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**INYUVESI  
YAKWAZULU-NATALI**

**OIL PRICES AND EXCHANGE RATES DYNAMICS  
IN SOUTH AFRICA**

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This dissertation is submitted in partial fulfilment of the requirements of the Master of Commerce degree in Economics.

## **Declaration**

I, **Nozipho Sinenhlanhla Dube**, declare that:

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**Oil prices and exchange rates dynamics in South Africa**

As the candidate's supervisor, I acknowledge that the dissertation has been submitted for examination. I have also perused the Turn-it-in report for the final dissertation and am of the view that any similarities between the candidates work and published or internet sources is incidental.



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Date: 09 December 2024

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To my family and friend, thank you for the support.

## **ABSTRACT**

The study examines the dynamics between oil prices and exchange rates in an oil-importing country to guide policymakers in their decision making. Furthermore, findings from this study seeks to decision makers to make informed and effective control measures. For this reason, this paper studies the effect of oil prices and oil price volatility on the rand-to-dollar exchange rate. It uses South African monthly data from 2000: M1 to 2023: M12, accessed from the Federal Reserve Bank of St Louis (FRED) and the World Bank. It employs the Structural Vector Autoregressive (SVAR) Model and further computes impulse responses and the forecast error variance decomposition (FEVD). The main findings of the study show that South African nominal exchange rates respond asymmetrically to changes in oil prices and that they tend to respond more to negative oil price shocks. The response of the South African nominal effective exchange rate to oil prices contradicts several author's work. The results further show that oil price volatilities cause the South African rand to depreciate.

**Keywords:** Oil prices; Exchange rates; Asymmetry; Oil-importing; Oil price volatility.

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## **CHAPTER 1: INTRODUCTION**

### **1.1 Background and motivation**

Oil serves as an energy source, significantly influencing and stimulating output in recent ages. Oil's importance originates from the rise of highly industrialized economies, and it is widely utilized today. Different stages of production require oil to function, including the extraction of raw materials, manufacture, and transportation. For this reason, it is a significant source of energy and production that impacts a nation's productivity, which in turn influences its growth. According to Ghalayini (2011) and Abdelsalm (2023), an increase in oil prices have a negative impact on economic growth in nations that import them, while they have a positive effect on economic growth in nations that export them.

According to the International Energy Agency (IEA), the major exporters of oil include Iraq, Saudi Arabia, Nigeria, Canada, Russia, and the United Arab Emirates. Most of these nations – Iraq, Saudi Arabia, Nigeria, and the United Arab Emirates - form members of the Organisation of the Petroleum Exporting Countries (OPEC), which is an organisation that is responsible for setting oil prices. The petrodollar system refers to the act of exchanging oil in dollars rather than any other currency; that is, all oil-importing countries pay dollars in exchange for oil (barrel of oil) to oil-exporting countries. Since oil prices are estimated in terms of dollars, oil prices and exchange rates are likely to influence each other (Lizardo & Mollick, 2010; Brahmasrene et al., 2014).

Some researchers, Zhang & Wei (2010), Albulescu & Ajmi (2021), and Brahmasrene et al. (2014), have attempted to investigate more on the underlying relationship between exchange rate and oil prices. One common finding was the bi-directional causality between exchange rates and oil prices. Zhang & Wei (2010) and Albulescu & Ajmi (2021) found that in the United States, exchange rates granger-caused oil prices during the Global Financial Crisis (GFC) in 2008-2009. Albulescu & Ajmi (2021) also argue that oil prices granger-causes exchange rates and that this causality increased after the GFC. Brahmasrene et al. (2014) conclude that exchange rates influence oil prices. Fowowe (2014), Lizardo & Mollick (2010), and Alia et al. (2015) argue that a rise in oil prices results in a depreciation of the rand-to-dollar exchange rate. The value of the US dollar depreciates relative to oil exporters' currency when oil prices

rise, as oil importers need more dollars to purchase oil. However, no evidence supports the bi-directional causality for small oil-importing countries like South Africa. No evidence supports that small oil-importing countries' exchange rates have a significant effect on oil prices, meaning only the world price of oil can affect these countries' exchange rates.

