COMPARATIVE ANALYSIS OF THE RELATIONSHIP BETWEEN THE PRODUCER AND CONSUMER PRICE INDEX OF BEEF AND CHICKEN MEAT IN SOUTH AFRICA FROM 1991 TO 2018

by

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DECLARATION OF ORIGINALITY

I, **Thabang Rasehla Aphane**, declare that this mini-dissertation hereby submitted to the University of Limpopo in partial fulfilment of the degree, Master of Science in Agricultural Economics, was prepared by me as a product of my own research and has not been submitted by me or anyone else at this institution or any higher learning institution in South Africa. All sources in this study had been acknowledged using references.

10 October 2022

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Aphane TR **Date**

DEDICATION

I dedicate this paper to my lovely late mother Molelekeng Olga Aphane, as a token of appreciation as she is not here to witness all my achievements.

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"Do not be afraid, for I am with you. Do not be anxious, for I am your God. I will fortify you, yes, I will help you, I will really hold you on to you with my right hand of righteousness" Isaiah 41:10. With that well said, I would like to thank Jehovah for the protection, strength, and love He gave to me during my studies. His words in the books of Proverbs 18:10 and Proverbs 3:5,6 kept me going throughout my studies.

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ABSTRACT

Beef and chicken meat play a very crucial role in providing food to South African consumers. However, the rise of food prices in South Africa is viewed to curtail progress and drives consumers into debt and forgone opportunity to access food. Hence, it is of importance to understand the consumer price index (CPI) of meat and the disaggregate components of beef and chicken meat producer price indexes (PPI) as they give a clear insight into how individual commodities contribute to the general and food price inflation.

The study aimed to comparatively analyse the relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat in South Africa from 1991 to 2018. The objectives of the study were to compare the indexes' variability, correlation, and causality between the different PPI and CPI components. The objectives were analysed using the Coefficient of variation (CV), the Pearson coefficient correlation, the Granger causality test, and the Vector Error Correction model.

The CV findings highlight that PPI beef had high variability (65%) compared to CPI meat (56.7%), whereas PPI chicken meat had low variability (49.2%) compared to CPI meat(56.7%). There was evidence of a positive correlation (0.99) between PPI beef and CPI meat as well as PPI chicken meat and CPI meat using Pearson coefficient correlation. In addition, a long-run relationship was found between PPI beef and CPI meat as well as between PPI chicken meat and CPI meat by using the VEC model. Granger causality results indicated that there was a unidirectional relationship from PPI chicken meat to CPI meat, and independent relationships were found from PPI beef to CPI meat, CPI meat to PPI beef as well as CPI meat to PPI chicken meat.

Based on the findings, the study recommends that policymakers, through evaluation of monetary policies, should continue maintaining a specific inflation target range as that will assist in stabilising meat prices in the economy. At the same time, protect meat producers against input price inflation using instruments such as input subsidies, grants, and the provision of modern technologies.

Keywords: CPI meat, PPI beef, PPI chicken meat, Coefficient of variation, Pearson correlation, VECM, Granger causality.

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DAFF	Department of Agriculture, Forestry and Fisheries
SARB	South African Reserve Bank
GVP	Growth Value Product
CPI	Consumer Price Index
PPI	Producer Price Index
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
FAO	Food and Agriculture Organisation
STATS SA	Statistics South Africa
CV	Coefficient of Variation
ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
CAM	Correlation Analysis Matrix
CEECs	Central and Eastern European Countries
MTAR	Momentum Threshold Autoregressive
CCSA	Competition Commission South Africa
WTM	Wavelet Transfer Method
DCI	Department of Communication and Information
QYJ	Enterprise Confidence Interval
ARCH	Autoregressive Conditional Heteroscedasticity
SC	Schwarz Criterion
HQ	Hannan-Quinn Information Criterion
ECT	Error Correction Term

EViews	Econometric Views
NAMC	National Agricultural Marketing Council
BFAP	Bureau Food and Agriculture Policy
CPFI	Food Price Index
CPIX	Consumer Price Index excluding Mortgage Costs

CHAPTER 1

INTRODUCTION

1.1 Background

A spike in the prices of agricultural commodities occurred in 2004, and in 2008 a peak in the prices of agricultural commodities was reached in South Africa (Fowowe, 2016). Thus, South Africa experienced two periods of food price crises, namely 2002/3 and 2007/8, with the 2002/3 crises mainly being caused by a sharp depreciation of South Africa's exchange rate, while the 2007/8 crises were caused by the trend in the global commodity prices though dominated by South African food price inflation (Kirsten, 2012). Rising food prices in South Africa are viewed as an enemy of progress, driving many households into debt and making the poor poorer (Mkhawani et al., 2016). Food security status at a household and national level in South Africa was negatively impacted by the rise in global food prices that occurred between 2006 and 2008 (Van Wyk and Dlamini, 2018). Furthermore, Van Wyk and Dlamini (2018) stated that the lack of access to finance and increased food prices make strengthening food security very difficult among households in South Africa. That can be observed between January 2014 and 2015, when the cost of food rose from R485 to R514, representing an increase of 45.3% to 48.0% for approximately 30% population of the poor in South Africa (Faber and Drimie, 2016).

Meat consumption has been fluctuating in South Africa due to the changes in demand for animal-derived protein sources essential for the human diet (Muchenje et al., 2018). That can be observed between 1965/66 and 1999/00, where the aggregate per capita consumption of red meat (beef, lamb, veal) decreased from 34.42kg to 19.2kg while white meat (poultry, fish, pig) increased from 2.98kg to 22.91kg in South Africa (Poonyth et al., 2001). In addition, South Africans consumed more meat in 2009 than in 1994. The increase in meat consumption was mainly driven by increased consumption of chicken and pig meat, while beef, mutton, and goat meat remained stable (Ronquest-Ross et al., 2015). In 2014, the per capita consumption of meat in South Africa was 38.5kg, 18.5kg, 4.5kg, and 3.6kg for chicken meat, beef, pork, and mutton, respectively (DAFF, 2019). Meat consumptive traits in South Africa are determined by price inflation, household income, and food security status, as low-income consumers purchase meat based on cost-effective trends (Erasmus and Hoffman, 2017). To further contextualise the study, a more detailed description of the South African meat industry is given in Chapter 2 of this present study.

The producer and consumer price indexes are valuable resources used for commercial and academic applications (Norman, 2008). For commercial purposes, the producer price index is widely used as a leading indicator for the consumer price index. Therefore, links between producer and consumer price indexes are crucial as they are the lead indicators of inflation (Caporale et al., 2002). While for academic purposes, the producer and consumer price indexes are used to statistically test their differences in composition and economic approach (Losada et al., 2018). The producer price index of beef measures the change in prices received by beef producers for beef and beef products they produce, while the producer price index of chicken meat measures the change in prices received by chicken meat producers for chicken and chicken products they produce (Anggraeni and Irawan, 2018). The consumer price index of meat measures the average prices for meat purchased by consumers (Ackay, 2011; Stewart, 2008).

Producer price index (PPI) and consumer price index (CPI) are available for each country in aggregated commodity groups (fruits, vegetables, meat) and single-item indexes such as wheat, maise, beef, and chicken (FAO, 2021). In South Africa, CPI is available in aggregated commodity groups under the food category (meat, fish, milk) with meat consisting of beef, pork, lamb, chicken, dried, salted, and smoked meat, other preserved or processed meat, and PPI is available in aggregated commodity groups as well as single-item indexes under food category (Stats SA, 2016). Meat weighed 5.7% in the CPI food group, while beef and chicken meat weighed 1.41% and 2.41%, respectively, in the meat weights by 2018/2019 (Stats SA, 2019). Therefore, this study focused on the CPI food group, specifically on the aggregated commodity group meat and PPI for the single-item indexes (beef and chicken meat) but not the general PPI and CPI. The CPI meat was used based on (Stats SA, 2019; FAO, 2021). Furthermore, this focus was to understand how individual commodities make contributions to inflation and economic policymaking in the meat industry in South Africa.

The main reason for a comparative analysis study was based on the statement made by Dorward (2013) that food prices should be compared with other price series to identify the price changes in the economy. Thus, the food price series (PPI chicken meat and CPI meat) were compared with other food price series (PPI beef and CPI meat) to identify the price changes. At the same time, to identify if a relationship exists between each price series (PPI chicken meat and CPI meat) and (PPI beef and CPI meat) while comparing the price changes of the two series.

Statistics South Africa uses retail and wholesale meat prices to construct the producer and consumer price indexes to provide upstream price movements (Competition Commission South Africa, 2020). Furthermore, Competition Commission South Africa (2020) stated that movements in upstream meat prices impact the ultimate meat prices paid by consumers and meat prices received by producers. Despite normal seasonal trends, beef and chicken meat prices in South Africa have continued to rise since 2004 (Makube, 2014). In addition, Mukube (2014) reported that in November 2006, meat prices doubled from less than R500 per tonne in 2005 to over R1430 per tonne in South Africa. Van Rensburg et al. (2020) indicated that meat fluctuates more than production costs in the short-run as monthly changes in meat prices are driven by dynamic adjustments, so prices take time to adjust. The meat price fluctuations were observed between 2015 and 2016 when the annual retail prices for chicken meat decreased by 9.27%, and annual retail prices for beef increased by 3.36% in South Africa (NAMC, 2016).

Changes in food price levels and volatility directly affect food availability as they impact food producers’ price expectations in Africa (Wossen et al., 2018). According to Ackello-Ogutu (2011), between 1974 and 2005, actual food prices declined by about 75%, as a result of an increase in the food price index, actual food prices increased to 9% in 2006 and 23% in 2007, then more than 50% between May 2007 and 2008 in Africa. Louw (2017) stated that the rapid rise in commodity and food prices in Africa was driven by the 2005-2008 commodity super-cycle, which subsequently led to a wave of commodity price and food inflation disclosures. Thus, the rise in food prices in sub-Saharan Africa between 2007 and 2008 has drawn increasing attention to the causes and consequences of food price volatility in the international food market and developing world countries (Minot, 2013). The producer prices of staple food in African countries with predominantly unimodal rainfall patterns have increased by 100%, and changes in the consumer prices in the major centres may be slightly less than transport costs resulting in shocks in production and consumption (Poulton et al., 2006; Gilbert et al., 2017).

Prices for agricultural commodities play an essential role in consumers' access to food in developing countries as they directly impact their actual income, particularly amongst the poor, who spend a large share of their income on food (Jha and Sinha, 2013). As such, an increase in demand for livestock products in middle-class developing countries is caused by an upsurge in population growth (Oluwaseun et al., 2020). However, population growth is not the only factor that causes an increase in the demand for livestock in developing countries. There are some factors (not inclusive) that also contribute to the increased demand. Some of these factors noted by Reeves et al. (2017) include stagnated wages, climate change, and urbanisation. Hence, the rising food prices have become a fundamental concern in many countries worldwide, causing food deprivation due to increased demand for livestock (Reeves et al., 2017). In addition, political connotations are slowly becoming the foremost concerns of worldwide stakeholders due to food prices that trigger government policies and programs (Ismaya and Anugrah, 2018). Furthermore, some scholars shared similar ideas that food prices are generally affected by demand factors as well as supply factors leading to a mismatch in supply-demand, resulting in domestic agricultural production failing to hold up with the rising demand (Malhotra and Maloo, 2017; Kareem, 2021; Oluwaseun et al., 2020). Moreover, commodity prices will, over time, rise and fall as a response to the pushes and pull of demand and supply (Basu, 2011).

An increase in food price inflation has caused an unanticipated increase in the general inflation rate since 1972 in developed countries such as the United States of America, imposing social costs due to higher food prices (Lamm, 1979). As a result, the central banks of inflation-targeting countries use inflation forecasts, explanations, or escape clauses in the event of non-achievement of the target, as well as the measurement of inflationary expectations as three measures to support the implementation of the monetary policies (Rossouw, 2007). In addition, the effect of inflation on economic growth and development has generated much controversy worldwide (Adusei, 2013). Similarly, in South Africa, the monetary policy of the South African Reserve Bank

(SARB) is to ensure price stability through an inflation-targeting strategy to reduce the effect of inflation on the economy (Mpofu, 2011).

1.2 Problem statement

Chicken meat and beef industries play a crucial role in providing food to consumers and contributing to producers' income (Idowu et al., 2021; Meissner et al., 2013). Even though chicken meat and beef industries as well as price stability are considered essential components in the South African economy, Tomlinson (1935) stated that there has been an increasing trend in meat prices in South Africa since 1930. These increasing trends have exposed both the consumers and producers of meat to price fluctuations that contributed to price instability in the South African economy (Motengwe, 2013). The consumer and producer price indexes are closely watched indicators to stabilise prices and monitor the purchasing power of money in the economy (Stats SA, 2008). Therefore, Ngidi (2015) cautioned that if the consumer and producer price indexes are not well understood and closely watched, it can lead to higher food price inflation. Moreover, this can result in consumers paying high prices and producers receiving low prices for output while experiencing high production costs.

In South Africa, previous research (Galodikwe, 2014; Meyer and Habanabakize, 2018) focused on analysing the overall relationship between producer and consumer price indexes. However, less attention has been received on the linkages, causation, interactions, and variation of individual commodities' producer and consumer price indexes. Therefore, there is a need for more research in analysing the relationship between the consumer price index of meat and producer price indexes of individual commodities (beef and chicken meat) between 1991 to 2018 in South Africa, which will be covered in this present study. This research will further analyse what happens when producer prices of beef and chicken meat in relation to consumer prices of meat vary over the years of analysis. In addition, if these meat price fluctuations are because of linkages and causation between the producer prices of beef, chicken meat, and consumer prices of meat. Thus, this study will contribute to this knowledge gap by adding to available knowledge and literature on consumer and producer prices in South Africa.

1.3 Rationale of the study

A sudden spike in prices of agricultural commodities makes forecasting and analysing prices of commodities a relevant, meaningful, and practical topic in recent times (Drachal, 2019). This study was motivated by the numerous studies (Mongale and Eita, 2014; Abidoye and Labuschagne, 2013; Schaling et al., 2014; Arezki et al., 2012) conducted on analysing of the prices of commodities and most importantly was influenced by the South African price hike in the red meat experienced in 2017 (DAFF, 2017) as well as an increase in the prices of chicken meat in 2013 (Hyland, 2015). Therefore, an increase in meat prices in South Africa has emerged as a significant source of underlying inflationary pressures in the economy due to its persistence beyond other commodities (Tshiakambila and Chisasa, 2017).

According to Drachal (2019), in some developing countries rising food prices can lead to political and economic instability, making analysing commodity prices a critical subject. For example, in Zambia, in Kitwe town, food riots were triggered due to a rapid increase in retail prices of maize, which pushed the government to respond to the global food crisis between 2007 and 2008 (Chapoto, 2014). Anarde and Hoofman (2015) indicated that agricultural prices are exposed to high price variation, and price variability is caused by weather conditions, biofuel growth, linkages between energy markets and agriculture, and varying economic conditions. Furthermore, the high price variability among agricultural commodities increases inflation (Ukoha, 2007). Hence, Arnade and Hoffman (2015) further stated that price variability is often detrimental and as a result, it can expose risk for producers and provide mixed signals to buyers of agricultural commodities. Therefore, it is of importance to track and understand how prices vary in the market to avoid political and economic instability.

Anggraeni and Irawan (2018) indicated that PPI affects CPI, and CPI affects PPI as such, a shock to the producer price index will affect the consumer price index and vice versa. Furthermore, PPI serves as a leading indicator of CPI. In support of the economic justification made by Anggraeni and Irawan (2018), this study tries to elaborate on the relationship between PPI beef, PPI chicken meat to CPI meat by indicating how beef and chicken meat producers face input inflation resulting in increased cost of production that is passed to meat consumers thereby, causing adjustment to income and cost of living. Also, from the analysis, information will be provided to market participants (consumers and producers) on how these two largest consumed meat types (beef and chicken meat) contribute to the meat price inflation by finding out if there is existence relationship between beef, chicken meat, and meat through the usage of indexes. Specifically, this study compared the price variability, relationship as well as correlation of producer and consumer price index of beef, chicken meat and meat.

1.4 Scope of the study

1.4.1 Aim of the study

The aim of the study was to comparatively analyse the relationship between the producer and consumer price index of beef and chicken meat in South Africa from 1991 to 2018.

1.4.2 Objectives of the study

I. To compare the producer and consumer price index variability of beef to meat as well as producer and consumer price index variability of chicken meat to meat from 1991 to 2018.

II. To determine the correlation between the producer price index of beef, chicken meat and the consumer price index of meat from 1991 to 2018.

III. To determine the causality relationship between the producer price index of beef, producer price index of chicken meat and the consumer price index of meat from 1991 to 2018.

IV. To determine the short and long-run relationship between producer price index of beef, producer price index of chicken meat and consumer price index of meat from 1991 to 2018

1.4.3 Hypotheses

I. There is no variability between the producer and consumer price index of beef to meat as well as the producer price index of chicken meat to meat from 1991 to 2018.

II. There is no correlation between the producer price index of beef, chicken meat and the consumer price index of meat from 1991 to 2018.

III. There is no causal relationship between the producer price index of beef, producer price index of chicken meat and the consumer price index of meat from 1991 to 2018.

IV. There is no short and long-run relationship between producer price index of beef, producer price index of chicken meat and consumer price index of meat from 1991 to 2018.

1.5 Organisational structure of the study

To achieve the goal of this research, this mini-dissertation was divided into 6 chapters.

Chapter 1 outlines the introduction, which has put the study in context by highlighting the background of the study, problem statement, rationale of the study, the scope of the study, which highlights the aim of the study, objectives, and hypotheses of the study.

Chapter 2 outlines the South African meat industry and food price inflation by providing an overview of the industry, highlighting the production, consumption, CPI, and PPI of meat as well as price variability.

Chapter 3 outlines the review of literature on concepts of consumer and producer price indexes that help to understand the economic and theoretical concepts of the study by firstly defining the key concepts of the study, economic models used and reviewing literature in South Africa and abroad.

Chapter 4 gives detail of the research methods used in the study by firstly providing a brief detail about the study area. Data collection and analytical techniques applied to achieve the objectives of the study.

Chapter 5 presents and discusses the results found, comparing the results found on consumer price index of meat and producer price index of beef and chicken meat, results on price variability, correlation, and causality.

Chapter 6 finally provides the summary, conclusion, and recommendation, as well as the limitations of the study.

CHAPTER 2

SOUTH AFRICAN MEAT INDUSTRY: AN OVERVIEW

2.1 Introduction

This chapter details the meat industry as it is important to understand how it functions. This chapter starts by familiarising the reader with the background of the meat industry in South Africa by focusing on production and consumption in the meat industry. Food price inflation in South Africa, with a focus on CPI and PPI meat, as well as price variability, is outlined in this chapter.

