PRICE TRANSMISSION IN THE BEEF VALUE CHAIN – THE CASE OF BLOEMFONTEIN, SOUTH AFRICA

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DECLARATION

I, Hermanus Louwrens Lombard, hereby declares that this dissertation submitted for the degree of *Magister Scientiae Agriculturae* in the Faculty of Natural and Agricultural Sciences, Department of Agricultural Economics at the University of the Free State, is my own independent work, and has not previously been submitted by me to any other university. I furthermore cede copyright of the thesis in favour of the University of the Free State.

Hermanus Louwrens Lombard　　　　Date

BLOEMFONTEIN

DEDICATION

This dissertation is dedicated to my parents,
Stefan and Wilna Lombard,
to whom I will always be grateful for this lifetime opportunity.

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"Success is where preparation and opportunity meet."

Bobby Unser

I firstly wish to thank our heavenly Father who has granted me the insight, guidance, calmness, perseverance and strength to complete this research. I also wish to thank my family and my best friend, Monique van Aardt, for their continued support, motivation, encouragement and the sacrifices they had to make for the duration of this thesis.

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The views expressed in this dissertation do not necessarily reflect those of the RMRDT, RPO or NRF.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADF	Augmented Dickey–Fuller
AIC	Akaike information criterion
ARCH	Autoregressive conditional heteroskedasticity
APT	Asymmetrical price transmission
A2/A3	Average producer price of classes A2 and A3 beef carcasses
B	Butchery
DAFF	Department of Agriculture, Forestry and Fisheries
DF	Dickey–Fuller
DLEA	Distributed lag effect asymmetry
ECM	Error correction model
EG	Engle and Granger model
EU	European Union
FSRPO	Free State Red Meat Producers' Organisation
GDP	Gross domestic product
GSM	Generalised switching model
LOP	Law of one price
M-TAR	Momentum threshold autoregressive model
MC-TAR	Momentum-consistent threshold autoregressive model
NERSA	National Energy Regulator of South Africa
OLS	Ordinary least squares
PP	Producer price
PR	Producer to retail
p^{in}	PP
p^{out}	RP
RMAA	Red Meat Abattoir Association
RP	Retail price
RTA	Reaction time asymmetry
SAMIC	South African Meat Industry Company
S1	Supermarket One
S2	Supermarket Two
S3	Supermarket Three
TAR	Threshold autoregressive model
US	United States
USDA	United States Department of Agriculture
VAT	Value-added tax
ΔRP_t	Change in RP
ΔPP_t	Change in PP

Price transmission in the Beef value chain – the case of Bloemfontein, South Africa

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Abstract

The primary objective of the study was to analyse the nature of price transmission in the Bloemfontein beef value chain. The deregulation of the South African agricultural market in 1996 led to an unknown difference between the producer and retail prices of beef, which raised concerns among producers. These concerns were caused by the possibility of asymmetry in the market, as the variation in the producer carcass (A2/A3) price and retail price does not always reflect the same relationship. Producers believed that they were carrying all the risk and that retailers fixed their prices, irrespective of the market price at that stage.

The first sub-objective of this study was to determine the existence of a long term relationship between producer and retail prices. Secondly, the short term nature of price transmission in the value chain was investigated to determine whether the marketing margin returned to the long term equilibrium after short term shocks, and how this had taken place. Thirdly, the causality of the market was investigated to determine whether the casual flow of information was bidirectional, unidirectional or undirectional.

The data preparation and the procedures applied to perform the analyses of this study, were the stationary test at levels and at first difference to eliminate any uneven data points or spikes that may skew results. To determine co-integration, four competing models (EG, M-TAR, TAR and MC-TAR) were applied to the three-year data. The model best suited to represent the level of price transmission for each specific data series, would be the one with the highest absolute Akaike information criterion (AIC) value. After confirmation of co-integration and type of transmission (symmetrical or asymmetrical), an error correction model (ECM) was matched with those data series that confirmed asymmetrical price transmission. The error correction model examined the responsiveness of one price to changes in another price at a different level in the chain, thus reflecting the correction ability by speed and magnitude. Lastly, Granger causality was used to analyse the direction of influence between the producer price and retail price.

The results firstly confirmed the existence of a long term relationship between the producer and retail prices at all four retail outlets (S1, S2, S3 and B) of the Bloemfontein beef market. The actual relationship of all four cases revealed an asymmetrical relationship, of which S1 and B were found to be positive asymmetric, while S2 and S3 were negative asymmetric, indicating that the market margin for S1 and B would thus increase (stretch) while the market margin for S2 and S3 would decline (shrink) in the long term.

Secondly, the short term nature of price transmission among the various retailers also showed significant differences. S1 and B both reacted quicker and more circumspect to an increase in the producer price than to a decrease. S2 and S3, on the other hand, reacted quicker and more circumspect to a decrease in the producer price than to an increase. The response of S3 in the case of a price increase was found to be insignificant.

Thirdly, results on the flow of market information indicated, at significant levels, that a flow of market information did exist in the markets of three of the four retailers. S1 exhibited significant bidirectional behaviour; S2 revealed undirectional flow of information and a unidirectional influence was identified in the case of S3 and the butchery (B) where information flowed only from the producer to retailer.

Despite the differences within different segments of the price transmission analyses, the transmission for each retailer with regard to speed and magnitude remained asymmetrical. Asymmetrical price transmission is the change of the price relationship between the producer and retail prices over time. In the case of Bloemfontein, the price transmission relationship of two of the retailers were beneficial for consumers, as the marketing margin declined over time, while the relationship of the other two retailers were detrimental to consumers. The asymmetrical price transmission in the Bloemfontein market could thus not be viewed as a negative factor only. It should, however, be borne in mind that for a market to exist sustainably in the long term, symmetrical price transmission should be the norm – as retailers with positive price transmission will price themselves out of the market, while the margin of those with negative price transmission will become so small, that they will be forced to close down.

Keywords: Price transmission, long term relationship, short term relationship, direction of influence, market responsiveness, red meat, beef value chain analysis

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

In the early 1990s the agricultural marketing boards were removed as a result of government intervention. This led to the deregulation of South Africa's agricultural markets. The red meat industry became exposed to a number of basic factors such as exchange rates, consumption, production levels and stock levels (both domestic and international) that play a role in determining prices. These factors caused prices to fluctuate more regularly than when the market had been regulated (Spies, 2011).

Due to a more influenced market, the red meat industry became increasingly volatile, which led to a greater difference between the producer price (PP) and retail price (RP). The ever increasing difference between the two prices raised concerns among producers (FSRPO, 2012). These concerns were brought about by the possibility of asymmetrical price transmission in the market, as the variation in the PP and the RPs does not always reflect the same relationship. Figure 1.1 illustrates the relationship of the PP and the RP of a single beef cut, rump, for a year. This relationship reflects concerns that the two variables, PP and RP, do not follow the same trend and that the margin between the two role-players thus varies over time.

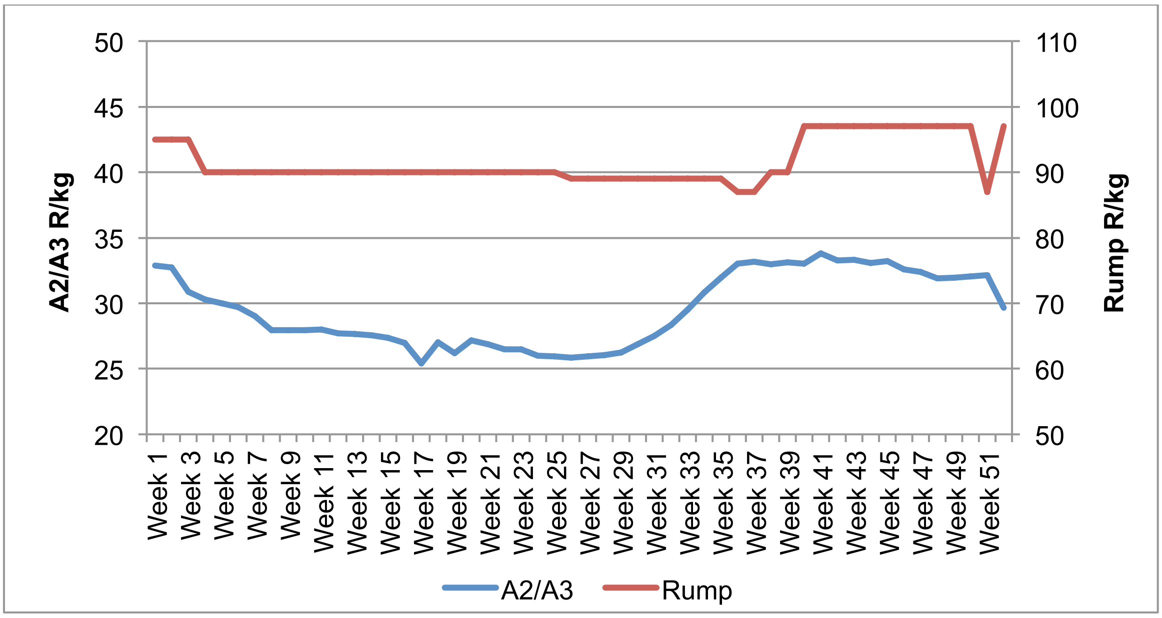

Figure 1.1: Weekly average producer price of classes A2/A3 beef carcass and rump steak.
Source: RMAA (2012) and own calculations.

The scenario presented in Figure 1.1 has led to a perception within the beef industry that the margin between the producer carcass prices (A2/A3) and the RPs for rump, does not maintain the same relationship over time. In terms of this perception, the retailer determines a selling price for beef irrespective of the market price paid for the carcass. Producers therefore believe that when the price of the carcass increases, the retailer increases the price of various beef cuts accordingly, but that when the carcass price decreases, the retailer does not maintain this relationship. This behaviour then leads to an increase in the RP margin over time. Any argument regarding this perception should, however, not be based on the comparison of the PP with the RP of one type of beef cut (rump). A carcass consists of many cuts, each with its own economic value, and the price of the carcass that the producer receives should therefore be compared to the combined price at which the retailer sells the entire carcass.

1.2 DESCRIPTION OF THE SOUTH AFRICAN RED MEAT INDUSTRY

An overview of South Africa's red meat industry is provided in order to establish a better understanding of the local red meat value chain, and more specifically the functioning and roles of its different segments.

South Africa is a developing country comprising of 1 219 090km^2 agricultural land, of which approximately 80% is mainly suitable for extensive livestock farming. Approximately 590 000km^2 of land involve cattle, sheep and goat farming, representing 53% of all agricultural land (DAFF, 2011). Since 1970, the agricultural sector as a whole has grown on average at 11.8% annually (DAFF, 2013b). The agricultural sector contributes 2.2% of the South African gross domestic product (GDP) (Statistics South Africa, 2014b).

The red meat industry is one of the largest industries in the South African agricultural sector. The commercial red meat sector consists of beef, mutton, lamb, goat meat and pork. Approximately 47.7% of South Africa's total gross value of agricultural production is contributed by the gross value of animal products (DAFF, 2012). Despite an increase of 11.6% in consumer meat prices during 2012, consumers continued to purchase meat which on average represented 33% of their food expenditure. Two of South Africa's main protein commodities are beef and lamb, totalling a consumption of approximately 864 670 tons of beef and 150 900 tons of lamb per annum. Of this, 10 014 tons of beef and 6 473 tons of lamb had to be imported in 2011 in order to satisfy the demand of the domestic market (DAFF, 2012).

There are approximately 37 500 commercial, 240 000 emerging and three million subsistence beef cattle farmers in South Africa. In August 2012 the number of cattle in South Africa was estimated at 13.84 million (DAFF, 2010). The most common production system used by farmers is the weaner production system, in which calves are weaned at approximately seven months of age and sold to a feedlot.

1.3 QUANTIFICATION OF THE SOUTH AFRICAN BEEF VALUE CHAIN

In order for price transmission to take place, a medium is required through which to transmit. In this study the medium is the value chain of the vertically integrated red meat industry. Spies (2011) is of the opinion that one should bear in mind that the theory of vertical integration consists of assumptions of which the applications may vary from sector to sector and from commodity to commodity. Motivated by economic welfare distribution, economists attempt to explain the relationship between farms and the market in lieu of the allocation of scarce economic resources, production and marketing efficiency in the economic system (Spies, 2011). The bold dotted line in Figure 1.2 illustrates the vertical medium that will be analysed.

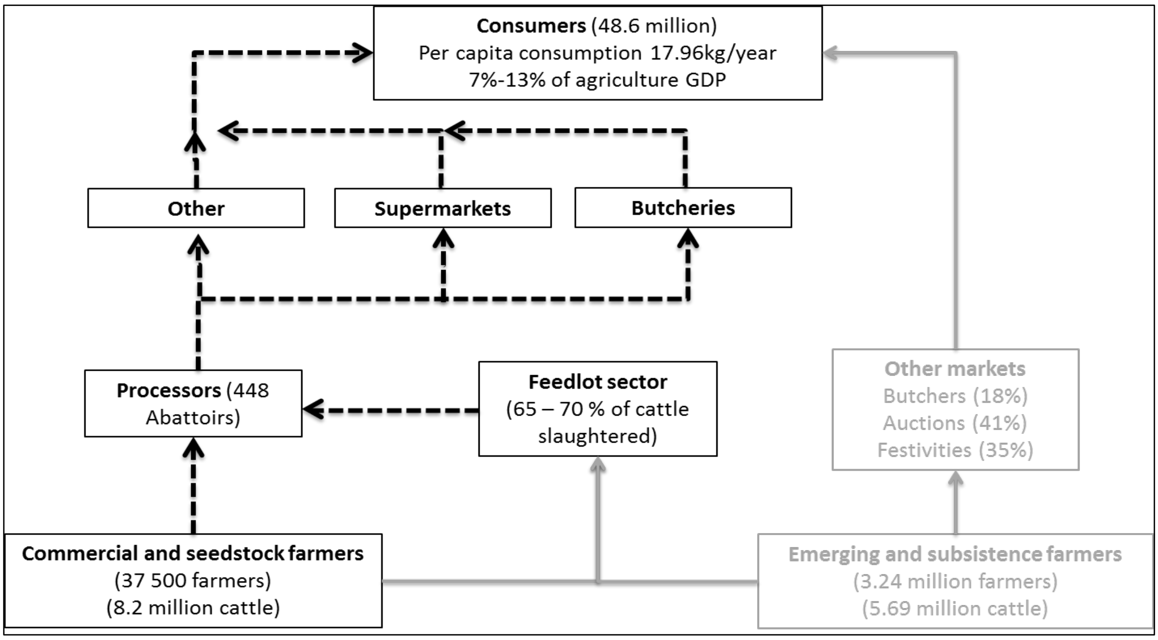

Figure 1.2: South African beef value chain
Source: Adopted from Spies (2011) and DAFF (2010)

The beef value chain starts with the producers who produce livestock (cattle). Their main objective is to align their production systems in such a way, that they utilise resources optimally. In other words, they produce at a level where maximum kilograms of meat is produced per hectare. The livestock produced is then sold and will follow the path of the value chain, as demonstrated in Figure 1.2. Livestock is sold either at an auction or directly to an abattoir or feedlot. An auction is a point of sale where supply and demand meet and where livestock is normally purchased by representative agents who buy either for the abattoir or the feedlot. A feedlot is the location where animals are fed until they reach a market-ready weight and fatness level. Livestock is slaughtered at the abattoirs, after which carcasses are classed and distributed to wholesalers, processors, butcheries and retailers. Consumers (the end user) purchase the final product at the end of the marketing channel (DAFF, 2011).

1.4 PROBLEM STATEMENT

The deregulation of the South African agricultural market in 1996 led to an undisclosed difference between the PP and RP of red meat, raising concerns among producers. These concerns were brought about by the possibility of asymmetry in the market, as the variation in the PP (A2/A3) and RPs did not always reflect the same relationship. Producers believed that they were carrying all the risk and that retailers were fixing their prices, irrespective of the market price at that stage.

Effective price transmission, or the lack thereof, has formed part of numerous research titles compiled by local and international authors, such as Hahn (1990), Babiker and Abdalla, (2009), Tey (2009), Spies (2011) and Rumánková (2012). Despite the differences in the main objectives of these studies on price transmission, other major differences exist, such as the country in which the scenario plays out, the commodity that determines the industry, the characteristics of the data used (frequency length of data), the unique level of infrastructure of each country, which influences marketing margins and the choice of time series (Rumánková, 2012; Babiker and Abdalla, 2009).

Despite the available literature on price transmission, producers are not satisfied with the current state of price transmission within the South African beef value chain. The marketing of livestock products has changed drastically since deregulation in 1996, with traditional price trends no longer applicable and consumer preferences and market interaction changing frequently.

The question remains whether price transmission between producers and retailers has changed. By using the latest available PP and RP data, and taking into consideration previous studies on price transmission, it is possible to determine the current state of price transmission in the market. Until 2015 the actual status of price transmission within the South African beef value chain was based mostly on the opinions of producers versus that of other role-players in the value chain, such as wholesalers and retailers. This study aims to contribute towards addressing concerns among beef producers regarding the true status of price transmission.

It is important to also emphasise that this study is unique in its own right. In general the data properties of price transmission analysis are based on national averages and monthly data over a shorter time series and with fewer observations. The line of price transmission analysis does not comprise only the usual PP to RP based on national averages, but rather PP to RP at four different retail outlets, with the PP based on the national average. The RPs of beef cuts were physically collected from each retail outlet in the same geographical area on a weekly basis over a period of three years.

1.5 OBJECTIVES

The primary objective of this study was to analyse the nature of price transmission in the Bloemfontein beef value chain.

In order to achieve this objective, the following secondary objectives were set:

- **To determine the existence of a long term relationship between price variables.**
  In order to verify the existence of a relationship, the following competitive models were applied: Engle and Granger (EG) model and three types of threshold adjustment models. These threshold models account for asymmetric adjustment as well, namely the threshold autoregressive (TAR) model, momentum threshold autoregressive (M-TAR) model and momentum-consistent threshold autoregressive (MC-TAR) model. These models were used to confirm co-integration and hence asymmetry in producer-retail beef market prices.

- **To determine the short term nature of price transmission in the market.**
  Once co-integration can be confirmed between producer and retailer prices in the long term, it is important to determine the nature of the relationship in terms of how prices are transmitted. The nature of the relationship will be measured by the use of the error correction model (ECM) in the short term. If the relationship between markets (producer and retailer) is asymmetric, changes in one price will not cause the same response from the alternate market. Therefore, it is important to investigate the nature of the adjustment to the disequilibrium in the market margin caused by economic shocks.

- **To determine the direction of the flow of price information between producers and retailers.**
  In asymmetric price transmission modelling, it is commonly assumed that the producer (input) price causes the retail (output) price. This is why many studies model output price responses to changes in input prices, thus implying that causality runs from input to output price. If causality flows in the opposite direction, the relationship between input and output prices will be miss-specified. This can be avoided by testing the direction of causality statistically. The direction of influence was determined by using the Granger causality test.

1.6 CHOICE OF STUDY AREA

Due to livestock producers having raised concerns over prices being set by retailers, the FSRPO contracted the Department of Agricultural Economics of the University of the Free State to investigate price transmission in the city of Bloemfontein in South Africa's Free State province. The price transmission data used in the study was collected from three supermarkets and a butchery in the Langenhoven Park suburb of Bloemfontein.

1.7 DISSERTATION OUTLINE

Chapter 2 is a literature review of studies conducted to determine the level of price transmission, the existence of asymmetry, the quantification of the red meat value chain and the influence of different time series on the end results, using the latest or best method as part of the procedure in order to determine the level of price transmission or asymmetry.

Chapter 3 describes the procedures used in this study. The focus will be on determining the existence of a long term relationship between the variables and the direction of influence (causality) in order to determine the level of price transmission or the lack thereof. *Chapter 4* discusses the manner in which the level of price transmission will affect the relationship between the variables, the potential of the variables to react on one another's change and the direction of influence. In conclusion *Chapter 5* will draw conclusions and set out certain recommendations based on the findings of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Economists and agricultural economists use different theories, assumptions and approaches to study price transmission. The literature reviewed in this study covers a wide range of approaches used to analyse price transmission for different commodities under various circumstances in national and international markets. This study focuses on the theory of price transmission, different types of transmissions, factors that play a role and the influence of data characteristics (frequency, length of time series and total number of observations). The latter part of the chapter will focus on the various methods used in previous studies to determine the effectiveness of price transmission or the lack thereof in the beef value chain of Bloemfontein.

