An investigation of the long-run relationship between import tariff, import quantity, production, and prices in the broiler sector of South Africa (April 2010 – June 2020)

by

Nkgadima Kgothatso

MINI DISSERTATION Submitted in partial fulfilment of the requirements for the

Degree

of

Master of Science

in

Agriculture (Agricultural Economics)

in the

Faculty of Science and Agriculture

School of Agricultural and Environmental Sciences

at the

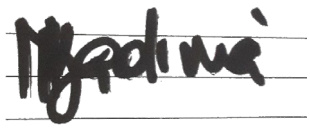
UNIVERSITY OF LIMPOPO

Supervisor: Dr. LC Muchopa

2022

DECLARATION

I, NKGADIMA KGOTHATSO declare that the mini-dissertation **(An investigation of the long-run relationship between import tariff, import quantity, production, and prices in the broiler sector of South Africa (April 2010 – June 2020))** hereby submitted to the University of Limpopo, in partial fulfilment of the degree Master of Science in Agricultural Economics has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.



16/02/2022

NKGADIMA K

Date

DEDICATION

This study is dedicated to my mother

ACKNOWLEDGEMENTS

Firstly, I express gratitude to God for being with me throughout my studies and for all the strength and courage to finish this study. I as well extend my genuine gratefulness and appreciation to my supervisor Dr. L.C Muchopa for all the support, guidance, and motivation. Your mentorship made it possible for me to complete this mini-dissertation and for that I am thankful.

Special thanks to my sponsor, Agri SETA, and Prof TP Mafeo as the Agri Seta-Grant holder for the financial support.

I extend my sincere appreciation to Gail Bradford from the Leading-Edge poultry software CC for providing me with broiler data needed in this dissertation and Izaak Breitenbach, the General Manager of the South African Poultry Association for permitting me to use their data for research purposes.

To my mom, thank you for your words of encouragement and prayers that carried me throughout my studies. To my siblings (Kgethego, Thapelo, Khomotso, Boitshepo, and Ponegelo), thank you for your love and support.

To my classmates, thank you for your backing and reassurance.

May God bless you!

ABSTRACT

The agricultural sector is dominated by broiler production and it is the key source of animal proteins followed by beef. South Africa is described as a net importer of chicken meat, given that broiler consumption of broiler is greater than supply. Additionally, the South African Poultry industry has raised concerns regarding the high influx of cheap broiler imports into the domestic market. This led to an increase of the ad valorem tariff charged on poultry imports in April 2020 from a previous adjustment in September 2013. It is vital to understand how import tariff changes affect the broiler sector since little is known about how domestic broiler production is responding to an increased tariff. The study, therefore, attempted to determine the relationship between domestic broiler production, import tariff, domestic prices, and import volume.

The study aimed to investigate the long-run relationship between import tariff, import quantity, domestic production, and prices (retail and producer) in the broiler sector of South Africa for the period (April 2010 – June 2020). Brazilian frozen chicken imports were selected for study given their relatively high domestic demand in South Africa. In addition, Brazil primarily faces the import tariffs charged by South Africa as the main country of origin for South African imports. The Augmented Dickey-Fuller test, Johansen Cointegration tests, and the Error Correction Model were used as analytical tools in achieving the study objectives.

The results for the Augmented Dickey-Fuller test and the Johansen cointegration test showed that all variables were stationary at first difference and cointegrated. The ECM results concluded the existence of a long-run relationship between domestic production, ad valorem tariff, and import volume. As the tariff charged changes, the domestic production increased by 4% in the long run which might be deemed a small advantage in terms of the production scale and therefore not sufficient. The study recommended that strategies that reduce barriers of entry for small-scale farmers such as reduced production costs be implemented to boost domestic production. Lastly, since domestic production is responding positively to tariff adjustment, a thorough investigation is necessary to prove dumping allegations against broiler importers as this will enable the country to impose anti-dumping duties on all countries.

Keywords: *frozen chicken, long-run relationship, ad valorem tariff, ECM*

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AIDS	Almost Ideal Demand System
AGOA	African Growth and Opportunity Act
AMIE	Association of Meat Importers and Exporters
BFAP	Bureau for Food and Agricultural Policy
DAFF	Department of Agriculture, Forestry and Fisheries
DTI	Department of Trade and Industry
ECM	Error Correction Model
ECT	Error Correction Term
EU	European Union
FPE	Final Prediction Error
HQ	HannaQuinn Information Criterion
IQF	Individually Quick-Frozen
ITAC	International Trade Administration Commission
NAMC	National Agricultural Marketing Council
OLS	Ordinary Least Squares
SAPA	South African Poultry Association
SC	Schwarz Information Criterion
SEE	Standard Error of Estimates
TDCA	Trade, Development and Cooperation Agreement
TREC	Turfloop Research Ethics Committee
VLOSC	VAR Lag Order Selection Criteria
WTO	World Trade Organization

CHAPTER ONE: INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Broiler production is a key producing sub-sector in South African agriculture and it is the source of animal proteins followed by beef and thus critical to the food security status of the country (Bureau for Food and Agricultural Policy (BFAP), 2019; South African Poultry Association (SAPA), 2016). Broiler production is practiced all over South Africa with North West and Mpumalanga being the main producing provinces. According to (DAFF, 2014), broiler meat is characterized by the highest per capita consumption compared to other sources of animal protein. It contributed about 20% of the total gross value of agricultural products and the poultry sector employs about 110 000 people (SAPA, 2019). Additionally, the poultry industry plays a vital role in agro-processing and it is a key force behind job creation and development (Ncube, 2018). It also offers the most affordable and ideal source of animal protein to South African households (BFAP, 2019; Nkukwana, 2018).

The South African poultry industry lies in the hands of very few commercial producers who operate in a vertically integrated setting whereby they account for the largest share in the value chain (Nkukwana, 2018; Goga & Bosiu, 2019; Louw *et al*., 2017). International trade and the economic growth of trading countries have a directly proportional relationship. Additionally, international trade affects the determination of exchange rates (Mkubwa *et al*., 2014). Trade policy in South Africa became more liberalized post-2008 but became more strategic post-2009 period to address the issues arising from trade liberalization (Kwaramba & Tregenna, 2014).

South Africa does not produce enough quantities of poultry to meet its domestic demand and hence the industry suffers from increased import competition (Department of Trade and Industry, 2017). The South African poultry industry presents numerous industrialization opportunities such as increased demand for frozen chicken portions. However, it might be difficult to fulfil those opportunities because imports for frozen chicken portions continue to rise too. Furthermore, the inability to respond to such opportunities may be attributed to the underlying domestic issues such as the high input costs that domestic producers are facing in South Africa (Goga & Bosiu, 2019).

Sub-Saharan Africa is the net importer of broiler meat while its consumption rate of poultry meat has been increasing during the period 2003 to 2015 (Ncube, 2018). Domestic broiler price is largely affected by high import volume from the Northern Hemisphere countries and Brazil. Countries from the European Union and Brazil produce broilers at very low cost and thus influence their prices as they are priced at a low range (Louw *et al.,* 2017). Moreover, South African broiler producers incur high input costs relative to Brazil and European Union countries and thus result in the imported poultry prices being very low and local producers being unable to compete with them (Banson *et al.,* 2015; Davids *et al.,* 2015).

There are different types of chicken imported into the country viz; frozen bone-in chicken portions, boneless chicken. Moreover, the South African Poultry Association (SAPA) reported in 2019 that, bone-in chicken portions represent almost 60% of total broiler demand in the country (SAPA, 2019). Each type is demanded by a different income group and demand is thus heterogenous. Disaggregation between broiler product groups will therefore provide more understanding of demand preferences and which income group is affected by increased import tariff. Delport *et al* (2017) claimed that meat products are heterogenous because different countries demand certain cuts relatively higher than other countries. Furthermore, this study focuses on frozen chicken imports due to their relatively high domestic demand and imports that have been pointed out in (Delport *et al.,* 2017). Consumers in the domestic market prefer bone-in products. This creates a market for larger foreign broiler producers since their domestic market i.e., the United States and European markets prefer breast portions, and consequently the large foreign producers supply bone-in chicken products to other countries at a lower price (SAPA, 2016).

Additionally, SAPA (2019) argued that a total of 4410 tonnes of poultry products were imported in 2019 which is an increase of 12,5% from 2018 with Brazil being the main exporting country in 2019. This led to an increase in *ad valorem* tariff charged on poultry imports as requested by the South African Poultry Association as a strategy to protect the domestic industry. The tariff rate for frozen chicken (HS code:020714) was recently increased by 25% from 37% to 62% and for boneless by 30% from 12% to 42% (Jooste, 2020). An *ad valorem* tariff levied on imports leads to an upward shift in the supply curve causing an increase in prices from the free trade market equilibrium in the domestic market. The levied tariff creates a loss for consumers through the

distortion of consumer surplus (Mohr, 2015). However, the foreign country loses as an amount of their product surplus that is transferred to the domestic government through tariff income (Addresson, 2019). Moreover, the level of tariff should not burden the poor household while improving the competitiveness of the domestic producers.

An increased level of protection will assure producers in the industry of great return on investment and thus will attract more producers into the poultry industry (Addresson, 2019). Nevertheless, the European Union (EU) and the United States of America (USA) can export to South Africa tariff-free due to the Trade, Development, and Cooperation Agreement (TDCA) and the African Growth and Opportunity Act (AGOA) respectively and therefore likely to reduce the effect of high tariffs on domestic chicken prices (Davids *et al., 2015*). This study will, therefore, focus on broiler imports from Brazil since it highly accounts for South African broiler imports that are affected by import tariffs (SAPA, 2019). Likewise, it is unknown to what extent will that protection be maintained and how will it affect both domestic producers and consumers of broiler meat in the country.

1.2. PROBLEM STATEMENT

The South African poultry industry contributes approximately 20.9% to the total gross agricultural production value (SAPA, 2018). However, according to the South African Poultry Sector Master Plan, 2019, there has been an observable lack of growth in poultry production pre- and post-2008. Resultantly, The Department of Trade and Industry has lately categorised the broiler sector as a sector at high risk of failure with the rising feed costs and increasing cheap imports being the main alleged sources of this distress (Davids & Meyer, 2017; Lemmer & Bowen, 2019). The South African Poultry industry has raised concerns regarding the high influx of cheap broiler imports into the domestic market. This led to an increase of the *ad valorem* tariff charged on poultry imports in April 2020 from a previous adjustment in September 2013 (Jooste, 2020). Increased import tariff increases the cost of importing and thus level the playing field for the domestic producers since it permits them to compete with foreign producers (DAFF, 2019).

Import duties were increased in 2020 from the previous adjustment of 2013 following SAPA'S request for an increase in import duties on selected frozen chicken products. SAPA based their request on concerns about the survival of the domestic broiler

production and possible job losses following a high influx of imported frozen chicken products. However, other studies and trade bodies argue that the industry's issues are of domestic origin and tariff increases will not solely solve those issues. Additionally, Fourie (2014) argued that increased tariffs may be a short-term solution to the poultry industry however with dire consequences to the poor consumers. Strategies applied to reduce food price volatility largely depend on how they are implemented and the government's ability to implement them. High government involvement has resulted in the inability to attain the desired results of food price stability (Gitau & Meyer, 2018). Moreover, price volatility is very high in markets with high government interventions (Jayne, 2012).

The study attempted to determine the long-run relationship in the broiler sector, how changes in import tariff affect domestic broiler volume products and later domestic prices. According to Mkhabela & Nyhodo (2011), poultry farm-retail price transmission is symmetric whereby changes in farm price results in similar price change in retail prices. Moreover, the domestic broiler prices are more responsive to import parity price variations which refer to prices that consumers are willing to pay for imported products than changes in feed prices (Davids & Meyer, 2017). It is thus crucial to understand how import tariff changes affect the broiler sector since little is known about how domestic broiler production is responding to tariff adjustments.

1.3. RATIONALE OF THE STUDY

Poultry is the cheapest, leading protein source and a means of improving the welfare of both rural and urban dwellers hence its consumption has been increasing over the years (BFAP, 2017; SAPA, 2018). Given the country's substantial reliance on chicken imports, the broiler industry has faced government intervention in terms of import tariffs intended to protect it from cheaply priced imports. An adjustment of import policy through an increase in *ad valorem* tariff levied on imports leads to an upward shift in the supply curve or a fall in supply causing an increase in consumer prices from the free trade market equilibrium in the domestic market as outlined by economic theory (Mohr, 2015). However, there is limited literature to support whether economic theory tallies with the actual behaviour of the domestic broiler industry which continues to be under threat (Phillips, 2020). Moreover, the increase in the level of tariff should not

burden the poor household while improving the competitiveness of the domestic producers (Davids, 2014).

This study contributes to the pool of knowledge by showing how increased tariffs affect local broiler production and domestic prices. The study is broiler-based and will thus provide literature essential for broiler industry-based policies. Some of the studies conducted used annual data and according to Vavra & Goodwin (2005), it is advisable to use both monthly and annual data if the time it takes to adjust to shocks is unknown. The study will provide recommendations that may act as the basis for encouraging investment in the sector and policy reformulation. Broiler-based policies can be targeted to reduce pressure from an increase in relatively cheaper imports and rising domestic feed costs. The findings of the study will further offer an improved understanding of the association between domestic and imported broiler products for the preservation of jobs in the domestic broiler industry. This will make a significant contribution to food security and preserve the sector.

1.4. AIM AND OBJECTIVES

1.4.1. Aim of the study

To investigate the long-run relationship between import tariff, import quantity, domestic production, and prices (retail and producer) in the broiler sector of South Africa for the period (April 2010 – June 2020).

1.4.2. Objectives

The objectives of the study are to:

1. Assess the stationarity and order of integration of the variables: import quantity, domestic broiler production and prices (producer and retail), and import tariff charged.
2. Analyse the existence of cointegration among the variables: broiler import quantity, domestic broiler production, domestic retail, and producer broiler prices, and import tariff charged.
3. Determine the long-run relationship between broiler imports quantity, import tariff charged, domestic broiler production, producer prices, and retail prices in South Africa for the period (April 2010- June 2020).