2.2 Background of the South African meat industry

The South African meat industry is divided into white meat (poultry and fish), which includes (chicken, turkey, hakes, sardines, squid, tilapia, trout, and toothfish) while red meat includes game meat, lamb, mutton, ostrich, preserved meat, sausages (DAFF, 2017). Within the livestock sector, the meat industry represents one of the essential agricultural sub-sectors in South Africa (Russo and von Blottnitz, 2017). For this reason, livestock products, notably meat, contributed to the increased gross value of animal products by 185% between 1995/2000 and 2006/2010 (Meissner et al., 2013). Moreover, meat exports specifically beef, chicken, mutton, and pork, contributed to the increase in gross value of animal products during 1995/2000 with an export value (R million) of 66.3, 93.2, 0.80, and 93.9, respectively (DAFF, 2006). The meat industry is vertically integrated up to the wholesale level (Russo and von Blottnitz, 2017). This integration is mainly fuelled by the existence of more feedlots and abattoirs owned by meat processors, moving further down to selling directly to the consumers in the value chain and influencing prices (Russo and von Blottnitz, 2017). To fully understand the South African meat industry, this study will consider the consumers' and producers' side.

2.2.1 South African meat consumer

From consumers' viewpoint, meat has been an essential component of the human diet for decades as it provides a rich source of essential nutrients required for development, growth, and maintenance (Muchenje and Njisane, 2015). Bureau for Food and Agricultural Policy (2013) indicated that during the period 2010 to 2012, there was an increase in the consumption of chicken meat, beef, and pork with an increase of 80.3%, 11.5%, and 53.7%, respectively, while sheep meat consumption declined by 14.8% as shown in Figure 1.

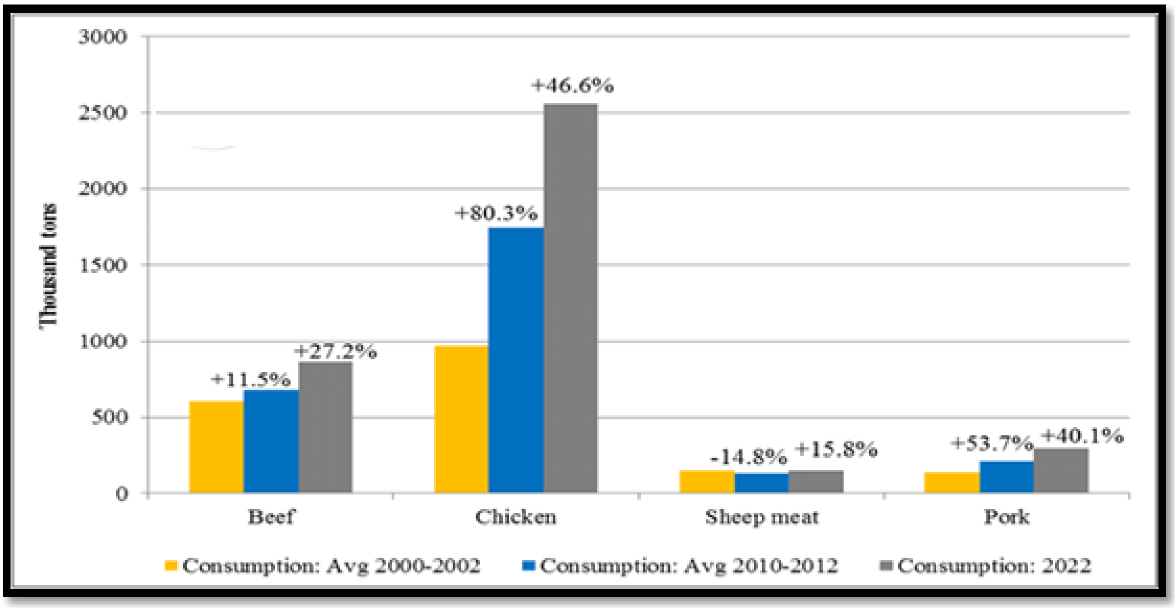


Figure 1: South African meat consumption

Source: BFAP (2013)

The fluctuations suggest that factors such as price, availability, income per capita, employment, and expenditure patterns were the major contributors to South African meat consumption. In addition, non-economic factors such as values, personality, lifestyle, racial factors, heritage and culture, as well as geographical location, play a greater role in determining meat consumption in South Africa (Erasmus and Hoffman, 2017; Taljaard et al., 2010).

The meat expenditure patterns of South African consumers influence the change in meat consumption patterns, resulting in a change in the average prices of meat in the economy (Stats SA, 2008). During 2005/2006, the middle class dominated the expenditure on chicken meat and the wealthy dominated spending on sheep meat and pork. Moreover, the middle-class and wealthy groups had large expenditures on beef and pork, while the low-income consumers preferred chicken meat followed by beef (Stats SA, 2008). According to Esterhuizen (2015), South African consumers spent approximately R165 billion on meat purchases by 2015 due to increased meat consumption. Madiba (2006) put forward the idea that when it comes to geographical location as a non-economic factor, there is no difference between consumption patterns in rural and urban areas concerning the consumption of meat (mutton and chicken) however, there is a difference when it comes to consumption of beef.

2.2.2 South African meat producer

From the producers' viewpoint, events of human population growth and an increase in the level of income results in an increase in the demand for meat in South Africa, making meat production an important aspect (Webb, 2013). Consequently, meat production in South Africa is increasing (Jankielsohn, 2015). Especially between 2012 and 2014, where there was an increase in the production of chicken meat, followed by beef, pork, and lamb, with the production growth expectation of 38%, 28%, 33%, and 17% by 2024, respectively, as shown in Figure 2.

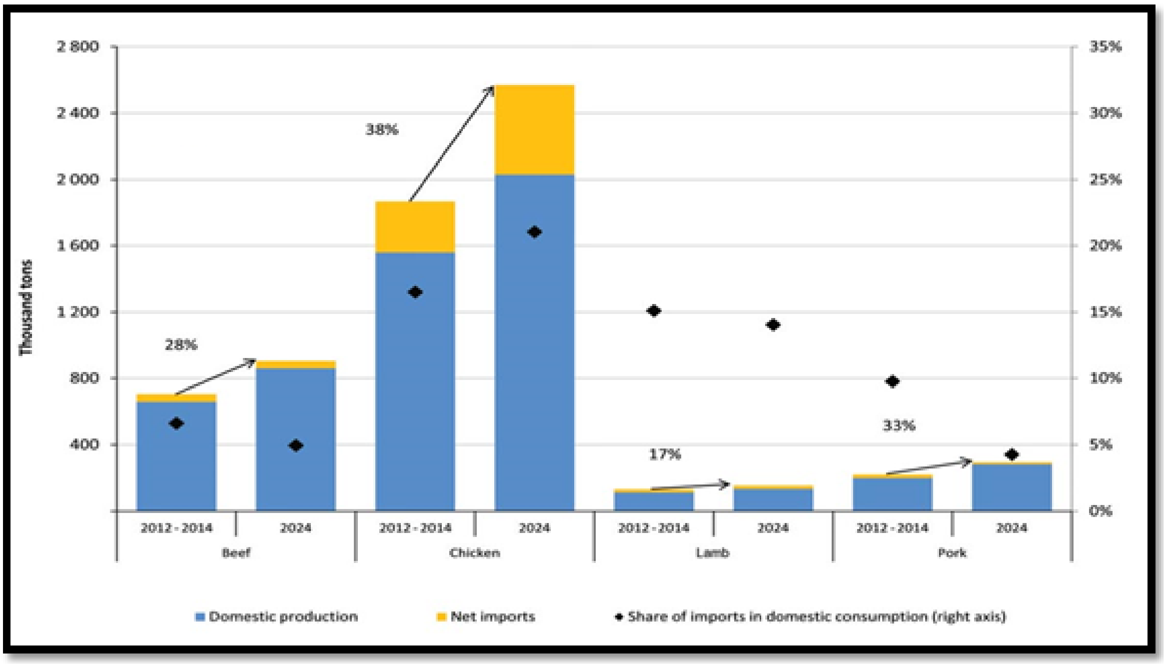


Figure 2: South African meat production

Source: BFAP (2013)

Various factors contribute to the changes in meat production in South Africa, such as drought, increased feed cost, poor market price, stock theft, market competition, and poor veterinary services (Nkonki-Mandleni et al., 2019; Assan, 2014). A detailed discussion on the production and consumption of the selected commodities (beef and chicken meat) will be provided in sub-heading 2.2.3.

2.2.3 Production and consumption of beef and chicken meat in South Africa

Beef cattle producers in South Africa include commercial beef cattle farmers, emerging black cattle farmers, and communal beef cattle farmers (Nevondo et al., 2019). While Nkukwana (2018) indicated that the chicken meat industry in South Africa includes fully integrated large chicken meat commercial producers, a high volume of small-scale chicken meat producers, and contract growers or individual producers. The main beef production systems common in South Africa are intensive, semi-extensive, and extensive, with the primary production involving grazing of beef cattle on pastures and extensive chicken production being practised with complete feeds and water (Oluwaseun et al., 2020; Nkukwana, 2018). According to DAFF (2019), total beef cattle production in South Africa in 2018 was 1 026.8 tonnes compared to 2019, which was 1 018.9 tonnes. South Africa's total chicken meat production in 2018 was 1.41 million tonnes, a 5% increase from 2017 (Berkhout, 2019).

Between 1970 and 2002, chicken meat consumption tripled from 7.7 kg per capita per year in 1970 to 21.2 kg per capita per year in 2002, at the cost of beef consumption (Delport et al., 2017). Delport et al. (2017) further stated that similar changes were observed between 2002 and 2005, where chicken meat consumption increased further to 39.6 kg per capita per year while beef decreased by 29%. The study conducted by Marandure et al. (2016) found that nearly 45% of consumers in the Eastern Cape Province indicated that they prefer beef meat (44%) over chicken meat (27%) however, consumers consume more chicken meat (51%) than beef meat (26%). The study also found that price was the most considered factor consumers consider when buying beef meat (Marandure et al., 2016).

Figures 3 and 4 highlight the production and consumption of beef cattle and chicken meat in South Africa. Consumption and production of beef cattle and chicken meat followed the same trend, increasing over the years of analysis.

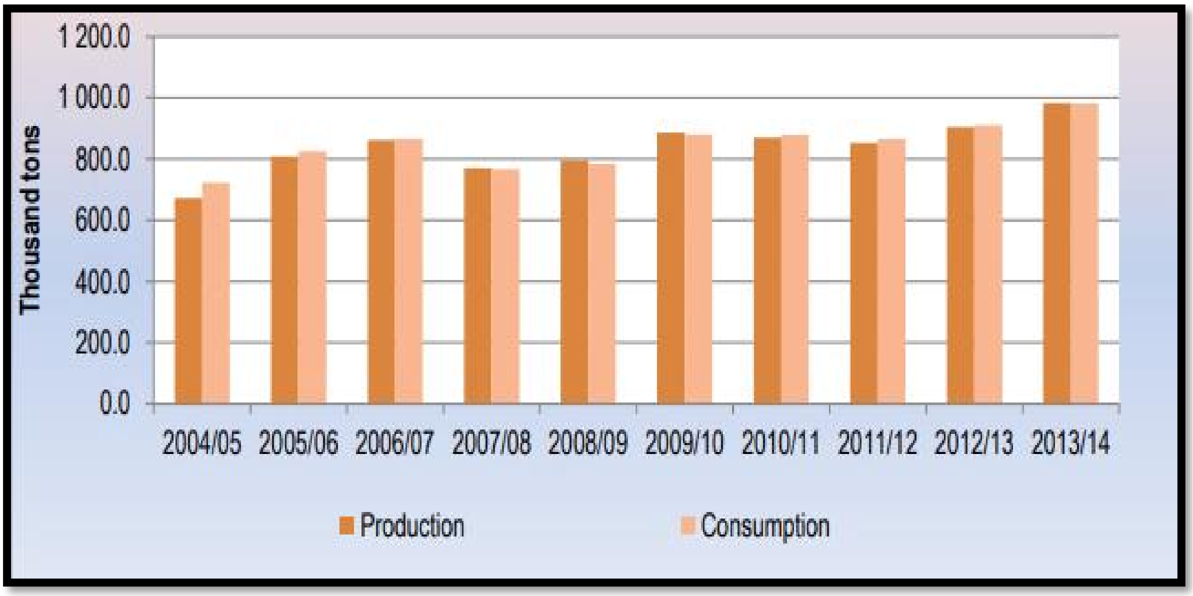


Figure 3: Production and consumption of beef cattle in South Africa

Source: DAFF (2015)

Beef cattle production and consumption in South Africa have increased from 2004 to 2014. However, there was a decline in beef cattle production during the period 2007/08, 2008/09, and 2011/12. According to DAFF (2015), the decrease in both consumption and production from 2007/08 to 2008/09 was due to the global economic meltdown, which led to a decreased disposable income for many consumers. While the 2011/12 decline might be due to factors such as global warming, acidification, land use, and non-renewable energy use, as mentioned by Nguyen et al. (2010) that might have contributed to the changes in production and consumption of beef cattle in South Africa.

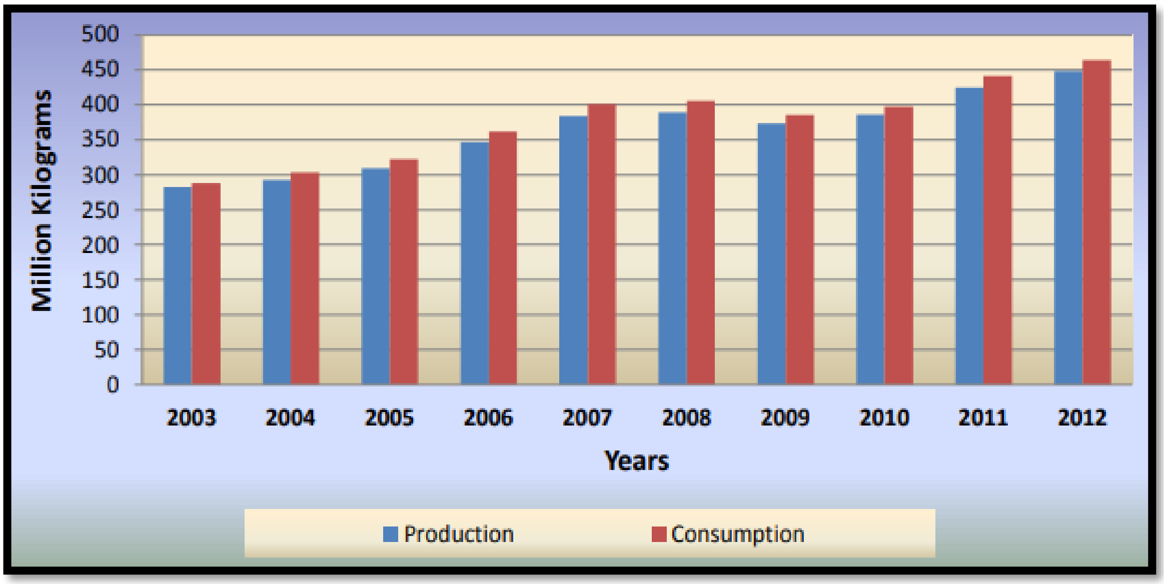


Figure 4: Production and consumption of chicken meat in South Africa

Source: DAFF (2013)

Even though there was more consumption of chicken meat than it was produced in South Africa, an increasing trend is observed. Along the years of analysis from 2003 to 2012, it is observed that in South Africa, chicken meat was consumed more than it was produced. However, in 2009 and 2010, there was a decline in the consumption and production of chicken meat. According to DAFF (2013), the slight decrease was caused by slow economic growth resulting from food price inflation. Since 2011, there has been an increase in chicken meat production, with consumption increasing more significant than production.

Comparatively, chicken meat production and consumption are more significant than beef cattle production and consumption in South Africa, as observed in Figures 3 and 4. This might be because chicken meat is a close substitute for beef. Thus, if there is more consumption of chicken meat due to its affordability, beef consumption becomes less and vice versa. Like any other industry, beef cattle production is exposed to significant limitations such as drought, diseases, parasites, poor access to markets, lack of finance, feed shortages, water scarcity, and production infrastructure (Mapiye et al., 2018). Similarly, chicken meat production faces challenges, including diseases and theft. (Idowu et al., 2018). In addition, other production constraints faced by beef cattle and chicken meat producers include the availability of energy sources, tenure systems, technical support, farmer support system, and credit facilities (Nompozolo and Igodan, 2002; Mtileni et al., 2012; Musemwa et al., 2008). These limitations result in changes in the production, consumption, and average prices of beef as well as chicken meat.

2.3 Food price inflation and trends

Inflationary pressures in South Africa normally generate due to increased food prices and price transmission processes that severely impact the economy (Tshiakambila and Chisasa, 2017; Louw et al., 2017; Rangasamy, 2011). That can be observed between 2005 and 2006, when food inflation rose to 9.3% from 2.1%, and it was a contributing factor when the overall inflation rose from 3.9% to 4.9% (Iddrisu and Alagidede, 2020). However, Iddrisu and Alagidede (2020) pointed out that overall inflation dropped from 13.9% to 6.9%, with food inflation dropping from 19.2% to 9.9% between August 2008 and June 2009. As such, CPI can be a better indicator of inflation as it considers foreign as well as food inflation (Amusa et al., 2013).

2.3.1 CPI and PPI in South Africa

Vink et al. (2004) indicated that Statistics South Africa compiles and disseminates different CPI aggregates, including the CPI, the Core Index, the consumer price index excluding mortgage costs (CPIX), and the Food Price Index (CPIF). Therefore, using aggregated weights of the sub-components (specific food groups) outperforms using the aggregate CPI to forecast (Aron and Muellbauer, 2010). This means using CPI meat to predict future meat inflation is better than using the general CPI. However, this study does not use CPI meat to predict future prices of meat and meat components but to check whether CPI meat can be used to predict future values of PPI (beef and chicken meat) and vice versa, which will be observed in Chapter 5 of this study. Furthermore, Figure 5 demonstrates how different CPI for food groups contribute to inflation, focusing on CPI meat. Moreover, understanding how commodity prices are in relation to inflation will assist this study in concluding and making a recommendation, as the CPI and PPI are clear indicators of inflation. As indicated in the background of this study, Statistics South Africa uses average retail and wholesale prices to construct PPI and CPI. Figures 6 and 7 indicate the annual average prices and trends for chicken meat and beef in South Africa.