Authors, including Ahmad & Hernandez (2013), Lizardo & Mollick (2010), and Fasanya et al. (2022), have had a consensus on the asymmetric relationship between exchange rates and oil prices. Increases in oil prices have a significant negative effect; however, decreases in oil prices do not have equal positive effects. Kumar's (2019) results revealed that although the negative and positive oil shocks have a significant impact on the exchange rate, the positive shock (increase in oil prices) is more noticeable. An increase in oil prices leads to an immediate decrease in the trade-weighted exchange rate. Small, imported oil-dependent countries suffer from the asymmetry of oil prices. These countries cannot anticipate the adverse effect they will experience when oil prices increase, which would have been better given that they know that an increase in oil prices is the same in magnitude as a decrease in oil prices. The asymmetric effect of oil prices on exchange rates differs across countries (Saidu et al., 2021). By asymmetric effect, we mean that the response of the exchange rate to positive and negative oil prices is not equal. So, among oil-importing countries, positive (negative) oil price shocks do not cause an equal depreciation (appreciation). This is because their currencies differ in strength. It is based on each country's reliance on oil imports. The authors found an asymmetric and symmetric effect of oil prices in Ghana and Morocco, two net oil importers, respectively.

According to Dr Sayidini the Chief Operating Officer of the Petroleum Agency SA, South Africa imports more oil than it is exporting, meaning it is one of the net-importers of oil. It imports most of its own from the members of the OPEC, Saudi Arabia (29%), Iran (23%), Nigeria (16%), and Angola (15%) (Mpofu, 2011). To purchase oil from oil-exporting countries, South Africa needs to convert their rands into dollars. Hence, unexpected exchange rate movements are likely to leave South Africa vulnerable to oil price shocks. In contradiction to this, Nzimande & Msomi (2016) argue that South Africa is not vulnerable to positive oil shocks. This is in line with the South African Oil and Gas Alliance which regards SA as having no significant oil reserves and producing oil from its cheap and abundant coal. The rand-to-dollar exchange rate has been averagely increasing (depreciation) for more than 3 decades, and

research shows that oil prices have also been increasing. Statistics show that in 1995, the oil price was \$27 a barrel, and the rand-to-dollar exchange rate was R3.63 for a dollar; however, currently, oil prices stand at \$85 a barrel and the rand-to-dollar exchange rate is R18.59 for a dollar.

Most of the oil-exporting countries originate from the Middle East – United Arab Emirates, Iraq, and Saudi Arabia - therefore, the development of conflicts in this region, such as the Houthi attack, threatens the supply and prices of oil. Since oil is a significant production input and is important in shaping economic development, an increase in its price would first result in depreciation for an oil-importing country, as stated previously, and this will further increase domestic goods prices as input price increases. Thus, the study of the relationship between oil prices and exchange rates remains important in serving as a guide for policymakers.

## **1.2 Problem Statement**

Due to economic growth and industrialisation, oil is becoming a highly significant natural resource that is traded globally, this is seen through its global use across sectors. Developing countries are deemed to be the most affected countries by oil price fluctuations as most of them are oil importers. In the case of South Africa as a developing and net oil importer, its government and the central bank have employed measures to lessen the effect of oil price increases, for instance, the short-term relief fund after the Russia-Ukraine war (Department of Mineral Resources and Energy, 2023). They argue that the initiative spills over to encouraging competition through lower cost of production. However, this is also likely to result in retaliation through price wars from trading partners where they will also reduce their prices in order to gain customers. The implication of this is a reduction in profit margins. Furthermore, the price wars will result in increased inflation rates in the long run. This contradiction results from the demand-pull inflation, where a price of a good increases when consumers demand more of the good. This then leaves policymakers at a disadvantage as they will be unsure of which effective policies to implement while ensuring that there is no negative spillover. Furthermore, given that the different oil price shocks affect the country differently, measures to curb the shocks' effects may need to also differ. It is, therefore, crucial to look at the relationship between oil prices and exchange rates since exchange rates transfer shocks into the country. This will assist by informing those in authority on the extent to which they can implement certain policies

without causing any contradiction and harming themselves. It is also important to examine the effect of oil prices asymmetrically as it will provide more accurate results.

### **Research Objectives:**

1. To examine the extent of the effect of oil prices on the rand-to-dollar exchange rate.
2. To determine if the South African exchange rates respond asymmetrically to positive and negative oil price shocks.

### **Research Questions:**

1. What is the effect of oil prices on the rand-to-dollar exchange rate?
2. Does the exchange rate respond asymmetrically to oil price shocks?