1.5. HYPOTHESES OF THE STUDY

1. The residuals of domestic broiler production, retail, and producer prices import tariff charged and total import quantity have a unit root. Its time series is non-stationary.
2. Cointegration does not exist among the variables: broiler import quantity, import tariff charged, domestic broiler production, and domestic retail broiler and producer prices.
3. There is no long-run relationship between broiler imports quantity, import tariff charged, and domestic broiler production and retail broiler and producer prices in South Africa for the period (April 2010 - June 2020).

1.6. ORGANIZATIONAL STRUCTURE

This study has five chapters, following this introductory chapter is a review of literature on the South African poultry industry and previous studies in South Africa and other parts of the world. The third chapter is about the methodology and analytical techniques employed including the description of the study area. Chapter four outlines the empirical findings of the study while the last chapter completes the study, by providing a summary, conclusions, study limitations, and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter outlines existing literature regarding the South African poultry industry and how international trade has affected the industry and the broiler sector over the years. This introduction is followed by general background and definition of the key concepts of the study. The definition of key concepts is followed by an outline of the South African Poultry Industry and a review of previous studies and lastly, a summary of the literature reviewed is presented.

2.1.1. General Background

David Ricardo (1817) outlined that a mutually beneficial trade between two countries will only occur if each country specializes in the production of commodities and trades with commodities, they produce at the lowest cost possible. Trade openness promotes efficient use of resources given the state of technology and thus makes the world to be better than before. Nevertheless, trade openness should be supported by appropriate macroeconomic policies, good management, and improved market access to produce a positive outcome on economic growth (Mkubwa *et al*., 2014). Moreover, international trade barriers tend to reduce the technology transfer between countries and could thus lead to technological backwardness by preventing competition for the domestic industry. Lack of competition will thus lead to a reduction in consumer surplus, protects inefficient broiler producers at an expense of economic welfare, and poor consumers who are more likely to rely on chicken for animal protein since it is cheaper than other meat products or animal protein sources such as beef (Davids & Meyer, 2017).

The world broiler sector is facing numerous challenges such as an increase in concerns about food quality, caring for the environment, and climate change. Consumers are now more concerned about ecological preservation and healthy eating and thus influence how broiler products are produced. With developing countries being exposed to the international market through trade liberalization, smallholder broiler producers are mostly to be hit hard due to their undeveloped production and marketing systems (Chang, 2007). Therefore, trade protection is necessary to stimulate growth and boost food security since the poultry sector has the potential to subsidize food trade surplus in the forthcoming years (Elsedig *et al.,* 2014). Developing countries

have shown substantial growth of both the demand and supply of broiler and thus implicate international exchange of meat products and production inputs of the broiler.

2.2. DEFINITION OF KEY CONCEPTS

2.2.1. Long-run relationship

A long-run relationship results when variables are integrated of a similar order for instance at levels or first differences. A long-run relationship between variables can be defined as variables that have the same trend and move closer together in the long run (Von Cramon-Taubadel & Fahlbusch, 1994). A long-run period is a period where all variables are not fixed and can be altered by external shocks or stimuli (Vavra & Goodwin, 2005).

2.2.2. *Ad Valorem* tariff

Ad valorem tariff refers to a tax amount that is charged as a percentage of the value of the product (Mohr, 2015). *Ad valorem* charged on poultry products should adhere to the terms and conditions of the World Trade Organisation and it is administered only if there is a need to protect domestic industry against a high influx of poultry imports. *Ad valorem* tariff distorts the market in the sense that it increases the equilibrium price of products and it creates a loss for consumers through the distortion of consumer surplus and transfers income to the government (Mohr, 2015).

2.2.3. Anti-dumping

Dumping occurs when producers sell their produce at prices lower than their cost of production in the foreign market or at a price than in their origin market. Dumping refers to selling products in a foreign or importing country at a low than normal price (Saloni, 2016). Dumping is against WTO rules as it reduces competition and leads to market imperfection. Anti-dumping refers to procedures or duties imposed on imports to protect domestic industry against unfair international trade for instance when foreign producers export their products at a lower price, that is below the market price and thus hinders domestic producers' ability to compete in the market (NAMC, 2021). Anti-dumping duties are therefore meant to protect the industry as it increases the cost of importing equivalent to the domestic market price. However, the anti-dumping measure can only be implemented if it is proven that dumped imports negatively affect the domestic industry (Saloni, 2016).

2.3. An overview of the South African Poultry Industry

The poultry industry contributed approximately 20% to the gross agricultural value production in 2019 making it the largest contributor (BFAP, 2019). South African agriculture is dualistic, whereby at one extreme some commercial farmers produce at a large scale, and at the other extreme, there are small-scale subsistence farmers. Broiler production is no exception as its structure is dualistic, with subsistence farmers who target the informal sale of live chickens at one end and large-scale commercial farmers on the other end of the range (Jayne, 2012). Table 1 shows the total number of chickens produced in each province as of December 2017.

Table 1: Provincial broiler production in South Africa

Province	Broiler birds	
		%
Eastern Cape	7 508 361	7.2
Free State	6 943 844	6.7
Gauteng	11 104 107	10.7
KZN	6 696 594	6.4
Limpopo	2 343 780	2.3
Mpumalanga	23 265 356	22.4
North West	24 286 311	23.4
Northern and Western Cape	21 746 385	20.9
Total	103 894 738	100

Source: SAPA, (2017)

The North West province was the highest producing province in 2017 as it accounted for 23.4% of the total chicken volume produced. Mpumalanga was the second most producing province at 22.4% hence both provinces accounted for over 45% of South Africa's total chicken production (SAPA, 2017).

The poultry industry is oligopolistic since its two large producers namely Astral foods and RCL Foods account for the highest market share (Goga & Bosiu, 2019). Goga & Bosiu (2019) further outlined that these two firms controlled about 46% of the poultry industry in 2018 i.e., they had a market share of about 46% with Astral foods being the leading producer in the same year. These two firms (RCL and Astral foods) can exercise their monopolistic power (Ncube & Zengeni, 2016). The oligopolistic nature of the industry makes it likely to collude. (Goga & Bosiu, 2019).

Additionally, the broiler sector is largely dominated by contractual agreements such as contract growers which account for 60-80% of the total domestic broiler production (Bosiu *et al*., 2017). Most smallholder farmers in the country are contract growers whereby they work under contract with production and processing firms to raise and sell chickens to them. Such agreements limit growth in the industry as they reduce the level of competition between chicken producers. In support, Mkhabela & Nyhondo (2011) indicate that the South African poultry industry lacks regulation, and very few large firms dominate the market thus have power over small producers. High market concentration thus increases the inequality in the market and the dualism in the agricultural sector (DAFF, 2014). High concentration may also be attributed to an uneven distribution of market share and market information, and high feed costs which act as a barrier to entry into the market.

Feed prices have been increasing since 2010 which negatively affects the broiler industry. Moreover, producer prices do not respond directly to an increase in feed price resulting in a cost-price squeeze (Davids & Meyer, 2017). Increasing feed prices can be attributed to the 2016 drought which reduced the volume and quality of maize and soybean produced in the country. South Africa relies on imports to meet its soybean demand which also affects the price of feeds (BFAP, 2019; SAPA, 2017). Moreover, feed prices are at most 70% of the overall cost of broiler production incurred (Bagopi *et al*., 2014). Feeds costs account for the highest cost of production and thus have a high influence on the retail price of chicken and the food security status of the country (Goga & Bosiu, 2019).

Since South Africa is a net importer of soybean and does not produce sufficient soybean to meet its domestic demand, the poultry industry rely on imported soybean as one of the main ingredients in broiler feed, the global supply of soybean thus influences total broiler production and domestic broiler prices (Goga & Bosiu, 2019). Being a net importer also explicates that the exchange rate has a direct effect on the competitiveness of the sector and since Rand has been depreciating over the years, uncertainties in the feed market have been increasing too (BFAP, 2019).

Electricity outages, competition from imports, and consumer preference for imported poultry meat are some of the constraints to the industry's development (Banson *et al.,* 2015). The local broiler producers are faced with continuous cost price squeeze as

the producer price of broiler remains constant with feed cost being on the rise because soybean is largely imported thus subjected to fluctuations in the exchange rate. High feed cost remains a concern since the long-run sustainability of chicken production is reliant on the feed market, yet there are uncertainties experienced in the feed market (Davids & Meyer, 2017). Moreover, most challenges in the sector arise from the inefficiencies that are prevalent in the sector such as high input costs, high cost of electricity, and frequent power cuts. Such challenges widen the gap between domestic demand and supply and thus create a market for poultry imports.

The difference between South Africa and leading global exporters for instance Brazil and the United States of America is that these countries can produce at minimal costs whereas South Africa relies on imported products for feeds which escalate its costs of production. Input costs influence the competitiveness of South Africa's broiler industry relative to large poultry exporters (BFAP, 2019). Production costs in South Africa are higher and have been increasing as compared to leading producers like Brazil and the United States. These countries are the leading producers of broiler and they are also surplus producers of soybean (Goga & Bosiu, 2019).

Domestic producers' ability to compete on a global scale depends on their ability to produce at minimal costs. Therefore, high production costs remain an issue in the poultry industry and thus leave domestic poultry producers at a comparative disadvantage (Goga & Bosiu, 2019). Brazil has a comparative advantage in producing chicken as compared to South Africa since the latter depends on soybean imports for chicken production (Goga & Bosiu, 2019). Both countries will be better off if south Africa imports chicken from Brazil. Nevertheless, the broiler sector plays a substantial part in South Africa in terms of employment and food security which tends to justify why the industry needs protection (Goga & Bosiu, 2019).

According to Delport *et al* (2017), meat products are heterogenous because they are valued differently and cater to the needs of different income-categorised consumers. consumers in the European countries demand high valued meat portions such as chicken breasts and wings whereas those in African countries demand low valued chicken portions such as bone-in drumsticks. Therefore, international trade occurs to maximize total carcass worth by selling different meat portions in different areas due to different demands in those countries. Trade between countries enables farmers to

take advantage of demand differences and prices. South Africa engages with different countries as it imports poultry mainly from the European Union and America. Figure 1 shows different country sources of poultry imports in South Africa.

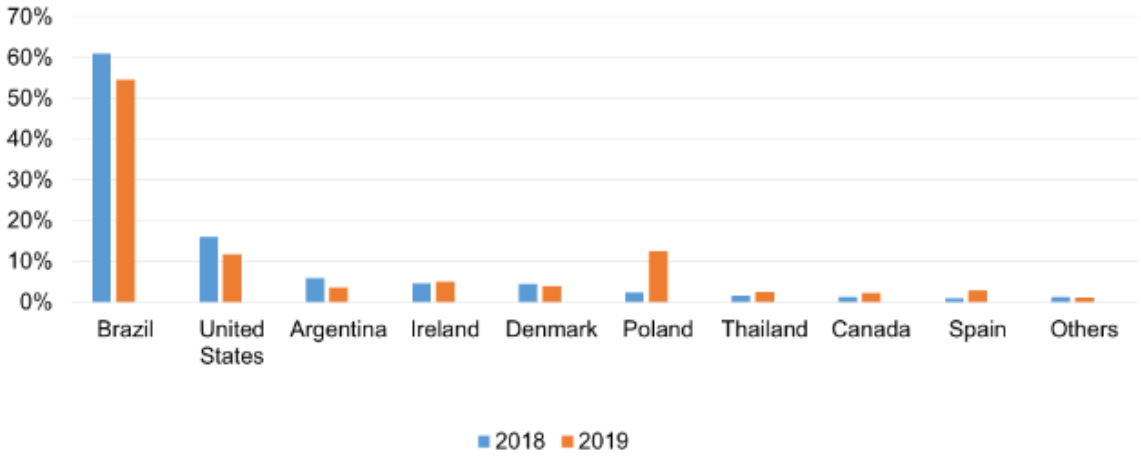

Figure 1: Sources of poultry imports in 2019

Source: SAPA, 2019

Brazil was the main source of poultry imports in both 2018 and 2019 whereby it accounted for over 54% of poultry imports in 2019 and 60% in 2018. The United States of America was the second exporting country as it imported over 10% of poultry imports in 2019 and 15% in 2018. Hence Figure 2 illustrates broiler imports from Brazil as the main exporter of Poultry products to South Africa.

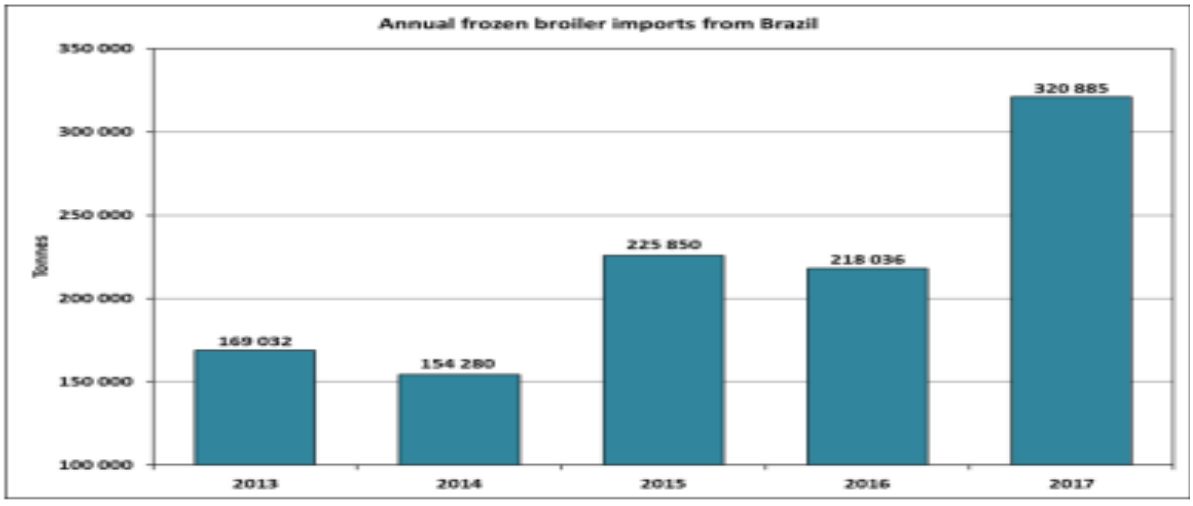

Figure 2: Annual frozen broiler imports from Brazil.

Source: (SAPA, 2017).