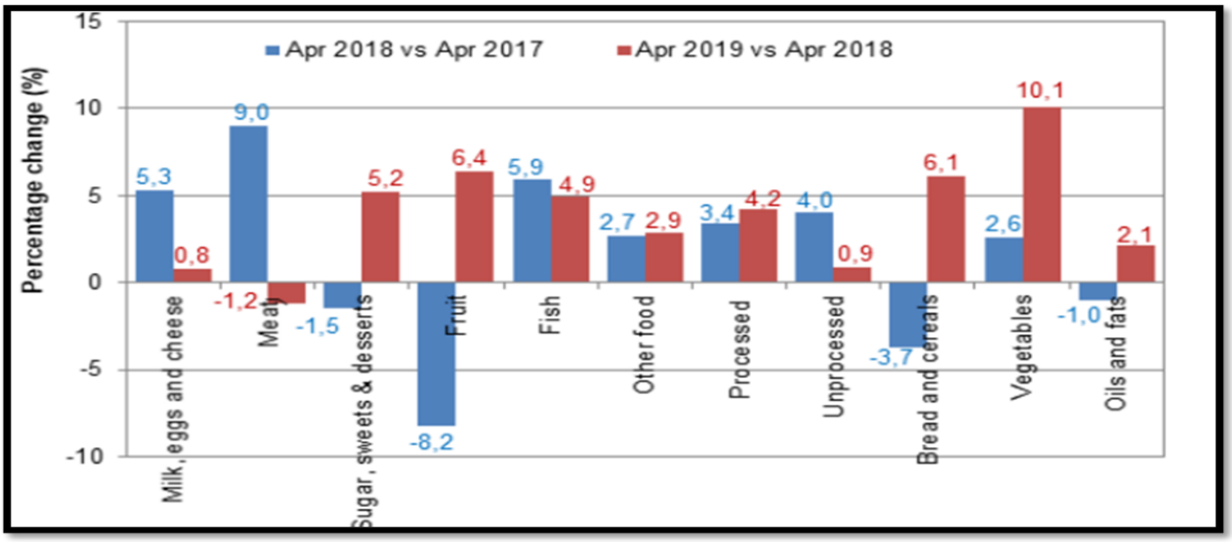


Figure 5: CPI for food groups in South Africa

Source: Stats SA (2018)

A 9.0% change in CPI meat was observed, which was greater than CPI for other food groups in April 2018 vs April 2017, as shown in Figure 5. This indicates that different types of meat contributed more to the CPI meat, implying an increase in inflation in the food prices was caused by CPI meat. However, the opposite is observed in April 2019 vs April 2018, where CPI meat decreased to -1.2%, indicating that consumption and production of meat types contributed less to the change in CPI meat. According to Moobi (2019), given the composition of food CPI, meat comprises the largest component, followed by bread and cereals, for South African consumers.

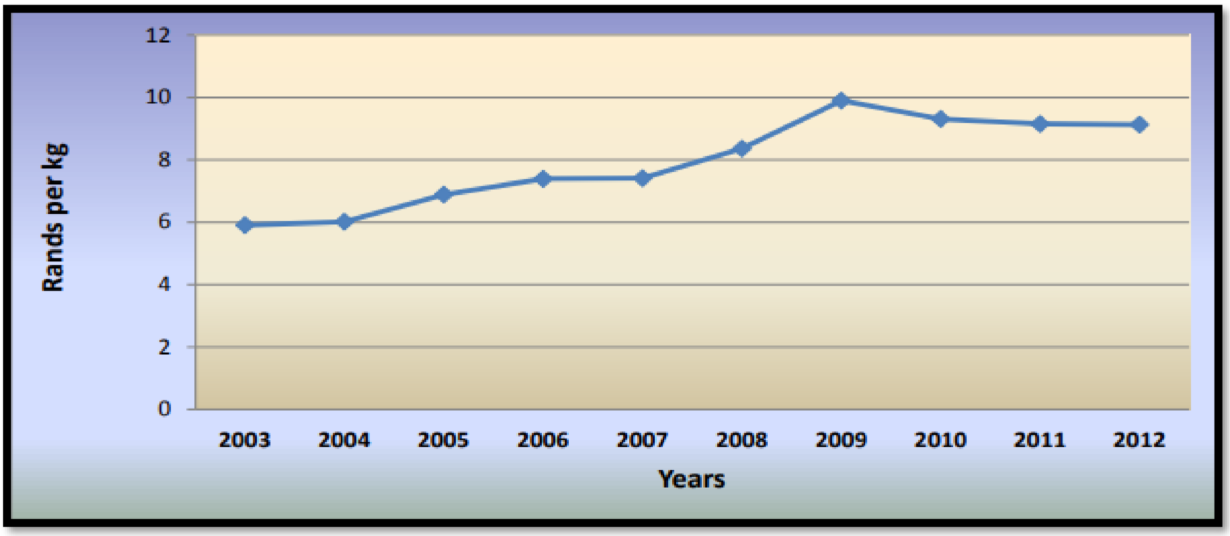


Figure 6: Annual average prices of chicken meat in South Africa

Source: SAPA (2013)

The annual average prices of chicken meat demonstrate an increasing trend, as shown in Figure 6. By 2009 the average producer price was R10/kg, with a decline observed from 2010 from R10/kg to approximately R8/kg in 2012. The decline in 2010 was due to an oversupply of chicken meat responding to the FIFA world cup held in South Africa and the low economic growth (DAFF, 2013). Therefore, this suggests that there has been an inflation in the prices of chicken meat, affecting both producers and consumers of chicken meat, with inflation experienced in the average prices of chicken meat.

Figure 7: Annual average prices of beef in South Africa

Source: DAFF (2015)

An increasing trend is observed in annual producer prices of beef in South Africa. There was an increase of R28/kg in 2013/14 compared to R15/kg in 2004/05. According to the Department of Agriculture, Fisheries, and Forestry (2015), the increase was mainly due to increased consumption caused by the rising living standards of many consumers and low domestic production in other years. Therefore, producers of beef experienced high price inflation in the prices of beef, resulting in consumers of meat purchasing meat at high prices.

2.3.2 Price variability in South Africa

Over the last decade, South Africa experienced two events during which food prices increased significantly due to a high degree of price variability (Uchezuba et al., 2010). Therefore, quantifying the price variability of agricultural products becomes an essential component during food price inflation as it can give an insight into profit variability (Jordaan et al., 2007). There are various economic as well as non-economic factors that contribute to the price variability of meat and meat products in South Africa. These factors include exchange rates, changes in trading volumes, trading shocks, a larger volume of price risk, profit margins, demand, and supply, poor planning of income and budgets, poor roads, lack of transportation to the markets from the farms, and high transaction costs (Paul and Motlaleng, 2007; Monk et al., 2010; Motengwe, 2013; Geyser and Cutts, 2007; Jordaan et al., 2007; Khapayi and Celliers, 2016). Moreover, economic factors can lead to highly variable meat prices, which complicates production decisions at every level of the value chain causing a negative trade balance (Spies, 2011). When prices are stable, their influence on demand is limited, while when prices are increasing, their influence on demand is more noticeable in South Africa (Masike and Vermeulen, 2020).

According to Dubihlela and Sekhampu (2014), the changes in food prices largely depend on the consumers' demand patterns and possible substitution effects in consumption. Furthermore, the demand for chicken is sometimes irresponsive to its price variation in poor households, which could be because beef, a substitute for chicken, is more expensive (Dubihlela and Sekhampu, 2014). Variations in meat prices (i.e., beef, chicken meat, mutton, and pork) are likely to cause prices of all other meats to vary over time (Badurally-Adam, 1998). Price variations have more minor effects on chicken meat imports than on imports of beef, pork, and other meat types (Taha and Hahn, 2015). Although price variability has a small impact on meat in South Africa, dumping large quantities of chicken meat by the suppliers (Brazil, USA, and EU) has threatened the cost of production and jobs in South Africa (Jörnling, 2017). Thus, dumping may also be a contributing factor to price variability.

2.4 Chapter summary

This chapter outlined the South African meat industry, an essential component of the human populace as it has provided essential nutrients and significant sources of dietary (proteins, fats, vitamins) for decades. Consumption and production of beef and chicken meat demonstrated a similar increasing trend. The CPI meat increased more in 2018 than other food groups, while average beef and chicken meat prices indicated an increasing trend with a slight decrease over the years. Various factors such as exchange rate, demand, supply, income, poor market price, and high transaction cost, amongst others, may contribute to price variability.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

This chapter outlines the review of previous studies conducted to understand the theory behind the consumer and producer price indexes. This chapter further outlines the previous studies conducted in South Africa and across the world on the consumer and producer price indexes.

3.2 Definition of key concepts

3.2.1 Consumer price index

The consumer price index measures average prices for a basket of goods commonly purchased by consumers that may be fixed or changed at specified intervals, such as yearly (Ackay, 2011; Saravanan, 2015; Stewart, 2008). Therefore, the consumer price index of meat measures average prices for meat purchased by consumers to determine whether meat prices are higher, lower, or stable over time. Furthermore, meat is edible tissues from an animal and used for food, which is widened to include musculature, organs such as livers, kidneys, brain, and other edible tissues (Boler and Woerner, 2017; Lawrie and Ledward, 2006).

3.2.2 Producer price index

The producer price index measures average changes in the prices that domestic producers receive for their output, and these price changes are measured at the producer level (Anggraeni and Irawan, 2018; Doherty, 2012). Therefore, the producer price index of beef measures the average changes in the prices beef producers receive for beef and beef products they produce. Whereas the producer price index of chicken meat measures the average changes in the prices chicken meat producers receive for chicken meat and chicken meat products they produce.

3.3 Review of previous studies

3.3.1 Previous studies on CPI and PPI in South Africa

In South Africa, there are limited studies on individual commodities' consumer and producer price indexes.

Mpofu (2011) conducted a study on money supply, interest rate, exchange rate, and oil price influence on inflation in South Africa. The study used a multiple regression approach to determine the relationship between the CPI and the macroeconomic variables (i.e., money supply, prime overdraft interest rate, exchange rate, and oil). Therefore, the analysis found that the four macroeconomic variables explain approximately 97% of the CPI movement, and the study used CPI to target inflation. While the discussion of the results makes some good economic points, the study conducted by Mpofu (2011) determined the relationship between the four macroeconomic variables excluding PPI, which makes the study different from the present study as it will include PPI and CPI as variables. Thus, the gap in the literature is filled.

Meyer and Habanabakize (2018) used the Autoregressive Distributed Lag (ARDL) econometric model, Error Correction Model, and Granger causality approach to establish the long and short-run relationships between the CPI, the PPI, and purchasing manager’s index. The study found that the variables cointegrated in the long-run, and causal relationships were found, with results indicating that CPI causes purchasing manager’s index and PPI causes purchasing manager’s index. Meyer and Habanabakize (2018) make interesting points by pointing out that the results found are not precisely what was expected or found during the study’s literature review process. Also, this shows that each country is unique and has a different set of relationships between economic variables.

Amusa et al. (2013) conducted a study on the long-run impact of inflation in South Africa using a Trivariate Structural Vector Autoregression model. The estimated results from the study indicated that the hypothesis of long-run super neutrality (LRSN) could not be rejected, implying that monetary policy in South Africa cannot be used to solve the significant and persistent unemployment problem in South Africa. However, the study conducted by Amusa et al. (2013) is different from the context of this present study. The important focus was on the long-run impact of inflation on the interest rate as in South Africa, CPI is used to measure inflation, and the analytical technique applied that is employing a Trivariate Structural Vector Autoregression model. Ocran (2010) conducted a study on exchange rate pass-through to domestic prices: the case of South Africa using impulse response and variance decomposition within the framework of an unrestricted VAR and differs from this present study. However, the interest was in the results (Ocran, 2010) found, which suggested that after a 1% shock to the nominal effective exchange rate, the level of CPI increases by 0.125%, while PPI pass-through elasticity is 20% after 24 months. This shows that favourable shocks to PPI inflation can have a considerable moderating effect on CPI inflation.

Galodikwe (2014) conducted a study on investigating the relationship between CPI and PPI in South Africa using correlation analysis, regression analysis, and scatter plots. Therefore, it was found that there is a linear relationship between PPI and CPI, and by using the correlation coefficient, a strong positive linear relationship between PPI and CPI was found. Galodikwe (2014) employed similar methods that this present study will use (correlation analysis and scatter plot). However, the study did not indicate the variation of CPI and PPI along the years of analysis, as well as the short-run and long-run impact between the variables. Therefore, this present study will fill this literature gap.

Alemu (2012) conducted a study on causality links between the CPI and PPI inflation in South Africa and tested causality within the Error Correction framework, including the Granger causality test. Based on empirical results, it was found that a dynamic relationship existed between the PPI and CPI and was characterised by unidirectional causality running from producer to consumer price inflation. Using asymmetric response, the study found that consumer price inflation reacts differently to positive and negative trends in producer price inflation. Alemu (2012) further found that consumer price rises faster than it falls in the economy.

3.3.2 Previous studies on CPI and PPI across the world

In Slovakia, Chi-wei et al. (2016) conducted a study on is there any relationship between the producer price index and the consumer price index? A rolling bootstrap approaches. The study used a time-varying rolling window approach to revisit the dynamic causal relationship between the PPI and the CPI. Therefore, it was found that there was an existence of bidirectional causality between the two series in several sub-samples. On the contrary, Ghazali et al. (2008) found unidirectional causality running from PPI to CPI using Engle-Granger and Toda-Yamamoto causality tests in the study conducted on whether producer prices cause consumer prices? Some empirical evidence. Chi-wei et al. (2016) further found that PPI has a more contributing role to the CPI in which the central bank can minimise inflation by taking specific predictive measures to keep the input prices under control.

In Turkey, Ulke and Ergun (2014) conducted a study on the relationship between consumer and producer price indices. The study used Johansen cointegration to test the presence of a long-run relationship between CPI and PPI, the VEC model to test the direction of movement for the series, and the Granger causality to test the causality relationship between CPI and PPI. The application of the model in the study is similar to that of this present study. However, this present study used the VEC model to test the relationship between PPI beef, PPI chicken meat, and CPI meat. In contrast, Ulke and Ergun (2014) used the VEC model to test for the direction of the movement of the series making the study different in terms of the application of this model. Furthermore, Ulke and Ergun (2014) found that there were different possible relationships between the CPI and PPI, which were: there is no relationship, there is a bidirectional relationship, and there is a unidirectional relationship from the CPI to the PPI.

In addition to studies conducted in Turkey, Berat and Keskin (2021) conducted a study to determine the relationship between the PPI, the CPI, and fiscal policy: 1996-2020 period. The study used Engle-Granger cointegration and Granger causation methods. Consequently, Berat and Keskin (2021) found a mutual and long-term relationship between the CPI and the PPI. On the contrary, in Nigeria, Oyekele and Ojediran (2018) conducted a study on exploring the relationship between CPI and PPI using Johansen and Engle-Granger approaches as well as the VAR technique. It was found that there was no long-run relationship and no causality relationship between CPI and PPI. Even though that was the case, it was further found that there is cointegration between PPI and CPI by using the Ordinary Least Square (OLS) in the Engle-Granger 2-step (Oyekele and Ojediran, 2018).

In Iran, Hakimipoor et al. (2016) conducted a study to investigate on causality relationship between CPI and PPI. It was found that the PPI is the cause of the CPI. The existence of the PPI can offer a valuable prediction about CPI and can help to recognise price pressure shocks which can result in a better prediction of the rate of inflation. Furthermore, Hakimipoor et al. (2016) applied the Granger causality test using Vector Auto-Regressive (VAR) models to answer the important question can the PPI forecast the CPI? In Mexico, Tiwari et al. (2014) conducted a study on the causality between consumer and producer prices. It was found that causality running from PPI to CPI exemplifies the cost-push nature of inflation, and the opposite is the indicator of demand-pull inflation. Tiwari et al. (2014) used the Wavelet Transform Method (WTM) approach.

In Indonesia, Anggraeni and Irawan (2018) conducted a study on causality analysis of the PPI and the CPI. The study used Granger causality based on the VAR model. The results indicated that there was a unidirectional relationship between the PPI inflation and the CPI inflation generally, a bidirectional relationship from the PPI inflation to the CPI inflation for the foodstuffs group, unidirectional from the CPI inflation to the PPI inflation for the clothing group, and no causality between the PPI inflation and the CPI inflation for processed food, beverage, cigarette, and tobacco group. Furthermore, the study focused on the CPI and PPI of groups rather than the general CPI and PPI in the Indonesian economy. In contrast, this present study focused on the CPI of groups and single-item index PPI. In Brazil, Ivo da Rocha Lima Filho (2019) conducted a study on does PPI lead to CPI? using traditional VAR and BVAR (Bayesian Vector Autoregressive) models. It was found that the PPI of final goods can be a good leading indicator for the domestic CPI.

In France, Germany, Sweden, Finland, and the Netherlands, the study conducted by Ackay (2011) on the causal relationship between the PPI and the CPI: empirical evidence from selected European countries used the VAR model to test the direction of causality. The results indicated a unidirectional causality between PPI and CPI, running from PPI to CPI in Finland and France and bidirectional causality between two indices in Germany. In the case of the Netherlands and Sweden, no significant causality was detected. Interestingly, the study indicated mixed results on the direction of causality between CPI and PPI for the selected countries. This may be due to attributed model misspecification errors, omission of essential variables, and content of the producer and consumer price indexes. In addition, Ackay (2011) found that PPI and CPI series are not cointegrated in France, Sweden, Finland, and the Netherlands, meaning that CPI cannot be predicted by looking at PPI. On the contrary, Topuz et al. (2018) found that there was bidirectional causality between the PPI and CPI in Turkey and UK.

Topuz et al. (2018) used VAR, impulse response, variance decomposition, and Granger causality tests to analyse the relationship between the producer and consumer price indexes: A two-country study (i.e., Turkey and UK). The study further found that inflation at the producer level will get reflected in the consumer prices after a lag period. Similarly, Martinez et al. (2013) found that the PPI leads the CPI in the study conducted in exploring the relationship between the CPI and the PPI: the Colombian case. On the contrary, Kar (2021) found that change in consumer prices leads the producer prices based on the demand-based pricing method, while a change in the producer prices leads the consumer prices based on the cost method. Topuz et al. (2018) conducted a comparative study however, it was in two different countries, and the study found that the results were similar despite the differences in the economic structure as well as the different economic conditions in both countries.

Özpolat (2020) analysed the relationship between the CPI and the PPI using a panel data approach, including unit root, cointegration, and causality in Central and Eastern European Countries (CEECs). Empirical findings of the study revealed that there was a long-run and bidirectional causality of the PPI and CPI in CEECs. In addition, the study by Özpolat (2020) emphasised that there is a long-term relationship between price indexes and observing any of these indexes can be used to achieve price stability targeting. Woo et al. (2019) conducted a study on the dynamic relationship between the CPI and PPI in the UK, France, and Germany from 1997 to 2013. The study used the Momentum-threshold Autoregressive (MTAR) cointegration model for empirical analysis. It was found that the CPI and the PPI are cointegrated with bidirectional long-run Granger causality between CPI and PPI. This shows that there is an existence of both the demand-pull and the cost-push nature of inflation in the economy of the UK, France, and Germany.