2.2 CONCEPT OF MARKET AND PRICE RELATIONSHIP

A market is the point of sale where a potential buyer and a potential seller meet and indicate their willingness to buy and sell goods and services at a market equilibrium price. Price transmission is essential, for it determines the actual price at the point of sale. Price needs to be transmitted in vertically integrated markets to ensure the existence of each segment in the value chain. Price is central to resource allocation, output levels and decision-making in economics (Uchezuba, 2010). Price, together with the level of resource allocation and output, plays a major role in maximising profit. If input prices change, producers adjust their production activities and produce where marginal cost equals marginal revenue. Therefore, producers are driven by relative input and output prices, and output prices influence the demand of the consumer for agricultural products, thereby influencing the level of output (Uchezuba, 2010; Spies, 2011).

Consumers aim to maximise their welfare and the uses they can derive from the consumption of agricultural products, subject to their budget constraints. Since the end consumers of agricultural products are price takers, they often have to adjust their demand according to the change in the commodity price. A price increase normally tends to force consumers to adjust their expenditure, because increasing prices diminish their buying power (Spies, 2011).

Besides the influence that price has on production and consumption decisions, price signals also drive commodity markets (Uchezuba, 2010). In order for market agents to make decisions, they need to have prevailing market price information at their disposal. Integrated and efficient markets are crucial for flawless and complete transmission of information. The question remains whether agricultural commodity markets are efficient and integrate into transition economics. If this is the case, price transmission should be reflected across markets and in the case of a market failure, price transmission will reflect inefficiencies as well as a welfare decline in the economic system (Uchezuba, 2010).

Price relationships within a market depend on the level at which market segments are horizontally and vertically integrated. This study focuses on the vertically integrated value chain with regard to price transmission within the beef value chain. The theory of vertical integration consists of many assumptions whose applications may differ among sectors and between commodities. Depending on the economic welfare distribution, production and marketing efficiency in the economic system, economists usually attempt to explain the relationship between the farm and the market, instead of explaining the allocation of scarce economic resources (Uchezuba, 2010).

The basic concept of vertical integration is captured in a market relationship which involves the integration of various stages of production, processing and marketing chain links in the vertical motion. The vertical agricultural market chain traditionally comprises of a set of economic stages that starts with the farmer and flows through to the processors, wholesalers and then to the retailers who sell the final product to consumers. Various stakeholders are involved in the value-addition process, by transforming and distributing agro-food products to the end consumer (Uchezuba, 2010).

2.3 THEORY OF PRICE TRANSMISSION

Price transmission is the actual price transmitted via various market segments. This process basically reflects the price relationship between different market segments. In the scope of this study, vertical price transmission is the primary mechanism through which different levels of the vertical production and market stages are linked. More specifically, this process reflects the relationship between the primary producer (input) on the one end of the value chain and the retailer (output) at the other end. Producer to retailer transmission reflects the flow of a change in the input price from the producer (farmgate) to the processing stage right up to the price offered at wholesale market level. Retail to producer transmission is the flow of a change in output prices, processing and production units or the price offered at the last point of sale in the value chain. The price transmissions via vertical segments in the chain are known as the primary mechanism (Meyer and Von Cramon-Taubadel, 2004).

In the case of vertically integrated markets, price theory suggests the existence of a long term equilibrium relationship between producer and retailer prices through such a market (Veselska, 2005). This theory implies that, in the long term, the price of goods will engage in economic activity reflecting economic value, which is directly correlated with the availability or scarcity of the goods or service (Veselska 2005). Given this theory on the equilibrium relationship, any external shock(s) to in- or output prices are expected to trigger an adjustment towards the new equilibrium in the short and long term. In the end, if a shock was initiated at in- or output price level, the price will deviate from the initial relationship between producers and retailers, and as it transmits through the vertical chain it should adjust back, maintaining the initial relationship and reflecting symmetrical price transmission.

Studies contradicting symmetrical price transmission behaviour, have revealed evidence that, in practice, transmission from producer to retailer may not always be homogenous in maintaining the same price relationship (symmetrical), but rather asymmetrical (Meyer and Von Cramon-Taubadel, 2004; Peltzman, 2000; Ward, 1982). Vertical price transmission from producer to retailer can thus be either symmetrical or asymmetrical. These two types of symmetry describe the efficiency of the transmission or the lack thereof throughout a value chain, from the start (producer) right down to the end where the retailer will sell the final product to the consumer.

According to canonical economic theory (perfect competition and monopoly), price transmission through the various segments of the value chain should be symmetrical, whether or not adjustments occur at the in- or output price (Peltzman, 2000; Meyer and Von Cramon-Taubadel, 2004; Alemu and Ogundeji, 2010). The response of market participants to a shock (change in price) can either stretch or squeeze the market margin, thus determining the type of transmission. The effectiveness of a transmission is measured by the magnitude and speed or size and timing of the response to the change in price (Alemu and Ogundeji, 2010). The market margin is the difference between the producer and retailer prices. The difference represents the relationship between these two prices as well as the cost of value addition that takes place from the farm to the shelf.

Symmetric price transmission exists when a change in input prices triggers an appropriate change in output price and vice versa (Meyer and Von Cramon-Taubadel, 2004). For the transmission to be symmetrical, the changes should be rapid and complete in both directions. This means that the relationship between the producer and retailer price will remain the same over time. Asymmetrical price transmission (APT) will be the outcome of a price change caused by a shock in the in- or output price which is not transmitted in a timely manner or at the same magnitude through the value chain. The lack of transmission will result in a change in the relationship between the price of producers and retailers over time (Peltzman, 2000; Meyer and Von Cramon-Taubadel, 2004; Alemu and Ogundeji, 2010).

Literature contains several classes of asymmetric price transmission. The two main classes of asymmetry relate to magnitude and speed and positive and negative asymmetry (Spies, 2011).

2.3.1 Magnitude and speed of asymmetry

When asymmetrical price transmissions (APT) occur there is disequilibrium in the market price, and the speed and magnitude of price transmission reflect the behaviour of the market participants. The speed and magnitude of transmission can both be asymmetrical (Von Cramon-Taubadel, 1998). Meyer and Von Cramon-Taubadel (2004) classify APT using graphic illustrations (Figures 2.1 to 2.3) to explain asymmetry with regard to the speed and magnitude with which producers and retailers respond to a change in price. Asymmetrical transmission relating to speed is the inability of either producers or retailers to react immediately to the shock (change in price), whether it represents an increase or decrease, and irrespective of the size of the adjustment. Speed accounts for the time that lapses between the price change and the initial response to the change. Magnitude is the size of the adjustment, which depends on the price change and the transaction volumes involved, and can be proportionally smaller or larger than the price change. APT can also be classified in combination with magnitude and speed.

Figures 2.1 to 2.3 represent the visual reflection of price transmission with regard to speed and magnitude responses to a change in either the PP (p^{in}) or RP (p^{out}). In Figure 2.1 illustrates the fact that the magnitude of the response of p^{out} to the change in p^{in} depends on the direction of the price change (increase or decrease). For example, in case of a decrease in p^{in}, p^{out} will respond with the same speed but not the same magnitude. (The grey area represents the lack in magnitude.) On the other hand, when p^{in} increases, p^{out} will increase by the same magnitude.

In Figure 2.2 it is the speed of response that depends on the direction of the price change. For example, if p^{in} increases, p^{out} will respond at the same time as the initial price change, implying that speed of response is efficient and price change is transmitted fully without any delay. In case of a decrease in p^{in}, the grey area represents the delay in the speed of fully transmitting price change on the p^{out} side.

Figure 2.3 represents APT in respect of a combination of speed and magnitude. In the event of an increase in p^{in} it takes two time periods (t1 and t2) to be fully transmitted to p^{out}, while a decrease in p^{in} requires three time periods (t1, t2, and t3) to reach achieve full transmission (Meyer and Von Cramon-Taubadel, 2004).

According to Uchezuba (2010), asymmetrical price transmission relating to a combination of speed and magnitude, can lead to temporary and permanent redistribution. Speed leads to temporary welfare redistribution from consumer to retailer, while asymmetry with respect to magnitude, leads to permanent welfare redistribution.

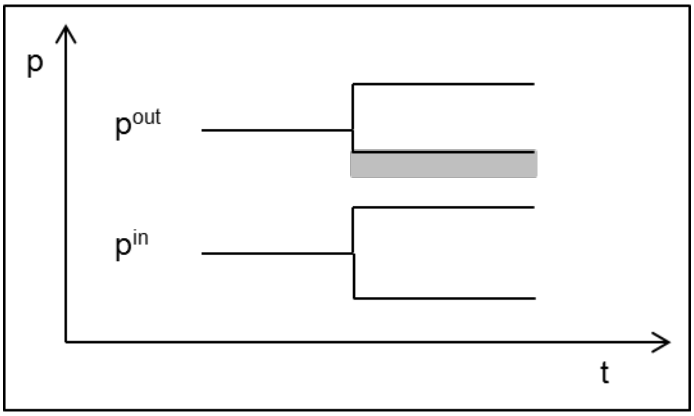

Figure 2.1: APT with respect to magnitude.
Source: Meyer and Von Cramon-Taubadel (2004).

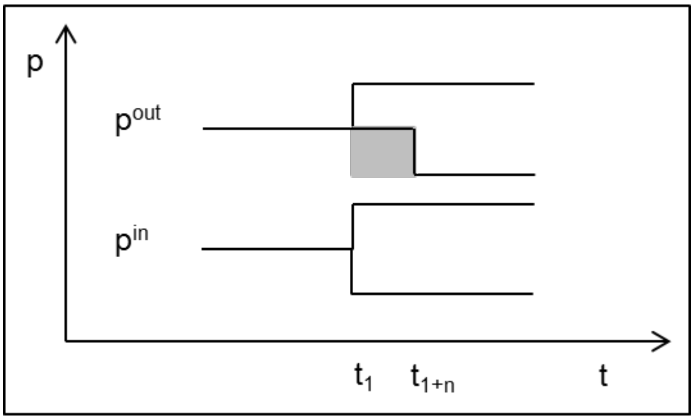

Figure 2.2: APT with respect to speed.
Source: Meyer and Von Cramon-Taubadel (2004).

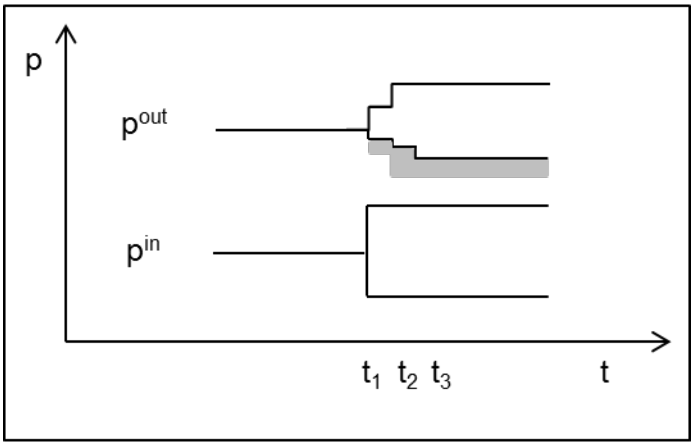

Figure 2.3: APT with respect to magnitude and speed.
Source: Meyer and Von Cramon-Taubadel (2004).

2.3.2 Positive and negative asymmetry

Asymmetrical price transmission can also be classed into positive and negative asymmetry. Peltzman (2000) and Meyer and Von Cramon-Taubadel (2004) provide different classifications for APT. Von Cramon-Taubadel (1998) suggests that asymmetry may show the reaction of price at one level of the market chain to a price change at another level, depending on whether the initial change is positive or negative.

Peltzman (2000) classifies APT as either positive or negative, based on the factor or factors that caused APT. If the retailer (output) price reacts more rapidly and completely to an increase in the producer (input) price than to a decrease, it is termed as positive asymmetry (Meyer and Von Cramon-Taubadel, 2004). Negative asymmetry, on the other hand, occurs when the retail (output) price reacts more rapidly and completely to a decrease in the producer (input) price, than to an increase.

Table 2.1 illustrates the responsiveness of producers and retailers towards transmitting and adjusting according to the altered equilibrium price. The responsiveness of the producer and retailer with regard to one another is reflected.

Table 2.1: Response of producer and retailer to a change in price

<table>
<tr><th colspan="3">Positive APT (producer)</th><th rowspan="9"></th><th colspan="3">Negative APT (retailer)</th></tr>
<tr><td colspan="3">Change in equilibrium price: ↓ (decrease)</td><td colspan="3">Change in equilibrium price: ↓ (decrease)</td></tr>
<tr><td rowspan="2">Response to change</td><td>Producer</td><td>Retailer</td><td rowspan="2">Response to change</td><td>Producer</td><td>Retailer</td></tr>
<tr><td>Greater</td><td>Smaller</td><td>Smaller</td><td>Greater</td></tr>
<tr><td colspan="3">Change in equilibrium price: ↑ (increase)</td><td colspan="3">Change in equilibrium price: ↑ (increase)</td></tr>
<tr><td rowspan="2">Response to change</td><td>Producer</td><td>Retailer</td><td rowspan="2">Response to change</td><td>Producer</td><td>Retailer</td></tr>
<tr><td>Smaller</td><td>Greater</td><td>Greater</td><td>Smaller</td></tr>
</table>

Source: Peltzman (2000)

In the event of positive APT, the response of the producer would be greater than that of the retailer in the case of a price decrease, meaning that the producer will react more fully or rapidly to a decrease in price. Correspondingly, in a negative APT scenario, the producer's response is smaller than that of the retailer. Thus, the retailer reacts more fully or rapidly to the decrease in price. Positive APT allows retailers the benefit of higher profit margins, other than would have been the case with symmetrical price transmission (Peltzman, 2000).

2.3.3 Other types of asymmetries

Manera and Frey (2005) extended the classification of asymmetry types. The extended classifications include new categories of asymmetry that depend on the two prior classification measurements. These new categories of asymmetry are (i) contemporary impact asymmetry, (ii) distributed lag effect asymmetry, (iii) cumulative impact asymmetry, (iv) reaction time asymmetry, (v) equilibrium adjustment path asymmetry, (vi) momentum equilibrium path asymmetry, (vii) regime effect asymmetry, (viii) regime equilibrium adjustment path asymmetry and (ix) spatial asymmetry. Based on the literature reviewed, the focus of this study will fall on *distributed lag effect asymmetry* and *reaction time asymmetry*.

Distributed lag is the response of retail (output) prices to positive or negative changes in the producer (input) prices, which is not transmitted instantly but rather distributed over a lag period. A weakening relationship between the PP and RPs, as a result from the delay in the flow and transmission of prices over time, is known as *distributed lag effect asymmetry (DLEA)* (Uchezuba, 2010). Several reasons have been cited as factors causing a delay in the responsiveness of reactions, such as government intervention, communication, adjustment cost, market imperfection and the type of product (perishable/storability) (Ward, 1982; Kinnucan and Forker, 1987; Goodwin and Holt, 1999; Meyer and Von Cramon-Taubadel's, 2004; Cutts and Kirsten, 2006).

When a price shock, positive and/or negative, occurs with regard to the PP (input price), the RP (output price) reaction time to readjust to an equilibrium level, tends to depend on whether an equilibrium relationship exists between these two variable prices. The readjustment of prices is not instant, but takes place over time and is called a time lag. The lagged time it takes the retailer (output) to readjust the price to an asymmetric input price (producer) shock is called *reaction time asymmetry (RTA)*. RTA can reflect the nature of the producer (input) shock, indicating if it is persistent or transitory (Uchezuba, 2010).

Time lag is a general term used by researchers and market participants for a lack in price transmission. Time lag is sometimes used incorrectly to describe the concern between different market segments, which in most cases are between producers and retailers, especially in the agricultural sector.

Alemu and Ogundeji (2010) analysed South African food markets in terms of DLEA and RTA, and the results obtained were more or less the same as that of other studies conducted in the context of only RTA or DLEA. It should be noted that the opinion of Alemu and Ogundeji (2010) regarding the interpretation of price transmission, is in line with canonical economic theory. The theory states that the effectiveness of price transmission is measured by size (magnitude) and timing (speed), and not just in timing, or better known as the lag. Alemu and Ogundeji (2010) found that price transmission between the PP and RPs is asymmetric. The direction of causation runs from the PP to the RP, suggesting that the response of retailers is more rapid and greater in size to shocks that shrink their market margins, than to shocks that stretch the margin.

Time lag is also often wrongly used in a combination of RTA and DLEA to reflect the responsiveness in terms of magnitude and speed among different market segments (farm, wholesale and retail) to a change in price. A few examples illustrate how two classifications are used in combination to describe the price transmission. There is concern over the fact that the response time of price transmission stimulated by an increase in price, will be transmitted more rapidly and at a greater magnitude from producer level (input) to retailer level (output) than in the case of a price decrease. A variety of national and international literature has revealed market linkages among farm, wholesale and retail markets in the red meat industry, livestock and various other products. Research in general has established the existence of significant lags in the adjustment of prices at various levels in the marketing channel (Goodwin and Harper, 2000; Hahn, 1990).

Goodwin and Harper (2000) completed an extensive literature study, which revealed that these so-called lags are usually caused by adjustment cost shocks. Analysing transmitted shocks through the various levels of the market revealed the key characteristic, the overall operation and the functionality of the market. Price is the primary driver linking various levels of the market, but the extent of adjustment and speed at which shocks are transmitted throughout the value chain, reflect the responsiveness of market participants to alternative market levels (Goodwin and Holt, 1999).

Peltzman (2000) detected regularities in the producer and consumer market output prices, which represents the ability to respond faster (shorter lag) in the case of an increase in input cost, than with a decrease. Although producer and retailer responses were asymmetrical in both markets, the magnitude of the response to the shock differed. In the case of a positive cost shock it was at least twice the magnitude of a negative response. The response in both cases was found to be substantial and extensive, lasting for a period of five to eight months.

Hahn (1990), Tomek and Robinson (1990), Bernard and Willett (1996), Peltzman (2000), Aguiar and Santana (2002), Ben-Kaabia et al. (2002), Meyer and Von Cramon-Taubadel (2004), Xia (2007), Propovics and Toth (2006) and Alemu and Ogundeji (2010) are al examples of literature reviews which detected APT. Each analysis has a different interpretation, but in general price transmission (symmetry/asymmetry) was interpreted in the context of prior classification measurements, magnitude (distribution) and speed (reaction time) adjustment. Asymmetrical price transmissions were generally found when prices increased. The transmission of a price increase would be quicker and of greater magnitude than in the case of a price decrease through the same market segments of the value chain, particularly from producer to retailer.

2.4 FACTORS INFLUENCING PRICE TRANSMISSION

A wide variety of economic literature has studied the relationship between prices, either spatial or vertical. The premise of an integrated market and full price transmission, corresponds with a standard competition model: In an undistorted frictionless world, the law of one price (LOP) is supposed to regulate spatial price relations, while pricing along production chains will depend exclusively on production cost, with all firms producing at the highest isoquant compatible with their isocost lines (Conforti, 2004).

Literature reviewed on price transmission indicate that there are different factors that can cause APT or influence the transmission of price in the red meat industry, from various value-adding chain segments right down to the retail product. Influential factors such as anticompetitive behaviour, information asymmetry, adjustment cost and political intervention (policies) are factors that may have a role to play in the case of positive APT. Negative APT, on the other hand, allows consumers to enjoy lower prices than in the case of symmetrical price transmission (SPT) conditions. This tendency may be caused by oligopolistic market structures, where the market is dominated by a relatively small number of sellers. Meyer and Von Cramon-Taubadel (2004) conclude that market participants in oligopolistic markets will react relatively more responsively, because retailers fear that they may lose their market share.

Aguiar (1990), as cited by Aguiar and Santana (2002), determined the main factors that cause asymmetrical transmission. In the first instance the characteristics of the product will influence the price decision, especially in the case of products that have a short shelf life (perishable), because retailers will not increase prices unnecessarily for fear of losing stock on hand.

Secondly, market concentration, or the intensity of the competition, also plays a role. If a retailer increases price too rapidly or lowers price too slowly, he might relinquish market share (lose consumers). The third factor is price expectation. When consumers expect a price increase due to a weakened currency or meat shortage, it is easier to transmit a price increase. The fourth factor is the degree of organisation of the consumer, because a disorganised consumer will be less focussed on checking and comparing price, making it easier for the retailer to transmit price increases (Aguiar and Santana, 2002).

Based on 16 countries and primarily basic food commodities, Conforti (2004) identified six groups of factors that affect price transmission. Conforti (2004) found a number of regularities between the 16 countries, but in view of efficient and less efficient price transmission, price transmission was found to be relatively more efficient for cereals, followed by oilseeds, while price transmission for livestock was generally inefficient.