Frozen broiler imports from Brazil have been increasing over the years. Broiler imports from Brazil contributed about 61,3% of total frozen broiler imports in 2017. This justifies the recent increase in the tariff charged on broiler import (SAPA, 2017). According to Bowen & Rautenbach (2020), the average price of frozen birds is R25.39/kg which is an increase of 2.0% and fresh whole birds are now sold at R25.00/kg which is an increase of 1.4%. Individually Quick-Frozen (IQF) poultry prices were 0.5% higher at R23.69/kg on week-on-week data.

Price hikes will likely downgrade the accessibility and utilization of chicken and thus likely reduce aggregate demand in the long run. This highlights that import volume is also subjected to other factors especially in the year 2020 as the COVID-19 pandemic disrupted international and supply systems of fresh produce such as fresh chicken, milk, and horticultural products. Local poultry producers are still facing issues such as lower live bird mass as values of key feed grains such as maize and soybeans continue to increase due to the high level of uncertainty in the feed market (Bowen & Rautenbach, 2020).

2.4. Trade agreements affecting the South African broiler industry

2.4.1. African Growth and Opportunity Act (AGOA)

African Growth and Opportunity Act is a trade preference region aimed at promoting economic development in Sub-Saharan Africa and it was formed in 2000. Sub-Saharan countries that are part of these trade agreements can export goods to the United States at free costs or are not subject to import duties (Frazer & van Biesebroeck, 2010). However, the member countries are subjected to annual reviews which assess their economic, political, and development progress since only developing countries with political stability and respect for human rights are given preferential trade rights (de Melo & Portugal-Perez, 2014). In exchange for access to the United States markets, South Africa allows US producers to export 65 000 tonnes of bone-in chicken duty-free. AGOA has recently been extended to 2025 but this extension had resulted in an increase in quota for the bone-in frozen chicken to the South African market to 69 972 tonnes and thus exposes producers to competition (Eckart, 2016).

2.4.2. Trade Development Cooperation Agreement (TDCA)

Trade Development Cooperation Agreement (TDCA) is a bilateral trade agreement between South Africa and the European Union (EU), and it was enacted in 1999. This trade agreement enables the EU to export into the South African market duty-free on certain products including chicken products (DAFF, 2009). This agreement was enacted in response to consumer preference since European consumers mainly prefer chicken breasts. Therefore, this creates a market for EU producers to supply South Africa with other chicken portions such as leg quarters that represent an unwanted surplus in their EU member countries of origin. Over 80% share bone-in portions originated from the EU between the period 2013-2015 and it entered tariff-free through the TDCA. However, not all countries in the European Union are given access to the South African market since the outbreak of the highly pathogenic avian influenza (HPAI) in Denmark, France, Germany, Hungary, the Netherlands, and Poland. Moreover, it was also proven that other companies in the United Kingdom, the Netherlands, and Germany were dumping chicken in South Africa and were therefore subjected to pay anti-dumping duties.

2.5. Review of previous studies

2.5.1. Review of studies in the poultry sub-sector of South Africa and elsewhere

Jayne (2012) conducted a study to explore possibilities for assimilating small-scale farmers into the commercial broiler sub-sector of South Africa. The study revealed that a production ceiling exists in the broiler value chain mainly due to demand and supply considerations of commercial and small-scale farmers. Small scale farmers have limited access to resources and credit and their target market is less sophisticated as compared to commercial farmers.

Davids & Meyer (2017) used time-series data to analyse the cointegrated long-run relationship between the wholesale price of chicken, imported chicken prices, feed, and beef prices. The study evaluated the competitiveness of South African chicken production in a global production setting. The results of the study revealed that domestic chicken prices are more responsive to import parity price alterations than changes in feed prices. Therefore, adjustments on trade policy governing the agricultural sector tend to have more influence over domestic chicken production. This study differs from Davids & Meyer (2017) in that it merged exchange rate into the

system or analysis mainly because soybean is imported and therefore affect the price of feeds and it focused on how domestic products react or adjust following an increase in import tariff rather than the competitiveness of the chicken industry.

Delport *et al* (2017) evaluated the demand for meat in South Africa by estimating an Almost Ideal Demand System (LA/AIDS). The study mainly focused on poultry as a major source of protein in South Africa and categorized it into two groups mainly Individually Quick-Frozen portions and others. The findings of the study revealed that both two categories of poultry meat are demand elastic and are luxury products. The authors explained that this is because most of the population is poor and mainly relies on poultry for protein diets and are, therefore, more likely to reduce expenditure devoted to poultry since meat is a luxury product to poor communities. Moreover, the poor and marginalized groups of people in the country are most likely to be hit hard when broiler prices increase as they solely rely on broiler products for animal protein (Mkhabela & Nyhodo, 2011).

A study by Kwaramba & Tregenna (2014) combined institutional and empirical analysis while being specific to the Harmonised System (HS) 6-digit tariff lines. Its uniqueness provided the information necessary for micro-level development. However, it focused on how tariff decisions are made in addition to the development of South Africa's trade policy, and the International Trade Administration Commission (ITAC)'s role in that process. Hence there is a gap in post tariff analysis, for instance how domestic prices respond from an empirical analysis in the broiler industry's point of view.

Saloni (2016) in the study "the determination of injury in South African anti-dumping investigations: recent approaches" highlighted that determination of injury and causality is important in anti-dumping investigations. Their study was about WTO consultation whereby Brazil confronted the anti-dumping procedures of South Africa. The study aimed to analyse investigative procedures of the ITAC, and the findings of the study revealed that ITAC is continuously failing to prove whether causality exists between dumped imports and injury to domestic industries. The study concluded that ITAC is ineffectual concerning injury determinations.

Karodia (2017) Identified the origins of the poultry industry's state of collapse through critical analysis of issues faced by the South African poultry industry. According to this

study, the poultry industry's failure is attributed to a lack of policy consistency, high uncertainty level, and lack of organization in the poultry value chain. The study argued that high import tariffs will not solve all industries' reasons for the collapse. Hence the South African economy needs to change to bring about economic development to its citizens. Moreover, Hejazi *et al* (2017) used a multinomial logit model to evaluate the effect of tariff changes on agri-foods imports. The results of the study revealed that tariff reductions provide a small increase in sustaining current trade relations.

Goldar *et al* (2012) assessed "the impact of the Doha Round of agricultural trade reforms on India's trade in agricultural products". The findings of this study indicated that tariff reductions will affect both imports and exports of agricultural products. India's exports of agricultural products will increase by 2-4% whereas imports will increase by 1% following a decrease in agricultural tariff rates. Nonetheless, the overall effect of tariff reductions on India's agricultural exports and domestic production is unlikely to be large.

Banson *et al* (2015) established a poultry project through the Biotechnology and Nuclear Agricultural Research Institute (BNARI) to examine the performance of poultry production and marketing in Ghana. The findings of the study discovered that a high feed conversion ratio could be the major contributing factor to the reduction in poultry production costs since feeds account for at least 70% of the total production costs. The study later emphasised the need for improved government intervention and policy enforcement to protect the domestic poultry industry.

Peterson & Orden (2005) used a partial equilibrium spatial model to assess the effect of sanitary barriers on the poultry international trade. The study found a significant effect of sanitary and other non-technical barriers to trade on world markets. The study highlighted that removal of non-technical trade barriers will expand global trade by at least 25%. In addition, the categorization between high-value poultry products (breasts and wings) and low-valued dark meat (drumsticks and thighs) is necessary for trade since consumer preference differs in both the northern and southern hemispheres. Such preference results in other countries mainly exporting dark meat such as European countries and others importing dark meat such as South Africa in response to consumer preference relative to domestic production (Peterson & Orden, 2005).

Rasaga *et al* (2020) studied the projections for improving the competitiveness of food that is domestically produced in West Africa with a focus on rice, chicken, and tilapia. The study found that consumers associate rice imports with quality and therefore prefer imported rice to domestically produced rice. The authors indicated that consumers are in favour of locally produced chicken and tilapia due to their freshness. Therefore, domestic tilapia and chicken could be competitive and import substitution policies would be effective if production and processing costs are minimized since they have a natural advantage of freshness as compared to imported produce.

Arnade & Davis (2019) analysed "The effect of Mexican policy and market changes on imports of U.S. broiler meat and feed products" using a two-stage Almost Ideal Demand System (AIDS) model. The study found a complementary relationship between broiler meat in Mexico and the USA. The study further outlined that as USA broiler meat prices increase due to tariffs, broiler meat demand in Mexico will also decline. Likewise, Bett *et al* (2012) also found a complementary relationship between domestic poultry meat and broiler meat imports in Kenya.

2.5.2. Review of the empirical literature on price transmission studies

Mkhabela & Nyhondo (2011) used Houck and Error Correction Model (ECM) to analyse farm-retail price transmission of poultry in Africa utilizing price data from 2000 to 2010. The study revealed that farm-retail price transmission of poultry in South Africa is symmetric. Moreover, the study further revealed that the retail price of poultry adjusts more to changes in decreasing farm prices. In addition, Serra, & Goodwin (2003) conducted a study on price transmission in the Spanish dairy sector. The findings of this study revealed that the Spanish dairy sector is symmetric since it is highly perishable.

Moreover, Vavra & Goodwin (2005) used a threshold vector Error Correction Model to identify possible non-symmetric price responses in the U.S. beef, chicken, and egg markets. The findings of this study revealed that an asymmetric price transmission exists in these markets. The study further highlighted the significance of the speed and magnitude of such adjustments.

Boetel & Liu (2010) analysed the retail-wholesale-farm price relation in the US beef and pork markets. Due to the study's results, the authors reaffirmed the relevance of

having structural breaks when analysing vertical price transmission relationships. Additionally, Adachi & Liu (2009) used monthly Japanese retail pork and farm price time-series data to assess the significance of permitting structural breaks in introductory data analysis studies through stationarity and cointegration tests. The study identified four structural breaks within the study period 1967 to 2008 which are accounted for through production costs changes, economic and trade regime changes.

Hatzenbuehler *et al* (2016) examined corn and soybean price responsiveness to exchange rates. Error Correction Model was used to test the hypothesis that agricultural commodity prices' high responsiveness to exchange rate is attributed to supply use factors such as limited stocks and policy shifts as they cause inelastic market demand. The empirical results of the study revealed that indeed corn prices are very reactive to variations in exchanges rate during a low stock period and soybean prices are very reactive to variations in supply-use factors or policy adjustments.

Chen & Saghaian (2016) used monthly data from 3 countries, namely Thailand, Vietnam, and the United States of America to investigate market integration and asymmetric price transmission in the international rice market. The results obtained from the Johansen test and threshold vector error correction model revealed that export rice price in all three countries is cointegrated and Vietnam prices react fast to long-run equilibrium. The study further revealed that market integration exists between these markets with Thailand and the United States of America being the price leaders in the international rice market.

2.6. CHAPTER SUMMARY

This chapter consisted of an overview of the South African Poultry industry and reviewed previous studies. The South African poultry industry is extremely concentrated with feed accounting for over 70% of total inputs costs. This indicates that grain producers have an influence on market price and could therefore have power over the industry. Moreover, there has been an influx of frozen broiler products which led to import broiler adjustments. However, this contradicts some of the trade agreements that South Africa has with top poultry producers in the world.

CHAPTER THREE: METHODOLOGY AND ANALYTICAL PROCEDURES

3.1. INTRODUCTION

This chapter provides the methodology and analytical tools used to achieve the study objectives. It has 8 sub-sections, with the first one being this introduction, followed by an overview of the study area (South Africa). The third and fourth sub-sections narrate the data collection methods and analytical tools used in the study. Sub-section five defines the variables used in this study whereas sub-section six introduces diagnostic methods used in the study and the last two sub-sections provide a discussion about ethical clearance and chapter summary.

3.2. STUDY AREA

The study was conducted in South Africa which is in the southern part of Africa and its neighbouring countries are Namibia, Botswana, Mozambique, Zimbabwe, eSwatini, and surrounding the Kingdom of Lesotho. The study focused on broiler imports from Brazil as the main broiler exporter that is affected by ad valorem broiler tariff adjustments. Broiler meat is produced all over the country with Mpumalanga and North West being the main producing provinces as shown in Figure 3.

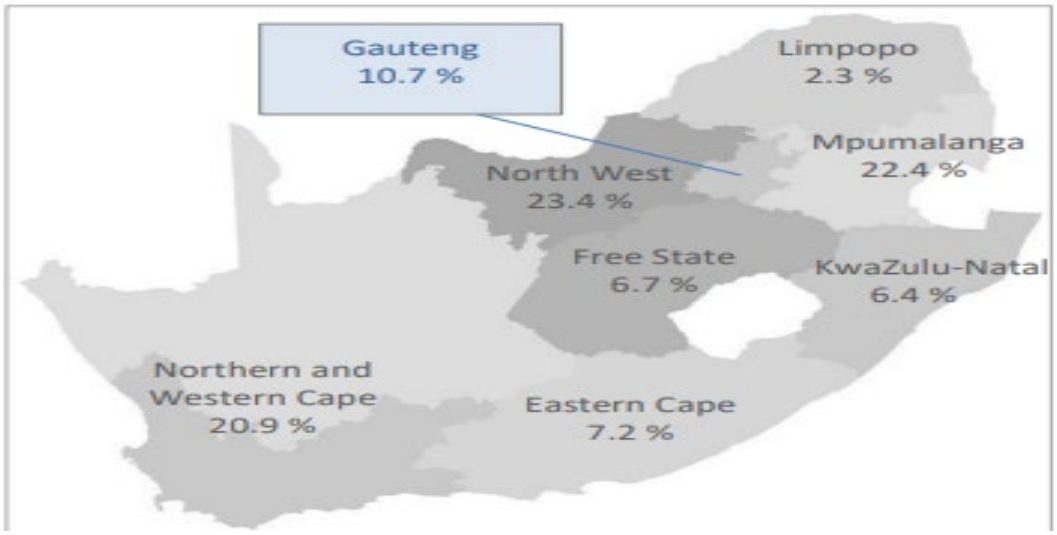

Figure 3: Distribution of broiler flock in South Africa (December 2017).

Source: SAPA (2017)

North West and Mpumalanga had the largest broiler flock in 2017 and thus making them the largest broiler producers in 2017 (SAPA, 2017).