Li and Xin (2019) and Husaini et al. (2019) conducted research that included the CPI and the PPI as variables, with different titles, approaches, and methodologies. However, their findings are similar if not related to the context of this study. For instance, Li and Xin (2019) conducted a study on the analysis of the factors affecting China's CPI using a multiple linear regression model. Furthermore, Li and Xin (2019) found that the multiple linear regression model has a high degree of predicting CPI, which can provide a reference value for the country to formulate macro policies related to the CPI. Husaini et al. (2019) conducted a study on energy subsidy and oil price fluctuation, and price behaviour in Malaysia. The study found that PPI was more sensitive to changes in the oil price than the CPI as such, the PPI was found to be affected more while the CPI was less affected.

3.4 Chapter summary

Previous studies conducted on CPI and PPI in South Africa and across the world were able to indicate that there is a relationship between CPI and PPI, while other scholars indicated that it is possible for a relationship not to exist between CPI and PPI. Various scholars considered different methods and analytical techniques, data from different periods, and economic theories regarding CPI and PPI. Notable from the reviewed literature is that comparative analysis was done on a country basis rather than on a commodity basis. Therefore, this study fills the information gap on CPI and PPI of individual commodities.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

Chapter 4 of this study outlines the methodologies used to address the objectives of the study. It outlines a brief background of the study area and a map to demarcate the location of the study area. This chapter further outlines the data collection methods and statistical package used as well as the sample size of the study. In addition, analytical techniques and frameworks used to address the objectives of the study are discussed. To comparatively analyse the relationship between the variables, the analytical techniques were applied separately between PPI beef and CPI meat as well as between PPI chicken meat and CPI meat. After that, the comparison was made.

4.2 Study Area

This study was conducted in South Africa, the Southernmost country in Africa, with a population of approximately 60 million (Stats SA, 2020). The surface area of South Africa covers 1 219 602 km square (GCIS, 2018). The country borders Namibia, Botswana, Zimbabwe, Mozambique, and Eswatini, while the mountainous kingdom of Lesotho in the Southeast is enclosed by South African territory, as shown in Figure 8. South Africa is a relatively dry country, with an average annual rainfall of about 464mm (Michel et al., 2003). According to the Department of Communication and Information South Africa (2018), agriculture, forestry, and fisheries sectors are crucial to South Africa's socio-economic development, and the primary agricultural sector contributes about 3% to the country's GDP, representing about 7% of formal employment.

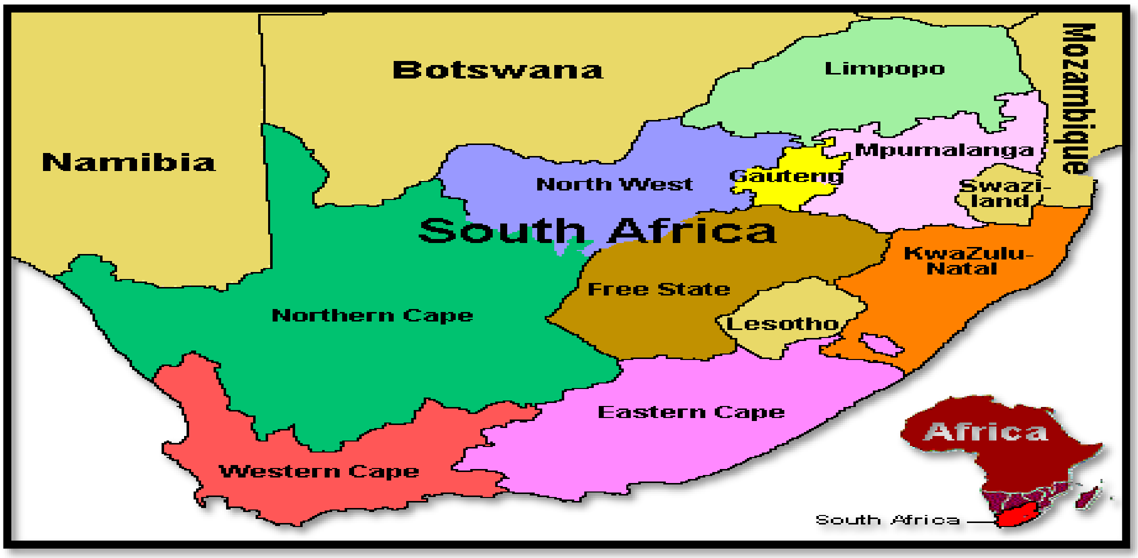


Figure 8: South African map

Source: Google map (2021)

4.3 Data collection

This study used publicly available secondary annual time series data accessed from the Food and Agriculture Organisation (FAO), Statistics South Africa (STATS SA), covering a period of 28 years from 1991 to 2018. The consumer price index and producer price index were the selected variables, while beef, chicken meat and meat were the selected commodities used in this study. The base year for PPI beef, PPI chicken meat and CPI meat was 2016=100. This study used the Econometric Views software package (EViews) 12 and Microsoft Excel to analyse the data.

4.4 Analytical techniques

The study used the Coefficient of variation method to compare the producer and consumer price index variability of beef and chicken meat from 1991 to 2018. After identifying the variation between the variables, then Pearson correlation coefficient analysis was used to determine the correlation between the producer and consumer price index of beef, chicken meat, and meat. However, the Pearson correlation coefficient analysis determines the magnitude of association and the direction of the relationship rather than the causation relationship. Therefore, the Granger causality test was used to determine if there is a causation relationship between the producer price index of beef, chicken meat and the consumer price index of meat.

Furthermore, the study adopted the steps developed by Li et al. (2019) to determine the short and long-run relationship between consumer price index and producer price index of beef, chicken meat, and meat from 1991 to 2018 using the Vector Error Correction model. The study comparatively analysed the relationship between the producer price index of beef, chicken meat, and consumer price index meat by identifying the unit roots. The study used Augmented Dickey-Fuller (1979) method to test whether the unit roots are stationary or non-stationary. If the unit root sequence on the variables is not stationary, the study considered using the first differences of the variables. Moreover, if the unit root sequence on the variables is stationary, the study determined the VAR model's maximum lag order (p).

The VAR model was constructed based on the maximum lag order (p) results, and the VAR stability verification was determined through the AR root charts. Therefore, the long-run cointegration relationship between the variables was analysed. Having found that the variables cointegrated in the long-run, the impulse response analysis was carried out to describe the impact of a standard deviation on the random error term on the current and future values of the variables. However, the impulse response function of the VAR model applied in this study was to support the VEC results in determining the short and long-run relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat, as explained further in the sub-heading 4.4.5. Thus, the short and long-term relationships were explored through the VEC model. The summary of the analysis of the objectives is presented in Table 1.

Table 1: Analysis of study objectives and method used to address each objective.

Objectives of the study	**Method of analysis**	**Reason for the model**
To compare the producer and consumer price index variability of beef to meat as well as producer and consumer price index variability of chicken meat to meat from 1991 to 2018.	Coefficient of Variation	To check the variation of the variables along the years of analysis.

To determine the correlation between the producer price index of beef, chicken meat and the consumer price index of meat from 1991 to 2018.	Pearson correlation coefficient analysis	To determine the direction and the strength of the relationship between the variables.
To determine the causality relationship between the producer price index of beef, producer price index of chicken meat and the consumer price index of meat from 1991 to 2018.	Granger causality test	To check if PPI beef can be used to forecast CPI meat and to check if PPI chicken meat can be used to forecast CPI meat
To determine the short and long-run relationship between producer price index of beef, producer price index of chicken meat and consumer price index of meat from 1991 to 2018	VAR (Impulse response), Johansen cointegration test and VEC model	To explore the short and long-run relationship between PPI beef and CPI meat and to explore the short and long-run relationship between PPI chicken meat and CPI meat

Source: Author's compilation (2021)

4.4.1 Framework steps of determining the relationship between CPI and PPI based on the Vector Error Correction model

The conceptual framework of analysis of the relationship is presented in Figure 9, while the steps of analysis were adopted from Li et al. (2019) as follows:

1. Akaike Information Criterion was used to determine the maximum lag order (p) of the Vector Autoregression (VAR) model.
2. Constructed the VAR(p) model with the maximum lag order (p), and an AR root chart was used to verify the stability of the VAR model.
3. Johansen cointegration was used to check if there is a long-run cointegration relationship between PPI beef and CPI meat, as well as the PPI chicken meat and CPI meat.
4. The impulse response functions of the VAR model were analysed based on the cointegration test.

5. Short and long-run relationship between PPI beef and CPI meat, as well as PPI chicken meat and CPI meat, were explored through the VEC model.

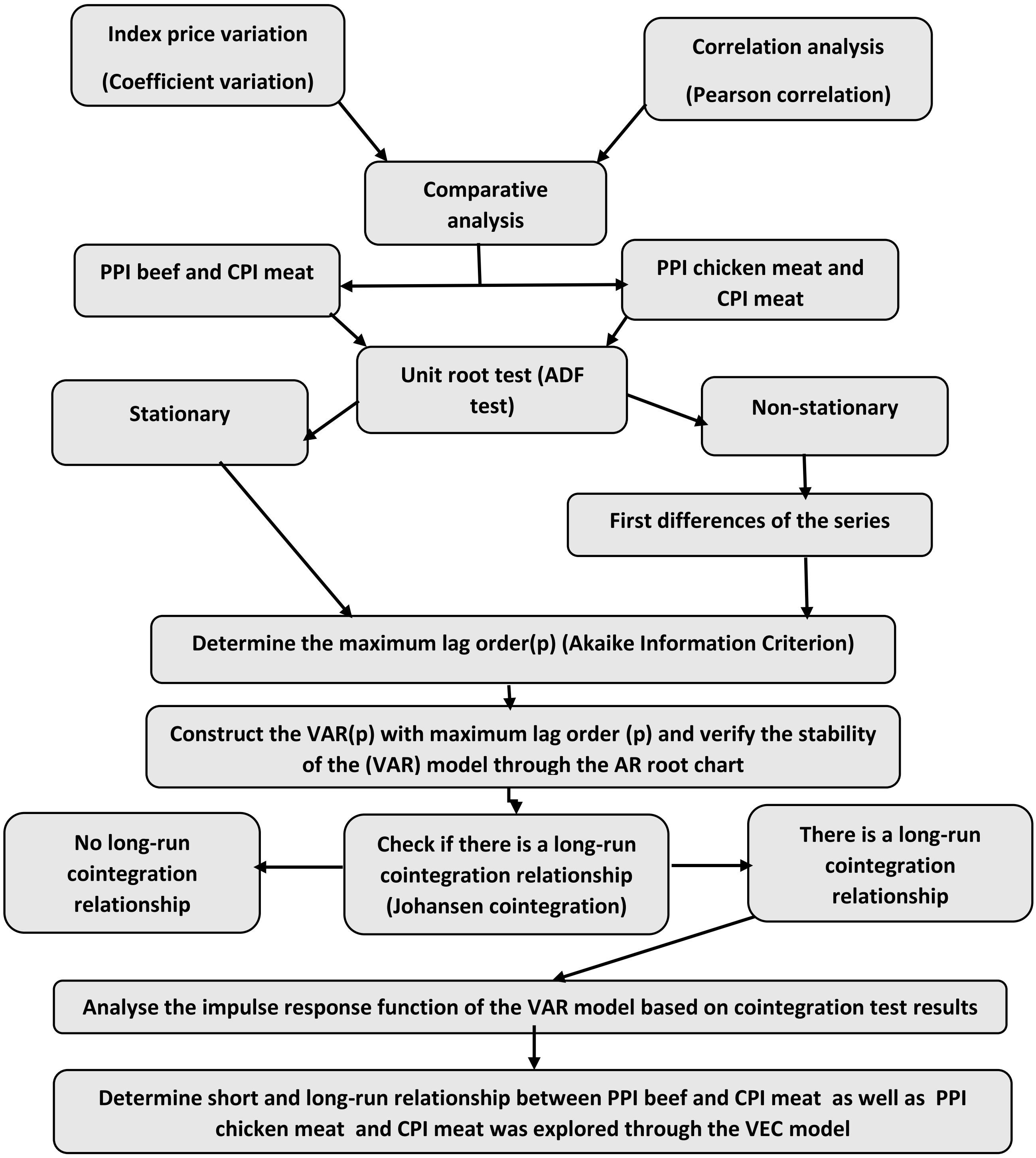


Figure 9: Conceptual framework of the analysis

Source: Author's compilation (2021)

4.4.2 Coefficient of variation

According to He and Oyadiji (2001), the Coefficient of variation may be used to compare the discreteness of experimental data under different conditions and parameters. He and Oyadiji (2001) have shown that the Coefficient of variation method can give results identical to that of the Taylor expansion method. The Coefficient of variation is widely used to measure the relative variation of a random variable to its mean or to assess and compare the performance of analytical techniques (Adelin and Zhang, 2010).

The general formula is as follows:

$$CV=\frac{S}{\bar{x}} \qquad (1)$$

Which may be written as:

$$S=\sqrt{\frac{\sum(X_i-\bar{x})^2}{N}} \qquad (2)$$

$$CV=\frac{\sqrt{\frac{\sum(X_i-\bar{x})^2}{N}}}{\bar{x}} \qquad (3)$$

Where:

CV = Coefficient of variation

S = Standard deviation for a sample

$\bar{x}$ = Mean for a sample

N= Denotes number of observations

$X_i =$ Observed values of PPI beef, PPI chicken meat and CPI meat

The study conducted by Rhiel (2004) on using the range to calculate the Coefficient of variation indicated that the Coefficient of variation is calculated by dividing the standard deviation by the mean. This study adopted the procedure of Rhiel (2004) to calculate the CV by calculating the mean and standard deviation, and then the CV for each series is calculated (PPI beef, PPI chicken meat, and CPI meat). Ojogho and Egware (2015) divided the entire period (1990-2014) into two sub-periods (January 1990-January 2002) and (February 2002-February 2014) when calculating the CV.

Thus, this study adopted the procedure of Ojogho and Egware (2015) by dividing the entire period (1991-2018) into two sub-periods (1991-2004) and (2005-2018).

The (1991-2004) sub-period was motivated by the food price inflation experienced in South Africa, with CPI food continuously varying with its main peaks that occurred during July 1992, September 1993, and February 2004 (NAMC, 2005). While the (2005-2018) sub-period was motivated by food price increases that occurred in 2006, 2007, 2008, and 2018 increasing CPI food (NAMC, 2008). The study applied this procedure to understand how producers' and consumers' price indexes varied over the years due to food price inflation. Furthermore, this study used Microsoft Excel as a software package with the support of Rhiel (2004); Ojogho and Egware (2015) procedures to calculate the CV.

4.4.3 Pearson correlation

The Pearson correlation coefficient is a correlation measure widely used to measure the relationship between two variables (Lee Rogers and Nicewander, 1988). Zhi et al. (2017) stated that the Pearson correlation coefficient method is a way to evaluate the correlation between two variables in the field of statistics. In correlated data, a change in the magnitude of one variable is associated with a change in the magnitude of another variable, either in the same (positive correlation) or in the opposite (negative correlation) direction (Schober et al., 2018). Moreover, Schober et al. (2018) further indicated that correlation is used in the context of a linear relationship between two continuous variables and is expressed as Pearson product-moment correlation. Mukaka (2012) indicated that Pearson coefficient analysis is simple to calculate and interpret, although the author noted that misuse of the method is widespread in much research. For instance, the author cautioned that relationships identified using Pearson correlation coefficients should be interpreted for what they are, which is for associations, not causal relationships (Mukaka, 2012). Asuero et al. (2006) defined the general model as:

$$r_{xy} = \frac{S_{XY}}{\sqrt{S_{XX}S_{YY}}} = \frac{\sum XiYi - \frac{\sum(xiyi)^2}{n}}{\sqrt{(\sum xi^2 - \frac{(\sum xi)^2}{n})(\sum yi^2 - \frac{(\sum yi)^2}{n})}} \qquad (4)$$

While the operational model is defined as:

$$r_{PPIb,CPIm} = \frac{S_{PPI,CPI}}{\sqrt{S_{PPIPPI}S_{CPICPI}}} = \frac{\sum PPIiCPIi - \frac{\sum(PPIiCPIi)^2}{n}}{\sqrt{(\sum PPIi^2 - \frac{(\sum PPIi)^2}{n})(\sum CPIi^2 - \frac{(\sum CPIi)^2}{n})}} \quad (5)$$

$$r_{PPIcm,CPIm} = \frac{S_{PPI,CPI}}{\sqrt{S_{PPIPPI}S_{CPICPI}}} = \frac{\sum PPIiCPIi - \frac{\sum(PPIiCPIi)^2}{n}}{\sqrt{(\sum PPIi^2 - \frac{(\sum PPIi)^2}{n})(\sum CPIi^2 - \frac{(\sum CPIi)^2}{n})}} \quad (6)$$

Where:

$\mathrm{PPI_b}$ = Producer price index of beef

$\mathrm{PPI_{cm}}$ = Producer price index of chicken meat

$\mathrm{CPI_m}$ = Consumer price index of meat

n = Denotes number of observations

Σ = Summation of PPI beef and CPI meat as well as PPI chicken meat and CPI meat

4.4.4 Augmented Dickey-Fuller

According to Mushtaq (2011), testing data for stationarity is very important in research because many economic and financial time series exhibit trend or non-stationarity behaviour. In addition, 30% of the Augmented Dickey-Fuller test results lead to correct analysis decisions (Mushtaq, 2011). The general model was defined by (Dickey and Fuller, 1979) as:

$$\triangle x_{i,t} = Kx_{i,t-1} + \sum_{k=1}^{n} \tilde{\omega}_{i,k} \triangle xi,_{t-k} + U_{k,t} \quad (7)$$

With the model hypotheses:

$H_0 = Non - stationary$

$H_A = stationary$

While the operational model is defined as:

$$\triangle PPI_{Bi,t} = KPPI_{Bi,t-1} + \sum_{k=1}^{n} \tilde{\omega}_{i,k} \triangle PPIi,_{Bt-k} + U_{k,t} \quad (8)$$

$$\triangle PPI_{CMi,t} = KPPI_{CMi,t-1} + \sum_{k=1}^{n} \tilde{\omega}_{i,k} \triangle PPIi,_{CMt-k} + U_{k,t} \quad (9)$$

$$\triangle CPI_{Mi,t} = KCPI_{CMi,t-1} + \sum_{k=1}^{n} \tilde{\omega}_{i,k} \triangle CPIi,_{CMt-k} + U_{k,t} \quad (10)$$

Where:

$\triangle PPI_{Bi,t}$ = Change in producer price index of beef

$\triangle PPI_{CMi,t}$ = Change in producer price index of chicken meat

$\triangle CPI_{Mi,t} =$ Change in consumer price index of meat

$PPI_{B,CMi,t-1}$ = Lagged values of producer price index of beef and chicken meat

$CPI_{Mi,t-1}$ = Lagged values of consumer price index of meat

$K =$ Coefficient of lagged values for producer price index of beef, chicken meat and consumer price index of meat, respectively

$\triangle PPIi,_{Bt-k}$ = Change in lagged values of producer price index of beef

