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THE IMPACT OF FUEL PRICE ON SUPPLY CHAIN COSTS

IN SOUTH AFRICA

By

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A DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS OF A

MASTER OF COMMERCE IN ECONOMICS DEGREE

DEPARTMENT OF ACCOUNTING, ECONOMICS AND FINANCE

FACULTY OF MANAGEMENT AND COMMERCE

UNIVERSITY OF FORT HARE

SOUTH AFRICA

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2024

ABSTRACT

Fuel price volatility significantly affects supply chain costs, impacting the competitiveness and sustainability of business in South Africa. This study examined the impact of fuel prices on supply chain costs in South Africa, exploring the effects on transportation, inventory and logistics management. The study used a time series data from 1990 to 2022 and considered a direct correlation between fuel price fluctuations and their subsequent impact on supply chain costs. The Autoregressive Distributed Lag Model (ARDL) was used to determine long term relationship between the variables. The Error Correlation Model (ECM) was also used in the study to determine the short-term relationship between the variables. The findings revealed that there is a strong positive long run correlation between fuel price and supply chain costs in South Africa by 0.462, and it is statistically significant at 1% level by observing the probability (P<0.0007) in the ARDL Long Run Table. This implies that for every 1% increase in fuel price will result in an increment of 0.462 in the total cost of supply chain. The findings indicate that fuel price increases significantly and contribute to rising supply chain costs, with disproportionate effects on companies and consumers. The study suggested based on the findings that companies in South Africa should familiarise themselves with route optimisation. Rising fuel costs can incentivise logistics companies to optimise their delivery routes to minimise fuel consumption. This could entail utilising sophisticated routing software to discover the most fuel-efficient routes or consolidating shipments to reduce the number of trips. In addition, companies have to investment in fuel-efficient vehicles: High and volatile gas prices can motivate logistics companies to invest in more fuel-efficient vehicles or technologies, such as hybrid or electric trucks, to reduce their dependence on traditional gasoline or diesel fuel. The study is limited to specific variables affecting the relationship between fuel price and supply chain costs in South Africa but acknowledges that other factors may also play a role. Additionally, events outside the research period may not be considered. This research contributes to understanding the implications of fuel price fluctuations on supply chain costs in South Africa, informing policymakers and industry stakeholders.

Keywords: Supply chain costs, fuel price, ARDL, ECM, South Africa

DECLARATION

The undersigned **Masonwabe Victor Zanekile**, student number **201700815**, declares that this research is my own original work, that it has not been submitted and will not be submitted to any other university for a similar degree or any other degree.

Signature :

Date : 08/04/2025

PLAGIARISM

I, **Masonwabe Victor Zanekile**, student number **201700815**, hereby declare that this dissertation is my own original work that has not been taken or stolen somewhere else, and that it complies with the University of Fort Hare plagiarism policy rules.

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RESEARCH ETHICS CLEARANCE

I, **Masonwabe Victor Zanekile** with student number **201700815**, confirm that I am familiar with the University of Fort Hare's research ethics policy and have made sure to adhere to the rules. I have received approval from the Research Ethics Committee at the University of Fort Hare, and my reference number is **HOM021SZAN01**.

Signature :

Date : 08/04/2025

ACKNOWLEDGEMENTS

I am thankful to God for granting me the strength and ability to do my research, as well as for being with me through all the difficult times I have faced when doing this dissertation. Furthermore, I want to convey my heartfelt appreciation to the individuals listed below.

- First of all, I want to thank my supervisor/s, Dr D. Hompashe and Dr S. C. Fobosi for providing me with quality research assistance.
- Secondly, I would like to thank the National Department of Transport for their financial support during my postgraduate studies, none of this would have been possible without your support.
- Lastly, my family and friends for all the prayers, words of encouragement and the support they have given me throughout the years.

DEDICATION

"Love recognises no barriers" Maya Angelou.

To my mother, Miss. Victoria Zanekile; My father Mr. Baxolele Msuthwana; My loving grandmother Mrs. Nosebenzile Zanekile; my late uncle Mr. Thembinkosi Zanekile; my late grandfather/s Mr. Jackson Zanekile and Mr. Fudukile Msuthwana; and to all my siblings.

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
BFP	Basic Fuel Price
COVID 19	Corona Virus
CNB	Czech National Bank
CPI	Consumer Price Index
CSCMP	Council of Supply Chain Management
CSCPI	Composite Supply Chain Pressure Index
DES	Discrete Event Simulation
DoE	Department of Energy
ECM	Error Correction Model
EDRSA	Energy Department of Republic of South Africa
EOQ	Economic Order Quantity
EU	European
FC	Fuel Consumption
FP	Fuel Price
GDP	Gross Domestic product
GFC	Global Financial Crisis
GFL	General Fuel Levy
HC	Holding Cost
IBLC	Inbond Landed Cost
IFR	Inflation Rate

IFREC	Inter-Faculty Research and Ethics Committee
IHC	Inventory Holding Cost
IOL	Independent Online
JELS	Joint Economic Lot Size
LPC	London Premier Centre
MFCs	Micro Fulfilment Centres
NEER	Nominal Effective Exchange Rate
OC	Ordering Cost
PC	Purchasing Cost
PP	Philips Perron
REER	Real Effective Exchange Rate
SAPIA	South African Petroleum Industry Association
SC	Supply Chain
STATS SA	Statistics South Africa
TC	Transportation Cost
TCSP	Total Cost of Supply Chain
ULP	Unleaded Petrol
US	United States
USD	United States Dollar

CHAPTER ONE

1.1. INTRODUCTION

A supply chain is a system used by a business and its suppliers for the production and distribution of a specific good or service (Luktevich, 2022). Supply chain participants include manufacturers, vendors, warehouses, transport companies, distribution facilities, and retailers (Perez, 2022). All the supply chain participants have their operational costs which in this study considered supply chain costs. Supply chain costs are defined as costs that amount to a significant percentage of the total selling price of a product (Raza, 2022). Fuel price is an important component in the supply chain, which unfortunately can fluctuate widely. Logistics industry must often pay attention to fuel prices as they go hand in hand with supply chain costs (Becker, 2022). For instance, goods are transported across the supply chain, from the point of production to the point of sale by trucks, ships, pipelines, and trains (Lisitsa, 2019). However, in that process of transportation, fuel costs are featured in each stage and added to the overall costs of the goods and services.

According to the Department of Energy, fuel prices have been creeping up since late 2018 (DoE, 2022). Recently, the cost of a barrel of oil has reached an all-time high due to several global factors, and these prices are reflected at gas stations. Considering these high fuel prices, people may have noticed that the cost of goods they buy in stores or online has increased. This is because companies must factor in supply chain costs, as it costs the suppliers more to move the products across the supply chain, and logistics companies have no choice but to raise their prices in line with fuel price trends (Chorley, 2022). For instance, a record high fuel prices mean increased operating and product costs, so both businesses and consumers are affected. From trucks to shipping containers to airplanes (Avetta, 2022). In addition, Schoemaker (2022) noted that for every 10% rise in the fuel price consumers are expected to pay about “12% to 15%” more for goods at the retail checkout; if the opposite happens it is likely for customers to pay less. However, not only the final price of goods and services will be affected, moving cargo will be more costly as well, leading to further obstructions and backlogs for industries, which would have long- and short-term impacts on supply chains and affect business flexibility (MAERSK, 2022). Ultimately, the average price of almost everything that we buy is to increase because of the fuel price changes.

Atkin (2022) commented on the impact of escalating fuel prices on the manufacturing supply chain. In his commentary, he stated that the persistent escalation of fuel prices presents a highly intricate challenge and is experienced at each phase of the supply chain. As fuel prices perpetually ascend, costs are transmitted through every segment of the supply chain, commencing with wholesale material costs, followed by transportation costs, distribution expenses, and equipment pricing. As a result, suppliers pass on the additional costs to the next level of the supply chain in support of their profit margins, so we see a domino effect in the supply chain. In some industries, costs are passed on to customers as they pay more for their products (Simchi-Levi, 2012).

The government is very anxious about the fluctuating cost of fuel in South Africa, which is mostly driven by the rand-dollar exchange rate and crude oil prices (Radebe, 2018). However, the change in fuel prices has been taking place for decades and there is no sign of it slowing down. According to the Department of Energy, the price of fuel in 2000 was only R1.73 per litre, based on the average of 95 and 93 unleaded gasoline prices. In January 2010, fuel prices had risen to R7.63 and R7.86, depending on where you lived and whether you used '93 or '95 fuel. In 2020, however, fuel prices had quickly risen to the R16 mark and had already passed that mark for domestic users of unleaded 95 fuels. After passing the R16 mark in January 2020, they fell to R11.51 in May (Prior, 2020). However, even though fuel prices decreased in May, the rate at which they increased in previous years and currently is high compared its decreases.

These high fuel fluctuations tend to bring obstructions to supply chain industries as they escalate costs. For instance, Gurtu, Jaber, Searcy (2015) indicated that high fuel prices could result in an increase in each subsequent order cost, as a result, cost of average order will rise for all shipments within a manufacturing cycle. Consequently, companies that have their suppliers in relative proximity may be in a better place to manage their supply chain costs more successfully in the future. However, companies that have made significant investments in global supply chains might need to re-evaluate their supply chain plans to address cost pressures.

The few studies that have been conducted on this topic South Africa (Havenga et al., 1994; Havenga et al., 2014; Wolhuter, 2022) did not mainly show the direct impact of fuel price on supply chain costs but focused mainly on the impact of fuel price on the logistics side of the supply chain, as well as the pressure on the supply chain resulting from fuel price. Supply chain pressures resulting from changes in fuel prices were also assessed, with studies mainly showing the results of these pressures on the final price of goods and services without breaking down the supply chain activities that led to this final price of goods and services at retail stores. *Therefore, it is in this regard that the research seeks to analyse the impact of fuel price on supply chain costs in South Africa, indicating the cost pressures presented by fuel price in the entire supply chain activities.*

1.2. STATEMENT OF PROBLEM

According to the Energy Department of the Republic of South Africa (EDRSA) (2022), the average price of gasoline in South Africa was US$1.18 per litre from 1992 to 2022, peaking at US$1.3 per litre in September 2022. As a result, Schoemaker (2022) highlights a critical issue for South Africa, emphasising the necessity for businesses and individuals to brace for the significant and widespread effects of rising fuel prices. Fuel price hikes trigger a chain reaction that reverberates through the entire supply chain, escalating costs from the procurement of raw materials to their transportation to manufacturing facilities. In addition, these increased costs extend to production, as well as the distribution of finished products to retail outlets. This cascading effect is not isolated to South Africa, as supply chains globally are also facing similar pressures due to rising fuel costs, underscoring the vulnerability of the logistics sector.

Becker (2022) states that fuel costs are a central element in the overall expenditure of any supply chain. As such, fluctuations in fuel prices have a direct impact on the logistics industry, where price volatility is a recurring challenge. The connection between fuel prices and supply chain costs is undeniable, and it is an issue that companies must navigate with caution. As history has shown, businesses involved in supply chain management can suffer substantial and often irreversible harm when fuel prices surge rapidly. Therefore, it is imperative for companies to adapt and manage these changes strategically to mitigate their long-term negative impact on operations and profitability.

Schoemaker (2022) notes that for every 10% increase in the price of fuel means that consumer pay about 12% to 15% more for goods at the retail checkout; conversely, customers are likely to pay less. The reason for this is that the companies that use transport logistics to distribute the goods will have higher costs. Therefore, the prices for the products will be increased to protect the profit margins of the suppliers (Logistics, 2022). Additionally, the cost of cargo movement could increase as well with more expensive fuels, causing more delays and backlogs for businesses, which would have short and long-term impacts on supply chains (MAERSK, 2022).

Jones (2022) also indicated that companies in the globe are feeling the impact of fuel price uncertainty, more especially the logistics service providers, retailers, carriers, distributers, and customers, the impact is felt by these industries through operating costs as they tend to escalate due to fuel price changes. Business Tech (2022) issued a report stating that in South Africa throughout 2022, fuel price has been increasing at a hight rate compared to its decreasing rate with the most expensive month being July, when petrol and diesel prices reached close to R27 and R26 per litre, respectively. Even though fuel prices pose challenges to these industries in South Africa, few have taken significant steps to address the problem. While fuel prices typically fluctuate, current state of fuel prices is unlikely to settle soon (Jones, 2022).

Fluctuating fuel prices provide an ideal opportunity to interact with other supply chain participants. Companies can work together to develop practices, regulations, and operating conditions that will reduce your aggregate fuel usage. Inquire with your carriers and consumers about how your company might cut fuel consumption and minimise the impact of rising costs (Stuyf, 2022). MAERSK (2022) also indicated that supply chains will have to develop more flexibility in logistics structures, generate additional opportunities by potential near and distant sourcing options, while coping with local and worldwide disruptions.

This study seeks to analyse the impact of fuel price on total supply chain costs in South Africa from 1990 to 2022, showing the far-reaching impact of fuel prices on the supply chain.

1.3. OBJECTIVE

The primary aim of the research is to analyse the impact of fuel price on supply chain expenses in South Africa, this is explored through the following specific objectives;

- Overview of fuel price and supply chain costs trends in South Africa from 1990 to 2022
- Econometric study of the impact of fuel price on supply chain costs in South Africa from 1990 to 2022, and
- Provide policy recommendations based on the results.

1.4. HYPOTHESIS TESTING

H_0: Fuel price has no significant impact on supply chain costs in South Africa.

H_1: Fuel price has a significant impact on supply chain costs in South Africa.

1.5. SIGNIFICANCE

The benefits of supply chain cost optimization are enormous and can include improved cash flow and lower inventory levels to improve production efficiency and customer service (LPC, 2022). However, high fuel prices can lead to higher costs for transporting goods and cause further delays and backlogs in the industry, which has long and short-term impacts on supply chains and affects business agility (MAERSK, 2022).

There is a paucity of literature addressing the impact of fuel prices and supply chain costs in South Africa. In particular, studies by Havenga et al., 1994; Havenga et al. 2014; Wholhuter, 2022 conducted in South Africa on the relationship between supply chain costs and fuel price indicated the impact of fuel prices mainly on the logistics side of the supply chain and not on the total supply chain costs. However, that does not come with the direct implications that fuel price has on supply chain costs. Logistics mainly focus on planning and coordinating operations to ensure smooth supply chain and trade processes (Jenkins, 2022). Supply chain is broader than logistics in that it aims to create a sustainable and cost-effective linkage between consumer demand and the provision of completed products (Jenkins, 2022). Therefore, the supply chain becomes a missing factor in the fuel price and supply chain nexus, and this study finds it important to understand how fuel price directly affects supply chain costs.

Since the supply chain is broader compared to logistics, this study seeks to reveal the wide implications of the fuel price on supply chain costs. For instance, Schoemaker (2022) highlighted that in the space of high fuel prices, costs might increase across the supply chain from raw material prices to the cost of moving them to factories, from production costs to the higher cost of distributing finished goods to distribution facilities and retail outlets. These are some of the wide implications expected from studying the impact of fuel price on total supply chain costs.

In this context, the research endeavour aims to investigate the impact of fuel pricing on supply chain costs in South Africa spanning the period from 1990 to 2022, while concurrently elucidating the relationship between fuel pricing and supply chain costs.

1.6. STUDY DELIMITATIONS

The study is limited to certain variables that will be used as these variables may not be the only factors that contribute to the relationship between supply chain costs and fuel price in South Africa. Also, some events that occurred outside of the research period that could have had an impact on supply chain costs may not be captured. Hence, the study will employ data for the period from 1990 to 2022. The study is restricted to the economy of South Africa, meaning the findings may not be generalised to economies of other countries. However, for international experience, the study could facilitate an enhanced comprehension of the correlation between supply chain costs and fuel prices of a country.

1.7. ETHICAL CONSIDERATIONS

This study will abide by the University of Fort Hare's norms of ethical conduct for research. The approval for the research endeavour will be requested from the Inter-Faculty Research and Ethics Committee (IFREC). Information and data obtained from secondary data sources, such as organisation websites, shall be properly stated and plagiarism attributes will be excluded in respect of intellectual rights.

1.8. ORGANISATION OF THE STUDY

The first chapter covers the introduction and background, problem statement, objectives, hypothesis, and significance of the study. Chapter two provides the overview and trends of the dependent and explanatory variables. Chapter three discusses both theoretical and empirical literature review. Chapter four provides research methodology. Chapter five provides the results interpretation. The last chapter, which is chapter six provides the conclusion, summary, and recommendations for policy, practice or action.

CHAPTER TWO

OVERVIEW OF THE TRENDS BETWEEN FUEL PRICES AND SUPPLY CHAIN COSTS IN SOUTH AFRICA

2.1. INTRODUCTION

This chapter delivers a comprehensive analysis of the impact exerted by fuel prices on supply chain costs in South Africa from1990 to 2022. Schoemaker (2022) emphasised that escalations in fuel prices are likely to have extensive repercussions on supply chains. The logistics industry is an integral part of the supply chain. The escalation of fuel price may result in heightened expenses relative to shipping of both intermediate goods and finished goods, which could ultimately have a remarkable impact on the total cost composition of goods and services.

The cost of virtually everything we buy will be up because of the fuel price hikes. The cost increases are to be expected across the entire supply chain - from the price of raw materials to the cost of transporting them to distribution facilities and retail outlets. Also, Gurtu et al. (2015) noted that companies with distant suppliers will have to revisit their business strategies in the long run to accommodate the fluctuating fuel prices. However, with the lowest fuel prices supply chain costs ease and businesses run smoothly.

In summary, the cost of fuel has a noteworthy impact on the efficiency and viability of the supply chain and logistics business. Fluctuations in fuel costs can affect pricing structures, route planning, capital investments, and the overarching strategies employed by logistics firms, thereby ultimately affecting the cost and efficiency of goods transportation.

This chapter is presented as follows; the first section covers a review of fuel prices in South Africa, and the second section discusses fuel price trends. Following this, a discussion of the background and trends in supply chain costs, fuel consumption, inflation (CPI), and real effective exchange rate is presented. At the end of this chapter, concluding remarks are given.

2.2. OVERVIEW OF FUEL PRICES IN SOUTH AFRICA

According to Competition Tribunal report, in South Africa, fuel prices are based largely on import parity pricing since the 1950s, which relates the national product price to its imported price. One of the primary aims of this strategy is to ensure that national prices align with global price trends to avoid the inefficient allocation of local resources. The Inbond Landed Cost (IBLC) formula was used to determine the import parity price for gasoline.

This formula was introduced in the 1950s and utilised to calculate the retail price of fuel until April 2003. It differentiates between the two groups of factors which influence fuel prices. The first reflects the effects of international development and the second reflects any domestic influence in this respect. The calculation of the global price component in the equation was determined using the current price of petroleum on the global market and the costs relative to shipping these goods and service to South Africa (Rangasamy, 2017).

National factors include taxes, duties, and margins added to the global price element to obtain retail fuel prices. In April 2003, the international component of the IBLC formula was replaced with the Basic Fuel Price (BFP). The BFP is also based on the principle of import price parity. However, the principal reason for this change was to obtain a more precise estimate of the worldwide pricing of petroleum products. This relies on daily spot prices reported in global markets instead of refinery prices from the previous month, as given by the Inbond Landed Cost formula (Rangasamy, 2017). The basic fuel price constituted approximately 42% of the overall fuel price. The Basic Fuel Price encompasses the purchase cost of fuel (denominated in US dollars) in addition to freight expenses, insurance premiums, storage charges, and financing costs. In the context of South Africa, the fuel price undergoes modification on the first Wednesday of each month and is influenced by two principal determinants: the Rand/US Dollar exchange ratio (which reflects the mechanism of fuel procurement), and global petroleum prices (which indicate the expenditure required for fuel acquisition) (Thirumalai, 2022; Lechman, 2022). All the other elements constituting fuel prices are local in nature. These comprises of levies, margins, taxes, distribution costs, and storage. According to Statistics South Africa (2022), the overall fuel levies and taxes account for R6,67 (33%) of the total price of fuel, and the storage and distribution costs account for R1,14 (6%) of the total fuel price. There are different types of fuels, most commonly, petrol and diesel. These two types of fuels are used in different engines for transportation. In addition, they are priced differently at their gas stations in South Africa, based on international oil fluctuations and vehicle capacities. Their prices are influenced by global and domestic factors. Global determinants comprise the reality that South Africa imports both crude oil and final products at prevailing international prices, which encompass additional importation expenses such as transportation costs.