3.3. DATA COLLECTION

The study used monthly secondary data covering the period of 122 months (April 2010 to June 2020). The data (Table 2) was attained from the SAPA, Standard Bank database, and ITC TRADEMAP. The period was appropriately chosen given the changes that became prevalent post the 2008 recession in South Africa. Kwaramba & Tregenna (2014) argued that the South African trade policy became more strategic post-2009 in the sense that trade policies were adjusted to suit each industry and protect domestic production. Therefore, data before 2009 will cause a disparity in analysis and thus have an impact on the empirical results of this study. The study also focused on broiler imports from Brazil since it is a leading exporter to South Africa which is highly affected by the recent tariff adjustments. Lastly, the study used EViews 12 software to analyse the data. Table 2 presents the list of data variables and their sources.

Table 2: List of data variables and sources.

Dependent variable: domestic broiler volume	South African Poultry Association (SAPA)
Independent variables	
Feed price index	South African Poultry Association (SAPA)
Retail price	South African Poultry Association (SAPA)
Producer price	South African Poultry Association (SAPA)
Exchange rate	Standard Bank database
Import broiler volume: 020714 Frozen cuts of broiler chickens (*Gallus domesticus)*	ITC Trademap
Import tariff charged	South African Poultry Association (SAPA)

3.4. ANALYTICAL TECHNIQUES

Econometric methods were used to analyse the data and quantify the relationship between the factors under study. The tests performed on the data together with the techniques used to analyse the data are discussed below.

3.4.1. Stationarity test

An Augmented Dickey-Fuller unit root test was conducted to assess the properties or features of the collected time series data (Vavra & Goodwin, 2005). Non-stationary data have a unit root and thus change over time resulting in relationships among variables being without economic meaning, even when significant (Nkoro & Uko, 2016).

The existence of unit root in secondary data indicates that exposure to external shocks may ultimately alter the pathway of variables. Time series is stationary in the mean value if it does not exhibit an increasing or decreasing design or trend. The Augmented Dickey-Fuller test was used to identify whether the error terms are stationary and thus signifies that the variables under study may have a long-run relationship and are stable around the mean value (Vavra & Goodwin, 2005). The general model together with the specific model used to test the relationship are indicated below:

General model: $\Delta Y_t = \alpha + \beta t + \partial Y_{t-1} + u_t$ equation (3.1)

Specific model: $\Delta DVt = \alpha + \beta t + \partial DV_{t-1} + \partial_1 \Delta DV_{t-1} + .. + \partial_n \Delta DV_{t-n} + u_t$ *(3.2)*

Where: DVt is domestic broiler volume produced at time t and $\Delta DVt = DVt - DV_{t-1}$

u_t is the disturbance term

$\alpha, \beta, and\ \partial$ are the parameters or coefficients

H_0: ∂=1 or 0 (not stationary)

H_1: -1 <∂ < 1 (stationary)

If ∂=1 or 0 then DVt is not stationary and the null hypothesis will be accepted. The null hypothesis postulate that domestic broiler volume does not have a unit root and the alternative hypothesis states that domestic broiler volume has a unit root and is non-stationary. The null hypothesis of non-stationary will be accepted if the p-value is greater than 5% or when the ADF statistic is less than the critical value. Since all variables are stationary at the first difference, the Johansen cointegration test was conducted to determine the long-run relationship between variables. Furthermore, the optimum lag length was estimated before the Johansen Cointegration test (Brook, 2008).

3.4.2. Lag order selection criteria

The study adopted the Vector Autoregressive (VAR) Lag Order Selection Criteria to estimate the ideal lag length to use in the Johansen cointegration test and Error Correction Model. The VAR Lag Order Selection Criteria uses the following measures: Schwarz Information Criterion (SC), Final Prediction Error (FPE), Sequential Modified LR test statistic, HannaQuinn Information Criterion (HQ), and the Akaike Information Criterion (AIC). However, (AIC) and (SC) are frequently used due to their high efficiency (Brooks, 2008). This study, therefore, adopted AIC to select the optimum lag number to use in the Johansen Cointegration test and ECM.

3.4.3. Cointegration test

Engle & Granger (1987) defined cointegrated variables as variables that move together in the same wavelength. A cointegration relationship can signal a long-term relationship between variables or rather indicate that variables will reach equilibrium in the long run. Cointegrated variables might deviate from one another in the short run but move together in the long run and an equilibrium level can be reinstalled if the system is exposed to a shock.

Johansen's cointegration test was used to assess the presence of a cointegration relationship between variables (Vavra & Goodwin, 2005). Co-integrated variables have the same unit root and order of stochastic shocks (Ferris, 2005). Co-integration implies that variables may react differently to shocks or external forces in the short run while maintaining their association in the long run (Vavra & Goodwin, 2005). The general model of the Johansen Cointegration test is as follows:

$$Y_t = \mu X_t + u_t \qquad (3.3)$$

If Y and X are integrated of order 1 then the disturbance term will also be integrated of the same order unless cointegration exists between X and Y (Engle & Granger, 1987). Therefore, the null hypothesis of no cointegration will be accepted if the disturbance term u_t is integrated of order 1. It will be rejected if the disturbance term is integrated of order zero since it means that the two variables are cointegrated. (Vavra & Goodwin, 2005). Nevertheless, if there is no cointegration between variables, Ordinary Least Squares (OLS) will be conducted to assess the association between import tariff, import volume, domestic broiler volume and prices, and exchange rate to address the third objective of the study.

The Johansen Cointegration test uses two statistics: The Eigenvalue and Trace statistics. Trace is built on the log-likelihood ratio $\ln[L_{MAX}(r) \div L_{MAX}(k)]$, and its null hypothesis states that the co-integration ranks are equal to r and the alternative hypothesis states that the cointegration ranks equals k. The Eigenvalue is built on the log-likelihood ratio $\ln[L_{MAX}(r) \div L_{MAX}(r+1)]$, and its null hypothesis states that the co-integration ranks are equal to r and the alternative hypothesis states that the cointegration ranks equals r+1 (Von Cramon-Taubadel & Fahlbusch, 1994; Vavra & Goodwin, 2005).

Additionally, variables that are integrated of the same order I(d) tend to be cointegrated or have a long-term relationship (Sere, 2006). Cointegrated variables may result from the stationary linear combination of variables that may individually have unit root but integrated, I(d). Therefore, the cointegration test analyses whether variables that individually contain a unit root have a long-run relationship. Hence, cointegration creates a robust statistical and economic foundation for error correction illustration, which produces both long and short-run information (Johansen & Juselius, 1990).

The null and the alternative hypotheses of the Johansen Cointegration test are stated as follows:

H_0: No cointegration among the variables

H_1: The variables are cointegrated

The null hypothesis will not be accepted if the critical value is less than Trace and Max-Eigen statistics at a 95% confidence level (Johansen & Juselius, 1990).

3.4.4. Error Correction Model

According to Boetel & Liu (2010), error correction vector autoregressive models define just how prices in the short run return to long-run price relationships when exposed to shocks. Engle & Granger (1987) further highlighted that alterations from the long-run equilibrium can be imitated in the short run in a cointegrated system. Therefore, the cointegration relationship between series is essential and sufficient for long-run relationships and hence it should be confirmed before the valuation of an error correction model. The presence of at minimum one cointegrating vector among the variables indicates that an ECM can be predicted to study the behaviour of the process of adjustment from short-run disequilibrium (Vavra & Goodwin, 2005).

Since the variables are cointegrated, an Error Correction Model (ECM) was projected to determine the long-run relationship between import broiler tariff and import and domestic broiler volume, exchange rate, and domestic broiler prices, including the short-run differences around this long-run relationship. The ECM gives a clear difference between the short-run and long-run effects and reduces the occurrence of multicollinearity between variables (Sere, 2006). ECM differentiates between positive and negative shocks of error terms and thus allows for asymmetric adjustments. ECM is grounded on linear error correction which revises any deviation from long-run equilibrium irrespective of the magnitude of the deviation (Vavra & Goodwin, 2005). In addition, Shoko *et al* (2016), explained that using data in a log form as compared to its natural format is beneficial as it provides estimates of short-run and long-run elasticity directly and it ensures that residuals are normally distributed. Transforming data into log form produces quality

and reliability concerning signs, values, and significance levels. The general model together with the specific model used to test the relationship are indicated below:

General model: $\Delta lnYt = A + \sum_{i=1}^{k} \mu \Delta lnY_{t-i} + \sum_{i=1}^{k} B\Delta lnX1_t + \sum_{i=1}^{k} D\Delta lnX2_{t-i} + \cdots + \sum_{i=1}^{k} \Delta Xn_{t-i} + W^{+}ECT_{t-1}^{+} + V^{-}ECT_{t-1}^{-} + u$ (3.4)

Specified model: $\Delta lnDVt = A + \sum_{i=1}^{k} \mu \Delta lnAD_{t-i} + \sum_{i=1}^{k} B\Delta lnRP_t + \sum_{i=1}^{k} C\Delta lnPP_{t-i} + \sum_{i=1}^{k} D\Delta lnER_{t-i} + \sum_{i=1}^{k} E\Delta lnDV_{t-i} + \sum_{i=1}^{k} F\Delta lnFP_{t-i} + \sum_{i=1}^{k} G\Delta IV_{t-i} + W^{+}ECT_{t-1}^{+} + V^{-}ECT_{t-1}^{-} + u$ (3.5)

Where:

A, B, C, D, F, G, W, V are the statistical parameters

t= number of lags (t=1,2,3,4)

k is maximum number of lags.

$\Delta lnDVt = DVt - DV_{t-1}$ which is lagged first differenced values of $\mathrm{lnDVt\ in\ period\ t}$

$\Delta lnADt = ADt - AD_{t-1}$ which is lagged first differenced values of $\mathrm{lnADt\ in\ period\ t}$

$\Delta lnIVt = IVt - IV_{t-1}$ which is lagged first differenced values of $\mathrm{lnIVt\ in\ period\ t}$

ECT_{t-1}^{+} = positive error correction term lagged to one period

ECT_{t-1}^{-} = negative error correction term lagged to one period

Inclusion of the error correction terms serves two purposes in the long run equilibrium i.e., it corrects any deviations from the previous periods and allows the dependent variable to respond to changes in the independent variables (Vavra & Goodwin, 2005). Error correction terms in equations (3.5) and (3.4) measure the deviation from the long-run equilibrium between domestic prices and domestic broiler production and import tariff charged. Moreover, the error correction term coefficient should be negative and significant to ensure that any divergence from the long-run equilibrium is adjusted (Dougherty, 2011).

3.5. DEFINITION OF VARIABLES

Variables in this study were chosen grounded on economic theory and due to prior studies, that cited them as the main issues in the poultry industry when addressing the anti-dumping of broiler in South Africa. The dependent variable of the ECM is domestic broiler production in volume as it depicts the total volume of broiler produced in each month. Table 3 presents the description of variables used in the study.

Table 3: Description of variables.

Variables	Description of variables	Measurements
Dependent variable: domestic broiler volume (DV)	A total volume of broiler produced each month	Number of birds
Independent variables		
1. *Ad valorem* import tariff (AD)	1= if a change in the ad-valorem tariff occurred in a particular month 0=otherwise	Dummy
2. Import broiler volume (IV)	Total broiler quantity imported each month from Brazil	Tonnes
3. Feed price index (FP)	Domestic broiler feed price index each month	(Rand/tonne)
4. Exchange rate (ER)	Number of Rands equivalent to one US dollar	SA Rands per US Dollar
5. Retail price (RP)	Retail price per month	Rands per kg
6. Producer price (PP)	Producer price per month	Rands per kg

3.5.*1 Ad valorem* tariff

Ad Valorem import tariff charged is expressed as a dummy variable to suit analytical techniques used in this study, that is to account for structural breaks in the study. A value of one is assigned to a period where import tariff was adjusted and zero where they were no adjustments or changes. Meyer & Von Cramon-Taubadel (2004) justified that structural breaks are necessary for price transmission studies as they help avoid rejecting the null hypothesis of symmetric transmission wrongfully. Structural breaks thus increase the statistical quality of asymmetric price transmission studies.

3.5.2. Import broiler volume

Import broiler volume is defined as the total broiler quantity imported each month from Brazil. The study focused on bilateral trade between South Africa and Brazil as the main exporter of broiler meat. The Brazilian government had previously raised concerns over unfair trade and high import tariffs charged on their broiler products. Brazil also has a comparative advantage in producing poultry as it is also a surplus producer of soybean (Goga & Bosiu, 2019). Moreover, the study focused on frozen chicken imports (HS code: 020714) as they represent about 60% of total domestic demand. The total import volume of bone-in broiler cuts has been increasing over the years and subjected to huge import tariff adjustments (Jooste, 2020).

3.5.3. Exchange rate

International trade and economic growth of trading member countries have a directly proportional relationship and on the determination of exchange rates (Silva & Hassani, 2015). The exchange rate has a direct influence on the competitiveness of the sector and the Rand has been depreciating over the years and thus increasing uncertainties in the feed market. Moreover, since all imports are valued at the US dollar, the South African industry is placed at a disadvantage as and when the Rand depreciates against the US dollar. This explains how the volatility of the international economy could affect the price of import goods in the country (Davids & Meyer, 2017; Hamad *et al.,* 2014). Additionally, the origin of South African imports and the distance between this origin and South Africa increases the cost of production in South Africa more specifically soybean imports (Davids & Meyer, 2017).

3.5.4. Domestic prices

Economic theory postulates that feed price correlates with producer and retail price and therefore affects the food accessibility of consumers (Food and Agriculture Organisation, 2011). The economic theory further highlights that an indirect relationship exists between quantity demanded and own price which explains that increasing retail prices will affect effective demand. However, producer prices and domestic production are likely to have a direct association such that as producer prices increase more farmers will be willing to produce and supply broiler products in the market. Moreover, grain producers have high bargaining power since feeds account for 70% of total production costs (Goga & Bosiu, 2019).

3.6. DIAGNOSTIC TESTS

Diagnostic tests refer to assessments that are conducted to check whether linear regression model assumptions are not violated. Violation of the classical Ordinary Least Square (OLS) assumptions harms the quality of the estimated model, variance may be inflated and thus lead to rejection of relevant variables and wrong recommendations. The study adopted the Jarque Bera test for normality test, Breusch-Godfrey Serial Correlation LM test for autocorrelation test, and the Breusch-Pagan-Godfrey test for heteroscedasticity.