$\triangle PPIi,_{CMt-k}$ = Change in lagged values of producer price index of chicken meat

$\triangle CPIi,_{Mt-k}$ = Change in lagged values of consumer price index of meat

$U_{k,t} =$ Error term

4.4.5 Vector Autoregression model

Using the VAR model, a set of theories can be established, including the impulse response analyses subject to both short-run timing and long-run restrictions, and an information criterion can be obtained to select the optimal lag (Yayi et al., 2021). In a VAR model, each variable is explained by its own lagged values and current as well as past values of the remaining variables resulting in a multi-equation, multivariable linear model (Rossi and Wang, 2019). Furthermore, Rossi and Wang (2019) mentioned that VAR models provide a systematic way to capture the rich dynamics across multiple time series and a coherent, credible approach to forecasting. However, the usage of the VAR in this study was not based on interpreting and forecasting the estimated parameters. However, it was used to interpret and understand the interrelationship between PPI beef, PPI chicken, and CPI meat through impulse response function. The general model of the VAR (p) model was defined by Frackler and Krieger (1986) as:

$$y_t = c_t + A_1 y_{t-1} + A_2 y_{t-2} + A_p y_{t-p} + U_t \qquad (11)$$

Which may be rewritten as:

$$\triangle y_t = c_t + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Pi_i \triangle y_{t-i} + U_t \quad (12)$$

Where:

$\triangle y_t =$ Denotes change PPI beef, PPI chicken meat and CPI meat

$\Pi =$ Coefficient of the lagged value

$U_t =$ Error term

$c_t =$ Deterministic term

4.4.6 Johansen cointegration test

Johansen cointegration uses two tests to determine the number of cointegrating vectors: the Maximum eigenvalue and the Trace test (Asari et al., 2011). In addition, Asari et al. (2011) indicated that the maximum eigenvalue tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of r+1 cointegrating vectors, and the trace test, tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of n cointegrating vectors. Dwyer (2015) stated that the Johansen cointegration test could be seen as a multivariate generalisation of the extended Augmented Dickey-Fuller test, in which the Johansen test provides estimates of all cointegrating vectors. The Johansen tests are based on eigenvalues of transformations of the data and the least-squares regression equation as well as the residuals (the error term) of the regression equation subject to unit root analysis (Dwyer, 2015; Rajab, 2011). The general model was defined by Johansen (1988) as:

$$y_t = c_t + A_1 y_{t-1} + A_2 y_{t-2} + A_p y_{t-p} + U_t \quad (13)$$

Which may be rewritten as:

$$\triangle y_t = c_t + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Pi_i \triangle y_{t-i} + U_t \quad (14)$$

Johansen proposed two likelihood ratio test which are:

Trace test

$$J_{trace} = -T \sum_{i=r+1}^{n} In(1 - \lambda_i) \quad (15)$$

Maximum eigenvalue test

$$J_{max} = -T In(1 - \lambda_{r+1}) \quad (16)$$

Where:

$T =$ Number of observations

$\hat{\lambda} =$ The $i\ th$ largest canonical correlation

$\triangle\, y_t =$ Denotes change in PPI beef, PPI chicken meat and CPI meat

$\Pi =$ Coefficient of the lagged value

$U_t =$ Error term

The study conducted by Ojiako (2021) indicated that the presence of a cointegrating vector is verified using the Trace test statistic and Maximum eigenvalue test statistic. Furthermore, Ojiako (2021) indicated that the decision rule is to reject at a 5% level if the value of the observed Trace statistic exceeds the 0.05 critical value, otherwise should not be rejected, and rejected at a 5% level if the value of the observed Maximum eigenvalue statistic is greater than the 0.05 critical value, otherwise, fails to reject the null hypothesis. Thus, the study used the decision rule of cointegration based on Ojiako's (2021) definition.

4.4.7 Vector Error Correction (VEC) model

Vector Error Correction model is used when a set of variables are found to have one or more cointegrating vectors (as explained in subheading 4.4.6), and the model adjusts for both short-run changes in the variables as well as deviations from equilibrium (Dalina and Liviu, 2015). In addition, Dalina and Liviu (2015) stated that lag length criteria are chosen based on the automated lag selection results on the statistical package to estimate the VEC model. According to Asari et al. (2011), a negative, as well as a significant coefficient, demonstrate that any short-term fluctuations between the independent and dependent variables lead to a stable long-run relationship between the variables. The general model of Vector Error Correction was defined by Hendry 1995 as:

$$\triangle\, X_t = a_0 + \lambda_1 EC_{t-1}^{1} + \textstyle\sum_{i=1}^{m} a_i \triangle\, x_{t-i} + \sum_{j=1}^{n} a_i \triangle\, Y_{t-j} + U_{1t} \qquad (17)$$

$$\triangle\, Y_t = \beta_0 + \lambda_2 EC_{t-1}^{2} + \textstyle\sum_{i=1}^{m} \beta_i \triangle\, x_{t-i} + \sum_{j=1}^{n} \beta_i \triangle\, Y_{t-j} + U_{2t} \qquad (18)$$

Where the operational model is defined as:

$$\triangle PPI_{Bt} = a_0 + \lambda_1 EC_{t-1}^1 + \sum_{i=1}^{m} a_i \triangle PPI_{Bt-i} + \sum_{j=1}^{n} a_i \triangle CPI_{Mt-j} + U_{1t} \quad (19)$$

$$\triangle PPI_{CMt} = a_0 + \lambda_1 EC_{t-1}^1 + \sum_{i=1}^{m} a_i \triangle PPI_{CMt-i} + \sum_{j=1}^{n} a_i \triangle CPI_{Mt-j} + U_{1t} \quad (20)$$

Where:

$\triangle PPI_{Bt}$ = Change in producer price index for beef

$\triangle PPI_{CMt}$ = Change in producer price index for chicken meat

$\triangle CPI_{Mt}$ = Change in consumer price index for meat

$\triangle PPI_{Bt-i}$ = Change in lagged value of producer price index for beef

$\triangle PPI_{Bt-i}$ = Change in lagged value of producer price index for chicken meat

$\triangle CPI_{Mt-j}$ = Change in lagged value of consumer price index for meat

a_i, β_i = Coefficient of the variables

a_0 = Deterministic term

U_{1t} = Error term

4.4.8 Granger casualty test

Granger causality measures whether one variable happens before another variable and helps in prediction (Sorensen, 2005). However, Sorensen (2005) mentioned that using Granger causality tests can lead to serious problems such as the wrong choice sampling period. Yii and Geetha (2017) stated that it is common for two economic time series to be either Granger causing non-Granger causing each other. According to Ghazali et al. (2008), the production chain view concerning the causal relationship between CPI and PPI is one in which changes in PPI cause CPI as a result of changes in producer prices which are passed on to consumers. Granger (1969) defined the general model as:

$$x_t = C_1 + \sum_{i=0}^{Px} a_i x_{t-i} + \sum_{j=1}^{Py} \beta_j x_{t-j} + U_t \quad (21)$$

While the operational model is defined as:

$$PPI_B = C_1 + \sum_{i=0}^{Px} a_i PPI_{t-b} + \sum_{j=1}^{Py} \beta_j CPI_{t-m} + U_t \quad (22)$$

$$PPI_{cm} = C_1 + \sum_{i=0}^{Px} a_i PPI_{t-cm} + \sum_{j=1}^{Py} \beta_j CPI_{t-m} + U_t \quad (23)$$

Where:

PPI_B = Producer price index of beef

PPI_{cm} = Producer price index of chicken meat

CPI_m = Consumer price index of meat

PPI_{t-cm} = Lagged producer price index for chicken meat

PPI_{t-b}= Lagged producer price index for beef

CPI_{t-m} = Lagged consumer price index for meat

Px, Py = Optimal lagged length

U_t = Error term

C_1 = Vector of deterministic term

4.5 Chapter summary

This chapter outlined the methodology used to achieve the aim of the current study, which was to comparatively analyse the relationship between the producer and consumer price index of beef and chicken meat in South Africa from 1991 to 2018. The study was conducted in South Africa and used publicly available secondary annual time series data accessed from the Food and Agriculture Organisation (FAO), Statistics South Africa (STATS SA), covering a period of 28 years from 1991 to 2018. Consumer and producer price indexes were the selected variables, while beef, chicken meat, and meat were the selected commodities used in this study. The analytical techniques, descriptions, and formulas were explained in detail. Coefficient of variation, Pearson correlation, Granger causality test, ADF test, Johansen cointegration test, the VEC test with the support of the VAR model (impulse response functions) were used to address the objectives of this study.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

This chapter outlines the empirical results of the study. Various test of the time series data is conducted on short and long-run equations, such as a detailed focus on the Coefficient of variation results, Pearson correlation analysis, the ADF test, VAR model maximum lag order establishment and verification of VAR model, Johansen cointegration test, analysis of impulse response function, VEC model establishment and parameter estimation, Granger causality test results and concludes with diagnostic tests.

5.2 Coefficient of variation

The mean, standard deviation, and the CV for each series were calculated (PPI beef, PPI chicken meat, and CPI meat) to produce the results in Table 2. The study adopted the procedure of Ojogho and Egware (2015) and divided the entire period (1991-2018) into two sub-periods (1991-2004) and (2005-2018), which coincided with prices increases pointed out in section 4.4.2.

Table 2: CV results for PPI beef, PPI chicken meat and CPI meat

	Mean	**Standard Deviation**	**Coefficient of Variation**
1991-2004			
PPI beef	25.13	8.05	32.02%
PPI chicken meat	37.76	10.27	27.20%
CPI meat	42.66	13.68	32.05%
2005-2018			
PPI beef	83.56	27.49	32.89%
PPI chicken meat	87.63	23.19	26.46%
CPI meat	116.99	32.97	28.18%
1991-2018			
PPI beef	54.35	35.77	65%

PPI chicken meat	62.69	30.89	49.2%
CPI meat	79.83	45.22	56.66%

Source: Author’s compilation (2021)

The CV for PPI beef was 32.02%, and the CV for CPI meat was 32.05% during the sub-period (1991-2004). The CV for PPI beef was 32.89%, and the CV for CPI meat was 28.18% during the sub-period (2005-2018), as indicated in Table 2. This implies that average beef prices from the producer's side indicated a high variation that contributed to a high variation in the average prices paid by the meat consumer during the sub-period (1991-2004). Interestingly, beef producers and meat consumers experienced approximately the same variation, indicating that most meat consumers purchased beef during the sub-period (1991-2004). However, the same cannot be said concerning the sub-period (2005-2018), as average prices of beef from the producer's side indicated a high variation that might have contributed to the low variation of the average prices paid by the consumers of meat. A 2% decline was observed in the prices paid by meat consumers, which might be because of the decline in the demand for beef due to its affordability during the sub-period (2005-2018). While from the beef producers, high price variation might be due to an increase in the cost of production, such as storage facilities and transport costs, as lack of sufficient storage and operating far from the market can delay beef reaching the market at the time of demand (Paul and Motlaleng, 2007; Monk et al., 2010).

The same can be said with the entire period as the CV for PPI beef was 65% which was high, and the CV for CPI meat was 56.66% which was low compared to the CV for PPI beef. Beef producers experienced high variability in the average prices of beef with low variability in the average prices paid by the meat consumers during the entire years of analysis (1991-2018). High variability is associated with high inflation. Therefore, beef producers experienced high inflation, with meat consumers experiencing low inflation. This might be because the meat consumers used their purchasing power to buy the close substitute of beef (chicken meat) when beef prices were high (Dubihlela and Sekhampu, 2014). At the same time, beef producers might be affected by climatic conditions (low rainfall, floods, high temperatures), which may affect beef production, resulting in increased beef prices (FAO, 2011). In addition, the sub-period (2005-2018) and the entire period (1991-2018) had high variability in the average prices of beef as compared to the sub-period (1991-2004). Furthermore, these results imply that during the sub-period (2005-2018) and the entire period (1991-2018), high inflation experienced in the meat industry resulted from high beef prices. This makes economic sense because, in South Africa, beef prices in the market are higher than other types of meat (chicken meat), which is why beef producers experience high price inflation.

Compared to the CV results for PPI beef and CPI meat, the CV for PPI chicken meat was dispersed around the mean with a CV of 27.20%, and the CV for CPI meat was 32.05% during the sub-period (1991-2004). Furthermore, the CV for PPI chicken meat was 26.46% and for CPI meat was 28.18% during the sub-period (2005-2018). This means that the producers' average prices of chicken meat had a lower variation than the average prices paid by the meat consumers during the sub-periods (1991-2004) and (2005-2018). The same is observed during the entire period (1991-2018) as CV for PPI chicken meat was 49.27% and 56.66% for CPI meat, indicating that average producer prices of chicken meat had low variation than the average prices paid by the consumers of meat which were high. This might be because of a decrease in chicken meat prices in the market, resulting in chicken meat producers reducing the supply of chicken meat, causing a low price variation. In addition, PPI chicken meat might not be the contributing factor to the high variation in the CPI meat during the sub-periods and entire period. Low price variability experienced by the chicken meat producers might be due to increased dumping by countries such as Brazil, the USA, and the EU threatening the domestic production of chicken, with producers receiving less profit (as explained in sub-heading 2.3.2 of this present study). As a result, consumers of meat purchase meat at a lower price than domestic prices (Jörnling, 2017). Furthermore, from the meat consumers, high price variability might be caused by a lack of proper planning of their income, budgets, and inability to use the purchasing power in the market, which results in consumers overspending on meat purchases. Thus, high price inflation is experienced by the consumers of meat (Paul and Motlaleng, 2007). This makes economic sense, in South Africa, prices of chicken meat are affordable as compared to beef prices, with consumers purchasing more chicken meat than beef because of its affordability.

In summary of the CV results, beef producers experienced high price variability compared to chicken meat producers, while meat consumers experienced low and high price variability. These results are consistent with the statement by Abbott and

Borot de Battisti (2011); NAMC (2005); NAMC (2008) that there was price variation in South Africa in meat prices during the period of 1992, 1993, 2004, 2006 to 2018 which quickly raised farmgate prices as results retail prices of meat were increased as well. In addition, this makes economic sense because meat consumers have a choice whereby, they can buy chicken meat when the prices of beef are high and vice versa. Hence, they experience low and high price variations. On the other hand, beef and chicken meat producers may experience competition from close substitutes, which sometimes makes it difficult to respond to price changes and changes in the choice of production. Reviewed studies in Chapter 3 did not indicate how PPI and CPI vary along the years of analysis. As such, this study fills the gap in the literature by calculating the Coefficient of variation of individual indexes (PPI beef and CPI meat as well as PPI chicken meat and CPI meat).

5.3 Correlation analysis

The strength and the direction of the relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat, can be demarcated through a matrix as shown in Table 3 and graphically as shown in Figures 10 and 11.

Table 3: Correlation analysis matrices (CAM) between PPI chicken meat and CPI meat as well as PPI beef and CPI meat.

	PPI chicken meat	**CPI meat**
PPI chicken meat	1.00	-
CPI meat	0.99	1.00

	PPI beef	**CPI meat**
PPI beef	1.00	-
CPI meat	0.99	1.00

Source: Author's compilation (2021)

Based on the results, it is evident that there is a strong positive relationship between PPI chicken meat and CPI meat, with a correlation coefficient of 0.99, which was positive (+). Comparatively, the correlation analysis matrix indicates a strong positive relationship between PPI beef and CPI meat in South Africa, with a correlation coefficient of 0.99, which was also positive (+). Therefore, this implies that inflation in meat prices in the South African economy is influenced by increased beef and chicken meat prices from the producer level and vice versa. This is economically acceptable because PPI affects CPI and CPI affects PPI; however, that does not mean that a conclusion can be drawn that (PPI beef causes CPI meat and PPI chicken meat causes CPI meat) as such causality test results are reported in the sub-section 5.10. Even though Galodikwe (2014) focused on the general CPI and PPI, the results found are related to the results found in this study but focusing specifically on PPI beef, PPI chicken meat, and CPI meat.

The scatter plot representing the direction and strength of the relationship was done, as shown in Figures 10 and 11, to indicate how PPI beef, PPI chicken meat, and CPI meat behave around the line of least squares through scatterplot points. The closer the data point is to the best line of fit, the closer the dispersion, the stronger the relationship. The further the data points are from the best line of fit and the further the dispersion, the weaker the relationship.

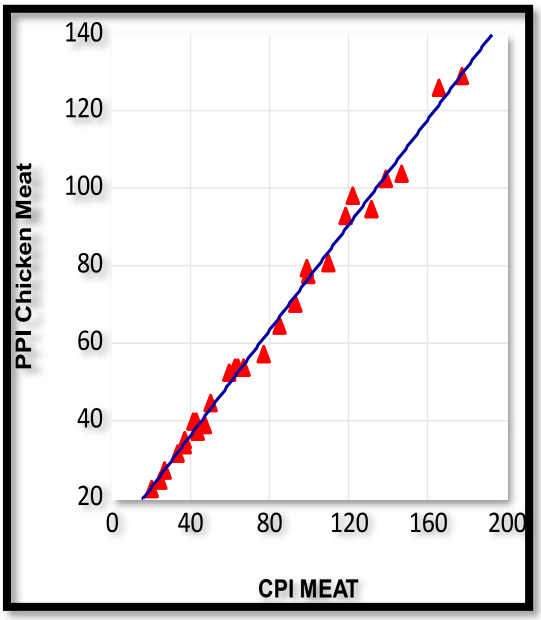


Figure 10: Direction and the strength of the relationship between PPI chicken meat and CPI meat

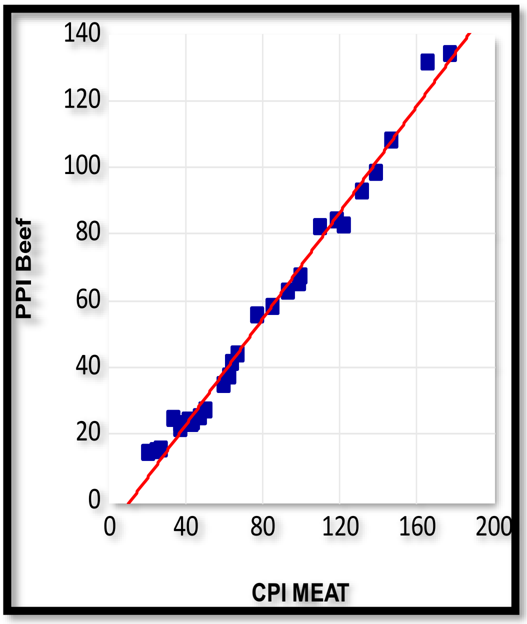


Figure 11: Direction and the strength of the relationship between PPI beef and CPI meat

Source: Author's compilation (2021)

From Figure 10, it is observed that PPI chicken meat and CPI meat are both moving in one direction. Typically, this suggests that as PPI chicken meat increases and PPI chicken meat decreases, CPI meat increases and CPI meat decreases, respectively.