According to Vanderschuren and Jobanputra (2005), oil constitutes a significant portion of a country's imports. A notable portion of imports consists of gasoline and diesel fuels, primarily utilised for transporting goods and services. Approximately 80% of the primary energy supply brought into South Africa comes in the form of oil. This is the biggest item in the country's imports. Following a period of low crude oil prices, there were substantial price rises in 2004. This results in financial and societal difficulties across the community and has prompted the government to find ways to lower the costs of fuel and refined products.

In recent years, there has been significant growth in the fuel industry in South Africa. Liquid fuel sector contributes around R300 billion to South Africa's GDP and provide about 100 000 direct and indirect jobs (Ratshomo, 2020). Therefore, the liquid fuels play a vital role in South Africa's economy.

The South African transport sector has fallen mostly upon petroleum fuels to meet its energy needs, with over 85% of fuel consumption being petrol and diesel. The country boasts a nameplate refining capacity of about 718,000 barrels per day. However, production from these refineries lies below the demand for petrol and diesel (Ratshomo, 2020). This has been the case and thus has really contributed to continued high imports of both finished petrol and diesel product imports.

2.2.1. Petrol fuel

According to Woosey (2021), petrol serves as a primary energy source for numerous heat engines and, notably, functions as a fuel for a significant proportion of automobiles. This fuel is used in many vehicles, including cars, motorcycles, motorboats, and airplanes. Gasoline has had a beneficial impact on our lifestyles by offering easy, immediate transportation options. This has created a global economy, which has moved people and materials worldwide. Fuel prices have increased since March 2011. The price of 95 unleaded petrol on the coast increased from R9.18 in March 2011 to R15.62 in March 2021, while the inland price of 93 ULP rose from R9.27 to R16.15. However, the current price is not always high, as 93 ULP hit R16.85 in October 2018 during the last oil price spike (Woosey, 2021).

2.2.2. Diesel fuel

Diesel fuel is a flammable liquid fuel utilised as a source of energy for diesel engines. It is commonly derived from petroleum fractions that exhibit lower volatility compared to those present in petrol. Diesel fuel is burned not by a spark but by the heat generated during compression of air in the cylinder to which the fuel is injected in internal-combustion diesel engines. Combustion of diesel fuel releases higher energy output, and for that fact, diesel engines normally attain better fuel economy than gasoline engines. Diesel fuel is commonly used in trucks, trains, boats, and barges (Petruzzello 2022).

The scenario with diesel fuel is a little more difficult to describe, as the Department of Energy only publishes wholesale prices for this type of fuel, but for what it is worth, the cost of low-sulphur diesel fuel on the coast increased from R8.71 in March 2011 to R13.58 in March 2021, a much lower percentage (56%) than gasoline prices, which amounted to 70% (Woosey, 2021).

2.2.2. General fuel levy

Ncanywa and Mgwangqa (2018) state that the fuel levy is a type of excise tax imposed on various petroleum products like gasoline, diesel, and biodiesel, and is overseen by the South African Customs and Excise Act No. 91 of 1964 (Salmons, 2011; Gordhan, 2012). In various other nations, a fuel levy is allocated for the financing of particular projects, whereas in the South African context, it is implemented on a national scale as part of the comprehensive funds utilised by the government. Fuel levies are taxes that are adjusted on a yearly basis in order to support various government spending initiatives (Reynolds & Schoor, 2005; Jibrin, 2012). The General Fuel Tax shall be charged for each litre of fuel sold. The price of the GFL is R3.96 per litre in South Africa and represents around 17% of every litre's sales volume. However, this represents approximately 23% of the overall fuel price (IOL, 2022; Thirumalai, 2022).

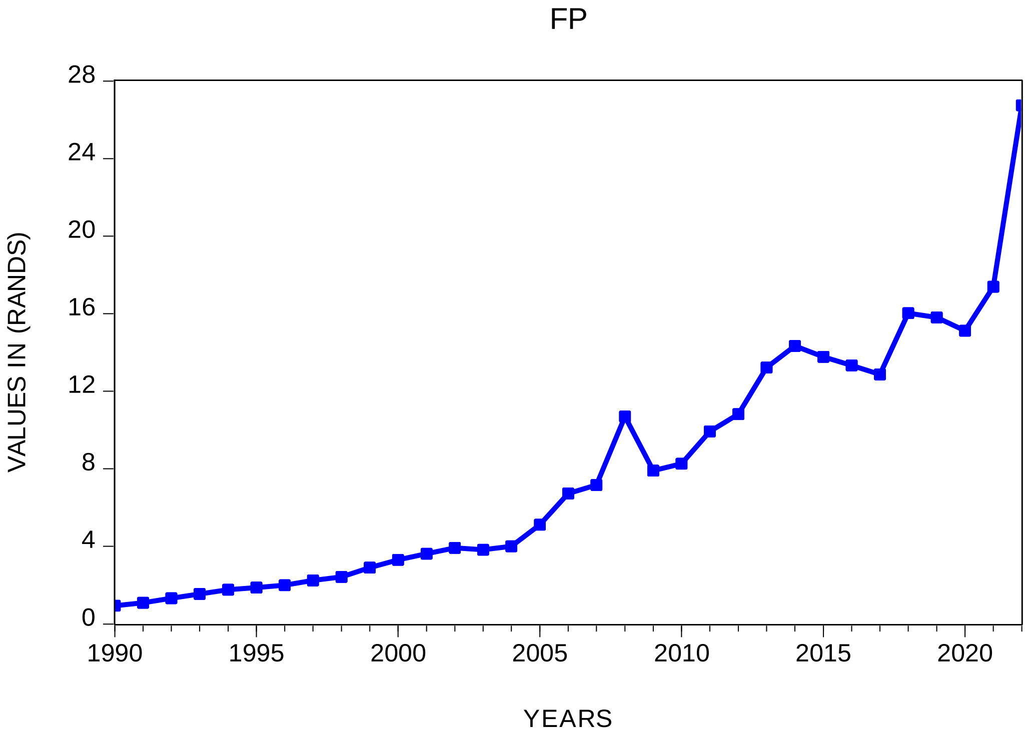

Figure 2.1: Trends on fuel prices in South Africa (FP)

Data Source: *World Bank Site*

Figure 2.1 illustrates fuel price trends in South Africa. Over the last few years, there has been a steady increase in fuel prices with several spikes and drops. This has been caused by the instability of international crude oil prices; gasoline prices are mainly affected by crude oil prices. Therefore, an increase in the main factor results in a positive impact on fuel prices. The price at which consumers buy fuel in South Africa is determined by a wide range of both global and domestic factors. Global factors consist the reality that South Africa import both crude oil and refined products at a price established on the international market, which incorporates importation expenses, such as shipping fees. For this reason, the historical prices of various fuels have continued to increase, for example petrol 93 and 95 or diesel 50ppm and 500ppm (SAPIA, 2022). The average price of fuel in South Africa has been recorded at US$1.09 per litre from 1992 until 2022, attaining a peak value of US$1.60 per litre in July 2022 and a minimum recorded value of US$0.43 per litre in December 1998 (EDRSA, 2022).

Over the preceding two decades, South Africa has witnessed a substantial escalation in fuel prices, averaging an increase exceeding 278%. Specifically, petrol 95 has experienced the most significant surge, with an increase of 368%, while diesel 50ppm has risen by 51% since the year 2008. It is noteworthy to highlight that Diesel 50ppm was introduced into the nation in 2006, with the earliest documented price records originating from 2008.

In 2008, the country saw a double-digit increase in fuel prices, with petrol 95 reaching R10.70 and diesel 50 ppm at R11.35. Fuel prices are subject to change during the period between 2008 and 2011, when petrol prices dropped below R10. Nevertheless, 2011 was the last year when petrol prices were below R10 (DoE, 2022).

Within the review period, the price of petrol 95 has more than doubled in South Africa if the latest increase in 2022 is to be excluded. The first was in 2008, it surged from R7.16 to R10.70 in just one year, recording a 49% year-on-year increase from the previous year. This event occurred amidst a global economic recession, characterised by South Africa experiencing inflation rates exceeding 11%, while the rand was valued at around R7.90 per dollar, indicative of a significant depreciation of the local currency at that point in time (Toit, 2022). It was in the same period that the quotation for Brent Crude light oil reached their record high of more than US$130 per barrel.

The main drivers of South Africa's fuel prices are the currency exchange rate of the rand against the dollar, as well as international oil prices, which have been key factors behind the price increases in 2008. The high prices lasted between one and two years, as Petrol 95 returned to R7.90 per litre in July 2009 (Toit, 2022). This was also caused by the decline in international oil prices in 2009, which provided some relief for South African fuel prices. However, starting from late 2009, local gasoline prices have escalated by 80% in actual numbers and 43% when adjusted for inflation.

The next significant rise in fuel prices occurred in July 2018, with petrol 95 increased to R16.02 a litre-a jump of 25% from last year's price, which was R12.86. The increased fuel prices, according to the Mail&Guardian report, were not due to the decline of the rand alone but to increased import prices for oil products and increments in general fuel and road accident fund levies to meet the inflation of 5% in that time. This year, the international oil price played no greater role, given that supplies were steady, and most of the adverse factors affecting fuel prices were concentrated on South Africa's borders. However, these higher prices did not last for a long time due to their failure to cross the R13 per litre mark again (SAPIA, 2022).

However, within a span of less than five years, the cost of gasoline in South Africa has rocketed by over 100%, rising from R12.86 per litre for petrol 95 in domestic rates in July 2017 to R26.74 per litre in July 2022, owing to the global oil prices and the Ukrainian war.

Comparatively, it took more than 11 years for the price of fuel to increase twofold from R6.12 per litre in May 2006 to R12.86 in July 2017. Although there have been fluctuations in fuel prices in the past, exemplified by the 2008 financial crisis and the 25% increase in 2018, there have been no drastic changes that South Africans have faced in the preceding five years (Toit, 2022). The rise in domestic fuel prices was big news in South Africa in 2022, as drivers consistently paid over R20 per litre throughout the year. July is the month that recorded the highest prices, with petrol and diesel prices hitting close to R27 and R26 per litre. The primary factor behind the price increase was the uncertainty of the international crude oil price. At the same time, the fuel levies charged on South Africa per litre are also an important contributing factor (Business Tech, 2022).

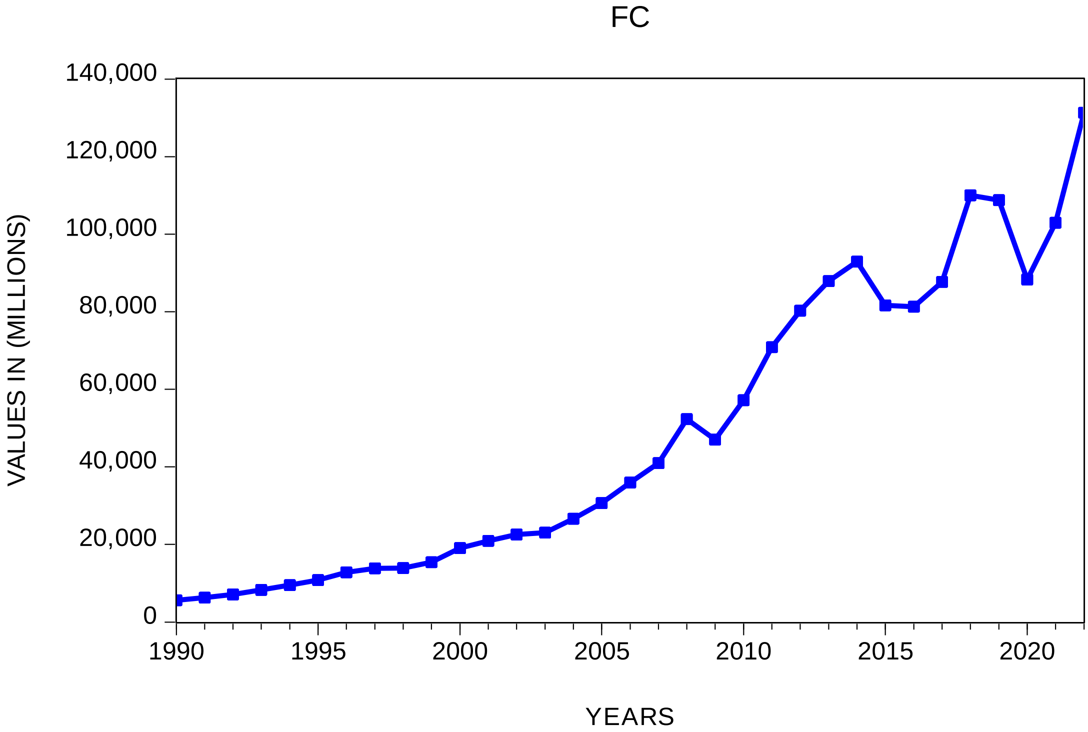

Figure 2.2: Trends on fuel consumption in South Africa (FC)

Data Source: *South African Reserve Bank*

Figure 2.2 illustrates fuel consumption trends in South Africa. Fuel consumption was steady from 1990 to 2000, averaging approximately 10.5 billion litres. The ratio between petrol and diesel production in South Africa's refineries, as well as the demand for both fuels, did not match. This has led to a surplus of diesel, in line with previous demand. However, this imbalance has been reduced by an increase in the share of diesel vehicles and the growing demand for liquid fuels. Moreover, between 2000 and 2006, petrol consumption in South Africa remained relatively stable with annual increases ranging from approximately 1.6% to a slightly higher percentage of premium grades introduced in 2006. During this period, diesel consumption growth, which averaged approximately 8% over the last five years, continued to stagnate (SAPIA, 2008).

The South African Petroleum Industry Association reported a 1.15% rise in gasoline consumption in South Africa from 11.4 billion litres to 11.5 billion litres between April 2007 and April 2008. There was a 0.9% decline in consumption in the latest quarter, suggesting a level of awareness. However, there was a significant 9.5% rise in diesel usage.

This could be due to the switch to diesel vehicles. Another factor, it is believed that it is the increasing use of diesel by the government, specifically by hauliers increasing coal supplies at Eskom power plants (Hoorn and van Schalkwyk, 2008).

In South Africa, the amount of petrol used decreased from 11.4 billion litres in 2009 to 11.1 billion litres in 2018. Over the past ten years, the demand for petrol has surpassed its national production. Imports rose to 2.4 billion litres in 2011 to satisfy the surplus demand but have since dropped to 1.4 billion litres in 2016 before rebounding in 2017 and 2018. On the other hand, the use of diesel rose by an average of 3% annually throughout the evaluation time frame. However, diesel consumption dropped by 10% in 2016 after peaking at 13.4 billion litres in 2015, but then rebounded to 12.9 billion litters in 2018 (DoE, 2018).

In 2019, there was an increase in South Africa's annual fuel consumption to 27 billion litres. However, owing to the COVID-19 pandemic, this number dropped significantly in 2020 to 23.19 billion litres. The demand for fuel decreased because of the national lockdown. To avoid spreading the coronavirus, there was a restriction on the movement of vehicles, and people were encouraged to remain in their homes. The lockdown measures gradually eased in 2021, resulting in an increase in fuel consumption to 25.18 billion litres (Charitar, 2022).

South Africa's crude oil consumption amounted to 521 000 barrels per day by the end of December 2022. Despite a significant change in the last few months, it appears that South Africa's petroleum consumption increased from January 2022 to December 2022, ending at 521 000 barrels per day (World Bank, 2022).

2.3. BACKGROUND ON SUPPLY CHAIN COSTS IN SOUTH AFRICA

According to Lapinskaite et al. (2014), there are a wide variety of definitions for the term supply chain. In summary, the supply chain constitutes the overall process of product movement from the supplier to end customer. Supply chain and logistics play a leading role in over 10% of the total costs for several companies. Therein also lies one of the greatest opportunities for cost savings and faster and more reliable delivery to customers, and customer satisfaction leads to sales. Logistics and supply chain management are crucial components in every economy and are key contributors to a country's competitiveness. The demand for products can only be met through proper and cost-effective delivery of goods and services. Moreover, roads are a major means of freight transportation throughout the country. Therefore, in order to achieve increased market shares of various products on the global market, South Africa must have world class supply chains so that it will be able to deliver goods efficiently (Ittmann 2010).

The importance of the supply chain concept has been recognised and evaluated by an increasing number of companies in the 21st century. A firm's supply chain plays an important strategic role in various activities. This process is regarded as one of the best practices for monitoring a company's distribution. The supply chain is generally not focused on improving profits; however, it has a major impact on profitability by optimising procedures and reducing the cost of finished products (Morana, 2013).

The primary aim of the supply chain is to manage all the planning activities. It integrates supply, demand, inventories, logistics capabilities, and sourcing activities. Its basic function is to connect the suppliers and the consumers. In order to achieve this goal, the supply chain manages all the operational activities such as buying, storing, and supplying goods. The supply chain should ensure that all functions listed above are balanced to obtain the best possible outcome. In addition, supply chain management can contribute to business strategy by the development and operation of a functional Supply Chain Strategy. The implementation of this principle may occur within the general enterprise process by acceding to a valuable asset at the end.

Currently, companies are looking for cost reductions to ensure competitiveness as consumption and production grow at an extraordinary rate. Supply chain expenditure has a major impact in the cost of the final product for manufacturing companies. To maintain a market, companies need to become more effective in view of growing globalisation. A reasonable price for a product is essential for maintaining the competitiveness and retention of customers. Approximately 55% of the total product price is associated with supply chain costs. It is supreme that the processes in the supply chain are constantly improved to reduce total costs, as they have an important effect on the overall cost of finished products (Lapinskaite & Kuckailyte, 2014).

In South Africa, supply chain costs have skyrocketed in recent years from raw materials to technology, infrastructure, and logistics. The costs of producing and transporting goods throughout the supply chain continue to increase. This is exacerbated by the ongoing shortage of semiconductors, raw materials, and industrial equipment, which provides a market advantage to whoever pays the most (Bain, 2022).

In many industries, costs related to delivering goods and services within a supply chain are on the rise. Regardless of this trend, South Africa lacks sufficient data on how supply chain participants view cost optimisation.

The most important element for managing supply chain costs and obtaining and maintaining a competitive edge is providing accurate information on processes in the supply chain. Nevertheless, operating costs are huge; for example, supply chain costs incurred by a large number of businesses, such as telecommunications companies, in providing goods and services. These costs impact the tariffs that end users pay (Mpanywa & Heerden, 2017).

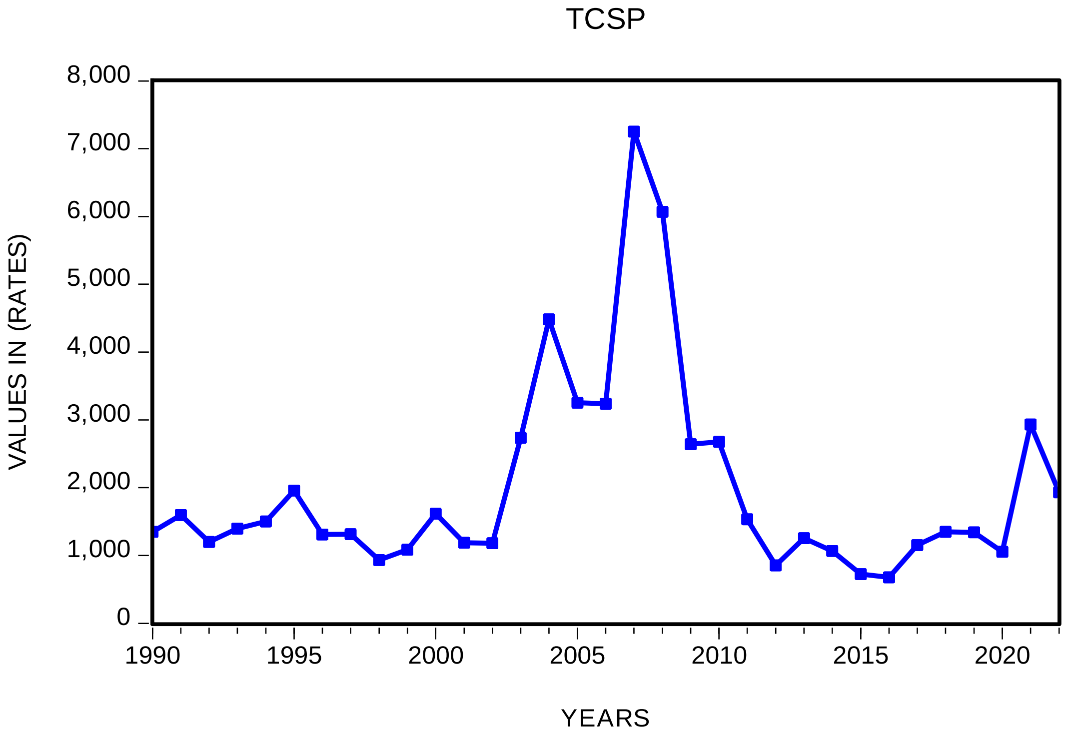

Figure 2.3: Trends on Supply Chain Costs in South Africa

Data Source: *South African Reserve Bank*

Figure 2.3 display the historical trends in the supply chain costs in South Africa. From 1990 to the early 2000s, fluctuations in supply chains were narrow. Previously absorbed supply chain costs increased to 2% or 3%, requiring reduction to maintain a strong bottom line for the business. Simultaneously, lower-cost imports resulted in extended supply chains to distant nations, leading to increased complexities in logistics.