3.6.1. Normality test

One of the OLS assumptions states that the error term is normally distributed. Violation of this assumption will result in the variance being unreliable and unstable. The study adopted the Jarque-Bera test to test data symmetry, to check whether the data set is normally distributed, negatively, or positively skewed (Jarque & Bera, 1980). Moreover, the null hypothesis states that the residuals are symmetric and hence favourable for the study.

H_0: The error term is normally distributed

H_1: The error term is skewed

The null hypothesis of normality will be acknowledged if the probability value of the Jarque-Bera test is above 5% and that implies that the alternative hypothesis is rejected. The alternative hypothesis will be accepted if the probability value is less than 0.05 (Jarque & Bera, 1980; Brooks, 2008).

3.6.2. Autocorrelation test

Autocorrelation refers to the correlation between disturbance terms or residuals associated with different observations. Autocorrelation affects the statistical quality of the model; it leads to its over or underestimation of coefficients and should therefore be detected earlier and corrected (Greene, 2000). The study adopted the Breusch-Godfrey Serial Correlation LM test to test for autocorrelation between disturbance terms in the series. The null hypothesis tested by this test states that there is no autocorrelation amongst the disturbance terms.

H_0: There is no autocorrelation

H_1: There is autocorrelation

The null hypothesis is favourable and will be accepted if the Prob. Chi-Square value is above 5% and thus implies the rejection of the alternative hypothesis. However, If the Prob. Chi-Square value is below 5%, the null hypothesis will not be accepted (Greene, 2000).

3.6.3. Heteroscedasticity test

One of the linear regression assumptions states that the variance of the disturbance terms is homoscedastic. However, violation of this assumption leads to heteroscedasticity and thus biased Standard Error of Estimates (SEE) (Richard, 2017). The study used the Breusch-Pagan-Godfrey test to measure the existence of the heteroscedasticity problem between the series.

The null hypothesis of the Breusch-Pagan-Godfrey test states that there is homoscedasticity or there is no heteroscedasticity.

H_0: there is homoscedasticity

H_1: there is no homoscedasticity

The null hypothesis of homoscedasticity will be accepted if the Prob. Chi-square is above 5% and will be rejected if Prob. Chi-square value is below 5% (Greene, 2000).

3.7. ETHICAL CONSIDERATION

The study complies with the ethical standards recommended by the TREC of the University of Limpopo however, the study does not require an ethical clearance certificate. The study was conducted with integrity, respect for intellectual property, confidentiality, and ownership of data risk assessment. All data will be treated with

confidentiality, all publicly available data sources are acknowledged accordingly and authorization to use part of the data was granted by the owners.

3.8. CHAPTER SUMMARY

This chapter described the study area and data collection methods and outlined analytical tools used in the study, including the description of variables used in the study. The study was conducted in South Africa mainly due to issues concerning the high influx of broiler imports and the role that the poultry industry plays in South Africa. The Augmented Dickey-Fuller test was used to test for stationarity and the Johansen Cointegration test was used to assess the cointegration relationship between the variables and to proceed with the Error Correction Model.

CHAPTER FOUR: EMPIRICAL RESULTS AND DISCUSSION

4.1. Introduction

In this chapter summary statistics of the data is presented, followed by tests for residuals i.e., normality tests, heteroskedasticity, and serial correlation tests. Furthermore, analytical results addressing the three objectives of the study are presented. Finally, the CUSUM test was used to test for model stability.

4.2. Descriptive statistics

Descriptive statistics were used to describe variables. Table 4 presents summary statistics such as the mean, median, minimum, and maximum values of the variables.

Table 4: Summary of descriptive statistics.

Variable	Mean	Median	Maximum	Minimum	Standard deviation	Skewness
DV	9 109.30	9 081.66	10 786.49	7 901.58	528.58	0.00016
ER	11.53	11.97	18.57	6.72	3.01	-0.53
FP	4734.66	4919	5 998	2 849	855.39	-0.795015
PP	35.47	19.26	2015	12.34	179.98	10.98
IV	6 488 092	5 475 782	21 394 539	858 344	4 047 748	1.472193
RP	39.15	39.48	55.74	27.54	7.10	0.015

Source: Own calculations

Where:

DV= Domestic broiler volume (tons)

ER=Exchange rate (R/ US dollar)

FP= Feed price (R/ton)

PP= Producer Price (R/kg)

IV= Import broiler volume (tons)

RP= Retail Price (R/kg)

The descriptive statistics presented in Table 4 show that on average, 18 218 740 chickens were slaughtered between the period April 2010– June 2020. 18 218 740 chickens slaughtered is equivalent to 9 109.3 tonnes since chickens are ready to be slaughtered at an average mass of 2kg. The maximum number of chickens produced is approximately 10 786.49 tonnes since 15 803 169 chickens were slaughtered during

the study period. Furthermore, at minimum domestic broiler production is 7 901.58 tonnes during the study period. An average of 6 488 092 tonnes of chicken was imported from Brazil for the period April 2010– June 2020. This indicates that the country highly relies on broiler imports to meet its domestic demand. Moreover, in the feed price index, the average feed price is valued at R4734.66 per tonne.

4.3. Diagnostic tests

4.3.1. Normality test

Figure 4 shows the results of the Jarque-Bera test. Since the probability value is 0.597983 which is above 0.05, the null hypothesis of a normal distribution is accepted signifying that the residuals are symmetric or normally distributed.

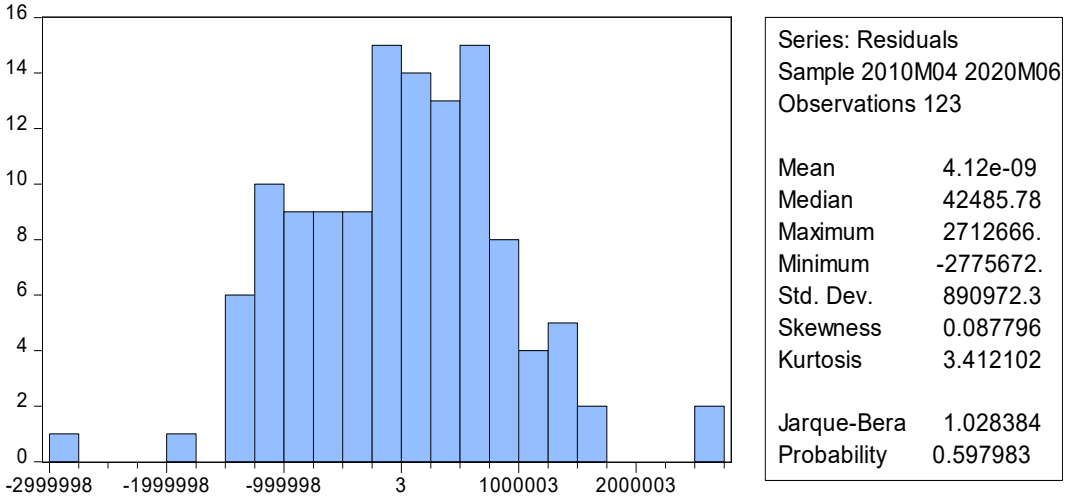

Figure 4: Jarque-Bera test

Source: Own calculations, 2021

4.3.2. Autocorrelation test

The study used the Breusch-Godfrey Serial Correlation LM Test to assess the level of correlation between residuals. The null hypothesis of the Breusch-Godfrey Serial Correlation LM Test conditions that there is no autocorrelation. From Table 5 Prob. Chi-Square is valued at 0.3915 which is greater than 0.05 and thus evident that the null hypothesis of no autocorrelation is accepted. There is no sign of autocorrelation in this series.

Table 5: Breusch-Godfrey Serial correlation LM test.

F-statistic	0.882514	Prob. F (2,114)	0.4165
Obs*R-squared	1.875338	Prob. Chi-Square (2)	0.3915

Source: Own calculations, 2021

4.3.3. Heteroscedasticity test

The study used the Breusch-Pagan-Godfrey test to assess the existence of the heteroscedasticity problem between the series of residuals. From Table 6, both Prob. Chi-square values are greater than 0.05 and therefore the null hypothesis of homoscedasticity is accepted. It can thus be decided that there is no evidence of heteroscedasticity between the residuals.

Table 6: Breusch-Pagan-Godfrey test.

F-statistic	0.538673	Prob. F (6,116)	0.7779
Obs*R-squared	3.334177	Prob. Chi-Square (6)	0.7659
Scaled explained SS	3.576515	Prob. Chi-Square (6)	0.7338

Source: Own calculations, 2021

4.4. Stationarity test

Table 7 and Table 8 show stationarity results at levels and first difference respectively, obtained from the Augmented Dickey-Fuller test.

Table 7: Stationarity test at levels.

Variable	ADF statistic	Critical value (5%)	Probability value	Results
DV	-2.919295	-2.885654	0.0461	Stationary
AD	-11.33230	-2.885249	0.0000	Stationary
RP	0.582584	-2.887190	0.9887	Not stationary
FP	-1.789283	-2.886074	0.3842	Not stationary
ER	-0.803403	-2.885450	0.8143	Not Stationary
PP	-11.03880	-2.885249	0.0000	Stationary
IV	-2.449787	-2.885249	0.1305	Not Stationary

Source: Own calculations, 2021

Ad Valorem tariff charged, producer price and domestic broiler volume are stationary and integrated to order 0 i.e. I(0) since their critical values are smaller than their ADF statistics in absolute terms. Whereas exchange rate, domestic broiler volume, retail price, and feed price are non-stationary, their null hypothesis is accepted in this regard.

Table 8: Stationarity at first difference.

Variable	ADF statistic	Critical value (5%)	Probability value	Result
IV	-12.26422	-2.885450	0.0000	Stationary
RP	-7.687546	-2.887190	0.0000	Stationary
PP	-10.72755	-2.885863	0.0000	Stationary
FP	-6.041030	-2.886074	0.0000	Stationary
DV	-7.878877	-2.886509	0.0000	Stationary
ER	-8.133907	-2.885450	0.0000	Stationary
AD	-10.56308	-2.886290	0.0000	Stationary

Source: Own calculations, 2021

All variables are stationary at the first difference and therefore integrated to order 1, I(1). Their critical values are smaller than their ADF statistic values in absolute terms at first difference. Hence, the null hypothesis was not accepted, and it can be concluded that the series is stationary and integrated to order 1, I(1). Since all variables are stationary and integrated of the same order e.g. I(1), a Johansen cointegration test was performed (Nkoro & Uko, 2016).

4.5. Lag order selection criteria

VAR Lag order selection criteria outcomes are shown in Table 9.

Table 9: Vector Autoregressive Lag Order Selection Criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3991.93	NA	7.02e+22	69.63358	69.92001	69.74984
1	-3479.47	953.6080	1.77e+19	61.34745	62.49316*	61.81248*
2	-3427.20	91.81663	1.34e+19*	61.06446*	63.06945	61.87827
3	-3398.81	46.90636	1.56e+19	61.19679	64.06107	62.35939
4	-3362.88	55.60800	1.60e+19	61.19807	64.92163	62.70945
5	-3337.81	36.18778	2.02e+19	61.38816	65.97100	63.24831
6	-3304.66	44.40119	2.26e+19	61.43761	66.87974	63.64654
7	-3377.66	33.33134	2.90e+19	61.59424	67.89565	64.15195
8	-3228.49	55.5921*	2.61e+19	61.36509	68.52579	64.27158
* indicates lag order selected by the criterion						

Source: Own calculations, 2021

Grounded on the results presented in Table 9, Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) chose one lag as the optimum lag length whereas the Akaike information criterion (AIC) and final prediction error chose lag two as optimum lag length. However, the sequential modified LR test statistic chose lag six. The study mainly focused on the outcomes of the former three criteria AIC, SC, and HQ as explained in sub-section 3.4.2. The study, therefore, opted for lag two as the optimum lag length as shown by the Akaike information criterion.

4.6. Cointegration test

The study used the Johansen cointegration test to address the second objective which was to analyse the presence of cointegration amongst the variables. The study used the two statistics of the Johansen cointegration test which are Trace statistics and the Max-Eigenvalue statistics to test the cointegration relationship between the variables. The null hypothesis tested in this study states that the is no cointegration amongst the variables under study. Table 10 presents Trace test results and Table 11 presents the Max-Eigenvalue statistics results.

4.6.1. Unrestricted Cointegration Rank Test (Trace)

Table 10: Unrestricted cointegration rank test (Trace).

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.3308	140.2734	125.6154	0.0047
At most 1	0.2528	92.8821	95.7537	0.0775
At most 2	0.2262	58.4942	69.8189	0.2845
At most 3	0.1205	28.2356	47.8561	0.8034
At most 4	0.0595	13.0813	29.7971	0.8879
At most 5	0.0483	5.8486	15.4947	0.7133
At most 6	0.0001	0.0131	3.8415	0.9088
Trace test indicates 2 cointegrating equation(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Source: own calculations, 2021

According to the findings of the Unrestricted Cointegration Rank Test (Trace) as shown in Table 10 the first row (none) which states that there is no cointegration among the variables, its null hypothesis is rejected at a 5 % level of significance since its critical value is less than the Trace statistic value. However, at most 1, at most 2,

at most 3, at most 4, at most 5, and at most 6 the null hypothesis is accepted since the Trace Statistic is less than the critical value at 5% level of significance.

4.6.2. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Table 11: Unrestricted cointegration rank test (Maximum Eigenvalue).

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.3308	47.3913	46.2314	0.0374
At most 1	0.2528	34.3879	40.0776	0.1903
At most 2	0.2262	30.2586	33.8769	0.1273
At most 3	0.1205	15.1544	27.5843	0.7359
At most 4	0.0595	7.2326	21.1316	0.9442
At most 5	0.0483	5.8355	14.2646	0.6344
At most 6	0.0001	0.0131	3.8415	0.9088
Max-eigenvalue test indicates 2 cointegrating equation(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-value				

Source: Own calculations, 2021

Table 11 indicates that in the first row (none) which states that there is no cointegration among the variables, its null hypothesis is rejected at a 5 % level of significance since its critical value is less than the Trace statistic value. Therefore, the results of the Unrestricted Cointegration Rank Test (Trace) in Table 10 are the same as the Unrestricted Cointegration Rank Test (Maximum Eigenvalue) results in Table 11. Consequently, the study concludes that cointegration exists among the variables: import quantity, import tariff, domestic broiler production, domestic broiler prices and exchange rate since the first statement in both tests states that there is no cointegration among the variables was rejected at 5% level of significance.