The data points support the findings in Table 3 in indicating that there is a strong relationship between PPI chicken meat and CPI meat, as they are very close to the best-of-fit line.

Comparatively, PPI beef and CPI meat move in one direction, as shown in Figure 11. The data points support the results in Table 3, indicating that there is a strong relationship between PPI beef and CPI meat. For that reason, they are very close to the best fit line, indicating that as PPI beef increases, CPI meat increases and vice versa. Substantially, it makes economic sense, as the correlation matrix results indicated that when beef and chicken meat producers face input inflation, the increase in their production costs is passed on to the consumers. Ultimately, consumers will purchase meat at higher prices, causing economic inflation.

The study conducted by Meyer and Habanabakize (2018) on the analysis of the relationship and causality between the consumer price index, the producer price index, and purchasing manager’s index in South Africa found that coefficients of correlation between PPI and CPI were the highest, while that between purchasing managers’ index (PMI) and PPI was the lowest. Youness et al. (2021) found that there was a significant correlation with the probability of less than 5% between the different variables, including the CPI and PPI, in the study conducted on exchange rate pass-through in Morocco: a structural VAR approach. The study conducted by (Meyer and Habanabakize, 2018; Youness et al., 2021) focused on general PPI and CPI however, their results are based on the economic theory that PPI affects CPI as well as CPI affects PPI and indicated that there is a positive correlation between PPI as well as CPI. Therefore, the findings of this present study are related to the findings of Meyer and Habanabakize (2018) and Youness et al. (2021) but descended to individual commodities.

The CV results in sub-heading 5.2 indicated that there is a low and high variation amongst the variables. However, the results do not indicate how one variable affects another during price variation. Furthermore, even though the correlation analysis results in sub-heading 5.3 indicated that there is a strong positive relationship amongst the variables. The results do not indicate if the relationship is in the short or the long-run, if one variable causes another variable, or if there is cointegration amongst the variables. As such, the study carried out the (VAR and VEC) tests, and the results are indicated from sub-heading 5.4 to 5.10 to support the results in sub-heading 5.2 and 5.3 and determine the short and long-run relationship between the variables.

5.4 Augmented Dickey-Fuller unit root test

The null and alternative hypotheses were stated as follows to produce the results in Tables 4 and 5.

H_0: Has a unit root/ non-stationarity

H_1: Does not have a unit root/ stationary

The critical value was -2.98 at intercept and -3.59 at trend and intercept, as shown in Table 4 for CPI meat, PPI beef, and PPI chicken meat. The decision rule is that the series is stationary when the ADF value is greater than the critical value at 5% with a probability value less than 0.05. This implies that the null hypothesis is rejected when the ADF value is greater than the critical value at 5%, with a probability value less than 0.05. In that case, the alternative hypothesis is accepted.

Table 4: Augmented Dickey-Fuller unit root test results at Levels

Sequence/ Variable	Test equation	ADF statistics	Test critical value at 5%	Probability value	Outcome
CPI meat	Intercept	4.171	-2.976	1.0000	Stationary
	Trend and intercept	0.895	-3.588	0.9996	Non-stationary
PPI beef	Intercept	2.381	-2.976	0.9999	Non-stationary
	Trend and intercept	-0.571	-3.588	0.9728	Non-stationary
PPI chicken meat	Intercept	3.528	-2.998	1.0000	Stationary
	Trend and intercept	-1.068	-3.588	0.9161	Non-stationary

Source: Author’s compilation (2021)

Table 4 indicates the results of the ADF stationarity test. The null hypothesis is rejected based on the decision rule that the statistical ADF values are greater than the critical values with the p values less than 0.05. This implies that the CPI meat and PPI chicken meat series are stationary at level. While the null hypothesis cannot be rejected, resulting in the PPI beef series being non-stationary at levels. However, this study wanted all the series to be stationary. For this reason, the test equation was changed from intercept to trend and intercept, and given the decision rule, the null hypothesis cannot be rejected. Therefore, all the variables were found to be non-stationary, and the ADF unit root test was done at the first difference to produce the results in Table 5.

Table 5: Augmented Dickey-Fuller unit root test results at first difference

Sequence/ Variable	**Test equation**	**ADF statistics**	**Test critical value at 5%**	**Probability value**	**Outcome**
D(CPI) meat	Intercept	-3.182	-2.981	0.0327	Stationary
	Trend and intercept	-5.000	-3.595	0.0023	Stationary
D(PPI) beef	Intercept	-4.789	-2.981	0.0007	Stationary
	Trend and intercept	-6.248	-3.595	0.0001	Stationary
D(PPI) chicken meat	Intercept	-5.378	-2.981	0.0002	Stationary
	Trend and intercept	-3.955	-3.603	0.0199	Stationary

Source: Author’s compilation (2021)

Table 5 indicates the first difference I (1) results, and the null hypothesis is rejected. This implies that the ADF statistics values are greater than the critical values, with the p values less than 0.05. Therefore, at the intercept, all the series were stationary. However, the study tested for stationarity at trend and intercept for control and reliability purposes. Based on the decision rule, the null hypothesis has a unit root is rejected, implying that all the series were stationary. Thus, this study was satisfied that all other statistical tests would not be spurious as there are no fluctuations over time, and results will not be fabricated. Lao et al. (2018) found that the first differences between the Entrepreneur Confidence Index (QYJ) and PPI were stationary, indicating that these variables are integrated of order one, I (1), thereby supporting the results of this study.

5.5 VAR model to select the maximum lag order

This study carried out the lag order selection criteria to obtain the correct specification of a VAR model. The decision to select the maximum lag order was based on the rule of thumb by Zhang et al. (2020), indicating that the sequence length determines the choice of the maximum lag order, and the criterion with the lowest value leads to the best model results. Table 6 indicates the results for optimal lag length to be used to identify the relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat and to be able to run the VAR model to determine the impulse response functions.

Table 6: Maximum lag order (p) results for PPI chicken meat, PPI beef and CPI meat

Maximum lag order (p) for PPI chicken meat and CPI meat						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-196.7659	NA	14973.00	15.28968	15.38646	15.31755
1	-126.4281	124.4437*	91.20316*	10.18678*	10.47711*	10.27038*
2	-124.3662	3.330778	106.6772	10.33586	10.81975	10.47520
Maximum lag order (p) for PPI beef and CPI meat						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-203.2301	NA	24618.42	15.78693	15.88371	15.81480
1	-126.7559	135.3005	93.53192	10.21199	10.50232*	10.29560
2	-120.5658	9.9999397*	79.63608*	10.04352*	10.52741	10.18286*
* Indicates lag order selected by the criterion						

LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion

Source: Author’s compilation (2021)

Table 6 indicates the maximum lag order p for PPI chicken meat, PPI beef, and CPI meat. The SC (Schwarz criterion), HQ (Hannan-Quinn information criterion), and AIC (Akaike Information Criterion) indicated that lag 1 was the appropriate lag to be used for PPI chicken meat and CPI meat. At the same time, the SC indicated that lag 1 was the appropriate lag to be used for PPI beef and CPI meat. Moreover, the AIC and HQ indicated that lag 2 was the appropriate lag for PPI beef and CPI meat. Based on the decision rule, lag order selection with a lower value with an asterisk leads to the best results. Therefore, the maximum lag order 1 will be best for PPI chicken meat and CPI meat, while the maximum lag order 2 will be best for PPI beef and CPI meat. Thus, the AIC is the minimum order p which this study chose to construct the VAR model and verification.

5.6 Establishment and verification of VAR model

The VAR maximum lag order (1) model based on the AIC was 10.18678 for PPI chicken meat and CPI meat as well as VAR maximum lag order (2) model based on AIC was 10.04352 for PPI beef and CPI meat, as shown in Table 6. Therefore, the AR root chart is used for verification of the VAR (1) and VAR (2) model stability, where the X and Y axes in Figures 12 and 13 represent the coefficients of the eigenvalues.

5.6.1 Established matrix form of VAR (1) and VAR (2) model

The VAR (2) for PPI beef and CPI meat, as well as VAR (1) for PPI chicken meat and CPI meat matrix was established to support Figures 12 and 13 in demonstrating that all eigenvalues of the companion-form matrix are less than unity in absolute value and the VAR (1) and (2) model are stable.

$$\begin{pmatrix} CPI\ meat \\ PPI\ chicken\ meat \end{pmatrix} = \begin{pmatrix} 4.812 \\ 5.926 \end{pmatrix} + \begin{pmatrix} -0.110 & 0.484 \\ -0.524 & 0.357 \end{pmatrix} \begin{pmatrix} CPI\ meat \\ PPI\ chicken\ meat \end{pmatrix}_{t-1} + U_t \quad (24)$$

$$\begin{pmatrix} CPI\ meat \\ PPI\ beef \end{pmatrix} = \begin{pmatrix} 2.154 \\ 0.383 \end{pmatrix} + \begin{pmatrix} 0.669 & 0.277 \\ 1.071 & 0.284 \end{pmatrix} \begin{pmatrix} CPI\ meat \\ PPI\ beef \end{pmatrix}_{t-1} +$$
$$\begin{pmatrix} -0.389 & -0.804 \\ 0.081 & -0.157 \end{pmatrix} \begin{pmatrix} CPI\ meat \\ PPI\ beef \end{pmatrix}_{t-2} + U_t \quad (25)$$

Source: Author’s compilation (2021)

5.6.2 Verification of stability of the VAR(1) and VAR (2) model

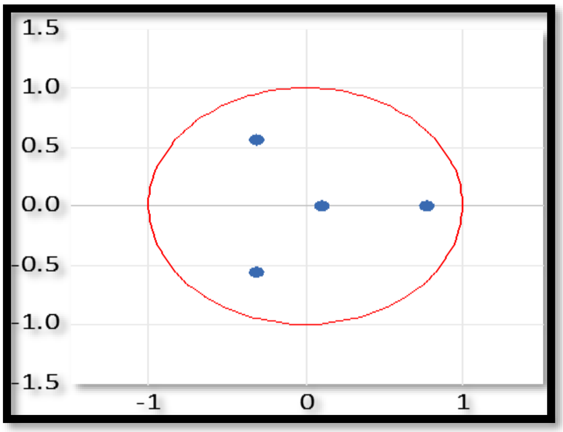


Figure 12: Distribution of AR roots for PPI beef and CPI meat: Inverse roots of AR characteristic polynomial

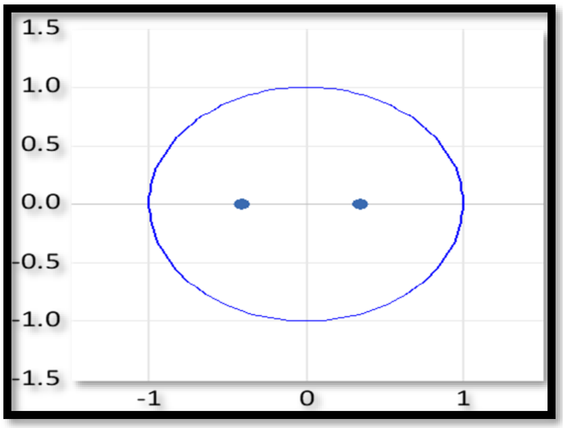


Figure 13: Distribution of AR roots for PPI chicken meat and CPI meat: Inverse roots AR characteristics polynomial

Source: Author’s compilation (2021)

The four points on the unit circle were (-0.1;0.57), (-0.0; -0.57), (-0.0;0.00) and (1.0;0.01). The reason for a four-point unit circle between PPI beef and CPI meat was because of VAR (2) of the AIC. Therefore, it is observed that the modulus of all unit root reciprocals for PPI beef and CPI meat lies within the unit circle, which means the established VAR (2) model is stable, as shown in Figure 12. PPI chicken meat and CPI meat had two points on the unit circle (-0.00;0.00) and (0.00; -0.00). This is because of the VAR (1) of the AIC. It is observed in Figure 13 that the modulus of all unit root reciprocals for PPI chicken meat and CPI meat lies within the unit circle, which means the established VAR (1) model is stable.

5.7 Johansen cointegration test results

A cointegration test was done to test whether the causal relationship described by the regression equation is a pseudo-regression. In other words, to check whether there is a long-term cointegration relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat. The cointegration test results are shown in Tables 7 and 8. This study made conclusions based on the decision rule indicated by Ojiako (2021). The policy implications of the Johansen cointegration test results are explained in detail in sub-heading 5.9.1, as these results support the VEC results.

Table 7: Johansen cointegration test results for PPI beef and CPI meat

Unrestricted Cointegration rank test (Trace)				
Hypothesised No of CE(s)	**Eigenvalue**	**Trace Statistics**	**5% Critical value**	**Prob.****
None	0.314149	14.84730	15.49471	0.0624
At most 1*	0.194907	5.419943	3.841465	0.0199
Unrestricted Cointegration rank test (Max-Eigen)				
Hypothesised No of CE(s)	**Eigenvalue**	**Max-Eigen statistics**	**0.05% Critical value**	**Prob.****
None	0.314149	9.427356	14.26460	0.2523
At most 1*	0.194907	5.419943	3.841465	0.0199
* Indicates rejection of the hypothesis at the 0.05 level ** Mackinnan-Haug-Michelis P values Trace and Max- Eigen test indicates r co-integrating model (s) at 5% significance level				

Source: Author's compilation (2021)

Table 7 indicates the Johansen cointegration test results for PPI beef and CPI meat at a 5% confidence interval. The Trace statistics was 14.84730, which was less than the critical value of 15.49471, meaning that the study failed to reject the null hypothesis. This implies that there is no cointegrating equation between the PPI beef and CPI meat at none. Furthermore, the null hypothesis that there is no cointegrating equation is rejected at most 1 since the Trace statistics was 5.419943, which was greater than the critical value of 3.841465 with the significant p value less than 0.05. Therefore, it can be concluded that there is a cointegrating relationship between PPI beef and CPI meat.

The Max-Eigen indicated no cointegrating equation at none. Since the Max-Eigen statistics value was 9.427356, which was less than the critical value of 14.26460, the study failed to reject the null hypothesis. This implies that there was no cointegration equation between PPI beef and CPI meat. The null hypothesis that there is no cointegration equation is rejected at most 1 since the Max-Eigen statistics was 5.419943, which was greater than the critical value of 3.841465 with the significant p value less than 0.05. This implies that there is a cointegrating relationship between PPI beef and CPI meat. Thus, Trace and Max-Eigen statistics indicated a cointegration relationship between PPI beef and CPI meat. The VEC model can be applied to test the short and long-term relationship between PPI beef and CPI meat.

Table 8: Johansen cointegration test results for PPI chicken meat and CPI meat

Unrestricted Cointegration rank test (Trace)				
Hypothesised No of CE(s)	**Eigenvalue**	**Trace Statistics**	**5% Critical value**	**Prob.****
None	0.482236	29.81330	15.49471	0.0002
At most 1*	0.386410	12.69916	3.841465	0.0004
Unrestricted Cointegration rank test (Max-Eigen)				
Hypothesised No of CE(s)	**Eigenvalue**	**Max-Eigen statistics**	**5% Critical value**	**Prob.****
None	0.482236	17.11414	14.26460	0.0172
At most 1*	0.386410	12.69916	3.841465	0.0004
* Indicates rejection of the hypothesis at the 0.05 level ** Mackinnan-Haug-Michelis P values Trace and Max- Eigen test indicates r co-integrating model (s) at 5% significance level				

Source: Author's compilation (2021)

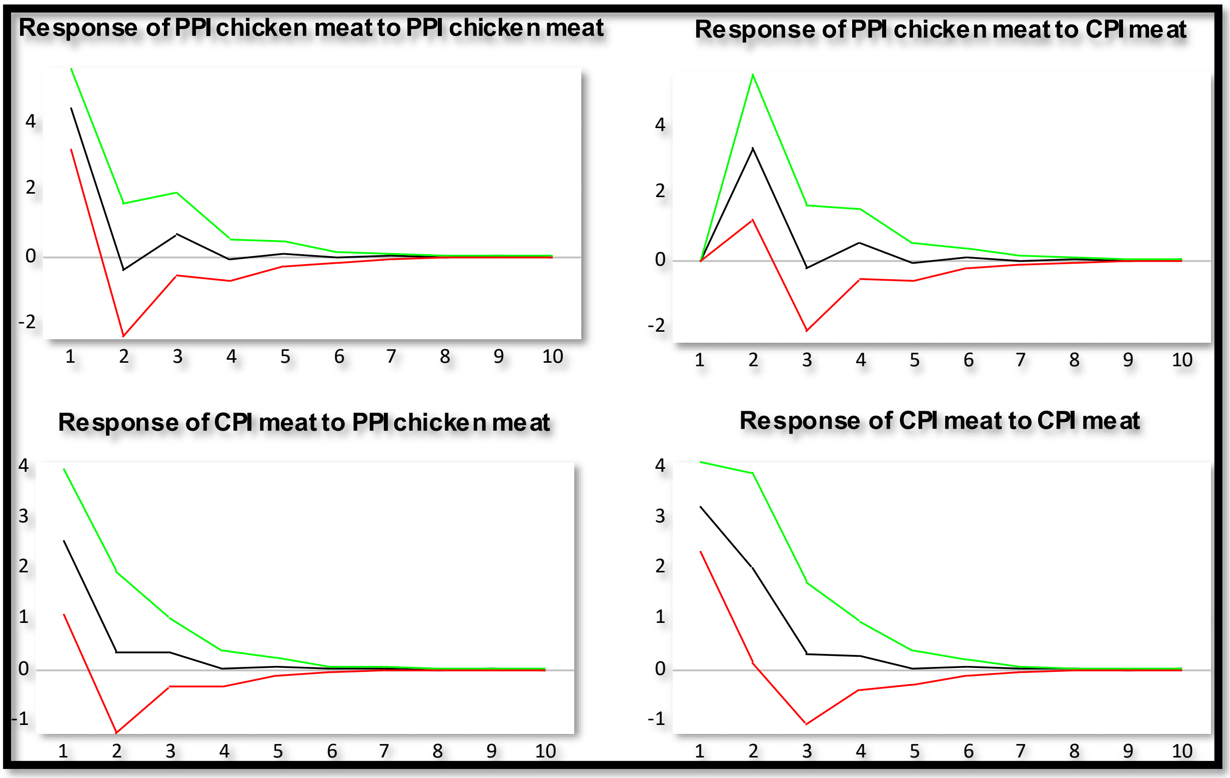
Table 8 indicates the Johansen cointegration test results for PPI chicken meat and CPI meat at a 5% confidence interval. The null hypothesis that there is no cointegration is rejected since the Trace statistics was 29.81330, which was greater than the critical value of 15.4947 at none. This implies that there was evidence of cointegration between PPI chicken meat and CPI meat. Furthermore, the Trace statistics was 12.69916, which was greater than the critical value of 3.841465 with a significant p value less than 0.05 at most 1. As such, there is a cointegration relationship between PPI chicken meat and CPI meat. Therefore, this implies that the null hypothesis is rejected.