Over time, supply chain costs fluctuated, and there are several episodes that have stood out. For example, examining the trend above, supply chain costs were high in the period of 2007 and 2008, just before the global financial crisis. In the period preceding the global financial crisis, namely, the world economy underwent a period of strong and synchronised expansion of the business cycle, as reflected by the sharp hike in global commodity prices and the swift expansion of the volume of international trade.

This resulted in a depletion of inventories, driving up transportation costs and the prices of most goods and services globally due to higher demand than supply. During that period, numerous new ships were constructed in order to enhance their storage space (Mefford, 2009). The following Global Financial Crisis and economic downturn caused a sudden decrease in demand, resulting in an abrupt turnaround for global supply chains. Excess capacity has resulted in a reduction in shipping costs, and ships/containers were momentarily suspended or withdrawn from operation. In addition, reduced demand for goods resulted in a slower decrease in inventories, with sharp decreases in commodity prices and shorter processing times.

After moving sideways in a relatively narrow range for more than ten years, the South African CSCPI increased sharply from June 2020 onwards. The increase in CSCPI was caused by the first COVID 19 hard lockdown, which reflected a decrease in inventories and supply shortages as demand recovered. At the end of 2020 and in early 2021, supply shortages likely became more severe as a result of a second wave of COVID-19 infection. The increase in Delta variant and untraditional domestic factors, including public unrest and Transnet port disruptions during July, have further affected supply chains since mid2021. Simultaneously, with rising international shipping costs coupled with increasing shortages of raw materials, pressure on supply chains around the world continues. In February 2022, the supply chain pressure index rose to its peak due to heightened supply chain pressures stemming from the Omicron variant, China's zero COVID-19 policy, and the Chinese Lunar New Year, which both have a detrimental effect on absenteeism among staff in addition to further depletion of already low inventories. Global and local supply chains could continue to be constrained due to the ongoing hostilities between Russia and Ukraine. However, on the positive side, there has been a decrease in supply chain cost inflation by the end of 2022, as shown in the above trend.

The effects on supply chains vary in source, intensity, and length of demand and supply disruptions during the global economic crisis and COVID-19 quarantines. The lockdowns due to COVID-19 caused disruptions in production, leading to shortages, port delays, and container relocations, but also sparked a remarkable increase in business activity and demand. Unlike the Global Financial Crisis, the global spread of COVID-19 is a completely unexpected external event that impacts both the demand and supply for goods and services unexpectedly, requiring crucial monetary and fiscal stimuli (Attinasi, Bobasu and Manu, 2021). The unanticipated rapid increase in demand after restrictions were lifted, especially for goods, led to an abrupt increase in trade volumes and prices, whereas supply was unable to keep pace, causing increased costs in the supply chain to restrict excessive demand.

2.4. BACKGROUND ON INFLATION RATE (CPI) IN SOUTH AFRICA

In the 1970s and the 1980s, South Africa's inflation was significantly greater than that of most other parts of the world because of a sharp rise in oil prices (Ricci, 2006). Nevertheless, South Africa’s main trading partners have experienced relatively weak inflation since the beginning of the 1980s which has led to lower import prices in South Africa. Initially, however, due to a major increase in the general money supply within South Africa relative to its trading partners, inflation rates in South Africa persisted at elevated levels throughout the majority of the 1980s. In light of the restrictions imposed on the nation and an array of foreign exchange controls, South Africa was compelled to implement a monetary policy characterised by relatively low interest rates aimed at stimulating economic activity in the short run. It was not until the 1990s, when restrictions were rescinded and the economy commenced a gradual process of liberalisation, that inflation rates began to fall (Sanlam, 2016).

Inflation rate in South Africa is commonly referred to inflation rate based on the consumer price index (CPI) over both short- and long-term. The South African CPI reflects the variations in the pricing of a typical assortment of goods and services that households in South Africa procure for their consumption needs. To estimate inflation, it assesses the percentage of CPI that has increased in the current period relative to the CPI in the previous period (Carson, Dziobek, & Enoch, 2002).

2.4.1. Targeting Inflation in South Africa

Since the 1990s, South Africa has been more frequently utilising inflation targeting, although in a casual and diverse way. In February 2000, it was declared that South Africa would implement structured inflation targeting as the framework for its monetary policy. Yet, prior to this declaration, the South African Reserve Bank had already been implementing "informal inflation targeting." Significant focus was given to achieving price stability, although no specific timeline for achieving this goal was mentioned. Initially, the framework also varied from formal inflation targeting as it utilised an intermediate target, the growth in money supply, to guide monetary policy decisions (Ricci, 2006).

Subsequently, in the late 1990s, the Reserve Bank adopted a strategy characterised as "eclectic" or "pragmatic" concerning inflation targeting. Within this paradigm, the evolution of monetary aggregates continued to be perceived as critical components in the inflationary process, yet the Reserve Bank precisely scrutinised developments in various financial and real indicators when determining the appropriate short-term interest rate (Merwe, 2004).

A formal inflation target was not introduced until the 2000 budget. Apart from eliminating uncertainty for the public, setting a formal inflation target also enhances cooperation among monetary policy and other economic policies implemented by the government. South Africa is among a small number of nations worldwide that have included the autonomy of their central bank in their constitution. However, it is essential for the central bank and finance minister to have regular consultations. The finance minister announces the inflation target level, but a committee made up of members from both institutions assist in the process (Merwe, 2004 & Ricci, 2006).

A greater degree of transparency is a characteristic of the inflation-targeting framework for monetary policy. Ensuring the legitimacy of monetary policy and controlling the growth of wages and other expenses, along with how businesses determine prices, ultimately leads to a decrease in inflation, and these are achieved through a formal framework targeting a set band, such as our 3% to 6% headline CPI. Moreover, the reliability of the target can be compromised by the time horizon in which its objectives have been established. One can anticipate that it would take approximately 18 to 24 months for a shift in interest rates to have a complete impact on inflation, therefore, in SA, a multiyear target approach was employed (Sanlam, 2016).

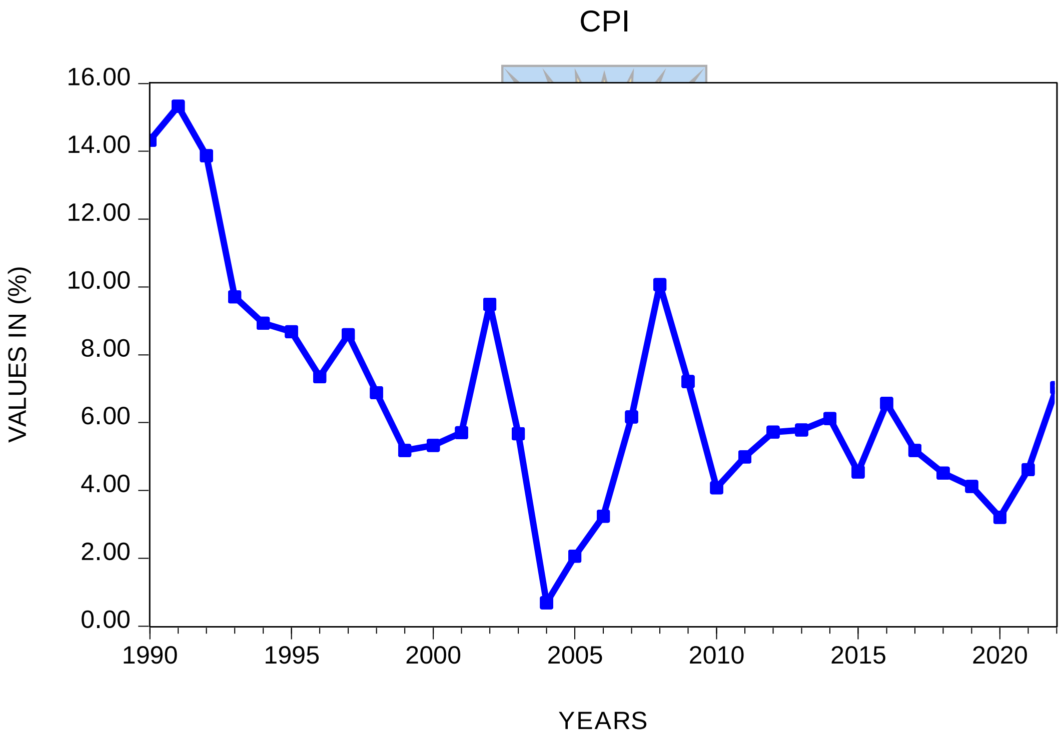

Figure 2.4: Trends on consumer price index in South Africa (CPI)

Data Source: *World Bank Site*

Figure 2.4 depicts inflation trends in South Africa. In the early1990s inflation was extremely elevated, pointing above the measure due to political unrest. Between 1994 and 2000, poverty in South Africa was at its highest due to inflation rates of approximately 8.8% in 1994 and 7.3% in 1996 (Özler, 2007; Ricci, 2006). However, in 2003, the country's economy recovered, and things improved as the apartheid government was formally removed and prices began to fall to reduce the poverty gap (Hollander & Havemann, 2021). In response to rising food costs and constant increases in administered prices, consumer inflation, which stood at an average of 5.2% in 2015, continued to increase (Statistics SA, 2022). During the latter part of 2015, administered price inflation, except petrol, rose to 8.4%, up from an average of 6.5% in the first quarter of the year. As a result, the Reserve Bank was forced to increase the repo rate by 6.75%, up from 5.75% in February 2015, as a result of worsening inflation prospects (Iddrisu, 2020).

Higher inflation estimates in 2016 were driven by higher food prices and a decrease in the exchange rates, given expectations that businesses would charge consumers more to compensate for weaker rands compared with previous years (Stats SA, 2016). From 2018 onwards, it was expected that the average yearly inflation rate would still exceed the target band of 6% owing to an increase in pass-throughs such as the impact of lower exchange rates on domestic inflation, moderate increases in world oil and electricity prices. The forecasted yearly average electricity cost rose by about 5.8% between 2016 and 2018. SOEs and local governments needed to increase revenues from administered prices in order to ensure that the benefits of the user-pay approach could be transmitted to customers. The rise in prices of goods has aided in the revival of worldwide inflation. The escalation in worldwide producer price inflation has been especially noticeable due to the higher significance of products in producer price indices relative to consumer price indices and their role as intermediate inputs in production (Gengele, 2018).

In 2019, compared to 2018, the average annual inflation rate of consumer prices for all urban areas in 2019 stood at 4,1%. This was below the corresponding average of 4,7 % in 2018 by 0,6 percentage points. According to Stats SA, the average annual consumer price inflation stood at 3.3%, which represents the average CPI for all urban areas in 2020 compared to that in 2019. This figure represents a decrement of 0.8 percentage points relative to the indicative average of 4.1% observed in 2019 (Stats SA, 2020).

In 2021 and 2022, headline inflation was primarily driven by transport, as discussed below. Between 2021 and 2022, the consumer inflation hit a 13-year peak at 7.8%, with transportation accounting for 44% (3.4 percentage points) of the total inflation rate (Stats SA, 2022).

2.5. BACKGROUND ON REAL EFFECTIVE EXCHANGE RATE IN SA

The real effective exchange rate represents the frequency with which a specific monetary amount can buy goods and services in other countries (once converted into a foreign currency). In practical terms, fluctuations in the real exchange rate are significantly more critical than its absolute value (CNB, 2022). The economy is affected by the real exchange rate through its influence on major economic factors like inflation, employment, and, notably, economic growth (Muzekenyi, Zuwarimwe, Kilonzo & Nheta, 2019). The real exchange rate fluctuations significantly influence the competitive positioning of local goods, resulting in an increase in either exports or imports, consequently changing the growth of trade balance. Economists now view the real exchange rate REER as a policy tool to encourage a country's economic growth (Sibanda, 2012). The transmission channels of REER impact on economic growth, on the other hand, are still a point of contention between them. Several economists emphasise the impact of the real effective exchange rate on trade balance advancement, whereas others focus on the impact on investment (Cakrani, 2014).

The real effective exchange rate is a critical estimate of a nation's product competitiveness. If REER is undervalued, local items are low priced compared to international ones, which might result in relocated demand, both domestic and foreign, for relatively free local goods and services. This will lead to increased exports and reduced imports, improving the trade balance and stimulating the local economy (Cakrani, 2014).

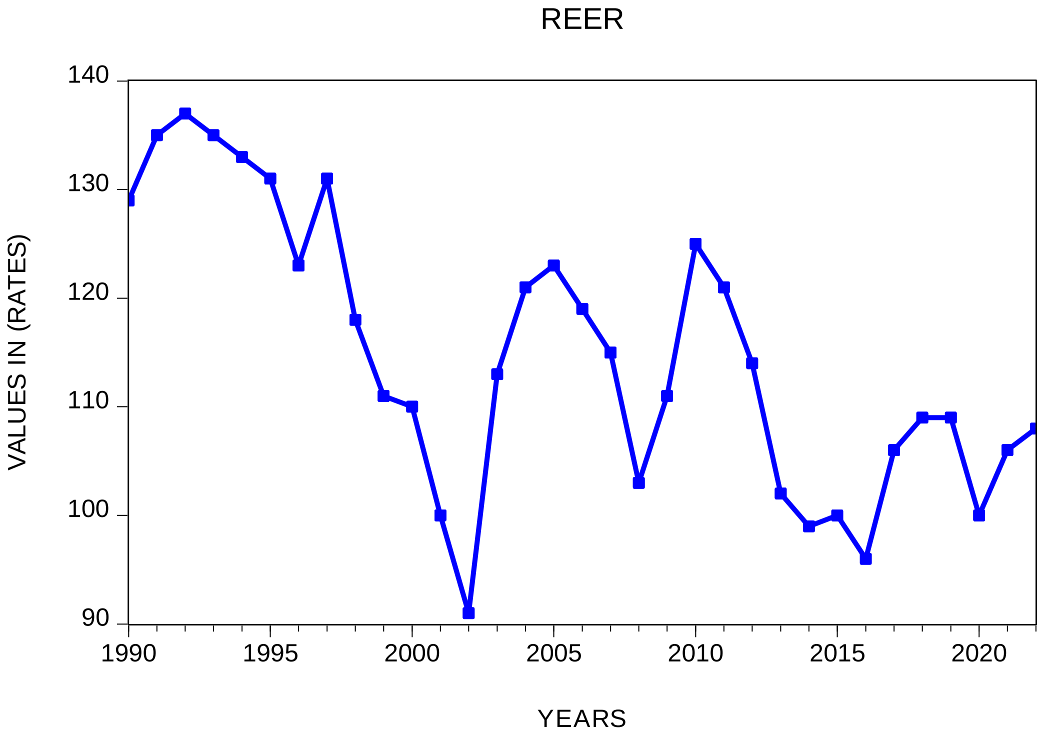

Figure 2.5: Trends on real effective exchange rate in South Africa

Data Source: *South African Reserve Bank*

Figure 2.5 presents the evolution of the real effective exchange rate in South Africa. The Real Effective Exchange Rate (REER) has exhibited cyclical fluctuations, characterised by intervals of appreciation followed by phases of currency depreciation, and currency fluctuations also indicating volatility. From the year 1970 to 2018, approximately five instances of significant REER currency movements were recognised, including two instances of appreciation and two instances of depreciation. Political conflicts in South Africa, along with economic penalties and restrictions on capital flow, greatly influenced the currency exchange rate of the country between the early 1970s and the pre-1994 democratic elections. This period was marred by a continual decrease in the nominal exchange rate, money leaving the country, slow GDP growth, and a favourable current account balance. A steady depreciation in capital outflows, sluggish GDP growth, and favourable current account balance tarnished this period. Between 1986 and 1993, the REER appreciated significantly, moving from about 81 in 1986 to 111.04 at the end of 1992, primarily owing to a decrease in South Africa's inflation rate. Moreover, during the period spanning from 1993 to 2001, the real effective exchange rate experienced a decline from a peak of nearly 110 to a trough of 71 towards the end of 2001, characterised by a significant depreciation of the currency between 1993 and 2001. This phenomenon transpired within the framework of enhanced macroeconomic conditions and the country's re-engagement with the global economy subsequent to its successful transition to democracy in 1994.

Several factors could have contributed to this, including a probable contagion impact from the Asian financial crisis of 1997–1998, low global commodity prices, and currency unpredictable strikes. The currency rose rapidly after the end of 2001, resulting in a period of appreciation from 2002 to 2006, during which the REER increased by approximately 34%. An increase in the NEER (nominal exchange rate) and a decrease in the inflation rate drove this episode. The degree and rate with which the rand recovered suggests that the currency was severely overvalued in 2001, necessitating a correction. Saayman (2007) observed that the appreciation of the South African currency in 2002 initiated deliberations regarding the suitable exchange rate and the competitive positioning of South African exports. The mining industry, the manufacturing sector, and labour unions articulated their concerns most vocally regarding the detrimental economic implications of the stronger currency.

After the 2007 global financial crisis, there was a decrease in worldwide trade, economic growth, and an uptick in financial market instability, leading to heightened concerns about emerging markets like South Africa. The REER fell from 90.78 in the first quarter of 2007 to 77.55 in the fourth quarter of 2008, before rebounding by approximately 30% to reach 106.76 in the second quarter of 2010. The REER progressively depreciated from its peak in 2010 to 81.20 by the end of 2014. The REER and NEER values were nearly the same from 2008Q3 to 2011Q4, however, from 2012Q1, REER was greater than NEER. Such changes, particularly the magnitude of the nominal exchange rate's depreciation, sparked new worries about if these movements were a true reflection of the economic basics of South Africa, and if the currency was priced correctly, or whether the exchange rate was misaligned (Khomo, Aziakpono and Camarero, 2020).

The REER increased in 2014 and early 2015 before declining again. The rise in the real effective rand in 2014 contrasts sharply with the deterioration of the nominal rand/dollar exchange rate. From 2018 to 2019, the actual effective exchange rate was stable, but after 2019, it began to fall until 2020, owing to the Corona virus outbreak, and it continued to fall since the country's economy and currency were both weak as shown in the above diagram.

However, in 2021, lockdown measures were gradually easing, and the economy was recovering; thus, the export volumes and the REER also gained value slightly and started to increase back-to-back, as shown in the diagram above. In 2022, South Africa's real effective exchange rate was 75.96%. This represents a further increase in South Africa's exchange rate. It recorded a significant increase against the U.S. dollar over the months, mainly because of better market attitudes after Joe Biden won the U.S. presidential election and positive advancements in Covid-19 vaccines.