After reviewing various literature studies on the factors influencing price transmission and the causes of APT, this study will focus on specific factors namely market structure, government intervention, adjustment cost, type of product, infrastructure and communication.

2.4.1 Market structure

The vertical price transmission of shocks via the market chain is a significant reflection of market characteristics, describing the overall operation and functionality of a market. Profit, the incentive for any entrepreneur, is determined by price, and price is the primary mechanism to which most market levels are linked (Goodwin and Holt, 1999).

Data collected over a period of dramatic increases in South African food prices, was used to determine how an increase in market concentration would correlate with or affect the degree of different asymmetrical levels between the PPs of various commodities and RPs (Cutts and Kirsten, 2006). Despite previous studies that found a non-competitive (low concentration) market environment to be ideal for the occurrence of APT, results contradicted the inverse correlation between concentration and the existence of APT. Results revealed that the degree of APT in certain South African industries, which are considered to be concentrated, was higher (Cutts and Kirsten, 2006).

The degree of competition in a market seems to be a major influencing and causative factor of APT (Meyer and Von Cramon-Taubadel, 2004). The reviewed literature all suggest that symmetric price transmissions are characterised by perfectly competitive markets, and asymmetry by non-competitive or imperfect markets (Ward, 1982; Bernard and Willett, 1996; Von Cramon-Taubadel, 1998; Aguiar and Santana, 2002; Ben-Kaabia et al., 2002; Meyer and Von Cramon-Taubadel, 2004; Propovics and Toth, 2006).

On the other hand, results from a study in Chicago in the United States contradict some of the other studies, documenting similar asymmetries in markets such as gasoline, agricultural products, etc., which are equal to non-competitive markets (Peltzman, 2000). Results suggest that there is an essential void in the general economic theory. General economic theory states that no pervasive tendency is suggested for prices to respond faster to one kind of cost than to another. The theory has taught us that when input prices increase or decrease, it will alter marginal cost and then output price will adjust symmetrically (Peltzman, 2000).

ATP would not occur as a result of the response to an individual's decision (supermarket chain) to cost. Average asymmetry would rather occur when a cost shock was to be filtered through only a fragment of the wholesale distribution system. It was found to exist between factory (differentiation of products) and RPs when there were numerous small intermediaries between the factory and the retail. It was also very clear that when a negative correlation existed between the volatility of price compared to asymmetry, the more volatile input prices were and the smaller the possibility of asymmetry (Peltzman, 2000).

2.4.2 Government intervention

Some price transmission studies focused on transition economy. Low developed price-discovery mechanisms and an ad hoc policy intervention caused by the inherited pre-1989 distorted markets and transitional economies, could be expected to have generally greater marketing margins and more pronounced price transmission asymmetries (Bakucs and Fertõ 2005).

Wholesalers and retailers face uncertainty in their attempts to determine the price of their goods based on the change in cost caused by government intervention, which can lead to APT (Kinnucan and Forker, 1987). If and when prices are transitory, wholesalers and retailers are reluctant to re-price their items in the short term due to menu cost. The motive of government's intervention can reduce uncertainty among wholesalers and retailers. One example is when government intervenes by establishing a price support programme in the form of a floor price for farm produce over an extended period. In these cases retailers tend to favour a permanent cost increase and will transmit the increase more rapidly and completely to the RP, than in the case of a decrease which will result in a slower and less complete response (Kinnucan and Forker, 1987).

2.4.3 Adjustment cost

Adjustment cost is the cost of adjusting the quantities and/or prices of input and/or outputs of a firm. Meyer and Von Cramon-Taubadel (2004) assumed that the adjustment of a price decrease or increase in the quantities and/or prices of input and/or outputs, will be asymmetrical, which implies that the magnitude and speed of a firm's response to the change will vary, depending on whether a price increase or decrease applies. Firms face different adjustment cost depending on whether the quantities and/or prices of input and/or outputs are increased or decreased, and it will thus determine the adjustment cost (Meyer and Von Cramon-Taubadel, 2004).

2.4.4. Type of product

The logic relating to perishable products with a short storability or shelf-life, is that retailers will resist the temptation to increase the price, for they might then be left with the spoiled product. Retailers that sell perishable products would therefore rather strive to sell quantities at a lower price per item relative to the higher price, than selling these types of products at the higher price but in lower quantities, thus risking a possible loss. The margin for APT to take place would therefore be smaller (Ward, 1982). Some South African industries are considered to be relatively concentrated, meaning that the degree of price transmission would diminish in the case of perishable products (Cutts and Kirsten, 2006).

A general conclusion is then that storability can influence the intensity of price transmission (Goodwin and Holt, 1999; Tomek and Robinson, 1990; Meyer and Von Cramon-Taubadel, 2004;

Cutts and Kirsten, 2006; Propovics and Toth, 2006). A Brazilian study's results contradict the ability of shelf life (storability) to change or influence the intensity of price transmission in the cases of price increases. High and rising inflation rates were expected due to Brazil's continual price increases, which may have led to assimilated intense transmission of price increments irrespective of the industry's market power (Aguiar and Santana, 2002).

2.4.5 Infrastructure

Six different geographical livestock markets studied in Sudan from 1990 to 2004, indicated the absence of a relationship between producer and retailer, meaning that price transmission was not effective and resulted in APT among some of the markets that were studied (Babiker and Abdalla, 2009).

The second portion of data for the period from 2000 to 2004, however, indicates the opposite. After some infrastructural facilities had been introduced to the market, further analysis showed that the same markets were reflecting a relationship between the producer and retail prices (co-integrated) for the second period. The relationship was influenced by the infrastructural facilities that contributed to better and more efficient transmission of the right price signals. Poor infrastructure, on the other hand, could effect a rise in marketing margins due to higher transport and delivery cost. It is therefore clear that the level of infrastructure will play a major role in the effectiveness of price transmission (Babiker and Abdalla, 2009).

2.4.6 Communication

Studies examining the price interrelationship and transmission from the producer to the retailer in the United States beef market, revealed that the transmission of a shock is uni-directional, with information flowing from the farm to the wholesale to retail markets, but not the opposite way (Goodwin and Holt, 1999). These results concluded that responsiveness to a price shock had increased due to more effective transmission of information through the vertical marketing chain via new technology communication streams (Goodwin and Holt, 1999). Babiker and Abdalla (2009) support the observation of Goodwin and Holt (1999) that poor infrastructural facilities equal poor communication services and that poor communication services equal an increase in marketing margins due to a lack in transmission of the right price signals.

2.5 DATA PROPERTIES INFLUENCING PRICE TRANSMISSION

The following section reviews data characteristics that may have an influence on the outcome (symmetrical or asymmetrical) and accuracy of a price transmission analysis. The factors reviewed include the total length of the time series, frequency of observations and total number of observations.

After 200 weekly observations of the German pork sector, the hypothesis of symmetrical price transmission from the producer to wholesaler was rejected and the alternative hypothesis of APT was accepted (Von Cramon-Taubadel 1998). An analysis on weekly data over the period of two years (104 observations) in the US pork sector, corresponded with the Von Cramon-Taubadel (1998) findings. The results revealed the same uni-directional price adjustments parameters and showed that information flowed only from farm to wholesale, to retail markets and not vice versa. Although the relationship between the different segments of the pork market was found to be co-integrated, the degree of price adjustment caused by a shock at another level, varied significantly in size (Goodwin and Harper, 2000). A time series over a period of three years based on monthly observations (36 observations) in the South African agro-food industries was found to be also asymmetrical (Cutts and Kirsten, 2006).

Throughout the literature review the contents of observations and length of time series proved sufficient for a successful analysis, yet it remained unclear whether length and observations had an influence on final results. The end results of various reviewed literature studies such as Hahn (1990), Tomek and Robinson (1990), Bernard and Willett (1996), Peltzman (2000), Aguiar and Santana (2002), Ben-Kaabia *et al*., (2002), Meyer and Von Cramon-Taubadel (2004), Propovics and Toth (2006), Xia (2007) and Alemu and Ogundeji (2010) mostly found APT. The interpretation of each analysis differs in a number of ways but APT was generally detected when the producer's price increased. The transmission of a price increase would be quicker and more encompassing than in the case of a price decrease through the same market segments of the value chain. The analysis of price transmission data series with longer time series lengths, were also considered and found to be symmetrical or asymmetrical in the short term and long term.

The price series of beef and pork in the USA was collected over a period of eight years on a monthly basis (96 observations). Results revealed producer, wholesaler and retailer prices of beef and pork to be asymmetrical. Asymmetrical price transmission resulted due to sensitivity not being constant, irrespective of the direction of the shock. Price transmission reaction in both markets was found to be more sensitive to any price increase shocks than to price decrease shocks, especially in the short term (Hahn, 1990).

A total of 108 monthly pork price observations in the Malaysian red meat value chain were collected from January 1997 to December 2008. The correlation coefficient between the two variables was positive and strong, indicating that an increase in the RP of pork was likely to lead to an increase in marketing margin of pork in Malaysia (Tey, 2009). With approximately twelve monthly average nominal producer prices of live pigs (approximately 120 observations over ten years), a RP was constructed based on the monthly producer price in order to examine price transmission through the vertical value chain. Although the relationship between the producer and RP was symmetrical over the full period, the direction of influence was found to be unidirectional (Bakucs and Fertõ, 2005) (Spanish lamb).

In Spain, the second largest lamb producer in the European Union (EU), the idea of RPs not reacting to changes quickly enough under the reigning market conditions, was a concern among producers and consumers. The study's main objective was to explore the non-linear adjustments in the price transmission mechanism throughout the marketing chain. Weekly data was used to divide the results into long and short term results (Ben-Kaabia and Gil, 2007). In the short term the transmission of prices and adjustments between the retailer and the farmer were found to be asymmetrical as well as representative of the mechanism of demand-pull transmission. In the long term the results indicated that any supply or demand shock was transmitted fully along the marketing chain, indicating that price transmission in the long term was perfectly integrated. This means that any price changes were fully transmitted (symmetrical) through the chain, whether on the in- or output side (Ben-Kaabia and Gil, 2007).

An examination of the influence of frequency on price transmissions is about testing whether time will lapse from one observation to the next will have an influence on the outcome of the analysis. For example: Will one observation per week deliver the same outcome as two observations per week over the same period? Literature revealed that there were not sufficient studies indicating the specific influence of frequency, although the analysis of data was possible, irrespective of the frequency.

Rumánková (2012) was one of the few researchers who analysed the influence of the time series frequency on price transmission from the farmgate price to the wholesale price. He also analysed the time series properties of the price transmission from the wholesaler to the consumer. The frequency of observations used for data collection was monthly and bi-weekly for best data sets. While the results reflected slight differences, they were insignificantly small and it was concluded that the choice of time series frequency does not have a critical influence on the results of price transmission. The analysis, however, showed that the selection of time series period can significantly influence the results of price transmission (Rumánková, 2012).

Aguiar and Santana (2002) found that, even if frequency could have an influence on the results, the type of product (perishable) that was going to be analysed might also have an influence on the frequency of observation. In the case of vegetables, monthly data might have skewed the results, because vegetables are perishable products with a much shorter shelf life than other commodities. The tendency in the case of vegetables is to market more rapidly, which masks the data as very intensive transmission of the price, especially in the case of reductions. It is suggested that future studies should make use of perishable product data collected on a weekly basis (Aguiar and Santana, 2002).

A review of articles on national and international studies ranging between 36 and 200 observations, two and ten years, weekly and monthly comparisons, no significant consensus could be found between possible influencing factors and transmission results. Any conclusion or assumption regarding influencing factors is vague and thus no fixed conclusions could be made.

An observation of reviewed results of various studies yielded the following conclusion: When APT did in fact occur, it occurred over the short term than the long term. The response in time/speed and the magnitude or size was very responsive in the short term. In the long term it straightened out the relationship of transmission between the producer and the retailer, and the response of the transmission will then be symmetrical in the long term.

2.6 PROCEDURES TO ANALYSE PRICE TRANSMISSION

Various literature reviews on price transmission indicated that a number of procedures have to be followed in order to investigate price transmission among different segments of the market chain (Granger, 1969; Wolffram, 1971; Houck, 1977; Heien, 1980; Wohlgenant, 1985; Hahn, 1990; Von Cramon-Taubadel, 1998; Bakucs and Fertõ, 2005;). In general the emphasis of most studies was on the impact of the shorter term response and the distributed lag effect that input price variations have on producers. The long term equilibrium relationship (co-integration) between producer and retailer was ignored instead of taken into consideration (Uchezuba 2010). Due to the evolution of the different statistical and analytical procedures, studies that made use of procedures which did not account for the long term relationship, are now considered as inaccurate accounts of asymmetrical price relationships (Uchezuba 2010). On methodological grounds the procedures used in previous studies can be criticised on various aspects of the model in order to obtain the best model to analyse price transmission or the lack thereof. Various procedures were considered in this study based on the experience and critiques of previous studies, the date of establishment (the latest model), and the most popular and best-fitted procedure according to data properties.

One of earliest price transmission studies dates back to 1969 and discovered a disequilibrium in the impact of the retailer-level demand shift in relation to the producer level supply shift price spread of the US (Granger, 1969). Granger (1969) investigated the comparative static implications of competitive market equilibrium from the farm-retail spread using the Granger-Sims causality test as a method to determine the direction of causality through the market segments.

Heien (1980) studied price transmission using a model characterised by mark-up pricing rules, but found that a new producer model was not always the answer. Wohlgenant (1985) demonstrated the correlation of lags and inventory holding on the part of the retailer, without developing a new formal model. Hahn (1990) measured the APT of the USA pork market using the generalized switching model (GSM). Von Cramon-Taubadel (1998) argued that APT would only present itself if the demand and/or supply shifts were skewed more towards a particular direction (positive or negative). Otherwise there would be no disequilibrium, which implied no APT, because there would be an equal occurrence of supply and demand transmission in both directions.

Most price transmission studies used a form of econometric specification introduced by Wolffram (1971) and later refined by Houck (1977). An inquiry as to whether the common belief of the middleman abusing his market power by passing on an increase in input prices to the consumer quicker and more circumspect than in the case of a decrease in the input price, proved this statement to be true. The relationship (co-integration) between the three different prices in the sector chain links namely the producer, wholesaler and retailers needs to be tested using the econometrical specifications.

However, Von Cramon-Taubadel (1998) found Germany's pork industry (from farmer to retailer) and Wolffram (1971) and Houck's (1977) specifications to be fundamentally inconsistent and inappropriate for testing APT between the three different links. He argued that the specifications did not provide sufficient exogeneity conditions necessary to make a valid conclusion regarding asymmetry. More improved and evolved procedures have been developed since the critique of Von Cramon-Taubadel (1998) regarding the specifications of Wolffram (1971) and Houck (1977). Co-integration or the lack thereof, better known as the non co-integration approach which describes the relationship between the producer and retailer price, can be tested using various recently evolved procedures, but the mutual goal is to determine the existence of a long term relationship between economic variables.

Goodwin and Harper (2000) investigated the US pork industry price transmission using the threshold co-integration model. Bakucs and Fertõ (2005) examined the Hungarian pork market in a co-integration framework using Johansen's maximum likelyhood approach. The three-regime threshold autoregressive model was used by Ben-Kaabia and Gil in 2007 to determine the effectiveness of price transmission in one of the biggest lamb industries of the European Union (EU), namely Spain. During August 2009 Tey (2009) used the Houck and ECM approach, only to find the Malaysian pork price transmission to be symmetrical.

The most commonly applied procedure to test co-integration in previous studies, has been Engle and Granger (1987), but despite its popular appeal they were criticised because of the symmetrical nature of price adjustments models. The Engle and Granger (EG) model assumes symmetry and linearity. Enders and Granger (1998) and Enders and Siklos (2001) suggested the use of the threshold adjustment models as alternative procedures, for example the threshold autoregressive (TAR) and the momentum threshold autoregressive (M-TAR) models. These procedures account for APT within the most vertically integrated markets. With the M-TAR, TAR and MC-TAR models one is able to make predictions in the short and long term.

Various studies have been conducted into the South African meat industry using these procedures. Spies (2011) conducted an analysis of the red meat value chain but the shortfall of the study was that there were only 52 observations and Spies (2011) also recommended that the methodology be applied every two to three years, but overall the EG, TAR, M-TAR and MC-TAR worked satisfactorily. Uchezuba (2010) performed an analysis on price transmission in the poultry industry, determining the long term co-integration relationship between producer-retail market chain links by means of EG, TAR and M-TAR procedures. The data used was based on time-series observations made from January 2000 to August 2008. Alemu and Ogundeji (2010) found the South African food market price transmission to be asymmetrical through various market segments using long term data series recorded from January 2003 to December 2008. The authors applied the traditional Engle and Granger (EG), the standardised Dickey-Fuller, the TAR model, the M-TAR model and the MC-TAR model to test for co-integration and APT. MC-TAR was then selected as the model best suited to represent the data analysis. These three studies are but a few examples of successful analyses conducted specifically in South Africa using these three procedures to analyse the effectiveness of price transmission or the lack thereof.

2.7 CONCLUSIONS

Price transmission has been the topic of various national and international research projects, each conducted within its own unique circumstances, influencing factors, testing procedures and type of market. The main objective of all reviewed studies were to determine an aspect of price transmission, such as the efficiency or the lack thereof, influential factors, causes, flow of information and the relation between market segments.

With reference to Peltzman's (2000) and Meyer and Von Cramon-Taubadel's (2004) interpretations on types of APT, note that for purposes of this study, price transmission is analysed from the following point of view: A change in price will take place in the PP while the RP is retained as the dependent variable, unlike Peltzman (2000) where the change is in the equilibrium price and both variables are independent. In other words, a change in the PP will lead to a change in the RP depending on the direction of change in the PP.

In the case of this study where the RP is the dependent variable, APT will be characterised by the responsiveness of the RP to the change in the PP. If the response of the RP is greater towards a price increase in the PP than to a decrease, it is characterised as positive APT. Negative APT occurs when the response of the RP leans more towards a decrease in the PP than to an increase in the PP.

When considering these two types of asymmetries, positive APT is harmful to the consumer while negative APT is beneficial. Positive asymmetry implies that cost increases will over time lead to a squeeze in the margin between PP and RP. Negative asymmetry implies a decrease in cost and stretches margins over time.

Looking at the literature reviewed APT is not an uncommon occurrence and is found within the agricultural sectors and food markets, with a number of possible factors serving as the reason for APT. It is important to remember that not all influencing or contributing factors are relevant for every case study. This is especially true when interpreting results and drawing conclusions about existing types of price transmission and the nature thereof, in order to determine and consider differences between markets.

Although it is difficult to determine a general trend, the literature review of national and international studies prompted the following generalised conclusion: Most research has found price transmission to be asymmetrical in the price adjustments made at various market levels. In general the direction of causality was found to flow from farm level towards wholesale and retail markets. Wholesale and retail markets were also found to be relatively less responsive to price increase or decrease shocks than in the case of producer markets. The use of different time series, albeit weekly or monthly, did not have a significant influence on the results of price transmission.

Procedures used in one of the first price transmission studies conducted in 1969 right up to the latest study, have differed and evolved over the years. Some were applied and adjusted to specific circumstances, types of data, or simply the preference of the researcher. It is impossible to draw a single line and use it as a given for each market, national or international. Time equals evolution and evolutions equals changes in the population (producers and consumers), technology, policies, infrastructure, consumer preferences, and the genetics of the commodities produced, etc. Markets ultimately change and an analysis of new and innovative thinking, methods and data must be done to determine whether older results are still relevant or not.

The literature review clearly indicated the importance of stating the direction of the price transmission that will be analysed, which prices will change, which variables are considered as the dependent variables, what is considered as a positive and negative shock and, finally, the type of transmission that will subsequently follow. It is also important to take note of possible reasons or factors that could play a role in the analysis and to use the latest and most popular procedures when analysing data.

CHAPTER **3**

PROCEDURES

3.1 INTRODUCTION

This chapter aims to provide insight into the data characteristics, data preparation and procedures used to perform the analyses of this study. A stationary test will be used to prepare the data to ensure that it is stationary. In order to determine the existence of co-integration, different procedures are used to measure the response of one price to a change in another price, as well as the causal direction between variables with respect to the red meat industry.

The procedu res and models used are the augmented Dickey-Fuller (ADF) for the stationary test and the four competing procedures for co-integration analyses are the EG model, the TAR model, the M-TAR model and the MC-TAR model. The Error Correction (EC) and the Granger Causality (GC) test are used to analyse the short term correction ability and the directions of influence between variables..