The Max-Eigen indicated that there is cointegration between PPI chicken meat and CPI meat when the series is at none. This is because the Max-Eigen statistics was 17.11414, which was greater than the critical value of 14.26460, meaning that the null hypothesis is rejected. Therefore, there is a cointegration relationship between PPI chicken meat and CPI meat when the series is at none. The null hypothesis that there is no cointegration is rejected because the Max-Eigen statistics was 17.114, which was greater than the 3.841465 critical value with the significant p value less than 0.05. Therefore, there is a cointegration relationship between PPI chicken meat and CPI meat. Thus, both Trace and Max-Eigen statistics indicated that there was a cointegration relationship between PPI chicken meat and CPI meat, the VEC model can be applied.

Comparatively, the study found that there was no cointegration for PPI beef and CPI meat at none, but there was cointegration between PPI chicken meat and CPI meat at none. However, cointegration was found between PPI beef and CPI as well as PPI chicken meat and CPI meat at most 1. Thus, there was a long-run cointegration relationship between PPI beef and CPI meat, as well as PPI chicken meat and CPI meat. Davudova (2020) found that there was a long-term stable relationship between GDP, CPI, PPI, and exchange rate processes considering the oil price and the impact of the COVID19 pandemic, which were in line with the results found in this study on the long-term cointegration relationship. In addition, Berat and Keskin (2021) found that there was a long-run cointegration relationship between PPI and CPI. However, (Davudova, 2020; Berat and Keskin, 2021) focused on general CPI and PPI, and this study focused on individual commodities (beef, chicken meat, and meat). The Johansen cointegration findings in this study are in contrast with Cerquera-Losada et al. (2018) found that PPI and CPI are not cointegrated in Colombia, Ecuador, and Paraguay, which the study focussed on general CPI and PPI in six South American countries.

5.8 Analysis of impulse response functions

This study uses the impulse response function to analyse the response of PPI beef and CPI meat as well as PPI chicken meat and CPI meat. The middle line is the impulse response function for the variables, while the two lines before and after the middle line represent the 95% confidence interval level (+2 and -2 S.E), as shown in Figures 14 and 15. The detailed explanation of the policy implications of the impulse response function is provided in sub-heading 5.9.1, to support the VEC findings.

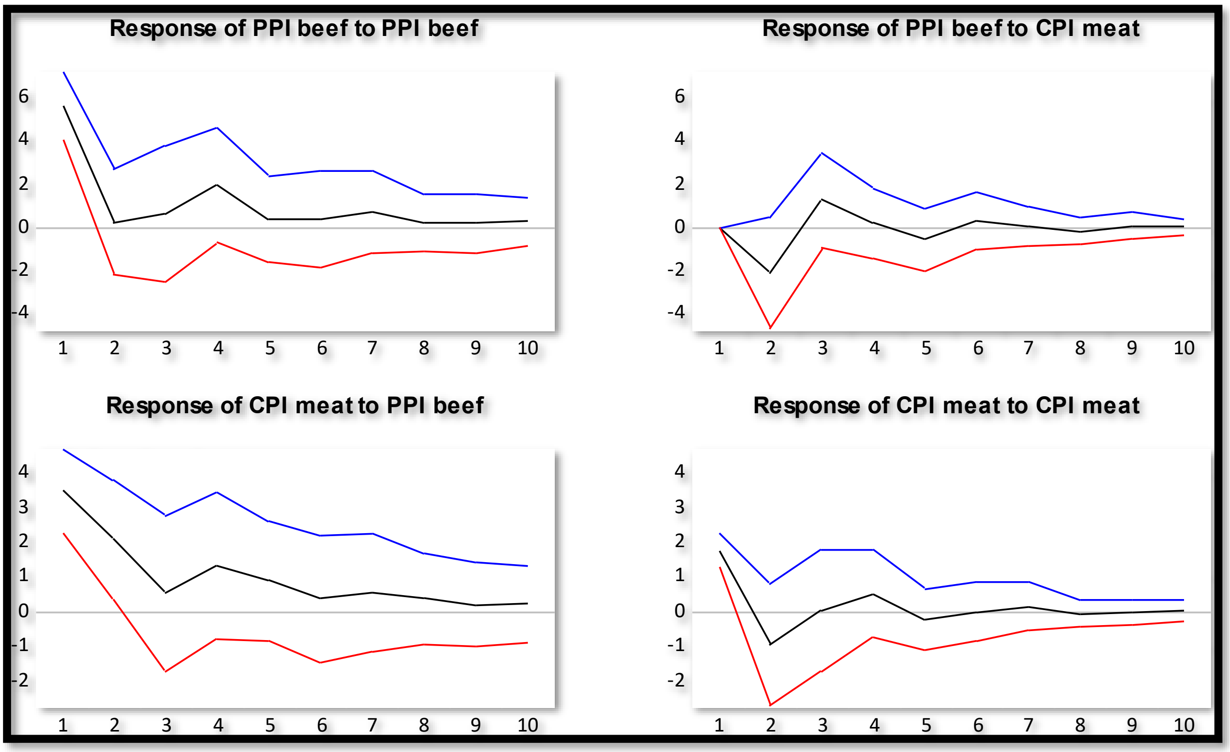


Key: +2S.E; Response of PPI chicken meat/CPI meat; -2S.E

Figure 14: Impulse response functions for PPI chicken meat and CPI meat

Source: Author's compilation (2021)

Figure 14 indicates the impulse response functions for PPI chicken meat and CPI meat. PPI chicken meat responded to its shock positively until period 3, and from there, the impact became positive until it stabilised in period 7. PPI chicken meat did not respond immediately to CPI meat shocks during period 1. However, PPI chicken meat responded positively to the CPI meat shock during period 2, then declined and became insignificant during period 3. Since period 4, a one standard deviation shock to the CPI meat increases the PPI chicken meat until the impact stabilises from period 7-10. Furthermore, CPI meat responded positively and significantly to a shock in PPI chicken meat. The impact declined and remained positive during period 1 and period 2, respectively. Therefore, CPI meat positively impacts PPI chicken meat until it stabilises from period 5 to 10. The response of CPI meat to itself is significant during period 1 until it stabilised.



Key: +2S.E; Response of PPI beef/CPI meat; -2S.E

Figure 15: Impulse response functions for PPI beef and CPI meat

Source: Author’s compilation (2021)

Figure 15 indicates the response of PPI beef to CPI meat. PPI beef responded positively to its impact shock, which was significant until period 10. Furthermore, PPI beef response to CPI meat shock was negative during periods 1 and 5. Since period 6, the PPI response to the shock in CPI meat was positive, indicating that in the long-run, the beef producers responded positively to the price changes of meat in the market until the impact stabilised in period 10. Also, the CPI response to a shock in PPI beef is positive throughout. The response of CPI to itself was negative during period 1, and from period 3 became positive until the impact stabilised in period 10.

In summary, the short and long-term interference can be observed between PPI chicken meat and CPI meat as well as PPI beef and CPI meat, implying that if there is a change in PPI chicken meat, CPI meat will positively change and vice versa. Also, if there is a change in PPI beef, CPI meat change positively and vice versa. These findings support the correlation results in sub-heading 5.2 of this chapter. However, sub-heading 5.9.1 will provide a further explanation of policy implication of these findings as they support the VEC results.

5.9 VEC model establishment and parameter estimation

Johansen cointegration test indicated that there is a long-term cointegration relationship between PPI beef and CPI meat, as well as PPI chicken meat and CPI meat, as shown in Tables 7 and 8. The impulse response indicated the interrelationship between PPI beef and CPI meat and PPI chicken meat and CPI meat, as shown in Figures 14 and 15. Therefore, based on the previous VAR (1) and VAR (2) models, respectively, the VEC model can be established to analyse the short and long-run relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat. VEC model results are indicated in Table 9. The policy implications of the VEC results in support of the Johansen cointegration and impulse response functions findings are explained in sub-heading 5.9.1.

Table 9: VEC model results for PPI chicken meat, PPI beef and CPI meat

PPI chicken meat and CPI meat				**PPI beef and CPI meat**			
Parameter	**Coefficient**	**Std. error**	**t-stats**	**Parameter**	**Coefficient**	**Std. error**	**t-stats**
ECT_{t-1}	-1.9800	0.4895	-4.0451	ECT_{t-1}	-1.0841	0.1146	-9.4581
D(PPI chicken meat(-1))	0.1319	0.3075	0.4292	D(PPI beef(-1))	-0.6447	0.7725	-0.8344
D(CPI meat (-1))	-0.3772	0.3567	-1.057	D(PPI beef (-2))	-0.2184	0.4431	-0.4929
Constant	0.1289	0.9237	0.13964	D(CPI meat (-1))	-0.7904	0.7976	-0.9909
R-squared		0.706667		D(CPI meat (-2))	-0.4832	0.5378	-0.8983
Adj. R-squared		0.664762		Constant	1.0538	1.2138	0.8681
F-statistics		16.86368		R-squared		0.629081	
Log likelihood		-71.25571		Adj. R-squared		0.526048	
Akaike AIC		6.020456		F-statistics		6.105634	
				Log likelihood		-72.01520	
				Akaike AIC		6.501267	

Source: Author's compilation (2021)

Based on the results, it can be observed that the adjustment coefficient indicated that the previous period deviation from the long-run equilibrium between PPI chicken meat and CPI meat as well as between PPI beef and CPI meat, is corrected in the current period with the adjustment speeds of 1.9800 and 1.0841, respectively.

PPI beef and CPI meat had the error correction term of -1.0841, which was greater than PPI chicken meat and CPI meat which was -1.9800. However, both PPI beef and CPI meat, as well as PPI chicken meat and CPI meat, had negative error term correction, which plays a role in inversely correcting the next period of PPI chicken meat and CPI meat as well as PPI beef and CPI meat values to achieve a long-term equilibrium state. Interestingly, there was a significant impact between PPI chicken meat and CPI meat, as well as PPI beef and CPI meat, as the t-statistical values were 4.045 and 9.4582, respectively.

PPI chicken meat and CPI meat had a high R-squared of 0.7067 compared to that of PPI beef and CPI meat which was 0.6291. This implies that the VEC was a good fit model to establish the long-term equilibrium state between PPI chicken and CPI meat compared to PPI beef and CPI meat. Furthermore, the R-squared of 0.7067 implies that 70.67% of variations of PPI chicken meat are explained by CPI meat, while the remaining 29.33% variations are explained by other variables that were not included in the model. The same can be observed between PPI beef and CPI meat with an R-squared of 0.6291, indicating that 62.91% variations in PPI beef are explained by CPI meat while 37.09% variations are explained by the excluded variables.

For each additional percentage-point increase in PPI chicken meat of the previous period, the current PPI chicken meat will increase by 13.20%. For each additional percentage-point increase in CPI meat of the previous period, the current PPI chicken meat will decrease by 37.73% in the short-run while other things are constant. Thus, the PPI chicken meat of the previous period has a positive effect on the PPI chicken meat of the current period, while CPI meat of the previous period has a negative effect on the PPI chicken meat of the current period. Comparatively, for each additional percentage-point increase in PPI beef of the previous period, the current PPI beef will decrease by 64.47%, and for each additional percentage-point increase in CPI meat of the previous period, the current PPI beef will decrease by 48.32% in the short-run while other things are constant.

The study conducted by Li et al. (2019) on the relationship between CPI and PPI based on the VEC model found that current CPI was affected by the reverse impact of the previous CPI, and the positive impact of the previous PPI and current PPI was affected by the previous CPI, the positive impact of the previous PPI. Therefore, the results are similar to the result found in this study. In addition, these findings in this study align with those of Kai and Xuemei (2018) and Cerquera-Losada et al. (2018), which found a long-term equilibrium between CPI and PPI. Furthermore, Mallick (2020) indicated that adjustment toward long-run equilibrium tends to persist more for negative deviations and respond more quickly toward positive deviations.

5.9.1 Policy implications of the VEC results

The Johansen cointegration results indicated a long-run cointegration relationship between PPI beef and CPI meat, as well as PPI chicken meat and CPI meat. The cointegration relationship indicates that in the South African economy, price stability achieved in the average prices of beef and chicken meat assures price stability in the average price of meat from the consumer level in the long-run. However, the VEC adjustment speeds indicated that PPI chicken meat had a slow convergence process to equilibrium as compared to PPI beef when it comes to CPI meat. Furthermore, the impulse response functions results also demonstrated that beef, chicken meat producers, and meat consumers do not respond immediately to price changes in the economy in the short-run. This implies that the available monetary policies and price control mechanisms take longer to stabilise the average prices of chicken meat compared to the average prices of beef in the long-run in South Africa. Therefore, beef, chicken meat producers, and meat consumers cannot use the available monetary policies to respond to price changes in the short-run. As a result, it takes time to achieve price stabilisation in the average prices of meat in the South African economy.

The VEC results indicated a long-run relationship between PPI chicken meat and CPI meat as well as PPI beef and CPI meat, with impulse response functions indicating the long-run impact shocks between the variables. This implies that, in South Africa, the available monetary policies focused on stabilising prices in the economy can allow beef, chicken meat, and meat consumers to distinguish the long-run price shocks. That is, the available monetary policies can allow beef and chicken meat producers to respond to price changes in the economy by giving beef and chicken meat producers a clear picture of what drives the meat demand. In other words, South African beef, and chicken meat producers, produce beef and chicken meat relative to its price. This means that when there is an increase in meat prices in the economy, beef, and chicken meat producers, might increase production and vice versa (based on the impulse response functions results). The same can be said with meat consumers that when beef and chicken meat prices are higher, the consumers may respond to price changes by buying substitutes such as lamb, pork, and mutton (based on the impulse response functions results).

5.10 Granger causality test results

Granger causality test was performed to investigate causality between PPI beef and CPI meat as well as PPI chicken meat and CPI meat, as shown in Table 10. Pairwise Granger causality is applied to identify the direction of the relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat, as shown in Table 11. The decision rule was that the null hypothesis is rejected if the probability value of the chi-square is 0.05.

Table 10: Granger causality test results for PPI beef, PPI chicken meat and CPI meat

PPI Beef and CPI meat				
Hypotheses	**Lags**	**Chi-square**	**Probability**	**Decision**
D(PPI beef) does not granger cause D(CPI meat)	2	5.589458	0.0611	Accept
D(CPI meat) does not granger cause D(PPI beef)	2	5.539070	0.0627	Accept
PPI chicken meat and CPI meat				
D(PPI chicken meat) does not granger cause D(CPI meat)	1	11.98690	0.0005	Reject
D(CPI meat) does not granger cause D(PPI chicken meat)	1	1.593522	0.2068	Accept

Source: Author's compilation (2021)

The study fails to reject the null hypothesis that PPI beef does not granger cause CPI meat as the probability value of the chi-square is 0.0611. The null hypothesis that CPI meat does not granger cause PPI beef is not rejected as the probability value of the chi-square is 0.0627. Comparatively, this study rejects the null hypothesis that PPI chicken meat does not granger cause CPI meat, meaning that there was evidence of short-run causality from PPI chicken meat to CPI meat as the probability value of the chi-square is 0.0005 and fails to reject the null hypothesis that CPI meat does not granger cause PPI chicken meat because the probability value of the chi-square is 0.2068. Thus, these results suggest that there is no flow from PPI beef to CPI meat, CPI meat to PPI beef, CPI meat to PPI chicken, but there is a flow from PPI chicken meat to CPI meat. The findings of the study are acceptable, as in the case of Mexico, Sidaoui et al. (2009) found that there was no causality between CPI and PPI and concluded that no causation was not driven by coefficients associated with short-run dynamics but by the long-run response of consumer prices to shocks of producer prices which leads to a temporarily higher inflation rate until the long-run equilibrium relationship between these indexes is satisfied again. Therefore, the same can be said in the South African context.

Table 11: Pairwise Granger causality test results for PPI beef, PPI chicken meat and CPI meat

PPI Beef and CPI meat				
Hypotheses	**Lags**	**f-stats**	**Probability**	**Decision**
D(PPI beef) does not granger cause D(CPI meat)	2	2.79473	0.0851	Accept
D(CPI meat) does not granger cause D(PPI beef)	2	2.76953	0.0867	Accept
PPI chicken meat and CPI meat				
D(PPI chicken meat) does not granger cause D(CPI meat)	1	5.95310	0.0225	Reject
D(CPI meat) does not granger cause D(PPI chicken meat)	1	36.2964	3.E-06	Accept

Source: Author's compilation (2021)

Based on Table 11, this study fails to reject the null hypothesis that PPI beef does not cause CPI meat because the probability value of the f-statistics is 0.085, indicating an independent relationship. Moreover, failing to reject the null hypothesis that CPI meat does not cause PPI beef because the probability value of the f-statistics is 0.0867 indicating an independent relationship. Comparatively, the study fails to reject the null hypothesis that CPI meat does not granger cause PPI chicken meat because the probability value of f-statistics is 3.E-06 indicates an independent relationship. However, the study rejects the null hypothesis that PPI chicken meat does not granger cause CPI meat because the probability value of the f-statistics is 0.0225, meaning that there is a unidirectional relationship. To further conceptualise these findings, Figure 16 was computed.

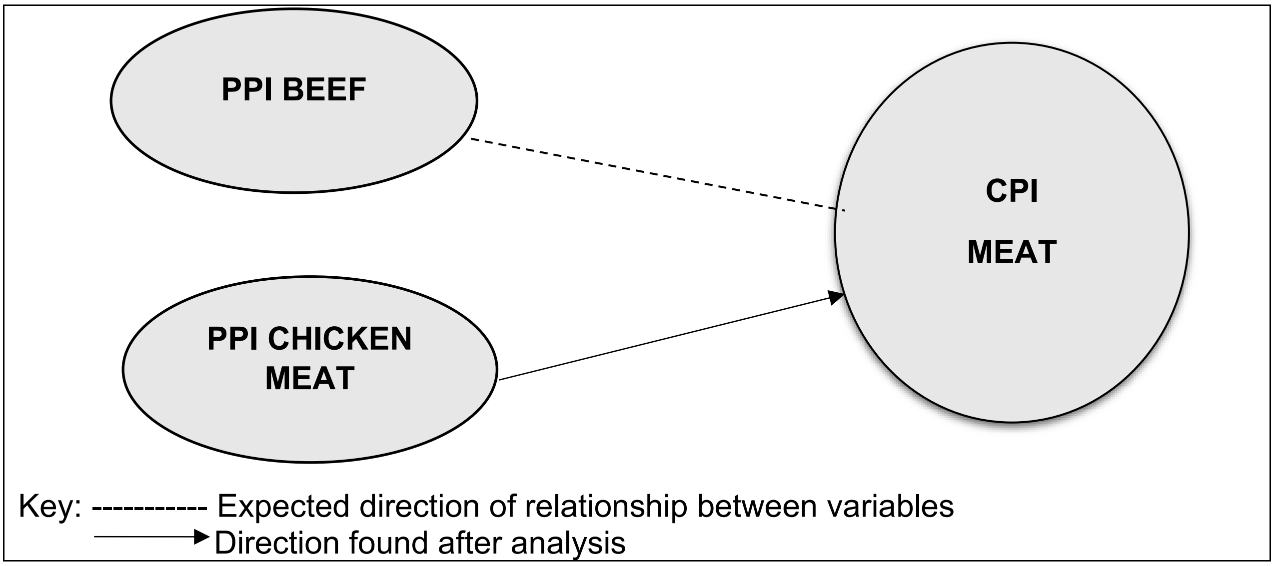


Figure 16: Direction of the causality between CPI meat, PPI beef and PPI chicken meat

Source: Author's compilation (2021)

The direction of the causality is indicated in Figure 16. Theoretically, the possibility of the direction would be from PPI beef to CPI meat as well as from PPI chicken meat to CPI meat, as Sidaoui et al. (2009) indicated that generally, there can be short-run causation from PPI to CPI and no causation from PPI to CPI can also occur. In the case of South Africa, as indicated in Figure 16, the dotted line demonstrates the expected causation from PPI beef to CPI meat. However, an independent relationship was found between PPI beef and CPI meat. This analysis implies that in the short-run South African beef producers cannot use CPI meat to predict future beef price values in the market. This is because the prices of meat in the market do not play a significant role in the prices received by beef producers. In addition, this might be because factors of production are fixed in the short-run, and prices take time to adjust.

