.57	0.60	0.80		0.63	0.63	0.64	0.63	0.63	0.64	0.70	0.70	0.67	0.60	0.68	0.69	0.68	0.65	0.61	0.50	0.65	0.55	0.55	0.57	0.60	0.65	0.66
	SAS							0.76	0.73	0.63	0.64	0.86		0.66	0.67	0.64	0.66	0.62	0.63	0.68	0.68	0.67	0.74	0.75	0.73	0.72	0.73	0.76	0.63	0.67	0.61	0.54	0.56	0.60	0.65	0.73
	PP								0.96	0.80	0.68	0.90		0.68	0.66	0.66	0.67	0.63	0.65	0.65	0.65	0.67	0.66	0.69	0.69	0.68	0.67	0.66	0.53	0.63	0.59	0.54	0.56	0.57	0.63	0.67
	PO									0.82	0.67	0.90		0.64	0.62	0.63	0.63	0.60	0.61	0.63	0.63	0.64	0.61	0.65	0.67	0.64	0.64	0.62	0.51	0.61	0.56	0.52	0.53	0.53	0.58	0.64
	PR										0.73	0.83		0.56	0.54	0.57	0.56	0.54	0.57	0.57	0.55	0.57	0.56	0.58	0.58	0.56	0.54	0.49	0.45	0.51	0.48	0.49	0.50	0.48	0.50	0.55
	PC											0.79		0.54	0.52	0.54	0.55	0.53	0.55	0.57	0.56	0.56	0.58	0.61	0.59	0.59	0.56	0.53	0.47	0.52	0.51	0.44	0.48	0.50	0.52	0.57
	All													0.74	0.73	0.73	0.74	0.71	0.73	0.75	0.74	0.75	0.73	0.78	0.78	0.76	0.75	0.73	0.59	0.71	0.65	0.60	0.63	0.64	0.69	0.75

Table 5.5: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship between the purchase prices of the different red meat carcass classes compared to purchase price of beef carcass classes for the period 2013 to 2017

		Pork class											
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All
Beef class	A2											
	A3											
	AB2											
	AB3											
	B2											
	B3											
	C2											
	C3											
	All											

		Beef class								
		A2	A3	AB2	AB3	B2	B3	C2	C3	All
Beef class	A2		0.97	0.97	0.98	0.93	0.92	0.87	0.85	0.97
	A3			0.94	0.95	0.90	0.89	0.85	0.82	0.94
	AB2				0.98	0.97	0.94	0.91	0.89	0.98
	AB3					0.95	0.94	0.89	0.87	0.98
	B2						0.95	0.93	0.90	0.97
	B3							0.93	0.91	0.97
	C2								0.97	0.95
	C3									0.93
	All									

		Sheep class														
		A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Beef class	A2	0.78	0.88	0.88	0.82	0.77	0.77	0.63	0.82	0.78	0.76	0.78	0.77	0.80	0.85
	A3	0.78	0.87	0.86	0.81	0.78	0.78	0.64	0.81	0.77	0.74	0.76	0.76	0.79	0.84
	AB2	0.79	0.89	0.88	0.82	0.75	0.76	0.64	0.84	0.79	0.81	0.82	0.80	0.83	0.86
	AB3	0.79	0.88	0.88	0.82	0.76	0.76	0.63	0.83	0.78	0.78	0.79	0.78	0.81	0.85
	B2	0.78	0.89	0.87	0.81	0.76	0.76	0.64	0.84	0.80	0.82	0.84	0.83	0.85	0.87
	B3	0.80	0.89	0.88	0.81	0.76	0.74	0.63	0.84	0.81	0.83	0.84	0.83	0.85	0.87
	C2	0.85	0.92	0.90	0.85	0.81	0.80	0.69	0.88	0.82	0.88	0.89	0.89	0.91	0.92
	C3	0.82	0.90	0.88	0.83	0.79	0.77	0.66	0.86	0.80	0.85	0.85	0.86	0.89	0.89
	All	0.82	0.92	0.91	0.85	0.79	0.79	0.66	0.87	0.82	0.83	0.85	0.84	0.87	0.90

Table 5.6: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship between the purchase prices of the different red meat carcass classes compared to purchase price of sheep carcass classes for the period 2013 to 2017

		Pork class											Beef class									Sheep class														
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Sheep Class	A0																						0.93	0.89	0.87	0.86	0.85	0.80	0.88	0.86	0.81	0.82	0.86	0.87	0.94
	A1																							0.96	0.91	0.91	0.89	0.78	0.93	0.89	0.87	0.88	0.90	0.92	0.98
	A2																								0.93	0.92	0.87	0.76	0.90	0.86	0.84	0.85	0.86	0.89	0.96
	A3																									0.89	0.86	0.74	0.86	0.81	0.79	0.81	0.81	0.84	0.92
	A4																										0.91	0.78	0.84	0.83	0.76	0.78	0.81	0.84	0.93
	A5																											0.77	0.83	0.81	0.73	0.75	0.79	0.82	0.90
	A6																												0.74	0.75	0.67	0.67	0.71	0.74	0.83
	AB2																													0.89	0.88	0.91	0.90	0.91	0.95
	AB3																														0.83	0.86	0.84	0.86	0.92
	B2																															0.94	0.91	0.90	0.90
	B3																																0.92	0.92	0.91
	C2																																	0.97	0.93
	C3																																		0.95

Pearson's R coefficient ($P_{x,y}$) for the relationship between the number of carcasses bought by abattoirs of the different carcass classes for the period 2013 to 2017 appears in Tables 5.7 to 5.9. Most of the significant correlations were positive; meaning as the number of carcasses bought by abattoirs of one class increased, so did the number of carcasses bought by abattoirs increase for the other. The significant negative correlations only occurred with the relationships with pork carcass classes, meaning as the number of one class increase the other decrease and *vice versa*.

Significant negative correlations:

- BP pork class X BR pork class and BS pork class
- BR pork class X beef A2, A3, AB3, C2, C3, sheep A1, A2, A3, A4, A5, AB2, AB3, C2 and C3
- BC pork class X sheep A2, A3, A4, A5, AB2, AB3, C2 and C3

- BU pork class X BS pork class
- BS pork class X sausage pigs, PP pork class, beef A2, A3, AB3, B2, B3, C2 and C3.

These results show that these carcass classes compete. Labuschagne *et al.* (2011) stated that different protein sources compete with each other. The positive correlations were due to the higher demand for meat and meat products by the South African consumer (Delport *et al.*, 2017).

Table 5.7: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship of the number of red meat carcass classes bought by abattoirs compared to the number of pork carcass classes for the period 2013 to 2017

		Pork class											
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All
Pork class	BP	0.2	-0.2	NS	NS	-0.3	0.7	0.6	0.5	0.3	NS	0.9
	BO		0.5	NS	NS	NS	NS	NS	NS	NS	NS	0.4
	BR			0.7	NS	NS	NS	NS	NS	NS	NS	NS
	BC				0.2	NS	NS	NS	NS	NS	NS	NS
	BU					-0.2	0.2	NS	NS	NS	NS	NS
	BS						-0.4	-0.2	NS	NS	NS	-0.3
	SAS							0.7	0.3	NS	NS	0.7
	PP								0.5	0.3	NS	0.7
	PO									0.4	NS	0.5
	PR										0.2	0.3
	PC											NS
	All											

		Beef class							
		A2	A3	AB2	AB3	B2	B3	C2	C3	All
Pork class	BP	0.7	0.6	0.6	0.5	0.7	0.5	0.7	0.7	0.7
	BO	NS	NS	NS	NS	NS	NS	NS	NS	NS
	BR	-0.3	-0.2	-0.2	-0.2	NS	NS	-0.2	-0.2	-0.3
	BC	NS	NS	NS	NS	NS	NS	NS	NS	NS
	BU	NS	0.2	0.2	NS	0.3	0.2	NS	NS	0.2
	BS	-0.4	-0.4	-0.4	-0.3	-0.4	-0.3	-0.4	-0.4	-0.4
	SAS	0.6	0.5	0.5	0.5	0.6	0.5	0.7	0.7	0.7
	PP	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
	PO	0.4	0.4	0.4	0.4	0.3	0.2	0.4	0.4	0.4
	PR	0.4	0.3	0.3	0.2	0.2	NS	0.3	0.2	0.4
	PC	NS	NS	NS	NS	NS	NS	NS	NS	NS
	All	0.6	0.5	0.6	0.5	0.6	0.5	0.7	0.7	0.6

		Sheep class												
		A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Pork class	BP	NS	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS	0.2	NS
	BO	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	BR	NS	-0.3	-0.3	-0.3	-0.3	-0.3	NS	-0.3	-0.4	NS	NS	-0.3	-0.4	-0.3
	BC	NS	NS	-0.2	-0.2	-0.2	-0.2	NS	-0.2	-0.2	NS	NS	-0.2	-0.2	-0.2
	BU	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	BS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	SAS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
	PP	NS	NS	0.2	0.2	0.2	0.2	NS	NS	0.2	NS	0.2	0.1	0.2	0.2
	PO	NS	0.3	0.4	0.4	0.4	0.3	NS	0.3	0.4	NS	0.2	0.3	0.3	0.4
	PR	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	PC	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	All	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5.8: The Pearson R correlation coefficient for the relationship of the number of red meat carcass classes bought by abattoirs compared to the number of beef carcass classes for the period 2013 to 2017