### **1.3 Significance and contribution of the study**

South Africa imports most of its oil from the Middle East; nevertheless, in recent years, there have been some economic disruptions in the Middle East. The Middle East uses the Red Sea and the Persian Gulf to export its oil, and this is how South Africa receives it. However, recently, there has been an attack on these vessels that threaten the supply and transportation of crude oil. Therefore, if the government is aware of how these developments affect the South African economy, it might implement policies that can curb or control the effects. Previous researchers have attempted to study the link between oil prices and exchange rate behaviour; however, they focused more on oil-exporting countries (Englama et al., 2010; Adeyini et al., 2012). In the context of oil-importing countries, the focus was more on the demand and supply shocks and some on the effect on economic activities (Chisadza et al., 2016; Berument et al., 2010). Therefore, drawing inference from the fundamentals, this study chooses to differ by aiming to explore the link between oil prices and exchange rate behaviour in an oil-importing country, South Africa. Moreover, the study contributes to both the literature and policymaking since the study can be used to inform policy in other small open economies with similar characteristics as South Africa.

## CHAPTER 2: LITERATURE REVIEW

Numerous studies, Lizardo & Mollick (2010), Beckmann et al. (2020), Akram (2009), and Bednarski et al. (2023), have studied the relationship between oil prices and exchange rate behaviour; however, given the lack of consensus, understanding the nature of the underlying relationship remains a challenge.

Most researchers have acknowledged the significance of oil prices in determining exchange rate behaviour (Akram, 2009; Sanusi & Kapingura, 2022). Since oil prices are quoted in dollars, oil price shocks refer to anticipated and unanticipated oil price changes in dollars relative to other currencies, accompanied by a shortage of supply. The mechanism underlying the effect of oil prices on exchange rates remains an important factor in recent centuries since globalisation has evolved. This effect has three channels, namely, the wealth effect, the portfolio effect, and the terms of trade effect. When oil prices increase, wealth is reallocated to oil-exporting countries from oil-importing countries. This is because when oil prices increase oil-exporting countries are likely to experience their currency appreciation relative to oil-importing countries currencies (Lizardo & Mollick, 2010; Sanusi & Kapingura, 2022). Therefore, oil exporting countries get richer in US dollar terms since oil prices are quoted in dollars. They get huge revenue increases, and this is seen as an improvement in the oil-exporting country's current account (Kisswani et al., 2019). Furthermore, an increase in oil prices also results in a trade balance improvement since the value of exports increases with the increase in oil prices. For energy-reliant sectors, the oil price increase is likely to lead to an increase in prices of goods, thus improving their terms of trade in oil-exporting countries (Amano & Norden, 1998). This results because the price of exports increases relative to import prices. Therefore, oil-exporting countries experience a currency appreciation (Al-mulali et al., 2012). However, the appreciation of their currency makes the other goods that they export expensive, which may reduce trade volumes.

Changes in oil prices may also be driven by exchange rate shocks; for instance, when there is a decrease in the real value of the dollar, oil prices increase (Akram, 2009). Therefore, since oil prices are quoted in dollar terms, changes in the value of the dollar are also likely to change oil prices (Lizardo & Mollick, 2010). An appreciation of the dollar, due to some exogenous factors, makes goods that are quoted in dollars (including oil) expensive. Exchange rates have

both negative and positive effects on oil prices (Coudert et al., 2016). If the demand for a good is elastic, an increase in its price will cause a decrease in quantity demanded. Therefore, a decrease in demand for oil will result in a reduction in oil prices (Beckman et al., 2020). However, not only the change in the US dollar particularly changes oil prices. During periods of growth in economic activities, the demand for the South African Rand, according to Sanusi & Kapingura (2022), increases. Hence, an increase in the demand for the Rand causes it to become expensive (appreciation), and since fewer Rands are needed to buy oil, oil prices then decrease. However, as South Africa is a small economy, changes in the Rand value cannot significantly alter global oil prices; hence, when oil prices change, it reflects a change in imported goods. Thus, this study treats oil price shock exogenously. The way that the exchange rates affect oil prices can be arguable given that oil is an inelastic good, with relatively not many substitutes (Greenemeier, 2020). Therefore, a reduction in oil demand is not something that is frequently experienced.