2.6. SUPPLY CHAIN COSTS AND FUEL PRICE

The following discussion provides a simplified view of what happens with both the price of fuel and its impact on supply chain costs. Fuel costs can account for 25-30% of a freight firms' costs (Jackson, 2022). To take this into account, the suppliers pass the cost to the next stage in the chain and charge their customers more. Think of the supply chain of virtually all consumer goods. If they have travelled from a supplier to a distributor and to a retailer, it is probable that the cost of their trip is influenced by the price of the fuel they utilised for the journey. Thus, when fuel prices increase, total transportation costs increase. Due to expensive transportation costs, suppliers raise the product prices to compensate for the higher costs of transporting goods to the market. consequently, retailers increase the price of its product to handle the rising transportation expenses, leading to the end customer required to pay a greater amount for the final product (Larsen, 2022). The extent to which the escalation in supply chain costs is reflected in elevated consumer prices is contingent upon the actions of producers and the configuration of the product market. Certain producers may offset some or all of the increased production expenses by cutting their profits, enhancing energy efficiency, or choosing different energy sources. Some may transfer all costs to customers. In this scenario, the effect of inflation is more significant compared to when it absorbs some of the cost (Kopdar and Liu, 2021).

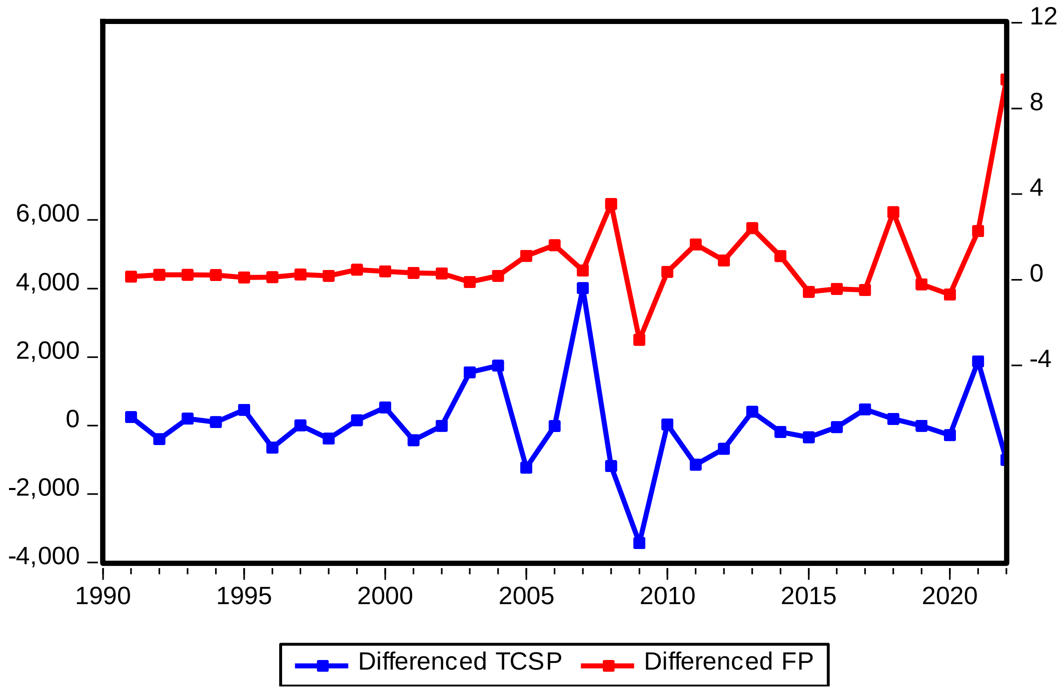

Figure 2.6: Relationship between Supply Chain Costs and Fuel Prices

Data source: *South African Reserve Bank*

Figure 2.6 disclose the relationship between supply chain costs and fuel prices in South Africa. After fluctuating in a relatively narrow range, it is proven that whenever fuel prices increase, the supply chain follows the trend; just as in the 1990s to the early 200s fuel prices were low and supply chain costs narrowly fluctuated. However, there is a noticeable circumstance in which these two variables exhibit a strong relationship based on their trends. From 2007 to 2008, these two variables both followed a huge upward trend, and this was also the time when the world economy faced a global financial crisis popularly known as the GFC. In 2008 the country saw a double-digit increase in fuel prices; the price per litre rose from R7.16 to R10.70 in 12 months, showing a 49% increase from the previous year. This occurred in the midst of a global recession; however, other factors caused such an incidence, which seemed to influence fuel prices. In this case, supply chain costs were also elevated in 2007 to 2008, the worldwide economy saw a robust and coordinated expansion in the economic cycle, demonstrated by the notable rise in fuel costs, global commodity prices, and the swift growth in global trade levels. This made inventories to be depleted, leading to an elevation of transport costs and the prices of most other goods and services internationally due to a surplus in demand.

However, the high prices lasted between one and two years, as Petrol 95 returned to R7.90 per litre in July 2009 (Toit, 2022). This abruptly reversed the pressure on global supply chains. The decrease in fuel prices has resulted in a reduction in transportation costs, and ships/containers were momentarily suspended or withdrawn from the service.

In 2018, fuel prices also experienced a sudden change, as Petrol 95 was recorded at R16.02 per litre in July of that year, following a previous cost of R12.86 in the preceding year, representing an increase of 25%. According to Mail&Guardian, this was not just caused by the weakening rand, but was also influenced by escalated expenses associated with the importation of oil products. Fluctuations in the price of fuel are associated with almost 50% of the transportation costs across the supply chain. These costs are transmitted to the consumer, and the price of goods continues to increase. Suppliers pass on the costs to the next stage of the supply chain, and a domino effect can be observed across the entire chain. As a result, Schoemaker (2022) indicated that for each 10% escalation in fuel prices, consumers would be required to incur an additional expenditure of roughly 12% to 15% for products at the retail point of sale.

In 2020 the country experienced a difficult time with COVID-19 restrictions being harsh to the economy resulting to a significant percentage drop in the economy. Fuel prices dropped during that period, shipping costs declined, and supply chain costs became easier because the restrictions were highly recommended, and movement was restricted in most areas. Production was stopped, resulting in the stoppage of most activities across the chain. However, the lockdown measures gradually eased in 2021, the economy rebounded, and the demand gradually increased. Therefore, the rising energy demand in 2021 has led to increases in fuel, oil, and energy prices and disruptions in global supply chains. In December 2021, disruptions in the global supply chain caused consumer price inflation in South Africa to rise to 5.9%, "mostly due to the impact of higher international crude oil prices on domestic fuel prices and transport costs" before moderating to 5.7% in January and February 2022 (Larsen 2022; Shankaran, 2022). However, on the positive side, there has been a slowing down of supply chain cost inflation although fuel price experienced another historical spike of R26.74 per litre, which might be the fact that in the same year fuel price moderated to R23.46 per litre (Business Tech, 2022).

2.7. CONCLUSION

The chapter detailed an analysis of fuel price and its impact on supply chain costs by examining the trends of the variables used in the study. The chapter presented the background and the trends of all the variables (supply chain costs, fuel price, fuel consumption, inflation rate (CPI), and real effective exchange rate). Moreover, this chapter observed the correlation between supply chain cost and fuel price, and the impact of fuel price on the supply chain which revealed a long-run positive relationship between the two main variables. Gurtu et al., (2015) indicated that high fuel prices could result to a rise in the cost of each subsequent order, as a result, cost of average order will rise for movement of goods and services within a manufacturing cycle. Consequently, companies that have made significant investments in global supply chains might be required to re-evaluate their supply chain plans to address cost pressures in the future. Similarly, Atkin (2022) elucidated the impact of fuel price volatility on the manufacturing supply chain dynamics. In his analysis, he articulated that the persistent increase of fuel prices presents a complex challenge that is felt throughout each phase of the supply chain. As fuel prices persist in their upward trajectory, expenses are disseminated across all segments of the supply chain, commencing with wholesale material costs followed by shipping charges, distribution expenses, and equipment costs. Consequently, suppliers incur additional costs at the next level of the supply chain to support their profit margins.

CHAPTER THREE

LITERATURE REVIEW

3.1. INTRODUCTION

This chapter consists of two main sections: theoretical and empirical reviews of the impact of fuel prices on supply chain costs. This is explained by the economic order (EOQ) theory, basic model with changing fuel prices, model for two-level coordinated supply chains, and rockets and feathers hypothesis. The aforementioned theories provide an understanding that fuel prices affect supply chain costs in the long run.

For instance, the EOQ theory and its two sub-models (model with varying fuel price and model for two-level coordinated supply chains) suggest that as fuel prices rise, the cost of each subsequent order will also rise, leading to a higher average order cost associated with all consignments within a manufacturing cycle. Entities that maintain their suppliers in proximity that is comparatively near will find themselves in a favourable position for handling their supply chain costs more efficiently in the future. Conversely, entities that have made substantial investments in global supply chains will be compelled to reassess their supply chain strategies in order to address cost-related difficulties or challenges (Gurtu et al., 2015).

The empirical studies in the following sections focus on the connection between fuel prices and supply chain costs. This chapter starts by introducing theoretical literature. This is then succeeded by a display of empirical research. The third section evaluates the theoretical and empirical research and justifies the significance of this study.

3.2. THEORETICAL LITERATURE

A theoretical review consists of theories that explain the relationship between fuel prices and supply chain costs. The theories which are used in the study include the economic order (EOQ) theory, basic model with changing fuel prices, model for two-level coordinated supply chains, and rockets and feathers hypothesis. These theories help to explain the relationship between fuel prices and supply chain costs in the study. According to the EOQ theory, the fuel price is a chaotic and unpredicted factor which puts pressure on logistics and supply chain. It further explains it by stating that firms with far suppliers will face increasing supply chain costs in the future, and that will result in re-evaluation of business strategies in the long run.

3.2.1. The economic order quantity theory

The theory of Economic Order Quantity (EOQ) was introduced by Ford Whitman Harris in 1913 (Lakshmi, 2022). However, his document circulated widely for many years before being rediscovered in 1988 (Erlenkotter, 1990). The EOQ theory primarily focuses on determining a firm's optimal order quantity that satisfies demand while concurrently minimising the aggregate costs associated with ordering, receiving, and maintaining inventory (Caldwell, 2021).

The formula for the Economic Order Quantity (EOQ) and the total cost is expressed as follows;

TC = OC + PC + HC………………………………………………………………………(1),

Where TC refers to the total cost, PC indicates the purchase cost, OC denotes the ordering cost, and HC signifies the holding cost. The primary objective of the EOQ equation is to ascertain the optimal quantity of product units that should be procured. When executed effectively, a firm can significantly reduce its expenditures associated with purchasing, logistics, and inventory storage. Companies with extensive supply chains and high variable expenses utilize a modified version of the EOQ formula in their computer software to calculate optimal production levels or ordering intervals.

This theory suggests that the fluctuating price of fuel affects logistics and supply chain costs, and the influence of fuel price fluctuations on transportation costs and lot size has not been thoroughly examined in existing research. The price of fuel has become one of the top ten difficulties in the supply chain sector (Gurtu, 2015). In support of this assertion, Schoemaker (2022) also stated that fuel price is just one more among many chaotic factors that have put pressure on the supply chain as it strengthens inflationary pressure across the chain.

The (EOQ) is reviewed and updated further to consider fuel prices through two sub-models. The relevance of the theory is explored in a two-level (vendor-buyer) supply chain in which the total costs of the stakeholders are jointly minimised by calculating their respective lot size and shipping volumes (Gurtu et al., 2015).

3.2.2. The basic model with changing fuel price

This model demonstrates the effects of adding fuel prices to supply chain expenses and lot size to offset the effects of transportation-related fuel costs. The changes in prices of fuel can no longer be overlooked in this segment and will be included in inventory decisions. According to a popular model in current literature, the buyer (level 1 in the supply chain) orders in line with the economic order quantity policy. The impact of changes in fossil fuel prices on transport cost and volume size is one of the constraints in the EOQ model which remains unexamined within the existing body of scholarly literature (Adriolo et al., 2014). In this model, transportation costs are considered the main drivers of cost movements in the supply chain and are similarly affected by fuel prices. Order costs are also affected by changes in fuel prices (Gurtu et al., 2015).

Considering the fuel costs, the total costs for the ith order are the sum of the order, storage and transport costs and are calculated as follows:

$TC_i = K + \frac{hq}{2}t + A_i$ ……………………………………………………………………(2)

Where transport cost (Ai) can be presented as;

$A_i = A_0 + A_1(1\text{-}i)\frac{q}{D}$ ……………………………………………………………………(3)

where $A_0 = 2dl\alpha$, $A1 = 2dl\beta$, 2 denotes a round trip, d is the distance travelled in kilometres; l is the fuel consumption in litres per kilometre and α is the fuel price in dollars at the time of the first order. The overall cost of a lot, including transportation costs per unit time for a lot is calculated by dividing equation (1) by the cycle time, as;

$TC_i(q) = \frac{D}{q}K + \frac{hq}{2} + \frac{D}{q}A_i$ ……………………………………………………………………(4)

and substituting the value of Ai from Equation (2) it can be presented as,

$TC_i\,(q) = \frac{D}{q}K + \frac{hq}{2} + \frac{D}{q}A_0 + A_1(i\text{-}1)$ ……………………………………………………(5)

The best value of q is obtained, which minimises equation (3). If the initial derivative is set to zero, then solve for q.

$q^* = \sqrt{2D(K + A0)}/h$ ……………………………………………………………………(6)

Replacing the value of q^* from Equation (4) in Equation (3) the minimum total cost will be,

$TC_i\,(q^*) = \sqrt{2}hD(K + A0) + A_1(i - 1)$ ……………………………………………………(7)

The EOQ formula without transportation cost is;

$qE = \sqrt{2}KD/h$ ……………………………………………………………………..(8)

which means that q* > qE. When transport costs are considered, it is recommended to order larger quantities than proposed by the EOQ formula. Moreover, as mentioned earlier, transport cost is a function of fuel price, fuel consumption, and distance; thus, transport costs increase with fuel price, fuel consumption, or distance. Consequently, the lot size increases. In general, fuel consumption per distance travelled decreases over time due to technological advances, although slightly, but the price of fuel depends on supply and demand, with globalisation having an impact on distances across the supply chain. Therefore, fuel costs increase in direct proportion to the distance travelled, as a result, supply chains that have a long distance between buyer and supplier locations will experience a sharp increase in their supply chain costs (Adriollo et al., 2014).

3.2.3. Model for tow-level coordinated supply chain

In this model, the seller and buyer constitute a two-level supply chain. The supply chain participants have the option of coordinating their actions. The JELS model is designed as a coordinated model because a non-coordinated supply chain raises costs. The scenarios considered and studied assume an ongoing change in fuel prices, which has an impact on order costs and the unit price of a product (Jaber and Zolfaghari, 2008 and Glock, 2013).

According to the model outlined above, changes in fuel prices, fuel consumption, and travel distances affect the order costs and lot sizes. The average order cost for all movements of goods and services in a manufacturing cycle will rise when fuel prices rise, as each subsequent order will cost more (Schoemaker, 2022). Fuel costs increase in direct proportion to the distance travelled and because of offshore outsourcing, if fuel prices rise much more quickly. As a result, supply chains that have a great deal of distance between buyer and vendor locations experience a significant increase in their supply chain costs (Gurtu et al., 2015).

3.2.4. Rockets and Feathers Hypothesis

According to the rocket and feather hypothesis of Bacon (1991), the adjustment of fuel prices to cost changes occurs faster relative to increasing costs than to decreasing costs, and the adjustment process is focused on the average price during increases. In support of this assertion, industry observers have observed that there appears to be an asymmetric "rocket and feather" pattern between the crude oil price and retail price of petroleum products. When the price of fuel escalates, the prices in the retail sector promptly reflect this change similar to a rocket, conversely, when the prices of fuel decrease, the reduction in retail prices transpires at a more gradual pace similar to a feather (Bacon & Kojima, 2010). The presence of rockets and feathers pricing imposes an extra cost to consumers compared to the situation of symmetry of price responses to cost increases and decreases (Kyungsoo & Lee, 2022).

3.3. EMPIRICAL LITERATURE

This section consists of evidence of studies that were conducted previously on the subject. It provides policy recommendations for policy makers to take informed decisions in the future as well as researchers who wish to research on the subject in the future to outline the gaps in the literature. The empirical literature is presented in following format: empirical review from developed countries, developing countries, and South Africa.

3.3.1. Studies from developed countries

Within a supply chain, transportation refers to the act of transferring raw materials, semi-finished, and final products from one location (an origin) to another (a destination). The cost of fuel is the driving factor for the transportation of products in the supply chain, and its variation therefore affects the costs of the supply chain up to the final price of the products (Gurtu, 2015).

Some authors in developed countries have looked at the impact of fuel prices on supply chain costs, Gohari, Matori, Yusof, Tolou and Myint, (2018) investigated how the cost of running freight transport vehicles was affected by the rise in gasoline prices. An operating cost equation was used in this study to evaluate the operational costs of various freight transport vehicles and to assess how operating costs changed throughout a range of fuel prices between the existing price and an increase of 100%. The equation includes relevant aspects such as gasoline price, vehicle maintenance cost, and driver compensation. It was found that an increase in fuel price does not have a uniform impact on the operating costs of different types of freight transport. The truck has the highest cost, while the train has the largest price increase, according to the comparison of the results using the equation and effective aspects considered. Finally, in terms of operational cost percentage increase when the rate of fuel price increase, the ship is the most effected transport, followed by truck and train. Fuel price increases have the greatest impact on ship operating costs. When fuel prices rise by 100%, the ship's operational costs increase by 87.8%. While 100% increases in fuel prices increased operational costs for trains and trucks by around 63.6% and 23.3%, respectively. Therefore, the costs in the supply chain increased more especially in the movement of products from one location to another.

In the Australian courier industry similar results were found by Wang (2018) in his investigation on how supply chain risk and uncertainty affected the efficiency of logistics. In his view, risk is a result of both the internal and external uncertainties that affect a supply chain, and that uncertainty raises risk inside supply networks. Several authors acknowledged that uncertainty was a problem in the supply chain and logistics industry, in such that it affects the performance of supply chains and logistics. The findings of the study have identified unstable fuel prices as one of the top supply chain uncertainties and risks which affect the logistics performance of Australian courier industry. Due to the unstable fuel prices, operational costs become a problem in the courier industry in Australia, in sense that the delivery costs charged to customers will have to be high to cover the high operational costs imposed by unstable fuel prices. Moreover, the findings show that supply chain uncertainty and risk have a severe effect on logistical performance.

Atkin (2022) has also commented on such influence in the manufacturing supply chain arising due to the increased price of fuel. In his commentary, he has underlined that the continued rise of fuel prices is very complex and felt across the whole life cycle of the supply chain. In this regard, due to the continued rise in fuel prices, the costs flow down throughout the whole life cycle of the supply chain in wholesaled material cost, shipping, cost of distribution as well as equipment prices. As a result, suppliers pass on the additional costs to the next level of the supply chain in support of their profit margins, so we see a domino effect in the supply chain. In some industries, costs are passed on to customers as they pay more for their products.

Similarly, Sarkar, Ullah and Kim (2017) found that there is a strong relationship between supply chain logistics and fuel price dependence. Fuel price is one of the most important factors that affects everything and most areas. Suppliers have to travel back and forth to deliver products to companies. Increased fuel prices can reduce their profit margin or increase the overall cost. So, to protect themselves from losses and decreasing profit margins, they increase the prices of their supplies.

Scheibe and Blackhurst (2018) found in this context that fuel price is influenced by some factors such as transportation constraints, refinery maintenance costs, geopolitical disruptions, and others. Based on the combination of these factors, it can be said that oil and fuel prices are expected to be under upward pressure for the remaining years. The price of fuel increases transportation costs, and supply cannot occur without transportation or vehicle use. Therefore, it is obvious that there is a link between the fuel price changes and the supply chain logistics.

Overall, it can be said that the changes in fuel prices have an impact on customers, employers, employees, and all stakeholders involved, as they have to pay high prices for their products.

Apthorp (2019) evaluated the direct impact of gasoline prices on logistics and supply chain. The findings of the paper revealed that the logistics sector is directly affected by the ongoing volatility of gasoline prices. Fuel price increases are present a challenge to freight management firms since they frequently require carriers to increase pricing or face financial losses. When transporters raise their fees, the consumer eventually pays that increase in the form of increased product pricing and higher shipping costs. Thus, this presents increased costs in the supply chain. Similar results were also found by Robbins (2022) when investigating the impact of fuel costs increases on logistics in the United States economy. He stated that firms continue to encounter challenges on all fronts throughout the entire manufacturing and distribution sector in the supply chain, from struggling to find qualified personnel to modifying their balance sheets to match increased raw-material prices. Increasing gasoline prices is one issue that is causing pain for companies of all shapes and sizes. Organisations are compelled to make a decision between sustaining loss-generating operations, increasing prices imposed on consumers, or inventing innovative methods to cut costs as fuel prices rise.