		Pork class											Beef class								Sheep class													
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Beef class	A2													0.8	0.9	0.7	0.8	0.5	0.8	0.7	1.0	0.2	0.3	0.3	0.3	0.2	NS	NS	NS	0.5	0.02	0.2	0.03	0.3	0.3
	A3														0.7	0.7	0.7	0.5	0.7	0.7	0.8	0.2	0.2	0.3	0.3	0.2	NS	NS	NS	0.3	NS	0.3	NS	0.3	0.3
	AB2															0.8	0.8	0.6	0.8	0.7	0.9	NS	0.2	0.3	0.3	0.2	NS	NS	NS	0.4	NS	0.2	NS	0.4	0.3
	AB3																0.7	0.7	0.7	0.7	0.7	NS	NS	0.3	0.4	0.3	0.3	NS	NS	0.3	NS	0.2	0.2	0.4	0.3
	B2																	0.7	0.9	0.9	0.8	NS	NS	NS	NS	NS	NS	NS	NS	0.3	NS	0.2	NS	0.2	NS
	B3																		0.7	0.8	0.6	NS	NS	0.2	0.2	NS	NS	NS	NS	0.2	NS	0.2	NS	0.2	NS
	C2																			0.9	0.9	NS	NS	0.3	0.3	0.2	NS	NS	0.1	0.3	NS	0.3	NS	0.3	0.3
	C3																				0.8	NS	NS	0.3	0.3	0.2	NS	NS	NS	0.3	NS	0.3	NS	0.3	0.2
	All																					0.2	0.3	0.3	0.3	0.2	NS	NS	NS	0.4	NS	0.3	NS	0.3	0.3

Table 5.9: The Pearson R correlation coefficient for the relationship of the number of red meat carcass classes bought by abattoirs compared to the number of sheep carcass classes for the period 2013 to 2017

		Pork class											Beef class								Sheep class											
		BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Sheep class	A0																						0.7	0.4	NS	NS	NS	NS	0.3	0.3	0.2	NS	0.2	NS	0.4
	A1																							0.8	0.6	0.6	0.6	0.6	0.6	0.6	0.4	0.4	0.7	0.6	0.8
	A2																								0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.8	0.8	1.0
	A3																									0.9	0.8	0.7	0.6	0.6	0.4	0.4	0.7	0.7	0.9
	A4																										0.9	0.9	0.7	0.7	0.4	0.5	0.8	0.8	0.9
	A5																											0.9	0.7	0.7	0.4	0.5	0.7	0.7	0.8
	A6																												0.6	0.5	0.4	0.4	0.7	0.7	0.7
	AB2																													0.7	0.6	0.4	0.7	0.7	0.7
	AB3																														0.4	0.5	0.5	0.7	0.7
	B2																															0.6	0.6	0.5	0.5
	B3																																0.4	0.6	0.5
	C2																																	0.8	0.9
	C3																																		0.8

Tables 5.10 to 5.12 represent the correlations ($P_{x,y}$) between the different red meat classes for the tonnage of meat bought by abattoirs, which were both positive and negative.

Negative correlations:

- BP pork class X BS pork class
- BO pork class XPP pork class, beef A2, A3, B2 and C2
- BR pork class X PP pork class, PO pork class, beef A2, A3, AB2, AB3, B2, C2, and C3, Sheep A1, A2, A3, A4, A5, A6, AB2, AB3, C2 and C3
- BC pork class X Sheep A2, A3, A4, A5, AB2, AB3, C2 and C3
- BS pork class X Sausage, PP pork class, beef A2, A3, AB2, B2, B3, C2 and C3

Positive correlations:

- BP pork class X Sausage, PP pork class, PO pork class, PR pork class, beef A2, A3, AB2, AB3, B2, B3, C2 and C3
- BO pork class X BR pork class

- BR pork class X BC pork class
- BU pork class X beef B2
- Sausage X PP pork class, PO pork class, beef A2, A3, AB2, AB3, B2, B3, C2 and C3
- PP pork class X PO pork class, PR pork class, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, Sheep A1, A2, A3, A4, A5, AB3, B3 and C3
- PO pork class X PR pork class, PC pork class, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, Sheep A1, A2, A3, A4, A5, AB2, AB3, C2 and C3
- PR pork class X PC pork class, beef A2, A3, AB2, AB3, B2, C2 and C3 and sheep AB3
- Beef A2 X beef A3, AB2, AB3, B2, B3, C2 and C3, sheep A0, A1, A2, A3, A4, A5, AB3, B3 and C3
- Beef A3 X beef AB2, AB3, B2, B3, C2 and C3, sheep A1, A2, A3, A4, AB3, B3 and C3
- Beef AB2 X beef AB3, B2, B3, C2 and C3, sheep A2, A3, A4, AB3, B2, B3 and C3
- Beef AB3 X beef B2, B3, C2 and C3, sheep A2, A3, A4, A5, AB3, B3, C2 and C3
- Beef B2 X beef B3, C2 and C3, sheep A2, A3, AB3 and C3
- Beef B3 X beef C2 and C3, sheep A2, A3, AB3 and C3
- Beef C2 X beef C3, sheep A2, A3, A4, AB3, B3 and C3
- Beef C3 X sheep A2, A3, A4, AB3, B3 and C3
- Sheep A0 X sheep A1, A2, AB2, AB3, B2, B3, C2 and C3
- Sheep A1 X sheep A2, A3, A4, A5, A6, AB2, AB3, B2, B3, C2 and C3
- Sheep A2 X sheep A3, A4, A5, A6, AB2, AB3, B2, B3, C2 and C3
- Sheep A3 X sheep A4, A5, A6, AB2, AB3, B2, B3, C2 and C3
- Sheep A4 X sheep A5, A6, AB2, AB3, B2, B3, C2 and C3
- Sheep A5 X sheep A6, AB2, AB3, B2, B3, C2 and C3
- Sheep A6 X sheep AB2, AB3, B2, B3, C2 and C3
- Sheep AB2 X sheep AB3, B2, B3, C2 and C3
- Sheep AB3 X sheep B2, B3, C2 and C3
- Sheep B2 X sheep B3, C2 and C3
- Sheep B3 X sheep C2 and C3
- Sheep C2 X sheep C3

The pattern observed was the same as with the number of red meat carcasses bought by the abattoir. The effect was due to the number of carcasses bought by abattoirs and not the mass of the carcasses. The results observed were due to the same reasons as that of the number of carcasses bought by abattoirs (discussed earlier).

Table 5.10: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship of the tonnage of meat bought by abattoirs of the different red meat carcass classes compared to tonnage of pork carcass classes for the period 2013 to 2017

Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class
	BP	BO	BR	BC	BU	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
BP		NS	NS	NS	NS	-0.3	0.7	0.7	0.4	0.3	NS	0.9	0.7	0.6	0.6	0.5	0.7	0.5	0.7	0.7	0.7	NS	NS	0.2	0.2	NS	NS	NS	NS	0.2	NS	NS	0.2	NS
BO			0.4	NS	NS	NS	-0.3	-0.3	NS	NS	NS	NS	-0.3	-0.3	-0.2	NS	-0.3	-0.2	-0.3	-0.2	-0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BR				0.7	NS	NS	NS	-0.3	-0.2	-0.2	NS	NS	-0.4	-0.3	-0.3	-0.2	-0.2	NS	-0.3	-0.3	-0.3	NS	-0.3	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3	-0.4	NS	NS	-0.3	-0.4
BC					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.2	-0.2	-0.2	-0.2	NS	NS	-0.2	NS	NS	-0.2	-0.2
BU						NS	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	0.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BS							-0.4	-0.2	NS	NS	NS	-0.3	-0.4	-0.4	-0.4	-0.3	-0.4	-0.3	-0.4	-0.4	-0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SAS								0.7	0.4	NS	NS	0.8	0.6	0.5	0.5	0.5	0.6	0.5	0.7	0.7	0.7	NS	NS	0.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PP									0.6	0.3	NS	0.7	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.6	NS	0.2	0.3	0.3	0.3	0.3	NS	NS	0.2	0.2	0.3	NS	0.3
PO										0.5	0.3	0.5	0.4	0.4	0.4	0.4	0.3	NS	0.4	0.3	0.4	NS	0.3	0.4	0.4	0.4	0.4	NS	NS	0.2	0.3	0.3	0.4	0.4
PR											0.3	0.3	0.4	0.3	0.3	0.2	0.3	NS	0.3	0.3	0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PC												NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
All													0.6	0.5	0.5	0.5	0.6	0.5	0.7	0.7	0.6	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5.11: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship of the tonnage of meat bought by abattoirs of the different red meat carcass classes compared to tonnage of beef carcass classes for the period 2013 to 2017

Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Pork class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Beef class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class	Sheep class
	BR	BC	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
A2											0.8	0.9	0.6	0.8	0.5	0.8	0.7	1.0	0.2	0.3	0.4	0.4	0.3	0.2	NS	NS	0.4	NS	0.3	NS	0.3	0.3
A3												0.7	0.6	0.7	0.5	0.8	0.7	0.9	NS	0.2	0.4	0.4	0.3	NS	NS	NS	0.4	NS	0.3	NS	0.4	0.3
AB2													0.8	0.8	0.6	0.8	0.7	0.9	NS	NS	0.4	0.3	0.3	0.2	NS	NS	0.4	NS	0.3	NS	0.4	0.3
AB3														0.7	0.7	0.7	0.7	0.7	NS	NS	0.4	0.4	0.3	0.3	NSNS	0.2	0.3	NS	0.2	NS	0.4	0.3
B2															0.8	0.9	0.9	0.8	NS	NS	0.2	NS	NS	NS	NS	NS	0.3	NS	0.2	NS	0.3	0.2
B3																0.7	0.8	0.6	NS	NS	0.3	0.2	NS	NS	NS	NS	0.2	NS	NS	NS	0.3	0.2
C2																	0.9	0.9	NS	NS	0.3	0.3	0.3	NS	NS	NS	0.3	NS	NS	NS	0.3	0.3
C3																		0.8	NS	NS	0.3	0.3	0.2	NS	NS	NS	0.3	NS	NS	NS	0.4	0.3
All																			NS	0.2	0.4	0.4	0.3	0.2	NS	NS	0.4	NS	0.3	NS	0.3	0.3