The main common finding of the bi-directional causality expressed above was discovered by several authors, (Beckmann et al., 2020; Jahan-Parvar & Mohammadi, 2011). This means that it is not only that oil prices affect exchange rates, but exchange rates also affect oil prices. Some authors argue that causality only runs from oil prices to exchange rate; Jahan-Parvar & Mohammadi (2011) used 14 oil-exporting countries and discovered that for only four countries oil prices affected the exchange rate. These results are similar to Amano & Norden (1998) who concluded that oil prices granger-cause exchange rates; however, exchange rates do not granger-cause oil prices in the US, a large country. Several other researchers (see, among others, Beckmann et al., 2020; Bal & Rath, 2015; Brahmairene et al., 2014) had the same discovery. However, one might argue that the causality between oil prices and exchange rates does not exist. Since oil price shocks refer to the increase in oil price quoted in dollar terms, when a country experiences a depreciation, oil prices will indeed increase; however, not in dollar terms but rather in domestic currency terms.

Studies across countries also present a long-run correlation between oil prices and exchange rates. Chen & Chen (2007) and Al Rasasi (2018) studied the G7 countries – Canada, France, Germany, Italy, Japan, the US, and the UK, and they confirmed the long-run relationship between oil prices and the exchange rate. Salisu et al. (2021) investigated the relationship between the BRICS countries and concluded that oil prices can be used to predict the exchange

rate for oil-importing countries – South Africa, China, and India. The same conclusions were made for Russia as an oil exporter.

Before 1971, oil prices were determined by the US government agencies, which then reduced their chance of being vulnerable to international shocks (Kilian, 2014). However, when the US became the net oil importer by 1973, the oil market became a global market. This, according to Killian (2014), resulted in high oil price volatility. Many other underlying factors further contribute to high oil price volatility because of this shift to the global market. Geopolitical tensions result in supply disruptions and tensions among countries like the Russia-Ukraine conflict which caused the supply chain among trading partners to break down. The Ukraine invasion caused oil price hikes and put pressure on the inflation rate (Bednarski et al., 2023; Neethling & Wyk, 2022). Tensions between countries do not only affect countries that are involved but this spills over to other trading partners. This is because, during these conflicts, some countries are prevented from participating in global trade as a form of sanction, therefore, resulting in shortages of supply of some goods.

According to Ebrahim et al. (2014), oil is the most globalised commodity making it subject to price volatilities. The author refers to oil price volatility as the standard deviation of oil prices in a given period. Several studies, including Chatziantoniou et al. (2021), Bourghelle et al. (2021), and Killian (2010) have shown the origins of oil price volatilities and how they affect the macroeconomy. Before 1971, oil prices were determined by the US government agencies, which then reduced their chance of being vulnerable to international shocks (Kilian, 2014). However, when the US became the net oil importer by 1973, the oil market became a global market. This, according to Killian (2014), resulted in high oil price volatility. Ural's (2016) results show that crude oil prices are highly volatile, and they have long-run effects. Many other underlying factors further contribute to high oil price volatility because of this shift to the global market. The key drivers of oil price volatility, which form part of the characteristics of a globalised market include, macroeconomic uncertainty and the price inelasticity of supply and demand for oil. The global disruptions – conflicts, wars, pandemics – especially in the oil-exporting countries threaten the future of trade, thus leading to uncertainties (Miroudot, 2020). Economic uncertainty differs across different shocks that hit the economy. Baker et al. (2020) argues that COVID-19 led to high uncertainties and was similar to the uncertainty caused by

the Great Depression. The effect of oil prices on economic uncertainty is not the same over time (Hailemariam et al., 2019). The authors claim that an increase in oil prices caused a reduction in economic uncertainty before the GFC; however, after the GFC, an increase in oil prices caused an increase in economic uncertainty. Uncertainties and price inelasticity are also vulnerable to geopolitical disturbances and economic speculation (Van Robays, 2016; Ebrahim et al., 2014; Bourghelle et al., 2021).

The recent major economic disturbances include the GFC, and the COVID-19 pandemic influenced oil prices and exchange rates (Turhan et al. 2014; Saidu et al., 2021; Reboredo et al., 2014). The GFC in 2008/2009 led to a reduction in demand, which was due to economic slowdown. This demand reduction led to a reduction in oil prices (Turhan et al., 2014; Saidu et al., 2021). Both Reboredo & Rivera-Castro (2013) and Reboredo et al. (2014) analysed this relationship using wavelet multi-resolution analysis and a detrended cross-correlation approach, respectively; however, they had the same conclusions. Before the GFC, the relationship between oil prices and exchange rates was unclear. However, after the crisis, the negative interrelationship between oil prices and the exchange rate was revealed.