Kpodar and Liu (2021) also discovered that the supply chain is impacted by the indirect consequences of a rise in fuel prices, which influences the costs of products and services that rely on fuel for production. How much rising production costs impact consumer prices hinges on how manufacturers act and the setup of the product market. Certain producers might offset the increased production expenses by lowering profits, enhancing energy efficiency, or choosing different energy sources. Others might transfer the entire cost to prices paid by consumers. In this situation, the effect of inflation would be more significant compared to if they covered some of the expenses.

Gurtu et al. (2015) investigated how fuel prices and emissions affect inventory policies. This study examines how shipment lot sizes and supply chain costs are affected by fluctuations in fuel prices and the implementation of a carbon tax on emissions from transportation. An analysis is conducted to demonstrate that rises in gasoline prices must be treated in a different way compared to other costs. In addition, a function for calculating the future prices of fuel future prices has been established. This function is used to determine future transportation costs. To highlight the effect of a carbon tax and rising transportation costs on different inventory management strategies, the EOQ models have been adjusted to incorporate these elements. The average order cost for all shipments in a manufacturing cycle will rise because of rising fuel prices because each subsequent order will cost more. In the future, businesses will be in a better position to manage the costs of their supply chains if their providers are in close proximity However, firms who have made significant investments on international supply chains will be required to review their supply chain procedure in order to address cost issues.

Milewska et al. (2022) examined the impact of increasing fuel costs on supply chain strategy in EU countries. The study highlighted that supply chain strategy has a substantial effect on energy use. This method specifies the position of individual connections in the chain (producers, suppliers, and distributors), which influences the logistics cost procedures, particularly shipping operations. Energy consumption in supply chains is a problem that is currently becoming more significant due to the quick rise in fuel prices. The primary objective of the analysis was to indicate how rising costs of fuel and energy affected the expenses of logistics operations and, consequently, the profitability of various supply chain methods. The viability of switching from international to national supply sources as a result of increasing energy prices was given special consideration. In addition, the study found a large increase in charges for transportation services due to increased fuel costs, particularly in maritime transportation.

A study by Allen, Murphy, Butterfield, Drummond, Robb, Higgins and Barden (2018) used a discrete event simulation (DES) to model the impact of fuel prices on transportation costs (TC) and inventory holding costs (IHC) in a three-tier aerospace supply chain (SC) scenario where suppliers deliver products via land/sea- or air freight. The results show the transportation decisions can be used to mitigate the influence of fuel prices on the TC. The value, weight and size of products transported throughout the SC also influence in whether TCs or IHCs drive total Supply Chain Costs. However, Allen et al. (2018) suggested that future work could apply the methodology to larger and more complex Supply Chains.

Another study by Min (2022) explored what may have caused fuel oil price hikes and to determine how significantly fuel oil prices influence commodity prices, and then they propose ways to mitigate energy-induced supply chain risks by analysing four decades of secondary data obtained from multiple sources. One of the findings revealed that fluctuations in fuel prices significantly impact supply chain costs by increasing transportation expenses, affecting inventory management, and influencing the pricing of commodities. This volatility necessitates risk mitigation strategies to enhance resilience against supply chain disruptions and maintain cost stability. Welborn (2010) found similar results in his analysis on fuel costs and supply chain decisions. The study outlined three significant areas where fuel prices are affecting U.S. supply chain decisions, namely, sourcing decisions, transportation modes, and product design and packaging. The findings indicated that fluctuations in fuel prices significantly increase transportation costs, which become a larger percentage of a product's total delivered cost. This prompts manufacturers to reassess outsourcing, transportation modes, and product design to enhance efficiency and reduce overall supply chain expenses.

Kartia, Hapsari, Nuswantoro and Pamungkas (2022) analysed the impact of fuel oil price hikes (BBM) on international trade transportation costs, exploring the complex relationships between crude oil prices, subsidy policies, and trade dynamics, and provides insights for businesses and government policies to enhance economic competitiveness. The research methodology employed involves a qualitative approach to gain comprehensive insights. The research highlighted that fluctuating fuel prices significantly impact transportation costs within the supply chain, affecting overall cost structures. The study also indicated that increased fuel prices lead to higher transportation expenses, which can influence pricing strategies and competitiveness in international trade. However, Kartia et al. (2022) primarily employed a qualitative methodology, which may limit the generalisability of the findings. While qualitative insights are valuable, they may not capture the full spectrum of quantitative data that could provide a more comprehensive understanding of the impact of BBM price increases on transportation costs/supply chain costs.

3.3.2. Studies from Developing Countries

Few studies were conducted on the subject in developing countries and the authors seem to have similar or related results. Arabi, Yaghoubi, and Tajik (2019) conducted an analysis based on the design of an algae supply chain network for biofuels with varying demand in the face of uncertain prices for alternative fuels. In their study they regarded fuel price as an uncertain parameter that will impact the performance of the supply chain. As a result, to deal with this uncertainty and develop the supply chain for algal biofuel, a two-stage stochastic programming method was adopted. The relevant results show that because of the current high prices in Iran, the fluctuation of the dollar exchange rate and its impact on the currency unit in Iran have significantly increased the final price of the biofuel and the operating costs for producers throughout the supply chain. Although, the selling price of the alternative fuel is stable for consumers. Therefore, refinery operators should raise the selling price appropriately to protect their profit, but this leads to a decrease in demand and consequently profit. Wan et al. (2019)

also found similar results and stated that due to the fluctuations of fuel prices shipping companies tend to charge expensive freight fees in the distribution process under supply chain. Due to those inflationary pressures in the supply chain, customers are left with a burden of high product prices at retail outlets.

Wan (2019) created a novel model that integrates a fuzzy belief rule technique with Bayesian networks to evaluate the risk elements of marine supply chains. In comparison to standard risk analysis approaches, the new model is able to improve the result accuracy in the presence of substantial uncertainty in risk data. Investigation of a real-world case involving a top-tier container shipping company shows that the fluctuating fuel prices, transportation of hazardous materials, unattractive markets, intense competition, and successive changes in exchange rates are the most key risk factors. However, this study disclosed that one significant risk factor for shipping operations is the variation in fuel prices. Shipping businesses should pay attention to it because it comes second with a high possibility and consequence.

According to Abdallah, Diabat and Simchi-Levi (2012), since the mid-1990s, many companies have attempted to reduce operating costs and achieve a lean supply chain by focusing on outsourcing production, offshoring, rationalizing facilities, and consolidating facilities. The reason for these trends was cheap oil. In fact, shipping costs made up just a small portion of overall operational expenses in many industries. However, the trend is starting to shift with the recent increase in oil prices. With the rise in crude oil prices, the significance of shipping costs increases in comparison to storage, manufacturing, and facility costs. Regional distribution centres have become more attractive. As oil prices rise, the cost of transportation abroad becomes more expensive, making it increasingly important to minimise the distance between distribution centres and retail outlets. Thus, the increased transportation costs will now force manufacturing companies to move to nearshoring in the supply chain as it will cost more to trade with companies located in distant areas.

Paul, Wahab and Cao (2014) evaluated supply chain coordination with energy price uncertainty. It is shown that both the overall cost and the number of consignments is increased with increasing gasoline price uncertainty. This further demonstrates the impact of fuel prices on supply chain coordination. In addition, the size of the consignments increases, the number of consignments declines, and the total cost increases when the fixed gasoline consumption is increased according to vehicle size, type, or age. This means that the decision on supply chain coordination will also have to be changed if the size or type of vehicle used for transport changes. The overall supply chain costs are increasing due to variations in fuel consumption.

Jian-Yu (2014) carried out a study examining the impact of fuel costs on the quantity and arrangement of production stocks in the U.S. They suggested that despite the importance of fuel costs in supply chain management, the consequences on inventory and sales remain uncertain. The increase in crude oil prices led to higher retail gasoline prices, affecting transportation expenses and company earnings. Based on location theory, businesses will move their stock to areas where gasoline costs are lower, resulting to decreased inventories in states with higher fuel prices. Aside from changes in fuel prices overtime, there are also variations in fuel expenses across different locations. These differences could also impact the design of the supply chain. In the US, differences in fuel costs between states occur because of varying fuel tax rates, market influence, and regulations on gasoline content.

Osei, Etuah, Nimoh, Asante, Abunyuwah, and Mensah (2022) conducted an analysis of does fuel price volatility induces price instability in the agricultural supply chain. This study is based on both time series and cross-sectional market survey data. The study used a Diagonal BEKK model to measure the volatility spill-over between agricultural commodity prices. The study reveals that food supply chain actors, including wholesalers, retailers, and farmers, perceive price volatility as a major challenge. It negatively impacts their decision-making, production planning, and financial stability. Wholesalers and retailers struggle with unpredictable costs, leading to difficulties in maintaining consistent supplies and negotiating stable contract prices with farmers. This unpredictability does not merely affect individual businesses; it reverberates throughout the entire supply chain, amplifying inefficiencies and exacerbating food insecurity. Overall, the study highlighted that fuel price instability is a critical factor that disrupts the efficiency and predictability of the agricultural commodity supply chain, affecting both market actors and food security in Ghana.

3.3.3. Studies from South Africa

In the context of South Africa, a limited number of research investigations have been undertaken concerning the topic at hand, studies by Havenga, Simpson, Bod and Viljoen (2014) and Wholluter (2022). Havenga et al. (2014) assessed the rising cost of logistics in South Africa: an uncertain future. The study highlighted the two detailed models that have been developed for South Africa during the initial ten years of the 21st century. The stated models are logistics cost survey and freight demand model. They offer a platform for evaluating and enhancing the freight logistics system of the country. These models enable scenario development for the main indicated risks. Logistics costs were calculated by relating freight flows at the commodity level to the cost of performing the associated logistics functions. The economy of South Africa is heavily reliant on transportation. Overdependence on road freight makes this situation worse. Moreover, the main cost driver of road freight is fuel, which in turn depends on the price of oil. The scenario analysis has highlighted the risk of this increase and policy instruments to minimise transport intensity should be encouraged to minimise this volatile input.

The analysis also showed that transportation costs have consistently represented the highest portion of overall logistics costs over the past ten years. Since 2010, the cost of logistics has increased rapidly as a share of transportable GDP reaching an estimated 46.7% of transportable GDP in 2013. As a result, it costs the country more each year to move goods and services up the supply chain. The study therefore concluded that the intensity of freight transport must be reduced in order to minimise dependence on fluctuating global oil prices.

Wolhuter (2022) evaluated supply chain pressures in South Africa. In his analysis he started about the severe disruptions caused by the COVID 19 on global supply chain that resulted in a national lockdown and the closing of ports in most nations, thus obstructing the shipping of tradable goods. South Africa being a small open economy also encountered supply chain interruptions and lack of certain imported products. The interruptions accelerated inflation due to factors such as the continuous imbalance between demand and supply, significant increase in transport costs and raw-material prices. The producer price inflation for raw intermediate goods risen to 23.1% in November and December 2021, indicating a shortage of unfinished goods. The consumer price inflation rate surged to 5.9% in December 2021, mainly because of the influence of increasing global crude oil prices on transportation and fuel cost.

3.4. Assessment of Literature

This study uses the Economic Order Quantity theory, basic model with changing fuel price, model for two-level conducted supply chain, and the rocket and feathers hypothesis. All three theories recognize that supply chain cost is affected by fuel prices. According to the EOQ, changing fuel prices puts pressure on the supply chain as they escalate costs. According to the two modes, fuel price affects the supply chain costs in the same way which is fuel costs rise in direct proportion to distance travelled, as a result, supply chains that have a long distance between buyer and supplier locations will experience a sharp increase in their supply chain costs.

A major criticism on the fuel price and supply chain cost studies reviewed is that the long-term effects of changing fuel prices on total supply chain costs have not been examined in adequate detail. The existing literature either ignores the direct and indirect implications of fuel price on the supply chain costs or includes them directly in the prices paid by customers for finished goods. For instance, there are only a few studies that analyse the influence of fuel price on supply chain costs, noticeably studies by Milewska et al., 2022; Robbins, 2022; Wolhuter, 2022; Havenga et al., 2014. These studies consist of both international and domestic evidence and most of them evaluated the impact of fuel price on the logistics side of the supply chain. Logistics concentrates on planning and coordinating activities to ensure a smooth flow of supply chain and commerce processes (Jenkins, 2022).

In that case the implications were limited to the logistics only without duelling much on the broader scope of the entire supply chain where we could see the effects fuel prices on areas such as the cost of from raw material prices to the cost of moving them to factories, from production costs to the higher cost of distributing finished goods to distribution facilities and retail outlets (Schoemaker, 2022). Therefore, the entire supply chain becomes the missing factor in literature as it has a broader scope compared to logistics.

Also, Allen et al. (2018) explored the impact of fuel prices on transportation costs (TC) and inventory holding costs (IHC) using discrete event simulation (DES) in a three-tier aerospace supply chain (SC) scenario. This study was limited to the transportation costs (TC) and Inventory holding costs (IHC) in a three-tier aerospace supply chain. Given the significant role fuel prices play in supply chain operations, it is essential to assess their impact on overall supply chain costs. Fluctuations in fuel prices directly affect transportation expenses, production costs, and overall economic efficiency, making this analysis crucial for both policymakers and industry stakeholders. However, existing literature lacks a comprehensive evaluation of this relationship, particularly in the context of South Africa. To address this gap, this study examines the impact of fuel price changes on supply chain costs in South Africa from 1990 to 2022. Employing the Autoregressive Distributed Lag (ARDL) model, the research effectively accounts for autocorrelation and determines the appropriate lag structure of the dependent variable, ensuring a robust and reliable analysis of this economic dynamic.

3.5. CONCLUSION

This chapter reviewed two theories with two sub models, the Economic Order Quantity theory, Basic Model with Changing Fuel Price, Model for two-level coordinated supply chain, and Rockets and Feathers Hypothesis. The main perception of these theories is that the uncertainty of fuel prices poses a threat to the supply chain. This simply means the current high fuel prices present an escalation of costs in the supply chain from manufacturing factories to customers at retail outlets. This chapter also reviewed empirical evidence from developing countries, developed countries and South Africa. Therefore, there is a necessity to perform an examination on this topic due to the presence of a noticeable gap in the existing literature.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1. INTRODUCTION

This chapter establishes the analytical framework applied in this research by presenting the model that will be employed to empirically evaluate the effects of fuel price on total cost of supply chain in South Africa from 1990 to 2022. The research methods, data sources, and diagnostics tests that will be employed in this research are discussed in this chapter. This study will also be using quantitative method which comprises of data collection from relevant sources to the researcher, such as the Reserve Bank of South Africa as well as the World Bank, etc. The approach typically involves utilising a specific method to obtain results and analysing the findings from the research.

4.2. RESEARCH DESIGN

This study will employ a correlational research design. This research design is chosen for its focus on relationships between variables without researcher interference and is non-experimental in nature. A correlation indicates how strong or in what way two (or more) variables are related to each other. A correlation can either be positive or negative in direction. Therefore, the design suits the study since the study is investigating the impact between fuel price and supply chain costs and the correlation between the two variables is anticipated to be positive/negative depending on the outcome of results.

4.3. RESEARCH APPROACH

This study will employ a quantitative research approach to explore the impact of fuel prices on supply chain costs. This research approach is applied because it includes gathering and assessing numerical data. It has the potential to identify patterns and averages, forecast outcomes, test causal correlations, and apply findings to larger groups. A quantitative method involves gathering data and converting it into numerical format to conduct statistical analysis and reach conclusions. The data will be gathered electronically from the websites of the South African Reserve Bank and the World Bank. It will be further ran using EViews 11 software to do statistical computations such as testing hypotheses and evaluating outcomes of the study.

4.4. MODEL SPECIFICATION

A model specification is used to find the correlation between two variables, which are the dependent and the explanatory variables. The EOQ theory posits that fluctuating fuel prices put pressure on logistics and supply chain costs. Therefore, in order to evaluate changes in total operating costs over a range of fuel prices between the current price and a 100 percent increase, Gohari et al. (2018) used a total operating cost equation. The equation is dependent on vital parameters, which include fuel prices, fuel consumption and vehicle maintenance costs.

The cost equation is as follows:

$$TC = [(Fp \times Fc \times Td) + (Wa \times Tt) + (Ma \times Td)] \times [Nc/Cv] \quad \ldots\ldots (9)$$

Total cost is the independent variable and is presented by TC; Fuel price, fuel consumption and travel distance are determined by Fp, Fc and Td. Respectively, wages, travel times, maintenance time, number of containers and vehicle capacity are covered by the following classifications: Wa, Tt, Ma, Nc, and Cv.

For this study equation (6) will be modified to include variables such as inflation rate (CPI) and real exchange rate (RER). However, for the model to fit well variables such as travel distance (Td), wage (Wa), travel time (Tt), maintenance (Ma), number of containers (Nv), and vehicle capacity (Cv) were removed. Therefore, to evaluate the impact of fuel price on supply chain costs the new empirical model will be stated as follows:

$$TCSP_t = \beta_0 + \beta_1 FP_t + \beta_2 FC_t + \beta_3 IFR_t + \beta_4 REER_t + \varepsilon_t \quad \ldots\ldots (10)$$

For the equation to be easily estimated I will introduce logarithms, Brooks (2008) states that when logarithms are being introduced into the model the exponential trend of the time series data is linearised. However, the exponential trend of the time series data that is already linearised will not be logged in the model.

Therefore, $\log TCSP_t = \beta_0 + \log\beta_1 FP_t + \log\beta_2 FC_t + \log\beta_3 IFR_t + \log\beta_4 REER_t + \varepsilon_t \ldots\ldots (11)$

Where:

- *TCSP: Total Cost of Supply Chain*
- *FP: Fuel Price (Petrol and Diesel)*
- *FC: Fuel Consumption*
- *IFR: Inflation Rate (CPI)*

- *REER: Real Exchange Rate*
- *B0: Intercept*
- *β1, β2, β3, and β4: Coefficients of the explanatory variables*
- *ε: Error term.*
- *t: Stands for time series.*

4.5. DISCUSSION OF VARIABLES AND PRIOR EXPECTATIONS

4.5.1. Supply chain costs

A supply chain is a system used by a business and its dealers for the production and distribution of a certain product. Participants in supply chain participants comprises of producers, suppliers, warehouses, transportation firms, distribution facilities, and retailers (Perez, 2022). The supply chain is the backbone of corporate activity. Hence, businesses need to be aware of all operations in the supply chain to ensure that it functions as it should (Chang, 2022). Supply chain costs are defined as costs that amount to a significant percentage of the total selling price of a product. Producers normally define and measure the supply chain costs in terms of total cost of ownership. Total cost of ownership is defined as the combination of the purchase or acquisition price of a good or service (Raza, 2022).

4.5.2. Fuel Prices (petrol and Diesel)

Fuel is often known as a substance that produces heat and light energy on burning. Some commonly used fuels are petrol and diesel, and they are used in automobiles (Sastry, 2020). Therefore, a fuel price is charged to a consumer when buying these types of fuels for their automobiles. The fuel price is composed of four major components. These are the wholesale margin, the retail margin, and the distribution and transportation costs (Stats SA, 2021). Fuel price is expected to be positively related to total cost of supply chain. This is because when the price of fuel is high the cost of each subsequent order will be high, leading to a rise in the average order cost for all shipments in a manufacturing cycle, or vice versa. This is supported by (Gurtu et al., 2015).

4.5.3. Inflation Rate (CPI)

Inflation refers to the rate of price increases over a given time period. Inflation is when prices go up in general, making things more expensive to buy, which increases the cost of living in a country (Boyle, 2022). Supply chain inflation can affect prices and drive-up supply chain costs, leading to further inflation and higher prices. The supply chain is directly affected by inflationary pressures. Hence, Inflation rate is expected to be positively related to the total cost of supply chain, and this is supported by (Ahuchogu, 2022).