Table 5.12: The Pearson R correlation coefficient ($P_{x,y}$) for the relationship of the tonnage of meat bought by abattoirs of the different red meat carcass classes compared to tonnage of sheep carcass classes for the period 2013 to 2017

		Pork class										Beef class									Sheep class																	
		BR	BC	BS	SAS	PP	PO	PR	PC	All	A2	A3	AB2	AB3	B2	B3	C2	C3	All	A0	A1	A2	A3	A4	A5	A6	AB2	AB3	B2	B3	C2	C3	All
Sheep class	A0																				0.7	0.3	NS	NS	NS	NS	0.3	0.3	0.2	NS	0.3	NS	0.4
	A1																					0.8	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.4	0.7	0.6	0.8
	A2																						0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.4	0.8	0.8	1.0
	A3																							0.9	0.8	0.7	0.5	0.6	0.3	0.4	0.7	0.7	0.9
	A4																								0.9	0.8	0.7	0.7	0.4	0.4	0.7	0.7	0.9
	A5																									0.9	0.6	0.7	0.4	0.5	0.7	0.7	0.8
	A6																										0.6	0.6	0.4	0.4	0.7	0.7	0.7
	AB2																											0.7	0.6	0.4	0.7	0.6	0.7
	AB3																												0.4	0.5	0.5	0.7	0.7
	B2																													0.6	0.6	0.5	0.5
	B3																														0.4	0.5	0.5
	C2																															0.8	0.8
	C3																																0.8

The main factors to look at are the number of carcasses bought by abattoirs and the price of each red meat carcass class. The results of this study showed that there were significant influences between the different carcasses of the different red meat species on each other for price. This interaction was due to specific meat classes, and not all the red meat carcass classes played a role in the effect. Labuschagne *et al.* (2011) confirmed that different meat types compete. Different meat types, therefore, influence the prices of each other. They do not only compete with other meat types but with other protein sources as well (Labuschagne *et al.* 2011).

The study showed that the tonnage of meat, the average number of carcasses, and the average purchase price of red meat carcasses bought by abattoirs influenced the average price of red meat carcasses bought by abattoirs.

The demand for basic commodities tends to be stable and generally is more responsive to changes in income and taste than price changes. In this situation, a small shift in supply or demand conditions could have a major impact on market prices. The demand for most raw agricultural commodities is steady throughout the year. The contrast between supply and demand for agricultural commodities could give rise to seasonal prices at production peaks, followed by higher prices as stocks are being depleted. Agricultural commodities are relatively price-inelastic, meaning quantities demanded and supplied changes proportionally less than price (Geyser & Cutts, 2007; Monk *et al.*, 2010). Demand estimation is important for informed decision making by industry stakeholders and policymakers (Lusk & Tonsor, 2016).

5.2. The relationships between different red meat carcasses and secondary products from red meat animals during the period 2013 to 2017

Table 5.13 illustrates Pearson's R correlation ($P_{x,y}$) of hide prices and tonnage of red meat carcass classes. In general, the results showed a negative correlation between the feedlot and veldt hide prices, and tonnage of meat, which means that if the tonnage of meat increase, there was a decrease in the price of hides and *vice versa*. The BR pork and BC pork classes had a positive correlation, meaning with increases in the tonnage of meat for these two classes there were increases in the hide prices. The relationship was coincidental, due to the relationship of these carcass classes with beef carcasses.

Negative correlations:

- BP pork class
- PP pork class
- PO pork class
- Beef A2
- Beef A3
- Beef AB2
- Beef AB3
- Beef C2
- Beef C3
- Beef carcasses
- Sheep A1
- Sheep A2
- Sheep A3
- Sheep A4
- Sheep A5
- Sheep A6
- Sheep AB2
- Sheep AB3
- Sheep B2
- Sheep B3
- Sheep C2
- Sheep C3
- Sheep carcasses

The results were due to the number of carcasses bought by abattoirs as well as the mass of the carcasses, as discussed later. Meaning as the number of carcasses and mass increase, there was a decrease in hide prices. As the tonnage of meat increased, there was an increase in the number of hides bought by abattoirs, and this exceeds the threshold of supply. There was a larger supply than demand, resulting in a decrease in price (Morris, 2009). The results observed for pork and sheep carcasses were due to their relationship with beef carcasses, as discussed earlier.

Table 5.13: The Pearson's R correlations ($P_{x,y}$) between the feedlot and veldt hide prices and tonnage of meat for the period 2013 to 2017

		Hide Prices	
		Feedlot	Veldt
Pork class	BP	-0.25	-0.25
	BO	NS	NS
	BR	0.47	0.46
	BC	0.35	0.34
	BU	NS	NS
	BS	NS	NS
	SAS	NS	NS
	PP	-0.25	-0.25
	PO	-0.37	-0.37
	PR	NS	NS
	PC	NS	NS
	All	NS	NS
Beef class	A2	-0.39	-0.40
	A3	-0.26	-0.26
	AB2	-0.41	-0.41
	AB3	-0.37	-0.36
	B2	NS	NS
	B3	NS	NS
	C2	-0.31	-0.30
	C3	-0.25	-0.24
	All	-0.38	-0.38
Sheep class	A0	NS	NS
	A1	-0.41	-0.40
	A2	-0.59	-0.59
	A3	-0.63	-0.63
	A4	-0.70	-0.70
	A5	-0.68	-0.68
	A6	-0.52	-0.52
	AB2	-0.55	-0.53
	AB3	-0.57	-0.58
	B2	-0.38	-0.37
	B3	-0.34	-0.34
	C2	-0.58	-0.56
	C3	-0.60	-0.59
	All	-0.63	-0.62

Table 5.14 represents Pearson's R correlation ($P_{x,y}$) between the feedlot and veldt hide prices and the number of red meat carcasses bought by abattoirs per carcass class for the period 2013 to 2017. As expected, the relationship reflects the same pattern as with tonnage of meat bought by abattoirs.

Positive correlations:

- BR pork class
- BC pork class

The relationship with tonnage was coincidental due to their relationship with beef carcasses.

Negative correlations:

- BP pork class
- PP pork class
- PO pork class
- Beef A2
- Beef A3
- Beef AB2
- Beef AB3
- Beef C2
- Beef C3
- Beef carcasses
- Sheep A1

- Sheep A2
- Sheep A3
- Sheep A4
- Sheep A5
- Sheep A6
- Sheep AB2
- Sheep AB3
- Sheep B2
- Sheep B3
- Sheep C2
- Sheep C3
- Sheep carcasses

The results observed for pork and sheep carcasses were due to their relationship with beef carcasses, as discussed earlier. The negative relationship was because of the increased supply of hides due to an increase in the number of carcasses that exceeded the demand for hides, causing a decrease in hide prices, noted by Morris (2009).

Table 5.14: The Pearson's R correlation ($P_{x,y}$) between the feedlot and veldt hide prices, and the number of carcasses bought by abattoirs per carcass class for the period 2013 to 2017

		Hide Prices	
		Feedlot	Veldt
Pork class	BP	-0.25	-0.25
	BO	NS	NS
	BR	0.45	0.44
	BC	0.36	0.35
	BU	NS	NS
	BS	NS	NS
	SAS	NS	NS
	PP	-0.20	-0.20
	PO	-0.37	-0.37
	PR	NS	NS
	PC	NS	NS
	All	NS	NS
Beef class	A2	-0.39	-0.39
	A3	-0.23	-0.23
	AB2	-0.38	-0.38
	AB3	-0.36	-0.36
	B2	NS	NS
	B3	NS	NS
	C2	-0.30	-0.30
	C3	-0.23	-0.23
	All	-0.37	-0.37
Sheep class	A0	NS	NS
	A1	-0.43	-0.42
	A2	-0.60	-0.59
	A3	-0.63	-0.63
	A4	-0.70	-0.70
	A5	-0.67	-0.67
	A6	-0.51	-0.51
	AB2	-0.57	-0.56
	AB3	-0.59	-0.60
	B2	-0.39	-0.38
	B3	-0.37	-0.37
	C2	-0.59	-0.57
	C3	-0.61	-0.60
	All	-0.64	-0.63

Table 5.15 represents the Pearson's R correlation ($P_{x,y}$) between feedlot and veldt hide prices and carcass class mass for the period 2013 to 2017. These were correlations were both positive and negative.

Positive correlations:

- BR pork class
- Sheep A3
- Sheep AB2
- Sheep AB3
- Sheep B2
- Sheep B3
- Sheep carcasses

Negative correlations:

- Beef A2
- Beef A3
- Beef AB2
- Beef B2
- Beef C2
- Beef carcasses

The results observed for pork and sheep carcasses were due to their relationship with beef carcasses, as discussed earlier. The negative relationship was because of the increased supply of hides due to an increase in the mass of carcasses, causing a decrease in hide prices (Morris, 2009).

Table 5.15: The Pearson's R correlation ($P_{x,y}$) between feedlot and veldt hide prices and carcass class mass for the period 2013 to 2017

		Hide Prices	
		Feedlot	Veldt
Pork class	BP	NS	NS
	BO	NS	NS
	BR	0.30	0.29
	BC	NS	NS
	BU	NS	NS
	BS	NS	NS
	SAS	NS	NS
	PP	NS	NS
	PO	NS	NS
	PR	NS	NS
	PC	NS	NS
	All	NS	NS
Beef class	A2	-0.26	-0.26
	A3	-0.42	-0.42
	AB2	-0.43	-0.43
	AB3	NS	NS
	B2	-0.20	-0.20
	B3	NS	NS
	C2	-0.22	-0.23
	C3	NS	NS
	All	-0.41	-0.41
Sheep class	A0	NS	NS
	A1	NS	NS
	A2	NS	NS
	A3	0.33	0.33
	A4	NS	NS
	A5	NS	NS
	A6	NS	NS
	AB2	0.29	0.29
	AB3	0.42	0.42
	B2	0.27	0.27
	B3	0.30	0.30
	C2	NS	NS
	C3	0.23	0.23
	All	0.33	0.34

Table 5.16 demonstrates the Pearson's R correlation ($P_{x,y}$) between the feedlot and veldt hide prices, and the average purchase price of carcass class for the period 2013 to 2017. Correlations were positive between pork carcass prices and feedlot and veldt hide prices, as well as between sheep A4 and A5 carcass classes. These results were coincidental due to their relationship with beef carcasses.