The stationary test was performed at different levels and at first difference to ensure that the mean, variance and co-variance of y, the price series, are constant. In order to determine co-integration, four competing models (EG, M-TAR, TAR, and MC-TAR) were applied to the three-year data. The model best suited to represent the level of price transmission for each specific data series, would be the one with the highest absolute Akaike information criterion (AIC) value. If the selected model is not able to meet the second round of required conditions, the model with the second best AIC value (second highest) will be considered for that specific data series.

After co-integration as well as the type of transmission that existed (whether symmetrical or asymmetrical) has been confirmed, an error correction model will be fitted. The error correction model will examine the responsiveness of one price to the change in another price at different levels in the value chain, reflecting the correct ability by speed and magnitude. Lastly the GC test will be fitted to analyse the direction of influence between the PP and RP.

3.2 DATA COLLECTION

The data generated for this study consists of two price series, namely the PP and RP. Data collection (observation) took place every week on Monday over a period of three years (156 observations).

The PP comprises the average price for class A2 and class A3 beef carcasses (in R/kg) which are calculated weekly by the Red Meat Abattoir Association (RMAA) and represents the average price that abattoirs pays producers (farmers/feedlots) for the carcasses of these classes in South Africa. Although carcass prices may differ among regions, the difference is relatively small and the national average price thus remains a representation of the PP. The RPs were collected by recording shelf prices at three supermarkets and a butchery in the Langenhoven Park area of Bloemfontein. The price of fillet (high value), rump (medium value) and stewing meat (low value) were collected.

Figure 3.1 represents the PP as well as the RPs for fillet, rump and stewing meat at supermarket 1 over a period of three years[1]. It is evident from Figure 3.1 that the different RPs do not always follow the same trend as the carcass price, while the three product prices also do not follow suit. In order to compare the carcass price with the RPs, it is necessary to obtain the price at which the retailer sells the whole carcass, and not individual cuts, so that the producer carcass price can be compared to the carcass price of the retailer.

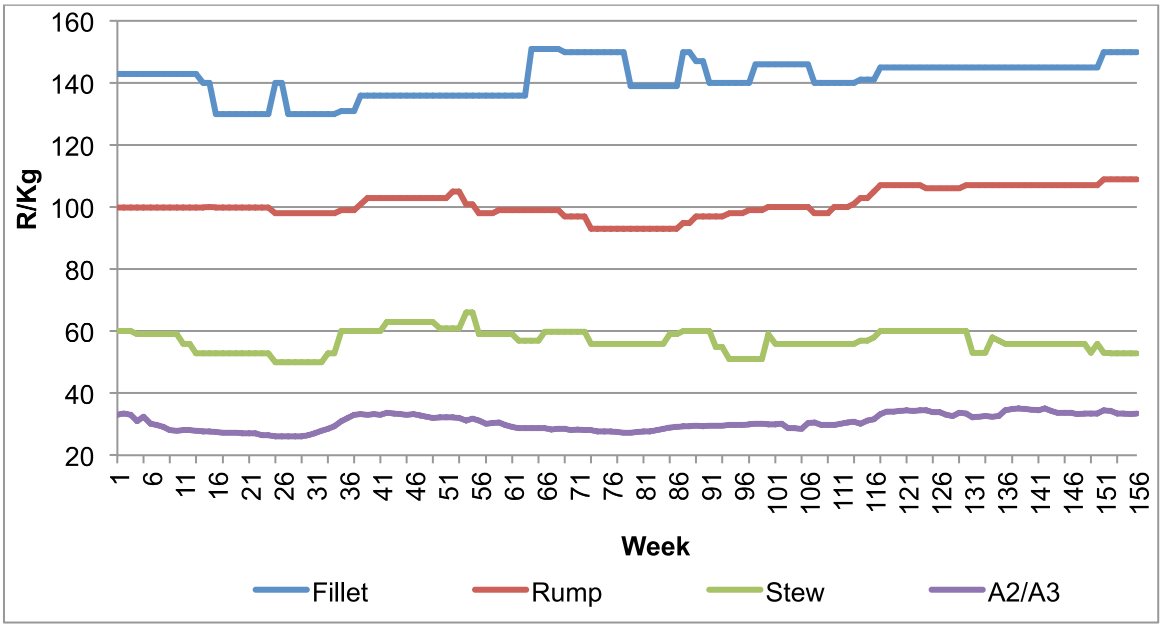

Figure 3.1: The price trend of supermarket 1 (S1).
Source: Own data collection and calculation.

Retailers use a so-called cutting test to calculate the RP of each cut from a specific carcass. The calculated RP then reflects the economic value of each cut, the supermarket's margin and the value added tax (VAT) levied on the product. Table 3.1 represents the beef cutting test used to determine an RP. The factor assigned to each cut gives an indication of the value of the specific cut in terms of the carcass price. The percentage of the cut in relation to the complete carcass remains the same, but retailers may vary the factor based on the product demand. The factor is multiplied with the carcass price to arrive at the price for which the retailer will sell the specific cut, after adding a margin (approximately 30%) and VAT (14%).

[1] Price trends for S2, S3 and B can be viewed in Appendix A.

Table 3.1: Beef cutting test for price formation

Carcass	R32.86/kg	220 kg									
Fore quarter 52%						Hind quarter 48%					
Cut	**%**	**kg**	**Factor**	**R/kg**	**R/kg 30% Margin Incl. VAT**	**Cut**	**%**	**kg**	**Factor**	**R/kg**	**R/kg 30% Margin Incl. VAT**
Whole quarter/kg	100.0	114.4	1.0	23.8	35.3	**Whole quarter/kg**	100.0	105.6	1.0	41.9	62.1
Body fat	2.8	3.2	0.5	11.9	17.7	**Body fat**	3.7	3.9	0.5	21.8	32.3
Shoulder	34.7	39.7	1.6	38.1	56.5	**Clean Bone**	14.7	15.5	0.1	5.0	7.5
Bone lean	19.8	22.6	0.2	4.8	7.1	**Bone with meat**	2.4	2.6	1.0	40.6	60.2
Bone with meat	0.0	0.0	0.5	11.9	17.7	**Cutting loss**	1.0	1.1		0.0	0.0
Brisket	14.5	16.6	0.9	21.4	31.8	**Fillet**	2.4	2.5	2.6	109.8	162.7
Chuck	0.0	0.0	1.3	31.0	45.9	**Short loin**	0.0	0.0	1.8	75.4	111.8
Neck,bone in	1.0	1.1	1.3	31.0	45.9	**Rump**	5.1	5.4	2.0	82.1	121.7
Prime rib	3.8	4.3	1.3	31.0	45.9	**Shin**	4.1	4.4	1.0	40.6	60.2
Back fillet	0.0	0.0	2.5	59.6	88.3	**Silverside**	9.8	10.4	1.5	62.8	93.1
Shin bone in	0.0	0.0	0.8	19.1	28.2	**Sirloin**	4.5	4.7	2.0	81.7	121.1
Short rib	4.9	5.6	0.8	19.1	28.2	**Short rib**	5.8	6.1	1.0	40.6	60.2
Bolo	1.0	1.1	1.3	31.0	45.9	**T-bone**	7.6	8.0	1.8	75.4	111.8
Trimmings	16.6	18.9	0.9	21.2	31.4	**Thick flank**	3.7	3.9	1.4	58.7	86.9
Cutting loss	1.0	1.1		0.0	0.0	**Topside**	7.6	8.0	1.5	62.8	93.1
						Trimmings	27.5	29.1	0.5	21.8	32.3
Total	**100.0**	**114.4**		**2726.5**	**4040.7**	**Total**	**100.0**	**105.6**		**4424.8**	**6557.6**
						Total (Carcass)				**R7 151.33**	**R 10 598.27**

Source: SAMIC (2008) as cited by Spies (2011) and own calculations.

For a proper price transmission analysis to be conducted, it is necessary to regenerate the price at which a retailer sells the complete carcass using the recorded differentiated product prices in a bid to compare it to the producer carcass price (R/kg).

To obtain a retail carcass (selling) price, it was necessary to calculate a collective retail carcass price. Using only one type of cut would have been pointless, as a carcass does not consist of one cut only and the economic value of each cut differs from the next. The reflection of the relationship between a high value retail cut only and the producer carcass price, would be inaccurate. The reverse calculation of a collective RP (carcass price) was calculated with the three meat cuts representing high, medium and low value cuts, namely fillet (high value), rump (medium value) and stewing meat (low value).

Figure 3.2 reflects the two carcass price time series over the three-year period with respect to three supermarkets (S1, S2, and S3), butchery (B) and a producer carcass price (A2/A3)[2].

[2] Data of producer and retailer carcass prices can be viewed in appendix B

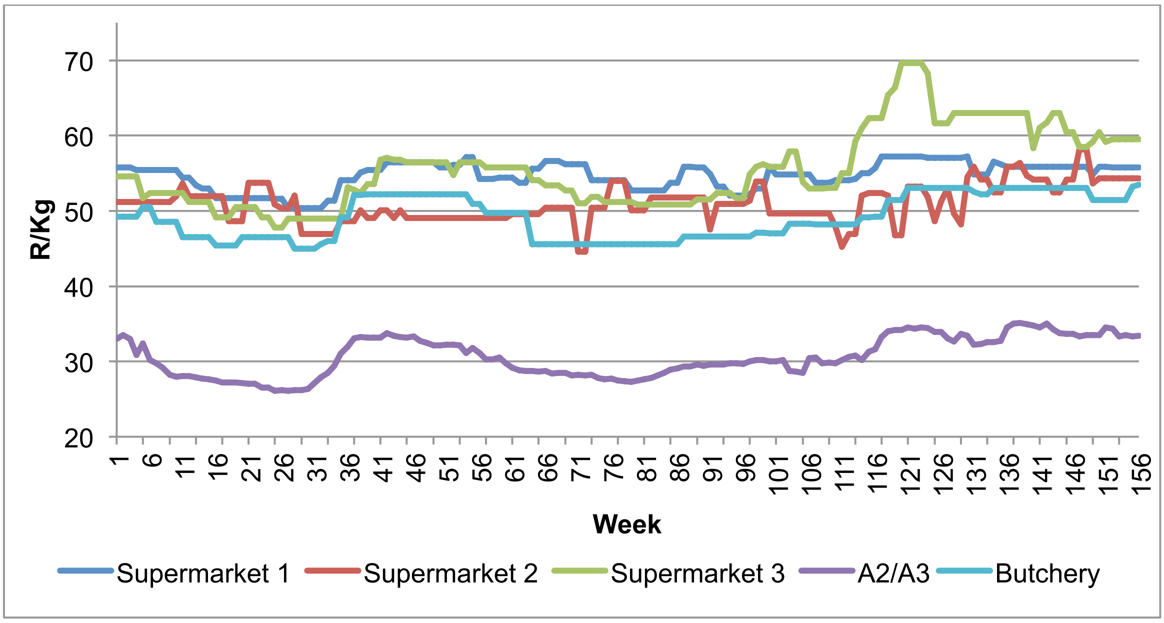

Figure 3.2: Abattoir carcass and calculated retail carcass prices.
Source: Own data collection and calculation.

The collective carcass price for each retailer compared to the producer carcass price, as indicated in Figure 3.2, tells a completely different story than the comparison of individual cuts with the carcass price as reflected in Figure 1.1 and Figure 3.1. From Figure 3.2 it is evident that the retail carcass price for each retailer is much more precise in its tracing of the curve of the abattoir carcass price, than was the case with the price of individual beef cuts. Since there are now only two price series to compare, namely the retail carcass price and the producer carcass price, the data analysis is therefore simplified.

3.3 DATA PREPARATION

Time series data can be stationary or non-stationary. When the mean, variance and co-variance do not vary over time, the time series is regarded as stationary. If the data series has varying means or time-varying variance, the data is regarded as non-stationary.

Data can either be generated by a stochastic trend process or it is characterised by a deterministic time trend. In the event of non-stationary data, the data is generated from a stochastic trend process, meaning it has no constant mean and varies in time. It requires first difference of the series to make it stationary. Data that is characterised by a deterministic time trend has a constant mean and is time invariant. Linear de-trending of the trend-stationary process makes it stationary (Uchezuba, 2010).

The way to distinguish between these two properties in a formal statistical test manner, is through a stationary test. The order of integration of the co-integrating variables should be determined in order to determine whether the economic variables are stationary or non-stationary. If the data series is non-stationary, data is differenced until it is found to be stationary (Spies, 2011). In this study, the augmented Dickey Fuller (ADF) test was used.

3.3.1 Augmented Dickey-Fuller (ADF)

Dickey & Fuller (1981) created the Dickey and Fuller (DF) test for the unit root. The constructed DF test was based on the assumption of independent and normal distributed error terms (Uchezuba 2005).

The unit root test equation (3.1) was suggested (Dickey & Fuller, 1979;1981):

$$y_t = \alpha + \beta t + \rho y_{t-1} + \varepsilon_t \qquad (3.1)$$

Where y_t is a linear function of time, and is independently and identically normally distributed with a mean of zero and a variance of one $\left(i.i.d, \varepsilon_t - \mathrm{N}(0.\sigma^2)\right)$. The assumption of the null hypothesis is that the series is an integrated difference-stationary process with a unit root, that is $\rho = 1$ against the alternative of $\rho < 1$. The DF model has been widely applied to test the statistical properties of time series (Nelson & Plosser, 1982). However, according to Uchezuba (2010), when the null hypothesis of difference stationary (unit root) is compared to the alternative trend stationary, it dominates stationary tests conducted on time series.

The DF test has been criticised for its assumptions that the error term U_t was uncorrelated. Dickey and Fuller developed another test known as the augmented Dickey-Fuller (ADF) test for a correlated error term. ADF was conducted by augmenting the DF equation and adding lagged values of the dependant variables ΔY_t (Dickey & Fuller, 1979, 1981; Gujarati, 2003).

The standard ADF test used to check the statistical properties of the series is expressed as:

$$\Delta y_t = \alpha + \beta t + \emptyset y_{t-1} + \sum_{i=1}^{k} \theta_i \Delta y_{t-1} + \varepsilon_t \qquad (3.2)$$

where

ε_t is a white-noise error term

and

$\Delta y_{t-1} = (y_{t-1} - y_{t-2}), \Delta y_{t-2} = (y_{t-2} - y_{t-3})$

In the ADF test for unit root in y_t , namely the RP and the PP, at time t, t denotes the deterministic time trend and Δy_{t-1} are the lagged first differences to accommodate serial correlation in the error term ε_t.

Despite the criticism of the unit root test methods discussed so far, i.e. DF and ADF on the grounds of size distortion and low power, the ADF test is still the preferred test (Ogundeji, 2007).

Engle and Granger (1987) also recommended the ADF test as it performed better. This study employed the ADF test because it was more generally accepted than any other method and takes into account the fact that serial correlation is prevalent in most time series.

The results of the unit root test conducted on the price series is contained in Table 3.2. The null hypothesis for this is that there is a unit root (non-stationary), with the alternative hypothesis of no unit root. The test was carried out at both levels and first difference with intercepts and trend components included where necessary.

Table 3.2: ADF unit root test*

Series	**Lag length**	**ADF statistics**	**Critical value (95%)**	**Prob.**	**Lag length**	**ADF statistics**	**Critical value (95%)**	**Prob.**
	Levels				First difference			
A2/A3	1	-2.798	-3.439	0.200	0	-11.019	-3.439	0.00*
S1	0	-3.266	-3.439	0.076	0	-15.285	-3.439	0.00*
S2	0	-5.320[1]	-3.439	0.000*	1	-12.116	-3.439	0.00*
S3	0	-2.345	-3.439	0.406	0	-11.722	-3.439	0.00*
B	0	-1.703	-3.439	0.745	1	-7.406	-3.439	0.00*

*All test are carried out at a significant level of 95%.
[1] Although it was found to be stationary, its first difference was used in the error correction model (ECM) in order to confirm with other parameters of the ECM that are in first difference.

Carcass (A2/A3), S1, S3 and the butchery (B) are non-stationary at levels, for the value of ADF statistics are smaller than the critical value and the probability (prob.) is insignificant at 5 %. S2 on the other hand is stationary at levels[1] with a significant probability of less than 5%. At first difference all price series are stationary, with ADF statistics greater than the critical value and with a significant probability of less than 5%. Therefore, S2 is I (0) while other prices are I (1), with the data series stationary at first difference co-integration.

3.4 CO-INTEGRATION TEST

The concept of modelling equilibrium or the long term relations of economic variables, was introduced by Granger (1981) as co-integration and analysed by Engle & Granger (1987). Two variables will be co-integrated if a long term relationship exists between them (Gujarati, 2003).

Co-integration analysis ensures that if economic variables deviate from the equilibrium conditions and the variables are individually stationary in the short term, the variables will be stationary in the long term as well. On the other hand, if two or more series are non-stationary, but their linear combination is stationary, then the series is considered to be co-integrated. The importance of estimating the co-integration relationship lies in revealing the existence of long term relationships and to avoid a spurious regression analysis (Gujarati, 2003; Ogundeji, 2007).

A widely applied co-integration test is the Engle and Granger (1987) (EG) co-integration procedure. Despite the popularity and success of EG as a test procedure, it was criticised due to the symmetric nature of its price adjustment. Enders (2004) pointed out that the error from the first regression will be transferred to the second and will influence the results. Subsequently, Enders and Granger (1998) and Enders and Siklos (2001) suggested the use of the threshold adjustments models, for example the TAR model, the M-TAR model and the MC-TAR model. These models account for the asymmetric price transmission prevalent in most vertically integrated markets (Spies, 2011).

3.4.1 Engle and Granger (EG) model

The Engle and Granger (1987) procedure considers two price variables, y and x. The long term equilibrium relationship between the two variables is estimated using simple ordinary least squares (OLS) using Equation 3.3:

$$y_t^{retail} = \alpha + \beta_1 x_t^{producer} + \mu_t \qquad (3.3)$$

Where, y_t is the RP and x_t is the PP and μ is the disturbance, better known the error term. The least square residuals of (3.3) are measures of the equilibrium error, $\mu_t = y_t - \alpha - \beta x_t$. Equation 1 describes the long term relationship between the series y_t and x_t. Secondly, a residual-bases test is used to test for co-integration. The null hypothesis of the test is that there is no co-integration relationship between the variables as opposed to the alternative of co-integration. If the null hypothesis is rejected, the alternative is accepted, which implies that the variables in the long term are co-integrated.

The test is conducted using the ADF test procedure as indicated by Equation 3.4:

$$\Delta\mu_t = \rho\mu_{t-1} + e_t \qquad (3.4)$$

$$\Delta\mu_t = \rho\mu_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta\mu_{t-1} + e_t \qquad (3.5)$$

If the null hypothesis is rejected, the residual series does not contain a unit root, hence the $\{y_t\}$ and $\{x_t\}$ sequences are co-integrated. If residuals obtained by fitting Equation 3.3 are not white noise, then equation (3.4) is augmented with an extra lag, and equation (3.5) is estimated (Enders, 2004)

3.4.2 Threshold autoregressive (TAR) model

The TAR model captures asymmetrically 'deep' movements in the time series (Uchezuba, 2010). Following equation (3.4), the TAR co-integration and adjustment process is quantified as follows:

$$\Delta\mu_t = \begin{cases} \rho_1\mu_{t-1} + \varepsilon_t & if\ \mu_{t-1} \geq r \\ \rho_2\mu_{t-1} + \varepsilon_t & if\ \mu_{t-1} < r \end{cases} \qquad (3.6)$$

where (r) represents a critical threshold value and ρ_1 and ρ_2 are the speed of adjustment parameters to be estimated. The sufficient condition for the stationary of $\{\mu_t\}$ is where $-2 < (\rho_1, \rho_2) < 0$. Enders and Granger (1998) quantified this adjustment as follows:

$$\Delta\mu_t = I_t\rho_1 (\mu_{t-1} - r) + (1 - I_t)\rho_2 (\mu_{t-1} - r) + \varepsilon_t \qquad (3.7)$$

where I_t is the Heaviside indicator and function such that:

$$I_t = \begin{cases} 1 & if\ \mu_{t-1} \geq r \\ 0 & if\ \mu_{t-1} < r \end{cases} \qquad (3.8)$$

Using the TAR model equations (3.7) and (3.8), the null hypothesis of unit root (no co-integration) is tested against the alternate of threshold co-integration.