4.5.4. Fuel Consumption

Fuel consumption is the amount of fuel consumed in driving a given distance. It is measured in gallons per 100 miles in the United States and in litres per 100 kilometres in Europe and other parts of the world (Das, 2020). Fuel consumption is an essential engineering measure that directly affects fuel use for 100 miles and can be applied as a direct indication of energy savings in terms of volume (Abdullah, 2022). Fuel consumption is expected to have a positive relationship with supply chain costs in a sense that the more fuel consumed the costs incurred by supply chains that have a great deal of distance between buyer and vendor locations (Gurtu, 2015).

4.5.5. Real Effective Exchange Rate

This exchange rate reflects the purchasing power of a currency more precisely since it has been modified to account for the impacts of inflation. The real exchange rate shows what you can buy (Pettinger, 2017). An increasing real exchange rate indicates that a country's products are getting more expensive in comparison to those of its rivals (Pettinger, 2017). Fluctuations in exchange rates expose supply chains to risk. Unexpected foreign exchange rate fluctuations have a crucial impact on international supply chain costs (CSCMP, 2022). For centuries, companies have been involved in worldwide supply chains. This is because of the numerous benefits companies derive from global trade, such as lower purchasing prices, increased client base, and superior quality of goods and services. Although companies have enjoyed the advantages of international supply chain for many years, there are also implicit variabilities and risks that can rapidly undermine profitability. One such risk that is widespread in these supply chains is foreign exchange risk. Companies might experience a rise in operational costs because of exchange rate fluctuations when buying goods or materials from foreign suppliers, or they may experience a decline in margins when selling their goods in countries where the exchange rate is lower. Therefore, the real exchange rate is expected to affect supply chain costs positively. This is supported by (Jian-yu Fisher Ke, 2018).

4.6. DATA SOURCES

This study will use data from 1990 to 2022, comprising yearly time series data. The selection of the study period is intended to encompass an extensive duration of economic activity, thereby facilitating the validation of trends and patterns associated with the interrelationship among the variables. This helps ensure that any unusual data points do not compromise the reliability of the relationship, ultimately leading to more precise findings. The main sources that will be used to compile data for the variables will be the websites of the Reserve Bank South African and World Bank.

4.7. ESTIMATION TECHNIQUES

The study will apply the Autoregressive Distributed Lag model (ARDL) in estimating the impact of fuel price on supply chain costs in South Africa. The ARDL technique is used because of its efficiency in estimation of long-run and short-run correlations, and problem of endogeneity is kept in a minimum in the model since it is free from residual correlation. The model fixes the problem of autocorrelation. When there is a single long run relationship, the ARDL procedure can distinguish between dependent and explanatory variables. That is, the ARDL approach assumes that only a single reduced form equation relationship exists between the dependent variable and the exogenous variables (Nkoro & Uko, 2016). In addition, one of the advantages of ARDL test is that it is more robust and performs better for small sample size of data. It provides robust estimates in small sample sizes. It distinguishes between short-term and long-term effects, crucial for understanding the dynamic relationship between variables (Menegaki, 2019). Unlike traditional co-integration techniques (e.g., Johansen test), ARDL performs well even with small datasets. It provides reliable estimates without requiring a large number of observations. The ARDL model estimates both short-run dynamics and long-run relationships simultaneously. This is crucial for understanding how variables interact over different time horizons. ARDL is a single-equation model, making estimation and interpretation simpler compared to systems of equations like Vector Error Correction Models (VECM) (Econometric Analysis Insight Blog, 2017).

The first step in the ARDL model is to identify whether a long-run correlation between variables exists by using the Bound F-statistic. If the F-statistic exceeds the upper bound (I1) values at all levels, it indicates that the variables are co-integrated, and both short-run and long-run tests will be performed. After determining the long-run correlation, the coefficients of long-run and short-run will be of the stated ARDL model.

$$InTCSPt = \delta 0 + \Sigma\beta 1In(FP)t\text{-}1 + \Sigma\alpha KIn(IFR)t\text{-}i + \Sigma\alpha KIn(FC)t\text{-}i + \Sigma\alpha KIn(RER)t\text{-}k + \varepsilon t \quad \text{...(12)}$$

The lag length of the ARDL model will be estimated using the Akaike Information Criterion (AIC).

4.8. STATIONARY TEST

Challis et. al. (1991) characterise stationarity as a stochastic process in which the statistical characteristics, like the mean and standard deviation, remain constant over time. If the mean and variance of a time series do not change over time, it is defined as being stationary. Conversely, time series data is considered non-stationary if either the mean or variance shows variability over time. According to Kumar (2021), stationarity is a crucial attribute of time series data that shows the constancy of statistical properties over time. Various time series analysis techniques, such as forecasting and modelling, are crucial. The study will employ Augmented Dickey-Fuller and Philips Perron tests to analyse stationarity. The unit root tests will be conducted to ensure that the order of integration of the variables to be used in a study is checked. According to Gujarati and Porter (2009), the stationary tests (ADF and Phillips Perron) allow the determination of the integration of variables.

4.8.1. Augmented Dickey Fuller

According to Chaudhary (2020), the Augmented Dickey-Fuller test (ADF test) is a widely used statistical test to determine the stationarity of a specific time series. It ranks among the most frequently employed statistical tests in the examination of a series' stationarity. Stationary is a very important factor in time series. According to Brooks (2008), although Phillips Perron admits automatic changes and hence permits autocorrelated residuals, ADF completely eliminates all structural effects from time series data, producing more reliable conclusions.

Yugesh (2021) explained that the augmented Dickey-Fuller test is a modified version of the Dickey-Fuller test where the series is adjusted for autocorrelation before being tested in a similar manner as the original test. The augmented Dickey-Fuller test relies on the t-statistic, which results in a negative value. The acceptance of the hypothesis is determined by this negative value, the more negative the number that indicates a higher likelihood of a unit root existing at a specific level in the time series.

When employing the ADF in a model, it can be expressed in mathematical terms as;

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \ldots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \quad \ldots\ldots(13)$$

Where:

- **α** is a constant
- **t** is the coefficient at time.
- **p** is the lag order of the autoregressive process.
- **ε** is the error term

In the Augmented Dickey-Fuller's mathematical model, additional differencing terms are included to account for discrepancies with the Dickey-Fuller test.

The unit root examination is subsequently performed assuming the null hypothesis???? = 0, in contrast to the alternative hypothesis of???? < 0. Upon obtaining a specific value for the test statistic.

$$DF_\tau = \frac{\gamma}{SE(\gamma)} \quad \ldots\ldots(14)$$

It can be compared to the equivalent critical value for the Dickey-Fuller test. The test utilises a distinct distribution for the determination of the critical values called the Dickey-Fuller table.

An important key factor to keep in mind is that the p-value from the test must be lower than the significance level (e.g., 0.05) to reject the null hypothesis, as it assumes a unit root. Thus, it can be concluded that the series is stationary.

Otero and Baum (2018) noted that the ADF test has long lasting appeal because it is based on regression and is therefore easy to calculate. Despite this distinct advantage, the ADF test is often criticised for having poor power properties.

4.8.2. Philips Perron

Phillips and Perron have come up with an extensive theoretical framework regarding the concept of unit root or non-stationarity. According to Quineche et. al. (2017), the PP-test deals with serial correlation in errors by incorporating a nonparametric correction factor for serial correlation, which relies on a reliable estimate of the long-term variance of the error process. The testing procedures are like ADF test; however, they include automatic correlation to address autocorrelated residuals within the DF test. The Phillips-Perron test faces many of the identical key constraints as the ADF test.

Hamilton (1994) also notes that the Phillips-Perron unit root test generally has better reliability than the Augmented Dickey-Fuller test because of the strong presence of serial correlation and heteroscedasticity.

A major advantage of the Philips-Perron (PP) test lies in its nonparametric nature and does not need the choice of serial correlation level like the ADF test. Instead, it employs an identical estimation methodology as the ADF test while adjusting the statistic to accommodate both autocorrelation and heteroscedasticity. A notable limitation of the PP test is its reliance on asymptotic theory (Arltova and Fedorova, 2016).

4.9. ERROR CORRECTION MODEL (ECM)

"The error correction model (ECM) is also used because it is a time series regression model based on the behavioural presumption that two or more-time series have an equilibrium correlation that discovers both short-term and long-term behaviour" (Lewis-Beck, 2004). The model of error correction is used to obtain the short-term elasticities as follows:

$$\Delta InTCSPt = \delta 0 + \Sigma\beta 1\Delta In(FP)t\text{-}1 + \Sigma\alpha K\,\Delta In(IFR)t\text{-}i + \Sigma\alpha K\,\Delta In(FC)t\text{-}i + \Sigma\alpha K\Delta In(RER)t\text{-}k + \varepsilon t \quad \ldots\ldots(15)$$

According to Sjo (2008), the ECM model includes a cointegration connection in its design, restricting the long-term adjustment patterns and the movement of endogenous variables towards their cointegration links, while also considering short-term integration dynamics. VECM measures the rate at which balance is restored in the model, indicating how quickly the dependent variable Y reverts to equilibrium following a change in the explanatory variable X. Error Correction Models are a theoretically based method for analysing both short-term and long-term impacts of one time series on another.

4.10. DIAGNOSTIC TESTS

To carry out a comprehensive examination of the impact of fuel prices on supply chain costs within the context of South Africa, it is imperative to perform diagnostic tests, as these tests serve to substantiate the findings acquired from the parameter assessment procedures derived from the proposed model. The diagnostic tests are performed to determine whether a model is fit will be performed after the longest run and short run testing has been carried out, where an analysis of misspecifications, relationship coefficients or heteroscedasticities can be used to verify its stability.

4.10.1. Normality Test

Brooks (2008) states that one must assume normality ($u_t \sim N(0, \sigma^2)$) when conducting a single or joint hypothesis test on model parameters. The Jarque-Bera test is frequently utilised to assess normality. The Jaque-Bera test employs the fact that a normally distributed random variable is defined by its mean and variance to test for normality. The distribution's standard third and fourth moments are identified as its skewness and kurtosis. Brooks (2008) defines skewness as the degree to which a probability distribution lacks symmetry around its mean, while kurtosis as the extent to which the distribution's tail is plump. In the context of this study, a normality test is employed.

4.10.2. Heteroscedasticity Test

The OLS model assumes that the variance of the errors remains constant, which is referred to as the homoscedasticity assumption. When errors do not have consistent variation, they are referred to as heteroscedastic. This research employs the White heteroscedasticity test. If the null hypothesis for the White test is not rejected, then homoscedasticity is present. Heteroscedasticity is present if the null hypothesis is rejected.

4.10.3. Autocorrelation Test

Brooks (2008) states that there is no covariance between the error terms over time. Therefore, it is believed that the errors do not coincide with one another. In the absence of a relationship among the errors, the presence of autocorrelation will be evident. If the ARDL coefficient estimates remain unbiased but inefficient even with a large sample size, it indicates the presence of autocorrelation. In addition, there is an autocorrelation if R^2 has been increased by more than the right value for positively correlated residuals. The autocorrelation test therefore needs to be performed.

4.10.4. Misspecification Test

A misestimation of errors occurs if certain key variables are missing from the model. if the omitted variable is not associated with all the variables present, the calculated coefficients of the other variables will be unfair and erratic (Brooks, 2008). In this study the Ramsey reset test shall be used to detect misspecifications.

4.12. CUSUM TEST AND CUSUM SQUARED TEST

The cusum test and cusum squared test will be made to evaluate the stability of the model that will be used in the study, and the Q statistic will be used to determine whether the errors of this model are serially independent.

4.13. CONCLUSION

This chapter detailed the methodology employed in the study, with the goal of providing a more in-depth explanation of how to conduct estimates on the impact of fuel prices on supply chain costs. This chapter provided Augmented Dickey-fuller and Phillips Perron unit root tests for stationary testing. Also, the ARDL model to be employed for estimating the long-run and short-run effects of fuel price on supply chain costs was provided. The ECM is used in the study to see if the model is good enough. The discussion also included diagnostic tests like heteroscedasticity, normality, autocorrelation, and misspecification. This chapter outlined all the techniques that were implemented, and they will be further explored in Chapter Five.

CHAPTER FIVE

ANALYSIS AND INTERPRETATION OF FINDINGS

5.1. INTRODUCTION

This chapter provides a comprehensive analysis and interpretation of the findings derived from the study. The study used ARDL and ECM models to estimate the impact of fuel prices on supply chain costs in South Africa from 1990 to 2022. This chapter further explains the methods utilised in the study, as previously outlined, with the use of data from South Africa to accomplish the objectives outlined in Chapter One. This shows how the objectives of this research were achieved. This further enhances the trend analysis in chapter two by detailing the application of analytical methods suggested on annually data from 1990 to 2022 within the study. The findings disclosed entail results from unit root tests and cointegration. Presuming the existence of a minimum of one cointegration relationship among the variables, the ARDL model was estimated, followed by the execution of ECM analysis. Subsequent to the ARDL and ECM evaluations, the study proceeded to conduct diagnostic tests to confirm the suitability of the model, with the E-views statistical package version being the econometric tool used in this study.

5.2. INFORMAL UNIT ROOT TEST

5.2.1. Graphical Displays

A graphical examination of the time series is a widely used informal assessment for determining stationarity. This entails a visual representation of the series, which serves as a crucial preliminary step in the comprehensive examination of the time series prior to the implementation of any formal statistical tests. This initial analysis of the data is crucial because it enables the identification of any data collection mistakes and changes in structure, as well as provides insight into the patterns and stability of the dataset. Figures 5.1 and 5.2 display plots of all variables considered in the supply chain cost model. Figure 5.1 exhibits the unit root at level and figure 5.2 shows the graphical unit root at the first difference.

The graphical representations in figure 5.1 indicate that each of the five variables have unit roots at levels. The variables (fuel price and fuel consumption) trended upward with a few fluctuations along the line. The other three variables (supply chain costs, inflation rate (cpi), and real effective rate) fluctuate significantly throughout the period, with major ups and downs.

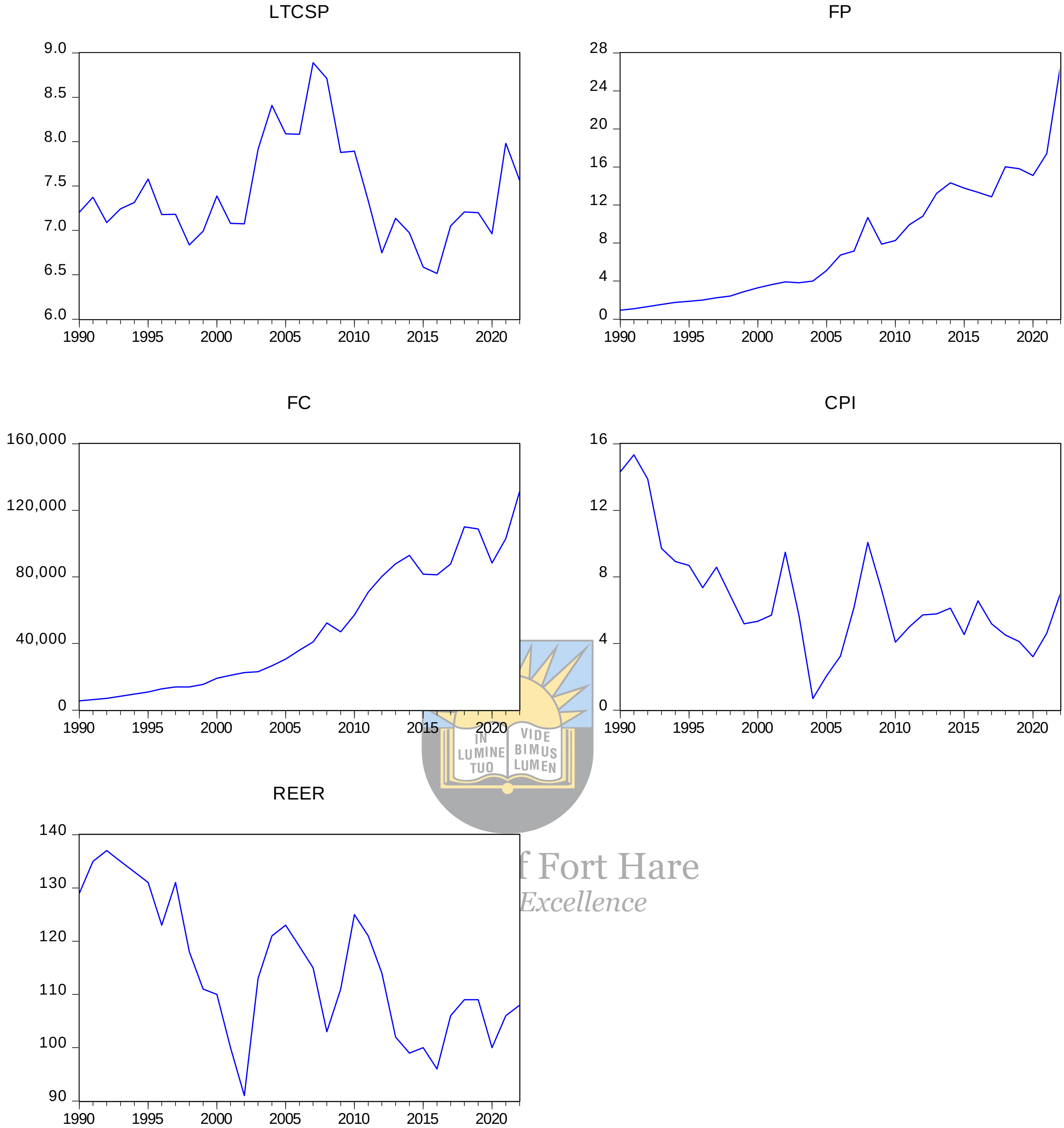

Figure 5.1: Graphical unit root test at level

Source: *Author's computation using EViews 11*

According to the analysis above, it is difficult to learn if the variables are stationary, especially ones like supply chain costs, inflation (cpi), and the real effective exchange rate that do not show a clear trend. As a result, further analysis was deemed necessary, leading the study to implement the first difference, as depicted in figure 5.2.

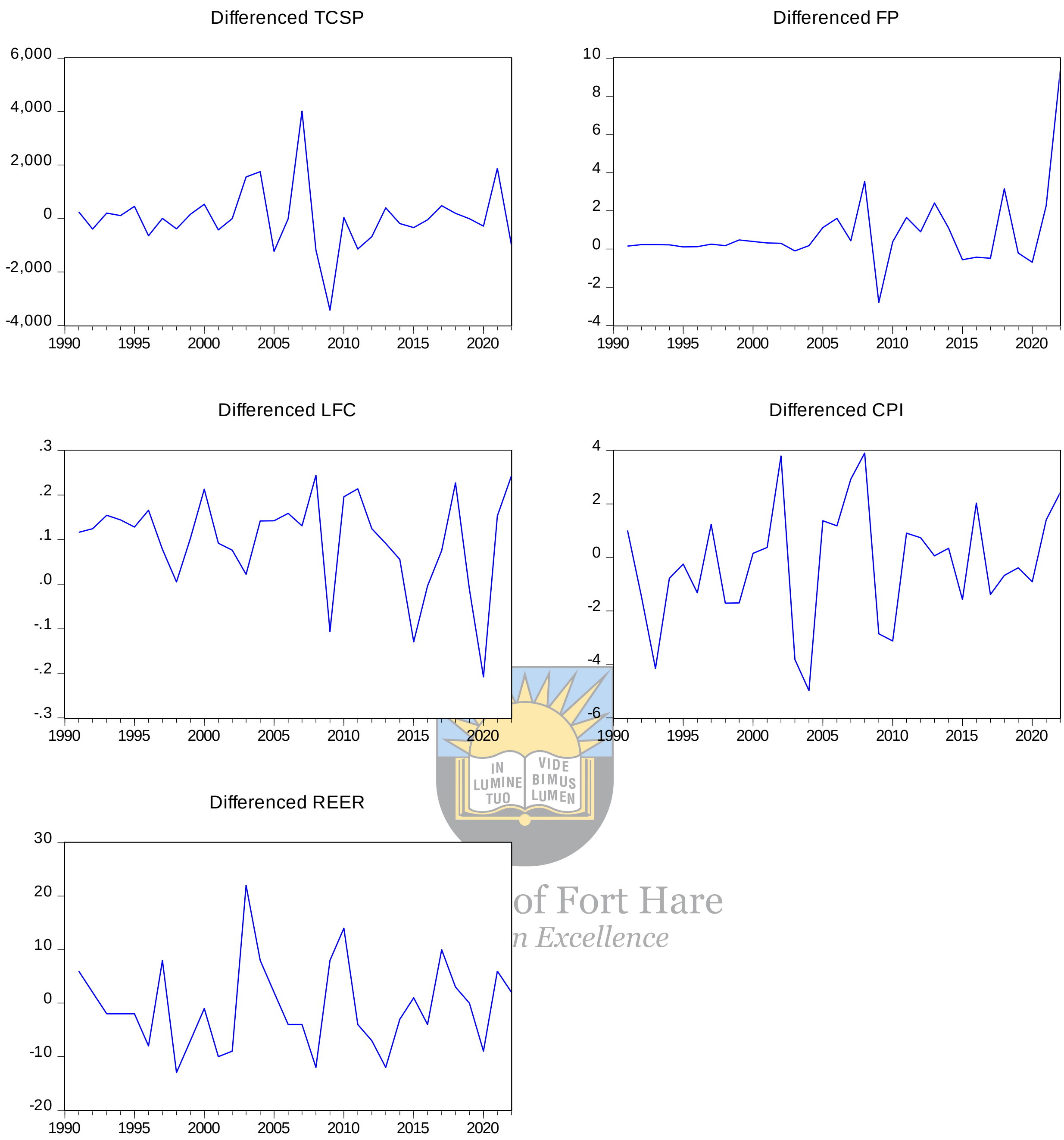

Figure 5.2: Graphical unit root test at difference

Source: *Author's computation using EViews 11*

Figure 5.2 display the time series in the first difference. The variables (TCSP, FP, FC, CPI and REER) display trends that adhere to a stationary white noise process, as they fluctuate near the average. Formal tests for stationarity were applied in addition to informal graphical examination of stationarity. The detailed discussion of the formal tests is presented in the following section.