Table 5.16: The Pearson's R correlation ($P_{x,y}$) between the feedlot and veldt hide prices and average purchase prices of carcass classes for the period 2013 to 2017

		Hide Prices	
		Feedlot	Veldt
Pork class	BP	0.32	0.32
	BO	0.28	0.28
	BR	0.28	0.28
	BC	0.40	0.39
	BU	NS	NS
	BS	NS	NS
	SAS	0.37	0.36
	PP	0.25	0.25
	PO	0.20	0.20
	PR	NS	NS
	PC	NS	NS
	All	0.26	0.25
Beef class	A2	NS	NS
	A3	NS	NS
	AB2	NS	NS
	AB3	NS	NS
	B2	NS	NS
	B3	NS	NS
	C2	NS	NS
	C3	NS	NS
	All	NS	NS
Sheep class	A0	NS	NS
	A1	NS	NS
	A2	NS	NS
	A3	NS	NS
	A4	0.26	0.26
	A5	0.27	0.27
	A6	NS	NS
	AB2	NS	NS
	AB3	NS	NS
	B2	NS	NS
	B3	NS	NS
	C2	NS	NS
	C3	NS	NS
	All	NS	NS

There was no correlation between bales of wool sold in South Africa and hide prices, wool price, the tonnage of meat bought by abattoirs, number of carcass classes bought by abattoirs, average mass and average purchase price for the period 2013 to 2017. Table 5.17 shows Pearson's R correlation ($P_{x,y}$) between wool prices and tonnage of meat bought by abattoirs for the period 2013 to 2017. There were positive and negative correlations.

Negative correlations:

- BO pork class X SA wool prices, European wool price and AWEX EMI
- BR pork class X SA wool prices, European wool price and AWEX EMI
- BS pork class X SA wool prices and AWEX EMI
- US wool price X beef A2, A3, B2 and beef carcasses

Positive correlations:

- SA wool price X BP pork class, BU pork class, sausage, PP pork class, PO pork class, PR pork class, pork carcasses, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef, sheep A3 and AB3

- US wool price X BS pork class, sheep A2, A4, A5, A6, AB2, B2, C2, C3 and sheep
- European wool price X BP pork class, sausage, PP pork class, PO pork class, pork, beef A2, A3, AB2, AB3, B3, C2 and C3, Beef, sheep A2, A3, A4, A5, AB2, AB3, C2, C3 and sheep
- AWEX EMI X BP pork class, BU pork class, sausage, PP pork class, pork, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef and sheep AB3

The effects of beef and pork carcasses were due to their relationship with sheep carcasses, as discussed earlier. If there was an increase in sheep carcasses, there was a decrease in wool (even though the relationship was NS). The decrease in wool supplied results in an increase in price due to an increase in demand for wool, and *vice versa* (Morris, 2009). The results were mainly due to the number of carcasses bought by abattoirs and not the mass of carcasses, as discussed later.

The relationship with US wool price was coincidental because there was a NS relationship between SA wool price and US wool price (as discussed later). The relationship between sheep carcasses and European wool price and Australian wool price was due to the relationship with SA wool prices (as discussed later).

Table 5.17: The Pearson's R correlation (Px,y) between wool prices and tonnage of meat bought by abattoirs for the period 2013 to 2017

		SA wool price	US wool price	Europe wool price	AWEX EMI
Pork **class**	**BP**	0.76	NS	0.52	0.55
	BO	-0.35	NS	-0.49	-0.26
	BR	-0.30	NS	-0.38	-0.27
	BC	NS	-0.30	NS	NS
	BU	0.29	NS	NS	0.27
	BS	-0.48	0.37	NS	-0.28
	SAS	0.65	NS	0.52	0.47
	PP	0.58	NS	0.60	0.37
	PO	0.45	NS	0.36	0.30
	PR	0.39	NS	NS	0.25
	PC	NS	NS	NS	NS
	All	0.65	NS	0.46	0.46
Beef **class**	**A2**	0.82	-0.34	0.39	0.57
	A3	0.82	-0.27	0.45	0.52
	AB2	0.71	NS	0.32	0.47
	AB3	0.51	NS	0.33	0.30
	B2	0.72	-0.31	0.30	0.50
	B3	0.40	NS	0.29	0.31
	C2	0.82	NS	0.41	0.52
	C3	0.71	NS	0.43	0.47
	All	0.84	-0.31	0.41	0.57
Sheep class	**A0**	NS	NS	NS	NS
	A1	NS	NS	0.29	NS
	A2	0.19	0.26	0.34	0.18
	A3	0.26	0.17	0.34	0.22
	A4	0.15	0.31	0.36	0.17
	A5	NS	0.36	0.33	NS
	A6	NS	0.43	NS	NS
	AB2	NS	0.32	0.29	NS
	AB3	NS	NS	0.32	0.27
	B2	NS	0.30	NS	NS
	B3	NS	NS	NS	NS
	C2	NS	NS	NS	NS
	C3	NS	0.37	0.31	NS
	All	NS	0.34	0.38	NS

Table 5.18 represents Pearson's R correlation ($P_{x,y}$) between wool prices and the number of carcasses classes bought by abattoirs for the period 2013 to 2017. Correlations were both positive and negative.

Negative correlations:

- BR pork class X SA wool prices, European wool price and AWEX EMI
- BS pork class X SA wool prices and AWEX EMI
- US wool price X sheep A0, beef A2, A3, B2 and beef

Positive correlations:

- SA wool price X BP pork class, BU pork class, sausage, PP pork class, PO pork class, PR pork class, pork, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef and sheep AB3
- US wool price X BS pork class, sheep A2, A4, A5, A6, B2, C2 and C3
- European wool price X BP, sausage, PP pork class, PO pork class, pork, beef A2, A3, AB2, AB3, B3, C2 and C3, beef, sheep A1, A2, A3, A4, A5, AB2, AB3, C2, C3 and sheep
- AWEX EMI X BP pork class, BU pork class, sausage, PP pork class, pork, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef and sheep AB3

The effects of beef and pork carcasses were due to their relationship with sheep carcasses, as seen earlier. As with tonnage, if there was an increase in sheep carcasses, there was a decrease in wool (even though the relationship was NS). The decrease in wool supplied, results in an increase in price due to an increase in demand for wool, and *vice versa* (Morris, 2009).

The relationship with US wool price was coincidental because there was a NS relationship between SA wool price and US wool price (as discussed later). The relationship between sheep carcasses and Europe wool price and Australian wool price was due to the relationship with SA wool prices (as discussed later).

Table 5.18: The Pearson's R correlation ($P_{x,y}$) between wool prices and number of carcass classes bought by abattoirs for the period 2013 to 2017

		SA wool price	US wool price	Europe wool price	AWEX EMI
Pork **class**	**BP**	0.77	NS	0.51	0.55
	BR	NS	NS	-0.36	-0.26
	BC	NS	-0.32	NS	NS
	BU	0.31	NS	NS	0.28
	BS	-0.49	0.34	NS	-0.29
	SAS	0.65	NS	0.54	0.49
	PP	0.61	NS	0.62	0.39
	PO	0.49	NS	0.37	0.32
	PR	0.40	NS	NS	NS
	PC	NS	NS	NS	NS
	All	0.69	NS	0.46	0.48
Beef **class**	**A2**	0.82	-0.35	0.39	0.57
	A3	0.82	-0.29	0.45	0.53
	AB2	0.72	NS	0.33	0.48
	AB3	0.56	NS	0.35	0.31
	B2	0.73	-0.33	0.29	0.50
	B3	0.43	NS	0.31	0.33
	C2	0.81	NS	0.38	0.51
	C3	0.72	NS	0.43	0.47
	All	0.85	-0.33	0.41	0.58
Sheep class	**A0**	NS	-0.25	NS	NS
	A1	NS	NS	0.30	NS
	A2	NS	0.28	0.34	NS
	A3	NS	NS	0.34	NS
	A4	NS	0.36	0.34	NS
	A5	NS	0.41	0.31	NS
	A6	NS	0.45	NS	NS
	AB2	NS	NS	0.27	NS
	AB3	0.31	NS	0.32	0.29
	B2	NS	0.28	NS	NS
	B3	NS	NS	NS	NS
	C2	NS	0.41	0.27	NS
	C3	NS	0.33	0.38	NS
	All	NS	0.29	0.35	NS

Table 5.19 illustrates the Pearson's R correlation ($P_{x,y}$) between wool price and average carcass class mass for the period 2013 to 2017. The results show positive and negative correlations.

Negative correlations:

- SA wool price X BR pork class, BC pork class, pork, beef B3 and C3, sheep AB3 and B2
- United states wool X sheep A3
- AWEX EMI X BC pork class and beef C3

The following positive correlations occurred:

- United states wool price X BC pork class, beef and sheep AB2
- European wool price X beef C2

As with tonnage and the number of carcasses bought by abattoirs, the relationship with pork and beef was due to their relationship with mutton and lamb. The resulting negative correlation between South African wool price and sheep carcass classes was coincidental. Due to the drought that occurred, a large number of carcasses were bought by abattoirs of lower mass, resulting in less wool being bought and higher demand, causing higher wool prices (Morris, 2009).