The convergence to Enders and Granger (1998) is the equilibrium point where $\Delta\mu_t = 0$ and when $\mu_{t-1} = r$, $\Delta\mu_t = 0$. However, if μ_{t-1} is above its long term equilibrium attractor (r), the adjustment $\Delta\mu_t = \rho_1(\mu_{t-1} - r)$, and if μ_{t-1} is below its long term equilibrium attractor (r), the adjustment $\Delta\mu_t = \rho_2(\mu_{t-1} - r)$. The value (r) is the attractor since the expected value of $\Delta\mu_t$ is zero when $\mu_{t-1} = r$. The test for symmetric adjustment is conducted with this type of model specification. Note that adjustments are symmetric if $\rho_1 = \rho_2$.

Enders (2004) demonstrated that a high order of error sequence can be estimated if the residuals are correlated. In such an instance, equations (3.7) and (3.8) are estimated instead of equations (3.8) and (3.9).

$$\Delta\mu_t = I_t\rho_1(\mu_{t-1} - r) + (1 - I_t)\rho_2(\mu_{t-1} - r) + \sum_{i=1}^{p} \beta_i\Delta\mu_{t-1} + \varepsilon_t \qquad (3.9)$$

Equation (3.9) is augmented with lagged changes in the error sequence to ensure the residual errors are white noise. A diagnostic check is required on the residuals in order to determine the appropriate lag length (Tong, 1983).

3.4.3 Momentum threshold autoregressive (M-TAR) model

Enders and Siklos (2001) introduced two other competing models within the threshold framework as an alternative to the TAR model, namely the momentum threshold autoregressive (M-TAR) model and the momentum consistent threshold autoregressive (MC-TAR) model. Note that the TAR model equation (3.7) is autoregressive decay and depends on the level of the adjustment parameter μ_{t-1}. The M-TAR model is able to allow the autoregressive decay to depend on the first difference of the threshold variable μ_{t-1} (Spies, 2011). Consequently it is then possible to allow the autoregressive decay to depend on the change in μ_{t-1} (i.e. $\Delta\mu_{t-1}$) rather than the level of $\Delta\mu_{t-1}$ as depicted in the TAR model of section 3.4.2. The M-TAR model can then be written as:

$$\Delta\mu_t = I_t\rho_1(\mu_{t-1} - r) + (1 - I_t)\rho_2(\mu_{t-1} - r) + \varepsilon_t \quad (3.10)$$

where I_t is the Heaviside indicator function such that

$$I_t = \begin{cases} 1 & if\ \Delta\mu_{t-1} \geq r \\ 0 & if\ \Delta\mu_{t-1} < r \end{cases} \quad (3.11)$$

M-TAR allows the threshold to depend on changes in previous levels of μ_t . M-TAR captures asymmetrically sharp or 'steep' movements and is introduced when the exact nature of the non-linearity is unknown (Uchezuba, 2010).

The theoretical justification for estimating MC-TAR is similar to that of M-TAR. The only difference is with regard to the value of the threshold r, which is no longer fixed at 0. It is considered unknown and determined alongside with the values of ρ_1 and ρ_2. This is done by searching for it over the potential threshold variable space by minimising the residual sum of squares (Alemu, 2012).

3.4.4 Model selection

This section will describe how the co-integration test was applied using different procedures. The aim of comparing the various approaches is to choose the best fitted procedure between EG, TAR, M-TAR and MC-TAR models. The reason for the comparison is that the co-integration test has been a long-standing tool for investigating the long term equilibrium relationship between variables and it is thus necessary to conduct an appropriate and comparable procedure selection.

In this study there are four scenarios for the beef commodity. Each scenario consists of two variables namely a producer carcass price and a collective carcass price which is representative of the retail outlet (supermarket 1, 2, 3 and butchery). For each scenario there is a table such as Table 3.3 in which all four competitive models were tested on the basis of the data collected at one retail outlet (supermarket 1, S1) and the producer carcass price.

The best fitted model was then selected based on the following criteria:

a) The model with the highest absolute Akaike information criterion (AIC) value was the first to be considered and once the selected model did not satisfy one of the conditions listed under point 2 below, the model with the second highest AIC was considered as the best alternative model. The best model selected would then be the one that exhibited the second highest AIC value closest to those that did not satisfy the conditions.

   Note: The EG approach explicitly assumes that the process exhibits symmetric adjustments towards the equilibrium, meaning that if EG was selected as the model with the highest AIC, then EG can only confirm co-integration and no additional results on the basis of alternative threshold formulations that assume asymmetrical adjustments (i.e., TAR, M-TAR, and MC-TAR), as in Enders and Siklos (2001).

b) If the highest AIC was found in one of the threshold models (TAR, M-TAR or MC-TAR), the necessary and sufficient conditions for co-integration as indicated by Petruccelli and Woolford (1984), as cited in Enders and Siklos (2001), are:
   a) That ρ_1 and ρ_2 are less than 0.
   b) That $(1+\rho_1{}^a)$ $(1+\rho_2{}^a) < 1$ for any value of t.

For example, when selecting the best fitted model for supermarket 1 in Table 3.3:

a) MC-TAR has the highest absolute AIC value (-7.550335).
b) Both the adjustment parameters $\rho_1{}^a$ (-0.082715) and $\rho_2{}^a$ (-0.905736) are smaller than 0 and negative.
c) The following equation must be full filled: $(1+\rho_1{}^a)$ $(1+\rho_2{}^a) < 1$
   Thus, (1+ (-0.082715)) (1+ (-0.905736)) < 1, which amounts to
   0.0864669 < 1

Thus MC-TAR for S1 has met the necessary conditions and is selected as the best fitted model.

The best-fitted model/procedure for each scenario was selected as the best adjustment mechanism, pending information criteria such as the AIC value.[3] In the case of S1, S2 and the butchery (B), MC-TAR was selected as the best fitted model, while M-TAR was selected in the case of S3, all augmented by one-, two-, one- and four-lagged changes respectively, determined by the highest actual AIC value.

[3] Comparing the four competitive procedures for other outlets can be viewed in Appendix B.

Table 3.3: Comparing the four competitive procedures for supermarket 1 (S1)

	Engle-Granger (EG)	**Threshold autoregressive (TAR)**	**Momentum-threshold autoregressive (M-TAR)**	**Momentum-consistent threshold autoregressive (MC-TAR)**
ρ_1 [a]	-0.158410 (-3.169021)	-0.154480 (-2.283021)	-0.410303 (-4.568722)	-0.082715 (-1.707809)
ρ_2 [a]	N/A	-0.162785 (-2.293021)	-0.068035 (-1.225496)	-0.905736 (-5.996574)
AIC	-7.398782	-7.385845	-7.456658	-7.550335
LAG	1	1	1	1
P1=p2=0- ϕ [b]	N/A	4.992351	10.89891	19.38369
$\rho_1=\rho_2$ [c]	N/A	0.007580 (0.9307)	11.08858 (0.0011)	27.00643 0.0000
γ	N/A	0	0	-0.008401
Q(3) [d]	3.2605 (0.353)	3.2744 (0.351)	1.6710 (0.643)	4.6233 (0.202)
Q(6) [d]	4.0841 (0.665)	4.0884 (0.665)	2.4240 (0.877)	8.3421 (0.214)
ARCH [f]	1.110988 (0.2936)	0.379287 (0.9688)	0.271316 (0.9926)	0.507798 (0.9066)

Notes: EG, Engle-Granger; AIC, Akaike information criterion; TAR, Threshold autoregressive model; M-TAR, momentum threshold autoregressive model; MC-TAR, momentum consistent threshold autoregressive model; ARCH, autoregressive cnditional heteroskedasticity.

[a] Entries are estimated value of ρ_1 and ρ_2 with t-statistic in parentheses.

[b] Entries in this row are the sample values of ϕ and ϕ^* . Critical values for two variables case and no lagged changes for ϕ (TAR and M-TAR) are 5.01, 5.98 and 8.24 at 10%, 5%, and 1%, respectively. The corresponding values for ϕ^* (MC-TAR) are 5.95, 6.95, and 9.27.

[c] Entries in this row are the sample F-statistic for the null hypothesis that the adjustment coefficients are equal. Significance levels are in parentheses.

[d] Q(p) is the p-value for the autocorrelation test of the first p residuals. It is based on Ljung-Box statistic.

[f] Test for first –order ARCH residuals. The numbers in parentheses report p-values

3.5 ERROR CORRECTION MODEL (ECM)

After confirming the presence of an equilibrium attractor (co-integration), the error correction model is fitted to investigate the short term dynamics of the long term relationship. This procedure was suggested by Enders and Granger (1998) and Enders and Siklos (2001). The model is fitted as follows:

$$\Delta y_t = I_t\rho_1(\mu_{t-1} - r) + (1 - I_t)\rho_2(\mu_{t-1} - r) + \sum_{i=0}^{k} \beta_i \Delta x_{t-i}$$
$$+ \sum_{i=1}^{k} \xi_i \Delta y_{t-i} + \sum_{=1i}^{k} \emptyset_{ni} \Delta x_{n,t-i} + \varepsilon_t \qquad (3.15)$$

where ρ_1 and ρ_2 are the adjustment coefficients for positive and negative disturbances respectively. The lag length k is determined by the general-to-specific method. The model is used in this study to analyse the price adjustment process in the beef value chain.

3.6 GRANGER CAUSALITY TEST

Granger's (1969) approach to the question as to whether x causes y is to see how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation. It is said that y is Granger-caused by x if x helps in the prediction of y, or equivalently if the coefficient on the lagged x's are statistically significant. Note that two-way causation is frequently the case; x Granger causes y and y Granger causes x. it is important to note that statement "x Granger causes y" does not imply that y is the effect or the result of x. The Granger causality test measures precedence and information.

In this study the causality test (Granger 1969) determines the causal direction between variables to identify whether causality runs from producer to retailer ($y \rightarrow x$) or vice versa (the arrow points the direction of causality). The F-statistics were employed to test the causal relationship based on the bivariate autoregressive model, as follows:

$$x_t = \sum_{i=1}^{n} \alpha_i \, y_{t-i} + \sum_{j=1}^{n} \beta_j \, x_{t-j} + u_{1t} \qquad (3.16)$$

$$y_t = \sum_{i=1}^{n} \lambda_i \, x_{t-i} + \sum_{j=1}^{n} \delta_j \beta_j \, y_{t-j} + u_{2t} \qquad (3.17)$$

where it is assumed that the disturbance u_{1t} and u_{2t} are uncorrelated. In passing, note that since there are two variables, bilateral causality is dealt with.

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_l x_{t-1} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} + \varepsilon_t \qquad (3.18)$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_l y_{t-1} + \beta_1 x_{t-1} + \ldots + \beta_l x_{t-l} + \psi_t \qquad (3.19)$$

For all possible pairs of $(x; y)$ series in the group, the reported F-statistics are the Wald statistics for the joint hypothesis:

$$\beta_1 = \beta_2 = \ldots = \beta_l = 0 \qquad (3.18)$$

3.7 SUMMARY

Data was collected on a weekly basis over a period of three years. In order to analyse these prices and the trend of both producer and retail carcass prices, certain data preparations needed to be done in order to employ the four competing procedures that would reveal the existence of a long term co-integrated relationship. The results of the selected procedures are discussed in chapter 4.

CHAPTER 4
RESULTS

4.1 INTRODUCTION

The price transmission results between the producer and retail sectors presented in this chapter, will be discussed on the basis of four retailers in Bloemfontein, of which three were supermarkets and one a butchery. The results will show the possible existence of a long term relationship, the ability of price to adjust to equilibrium shocks and the direction of influence between the variables. The data used for the results were weekly RPs and PPs collected over a period of three years, from 2012 to 2014.

Co-integration was used to estimate the existence of a long term relationship between the producer and retail prices over time, by applying the best fitted model (EG, TAR, M-TAR or MC-TAR) for each retailer. In order to determine how prices would adjust to an economic shock individually in the short term, the error correction model (ECM) was used, while the impulse-response function graphically represents the dynamic interrelationship between the variables. The Granger causality test was employed to determine the causal direction of the flow of market information in the long term.

Note that changes in price (positive or negative) will take place in the PP and the RP will be considered as the dependent variable for purposes of this analysis. The nature of price transmission adjustments will be analysed from the following point of view: A negative shock follows an increase in the PPs which decrease (squeeze) the marketing margin, while a positive shock occurs when the PP decreases and the marketing margin increases (stretches).

4.2 LONG TERM RELATIONSHIP BETWEEN PRODUCER AND RETAIL PRICES

The objective of the co-integration test is to determine the existence of a long term relationship between the linear combination of producer and retail prices. If, in the long term, the prices move together, price transmissions are found to be symmetrical. When prices do not move together, price transmission is asymmetrical and the need arises to conduct an in-depth determination of the nature of the price adjustments to the equilibrium.

Table 4.1 reflects the results of the best fitted co-integration model for each retailer. The results indicate the relationship between the PP and the price of the various retailers.

Table 4.1: Estimates of price transmission in the Bloemfontein beef market.

Retail outlet	**S1**	**S2**	**S3**	**B**
Procedure type	**MC-TAR**	**MC-TAR**	**M-TAR**	**MC-TAR**
ρ_1^a	-0.082715 (-1.707809)	-0.919323 (-7.461265)	-0.444994 (-6.070304)	0.084353 (-1.753810)
ρ_2^a	-0.905736 (-5.996574)	-0.174910 (-2.867509)	-0.030422 (-0.636397)	-0.999620 (-9.002545)
AIC	-7.550335	-5.809469	-6.364179	-7.487085
LAG	1	2	4	1
P1=p2=ϕ^b	19.38369	30.74292	14.01841	41.40322
$\rho_1=\rho_2^c$	27.00643 0.0000	30.83049 0.0000	11.91513 (0.0007)	59.26808 0.0000
γ	-0.008401	0.014444	0	-0.01369
Q(3)[d]	4.6233 (0.202)	1.7063 (0.636)	1.2777 (0.734)	3.9409 (0.268)
Q(6) [d]	8.3421 (0.214)	5.5988 (0.470)	2.3772 (0.869)	4.5008 (0.609)
ARCH[f]	0.507798 (0.9066)	0.634890 (0.8092)	0.908795 (0.5403)	0.320621 (0.9846)

Notes: EG, Engle-Granger; AIC, Akaike information criterion; TAR, threshold autoregressive model; M-TAR, momentum threshold autoregressive model; MC-TAR, momentum consistent threshold autoregressive model; ARCH, autoregressive conditional heteroskedasticity.
[a] Entries are estimated value of ρ_1 and ρ_2 with t-statistic in parentheses.
[b] Entries in this row are the sample values of ϕ and ϕ^* . Critical values for two variables case and no lagged changes for ϕ (TAR and M-TAR) are 5.01, 5.98 and 8.24 at 10%, 5%, and 1%, respectively. The corresponding values for ϕ^* (MC-TAR) are 5.95, 6.95, and 9.27.
[c] Entries in this row are the sample F-statistic for the null hypothesis that the adjustment coefficients are equal. Significance levels are in parentheses.
[d] Q(p) is the p-value for the autocorrelation test of the first p residuals. It is based on Ljung-Box statistic.
[f] Test for first –order ARCH residuals. The numbers in parentheses report p-values.

In addition to the conditions set by Petruccelli and Woolford (1984) as highlighted in section 3.4.4 of chapter 3 of this study, Enders and Siklos (2001) introduced two other competing models with alternative adjustment specifications, but within the threshold framework. To test for co-integration in the long term, it was necessary to jointly test for the null hypothesis that is $\rho_1{}^a = \rho_2{}^a = 0$ against its alternative hypothesis of $\rho_1^a = \rho_2^a \neq 0$, where the alternative hypothesis represents the existence of co-integration or a long term relationship. The critical values in Table 4.1 are the computed F-statistics ϕ and ϕ^* which are significant for S1, S2, S3 and B (Table 4.1, Column 2, 3 & 5, Row 7) as 19.38369, 30.74292, 14.01841 and 41.40322 are all higher than the corresponding critical value at 1%, level of significance. The null hypothesis for the test was thus rejected. Therefore the results indicate that in the case of S1, S2, S3 and B there are long term relationships between the producer and retailer prices, thus confirming the existence of co-integration in the long term.

Although the co-integration test confirms a long term relationship between the PP and the RP, the specifics of the relationship is still unknown. The mere existence of a long term relationship can thus not be seen as a positive or negative element in the market. A long term relationship between the producer and RP in the market is preferable, as long as this relationship is symmetrical. The relationship between the prices should therefore reflect the same changes, in speed and magnitude, keeping the margin between the PP and RP constant. The confirmed long term relationship should therefore be evaluated in terms of symmetry.

4.2.1 Symmetrical properties of the long term relationship

Seeing that the co-integration between producer and retail prices has been confirmed, it is now important to determine the nature of these relationships with regard to the manner in which price changes are transmitted. The test for symmetry indicates how role-players respond to negative and positive price shocks. If role-players on either side of the market react similarly, the relationship between the variables is symmetrical, while the relationship will be considered asymmetrical when the reactions to a shock in the market are not the same on both sides.

Symmetry in adjustment is determined by testing the null hypothesis of $\rho_1{}^a = \rho_2{}^a$ against its alternative of $\rho_1{}^a \neq \rho_2{}^a$ (asymmetry). According to the results, the symmetric null hypothesis (H_0) was rejected at conventional significance levels (F-statistic of H_0 is 0.000) for all four retailers (Table 4.1, Column 2, 3, 4, 5, Row 8). The alternative hypothesis (H_a) of asymmetry is therefore accepted for price transmission between producer and RPs.

Asymmetry can however be classified as either positive or negative asymmetric price transmission (APT), and is characterised by the responsiveness of the RP to a change in the PP. If the RP shows a greater response towards a price increase in the PP than to a decrease, it is classified as positive APT. Negative APT occurs when the response of the RP is greater towards a decrease in the PP than to an increase.

The type of APT, or the responsiveness of the RP to a change in the PP, is determined by the positive ($\rho_1{}^a$) and negative ($\rho_2{}^a$) parameter values (Table 4.1, Row 3 and 4) that present the deviations from the long term equilibrium. The positive and negative values represent the speed and magnitude at which a unit change in price (positive or negative shock) will be eliminated or absorbed by the market in the first week, while the discrepancies of the two shocks persist in the following week. The smaller the value of the parameters, the smaller the response and the greater the discrepancy towards the next week.

Retail outlets S1 ($\rho_1{}^a$ = -0.082715 and $\rho_2{}^a$ = -0.905736) and B ($\rho_1{}^a$ = -0.084353 and $\rho_2{}^a$ = -0.999620) both exhibited a greater response towards a price increase than to a decrease. Positive and negative deviations from the long term equilibrium are eliminated at 8.27% and 90.57% per week for S1 and at 8.43% and 99.96% per week for B. In both cases the discrepancies in shock will continue into the following week/s. The results suggest that in the case of S1 and B, a deviation from the equilibrium will persist due to positive shocks (a decrease in PP) rather than to negative shocks (an increase in PP). These retailers are therefore quicker to respond to shocks that squeeze their margins than to those that stretch them, which results in positive APT in the long term.

In the case of S2 ($\rho_1{}^a$ = -0.919323 and $\rho_2{}^a$ = -0.174910) and S3 ($\rho_1{}^a$ = -0.444994 and $\rho_2{}^a$ = -0.030422) the response is in the opposite direction. S2 and S3 respond quicker to shocks that stretch their margins (decrease in price) than to those that squeeze their margins (increase in price). This implies that if positive and negative deviations from the long term equilibrium are eliminated at 91.93% and 17.49% of the change in price per week for S2 and 44.49% and 3.04% per week for S3, the discrepancies of these shocks will lead to negative APT in the long term.

The t-statistics value for each of the parameter values are significant for all four the retailers, except for $\rho_2{}^a$ = -0.030422 in S3 which is insignificant. The insignificance of the t-statistic (-0.6363), together with the small adjustment (3.04%) in the case of a negative shock, implies that basically no response will take occur in the event of a PP increase, although a small magnitude and speed of adjustment will apply in the case of a negative shock.

The diagnostic tests (Q (3) [d], Q (6) [d] and ARCH[f]) presented in Table 4.1 for the fitted models, indicate no autocorrelation and orthogonal (serially uncorrelated) residuals.

The positive APT in the case of S1 and B means that in the long term the margin between the producer and RP will increase, driving the two prices further apart as the reaction of the retailer is more complete to an increase in the PP than to a decrease. In the case of S2 and S3, the negative APT will thus cause the margin between the producer and RP to decrease over time, as the reaction of the retailers is more complete to a price decrease than to a price increase, thus driving the two prices closer together.