5.3. DESCRIPTIVE STATISTICS

Descriptive statistics help to logically simplify vast amounts of data. It mininises a vast dataset into a brief overview. In simpler terms, it implies "what is" or "what the data show" by explaining the fundamental characteristics of the content in a study. Every descriptive statistic includes a measurement of dispersion or measurement of central tendency (Sharma, 2019).

Table 5.1: Descriptive statistics

	LTCSP	**LFC**	**FP**	**CPI**	**REER**
Mean	7.413896	10.39908	7.940000	6.694848	114.6667
Median	7.206229	10.48975	6.730000	5.780000	113.0000
Maximum	8.889074	11.78522	26.74000	15.33000	137.0000
Minimum	6.515897	8.624432	0.940000	0.690000	91.00000
Std. Dev.	0.572609	0.976909	6.312935	3.300168	12.70253
Skewness	0.885167	-0.268258	0.888855	0.960584	0.151791
Kurtosis	3.245426	1.732831	3.355030	3.844418	1.989832
Jarque-Bera	4.392184	2.603652	4.518659	6.055399	1.529826
Probability	0.111237	0.272035	0.104420	0.048427	0.465374
Sum	244.6586	343.1697	262.0200	220.9300	3784.000
Sum Sq. Dev.	10.49219	30.53923	1275.301	348.5154	5163.333
Observations	33	33	33	33	33

Source: *Author's computation using EViews 11*

Table 5.1 presents the descriptive statistics for the variables used in the study. The mean values for each variable represent their central tendency, with each variable having a distinct mean. Additionally, each variable has its own standard deviation, reflecting the degree of variability around its mean. As seen in the table, the standard deviations of all variables are small relative to their respective means, indicating that the variables used in the study exhibit a low variability and are not widely dispersed.

5.4. TESTING FOR STATIONARITY (FORMAL UNIT ROOT TEST)

Stationarity test is crucial as it is necessary for standard economic theories. Stationarity is a critical term in a time-series analysis. This implies that the statistical characteristics of a time series (or, more precisely, the mechanism producing it) remain constant over time. Stationarity is important as it forms the basis for numerous valuable analytical methods, statistical tests, and models (Palachy, 2019). Stationarity is evident in the table displays depicted in the unit-root test findings presented below. This study employs the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests both at level and at first difference. In Table 5.2, the findings of the ADF and PP tests are shown in the level series. The outcome confirms that not only were formal unit root tests necessary for all variables to reach stationarity at the level series, but first differencing was also needed for those that were non-stationary at the level.

Table 5.2: Formal unit root test at level

	Augmented Dickey-Fuller			**Philips Perron**		
Variable	**Intercept**	**Intercept and Trend**	**None**	**Intercept**	**Intercept and Trend**	**None**
LTCSP	-3.091683**	-3.028969	-0.048670	-2.229696	-2.194641	-0.012454
FP	1.697610	-0.969825	2.985819	3.122971	0.030267	4.664486
FC	1.283123	-1.841624	3.648493	3.216509	-1.143660	5.262635
CPI	-3.840573***	-3.779985**	-2.214232**	-3.688330***	-1.988198	-1.777176*
REER	-2.476761	-3.522176*	-0.666770	-1.758608	-2.498024	-0.980522

(**)[***] Statistically significant at 10(5)[1]

Source: *Author's computation using EViews 11*

Table 5.3 below represents the findings acquired from the Augmented Dickey-Fuller and Philips Perron tests at first difference. These results are required to bring the variables that were not stationary at level series to at least be stationery at first difference.

Table 5.3. Formal unit root test at first difference

	Augmented Dickey-Fuller			**Philips Perron**		
Variable	**Intercept**	**Intercept and Trend**	**None**	**Intercept**	**Intercept and Trend**	**None**
LTCSP	-2.702555*	-3.874795**	-2.754468***	-5.861004***	-5.756632***	-5.964774***
FP	-2.920310*	-3.327271*	-2.231214**	-2.465542	-2.019232	-2.257514**
FC	-6.378010***	-5.326921***	-1.190936	-3.375613**	-4.405053***	-3.507908***
CPI	-5.110130***	-5.802766***	-4.922703***	-4.833491***	-8.532986***	-4.777894***
REER	-4.511363***	-4.492508***	-4.489548***	-6.114138***	-7.409680***	-5.305370***

(**)[***] Statistically significant at 10(5)[1]

Source: *Author's computation using EViews 11*

The findings from the above tables (5.2 and 5.3) demonstrate that the null hypothesis of non-stationarity cannot be rejected when variables are at levels due to the majority of non-stationary variables. Upon implementing the test on the first differences of the series, all variables achieved stationarity. As a result, the variables employed in the cointegration regression are characterised as first difference stationary.

Graphical analysis acts as a reference point for formally measuring the unit root test. Table 5.2 and table 5.3 distinctly illustrate that it is evident that the series (fuel price and fuel consumption) does not exhibit stationarity at the levels. However, the variable CPI is stationary on both Augmented Dickey-Fuller (ADF) and Philips Perron (PP); under PP, it is nonstationary only at the intercept and trend. LTCSP is stationary at the level only at the intercept of the ADF. Also, real effective exchange rate (REER) is stationary at level only at the intercept and trend of ADF. When the test was applied to the first difference of the series in Table 5.3, most of the variables became stationary. However, the fuel price is nonstationary at the intercept and trend of the Philips Perron. This stipulates that the variables are of mixed order, and that the ARDL model is the best model to use in such a case. Therefore, the majority of variables in the cointegration regression exhibit first difference stationarity.

5.5. MODELLING APPROACH

This section provides the ARDL Bound tests for co-integration, the predicted long-run coefficients of the ARDL model, the error correction model, the model of diagnostic tests, cusum tests and cusum of squares, and the Q-statistic.

5.5.1 ARDL Regression Model

It is critical to choose the correct lag number when executing the ARDL model so that good results can be obtained. After selecting the lag length. The sequence of delays can be chosen using Akaike Information Criteria (AIC). AIC is employed to choose the length of the lags in the study, and the lags chosen are (2, 2, 4, 3, 4). Figure 5.3 below presents the results of lag selection.

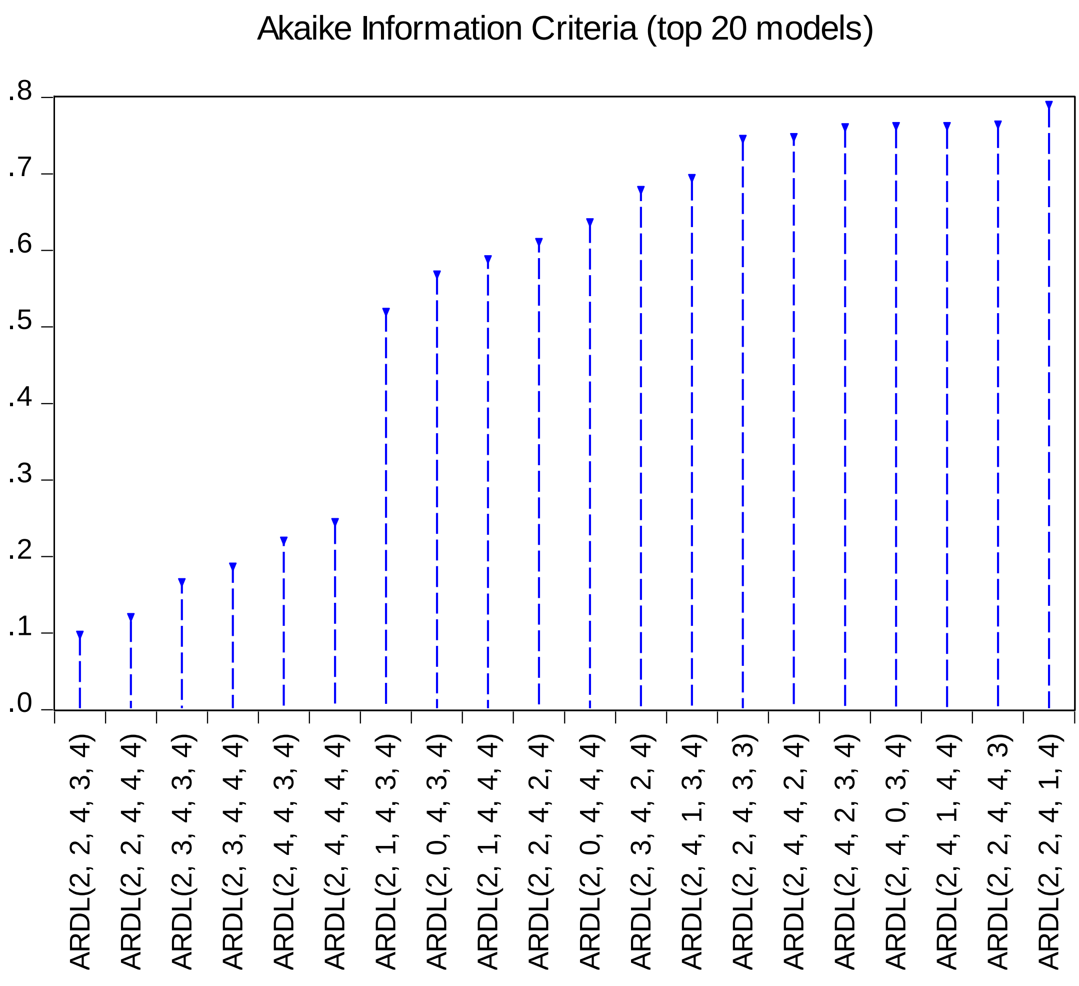

Figure 5.3. ARDL lag selection

Source: *Author's computation using EViews 11*

Following the ARDL lag selection, the Bound F-test is determined to ensure co-integration. Co-integration exists if the F-statistic is bigger relative to the upper-bound value (I1). The ARDL bounds test approach to cointegration provides evidence of a long-run equilibrium relationship among the variables used in the study (Montenegro, 2019). In this model, the F-Statistic is 7.337572 and is bigger than the upper bound (I1) values at all levels of significance. Therefore, cointegration exists among the variables because of the observed results in Table 5.4.

Table 5.4: Bound F Test

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	7.337572	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: *Author's computation using EViews 11*

Following the Bound F-test, the next step is to test the long-run and short-run effects of all independent variables used in the study on the dependent variable. Thus, table 5.5 illustrates that the variables (fuel price, fuel consumption, and inflation (CPI)) have a long-run impact on supply chain costs, as their coefficients are statistically significant. However, the real effective exchange rate is shown to have no long-run impact on supply chain cost, since it was statistically insignificant in the results.

Table 5.5: ARDL Long Run Form

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**

Constant	6.722192	0.784631	8.567325	0.0000
FP	0.462085	0.092590	4.990685	0.0007
FC	-7.98E-05	1.38E-05	-5.778421	0.0003
CPI	-0.072343	0.031737	-2.279425	0.0486
REER	0.010433	0.007386	1.412560	0.1914

Source: *Author's computation suing EViews 11*

The empirical results from the table above show the long-run relationship between explanatory variables (FP, FC, CPI and REER) and the dependent variable Total Supply Chain Costs (TCSP). From the findings, the long run co-integrating equation can be estimated as follows:

$$LTCSP_t = 6.722 + 0.462*FP - 0.0001*FC - 0.072*CPI + 0.010*REER + \varepsilon_t \ldots\ldots\ldots\ldots\ldots(16)$$

Fuel Price (FP): The findings show a strong positive long-term relationship between fuel price and supply chain costs, given that the coefficient of fuel price is positive at (0.462) and statistically significant at 1% level. This means that for a 1% increase in fuel price, the supply chain costs increase by (0.462). Therefore, the results of this study provide a strong empirical support for the hypothesis that a rise in fuel costs leads to higher supply chain costs, which aligns with the predictions of the Economic Order Quantity (EOQ) Model. According to the EOQ Model, any increase in fuel costs will lead to an increase in the overall cost of managing inventory. Fuel costs directly affect transportation costs, a major component of supply chain expenses (Atkin, 2022). Similarly, Gurtu et al. (2015) stated that changing fuel prices puts pressure on supply chain costs. This positive long-run relationship is supported by (Kopdar et al. (2021), Sarka et al. (2017,) Scheibe et al. (2018). This simply provides the relevant results for the study because the two variables are the main variables of interest in the study.

Fuel Consumption (FC): The findings reveal a negative correlation between fuel consumption and supply chain costs at (-7.98E-05) and that FC is statistically significant at the 1% level. This illustrates that for every 1% increase in Fuel Consumption there will be a decrease in supply chain costs by (-7.98E-05). This is in contrast to the prior expectations of the study; a possible explanation would be the strategic placement of goods closer to their final customer in order to reduce fuel costs; less miles equals less diesel fuel consumed. Transporting goods to consumers is an essential component of business activity that will be there forever. However, companies are increasingly turning to micro fulfilment centres (MFCs) to help minimise these delivery distances and, as a result, their fuel costs (Averitt, 2022). In support of this notion, Gurtu, et al., (2015) highlight that in the future, businesses will be in a better position to manage the costs of their supply chains if their providers are in close proximity.

Inflation Rate (CPI): The findings reveal that there exists an inverse correlation between inflation rate and supply chain costs, given that the coefficient of CPI is negative at (-0.072) and statistically significant at the 5% level. This implies that for a 1% increase in inflation rate there is a decrease of (-0.072) in the supply chain costs. This also contradicts the priori expectations of the study. In this scenario, one potential reason is that CPI functions as a price index, reflecting the costs of a diverse market basket of consumer goods and services typically bought by households. Due to the involvement of the middleman, such as the retailer determining prices for consumers, the index does not directly represent supply chain costs. However, the PPI offers a fascinating view on how supply chain disruptions and resilience can affect outcomes (Viswanathan, 2022).

Real Effective Exchange Rate (REER): The findings confirm that real effective exchange rate has an insignificant positive long run relationship with supply chain costs at (0.010) and it is statistically insignificant due to the p-value is above the levels of significance. As a result, that simply imply that REER affect the supply chain costs insignificantly in the long run. Due to the intrinsic characteristics of supply chains, any changes in exchange rates will affect only the flow of money throughout the chain (Trugian, 2022).

The Error Correction Model (ECM) is then undertaken to have both long run and short run of the information incorporated in Table 5.6 below.

Table 5.6: Error Correction Model (ECM)

ARDL Error Correction Regression		
Dependent Variable: D(LTCSP)		
Selected Model: ARDL(2, 2, 4, 3, 4)		
Case 2: Restricted Constant and No Trend		
Date: 11/19/23 Time: 08:39		
Sample: 1990 2022		

Included observations: 29				
ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LTCSP(-1))	1.045521	0.149270	7.004225	0.0001
D(FP)	0.006602	0.039119	0.168761	0.8697
D(FP(-1))	-0.327891	0.069437	-4.722157	0.0011
D(FC)	1.60E-05	7.12E-06	2.248085	0.0512
D(FC(-1))	8.19E-05	1.48E-05	5.527641	0.0004
D(FC(-2))	6.64E-05	1.12E-05	5.930092	0.0002
D(FC(-3))	6.66E-05	9.94E-06	6.700640	0.0001
D(CPI)	0.047952	0.025261	1.898305	0.0901
D(CPI(-1))	0.110797	0.027612	4.012624	0.0031
D(CPI(-2))	0.097338	0.022797	4.269782	0.0021
D(REER)	0.042579	0.006606	6.445393	0.0001
D(REER(-1))	0.023807	0.007650	3.111915	0.0125
D(REER(-2))	0.036546	0.007324	4.989752	0.0007
D(REER(-3))	0.029854	0.005746	5.195996	0.0006
CointEq(-1)*	-1.545027	0.186699	-8.275506	0.0000
R-squared	0.916067	Mean dependent var		0.011110
Adjusted R-squared	0.832134	S.D. dependent var		0.447906
S.E. of regression	0.183513	Akaike info criterion		-0.246816
Sum squared resid	0.471479	Schwarz criterion		0.460406

Log likelihood	18.57884	Hannan-Quinn criter.		-0.025323
Durbin-Watson stat	2.751771			
* p-value incompatible with t-Bounds distribution.				

Source: *Author's computation using EViews 11*

The error-correction coefficient CointEq(-1)* is negative (-1.545027) as needed and it is strongly significant at 1% level as observed by looking at its probability value. This confirms that there are short run effects through the speed of adjustment. This also means that there is correction of disequilibrium of the previous period at a speed of 1.54%.

5.6. DIAGNOSTIC TESTS

After the ECM, the diagnostics tests follow in table 5.7 below to test for normality, serial correlation, auto-regressive conditional heteroskedasticity and misspecification of the model used in the study. The probability values of all the tests have to be above 10% level of significance in order for the diagnostic tests to provide relevant results for the model.

Table 5.7: Residual Diagnostic Tests

Test type	**Null hypothesis**	**Test static**	**Probability value**	**Conclusion**
Jarque-Bera Test	Normally distributed	JB = 1.342932	0.510959	Accept H0 – the residuals are normally distributed.
Heteroskedasticity Test: White	Residuals are homoscedastic	Obs R^2 = 18.44891	0.4927	Accept H0 – the residuals are homoscedastic.
Breusch-Godfrey Serial Correlation LM Test	Residuals are not auto correlated	Obs R^2 = 7.699174	0.1032	Accept H0 – the residuals are not autocorrelated.
Ramsey RESET Test	The model is correctly specified	LR Test = 0.943369	0.3731	Accept H0 – the model is correctly specified.

Source: *Author's computation using EViews 11*

Table 5.7 illustrates the findings after the model used in the study was tested for normality, serial-correlational, auto-regressive conditional heteroskedasticity and misspecification. The findings above show that the model has a normal distribution, no autocorrelation in the model and the model can be relied on because it cannot suffer from misspecifications. This is because all the probability values of the diagnostic tests are above 10% level of significance.

Following the diagnostic tests, cusum and cusum of squares tests are made in figure 5.4 and 5.5 below to check the stability of the model used in the study.