The relationship with US wool price was coincidental because there was NS relationship between SA wool price and US wool price (as discussed later). The relationship between sheep carcasses and European wool price and Australian wool price was due to the relationship with SA wool prices (as discussed later).

Table 5.19: The Pearson's R correlation coefficient ($P_{x,y}$) between wool prices and average carcass class mass for the period 2013 to 2017

		SA wool price	US wool price	Europe wool price	AWEX EMI
Pork **class**	**BP**	-0.30	NS	NS	NS
	BO	NS	NS	NS	NS
	BR	-0.42	NS	NS	NS
	BC	-0.39	NS	NS	-0.36
	BU	NS	NS	NS	NS
	BS	-0.31	NS	NS	NS
	PP	NS	NS	NS	NS
	PO	NS	NS	NS	NS
	PR	NS	NS	NS	NS
	PC	NS	NS	NS	NS
	All	NS	NS	0.33	NS
Beef **class**	**A2**	NS	NS	NS	NS
	A3	NS	NS	NS	NS
	AB2	NS	NS	NS	NS
	AB3	NS	NS	NS	NS
	B2	NS	NS	NS	NS
	B3	NS	NS	NS	NS
	C2	-0.27	NS	NS	-0.26
	C3	NS	0.28	NS	NS
	All	NS	-0.27	NS	NS
Sheep class	**A0**	NS	NS	NS	NS
	A1	NS	NS	NS	NS
	A2	NS	NS	NS	NS
	A3	NS	0.32	NS	NS
	AB2	-0.32	NS	NS	NS
	AB3	-0.26	NS	NS	NS
	B2	-0.30	NS	NS	NS
	B3	NS	NS	NS	NS
	C2	NS	NS	NS	NS
	C3	NS	NS	NS	NS
	All	NS	NS	NS	NS

Table 5.20: The Pearson's R correlation (Px,y) between wool price and the average purchase price of carcass classes for the period 2013 to 2017

		SA wool price	US wool price	Europe wool price	AWEX EMI
Pork class	**BP**	0.53	-0.53	0.15	0.32
	BO	0.60	-0.49	0.22	0.38
	BR	0.61	-0.41	0.24	0.38
	BC	0.42	-0.46	0.09	0.34
	BU	NS	-0.30	NS	NS
	BS	0.54	-0.40	NS	0.31
	SAS	0.38	-0.61	NS	0.28
	PP	0.54	-0.51	0.27	0.33
	PO	0.54	-0.48	NS	0.33
	PR	0.59	-0.28	0.36	0.50
	PC	0.54	-0.44	NS	0.50
	All	0.58	-0.51	NS	0.42
Beef class	**A2**	0.80	-0.50	0.38	0.56
	A3	0.70	-0.50	0.32	0.50
	AB2	0.85	-0.48	0.43	0.60
	AB3	0.83	-0.50	0.40	0.58
	B2	0.80	-0.52	0.40	0.57
	B3	0.81	-0.43	0.45	0.57
	C2	0.74	-0.51	0.40	0.56
	C3	0.72	-0.48	0.39	0.54
	All	0.81	-0.52	0.40	0.59
Sheep class	**A0**	0.55	-0.55	0.31	0.50
	A1	0.68	-0.60	0.31	0.53
	A2	0.71	-0.55	0.33	0.53
	A3	0.60	-0.54	0.28	0.47
	A4	0.50	-0.53	NS	0.42
	A5	0.44	-0.56	NS	0.38
	A6	0.46	-0.58	NS	0.41
	AB2	0.68	-0.55	0.33	0.53
	AB3	0.59	-0.56	NS	0.49
	B2	0.71	-0.41	0.43	0.57
	B3	0.69	-0.42	0.40	0.58
	C2	0.60	-0.47	0.36	0.49
	C3	0.63	-0.52	0.32	0.48
	All	0.64	-0.58	0.31	0.52

Table 5.20 represents Pearson's R correlation ($P_{x,y}$) between wool prices and the average purchase price of carcasses for the period 2013 to 2017. Both negative and positive correlations occurred. There was a negative correlation between United States wool prices and the following:

- BP pork class
- BO pork class
- BR pork class
- BC pork class
- BU pork class
- BS pork class
- Sausage
- PP pork class
- PO pork class
- PR pork class
- PC pork class
- Pork carcasses
- Beef A2
- Beef A3
- Beef AB2
- Beef AB3
- Beef B2
- Beef B3
- Beef C2
- Beef C3
- Beef carcasses
- Sheep A0
- Sheep A1
- Sheep A2
- Sheep A3
- Sheep A4
- Sheep A5
- Sheep A6
- Sheep AB2
- Sheep AB3
- Sheep B2
- Sheep B3
- Sheep C2
- Sheep C3
- Sheep carcasses

The following positive correlations occurred:

- SA wool prices X BP pork class, BO pork class, BR pork class, BC pork class, BS pork class, sausage, PP pork class, PO pork class, PR pork class, PC pork class, pork, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef, sheep A0, A1, A2, A3, A4, A5, A6, AB2, AB3, B2, B3, C2, C3 and sheep

- European wool prices X PP pork class, PR pork class, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef, sheep A0, A1, A2, A3, AB2, B2, B3, C2, C3 and sheep
- AWEX EMI X BP pork class, BO pork class, BR pork class, BC pork class, BS pork class, sausage, PP pork class, PO pork class, PR pork class, PC pork class, pork, beef A2, A3, AB2, AB3, B2, B3, C2 and C3, beef, sheep A0, A1, A2, A3, A4, A5, A6, AB2, AB3, B2, B3, C2, C3 and sheep

The relationship with pork and beef was due to their relationship with mutton and lamb. The relationship with US wool price was coincidental because there was a NS relationship between SA wool price and US wool price (as discussed later). The relationship between sheep carcasses and European wool price and Australian wool price was due to the relationship with SA wool prices (as discussed later).

The relationship observed between the purchase price of sheep carcasses and SA wool prices related to the relationship of the number of sheep carcasses bought by abattoirs and purchase price of sheep carcasses and the relationship of SA wool prices and the number of sheep carcasses bought by abattoirs (as discussed earlier).

Table 5.21 represents Pearson's R correlation (Px,y) between wool prices for the period 2013 to 2017. The wool prices of SA wool prices positively correlated with European wool price and AWEX EMI, US wool price positively correlated with European wool price, and European wool price positively correlated with AWEX. This was due to the trading of South African wool mainly with Europe and Australia, who were the largest wool producers in the world.

Table 5.21: The Pearson's R correlation ($P_{x,y}$) between wool prices for the period 2013 to 2017

	SA wool price	US wool price	Europe wool price	AWEX EMI
SA wool price		NS	0.59	0.67
US wool price			0.38	NS
Europe wool price				0.55
AWEX EMI				

CHAPTER 6:
RESULTS AND DISCUSSION: LINEAR REGRESSION

For this study, price dynamics of supply was defined as the multiple dimensional influences of different variables on price resulting in partial regression coefficients values (β_p), for example, the relationship of different red meat types (pork, beef, and sheep) on the purchase price of pork, bought by abattoirs. According to Stotts (2013), the demand for one meat product would influence the demand for the other meat products. The demand of a product changes and emerges over time due to the following factors: relative price, the income of the consumer, health trends, food safety, product characteristics, new competing products, a shift in consumer demography and lifestyle (Tomek & Cochrane, 1962; Lusk & Tonsor, 2016). Differences in food demand across income categories, at a point in time, could provide clues to the changes in demand that could result from sustained economic growth. In particular, household survey data could be used to identify the effect of the price and income on demand for different commodities (Akinleye & Rahji, 2007).

The last complete study of supply and demand in the South African meat industry was done 35 years ago by Du Toit (1982) when South Africa was functioning under a divisive political system. The study focused mainly on beef and sheep meat production, although pigs and poultry were included. Du Toit (1982) concluded with an Ordinary Least Squares (OLS) model to calculate demand. Hancock, Nieuwoudt and Lyne (1984) published results of a study that was built on the results of Du Toit (1982), which concluded with a single and simultaneous OLS equation for demand. Loubser (1990) produced an updated version of the OLS, which was followed by the Rotterdam model (Badurally-Adam 1998). Lately, the Almost Ideal Demand System (AIDS) model is used to determine the demand for meat. However, none of these formulas describes the demand of meat entirely. There is no correct or final demand relationship for a specific commodity market, and thus the monitoring of any particular commodity is an on-going process (Delport *et al.*, 2017).

Making use of the output from the correlations, linear regressions were compiled. The equations that resulted from this analysis showed the interaction of the different red meat (pork, beef, and mutton and lamb) and red meat carcass class factors (tonnage of meat, number of carcasses bought by abattoirs, the mass of carcasses bought by abattoirs (kg) and purchase price (R/kg)) on the price that the abattoir paid for red meat carcasses. All these equations were observational equations that could be used to understand the relationships better.

6.1 The partial regression coefficients between red meat carcass classes

The partial regression coefficients values (β_p) derived from the linear regression model between average price (R/kg) of types of red meat carcasses over the 2013 to 2017 period and tonnage of different red meat carcass occur is shown in Table 6.1. The table shows the price dynamics between the average purchase price of red meat types (y_i) and the tonnage of red meat types (x_{ip}). Pork average purchase price, bought by abattoirs, compared to other red meat carcasses bought, was a function of the average purchase price of sheep carcasses bought (0.23), the tonnage of beef carcasses bought (0.001), and the tonnage of sheep carcasses bought (-0.006). The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set. This analysis showed that the average purchase price had the most significant influence on pork price. Both these

had a positive relationship, whereas the tonnage of pork, beef, and sheep had an inverse (negative) relationship.