Although the ideal situation in price transmission is symmetry, that is clearly not the case with either of these retailers, as all of them revealed asymmetry. It may however be argued, from a consumer point of view, that long-term negative APT is the more ideal situation as the RP moves closer to the PP resulting in a smaller margin that the consumer has to pay for beef. For retailers negative APT is, however, not sustainable over the long term as somewhere in the future the decreasing margin will meet the increasing cost trend, resulting in a loss for retailers. Positive APT, on the other hand, is certainly the more ideal situation for retailers as the margin increases with the RP increasing faster than the PP. Positive APT may however also not be sustainable, as at some point in the future the price of beef at these retailers will be so high, that consumers will either move to other retailers or to other sources of protein.

Apart from the long term symmetrical relationship between prices, it is also important to analyse the price adjustment dynamics to economic shocks in the short term. The nature of price transmission in the short term will then indicate how fast the RP will react to a shock in the PP and return to the long-term relationship (equilibrium) between the variables.

4.3 NATURE OF PRICE TRANSMISSION IN THE SHORT TERM

The nature of price transmission dynamics amidst an economic shock arising from alternative markets in the short term, was analysed by fitting an asymmetric error correction model (ECM), which analyses positive and negative price adjustments. The model is free from autocorrelation and the residuals are orthogonal (serially uncorrelated), looking at the diagnostic tests (Q (3) [d], Q (6) [d] and ARCH [f]).

Table 4.2 represents the ECM results for the price adjustment of beef for all four retailers. The results of ECM in Table 4.2 are obtained with the RP as the dependent variable. The speed of adjustment lies between zero and one (0-100%). The closer it lies to one, the faster the adjustment.

Table 4.2: The error correction model for all four retailers

	Supermarket 1 (MC-TAR)	**Supermarket 2** (MC-TAR)	**Supermarket 3** (M-TAR)	**Butchery** (MC-TAR)
	$\Delta \boldsymbol{RP_t}$	$\Delta \boldsymbol{RP_t}$	$\Delta \boldsymbol{RP_t}$	$\Delta \boldsymbol{RP_t}$
Constant	0.0003 (0.8798)[a]	-0.00111 (-1.031909)[a]	-0.001442 (-1.777018)[a]	-0.001030 (-2.715470)[a]
$\Delta \boldsymbol{RP_{t-1}}$	-0.2134 (-2.8962)[a]	0.097628 (1.310728)[a]	0.108088 (1.437051)[a]	-0.001141 (-0.018359)[a]
$\Delta \boldsymbol{PP_t}$	0.1699 (2.9795)[a]	0.052743 (0.389353)[a]	0.129597 (1.404516)[a]	0.217774 (0.0000)[a]
$\Delta \boldsymbol{PP_{t-1}}$	0.0729 (1.1958)[a]	-0.002758 (0.020274)[a]	0.168295 (1.861362)[a]	0.053047 (0.3099)[a]
$\boldsymbol{err\ +_{t-1}}$	-0.0997 (-1.9704)[a]	-0.941311 (-7.462307)[a]	-0.342015 (-5.044077)[a]	-0.098562 (-2.450944)[a]
$\boldsymbol{err\ -_{t-1}}$	-0.9494 (-6.2361)[a]	-0.173265 (-2.801152)[a]	-0.012804 (-0.316787)[a]	-0.913394 (-9.735638)[a]
Q(3)	4.5728 (0.206)[b]	1.8274 (0.609)[b]	2.6136 (0.455)[b]	3.8223 (0.281)[b]
Q(6)	8.6352 (0.195)[b]	5.6158 (0.468)[b]	4.0535 (0.669)[b]	5.3178 (0.504)[b]

a. Numbers in parentheses are t-ratios. b. Numbers in parentheses are probabilities.

In Table 4.2 the ΔPP_t coefficient shows the effect which a unit change in the PP will have on the RP (dependent variable) as well as the adjustments coefficients and their significance ($err\ +_{t-1}$ and $err\ -_{t-1}$) of how the RP will respond to the positive or negative shocks in PP. The positive component ($err\ +_{t-1}$) indicates that the margin is above its long term equilibrium value, whereas the opposite holds for the negative component ($err\ -_{t-1}$). If the t-statistics of the adjustment coefficients are both statistically different from zero, the RP responds to both positive and negative shocks. The shock that is greater in size is the one that will have a greater change in the RP via its speed and magnitude.

It is evident from Table 4.2 that S1 and B react faster and at a greater magnitude, to a price increase than to a price decrease. As for S1 and B, the speed of return to the equilibrium is 94.94% and 91.33% respectively for a price increase ($err -_{t-1}$), while for a price decrease ($err +_{t-1}$) the speed of return is only 9.97% and 9.85% respectively. S2 and S3 exhibit opposite results and a decrease in price will be transferred quicker and at a greater magnitude than an increase in price. In the case of S2 and S3 the speed of return to the equilibrium is 94.13% and 34.20% respectively for a price decrease ($err +_{t-1}$), while it is only 17.32% and 1.28% respectively on the evening of a price increase ($err -_{t-1}$).

In order to graphically represent the nature of price transmission in the short term, an impulse-response function was fitted to the ECM results. The impulse-response function helps to investigate the dynamics and interrelationships between the producer and retailer prices and reflects how long it will take for the RP to return to a long term equilibrium after short term shocks in the PP. Figure 4.1 to Figure 4.4 illustrate the impulse response effect of marketing margins to a price shock of one unit increase and a unit decrease (positive and negative) in the PP for each of the retailers. The impulse-response function for each retailer is determined by the specifications (coefficients, ΔRP_t and ΔPP_t) of speed and magnitude for the specific retailer. Remember that the RP is considered as the dependent variable and the change in the PP is the independent variable.

Retail outlets were grouped according to their similarity in adjustment ability, as explained by the interpretation of the $err +_{t-1}$ (positive component) and $err -_{t-1}$ (negative component) coefficients in the short term. Figure 4.1 and Figure 4.2 represent the relationship and adjustment ability between the PP and RP for S1 and B respectively in the beef industry. The speed of return to long term equilibrium in S1 is 9.97% and 94.94% respectively for a unit decrease in price ($err +_{t-1}$) and a unit increase in price ($err -_{t-1}$), while it is 9.85% and 91.33% for B.

In the case of S1 (Figure 4.1) a change in PP (decrease or increase) will influence the RP (positive or negative) by 0.1699 units (ΔPP_t coefficient) while the marketing margin will be influenced by the remainder which is 0.83 units (1 - 0.1699)[4]. One unit change in the PP will thus influence the profit margin of the retailer by 0.83 units. In the case of an increase in the PP (negative shock to the market margin) the change in the margin will be corrected by a factor of 0.94 per week. A decrease in the PP (a positive shock to the market margin) will be corrected by a factor of 0.09 units per week. Therefore in the event of a R1.00 shock in the PP, increase or decrease, the market margin will in the short term change with R0.83. In the event of an increase

[4] Coefficient of a change in the PP

in the PP, the large correction factor (0.94) will ensure that the market margin returns to the long term equilibrium completely in only 3.5 weeks. However, a decrease in the PP will take more than 38 weeks to return to the long term equilibrium due to the small correction factor (0.09).

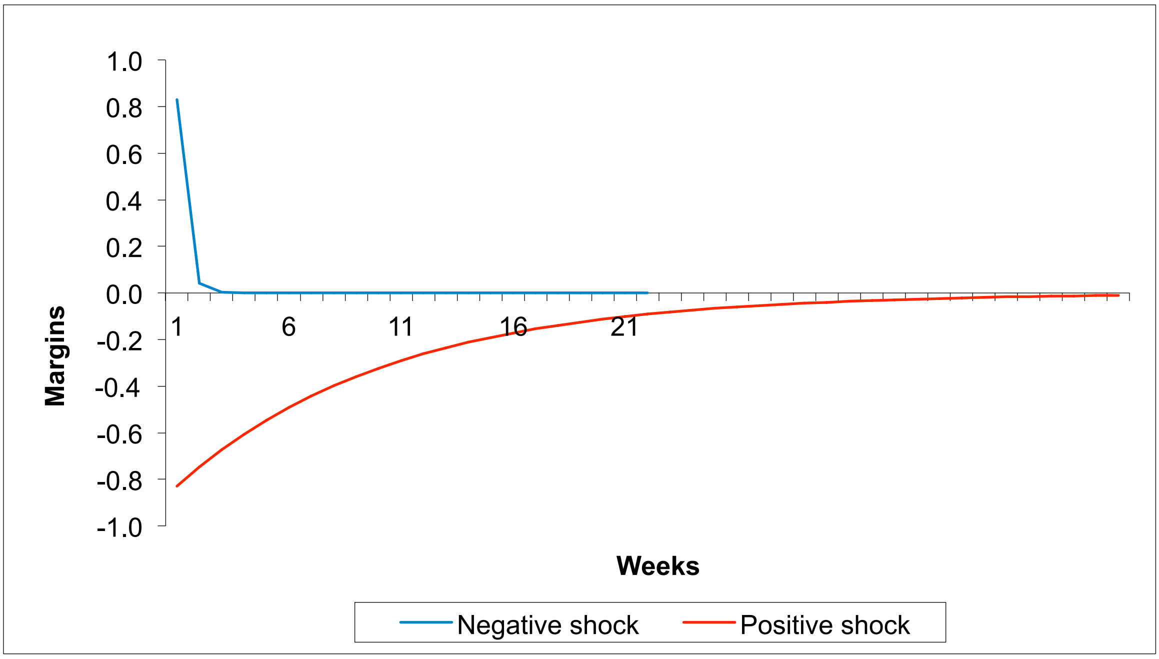

Figure 4.1: Response in speed and magnitude to a unit shock in PP for S1.

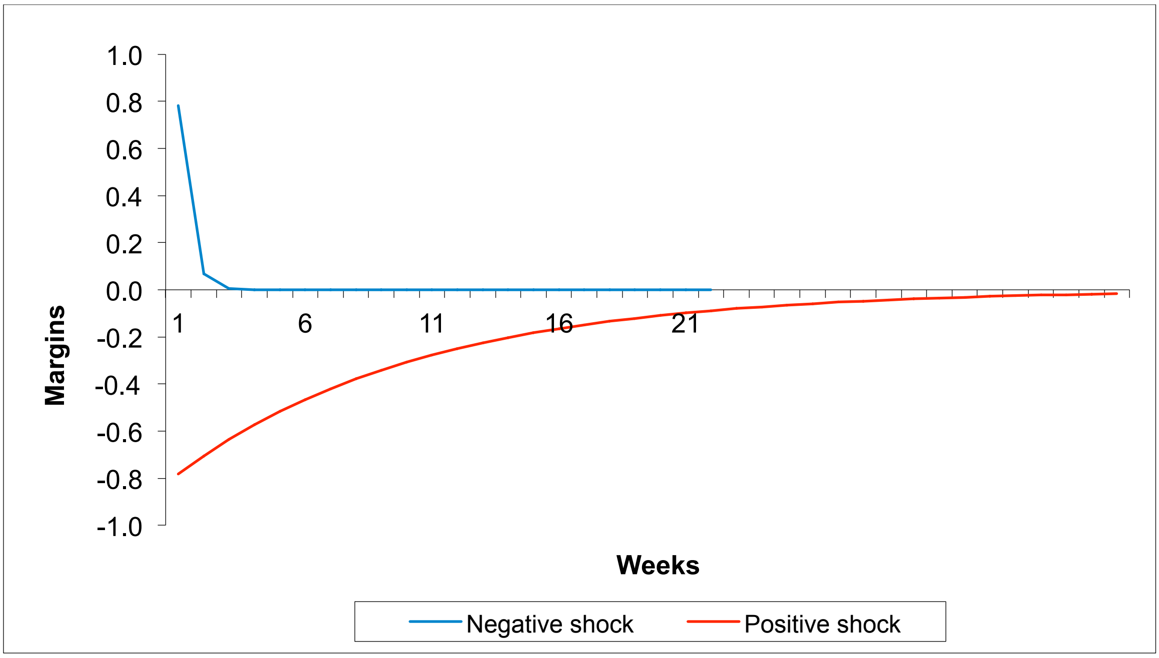

Figure 4.2: Response in speed and magnitude to a unit shock in PP for B.

The results for B (Figure 4.2) are similar for that of S1, but a unit change in the PP will have a lesser effect on the margin. The ΔPP_t coefficient for B is 0.2177 which means that a R1.00 change in the PP will influence the market margin with the remainder of the coefficient (0.7823) (calculated by 1-0.217774) or R0.78. In the event of an increase in PP it will take approximately five weeks for the margin to return to long term equilibrium, as a price increase is corrected by a factor of 0.91 units per week. A return to the long term equilibrium after a price decrease is much slower than in the case of a price increase, and will take more than 38 weeks to completely return to the long term equilibrium due to the small correction factor of 0.098 per week.

The positive APT for S1 and B that was identified in the long term, is now confirmed for these retailers in the short term as well, as S1 and B return to the long term equilibrium faster after a price increase than after a price decrease. This generally implies that S1 and B will absorb a change in PP much faster when margins are squeezed, than when they are stretched.

The results for S2 and S3 indicate that their response to a change in PP is the opposite of that of S1 and B. Figure 4.3 and Figure 4.4 show the responsiveness of S2 and S3 respectively with regard to a change in PP. The speed of adjusting back towards the long term equilibrium between PP and RP for S2 are 94.13% per week for a price decrease and 17.32% per week for a price increase, while for S3 it is 34.20% and 1.28% per week respectively.

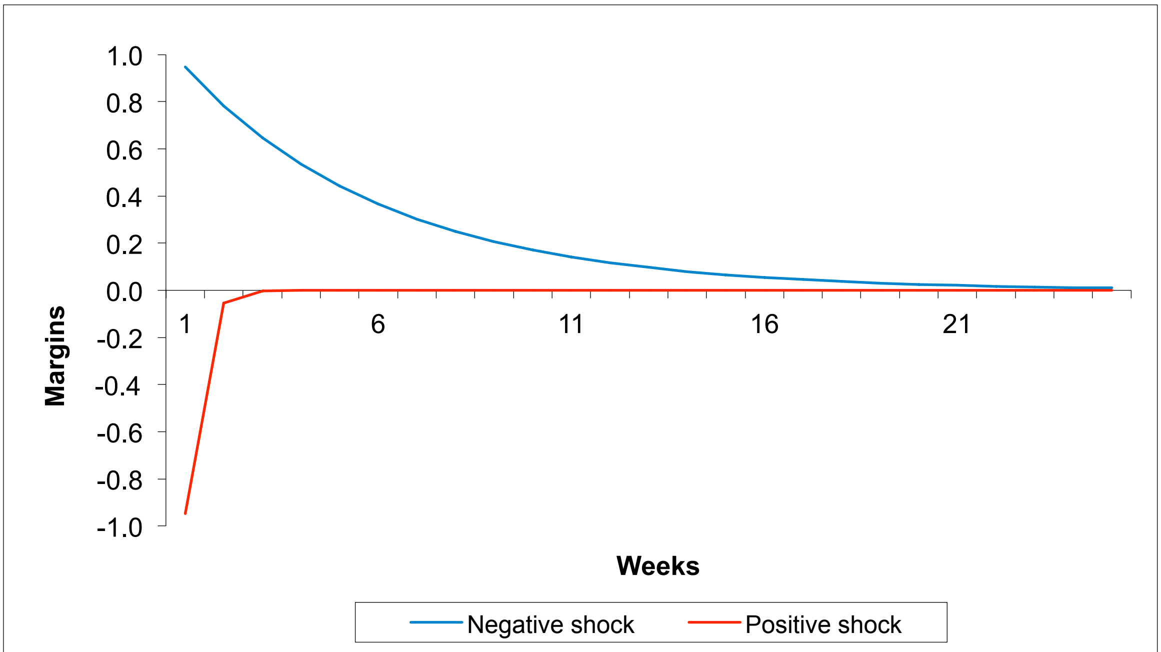

Figure 4.3: Response in speed and magnitude to a unit shock in PP for S2.

A unit change in the PP, whether positive or negative, will affect the RP of S2 (Figure 4.3) by 0.0527 units (ΔPP_t coefficient), while the market margin will be influenced by 0.947 units ($1 - \Delta PP_t$). The influence of R0.95 on the market margin following a change of R1 in the PP will be corrected by a factor of 0.1732 per week for a price increase and 0.9413 for a price decrease. In the event of a negative shock to the market margin (increase in PP), the margin will thus take approximately 25 weeks to return to its long term equilibrium, while it will take only approximately four weeks for the margin to return to the long term equilibrium after a positive market margin shock (decrease in PP).

In the event of a change in PP, in the market for S3 (Figure 4.4), whether positive or negative, the RP will be influenced by 0.1295 units while the market margin will change with the remainder or 0.8705. A R1 decrease in the PP will thus increase the market margin by R0.87 and will take approximately 13.5 weeks to return to the long term market margin equilibrium as the correction factor is 0.342 units per week. A negative shock, or increase in PP, will lower the market margin by R0.87, but despite the insignificant t-value of the negative response, the correction factor here is only 0.0128 units per week. The market margin will take so long to return to long term equilibrium, that it is not significant in the short term anyway.

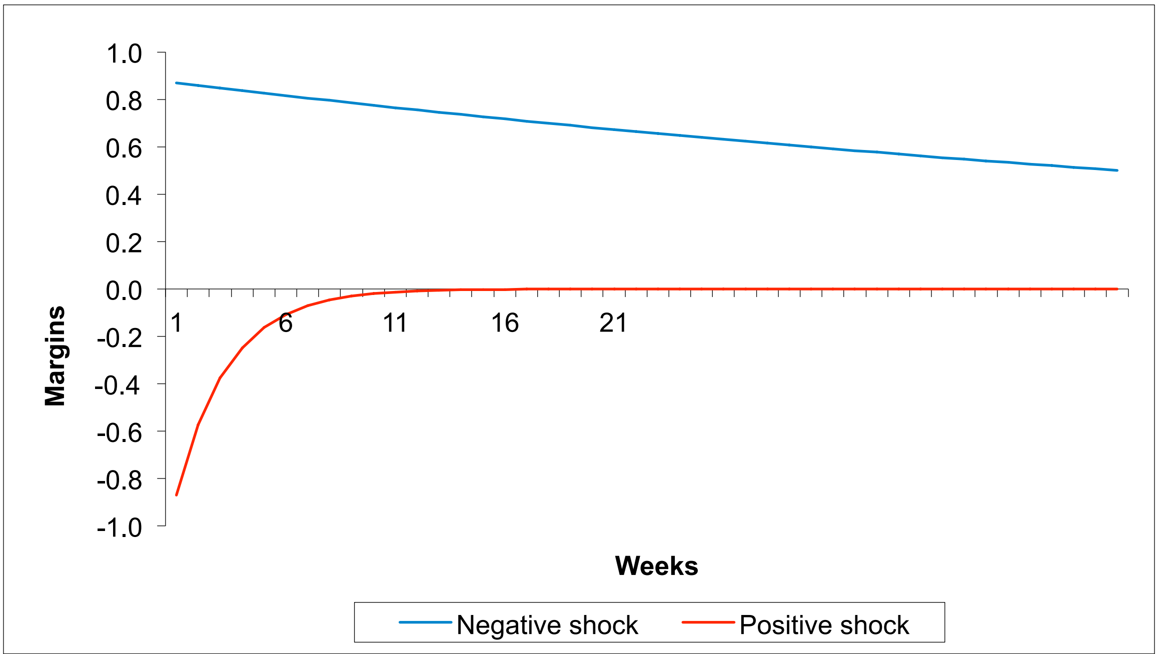

Figure 4.4: Response in speed and magnitude to a unit shock in PP for S3.

In the case of S2 and S3 the response of RP and the ability of the market margin to return to its long term equilibrium, are quicker and more encompassing in respect of a stretch of the market margin, than with regard to a squeeze of the margin. In the short run negative APT is thus evident in the case of S2 and S3 and confirms the negative APT that was detected in the long term.

In the short term the t-value reveals the same trend detected in the long term. In the case of all four retailers the RP responded to both positive and negative shocks in the PP, but different speed and magnitudes were recorded in the short term, except for the negative parameter of S3, which is insignificant (-0.3167). For two retailers, S1 and B, the RP responded more significantly towards a negative shock in the PP than to a positive shock, while S2 and S3 responded more significantly to a positive shock.

A comparison of the actual value of the positive and negative shock in each case revealed that the speed of adjustment towards the new equilibrium varies significatly within the beef market. The different adjustments following a shock in PP, confirms the APT with regard to speed and magnitude between the PP and RP. This means that the response time in respect of speed and magnitude in reaction to a change in the PP, does not correspond with that of the RP. Although the nature of price transmission for each retailer differs from the next, the responses of all four retailers resulted in APT according to speed and magnitude.