4.7. Error Correction Model

Error Correction Model was used to address the third objective which is to determine the long-run relationship between *ad valorem* tariff charged, broiler imports quantity, domestic broiler production, producer and feed prices, and retail prices in South Africa.

Table 12 presents results obtained from the Error Correction Model whereby domestic production is the dependent variable.

Table 12: Error Correction Model results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004049	0.004746	0.853088	0.3956
D(LogDV (-1))	-0.329563	0.130465	-2.526060	0.0130**
D(LogDV (-2))	-0.251964	0.095142	-2.648289	0.0094***
D(LogIV (-1))	0.036277	0.015889	2.283213	0.0245**
D(LogIV (-2))	0.006995	0.015510	0.450974	0.6529
D(LogPP (-1))	0.099051	0.088065	1.124745	0.2633
D(LogPP (-2))	-0.045430	0.101040	-0.449627	0.6539
D(LogFP (-1))	0.094058	0.180055	0.522384	0.6025
D(LogFP (-2))	-0.026451	0.175922	-0.150356	0.8808
D(LogRP (-1))	-0.248148	0.215486	-1.151574	0.2521
D(LogRP (-2))	-0.177483	0.242149	-0.732948	0.4652
D(AD(-1))	0.002999	0.021466	0.139714	0.8892
D(AD(-2))	0.041826	0.022859	1.829740	0.0702*
D(LogER (-1))	0.001289	0.004154	0.310325	0.7569
D(LogER (-2))	0.003376	0.004075	0.828481	0.4093
ECT (-1)	-0.530835	0.155108	-3.422353	0.0009***
***, **, * represent 1% level of significance, 5% level of significance, and 10% level of significance respectively				
R-squared	0.549172			
Adjusted R-squared	0.484148			
F-statistic	8.445768			
Prob(F-statistic)	0.000000			

Source: Own calculations, 2021

The error correction term in Table 12 is significant at a 1% level of significance and has a negative coefficient (-0.53). A negative coefficient implies that the equilibrium estimated equation or system will be re-attained after exposure to shock or external factors and the long-run disequilibrium will be corrected in the short-run (Gujarati & Porter, 2009). Additionally, Brooks (2008), highlighted that a long-run relationship is

necessary for variables to return to equilibrium once exposed to shock. The speed of adjustment of this system is 53% which indicates that 53% of disequilibrium is corrected in the first month. This implies that domestic volume produced is moderately responsive to changes in *ad valorem* tariff charged and past months' broiler volume produced and import volume.

Log of import volume is significant at a 5% level of significance and has a direct long-run relationship with domestic broiler production. A unit increase in import broiler volume will result in a 0.036 growth in domestic broiler volume produced which is equivalent to a 3.6% increase. Therefore, they follow the same direction or have a direct relationship however, domestic broiler volume increases with a lesser magnitude. This implies that a complementary relationship exists between domestic production and import volume lagged to one month. This is in support of Bett *et al* (2012) who observed a complementary relationship between domestic poultry meat and broiler import in Kenya. Additionally, Arnade & Davis (2019) also found a complementary relationship between broiler meat in Mexico and the United States of America.

Log of past domestic broiler volume was found to be statistically significant at both 1% and 5% level and past domestic broiler volume has an indirect relationship with current domestic broiler volume. A unit increase in past domestic broiler volume will result in a 0.025 (2.5%) reduction in the current production level. This implies that domestic broiler producers tend to get discouraged over time and opt to reduce the level of production in the long run. This may be due to other domestic factors which hinder production such as high feed costs and electricity cuts (Bansen *et al.,* 2015; Goga & Bosiu, 2019). These results are in support of Bosiu *et al* (2017) who argued that high market concertation dominates the poultry industry and therefore limits growth and competition in the domestic market. Market dominants have the potential to influence smallholder broiler farmers since they are in contractual agreements and thus lead to poor industry growth.

Ad valorem tariff is statistically significant at a 10% significance level and has a positive relationship with domestic broiler production. As the *ad valorem* tariff charged lagged to two months changes, domestic broiler production will increase by 0.04 which is equivalent to 4% growth. Domestic broiler production responds positively to import tariff increases. This is in support of Lu *et al* (2013) who found that an increase in the

final US anti-dumping duties led to a decrease in Chinese exports to the United States of America by 0.6%. Additionally, Meyer *et al* (2021) outlined that broiler imports are expected to decline as import duties increases. Import duties thus have a significant role in diverting domestic demand from imports to domestic production. Likewise, Goldar *et al* (2012) found that a decrease in agricultural tariff rates will have an impact on both imports and exports of agricultural products. It will result in approximately a 2-4% growth in agricultural exports to the US markets which is in line with this study's results.

However, Davids *et al* (2015) state that increasing tariffs is less likely to be adequate to sustain production in the long run since the industry is facing numerous challenges such as high feed costs and power cuts. A study by Fourie (2013) states that a rise in tariff will result in a rise in food prices and that will be detrimental to the livelihood of the poor. This contrasts with the results of this study since domestic production is responding positively to tariff adjustments. This positive relationship implies that increasing tariffs tend to boost producer confidence and are more likely to motivate farmers to direct more resources to broiler production in the long run.

The adjusted R-squared is valued at 48% which indicates that 48% of the domestic broiler volume produced is explained by the independent variables and 52% is explained by variables that are omitted in the model. However, the probability value of the F-statistic is 0.000 which highlights that the model is correctly specified, and the independent variables are jointly significant. Although the study could not find any significant evidence between domestic broiler production and feed price, domestic prices. Feed quality and costs continue to be a major challenge to farmers and thus affect producer price or farm gate prices since an increase in feed price is not accompanied by increases in broiler producer prices (Davids & Meyer, 2017; Louw *et al.,* 2011). Moreover, Goga & Bosiu (2019) further highlighted that to minimize the effect of imports without affecting broiler accessibility, the retail to feed price ratio should be regulated as a significant indicator of the competitiveness of the industry on an international level.

Stability test for the estimated Error Correction Model

Figure 5 illustrates the results of the CUSUM test which was performed to test the stability of the ECM.

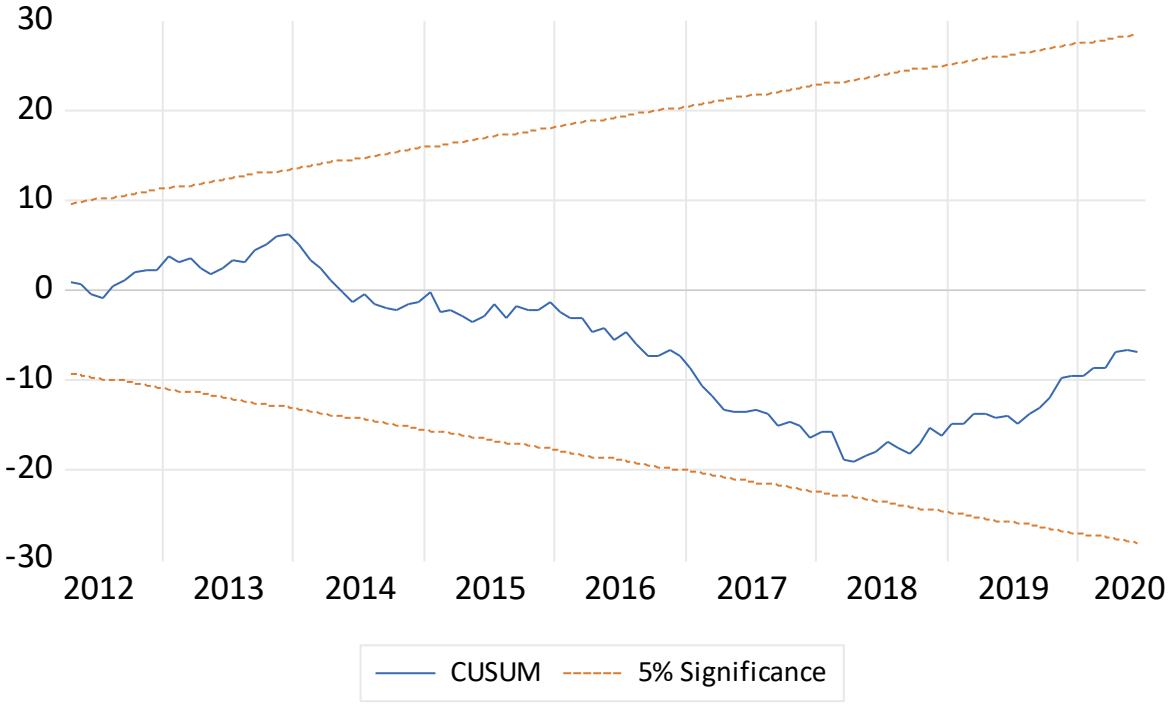

Figure 5: CUSUM test results for Error Correction Model.

The plot of CUSUM falls within the five percent range and hence, the null hypothesis is acknowledged which indicates that the ECM is correctly specified.

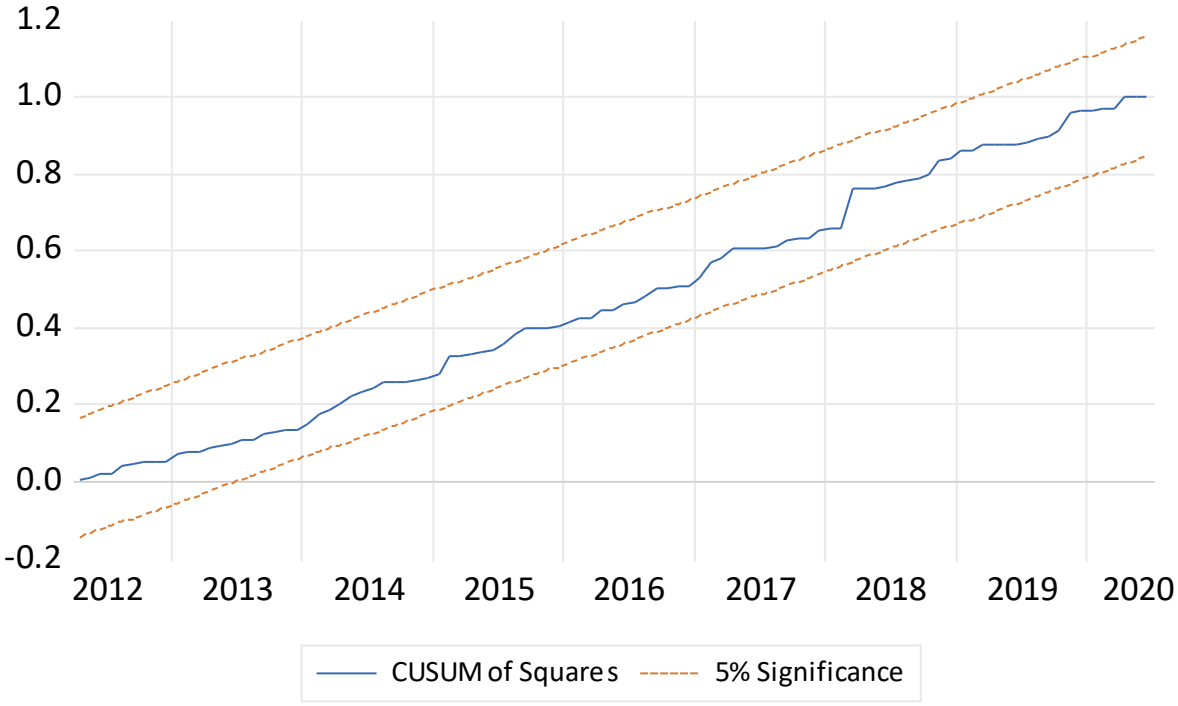

Figure 6: CUSUM of squares test results for Error Correction Model.

The plot for the CUSUM of squares falls within the five percent range and hence, the null hypothesis is acknowledged which indicates that the ECM is correctly specified.

4.8. Chapter summary

This chapter provided an overview of broiler data analysis for the period April 2010 to June 2020. Descriptive statistics of the original data were presented, and diagnostic tests were performed. Results of diagnostic tests indicated that their residuals are normally distributed, homoscedastic with no sign of autocorrelation problem. Lastly, the long-run relationship between variables was determined and the stability of the model was tested through the CUSUM test.

CHAPTER 5: SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1. INTRODUCTION

This chapter provides an overview of the findings of the study and draws a conclusion based on the results presented in Chapter 4. This chapter later makes recommendations founded on the results of the study.

5.2. SUMMARY AND DISCUSSION

The study was conducted in South Africa and time-series data was used to investigate the long-run relationship between import tariff, import quantity, domestic production, and domestic prices in the broiler sector of South Africa for the period (April 2010 – June 2020). The study had three objectives; to assess the order of integration and stationarity of the variables: import quantity, domestic production, domestic prices, and import tariff, to analyse the existence of cointegration among the variables: import quantity, import tariff, domestic broiler production, domestic retail, feed, and producer broiler prices and lastly, to determine the long-run relationship between broiler imports quantity, domestic broiler production, import tariff and domestic prices in South Africa for the period (April 2010 – June 2020).

The research hypotheses of the study stated that: The residuals of domestic broiler production, retail, feed and producer prices, import tariff, and import quantity have a unit root; Cointegration does not exist among the variables: import tariff, import quantity, domestic broiler production, and domestic retail, feed and producer prices and finally, there is no long-run relationship between broiler import quantity, import tariff, domestic broiler production, and domestic prices in South Africa for the period (April 2010– June 2020).

Descriptive statistics results of the original data revealed that an average of 18 218 740 chickens was slaughtered between the period April 2010– June 2020 which is equivalent to 9 109.3 tonnes and the number of birds slaughtered ranged from 10 786.49 to 7.901.58 tonnes. An average of 6 488 092 tonnes of broiler was imported from Brazil and import broiler volume ranges from 858 344 to 21 394 539 tonnes for 123 months studied. Diagnostic test results revealed that the residuals are symmetric, homoscedastic, and not correlated.