The average purchase price of beef carcasses bought by the abattoir was a function of the average purchase price of sheep carcasses obtained (0.43), the average purchase price of pork carcasses bought (0.31), and tonnage of meat of beef carcasses bought (0.01). The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set. This analysis showed that the average purchase price of the other red meat carcasses had the most considerable influence, with a positive relationship. In contrast, the tonnage of pork, beef, and sheep had an inverse relationship.

The purchase price of sheep carcasses bought by abattoirs was a function of the average purchase price of beef carcasses bought (1.19) and the average purchase price of pork carcasses bought (0.58). The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set. The analysis showed that the purchase price of the other red meat carcasses had the strongest influence, followed by the mass of sheep. All the previous factors had a positive relationship, whereas the number of pork and beef carcasses had an inverse relationship. All the results observed were due to the correlations between beef, pork and sheep carcasses.

The average mass and number of carcasses bought were not included in these equations, as tonnage of meat represents the combined influence of these two factors and including these factors would only result in multicollinearity. However, a linear regression equation was performed with average mass (x_{ip}), the number of carcasses bought (x_{ip}) and the average price of carcass classes on the price dynamics of red meat (x_{ip}). From this equation, it was determined that the effects observed in Table 6.1 on tonnage were mirrored in the number of carcasses bought, and mass does not influence the price dynamics of red meat prices.

The equations that resulted from this analysis showed the interactions between the different types of red meat (pork, beef, and sheep) and tonnage of red meat, and purchase price (R/kg)) on the price that the abattoir paid for red meat carcasses. All these equations were observational equations that could be used to understand the relationships better.

The study showed that the tonnage of meat and the average purchase price of red meat carcasses bought by the abattoir influenced the average price of red meat carcasses obtained by the abattoir. It was expected that the different types of red meat carcasses would affect the price dynamics of each other. It was, however, not expected that the tonnage of meat and the average purchase price would not contribute equally or, in some cases, would not contribute at all to the resulting price dynamics of meat supplied to the abattoirs.

From the following equations, it could be seen how each factor influenced the price of red meat carcasses according to the different red meat carcass classes. This indicates factors per class that need to be considered by the abattoirs before the purchase price was determined. All the results observed were due to the correlation between beef, pork and sheep carcasses, as discussed earlier.

Table 6.1: Partial regression coefficients (β_p) of linear regression equations for price dynamics of red meat carcass types compared to other red meat carcass factors (tonnage of meat and the average purchase price of carcasses) over the period 2013 to 2017.

		Average purchase price (R/kg)		
		Pork (y_1)	**Beef (y_2)**	**Sheep (y_3)**
Tonnage of meat	**Pork (β_1)**	NS	0.01**	NS
	Beef (β_2)	0.001**	NS	NS
	Sheep (β_3)	-0.006**	NS	NS
Average purchase price of carcasses (R/kg)	**Pork (β_4)**		0.31*	0.58*
	Beef (β_5)	NS		1.19**
	Sheep (β_6)	0.23**	0.43**	
	R^2	0.82	0.93	0.91

* significant at the 5% level of significance, ** significant at the 1% level of significance

The partial regression coefficients values (β_p) derived from the linear regression model between the purchase price of red meat over the period 2013 to 2017 and the tonnage of red meat carcass classes appear in Table 6.2. These show the price dynamics between the average purchase price (y_i) and the tonnage per carcass classes (x_{ip}). The price dynamics for the supply of red meat carcasses bought by the abattoir were mainly influenced by the tonnage of the A6 sheep carcass class. The purchase price of pork carcasses obtained by the abattoir was a function of the tonnage of BP pork class (0.01), PC pork class (2.53), beef A2 (0.001), beef B3 (0.07) and sheep A6 (-0.46). The purchase price of beef carcasses bought by the abattoir was a function of the tonnage of BP pork class (0.01), sausage pigs (0.04), beef AB2 (0.04), sheep A2 (0.03), sheep A3 (-0.12) and sheep A6 (-0.52). The purchase price of sheep carcasses bought by the abattoir was a function of the tonnage of sausage pigs (0.09), beef A2 (0.01), beef A3 (-0.02), beef B3 (0.16), sheep A2 (0.06), sheep A3 (-0.21) and sheep A6 (-1.09). The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equations for the data set.

A linear regression equation was determined for the average purchase price (y_i) compared to the number of red meat carcass classes (x_{ip}) bought. The results of the equation mirrored the results obtained from the equation found in Table 6.2 (linear regression between the average purchase price (y_i) compared to tonnage of red meat carcass classes (x_{ip}) bought). Confirming the earlier results that the effects observed from the tonnage of red meat were due to the number of carcass classes bought and not due to the mass of the carcass classes.

Table 6.2: Partial regression coefficients (β_p) of linear regression equations for the price dynamics of the supply of red meat carcass types compared to the tonnage of meat of each red meat carcass class over the period 2013 to 2017.

			Average purchase price (R/kg)		
			Pork (y_1)	**Beef (y_2)**	**Sheep (y_3)**
Tonnage of meat	**Pork classes**	**BP (β_1)**	0.01**	0.01*	NS
		BO (β_2)	NS	NS	NS
		BR (β_3)	NS	NS	NS
		BC (β_4)	NS	NS	NS
		BU (β_5)	NS	NS	NS
		BS (β_6)	NS	NS	NS
		SAS (β_7)	NS	0.04*	0.09**
		PP (β_8)	NS	NS	NS
		PO (β_9)	NS	NS	NS
		PR (β_{10})	NS	NS	NS
		PC (β_{11})	2.53**	NS	NS
	Beef classes	**A2 (β_{12})**	0.001*	NS	0.01**
		A3 (β_{13})	NS	NS	-0.02**
		AB2 (β_{14})	NS	0.04**	NS
		AB3 (β_{15})	NS	NS	NS
		B2 (β_{16})	NS	NS	NS
		B3 (β_{17})	0.07**	NS	0.16**
		C2 (β_{18})	NS	NS	NS
		C3 (β_{19})	NS	NS	NS
	Sheep classes	**A0 (β_{20})**	NS	NS	NS
		A1 (β_{21})	NS	NS	NS
		A2 (β_{22})	NS	0.03**	0.06**
		A3 (β_{23})	NS	-0.12**	-0.21**
		A4 (β_{24})	NS	NS	NS
		A5 (β_{25})	NS	NS	NS
		A6 (β_{26})	-0.46**	-0.52**	1.09**
		AB2 (β_{27})	NS	NS	NS
		AB3 (β_{28})	NS	NS	NS
		B2 (β_{29})	NS	NS	NS
		C2 (β_{30})	NS	NS	NS
		C3 (β_{31})	NS	NS	NS
		R^2	0.8	0.9	0.9

* significant at the 5% level of significance, ** significant at the 1% level of significance

The partial regression coefficients values (β_p) derived from the linear regression model between the purchase price of red meat over the period 2013 to 2017 and the average mass of red meat carcass classes occur in Table 6.3. These show the dynamics between the average purchase price of red meat carcasses and the average mass of carcasses bought of the different carcass classes. From these equations, it could be observed that BC pork class (β_p) and C3 beef (β_p) carcass classes played a significant negative role in the price of red meat (y_i). The purchase price of pork was a function of the mass of A5 sheep (0.65), BP pork class (-0.82), BC pork class (-0.20), Sausage pigs (-0.05) and C3 beef (-0.08). The beef average purchase price was significantly influenced by BR pork class (-0.53), BC pork class (-0.37), Sausage pigs (-0.10), PP pork class (0.29), AB2 beef (0.13), AB3 beef (-0.14), C3 beef (-0.15) and A0 sheep (1.46) carcass classes. The dynamics of the sheep average purchase price were significantly positively influenced by PP pork class (0.59), AB2 beef (0.32), A5 sheep (1.28) and C2 sheep (0.73) carcass classes, meaning that as these factors values increase so did the purchase price (and *vice versa*). As well as a significantly negatively influenced by BC pork class (-0.59), AB3 beef (-0.23) and C3 beef (-0.25) carcass classes, meaning as these factors increased, the purchase price decreased (and *vice versa*). The coefficient of

determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set.

Table 6.3: Partial regression coefficients (β_p) of linear regression equations for the price dynamics of the supply of red meat carcass types compared to the average mass for each red meat carcass class over the period 2013 to 2017.

			Average purchase price (R/kg)		
			Pork (y_1)	**Beef (y_2)**	**Sheep (y_3)**
Average mass	**Pork classes**	**BP (β_1)**	-0.82**	NS	NS
		BO (β_2)	NS	NS	NS
		BR (β_3)	NS	-0.53**	NS
		BC (β_4)	-0.20**	-0.37**	-0.59**
		BU (β_5)	NS	NS	NS
		BS (β_6)	NS	NS	NS
		SAS (β_7)	-0.05*	-0.10*	NS
		PP (β_8)	NS	0.29*	0.59**
		PO (β_9)	NS	NS	NS
		PR (β_{10})	NS	NS	NS
		PC (β_{11})	NS	NS	NS
	Beef classes	**A2 (β_{12})**	NS	NS	NS
		A3 (β_{13})	NS	NS	NS
		AB2 (β_{14})	NS	0.13*	0.32**
		AB3 (β_{15})	NS	-0.14**	-0.23**
		B2 (β_{16})	NS	NS	NS
		B3 (β_{17})	NS	NS	NS
		C2 (β_{18})	NS	NS	NS
		C3 (β_{19})	-0.08**	-0.15**	-0.25**
	Sheep classes	**A0 (β_{20})**	NS	1.46*	NS
		A1 (β_{21})	NS	NS	NS
		A2 (β_{22})	NS	NS	NS
		A3 (β_{23})	NS	NS	NS
		A4 (β_{24})	NS	NS	NS
		A5 (β_{25})	0.65**	NS	1.28*
		A6 (β_{26})	NS	NS	NS
		AB2 (β_{27})	NS	NS	NS
		AB3 (β_{28})	NS	NS	NS
		B2 (β_{29})	NS	NS	NS
		C2 (β_{30})	NS	NS	0.73**
		C3 (β_{31})	NS	NS	NS
		R^2	0.73	0.81	0.76

*: significant at the 5% level of significance, **: significant at the 1% level of significance

Table 6.4 shows the partial regression coefficient values (β_p) of the linear model between the average purchase price of red meat carcasses (pork, beef, sheep) (y_i) and the average purchase price of carcass classes bought (R/kg) (x_{ip}) over the period 2013 to 2017. From this table, the price dynamics between the red meat types average purchase price and the red meat carcass classes purchase price could be observed. With this equation, multiple combinations of the independent variables (red meat carcass classes) were possible due to high multicollinearity that existed between them. This equation was performed by eliminating the variables with the highest multicollinearity one by one until there were no more variables with multicollinearity.