Looking at the diagnostic tests (Q (3) [d], Q (6) [d] and ARCH[f]) presented in Table 4.2 for the ECM, it is clear that there is no autocorrelation and the residuals are serially uncorrelated.

4.4 FLOW DIRECTION OF MARKET INFORMATION

The Granger (1969) causality test was performed to determine the causal direction of information flow between variables, to identify whether causality runs from retailer to producer (y→x) or vice versa (the arrow indicates the direction of causality). The Granger causality test was used to test the null hypotheses stating that the RPs does not affect the PP (S1 ⇏A2/A3) and that the PP does not affect the RP (A2/A3 ⇏ S1), as shown in Table 4.3. Results can however either be undirectional (no influence on each other), unidirectional (influence flow one way) or bidirectional (influence if in both directions).

Table 4.3: Granger causality test results for beef

Null Hypothesis	F-Statistic	Probability
S1 ⇏A2/A3	3.32645	0.0386**
A2/A3 ⇏ S1	7.61983	0.0007*
S2 ⇏A2/A3	0.46450	0.6294
A2/A3 ⇏ S2	1.88571	0.1553
S3 ⇏A2/A3	1.94554	0.1465
A2/A3 ⇏ S3	7.92196	0.0005*
B⇏A2/A3	0.49680	0.6095
A2/A3 ⇏ B	18.1209	0.0000*

* and ** denote significance at a 1% and 5% significance level respectively.

The results in Table 4.3 clearly indicate that causality differs among the various retailers. S1 is the only retailer which presents bidirectional causality. Information therefore flows from the producer to the retailer and from the retailer to the producer. A change in PP thus causes the RP of S1 to change and a shock in RP should also influence PP. In the case of S3 and B there is unidirectional causality with the flow of information only from producer to retailer. Contrary to the other retailers, S2 reflects undirectional causality. In the case of S2 there is thus basically no flow of information, leaving the PP and RP without an influence on one another.

Bidirectional causality is the ideal environment for producers, retailers and consumers to operate in. The fact that information flows in both directions in the market, ensures that in the event of a change in PP, the RP will react and the change will be carried over to the consumer. When the RP changes, on the other hand, the information is also transferred back into the stream towards the producer, and the PP will consequently be affected in the same direction.

The second best alternative is unidirectional causality which indicates that there is at least some flow of information, albeit not in both directions. In this study the flow of information from producer to retailer is considered more important, as the focus of the study is on the reaction of the various retailers to a change in the PP.

Causality yielded significant results for three of the four retailers, S1, S3 and B. All three retailers at least proved to react to changes in the PP, and a change in PP is thus likely to be transferred to the consumer. S2 however, did not reveal significant results, as there is no proof of information flow. Thus the RP of S2 does not show any relationship with the PP and a change in the PP will thus not be transferred to the consumer price.

4.5 CONCLUSIONS

The objective of this study was to evaluate the nature of price transmission in the beef value chain in Bloemfontein. In order to evaluate the nature of price transmission, a few sub-objective(s) needed to be investigated in order to reach a conclusion regarding the main objective.

The first sub-objective was to determine the existence of a long term relationship between the PP and RP. Secondly the short term nature of price transmission in the value chain was investigated to determine how and whether the marketing margin actually returns to the long term equilibrium after having absorbed short term shocks. Lastly the causality of the market was investigated to determine whether the casual flow of information is bi-directional, uni-directional or un-directional.

The existence of a long term relationship between the PP and RP was confirmed for all four retail outlets (S1, S2, S3 and B) of the beef market. The existence of such a relationship confirmed that the PP and RP for each case shared a certain price transmission nature over time and that responses of the variables to fluctuations would reveal the relationship. In the Bloemfontein beef market an analysis of the price transmission of S1, S2, S3 and B proved the transmission to be asymmetrical. Asymmetrical price transmission means that a change in the price at one level of the chain does not have the same effect at another level of the chain, as the change is not transmitted fully and immediately throughout the different segments of the chain. The type of asymmetry, however, differed among the retailers. S1 and B were found to be positive asymmetric while S2 and S3 were negative asymmetric. The market margin for S1 and B thus increased over time (stretch), while the market margin for S2 and S3 declined (shrunk) in the long term.

The short term nature of price transmission for the different retailers also showed significant differences between one another. S1 and B both reacted faster and more completely to an increase in the PP than to a decrease. The time that the market margin took to return to the long term equilibrium after a shock in the PP, were four and five weeks for S1 and B respectively in the case of a PP increase, and more than 38 weeks for both retailers in the case of a PP decrease.

S2 and S3, on the other hand, reacted quicker and more completely to an decrease in the PP than to an increase. The market margin would take respectively four and 14 weeks for S2 and S3 to return to the long term equilibrium after a decrease in the PP. However, an increase in the PP would take 25 weeks to fully transmit in the case of S2, while for S3 the correction coefficient was so small that the market margin would basically not return to the long term equilibrium position.

The causality analyses indicated that S1 exhibited significant bi-directional behaviour, S2 revealed undirectional flow of information and a unidirectional influence was found in the case of S3 and B. The results thus indicated that significant levels of market information existed at three of the four retailers and that the PPs indeed influenced the RP. The fact that the RP reacted to changes in the PP through the flow of market information indicated that no price fixing occurred in the market, as no causality would have been present in the event of price fixing.

While it may seem simplistic to state in final conclusion that the results revealed that all the retailers in question exhibited APT, there are in fact too many other factors that should also be considered when deciding on the nature of price transmission in the market. Although it is true that APT was found in the market in the case of all four retailers, it must be borne in mind that while two of them exhibited positive APT, the other two did in fact exhibit negative APT. The market margin of two of these retailers thus increased (stretched) over time and detrimentally affected consumers, while the market margin of the other two retailers actually decreased over time and therefore proved to benefit consumers.

The evidence of causality in the case of three of the four retailers is also a positive indication of the nature of price transmission in Bloemfontein, as it reveals that price fixing does not exist in the market and that the RP therefore does react to a change in the PP. The Bloemfontein beef market can therefore not be declared problem-free in terms of price transmission, but it can also not be declared as problematic. The reasons for the APT behaviour should, however, be subjected to further analysis in a bid to find solutions to the current behaviour, so that the market can be driven towards a symmetrical relationship between the PP and RP.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter provides a summary of and conclusion to the study. The final section is devoted to recommendations based on the study findings.

5.2 SUMMARY

The deregulation of the South African agricultural market in 1996 led to the creation of an unknown difference between the PP and RP of beef. This difference raised concerns among producers with regard to the possibility of asymmetry in the market, as the difference between the producer carcass (average price of beef carcasses A2 and A3) price and RP did not always reflect the same margin relationship.

Currently the actual status of price transmission within the South African beef value comprises mostly of the opinion of producers versus that of other role-players in the value chain, such as wholesalers and retailers. The primary objective of the study was to analyse the nature of price transmission in the Bloemfontein beef value chain, in order to help resolve concerns within the red meat industry regarding the actual status of price transmission.

The first sub-objective was to determine the existence of a long term relationship between the PP and RP. Secondly, the short term nature of price transmission in the value chain was investigated to determine how, and whether, the marketing margin returned to its long term equilibrium following short term shocks. Thirdly, the causality of the market was investigated to determine whether the casual flow of information was bidirectional, unidirectional or undirectional.

5.2.1 Literature review

The literature review of price transmission indicated that since the deregulation of the South African agricultural markets in the 1990s, prices had become more exposed to factors causing price fluctuation, than when the market had been regulated. Price transmission is nothing new and remains a concern in other countries and industries, and in this case more specifically to the South Africa red meat industry. The literature studied mostly concerned price transmission in the agricultural sectors and related to different commodities in different parts of the world.

According to the literature, price transmission can be classified into symmetrical as well as asymmetrical price transmission (APT) of which APT is the most common. Although the nature of price transmission can be quantified by the speed and magnitude according to each parameter (price increase or decrease), APT can further be classified into positive and negative APT, exploiting the nature of the price relationship rather than only the actual relationship between the price series.

Different authors identified various factors that could influence or cause price transmission at different levels of the value chain and based their arguments as to what led to their results, on some of the reviewed influencing factors. The causative factors that were considered important because of their relevancy to this study, were factors such as market structure, government intervention, product type, adjustment cost and menu cost.

In the reviewed articles, data properties emphasised the uniqueness of this study. Although previous studies had different data lengths and number of observations, none of the reviewed studies used 156 weekly data points over three years as this study did. Collections were either over longer periods with fewer observations, or over shorter periods with fewer observations than in this study. In this study, data was collected weekly over 156 weeks. Furthermore, the national average PPs for classes A2 and A3 beef carcasses were compared to the RPs of different beef cuts which were physically collected weekly at each of four retail outlets and not merely compared to the national averages of retailers.

Various literature studies articles on price transmission showed a number of procedures which were used to investigate it between different segments of the market chain, more specifically between the producer and retailer**.** The procedures selected for this study were based on the experience and critiques of such previous studies, the date of establishment (the latest model), the most popular and the best fitted procedure according to the data properties.

5.2.2 Procedures

The Augmented Dickey Fuller (ADF) stationary test was used as a preparation of data for further analyses of the relationship between PP and RP of the four retailers (S1, S2, S3 and B). Various procedures were used to analyse the nature of price transmission as per the three sub-objectives.

Firstly, the four competing procedures used to determine the existence of a long term relationship by a co-integration analysis, were the Engle and Granger (EG) model, the threshold autoregressive (TAR) model, the momentum threshold autoregressive (M-TAR) model and the momentum-consistent threshold autoregressive (MC-TAR) model. From the applied procedures, the response of each variable could be determined by the parameters. Secondly, as a measurement of the short term correction ability, the response via speed and magnitude of the parameters to a positive and negative shock, was analysed by the error correction model (ECM). Thirdly the Granger causality test was used to determine the direction of influence between variables.

5.2.3 Results

The results of price transmission between the producer and retail were analysed on the basis of four retailers in Bloemfontein, of which three are supermarkets and the fourth is a butchery. The results discussed the possible existence of a long term relationship, the price adjustment ability to equilibrium shocks and the direction of influence between variables. The data used for the results were RPs and PPs collected weekly over a period of three years, from 2012 to 2014.

The first sub-objective was to determine the existence of a long term relationship between the PP and RP. The null hypothesis for the test was rejected and the results indicated that in the case of S1, S2, S3 and B, the alternative hypothesis was accepted, confirming the existence of a long term relationship. The parameters of three of the four retailers' values showed significant responses towards any price change, whether positive or negative. In the case of S3 $\rho_2^a = -0.030422$ was insignificant for a negative shock. This implied that although the magnitude and speed of adjustment was so small towards a negative shock, no response would take place in the event of a PP increase.

The second sub-objective was to determine the nature of price transmission dynamics towards an economic shock arising from the alternate market in the short term. The t-value revealed the same results as in the long-term cases. At four retailers, RP responded to both positive and negative shocks in the PP, but at different speed and magnitudes in the short term with the negative parameter of S3 as insignificant (-0.3167) in the short run as well. In the long term and short term, two retailers namely S1 and B's RP responded more significantly towards a negative shock in the PP than to a positive shock. S2 and S3 responded more significantly to a positive shock. Although the nature of transmission in each retailer's case differed from the next, all four revealed APT according to speed and magnitude.

Remember that APT is a change in the price at one level of the chain which does not correspond with the effect at another level of the chain, for the change is not transmitted fully and immediately through the different segments of the chain by the same speed and magnitude. The type of asymmetry was different between the retailers as S1 and B were found to be positive asymmetric while S2 and S3 were negative asymmetric. The market margin for S1 and B thus increased over time (stretched) while the market margin for S2 and S3 declined (squeezed) in the long term.

The third sub-objective was to determine the causal direction of information flow between variables, to identify whether causality ran from retailer to producer or vice versa. Significant information flow was confirmed with three of the four retailers, namely S1, S3 and B. S1 revealed the ideal relationship with bidirectional information flow in both ways. In S3 and B the significant causal direction was unidirectional to changes in the PP, meaning that information only flowed from producer to retailer and thus only a change in PP would be carried over to the consumer.

The RP of S2 did not show any significant relationship with the PP and a change in the PP would thus not be carried over to the consumer.

5.3 CONCLUSIONS

The results confirmed the existence of a long term relationship between the PP and RP in all four retail outlets (S1, S2, S3 and B) of the beef market. The relationship was analysed over the long- and short term and the price transmissions at S1, S2, S3 and B were found to be asymmetrical. The actual asymmetry, however, differed between the retailers, as S1 and B were found to be positively asymmetric while S2 and S3 were negatively asymmetric. The market margins for S1 and B in the long term thus increased over time (stretched), while the market margin for S2 and S3 deceased (squeezed).

The data analyses revealed that retail outlets S1 and B were found to be detrimental to the consumer with positive APT, whereas S2 and S3 reflected the opposite with negative APT price adjustment behaviour, which would benefit the consumer over time.

Despite all the statistical answers derived from the results and despite being able to reach a conclusion with regard to the main objective, it is important to understand the functioning of the entire beef value chain in order to gain a better understanding of the changes in the producer to retail (PR) price margin. Important aspects regarding the four retail outlets, observations made during data collection, the results of the analysis, reviewed literature, existing knowledge of the South African red meat industry and current economic circumstances, should also be taken into account. The following factors probably played a role in the nature of price transmission of non-symmetry persisting in Bloemfontein and the differences between retailers.

Input cost and *processing cost* have an influence on the PR price margin and changes such as the cost of labour, transport, electricity, maintenance and packaging are factors that affect the entire value chain. An increase at input costs will affect the PR price margin. However, in a perfect competitive market structure a price change should behave symmetrically in both directions. This means that the relationship of the price margin should remain the same. For example, if the PP decreases as a response to a decrease in labour tariffs, then the RP and the price margin are supposed to adapt accordingly. However, judging by the size of the parameters it is clear that symmetrical changes are not the rule in all four of these retailers.

Meat is a *perishable product* that should be handled according to very strict measures at check points throughout the cold chain, as its actual shelf life is not very long as fresh meat is kept cool and not frozen. As a result of lack in the upgrading of Eskom's *infrastructure* over the past years, it is now facing a crisis and with load scheduling enforced to manage electricity shortage. The ripple effect is enormous and has a huge impact on the economy. As an example of *government* *intervention,* NERSA, the National Energy Regulator of South Africa, has the power to increase electricity tariffs if funds are needed to maintain production and rectify the Eskom backlog.

Over and above load shedding and possible increases in electricity running cost, Eskom poses a direct threat to the cold chain of various products, in this case to the red meat cold chain. As unexpected electricity cuts may lead to major losses, retailers had to take contingency measures by purchasing big and expensive generators to minimise the risk of losses. Retailers did not budget for this huge capital outflow. The quickest way of re-obtaining the capital outflow of standby generators or to maintain profit without being influenced by higher electricity tariffs, would be to increase prices.

Aside from external factors there are also internal factors that can possibly contribute to fluctuations in price of RPs and between outlets. One should remember that retailers are from different supermarket chains and even retailers of the same chain in different geographical areas, differ in many ways. Observations revealed a difference in capacity and facilities among retailers. Although retailers only buy enough carcasses to supply their demand for the week and then buy in fresh meat the next week, they remain exposed to possible higher prices (price-takers). Those retailers that have greater storage facilities (fridges) have a competitive advantage as they are able to maintain a more stable price and/or to negotiate for a better price, as they have bargaining power allowing them to buy on a large scale when prices are low, and to negotiate prices. S2 is an example of a retailer that was able to maintain a more stable price.

Outlets that are able to manage a change in prices are able to minimise their *menu cost*. Menu cost is the actual cost of rebranding, changing the price on the system, removing packaging and rebranding the packets. Retailers that manage to maintain a more constant price do not have to re-brand each time a new batch of carcasses is purchased. The retailer that is unable to maintain stable prices is exposed to higher menu costs and an increase in price might account for the increase in cost.

Furthermore even if all the retailers had the same facilities and price management practices, there would still be a variation in prices. Differences do not exist only between retailers of different regions and retail groups, but in PP as well. The PP (carcass price) used for this study was a national average price which differed from region to region, influencing the price margin and the "beef cutting test", as suppliers differed from outlet to outlet. If regulating the PP was an option, the RP would still differ between retailers depending on how a specific retailer "balanced" a carcass in terms of the pricing of the individual cuts, given the varying demand factors within and between regions.

Demand factors bring us to the next influencing factor, namely the market structure with respect to competition and market demand. An analysis of the competition with regard to the number of outlets versus the geographical area of consumers they supply to, revealed relatively healthy competition. But competition melts down to a marketing strategy which is determined by demand and the type of consumer the retailer wishes to attract. Consumer preferences and habits differ, for example in their frequency of buying: some buy twice a week, some weekly and others monthly. Consequently retailers' marketing strategies must differ, some catering for weekly buyers by offering smaller parcels of meat and others for monthly buyers who wish to purchase a bulk pack. Most of the special retail offers on the bulkier packs, are designed to attract consumers. Retailers presenting special offers, make less profit per kilogram on bulk sales, but the total number of kilograms sold increase. The retailer who caters for the weekly buyer has to counter the specials of other retailers with a special in order to maintain his market share. So as not to confuse their regular buyers by fluctuation in the prices of luxury cuts such as fillet, these weekly specials mostly focus on special prices for the less expensive cuts and products, such as mince and stewing beef.

Despite the differences within the segments of price transmission analysed, the transmission nature for each retailer with respect to speed and magnitude, remained asymmetrical. APT is the change of the price relationship between PPs and RPs over time. In the case of Bloemfontein, the price transmission relationship of two of the retailers would have been beneficial for consumers if it had led to lower RPs (negative APT), as the marketing margin would have decreased over time. As for the other retailers, the price transmission relationship would have been detrimental for consumers when it led to higher RPs (positive APT) as the market margin would have increased over time.

After consideration of influencing factors, the bigger picture showed a trend in which transmission remained asymmetrical for Bloemfontein in the Langenhoven Park area. The APT within Bloemfontein's market could thus not be regarded only as a negative factor. However, for a market to exist sustainably in the long term, symmetrical price transmission should be the norm, but retailers with positive APT will price themselves out of the market and those with negative price transmission would become so insignificant, that they would have to close down. A positive contribution towards addressing producers' concerns is that price fixing among retailers is definitely not an option, for there are too many differences.

5.4 RECOMMENDATIONS

It is recommended that further research be conducted in a bid to broaden this study, and that the results and findings of past studies in this field as well as the following suggestions and recommendations, be borne in mind.

This study should be repeated in other market areas of Bloemfontein and in other provinces, in order to determine the level of price transmission in other areas of South Africa. It is, however, recommended that the research is not conducted based on averages, but rather on a more representative way as in this study (four RPs). The motivation for this is that all market participants are not the same. Their facilities, supply chain and reaction to market changes all differ. If and when an analysis is done using averages, the results can be skewed and represent only the larger participants in that market.

Based on the literature reviewed and the data properties employed, it is suggested that more research be done into the influence of data properties and their influence on the outcome of the study. Research can be devoted to a more in-depth analyses on the actual effect of the influencing factors of data properties and the significance thereof. The reason for this is that when price transmission is found to be unacceptable, the influencing factors cannot be used as the reason for the cause of the results, unless it has an actual significant.

Since the South African market is a deregulated free market, there is no way for retail outlet prices to be regulated and in no way can the prices obtained by producers be fixed or determined beforehand. It is suggested that producers remain informed by taking note of the current price transmission status. Furthermore, producers should rather focus on what they can change and on more productive and efficient ways of producing red meat. Producers can collaborate with producer organisations to educate the consumer to become more selective regarding their support of red meat outlets, applying indirect pressure on outlets to remain market related and competitive, hopefully maintaining the PR margin more symmetrically.

Lastly, as a general recommendation, it is important for the producer, retailer and consumer, as well as for researchers, to gain an understanding of the functioning of the entire red meat value chain in order to better understand the changes in the producer to retail price margin. It is also important to evaluate the results within reigning market conditions where prices are created and passed on. There are various factors which can play a role, such as seasonal changes, economic status, the type of retailer or group, the specific point in the value chain and the angle of interpretation.