The results for the Augmented Dickey-Fuller test and the Johansen cointegration test showed that the time series is stationary at first difference and cointegrated. The optimal lag length chosen by Akaike Information Criterion was two. Since the series was stationary and cointegrated, the Error Correction Model was estimated to determine whether a long-run relationship exists between the variables under study. Domestic broiler volume was the dependent variable in the Error Correction Model, and it was determined that past domestic broiler volume, ad valorem tariff charged and import volume were significant and had a long-run relationship with domestic broiler volume. ECM had a speed of adjustment of 53% which explains that 53% of disequilibrium is reverted in one month. This implies that following a tariff adjustment, domestic production will adjust to changes by 53% in the first month and 47% in the second month. Lastly, the CUSUM test results revealed that the error correction model is stable.

5.3 CONCLUSION

The study had three null hypotheses and all these hypotheses were rejected since the findings of the study revealed that the series was stationary, integrated of order 1, and cointegrated. These results indicated that a possible long-run relationship exists between the variables. The findings of the study also indicated that a long-run relationship exists between domestic broiler volume, import volume, ad valorem tariff charged, and domestic broiler volume of the past two months. These results imply that the domestic production system will be able to adjust to changes in tariff changes within 2 months. This optimum lag period is equivalent to the broiler production cycle since farmers are not able to respond to any changes in the market once the production cycle is initiated. Domestic production has a positive relationship with changes in ad valorem tariff, even though it increases at a small proportion to changes in import tariff charged. The complementary relationship between import volume and domestic production can be attributed to consumer preference over bone-in chicken portions which continuously creates a market for chicken imports to supplement domestic production.

5.4. RECOMMENDATION

The following recommendations are based on the findings of the study. The study found a long-run relationship between domestic production, *ad valorem* tariff, and import volume.

a) Firstly, a reduction in barriers of entry for small-scale domestic broiler producers into the domestic market such as reduced production costs would boost domestic production. A reduction in production costs will increase farm revenue and farmers' share of the final product and thus increase farmers' ability to compete in the international market. Increased government investment and support are therefore necessary to help rural small-scale farmers to progress into intensive broiler production.
b) Domestic production is responding well to tariff adjustments, however since not all broiler imports are subjected to import duties, a thorough investigating is necessary to prove dumping allegations against broiler exporters as this will enable the country to impose anti-dumping duties on all countries. This will also prevent retaliation by those countries.
c) An increase in market access for small-scale farmers to broiler exports in both SACU and SADC regions will increase returns to investment and therefore acts as a motivation for farmers to produce broilers for the international market. Moreover, farmers' support in production and marketing will help them meet the market requirements in the European Union and will also enable the country to capitalise on the TDCA trade agreement to supply this market with high valued chicken portions that are of demand in the EU.

5.5. LIMITATION OF THE STUDY

The study did not cover the following parts:

a) The relationship between import volume and small-scale chicken production and whether the oligopolistic nature of the poultry industry is attributed to its inability to compete with imported broiler products.
b) Effectiveness of Anti-dumping duties charged on some of largest broiler producing countries and lastly,
c) The impact of EU and USA imports on domestic production and the industry.

5.6. AREAS OF FURTHER RESEARCH

a) Further research can be conducted on areas such as the effects of trade agreements on the broiler industry. It is still to be proven whether all South Africa's trade partners abide by the rules set by the World Trade Organisation hence such empirical studies could enhance the agricultural sector's trade and competitiveness.

b) Research studies may also be diverted to focus on consumers to investigate consumers' willingness to pay for domestic broiler products and consumer preference for imported chicken.

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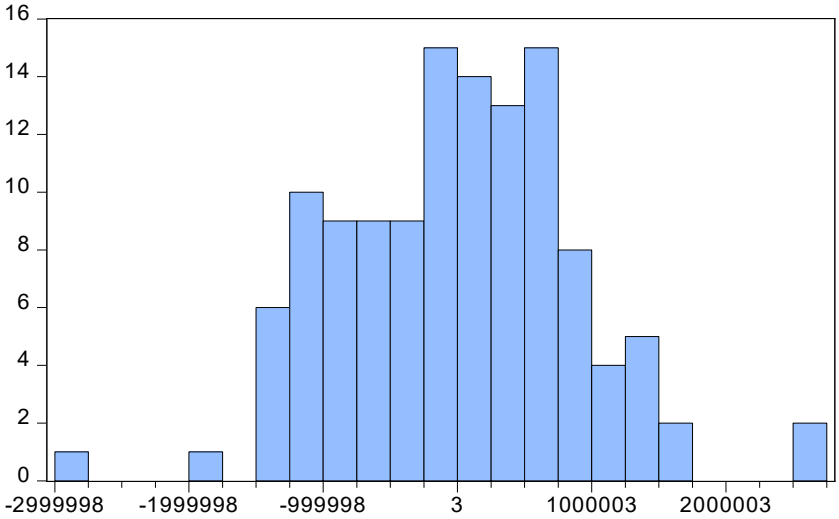
APPENDICES

Appendix 1: Descriptive statistics results

	AD	DV	ER	FP	IV	RP	PP
Mean	0.032520	18218740	11.52915	4734.659	6488092.	39.15325	35.47171
Median	0.000000	18163322	11.97000	4919.000	5475782.	39.48000	19.26000
Maximum	1.000000	21572988	18.57070	5998.000	21394539	55.74000	2015.000
Minimum	0.000000	15803169	6.719800	2849.000	858344.0	27.54000	12.34000
Std. Dev.	0.178103	1057169.	3.006459	855.3954	4047748.	7.099742	179.9849
Skewness	5.271016	0.320642	-0.053338	-0.795015	1.472193	0.015337	10.94855
Kurtosis	28.78361	2.995613	1.941451	2.658150	4.987095	1.926810	120.9174
Jarque-Bera	3976.637	2.107729	5.801012	13.55592	64.66705	5.907474	73717.92
Probability	0.000000	0.348588	0.054995	0.001139	0.000000	0.052144	0.000000
Sum	4.000000	2.24E+09	1418.086	582363.0	7.98E+08	4815.850	4363.020
Sum Sq. Dev.	3.869919	1.36E+14	1102.733	89267560	2.00E+15	6149.574	3952135.
Observations	123	123	123	123	123	123	123

Appendix 2: Results of Jarque-Bera normality test



Series: Residuals
Sample 2010M04 2020M06
Observations 123

Mean	4.12e-09
Median	42485.78
Maximum	2712666.
Minimum	-2775672.
Std. Dev.	890972.3
Skewness	0.087796
Kurtosis	3.412102
Jarque-Bera	1.028384
Probability	0.597983

Appendix 3: Results of Breusch-Godfrey Serial Correlation LM test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.882514	Prob. F(2,114)	0.4165
Obs*R-squared	1.875338	Prob. Chi-Square(2)	0.3915

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 04/12/21 Time: 23:02
Sample: 2010M04 2020M06
Included observations: 123
Pre sample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER	-0.147146	2.233079	-0.065894	0.9476

FP	17.23322	242.0495	0.071197	0.9434
PP	55.83502	571.4879	0.097701	0.9223
IV	0.003763	0.027640	0.136146	0.8919
RP	-45.99711	404.0805	-0.113832	0.9096
AD	2590.003	471171.0	0.005497	0.9956
C	-17263.83	498241.1	-0.034650	0.9724
RESID(-1)	0.116323	0.094787	1.227201	0.2223
RESID(-2)	0.035373	0.095335	0.371043	0.7113

R-squared	0.015247	Mean dependent var	4.12E-09
Adjusted R-squared	-0.053859	S.D. dependent var	890972.3
S.E. of regression	914651.0	Akaike info criterion	30.36083
Sum squared resid	9.54E+13	Schwarz criterion	30.56660
Log-likelihood	-1858.191	Hannan-Quinn criteria.	30.44441
F-statistic	0.220629	Durbin-Watson stat	2.008849
Prob(F-statistic)	0.986610		

Appendix 4: Breusch-Pagan-Godfrey Heteroskedasticity test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.538673	Prob. F(6,116)	0.7779
Obs*R-squared	3.334177	Prob. Chi-Square(6)	0.7659
Scaled explained SS	3.576515	Prob. Chi-Square(6)	0.7338

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 04/12/21 Time: 23:10
Sample: 2010M04 2020M06
Included observations: 123

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.56E+11	6.76E+11	0.675031	0.5010
ER	-1282525.	3012977.	-0.425667	0.6711
FP	3.71E+08	3.28E+08	1.132285	0.2598
PP	-4008402.	7.72E+08	-0.005190	0.9959
IV	61696.14	37329.80	1.652731	0.1011
RP	-4.30E+08	5.46E+08	-0.787252	0.4327
AD	-1.88E+11	6.38E+11	-0.294276	0.7691

R-squared	0.027107	Mean dependent var	7.87E+11
Adjusted R-squared	-0.023215	S.D. dependent var	1.23E+12
S.E. of regression	1.24E+12	Akaike info criterion	58.58866
Sum squared resid	1.79E+26	Schwarz criterion	58.74871
Log-likelihood	-3596.203	Hannan-Quinn criteria.	58.65367
F-statistic	0.538673	Durbin-Watson stat	1.962692
Prob(F-statistic)	0.777871		

Appendix 5: Results for Augmented Dickey-Fuller Test

1. Ad valorem

Null Hypothesis: AD has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.33230	0.0000
Test critical values:	1% level	-3.484653	
	5% level	-2.885249	
	10% level	-2.579491	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(AD)
Method: Least Squares
Date: 08/15/21 Time: 08:13
Sample (adjusted): 2010M05 2020M06
Included observations: 122 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AD(-1)	-1.033898	0.091235	-11.33230	0.0000
C	0.033898	0.016520	2.051957	0.0423

R-squared	0.516949	Mean dependent var	0.000000
Adjusted R-squared	0.512924	S.D. dependent var	0.257130
S.E. of regression	0.179453	Akaike info criterion	-0.581549
Sum squared resid	3.864407	Schwarz criterion	-0.535581
Log likelihood	37.47448	Hannan-Quinn criter.	-0.562878
F-statistic	128.4211	Durbin-Watson stat	2.002379
Prob(F-statistic)	0.000000		

1st difference

Null Hypothesis: D(AD) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.56308	0.0000
Test critical values:	1% level	-3.487046	
	5% level	-2.886290	
	10% level	-2.580046	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(AD,2)
Method: Least Squares
Date: 08/15/21 Time: 08:23
Sample (adjusted): 2010M10 2020M06
Included observations: 117 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(AD(-1))	-4.462198	0.422433	-10.56308	0.0000
D(AD(-1),2)	2.551832	0.372531	6.849987	0.0000
D(AD(-2),2)	1.731099	0.295754	5.853179	0.0000
D(AD(-3),2)	1.032216	0.198621	5.196919	0.0000
D(AD(-4),2)	0.455183	0.097944	4.647380	0.0000
C	0.007015	0.017364	0.403995	0.6870

R-squared	0.837360	Mean dependent var	0.000000
Adjusted R-squared	0.830034	S.D. dependent var	0.454859
S.E. of regression	0.187524	Akaike info criterion	-0.459897
Sum squared resid	3.903352	Schwarz criterion	-0.318247
Log likelihood	32.90399	Hannan-Quinn criter.	-0.402389
F-statistic	114.2981	Durbin-Watson stat	2.061971
Prob(F-statistic)	0.000000		

2. Domestic volume

Null Hypothesis: DV has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.919295	0.0461
Test critical values:	1% level	-3.485586	
	5% level	-2.885654	
	10% level	-2.579708	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DV)
Method: Least Squares
Date: 08/15/21 Time: 08:13
Sample (adjusted): 2010M07 2020M06
Included observations: 120 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DV(-1)	-0.313479	0.107382	-2.919295	0.0042
D(DV(-1))	-0.500505	0.106287	-4.708986	0.0000
D(DV(-2))	-0.375088	0.087219	-4.300518	0.0000
C	5769733.	1955884.	2.949936	0.0038

R-squared	0.451964	Mean dependent var	33004.76
Adjusted R-squared	0.437791	S.D. dependent var	1195533.
S.E. of regression	896417.8	Akaike info criterion	30.28297
Sum squared resid	9.32E+13	Schwarz criterion	30.37588
Log likelihood	-1812.978	Hannan-Quinn criter.	30.32070
F-statistic	31.88830	Durbin-Watson stat	1.927692
Prob(F-statistic)	0.000000		

1st difference

Null Hypothesis: D(DV) has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.878877	0.0000
Test critical values:	1% level	-3.487550	
	5% level	-2.886509	
	10% level	-2.580163	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DV,2)
Method: Least Squares
Date: 08/15/21 Time: 08:25
Sample (adjusted): 2010M11 2020M06
Included observations: 116 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DV(-1))	-4.203840	0.533558	-7.878877	0.0000
D(DV(-1),2)	2.365300	0.481205	4.915365	0.0000
D(DV(-2),2)	1.546232	0.397160	3.893221	0.0002
D(DV(-3),2)	1.064903	0.299845	3.551517	0.0006
D(DV(-4),2)	0.509358	0.190530	2.673369	0.0087
D(DV(-5),2)	0.196738	0.092940	2.116834	0.0365
C	106894.4	80518.12	1.327582	0.1871

R-squared	0.828030	Mean dependent var	-5370.345
Adjusted R-squared	0.818564	S.D. dependent var	2010532.
S.E. of regression	856391.7	Akaike info criterion	30.21729
Sum squared resid	7.99E+13	Schwarz criterion	30.38346
Log likelihood	-1745.603	Hannan-Quinn criter.	30.28474
F-statistic	87.47216	Durbin-Watson stat	2.028400
Prob(F-statistic)	0.000000		

3. Exchange rate

Null Hypothesis: ER has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.803403	0.8143
Test critical values:	1% level	-3.485115	
	5% level	-2.885450	
	10% level	-2.579598	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ER)
Method: Least Squares
Date: 08/15/21 Time: 08:14
Sample (adjusted): 2010M06 2020M06
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ER(-1)	-0.011126	0.013849	-0.803403	0.4234
D(ER(-1))	0.271852	0.092380	2.942749	0.0039
C	0.182437	0.163419	1.116377	0.2665

R-squared	0.069161	Mean dependent var	0.078708
Adjusted R-squared	0.053384	S.D. dependent var	0.455845
S.E. of regression	0.443511	Akaike info criterion	1.236293
Sum squared resid	23.21084	Schwarz criterion	1.305610
Log likelihood	-71.79571	Hannan-Quinn criter.	1.264445
F-statistic	4.383651	Durbin-Watson stat	1.869530
Prob(F-statistic)	0.014575		