Furthermore, as indicated in sub-heading 5.3 of this chapter that correlation does not necessarily mean there is causation. In other words, PPI beef and CPI meat had a strong positive relationship, but beef producers cannot use CPI meat to predict beef price inflation even though they move in one direction. These findings are contrary to those of Woo et al. (2019) and Chi-wei et al. (2016), that found that CPI and PPI are cointegrated with bidirectional long-run Granger causality between CPI and PPI. This contradiction of the results between South Africa and the UK, France, Germany, as well as Slovakia, is economically acceptable because countries have different monetary policies and use different types of predictive measures to estimate inflation in the economy.

Comparatively, in the study, there was a unidirectional relationship between PPI chicken meat to CPI meat, as indicated by the arrow in Figure 16. The implication to the South African context is that chicken meat producers use CPI meat to predict the price inflation of chicken meat in the short-run even though prices take time to adjust. In other words, meat prices in the market play a significant role in the prices received by chicken meat producers. These results are similar to those found by Meyer and Habanabakize (2018) and Ghazali (2008), which found a unidirectional causal relationship between CPI and PPI. Interestingly, this study found that there are independent relationships between PPI beef to CPI meat, CPI meat to PPI beef as well as CPI meat to PPI chicken meat as such, they are similar to the results of Oyekele and Ojediran (2018), that found that there was no causality between PPI and CPI.

Therefore, the result found by (Meyer and Habanabakize, 2018; Ghazali, 2008; Woo et al., 2019; Chi-wei et al., 2016; Oyekele and Ojediran, 2018) are related to this study even though this study focused on CPI meat and disaggregated components of beef and chicken meat producer price indexes.

5.11 Diagnostic tests

Testing for accuracy of the results found in this study, serial correlation and heteroskedasticity tests were performed to find results shown in Tables 12 and 13. Heteroskedasticity test was performed to check the variance of the errors between the variables, while the serial correlation test was performed to check whether the error terms of the time series from one period to another exist.

5.11.1 Serial correlation

The null and alternative hypotheses were stated as follows to produce the results in Table 12.

H_0: There is no serial correlation

H_1: There is serial correlation

Table 12: Serial correlation results between CPI meat, PPI beef and PPI chicken meat

PPI chicken meat and CPI meat			
F-statistics	0.003876	Prob. F (1.25)	0.9509
Obs* R-squared	0.004340	Prob. Chi-square	0.9475
PPI beef and CPI meat			
F-statistics	0.893146	Prob. F (1.25)	0.4237
Obs* R-squared	2.027634	Prob. Chi-square	0.3628

Source: Author's compilation (2021)

The study performed a serial correlation test on CPI meat and PPI chicken meat as well as CPI meat and PPI beef, as the results are indicated in Table 12, this study found that the probability value of the f-statistics is greater than 0.05, meaning that the study fails to reject the null hypothesis. This implies that there was no evidence of a serial correlation between CPI meat and PPI chicken meat. The study further found that the probability value of f-statistics and chi-square are both greater than 0.05, meaning that the study fail to reject the null hypothesis as such, there was no evidence of a serial correlation between CPI meat and PPI beef.

5.11.2 Heteroskedasticity test: ARCH

The null and alternative hypotheses were stated as follows to produce the results in Tables 13.

H_0: There is no heteroskedasticity

H_1: There is heteroskedasticity

Table 13: Heteroskedasticity results between CPI meat, PPI chicken meat and PPI beef

PPI chicken meat and CPI meat			
F-statistics	1.515742	Prob. F (1.25)	0.2297
Obs* R-squared	1.543424	Prob. Chi-square (1)	0.2141
PPI beef and CPI meat			
F-statistics	0.094421	Prob. F (2.22)	0.9103
Obs* R-squared	0.212768	Prob. Chi-square (2)	0.8991

Source: Author's compilation (2021)

By using the Autoregressive Conditional Heteroskedasticity approach to test for heteroskedasticity, Table 13 indicates that the null hypothesis cannot be rejected because the probability value of f-statistics of 0.2297 and probability value for chi-square was 0.2141 for CPI meat and PPI chicken meat which were both greater than 0.05 indicating that there was no evidence of heteroskedasticity. The same can be said with CPI meat and PPI beef because the probability value of the f-statistics is 0.9103 with the chi-square of 0.8991, which were both greater than 0.05, indicating that there was no evidence of heteroskedasticity. Youness et al. (2021) supports the results on serial correlation and heteroskedasticity as they found that there was no serial correlation and heteroskedasticity and concluded that the model was valid.

5.12 Chapter summary

The findings of this study presented in this chapter demonstrated the existence of indexed price variation, correlation, and causality relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat. Furthermore, the impulse response functions estimated the impact of the variables in the short and long-run. The VEC results demonstrated the impact of the previous and current period, indicating that there is a short and long-run relationship between PPI beef and CPI meat as well as PPI chicken meat and CPI meat.

CHAPTER 6

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

A comparative analysis of the relationship between the producer and consumer price index of beef and chicken meat in South Africa from 1991 to 2018 was carried out and this chapter summarises the main findings of the study and based on the findings, this chapter gives policy recommendations to improve the meat industry.

6.2 Summary

The study was aimed at comparatively analysing the relationship between the producer and consumer price index of beef and chicken meat in South Africa from 1991 to 2018. The first objective was to compare the producer and consumer price index variability of beef to meat as well as chicken meat to meat from 1991 to 2018. The second objective was to determine the correlation between the producer price index of beef, chicken meat and the consumer price index of meat from 1991 to 2018. The third objective was to determine the causality relationship between the producer price index of beef, producer price index of chicken meat and the consumer price index of meat from 1991 to 2018. The fourth objective was to determine the short and long-run relationship between the producer price index of beef, producer price index of chicken meat and consumer price index of meat from 1991 to 2018.

The Coefficient of variation indicated that there was high variability between PPI beef as compared to CPI meat and a low variability between PPI chicken meat as compared to CPI meat during the entire period (1991-2018). The Pearson correlation results indicated that both CPI meat and PPI beef as well as CPI meat and PPI chicken meat had a strong positive relationship, and the scatter plots graph indicated the direction and magnitude of the relationship where all the variables moved in one direction.

ADF test results indicated that both PPI beef and CPI meat as well as PPI chicken meat and CPI meat variables were not stationary at level form. Variables were stationary once differenced. The maximum lag order and establishment as well as verification of the VAR model were determined. Furthermore, the maximum lag for CPI meat and PPI chicken was VAR (1) and for CPI meat and PPI beef was VAR (2) based on AIC. The AR roots charts indicated that all modulus points were all falling inside the circle and they were stable.

Johansen cointegration indicated that PPI beef and CPI meat as well as PPI chicken meat and CPI meat cointegrated. The impulse response functions indicated that there was short and long-term interference between PPI beef and CPI meat as well as PPI chicken meat and CPI meat. The VEC model results indicated a short and long-term relationship between CPI meat, PPI chicken meat and PPI beef. There was no short-run causality between the PPI beef and CPI meat, but there was causality between PPI chicken meat and CPI meat based on Granger causality test results. Pairwise Granger causality test indicated a unidirectional relationship from PPI chicken meat to CPI meat and no relationships between PPI beef to CPI meat, CPI meat to PPI beef as well as CPI meat to PPI chicken meat. Diagnostic tests indicated there was no serial correlation and heteroskedasticity between PPI chicken meat and CPI meat as well as between PPI beef and CPI meat which means that the results obtained from the study were accurately analysed.

6.3 Conclusion

The study concludes that based on the VEC results, there was a short and long-run stable relationship between PPI chicken meat and CPI meat as well as PPI beef and CPI meat. The coefficient error correction term is a negative value, which inversely corrects the next period of PPI beef and CPI meat as well as PPI chicken meat and CPI meat values. Thus, the aim of the study was achieved.

There were four hypotheses. Hypothesis one stated that there was no variability between the producer and consumer price index of beef to meat as well as the producer price index of chicken meat to meat from 1991 to 2018. Thus, it is rejected because the coefficient of variation indicated a variation between PPI beef and CPI meat as well as PPI chicken meat and CPI meat. Hypothesis two stated that there is no correlation between the producer price index of beef, chicken meat and consumer price index of meat from 1991 to 2018, which is rejected because the Pearson correlation results indicated that there was a strong positive correlation between PPI beef and CPI meat as well PPI chicken meat and CPI meat. Hypotheses three stated that there is no causal relationship between the producer price index of beef, producer price index of chicken meat, and the consumer price index of meat from 1991 to 2018. Hypothesis three cannot be rejected because Granger causality results indicated no causality from PPI beef to CPI meat. At the same time, hypothesis three is rejected because PPI chicken meat does Granger cause CPI meat in the short-run. Hypothesis four stated that there is no short and long-term relationship between producer price index of beef, producer price index of chicken meat and consumer price index of meat from 1991 to 2018 which cannot be rejected as the short and long-run relationships were identified.

6.4 Recommendations

The study recommends that the policy makers, through institutional arrangements such as the South African Reserve Bank, should continue maintaining a specific inflation target range through the inflation-targeting strategy framework and evaluate the monetary policies. Furthermore, effective input price control mechanisms should be improved if available and be introduced if they do not exist. This is because this study has proven that there is a short and long-run relationship between CPI meat and PPI chicken meat as well as CPI meat and PPI beef based on the VEC results in support of the impulse response functions results. This will assist in controlling input price inflation from beef and chicken meat producers in the short-run. Ultimately, producers of beef and chicken meat will be able to produce at a low cost of production. Consequently, meat prices in the long-run will be stabilised, resulting in low levels of inflation rate in the meat industry and economy at large. Thus, both the producers of (beef and chicken meat) and consumers will be protected against price instability as such that will give businesses opportunities to invest in the meat industry. This recommendation is further supported by the Pearson Correlation results that indicated a link between PPI beef and CPI meat as well as PPI chicken meat and CPI meat.

There is a unidirectional relationship between PPI chicken meat CPI meat based on Granger causality results. Thus, the study recommends that chicken meat producers should use CPI meat to predict inflation in the prices they receive for chicken meat and chicken meat products they produce when making price decisions. While there is an independent relationship between PPI beef and CPI meat, beef producers should develop predictive measures that will allow them to predict inflation in the average prices they receive for beef and beef products they produce. The predictions should continue to be on a monthly basis rather than on annual basis to allow short-term fluctuations to be captured and assist in speeding up the decision-making process as well as exploring more relationships between PPI and CPI of individual commodities.

6.5 Limitations of the study

The study of comparative analysis of the relationship between the producer and consumer price indexes of beef and chicken meat in South Africa from 1991 to 2018 had the limitation that there was no publicly available monthly data for PPI beef and PPI chicken meat. To overcome this limitation, this study opted to use annual data. Besides the limitation, the results and conclusions are still reasonable.

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APPENDICES

Appendix 1: Correlation analysis matrix results for CPI meat and PPI beef cattle

Correlation Probability	CPI_MEAT	PPI_BEEF_...
CPI_MEAT	1.000000	

PPI_BEEF_CATTLE	0.994701	1.000000
	0.0000	-----

Appendix 2: Correlation analysis matrix results for CPI meat and PPI beef

Correlation Probability	CPI_MEAT	PPI_CHICKEN
CPI_MEAT	1.000000	

PPI_CHICKEN	0.996431	1.000000
	0.0000	-----

Appendix 3: Maximum lag order p results for PPI beef and CPI meat

VAR Lag Order Selection Criteria
Endogenous variables: PPI_BEEF_CATTLE CPI_MEAT
Exogenous variables: C
Date: 12/14/21 Time: 22:08
Sample: 1991 2018
Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-203.2301	NA	24618.42	15.78693	15.88371	15.81480
1	-126.7559	135.3005	93.53192	10.21199	10.50232*	10.29560
2	-120.5658	9.999397*	79.63608*	10.04352*	10.52741	10.18286*

Appendix 4: Maximum lag order p results for PPI chicken meat and CPI meat

VAR Lag Order Selection Criteria
Endogenous variables: PPI_CHICKEN CPI_MEAT
Exogenous variables: C
Date: 12/14/21 Time: 22:11
Sample: 1991 2018
Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-196.7659	NA	14973.00	15.28968	15.38646	15.31755
1	-126.4281	124.4437*	91.20316*	10.18678*	10.47711*	10.27038*
2	-124.3662	3.330778	106.6772	10.33586	10.81975	10.47520

Appendix 5: Johannes cointegration results for PPI chicken meat and CPI meat

Date: 12/14/21 Time: 22:26
Sample (adjusted): 1993 2018
Included observations: 26 after adjustments
Trend assumption: Linear deterministic trend
Series: CPI_MEAT PPI_CHICKEN
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.482236	29.81330	15.49471	0.0002
At most 1 *	0.386410	12.69916	3.841465	0.0004

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.482236	17.11414	14.26460	0.0172
At most 1 *	0.386410	12.69916	3.841465	0.0004

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix 6: Johannes cointegration results for PPI beef and CPI meat

Date: 12/14/21 Time: 22:33
Sample (adjusted): 1994 2018
Included observations: 25 after adjustments
Trend assumption: Linear deterministic trend
Series: CPI_MEAT PPI_BEEF_CATTLE
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.314149	14.84730	15.49471	0.0624
At most 1 *	0.194907	5.419943	3.841465	0.0199

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.314149	9.427356	14.26460	0.2523
At most 1 *	0.194907	5.419943	3.841465	0.0199

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix 7: VECM results for PPI beef and CPI meat

Vector Error Correction Estimates
Date: 12/14/21 Time: 22:58
Sample (adjusted): 1995 2018
Included observations: 24 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
D(PPI_BEEF_CATTLE(-1))	1.000000	
D(CPI_MEAT(-1))	-1.084134	
	(0.11462)	
	[-9.45819]	
C	1.436376	
Error Correction:	**D(PPI_BEE...**	**D(CPI_MEAT,2)**
CointEq1	0.264940	1.372581
	(0.92011)	(0.61999)
	[0.28794]	[2.21388]
D(PPI_BEEF_CATTLE(-...	-0.644656	-0.764590
	(0.77255)	(0.52056)
	[-0.83445]	[-1.46879]
D(PPI_BEEF_CATTLE(-...	-0.218443	-0.474509
	(0.44310)	(0.29857)
	[-0.49299]	[-1.58928]
D(CPI_MEAT(-1),2)	-0.790392	0.037778
	(0.79760)	(0.53744)
	[-0.99096]	[0.07029]
D(CPI_MEAT(-2),2)	-0.483184	0.025686
	(0.53788)	(0.36243)
	[-0.89832]	[0.07087]
C	1.053840	1.094258
	(1.21387)	(0.81793)
	[0.86816]	[1.33784]
R-squared	0.629081	0.535597
Adj. R-squared	0.526048	0.406597
Sum sq. resids	567.6151	257.7148
S.E. equation	5.615529	3.783846
F-statistic	6.105634	4.151895
Log likelihood	-72.01520	-62.54012
Akaike AIC	6.501267	5.711677
Schwarz SC	6.795780	6.006190
Mean dependent	-0.274167	0.208333
S.D. dependent	8.156874	4.912001

Appendix 8: VECM results for PPI chicken meat and CPI meat

Vector Error Correction Estimates
Date: 12/14/21 Time: 23:58
Sample (adjusted): 1994 2018
Included observations: 25 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
D(PPI_CHICKEN(-1))	1.000000	
D(CPI MEAT(-1))	-0.773541 (0.15763) [-4.90735]	
C	0.301358	
Error Correction:	D(PPI_CHI...	D(CPI MEAT,2)
CointEq1	-1.980080 (0.48950) [-4.04514]	-0.341867 (0.44194) [-0.77356]
D(PPI_CHICKEN(-1),2)	0.131988 (0.30752) [0.42920]	-0.126112 (0.27765) [-0.45421]
D(CPI_MEAT(-1),2)	-0.377248 (0.35673) [-1.05753]	-0.444916 (0.32207) [-1.38143]
C	0.128994 (0.92375) [0.13964]	0.730386 (0.83401) [0.87575]
R-squared	0.706667	0.375214
Adj. R-squared	0.664762	0.285958
Sum sq. resids	437.6656	356.7595
S.E. equation	4.565219	4.121717
F-statistic	16.86368	4.203830
Log likelihood	-71.25571	-68.70079
Akaike AIC	6.020456	5.816063
Schwarz SC	6.215477	6.011083
Mean dependent	0.015200	0.372000
S.D. dependent	7.884702	4.877715

Appendix 9: Granger causality test results for CPI meat and PPI beef

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 12/17/21 Time: 20:33
Sample: 1991 2018
Included observations: 25

Dependent variable: D(CPI_MEAT)

Excluded	Chi-sq	df	Prob.
D(PPI_BEEF_CATTLE)	5.589458	2	0.0611
All	5.589458	2	0.0611

Dependent variable: D(PPI_BEEF_CATTLE)

Excluded	Chi-sq	df	Prob.
D(CPI_MEAT)	5.539070	2	0.0627
All	5.539070	2	0.0627

Appendix 10: Granger causality test results for CPI meat and PPI chicken meat

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 12/17/21 Time: 20:39
Sample: 1991 2018
Included observations: 26

Dependent variable: D(CPI_MEAT)

Excluded	Chi-sq	df	Prob.
D(PPI_CHICKEN)	1.593522	1	0.2068
All	1.593522	1	0.2068

Dependent variable: D(PPI_CHICKEN)

Excluded	Chi-sq	df	Prob.
D(CPI_MEAT)	11.98690	1	0.0005
All	11.98690	1	0.0005