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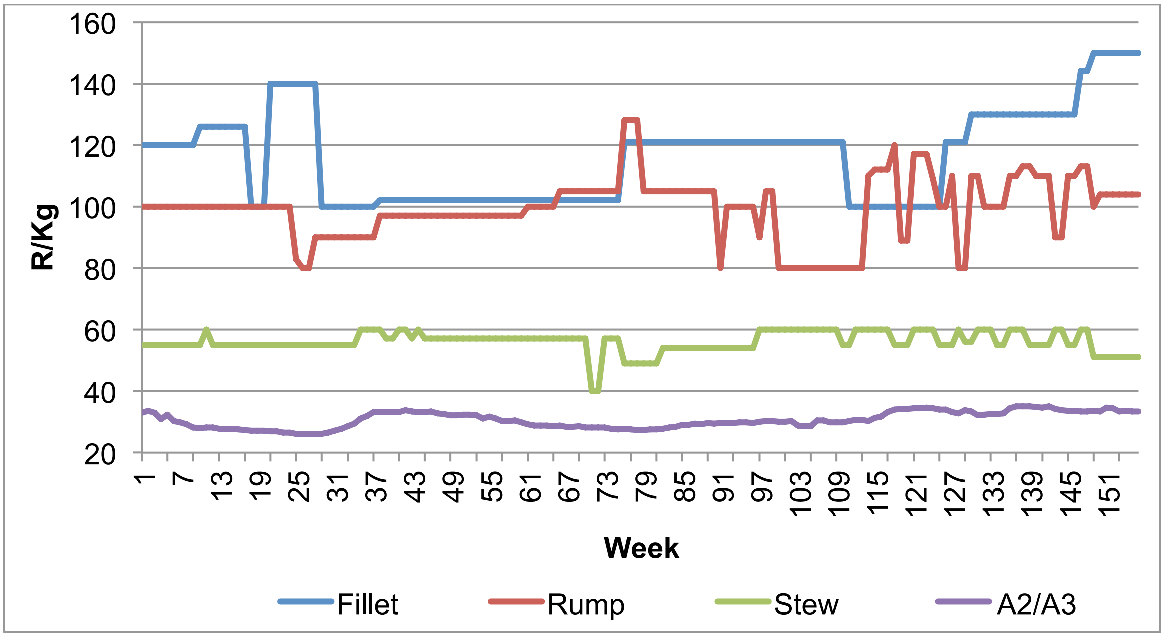

Figure A1: The price trend of supermarket 2 (S2).
Source: Own data collection and calculation

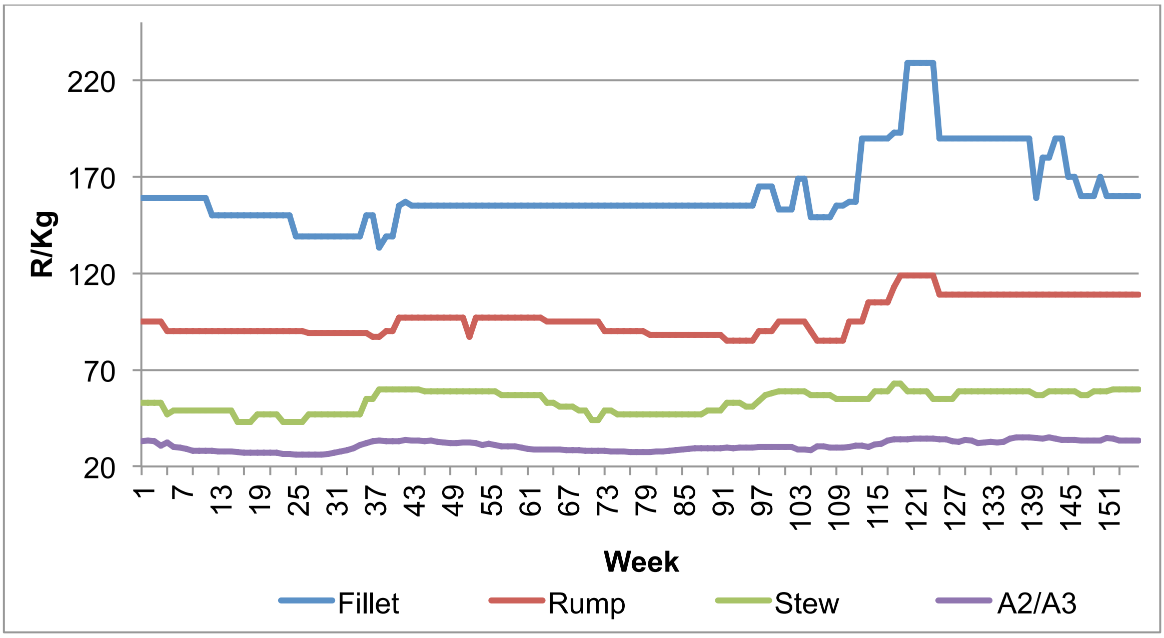

Figure A2: The price trend of supermarket 3 (S3).
Source: Own data collection and calculation.

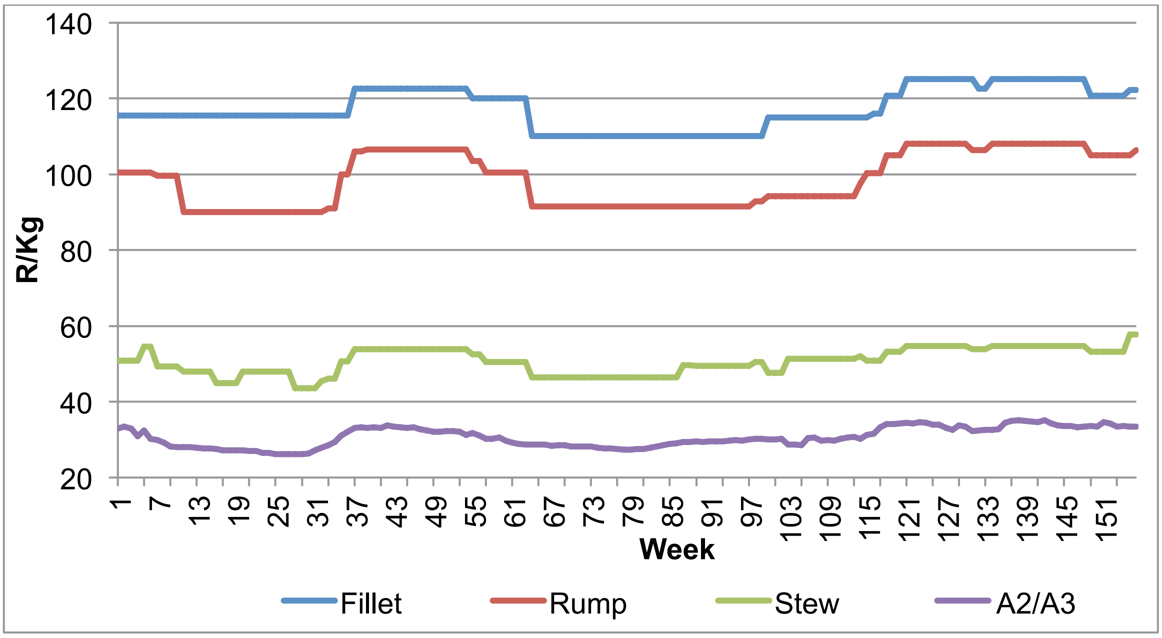

Figure A3: The price trend of butchery (B).
Source: Own data collection and calculation.

Table B1: Data of abattoir carcass and calculated retail carcass prices.

BEEF																	
2012	S1	S2	S3	S4	A2/A3	2013	S1	S2	S3	S4	A2/A3	2014	S1	S2	S3	S4	A2/A3
Week1	55.81	51.15	54.59	49.24	33.00	Week 53	56.10	49.05	56.49	52.22	32.10	Week 105	54.82	49.61	53.84	48.25	28.50
Week 2	55.81	51.15	54.59	49.24	33.50	Week 54	57.13	49.05	56.49	52.22	31.15	Week 106	54.82	49.61	52.99	48.25	30.40
Week 3	55.81	51.15	54.59	49.24	33.00	Week 55	57.13	49.05	56.49	50.93	31.78	Week 107	53.72	49.61	52.99	48.25	30.55
Week 4	55.46	51.14	54.59	49.24	30.90	Week 56	54.21	49.05	56.49	50.93	31.12	Week 108	53.72	49.61	52.99	48.25	29.75
Week 5	55.44	51.15	51.68	50.53	32.40	Week 57	54.21	49.05	55.80	49.71	30.25	Week 109	53.72	49.61	53.07	48.25	29.85
Week 6	55.44	51.17	52.37	50.53	30.20	Week 58	54.21	49.05	55.80	49.71	30.30	Week 110	54.06	47.89	53.07	48.25	29.75
Week 7	55.44	51.17	52.37	48.54	29.80	Week 59	54.38	49.05	55.80	49.71	30.55	Week 111	54.06	45.22	55.02	48.25	30.15
Week 8	55.44	51.17	52.37	48.54	29.20	Week 60	54.38	49.05	55.80	49.71	29.75	Week 112	54.06	46.94	55.02	48.25	30.60
Week 9	55.44	51.17	52.37	48.54	28.20	Week 61	54.38	49.57	55.80	49.71	29.20	Week 113	54.23	46.94	59.22	48.25	30.75
Week 10	55.44	51.93	52.37	48.54	28.00	Week 62	53.70	49.57	55.80	49.71	28.80	Week 114	55.04	52.04	60.92	49.10	30.15
Week 11	54.41	53.65	52.37	46.48	28.10	Week 63	53.70	49.57	55.80	49.71	28.75	Week 115	55.04	52.38	62.30	49.11	31.25
Week 12	54.41	51.93	51.22	46.48	28.10	Week 64	55.60	49.57	54.08	45.54	28.70	Week 116	55.72	52.38	62.30	49.24	31.65
Week 13	53.38	51.93	51.22	46.48	27.85	Week 65	55.60	49.57	54.08	45.54	28.65	Week 117	57.26	52.38	62.30	49.24	33.25
Week 14	53.00	51.93	51.22	46.48	27.75	Week 66	56.63	50.42	53.40	45.54	28.70	Week 118	57.26	52.02	65.42	51.44	34.05
Week 15	53.01	51.93	51.22	46.48	27.65	Week 67	56.63	50.42	53.40	45.54	28.40	Week 119	57.26	46.75	66.44	51.44	34.15
Week 16	51.73	51.93	49.16	45.43	27.45	Week 68	56.63	50.42	53.40	45.54	28.45	Week 120	57.26	46.75	69.64	51.44	34.20
Week 17	51.73	51.93	49.16	45.43	27.25	Week 69	56.17	50.42	52.71	45.54	28.50	Week 121	57.26	53.23	69.64	53.04	34.48
Week 18	51.73	48.62	49.16	45.43	27.20	Week 70	56.17	50.42	52.71	45.54	28.15	Week 122	57.26	53.23	69.64	53.04	34.34
Week 19	51.73	48.62	50.53	45.43	27.20	Week 71	56.17	44.57	50.99	45.54	28.25	Week 123	57.26	53.23	69.64	53.04	34.55
Week 20	51.73	48.62	50.53	46.48	27.10	Week 72	56.17	44.57	50.99	45.54	28.18	Week 124	57.09	51.87	68.27	53.04	34.45
Week 21	51.73	53.71	50.53	46.48	27.00	Week 73	54.11	50.42	51.86	45.54	28.20	Week 125	57.09	48.62	61.60	53.04	33.95
Week 22	51.73	53.71	50.53	46.48	27.00	Week 74	54.11	50.42	51.86	45.54	27.79	Week 126	57.09	51.30	61.60	53.04	33.95
Week 23	51.73	53.71	49.16	46.48	26.55	Week 75	54.11	50.42	51.17	45.54	27.64	Week 127	57.09	53.00	61.60	53.04	33.08
Week 24	51.73	53.71	49.16	46.48	26.50	Week 76	54.11	54.00	51.17	45.54	27.75	Week 128	57.09	49.61	62.98	53.04	32.66
Week 25	51.63	50.82	47.76	46.48	26.10	Week 77	54.11	54.00	51.17	45.54	27.50	Week 129	57.09	48.24	62.98	53.04	33.69
Week 26	51.63	50.31	47.76	46.48	26.15	Week 78	54.11	54.00	51.17	45.54	27.35	Week 130	57.26	54.48	62.98	53.04	33.42
Week 27	50.36	50.31	48.97	46.48	26.10	Week 79	52.72	50.08	51.17	45.54	27.30	Week 131	54.85	55.86	62.98	52.52	32.20
Week 28	50.36	52.01	48.97	44.95	26.15	Week 80	52.72	50.08	50.83	45.54	27.50	Week 132	54.85	54.16	62.98	52.20	32.34
Week 29	50.36	46.92	48.97	44.95	26.15	Week 81	52.72	50.08	50.83	45.54	27.60	Week 133	54.85	54.16	62.98	52.20	32.60
Week 30	50.36	46.92	48.97	44.95	26.40	Week 82	52.72	51.80	50.83	45.54	27.80	Week 134	56.57	52.44	62.98	53.04	32.54
Week 31	50.36	46.92	48.97	44.95	27.10	Week 83	52.72	51.80	50.83	45.54	28.15	Week 135	52.45	52.44	62.98	53.04	32.70
Week 32	50.36	46.92	48.97	45.60	27.85	Week 84	52.72	51.80	50.83	45.54	28.45	Week 136	55.88	55.86	62.98	53.04	34.50
Week 33	51.39	46.92	48.97	46.01	28.50	Week 85	53.75	51.80	50.83	45.54	28.90	Week 137	55.88	55.86	62.98	53.04	35.00
Week 34	51.39	46.92	48.97	46.01	29.40	Week 86	53.75	51.80	50.83	45.54	29.10	Week 138	55.88	56.37	62.98	53.04	35.10
Week 35	54.10	48.64	48.97	49.12	31.00	Week 87	55.85	51.80	50.83	46.60	29.35	Week 139	55.88	54.65	62.98	53.04	34.95
Week 36	54.10	48.64	53.11	49.12	32.00	Week 88	55.85	51.80	50.83	46.60	29.30	Week 140	55.88	54.14	58.35	53.04	34.78
Week 37	54.10	48.64	52.77	52.10	33.10	Week 89	55.81	51.80	51.52	46.57	29.55	Week 141	55.88	54.14	61.02	53.04	34.54
Week 38	55.08	50.09	52.37	52.10	33.25	Week 90	55.81	51.80	51.52	46.57	29.45	Week 142	55.88	54.14	61.71	53.04	35.05
Week 39	55.42	49.05	53.60	52.22	33.15	Week 91	54.92	47.55	51.52	46.57	29.55	Week 143	55.88	52.46	62.98	53.04	34.23
Week 40	55.42	49.05	53.60	52.22	33.20	Week 92	53.19	50.95	52.38	46.57	29.60	Week 144	55.88	52.46	62.98	53.04	33.77
Week 41	55.42	50.09	56.83	52.22	33.15	Week 93	53.19	50.95	52.38	46.57	29.55	Week 145	55.88	54.14	60.43	53.04	33.67
Week 42	56.44	50.09	57.08	52.22	33.75	Week 94	52.00	50.95	52.38	46.57	29.75	Week 146	55.88	54.14	60.43	53.04	33.65
Week 43	56.44	49.05	56.83	52.22	33.45	Week 95	52.00	50.95	51.70	46.57	29.80	Week 147	55.88	58.15	58.47	53.04	33.30
Week 44	56.44	50.09	56.83	52.22	33.25	Week 96	52.00	50.95	51.70	46.57	29.70	Week 148	55.88	58.15	58.47	53.04	33.46
Week 45	56.44	49.05	56.49	52.22	33.15	Week 97	52.17	51.31	54.85	46.57	30.00	Week 149	54.85	53.61	59.16	51.44	33.54
Week 46	56.44	49.05	56.49	52.22	33.30	Week 98	52.93	53.86	55.88	47.11	30.15	Week 150	55.88	54.29	60.43	51.44	33.47
Week 47	56.44	49.05	56.49	52.22	32.75	Week 99	52.93	53.86	56.22	47.11	30.20	Week 151	55.83	54.29	59.16	51.44	34.56
Week 48	56.44	49.05	56.49	52.22	32.45	Week 100	55.85	49.61	55.89	47.01	30.00	Week 152	55.81	54.29	59.51	51.44	34.32
Week 49	56.44	49.05	56.49	52.22	32.10	Week 101	54.82	49.61	55.89	47.01	30.05	Week 153	55.81	54.29	59.51	51.44	33.37
Week 50	55.76	49.05	56.49	52.22	32.15	Week 102	54.82	49.61	55.89	47.01	30.15	Week 154	55.81	54.29	59.51	51.44	33.53
Week 51	55.76	49.05	56.49	52.22	32.25	Week 103	54.82	49.61	57.93	48.25	28.75	Week 155	55.81	54.29	59.51	53.25	33.35
Week 52	56.10	49.05	54.78	52.22	32.25	Week 104	54.82	49.61	57.93	48.25	28.65	Week 156	55.81	54.29	59.51	53.48	33.40

Source: RMAA (2012) and own data collection and calculations.

Table B2: Comparing the four competitive procedures for supermarket 2 (S2).

	Engle-Granger (EG)	**Threshold autoregressive (TAR)**	**Momentum-threshold autoregressive (M-TAR)**	**Momentum-consistent threshold autoregressive (MC-TAR)**
ρ_1 [a]	-0.255658 (-3.876614)	-0.321672 (-2.507208)	-0.542400 (-5.182244)	-0.919323 (-7.461265)
ρ_2 [a]	N/A	-0.239544 (-3.358102)	-0.136786 (-1.889594)	-0.174910 (-2.867509
AIC	-5.646007	-5.635351	-5.709866	-5.809469
LAG	2	2	2	2
P1=p2= ϕ [b]	-	7.662210	14.01841	30.74292
$\rho_1=\rho_2$ [c]		0.360370 (0.5492)	11.91513 (0.0007)	30.83049 0.0000
γ	-	0	0	0.014444
Q(3) [d]	0.1960 (0.978)	0.0947 (0.992)	0.7488 (0.862)	1.7063 (0.636)
Q(6) [d]	2.2868 (0.898)	2.3081 (0.889)	5.33484.9425 (0.551)	5.5988 (0.470)
ARCH [f]	0.858869 (0.5902)	0.922328 (0.5269)	0.836342 (0.6130)	0.634890 (0.8092)

Table B3: Comparing the four competitive procedures for supermarket 3 (S3).

	Engle-Granger (EG)	**Threshold autoregressive (TAR)**	**Momentum-threshold autoregressive (M-TAR)**	**Momentum-consistent threshold autoregressive(MC-TAR)**
ρ_1 [a]	-0.148090 (-3.328344)	-0.125855 (-2.174752)	-0.444994 (-6.070304)	-0.575635 (-5.443553)
ρ_2 [a]	N/A	-0.174389 (-2.795345)	-0.030422 (-0.636397)	-0.085305 (-2.023001)
AIC	-6.223918	-6.213175	-6.364179	-6.256961
LAG	4	4	4	4
P1=p2= ϕ [b]	-	5.696445	14.01841	16.40787
$\rho_1=\rho_2$ [c]		0.363326 (0.5476)	11.91513 (0.0007)	19.13237 0.0000
γ	-	0	0	0.02101
Q(3) [d]	0.8137 (0.846)	0.8592 (0.835)	1.2777 (0.734)	3.5905 (0.309)
Q(6) [d]	1.6587 (0.948)	1.7250 (0.943)	2.3772 (0.869)	4.0538 (0.664)
ARCH [f]	0.891215 (0.5578)	0.841461 (0.6078)	0.908795 (0.5403)	1.134816 (0.3379)

Table B4: Comparing the four competitive procedures for butchery (B).

	Engle-Granger (EG)	**Threshold autoregressive (TAR)**	**Momentum-threshold autoregressive (M-TAR)**	**Momentum-consistent threshold autoregressive (MC-TAR)**
ρ_1 [a]	-0.213003 (-3.633607)	-0.243195 (-3.223379)	-0.469378 (-5.034737)	-0.084353 (-1.753810)
ρ_2 [a]	N/A	-0.177841 (-2.207359)	-0.121742 (-2.056523)	-0.999620 (-9.002545)
AIC	-7.171508	-7.161112	-7.222819	-7.487085
LAG	3	3	1	1
P1=p2= ϕ [b]	-	6.778361	14.25464	41.40322
$\rho_1=\rho_2$ [c]		0.406563 (0.5247)	10.43726 (0.0015)	59.26808 0.0000
γ	-	0	0	-0.01369
Q(3) [d]	0.2685 (0.966)	0.2762 (0.964)	1.3678 (0.713)	3.9409 (0.268)
Q(6) [d]	0.4391 (0.999)	0.4134 (0.999)	1.7766 (0.939)	4.5008 (0.609)
ARCH [f]	0.222760 (0.9971)	0.841461 (0.6078)	0.227438 (0.9968)	0.320621 (0.9846)