1st difference

Null Hypothesis: D(ER) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.133907	0.0000
Test critical values:	1% level	-3.485115	
	5% level	-2.885450	
	10% level	-2.579598	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ER,2)
Method: Least Squares
Date: 08/15/21 Time: 08:14
Sample (adjusted): 2010M06 2020M06
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ER(-1))	-0.740250	0.091008	-8.133907	0.0000
C	0.055375	0.041081	1.347950	0.1802

R-squared	0.357314	Mean dependent var	-0.011122
Adjusted R-squared	0.351913	S.D. dependent var	0.550098
S.E. of regression	0.442850	Akaike info criterion	1.225219
Sum squared resid	23.33780	Schwarz criterion	1.271430
Log likelihood	-72.12574	Hannan-Quinn criter.	1.243987
F-statistic	66.16044	Durbin-Watson stat	1.861232
Prob(F-statistic)	0.000000		

4. Import volume

Null Hypothesis: IV has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.449787	0.1305
Test critical values:	1% level	-3.484653	
	5% level	-2.885249	
	10% level	-2.579491	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IV)
Method: Least Squares
Date: 08/15/21 Time: 08:15
Sample (adjusted): 2010M05 2020M06
Included observations: 122 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IV(-1)	-0.095403	0.038943	-2.449787	0.0157
C	609170.3	298025.9	2.044018	0.0431

R-squared	0.047630	Mean dependent var	-10487.75
Adjusted R-squared	0.039694	S.D. dependent var	1776403.
S.E. of regression	1740790.	Akaike info criterion	31.59383
Sum squared resid	3.64E+14	Schwarz criterion	31.63980
Log likelihood	-1925.224	Hannan-Quinn criter.	31.61250
F-statistic	6.001455	Durbin-Watson stat	2.125137
Prob(F-statistic)	0.015738		

1st difference

Null Hypothesis: D(IV) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.26422	0.0000
Test critical values:	1% level	-3.485115	
	5% level	-2.885450	
	10% level	-2.579598	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(IV,2)
Method: Least Squares
Date: 08/15/21 Time: 08:16
Sample (adjusted): 2010M06 2020M06
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(IV(-1))	-1.132642	0.092353	-12.26422	0.0000
C	-12111.39	161406.8	-0.075036	0.9403

R-squared	0.558296	Mean dependent var	-32895.06
Adjusted R-squared	0.554584	S.D. dependent var	2660159.
S.E. of regression	1775377.	Akaike info criterion	31.63331
Sum squared resid	3.75E+14	Schwarz criterion	31.67953
Log likelihood	-1911.816	Hannan-Quinn criter.	31.65208
F-statistic	150.4111	Durbin-Watson stat	1.994234
Prob(F-statistic)	0.000000		

5. Feed price

Null Hypothesis: FP has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.789283	0.3842
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FP)
Method: Least Squares
Date: 08/15/21 Time: 08:17
Sample (adjusted): 2010M09 2020M06
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FP(-1)	-0.025540	0.014274	-1.789283	0.0763
D(FP(-1))	0.320417	0.088377	3.625593	0.0004
D(FP(-2))	-0.133791	0.089655	-1.492288	0.1384
D(FP(-3))	0.281586	0.089630	3.141636	0.0021
D(FP(-4))	-0.304995	0.088629	-3.441261	0.0008
C	144.0507	69.09831	2.084721	0.0394

R-squared	0.209609	Mean dependent var	26.32203
Adjusted R-squared	0.174324	S.D. dependent var	134.8972
S.E. of regression	122.5767	Akaike info criterion	12.50486
Sum squared resid	1682806.	Schwarz criterion	12.64574
Log likelihood	-731.7868	Hannan-Quinn criter.	12.56206
F-statistic	5.940398	Durbin-Watson stat	1.975146
Prob(F-statistic)	0.000066		

1st difference

Null Hypothesis: D(FP) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.041030	0.0000
Test critical values:	1% level	-3.486551	
	5% level	-2.886074	
	10% level	-2.579931	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FP,2)
Method: Least Squares
Date: 08/15/21 Time: 08:17
Sample (adjusted): 2010M09 2020M06
Included observations: 118 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FP(-1))	-0.853299	0.141251	-6.041030	0.0000
D(FP(-1),2)	0.178746	0.132400	1.350050	0.1797
D(FP(-2),2)	0.038593	0.109248	0.353262	0.7245
D(FP(-3),2)	0.317902	0.089191	3.564279	0.0005
C	22.22667	11.90234	1.867420	0.0644

R-squared	0.466519	Mean dependent var	0.186441
Adjusted R-squared	0.447634	S.D. dependent var	166.5270
S.E. of regression	123.7650	Akaike info criterion	12.51610
Sum squared resid	1730909.	Schwarz criterion	12.63350
Log likelihood	-733.4496	Hannan-Quinn criter.	12.56376
F-statistic	24.70405	Durbin-Watson stat	1.979548
Prob(F-statistic)	0.000000		

6. Retail price

Null Hypothesis: RP has a unit root
Exogenous: Constant
Lag Length: 9 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.582584	0.9887
Test critical values:	1% level	-3.489117	
	5% level	-2.887190	
	10% level	-2.580525	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RP)
Method: Least Squares
Date: 08/15/21 Time: 08:18
Sample (adjusted): 2011M02 2020M06
Included observations: 113 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RP(-1)	0.007126	0.012232	0.582584	0.5615
D(RP(-1))	-0.774324	0.097109	-7.973744	0.0000
D(RP(-2))	-0.560628	0.119013	-4.710631	0.0000
D(RP(-3))	-0.252456	0.124460	-2.028417	0.0451
D(RP(-4))	-0.274250	0.123742	-2.216302	0.0289
D(RP(-5))	-0.523277	0.122109	-4.285321	0.0000
D(RP(-6))	-0.339931	0.128386	-2.647731	0.0094
D(RP(-7))	-0.511563	0.131185	-3.899553	0.0002
D(RP(-8))	-0.571967	0.127672	-4.479958	0.0000
D(RP(-9))	-0.338220	0.121729	-2.778474	0.0065
C	0.730037	0.486185	1.501563	0.1363

R-squared	0.479068	Mean dependent var	0.180442
Adjusted R-squared	0.427996	S.D. dependent var	1.095905
S.E. of regression	0.828843	Akaike info criterion	2.554704
Sum squared resid	70.07208	Schwarz criterion	2.820202
Log likelihood	-133.3408	Hannan-Quinn criter.	2.662440
F-statistic	9.380287	Durbin-Watson stat	1.932103
Prob(F-statistic)	0.000000		

Null Hypothesis: D(RP) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.687546	0.0000
Test critical values:	1% level	-3.489117	
	5% level	-2.887190	
	10% level	-2.580525	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RP,2)
Method: Least Squares
Date: 08/15/21 Time: 08:19
Sample (adjusted): 2011M02 2020M06
Included observations: 113 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RP(-1))	-5.069362	0.659425	-7.687546	0.0000
D(RP(-1),2)	3.304583	0.609464	5.422110	0.0000
D(RP(-2),2)	2.757058	0.551342	5.000628	0.0000
D(RP(-3),2)	2.514967	0.488005	5.153566	0.0000
D(RP(-4),2)	2.251208	0.426340	5.280309	0.0000
D(RP(-5),2)	1.736696	0.366802	4.734696	0.0000
D(RP(-6),2)	1.404481	0.294962	4.761557	0.0000
D(RP(-7),2)	0.899237	0.209443	4.293465	0.0000
D(RP(-8),2)	0.333207	0.121034	2.753003	0.0070
C	0.998729	0.153332	6.513493	0.0000

R-squared	0.821136	Mean dependent var	-0.013097
Adjusted R-squared	0.805507	S.D. dependent var	1.873367
S.E. of regression	0.826181	Akaike info criterion	2.540327
Sum squared resid	70.30524	Schwarz criterion	2.781688
Log likelihood	-133.5285	Hannan-Quinn criter.	2.638269
F-statistic	52.53946	Durbin-Watson stat	1.930642
Prob(F-statistic)	0.000000		

7. Producer price

Null Hypothesis: PP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.03880	0.0000
Test critical values:	1% level	-3.484653	
	5% level	-2.885249	
	10% level	-2.579491	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PP)
Method: Least Squares
Date: 08/15/21 Time: 08:19
Sample (adjusted): 2010M05 2020M06
Included observations: 122 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PP(-1)	-1.007647	0.091282	-11.03880	0.0000
C	35.93376	16.74747	2.145623	0.0339

R-squared	0.503835	Mean dependent var	0.035246
Adjusted R-squared	0.499700	S.D. dependent var	256.5476
S.E. of regression	181.4609	Akaike info criterion	13.25621
Sum squared resid	3951365.	Schwarz criterion	13.30218
Log likelihood	-806.6291	Hannan-Quinn criter.	13.27489
F-statistic	121.8551	Durbin-Watson stat	2.000173
Prob(F-statistic)	0.000000		

1st difference

Null Hypothesis: D(PP) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.72755	0.0000
Test critical values:	1% level	-3.486064	
	5% level	-2.885863	
	10% level	-2.579818	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PP,2)
Method: Least Squares
Date: 08/15/21 Time: 08:20
Sample (adjusted): 2010M08 2020M06
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PP(-1))	-2.500313	0.233074	-10.72755	0.0000
D(PP(-1),2)	0.750546	0.172847	4.342248	0.0000
D(PP(-2),2)	0.250350	0.090282	2.772984	0.0065
C	0.126665	19.07279	0.006641	0.9947

R-squared	0.791592	Mean dependent var	-0.005462
Adjusted R-squared	0.786155	S.D. dependent var	449.9227
S.E. of regression	208.0595	Akaike info criterion	13.54656
Sum squared resid	4978207.	Schwarz criterion	13.63998
Log likelihood	-802.0204	Hannan-Quinn criter.	13.58449
F-statistic	145.6004	Durbin-Watson stat	2.100244
Prob(F-statistic)	0.000000		

Appendix 6: Results of Vector Auto-Regressive lag order selection criteria

VAR Lag Order Selection Criteria
Endogenous variables: IV PP RP FP ER AD
Exogenous variables: C DV
Date: 08/15/21 Time: 09:03
Sample: 2010M04 2020M06
Included observations: 115

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3991.93...	NA	7.02e+22	69.63358	69.92001	69.74984
1	-3479.47...	953.6080	1.77e+19	61.34745	62.49316*	61.81248*
2	-3427.20...	91.81663	1.34e+19*	61.06446*	63.06945	61.87827
3	-3398.81...	46.90636	1.56e+19	61.19679	64.06107	62.35939
4	-3362.88...	55.60800	1.60e+19	61.19807	64.92163	62.70945
5	-3337.81...	36.18778	2.02e+19	61.38816	65.97100	63.24831
6	-3304.66...	44.40119	2.26e+19	61.43761	66.87974	63.64654
7	-3277.66...	33.33134	2.90e+19	61.59424	67.89565	64.15195
8	-3228.49...	55.59021*	2.61e+19	61.36509	68.52579	64.27158

* 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

Appendix 7: Results for Johansen co-integration test

Date: 08/15/21 Time: 08:50
Sample (adjusted): 2010M09 2020M06
Included observations: 118 after adjustments
Trend assumption: Linear deterministic trend
Series: AD DV ER FP IV RP PP
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.330765983...	140.2734105...	125.6154330...	0.004700420...
At most 1	0.252800289...	92.88207603...	95.75366141...	0.077536654...
At most 2	0.226189621...	58.49418803...	69.81888751...	0.284509493...
At most 3	0.120522151...	28.23563393...	47.85612715...	0.803398997...
At most 4	0.059452943...	13.08125955...	29.79707334...	0.887866775...
At most 5	0.048250869...	5.848614954...	15.49471287...	0.713334459...
At most 6	0.000110730...	0.013066886...	3.841465498...	0.908788846...

Trace test indicates 1 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 *	0.330765983...	47.39133452...	46.23141975...	0.037406458...
At most 1	0.252800289...	34.38788799...	40.07757358...	0.190297469...
At most 2	0.226189621...	30.25855410...	33.87686661...	0.127325871...
At most 3	0.120522151...	15.15437437...	27.58433778...	0.735920436...
At most 4	0.059452943...	7.232644596...	21.13161629...	0.944187615...
At most 5	0.048250869...	5.835548068...	14.26460015...	0.634417107...
At most 6	0.000110730...	0.013066886...	3.841465498...	0.908788846...

Max-eigenvalue test indicates 1 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 7: Results for Error Correction Model

Dependent Variable: D(LDV)
Method: Least Squares
Date: 08/15/21 Time: 09:50
Sample (adjusted): 2010M07 2020M06
Included observations: 120 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LDV(-1))	-0.329563	0.130465	-2.526060	0.0130
D(LDV(-2))	-0.251964	0.095142	-2.648289	0.0094
C	0.004049	0.004746	0.853088	0.3956
D(LIV(-1))	0.036277	0.015889	2.283213	0.0245
D(LIV(-2))	0.006995	0.015510	0.450974	0.6529
D(LFP(-1))	0.094058	0.180055	0.522384	0.6025
D(LFP(-2))	-0.026451	0.175922	-0.150356	0.8808
D(LRP(-1))	-0.248148	0.215486	-1.151574	0.2521
D(LRP(-2))	-0.177483	0.242149	-0.732948	0.4652
D(LPP(-1))	0.099051	0.088065	1.124745	0.2633
D(LPP(-2))	-0.045430	0.101040	-0.449627	0.6539
D(AD(-1))	0.002999	0.021466	0.139714	0.8892
D(AD(-2))	0.041826	0.022859	1.829740	0.0702
D(LER(-1))	0.001289	0.004154	0.310325	0.7569
D(LER(-2))	0.003376	0.004075	0.828481	0.4093
RESID01(-1)	-0.530835	0.155108	-3.422353	0.0009

R-squared	0.549172	Mean dependent var	0.001825
Adjusted R-squared	0.484148	S.D. dependent var	0.065904
S.E. of regression	0.047334	Akaike info criterion	-3.139613
Sum squared resid	0.233012	Schwarz criterion	-2.767947
Log likelihood	204.3768	Hannan-Quinn criter.	-2.988678
F-statistic	8.445768	Durbin-Watson stat	1.894256
Prob(F-statistic)	0.000000		