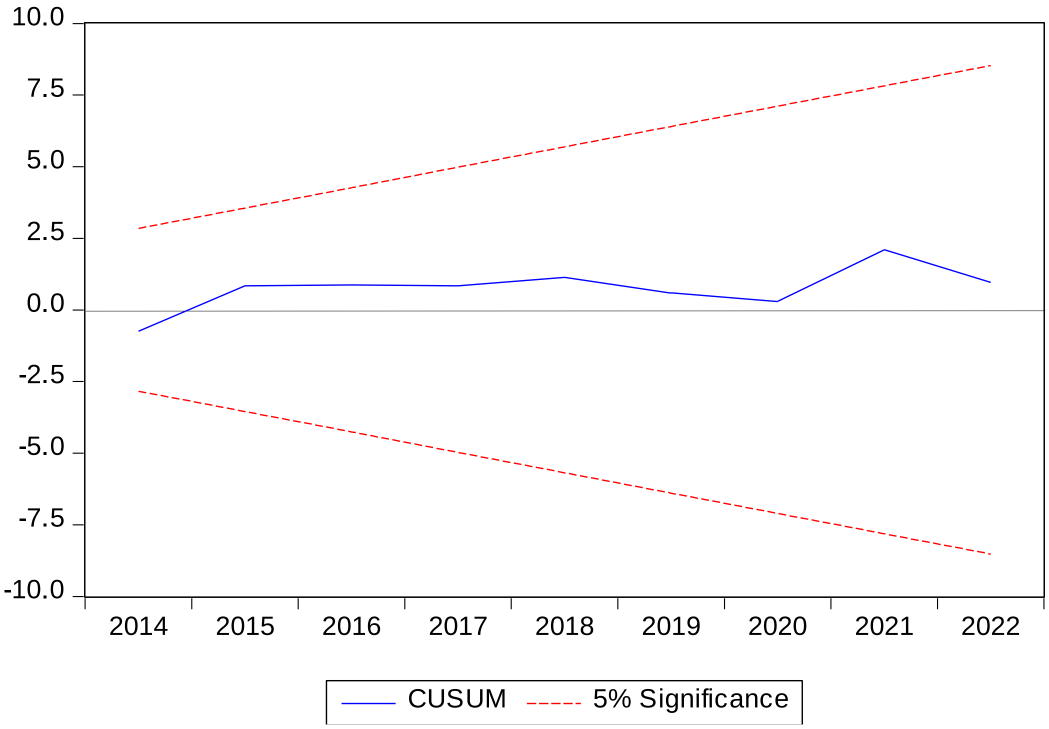

Figure 5.4: CUSUM Test

Source: *Author's computation using EViews 11*

Both figures 5.4 (Cusum Test) and 5.5 (Cusum of Squares Test) were conducted to evaluate stability at 5% level of significance, in figure 5.4, it can be concluded that the model is stable because the cumulative sum lies between the critical lines without crossing them. In figure 5.5, it can also be concluded that the model is stable since the cumulative sum did not cross the critical values, although it came close in 2020, however, it started to move further away from the critical values in the following years.

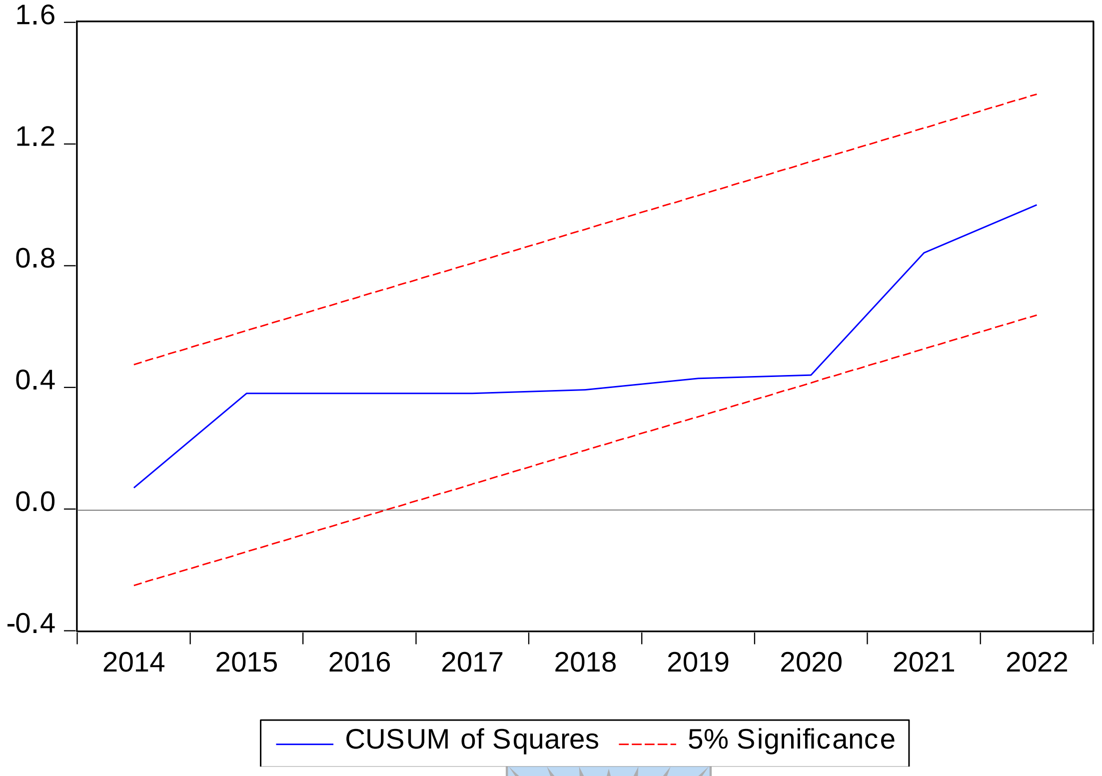

Figure 5.5: CUSUM of Squares

Source: *Author's computation using EViews 11*

Ultimately, the Q-statistic follows to test if the errors of this model are serially independent. The p-values in the Q-stat have to be above the 10% level of significance similarly to the case of diagnostic tests. The Q-Stat is presented in Table 5.8 below.

Table 5.8: Q-Statistic

Date: 11/19/23 Time: 14:24						
Sample: 1990 2022						
Included observations: 28						
Q-statistic probabilities adjusted for 2 dynamic regressors						
Autocorrelation	**Partial Correlation**		**AC**	**PAC**	**Q-Stat**	**Prob***
. | . |	. | . |	1	-0.012	-0.012	0.0046	0.946
. |* . |	. |* . |	2	0.133	0.133	0.5743	0.750
. *| . |	. *| . |	3	-0.138	-0.137	1.2113	0.750

<table>
<tr><td>. |**. |</td><td>. |**. |</td><td>4</td><td>0.292</td><td>0.285</td><td>4.2057</td><td>0.379</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>5</td><td>-0.060</td><td>-0.044</td><td>4.3371</td><td>0.502</td></tr>
<tr><td>. *| . |</td><td>.**| . |</td><td>6</td><td>-0.187</td><td>-0.301</td><td>5.6723</td><td>0.461</td></tr>
<tr><td>. *| . |</td><td>. | . |</td><td>7</td><td>-0.136</td><td>-0.028</td><td>6.4122</td><td>0.493</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>8</td><td>-0.011</td><td>-0.046</td><td>6.4172</td><td>0.601</td></tr>
<tr><td>. |* . |</td><td>. |* . |</td><td>9</td><td>0.102</td><td>0.104</td><td>6.8789</td><td>0.650</td></tr>
<tr><td>.**| . |</td><td>.**| . |</td><td>10</td><td>-0.314</td><td>-0.247</td><td>11.477</td><td>0.322</td></tr>
<tr><td>. |* . |</td><td>. |* . |</td><td>11</td><td>0.104</td><td>0.161</td><td>12.010</td><td>0.363</td></tr>
<tr><td>. | . |</td><td>. |* . |</td><td>12</td><td>0.047</td><td>0.127</td><td>12.125</td><td>0.436</td></tr>
<tr><td colspan="7">*Probabilities may not be valid for this equation specification.</td></tr>
</table>

Source: *Author's computation using EViews 11*

Table 5.8 depicts the results after the model was tested for Q-statistic. The p-values recommend that there is no proof of autocorrelation in the residuals of the model, since all the p-values are above 10% level of significance. This is good news for the model, however, the raw data revealed autocorrelation, and it was removed by differencing the series.

5.7. CONCLUSION

The chapter discussed the findings derived from the models discussed in the preceding chapter. It commenced with the examination of the time series data qualities utilising three distinct approaches for testing unit roots. Each of the approaches employed validated that the variables are classified as order one I(1). The research aimed to establish if there is a significant connection between fuel prices and supply chain costs. The research conducted the ARDL long-term regression and revealed a positive correlation between the two variables, with a positive coefficient of (0.462). This suggests that a 1% increase in fuel prices result to an equivalent increase of (0.462) in supply chain costs. The findings provide a response to the study's major purpose, indicating that fuel prices have to be lowered, or companies have to switch to energy efficient measures to lower supply chain costs. Companies have to implement energy efficient measures such as having their suppliers in close proximity to avoid long distance travel, the lower the distance, the less impact fuel price has on the movement of goods across the chain, and thus, the better position it becomes for businesses to manage the costs of their supply chain.

The ECM was also calculated to analyse the relationship between the variables in both the long-term and short-term. The equation derived from the long-term analysis indicated that a majority of the variables utilised within the model exhibit statistical significance. The study further used Bound F-test to test the model for normality, serial-correlational, auto-regressive conditional heteroskedasticity, and misspecifications. The findings indicated that the model used in the study has a normal distribution, no autocorrelation in the model and the model can be relied on because it cannot suffer from misspecifications. CUSUM test and CUSUM of Squares followed to test the stability of the model at 5% significance level, and the results proved the model to be stable. The Q-statistic was also tested to find if the errors of this model are serially independent. The p-values recommend that there is no proof of autocorrelation in the residuals of the model, all the p-values are above 10% significance level.

CHAPTER SIX

STUDY SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

6.1. INTRODUCTION

This chapter offers a comprehensive conclusion derived from the empirical findings of the research and proposes policy recommendations for subsequent policy formulations, while also articulating the implications of the findings within the South African context. This chapter discusses the policies that will evaluate the impact of fuel prices on supply chain costs in future. A summary of the study and the results obtained in chapter five using ARDL model to check correlation between fuel prices and supply chain costs will be provided in this chapter. This is also the last chapter of the study which is considered as a concluding chapter of the analysis. Therefore, it is critical to highlight all the key aspects of the study in this chapter.

6.2. SUMMARY AND CONLUSION OF THE STUDY

The study aimed to examine the impact of fuel price on supply chain costs in South Africa from 1990 to 2022. The data that is used in the study is on yearly basis and it was obtained from the South African Reserve Bank and the World Bank site. The model used in the study is ARDL model which proved to be the suitable model in explaining the variables. Moreover, the model was used because the variables in the study are mixed and the ARDL model is suitable in such a case.

The empirical findings acquired in chapter five can be summarised as follows: The ARDL long run regression revealed a positive correlation between fuel price and supply chain costs which are the main variables of the study. Therefore, for the primary objective of the analysis it means that fuel price positively affects supply chain costs, meaning an increase/decrease in fuel price will result to a similar outcome on supply chain costs in the long run. For instance, a 1% increase in fuel price will result to a (0.462) increase in supply chain costs as observed in the ARDL long run regression table which is conducted in chapter five of the study. The ECM model was estimated to assess the relationship between the variables in both the long run and short run. The error correction coefficient confirmed that there are short run effects through the speed of adjustment. This means that there is correction of disequilibrium of the previous period at a speed of 1.54%, as observed in the ECM table in chapter five.

The study further conducted diagnostic tests to check normality, serial-correlational, auto-regressive conditional heteroscedasticity, and misspecification. The results confirmed that the model has a normal distribution, no autocorrelation in the model and the model can be relied on because it cannot suffer from misspecifications. CUSUM test and CUSUM of Squares followed to test the stability of the model at 5% significance level, and the results proved the model to be stable. Ultimately, the model was tested for Q-statistic to find if the errors of this model are serially independent. The p-values recommend that there is no proof of autocorrelation in the residuals of the model, hence all the p-values are above 10% level of significance.

All the econometric methods applied to obtain the results of the study achieved the objective of the study as the results indicated a correlation of a favourable nature between supply chain costs and fuel prices. High fuel prices push up the average order cost in virtually every manufacturing process. The rise in fuel prices usually results in higher costs throughout supply chains, impacting everything from raw material prices and transportation costs to manufacturing and distribution expenses for finished products. Fuel prices are essential in determining the effectiveness and financial success of the logistics sector. Changes in fuel prices can impact pricing, route planning, investment choices, and overall strategies for logistics firms, ultimately influencing the cost and efficiency of transporting goods. As already stated, high fuel costs negatively impact all points in supply chains, and it has a tendency to compound as the number of 'links' in the chain increases. Therefore, the positive result obtained between fuel price and the total supply chain costs highly suits the relationship between the two variables.

6.3. POLICY RECOMMENDATIONS FOR FUTURE ANALYSIS

The research findings showed numerous policy recommendations which have an impact on supply chain costs and fuel prices. A positive relationship between supply chain costs and fuel prices explains that an increase in fuel price will result to an increase in supply chain costs, hence, there is a positive link between the two variables. According to existing literature, fuel price is identified as the latest disruptive element in the supply chain, impacting costs at every stage from raw material prices to transportation expenses, manufacturing costs, and distribution of finished goods to retail locations.

Therefore, this study recommends that companies in South Africa should familiarise themselves with route optimisation. Rising fuel costs can incentivise logistics companies to optimise their delivery routes to minimise fuel consumption. This could entail utilising sophisticated routing software to discover the most economical routes for fuel or consolidating shipments to reduce the number of trips. Moreover, companies have to investment in fuel-efficient vehicles: High and volatile gas prices can motivate logistics companies to invest in more fuel-efficient vehicles or technologies, such as hybrid or electric trucks, to reduce their dependence on traditional gasoline or diesel fuel. With less dependence on gasoline that means less impact fuel price has on their supply chain costs and thus less prices to be paid by customers at retail outlets. Ultimately, less dependence on fuel prices can lower the average order cost in virtually every production cycle. Costs can be minimised by decreasing dependence on fuel throughout the entire supply chains, from raw material costs to transportation costs to factories, and from manufacturing expenses to the rising cost of distributing finished products to distribution centres and retail stores.

For future research, the study acknowledges limitations in the variables used, suggesting that future research could explore additional factors beyond fuel price, exchange rate, fuel consumption, and inflation rate that contribute to supply chain costs. The study mentions that events outside the research period (1990–2022) were not captured, therefore, the impact of external events such as, future studies could examine how specific global or local events, such as pandemics or geopolitical conflicts, impact supply chain costs in South Africa. Additionally, future research could delve into how fuel price fluctuations affect specific sectors or industries within South Africa, such as agriculture, mining, or manufacturing, to provide tailored mitigation strategies.

6.4. STUDY LIMITATIONS

The study is limited to certain variables that will be used as these variables may not be the only factors that contribute to the relationship between supply chain costs and fuel price in South Africa. Also, some events that occurred outside of the research period that could have had an impact on supply chain costs may not be captured. Hence, the study will employ data for the period from 1990 to 2022. The study is restricted to the economy of South Africa, meaning the findings may not be generalised to economies of other countries. However, for international experience, the study could facilitate an enhanced comprehension of the correlation between supply chain costs and fuel prices of a country.

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APPENDIX LIST

Raw Data Table

Period	TCSP	FP	FC	CPI	REER
1990	1347.5	0.94	5566	14.32	129
1991	1595.4	1.09	6252	15.33	135
1992	1198.7	1.32	7081	13.87	137
1993	1398.1	1.55	8262	9.71	135
1994	1502.3	1.77	9543	8.93	133
1995	1957	1.88	10847	8.68	131
1996	1310.1	2	12804	7.35	123
1997	1315.6	2.25	13845	8.59	131
1998	930.8	2.43	13916	6.88	118
1999	1086.8	2.9	15419	5.18	111
2000	1615.3	3.3	19079	5.33	110
2001	1187.2	3.62	20915	5.7	100
2002	1181.8	3.92	22575	9.49	91
2003	2733.6	3.82	23078	5.67	113
2004	4482.9	4	26598	0.69	121
2005	3252.8	5.12	30666	2.06	123
2006	3239.3	6.73	35945	3.24	119
2007	7252.3	7.16	40965	6.17	115
2008	6069.8	10.7	52283	10.07	103
2009	2641.2	7.9	47014	7.21	111
2010	2674.8	8.27	57201	4.08	125
2011	1531.8	9.92	70855	4.99	121
2012	853.3	10.82	80240	5.72	114
2013	1255.8	13.23	87929	5.78	102
2014	1065.4	14.33	92942	6.12	99
2015	725.8	13.77	81662	4.54	100
2016	675.8	13.34	81321	6.57	96
2017	1152.6	12.86	87687	5.18	106
2018	1347.8	16.02	110048	4.51	109
2019	1340.7	15.81	108791	4.12	109
2020	1056.4	15.12	88322	3.21	100
2021	2931.3	17.39	102950	4.61	106
2022	1929.6	26.74	131297	7.03	108

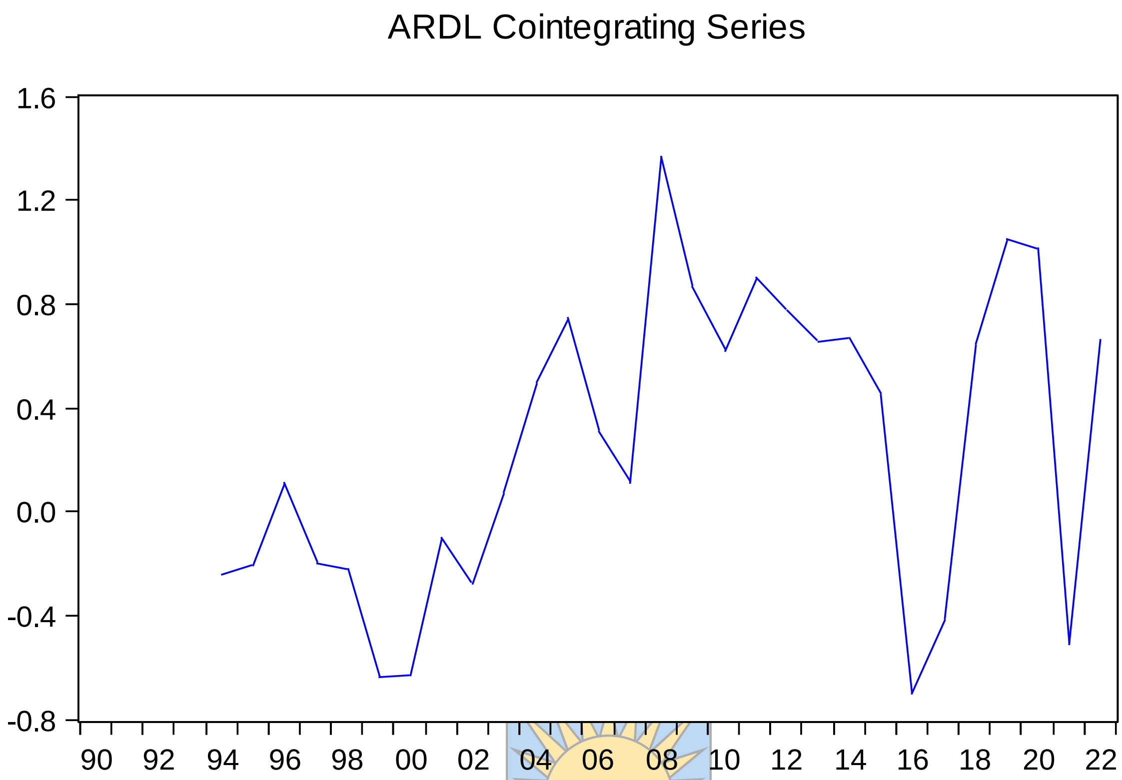
Bound F-Test Table

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	7.337572	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

ARDL Long Run Table

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
FP	0.462085	0.092590	4.990685	0.0007
FC	-7.98E-05	1.38E-05	-5.778421	0.0003
CPI	-0.072343	0.031737	-2.279425	0.0486
REER	0.010433	0.007386	1.412560	0.1914
C	6.722192	0.784631	8.567325	0.0000
EC = LTCSP - (0.4621*FP -0.0001*FC -0.0723*CPI + 0.0104*REER + 6.7222)				

ARDL Cointegration Series



Histogram: Normality Test