Pork average purchase price bought by abattoirs during this period was a function of the purchase price of BR pork class (0.39), BU pork class (0.14), sausage (0.19), PR pork class (0.30), C3 beef (-0.09) and A1 sheep (0.06) carcass classes. The price dynamics of beef carcasses bought during this period were significantly influenced by the carcass class price AB3 beef (0.61), and C2 beef (0.61) carcass classes. The purchase price of sheep bought

was a function of the price of BO pork class (0.37), A0 sheep (0.32) and B2 sheep (0.60) carcass classes. The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set. All the results observed were due to the correlation between beef, pork and sheep carcasses.

Table 6.4: Partial regression coefficients (β_p) of linear regression equations for the price dynamics of the supply of red meat carcass types compared to the average purchase price of carcasses of red meat carcass classes over the period 2013 to 2017.

			Average purchase price (R/kg)		
			Pork (y_1)	**Beef (y_2)**	**Sheep (y_3)**
Average purchase price	**Pork class**	**BP (β_1)**	NS	NS	NS
		BO (β_2)	NS	NS	0.37**
		BR (β_3)	0.38**	NS	NS
		BC (β_4)	NS	NS	NS
		BU (β_5)	0.14**	NS	NS
		BS (β_6)	NS	NS	NS
		SAS (β_7)	0.19**	NS	NS
		PP (β_8)	NS	NS	NS
		PO (β_9)	NS	NS	NS
		PR (β_{10})	0.30**	NS	NS
		PC (β_{11})	NS	NS	NS
	Beef class	**A2 (β_{12})**	NS	NS	NS
		A3 (β_{13})	NS	NS	NS
		AB2 (β_{14})	NS	NS	NS
		AB3 (β_{15})	NS	0.61**	NS
		B2 (β_{16})	NS	NS	NS
		B3 (β_{17})	NS	NS	NS
		C2 (β_{18})	NS	0.37**	NS
		C3 (β_{19})	-0.09*	NS	NS
	Sheep class	**A0 (β_{20})**	NS	NS	0.32**
		A1 (β_{21})	0.06*	NS	NS
		A2 (β_{22})	NS	NS	NS
		A3 (β_{23})	NS	NS	NS
		A4 (β_{24})	NS	NS	NS
		A5 (β_{25})	NS	NS	NS
		A6 (β_{26})	NS	NS	NS
		AB2 (β_{27})	NS	NS	NS
		AB3 (β_{28})	NS	NS	NS
		B2 (β_{29})	NS	NS	0.60**
		C2 (β_{30})	NS	NS	NS
		C3 (β_{31})	NS	NS	NS
		BP (β_1)	NS	NS	NS
		R^2	0.98	0.99	0.98

, *: significant at the 5% level of significance, **: significant at the 1% level of significance

The main factors to look at are the number of carcasses bought and the price of each red meat carcass class. The results of this study showed that there were significant influences between the different carcasses of the various red meat species on each other's prices. This interaction depends on specific meat classes, and not all the red meat carcass classes played a role in the effect. Labuschagne *et al.* (2011) confirmed that different meat types compete. Different meat types, therefore, influence the prices of each other. They do not only compete with other meat types, but with other protein sources as well (Labuschagne *et al.*, 2011).

The study showed that the tonnage of meat, average mass, the average number of carcasses, and the average purchase price of red meat carcasses bought by the abattoir had a significant influence on the average price of red meat carcasses obtained by the abattoir. Different red meat carcasses influenced the price dynamics of red meat. The carcass factors

(tonnage of meat, average mass, the average number of carcasses bought and average purchase price) did not contribute equally or, in some cases, NS contribution was observed on the resulting price dynamics of supply.

Commodity prices, in general, are considered to have high volatility; this volatility increases the risk of paying higher prices for a specific commodity. For various reasons, commodity prices, and in particular agricultural prices, are subject to significant fluctuations in both domestic and international markets (Geyser & Cutts, 2007; Jordaan & Grové, 2007; Ayankoya *et al.*, 2016).

The demand for primary commodities tends to be stable and generally is more responsive to changes in income and taste than price changes. In this situation, a small shift in supply or demand conditions could have a significant impact on market prices. The demand for most raw agricultural commodities is steady throughout the year. Demand estimation is vital for informed decision making by industry stakeholders and policymakers (Lusk & Tonsor, 2016). The main factors that affect the price of a product have to do with factors influencing the supply and demand for that product. The factors that affect the supply of a product include the production system, the efficiency of production, feed costs (Schulz, 2013; Stotts, 2013). The factors affecting the demand for a product have to do with the consumer and include reasons like the healthiness of the product, the budget of the consumer, the income of the consumer, economic growth, and urbanisation (Zotte, 2002; McCarthy *et al.*, 2003, 2004; Hahn, 2004; Davids *et al.*, 2013). Culture and religion also play a role in the demand for meat because some cultures and religions do not eat specific meat products, or eat particular meat products only at certain times of the year (Ackerman & Tellis, 2001).

A meta-analysis of meat from data across the world was carried out on price elasticity of meat, and it was concluded that the demand for beef, lamb and fish tends to be more elastic compared to poultry. The elasticity of meat products is particularly sensitive to the specification of demand, chosen estimation method and publication characteristics (Gallet, 2010). Gallet (2010) found that pork was significantly more responsive to price than the other meat types.

Furthermore, the analysis revealed that the influence that was observed was due to specific carcass classes and their particular factor (tonnage of meat, average mass, the average number of carcasses bought and average purchase price) and not due to all the carcass classes.

In the current system, producers sell their animals per contract for R/kg and not per carcass class of the animals obtained (Alemu & Ogundeji, 2010). Since producers in South Africa only receive R/kg animal or carcass, and not for carcass classes derived for the animals marketed, it becomes more critical for the buyer at the abattoir or the person determining the price to incorporate the different influences of the different carcass classes into the pricing of red meat.

6.2 The partial regression coefficients between red meat carcasses and secondary products of red meat animals during the period 2013 to 2017

Table 6.5 is a representation of the partial regression coefficients (β_p) for red meat carcasses (pork, beef, mutton and lamb) (y_i) with regards to secondary products (number of hides sold, feedlot hide price, veldt hide price, SA wool price, US wool price, European wool price and Australian wool price) (x_{ip}). The relationships observed relate to the interaction of the different red meat carcasses on each other, which filter through to the products.

Pork price was a function of US wool price (-0.01), veldt hide price (0.49), SA wool price (0.001), European wool price (0.01) and the number of wool bales sold in South Africa

(0.0002). All the results observed were due to the correlation between beef, pork and sheep carcasses, as discussed earlier. The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set.

The price of beef was negatively affected by Australian wool prices (-0.01), whereas feedlot hide prices had a non-significant effect on beef prices. Beef price was a function of Number of Hide (0.0003), Veldt Hide price (0.53), SA (c/kg) wool price (0.001), European (c/kg) wool price (0.01) and AWEX EMI (-0.01). The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set.

Sheep price was a function of the number of hides (0.001), feedlot hide prices (0.81) and Australian wool price (0.03). The relationships observed were coincidental. The coefficient of determination (R^2) for these equations shows that the linear regressions were the best-fit equation for the data set.

Table 6.5: Partial regression coefficients of linear regression equations for price dynamics of red meat carcasses with regards to products (feedlot hide price, veldt hide price, SA wool price, US wool price, European wool price and Australian wool price) over the period 2013 to 2017

	Average purchase price (R/kg) ()		
	Pork (y_1)	**Beef (y_2)**	**Sheep (y_3)**
Number of Hide (β_1)	NS	0.0003**	0.001**
Feedlot Hide price (β_2)	NS	NS	0.81*
Veldt Hide price (β_3)	0.49**	0.53**	NS
SA (c/kg) wool price (β_4)	0.001**	0.001**	NS
US (c/kg) wool price (β_5)	-0.01*	NS	NS
European (c/kg) wool price (β_6)	0.01**	0.01*	NS
AWEX EMI (β_7)	NS	-0.01*	0.03**
Number of wool bales (β_8)	0.0002*	NS	NS
R^2	0.83	0.89	0.76

* significant at the 5% level of significance, ** significant at the 1% level of significance

The relationship observed between beef and pork carcasses, and wool prices relate more to their relationship with sheep carcass than the wool prices as such (as discussed earlier). The graph generated from the residuals (R^2) of all the above equations shows that the linear regression equation was the best-fit equation for the data (Abdel-Salam, 2008; Hoang, 2012). Labuschagne *et al.* (2011) confirm that different meat carcass competes. Different meat carcasses, therefore, influence the prices of each other. They do not only compete with other types of meat carcasses but also with other protein sources as well (Labuschagne *et al.*, 2011). Demand estimation is essential for informed decision making by industry stakeholders and policymakers (Lusk & Tonsor, 2016).

CHAPTER 7:
CONCLUSION

The study showed that the tonnage of meat and the average purchase price of red meat carcasses bought by the abattoir influenced the average price of red meat carcasses obtained by the abattoir. It was expected that the different types of red meat carcasses would affect the price dynamics of each other. It was, however, not expected that the tonnage of meat and the average purchase price would not contribute equally or, in some cases, would not contribute at all to the resulting price dynamics of meat supplied to the abattoirs.

The price dynamics for the supply of red meat carcasses bought by the abattoir were mainly influenced by the tonnage of the A6 sheep carcass class. The purchase price of pork carcasses obtained by the abattoir was a function of the tonnage of BP pork class (0.01), PC pork class (2.53), beef A2 (0.001), beef B3 (0.07) and sheep A6 (-0.46). The purchase price of beef carcasses bought by the abattoir was a function of the tonnage of BP pork class (0.01), sausage pigs (0.04), beef AB2 (0.04), sheep A2 (0.03), sheep A3 (-0.12) and sheep A6 (-0.52). The purchase price of sheep carcasses bought by the abattoir was a function of the tonnage of sausage pigs (0.09), beef A2 (0.01), beef A3 (-0.02), beef B3 (0.16), sheep A2 (0.06), sheep A3 (-0.21) and sheep A6 (-1.09). The coefficient of determination (R^2) for these equations showed that the linear regressions were the best-fit equation for the data set.

Pork average purchase price bought by abattoirs during this period was a function of the purchase price of BR pork class (0.39), BU pork class (0.14), sausage (0.19), PR pork class (0.30), C3 beef (-0.09) and A1 sheep (0.06) carcass classes. The price dynamics of beef carcasses bought during this period were significantly influenced by the carcass class price AB3 beef (0.61), and C2 beef (0.61) carcass classes. The purchase price of sheep bought was a function of the price of BO pork class (0.37), A0 sheep (0.32) and B2 sheep (0.60) carcass classes. All the results observed were due to the correlations between beef, pork and sheep carcasses.

Pork price was a function of US wool price (-0.01), veldt hide price (0.49), SA wool price (0.001), European wool price (0.01) and number of wool bales sold in South Africa (0.0002). All the results observed were due to the correlation between beef, pork and sheep carcasses, as discussed earlier. The price of beef was negatively affected by Australian wool prices (-0.01), whereas feedlot hide prices had a non-significant effect on beef prices. Beef price was a function of Number of Hide (0.0003), Veldt Hide price (0.53), SA (c/kg) wool price (0.001), European (c/kg) wool price (0.01) and AWEX EMI (-0.01). Sheep price was a function of the number of hides (0.001), feedlot hide prices (0.81) and Australian wool price (0.03). The relationships observed were coincidental.

The results of this study showed that there were significant influences between the different red meat carcasses and that these effects were as a result of specific carcass classes. Not all the red meat carcass classes played a significant role, and these that played a role did not contribute equally to the resulting effect.

The outcome of the study supported the hypothesis that carcass type and specific meat classes within carcass types were responsible for the differences in meat carcass prices. There was a differentiation in price between different meat classes, which affected the price of other classes. Still, meat classes were identified that did not influence the dynamics of meat prices.

The value in the analysis pointed directly to the classes that to a greater or lesser extent influenced price with an interactive effect between meat types. The analysis revealed that the

influence that was observed was due to specific carcass classes and their specific factor (tonnage of meat, average mass, the average number of carcasses bought by abattoirs and average purchase price) and not all the carcass classes. For price determination by buyers at the abattoir, processors and retailers as well as traders at the Johannesburg stock exchange (JSE), the different and combined influences of the different carcass classes on red meat price should be taken into consideration.

Literature showed/reported that the red meat carcass classification system was not completely bi-directional. Since more and more producers were selling their beef on a contract basis per kg animal and due to the lack of feedback or communication from the buyers, producers were unable to aim their production practices towards producing the best quality meat for the consumer. The classification system only functioned in the abattoir. They sold meat according to the classification system, and then the buyers would use the meat for different purposes, and the consumer did not know which class of meat they were buying and consuming. With the pork classification, the carcasses were not branded according to the classes, and the consumer could accordingly buy any class without knowing what class it was.

It would appear that there was some degree of bi-directional communication without realising that this was occurring. Concerning the consumer, certain carcass classes were used for fresh meat, whereas certain classes were used for processing. This resulted in the best quality meat being sold by abattoirs to the consumer as fresh meat and the poorer quality meat as processed products, hereby communicating to the consumer.

Concerning the producers of red meat carcasses, from the results of this study, there was a trend of the producers producing towards the higher-priced carcass classes (BP pork class, BO pork class, PP pork class, A2 beef, A3 beef, A2 sheep and A3 sheep), showing that there was some sort of communication flowing back to the producer. This may have been due to the fact that most of the animals were produced in these classes according to the optimum muscle to fat ratio for optimum price in R/kg, as well as the natural production cycle on the farm.

A great deal has changed since the Apartheid era. The Du Toit (1982) study that was done during the Apartheid era was conducted, to offer producers with optimal prices, all factors (including carcass classes and external factors) influencing red meat prices must be taken into consideration when determining the price.

In 1994, the population and political dynamics of South Africa changed dramatically. The change impacted on the reordered national marketing and consumer profiles. Formerly, the country was divided into South Africa proper and homelands, of which four were independent and not considered part of South Africa. During the Apartheid era, the South African Livestock and Meat Industries Control Board (Meat Board) controlled the access of red meat to controlled areas and abattoirs. The controlled access to markets on a quota system influenced the price of red meat sold at auction at abattoirs. The independent homeland regions were discriminated against and did not receive access to the controlled markets. The system skewed the real picture of the supply, demand for and price of red meat. After the abolishment of the Apartheid policies, radical deregulation of the controlled markets occurred.

The control boards were abolished by 1998 with the implementation of the Agricultural Product Act (Act 47 of 1996). The implementation of the Act opened access to the red meat markets to the entire population, which also meant that the supply of and demand for red meat and subsequent the prevailing social and economic forces of the whole population influenced pricing.

Currently, planning by red meat producers would not be influenced by the interactions of commodities and red meat, since their decision-making was not based on either carcass

classes or the price of specific carcass classes. Decisions are based on the ratio between muscle and fat as well as the maximum profitability per animal based on input versus output cost. This is because producers are paid on a R/kg basis for carcasses and not according to the classification system. The price is negotiated before animals are brought to the abattoir according to contract or according to market information published by the JSE. Planning by red meat producers would not occur until producers are paid by carcass class and not just R/kg, and the different influences of the different carcass classes are not taken into consideration.

Even though this study was done in South Africa on its classification system, these principles could be applied to other countries and their specific classification system where applicable. Further studies would be required to determine the combined effect on the price and supply, as well as on demand with regard to the internal factors and external factors affecting them.

CRITICAL REVIEW

The last time a full study was undertaken on demand for red meat in South Africa was undertaken in 1982, under a completely different political and marketing system. Since that time, a great deal has changed in South Africa and the world. The 1982 study did not take into consideration the red meat classification system. No study could be found in the literature on the interaction of different carcass classes or grade on the demand and price dynamics of red meat worldwide. It is assumed by scientists and the industry that carcass classes play a role in the price of meat, but the interaction of these classes is not known. This PhD study set out to investigate the interaction between the different red meat carcass classes in determining the price of different red meat.

To validate that a relationship does exist as assumed only one whole year's data was used to determine the correlations between the red meat prices and different red meat carcass classes. After the validation was completed, an additional two years was added, resulted in a period range of 2013 to 2015. These years were at the time the only years that complete data sets were available. All the statistics were completed by me, with regards to the ANOVA analysis, correlations and price dynamics. Under guidance, the effects of wool and hide prices on the price dynamics of red meat was added, but this resulted in cumbersome equations, and the results of the wool and hide were not significant in combination with the red meat carcass class. A decision was made to look at these factors on their own.

By the time all the statistics mentioned above were completed and written up, another year's data set was available. Feedback from the supervisors suggested that 2016 should also be added and the statistics be revised accordingly. After the implementation of changes due to the added year, an article was written with regards to the price dynamics of red meat in relation to the red meat carcass classes. The feedback from the reviewers of the article, prompted a validation of the statistics by a statistician, and at that time 2017's full data set also become available. The data set of 2017 was added to the raw data, and the statistics were undertaken by a statistician, who confirmed the results of the previous statistics. The coefficients in the equations only changed slightly with the added year.

A revised article was submitted for peer review, but it was difficult to find a relevant journal, as this study is a combination of animal science and agricultural economics. The peer-review journals available in these fields specialized in only one of the fields, and the article was not deemed to match the scope of the journal. Therefore, under guidance, the concept of post-apartheid was added. This concept added value and assisted in a better fit into the scope of peer review journals. The introduction of the post-apartheid concept was possible due to the 1982 study was completed during apartheid, and this PhD study was completed after the abolishment of apartheid, and a great deal of changes occurred in between.

It was a struggle to find relevant literature for the literature review and for comparison with this PhD study as this is the first study that relates to the dynamic relationship between red meat prices and carcass classes or grades. Which in effect, shows the merit of the study but made it difficult to find reference materials.

This PhD was initially written with each chapter able to stand alone as a separate article, this caused problems with repetition of literature and methodology, creating a very bulky, messy document. This layout was revised into the current form, where the repetition of literature and methodology was minimized.

For me, the study taught me endurance, to take it calmly and not to rush through the work, and to be clear and explicit. It also taught me not to take rejections personally and to

build on the criticisms that were given. Through this and with the support I enjoyed as I have already acknowledged, I gained confidence in my abilities and presentation skills.

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