Geopolitical tensions result in supply chain disruptions and tensions among countries like the Russia-Ukraine conflict which caused the supply chain among trading partners to break down. The Ukraine invasion caused oil price hikes and put pressure on the inflation rate (Bednarski et al., 2023; Neethling & Wyk, 2022). When oil-exporting countries experience disruption in their regions, for instance, conflicts and global crises like the COVID-19, this threatens the supply of oil (Priya et al., 2021). The pandemic resulted in trade restrictions as a measure to curb infections, which further resulted in a reduction in oil demand. Reduction in oil demand leads to oil prices reaching negative during the period of the pandemic (Bourghelle et al., 2021). According to Zhang et al. (2009), the GFC also led to a drop in oil prices. The authors argue that countries demand more oil due to the fear of supply disruptions, which introduces expectations as a factor that leads to oil price shocks. If countries or people expect oil prices to increase or there are shortages of supply, they tend to store more oil for future use. Huang et al. (2020) argue that when oil prices are unexpected, their effect on exchange rates tends to be greater than when oil prices are steady. Juvenal & Petrella (2015) refer to this cause as the speculative demand shock. Tensions between countries do not only affect countries that are

involved but this spills over to other trading partners. This is because, during these conflicts, some countries are prevented from participating in global trade as a form of sanction, therefore, resulting in shortages of supply of some goods. The supply and demand shocks caused by the COVID-19 pandemic are also attributes of oil price volatilities during the pandemic era.

Oil price volatility has been proven to have led to an asymmetric response of macroeconomic variables to oil price changes (Ebrahim et al., 2014). They cite Knut Anton Mork (1989), who first validated this asymmetry. They confirm that his findings state that economic activities respond negatively and more to oil price increases. Most studies including Huang et al. (2020) acknowledge the asymmetric effect of oil prices on the exchange rate. The main conclusion is that the effect of oil price increases and oil price decreases on the exchange rate differs. A country cannot expect that if a 10% increase in oil price causes the exchange rate to depreciate by 5%, then it must be that a 10% decrease in oil price will cause a 5% appreciation. Therefore, in estimating the effect of oil prices on the exchange rate, oil price shocks are decomposed into positive shocks (increase in oil prices) and negative shocks (decrease in oil prices). Doing so allows the study to further address its second objective, as it will show the effect each oil price shock has on the exchange rate. Saudi et al. (2021); Kisswani et al. (2018); Baek & Choi (2021) and Baek & Kim (2020) found a long-run asymmetry in Ghana, Côte d'Ivoire and Senegal; Malaysia, and Indonesia. The authors, Saudi et al. (2021) and Kisswani et al. (2018) also found a long-run symmetric effect in South Africa, Kenya, Morocco, the Philippines, Singapore, and Thailand. Using the symmetric and asymmetric cointegration test and the error-correction model, Ngoma et al. (2016) confirm the long-run symmetry in South Africa and the long-run asymmetry in Ghana. However, in their research both these countries were explained as oil-exporting countries. Therefore, it is crucial to account for the symmetry of oil prices when studying its relationship with other macroeconomic variables as it might lead to bias and misleading results (Ural, 2016).

According to Yang et al. (2023), when oil prices change, negative shocks impact outweigh positive shocks; however, the magnitude is unknown. This may result from the inflationary pressures that the domestic country faces when oil prices increase, whereas, when the price falls, it is not fully felt as the country still faces many other economic challenges apart from the relief of oil prices. Without the government's knowledge of this phenomenon, it may result

in unnecessary policies and overspending as a measure of protecting the country's economy. This study will therefore contribute to this literature by further analysing how exchange rates respond to oil price volatilities in South Africa.

According to the IEA (2021), oil consumption has increased worldwide. During the international conflict, most countries fear the disruption of oil supply, hence, they demand more oil imports, which in turn increases oil prices (Barsky & Killian, 2002; Killian, 2014). An increase in a country's production requires an increase in energy consumption, this is due to the increase in demand for factors like transportation. Hence, oil prices will increase if the demand for oil increases while the supply remains constant. An increase in GDP, all else equal, will result in an increase in oil prices (Beckmann et al., 2020). However, technological advancements can lead to oil price decreases even if the GDP is increasing. Oil alternatives such as coal or solar power can reduce the oil demand, thus reducing oil prices. This argument attests to the argument made by Nzimande & Msomi (2016). They argue that South Africa is less vulnerable to positive oil price shocks (increase) due to its reliance on coal. However, evidence shows that South Africa has been hit by recent oil price shocks (Yildiz et al., 2021). Recent oil price shocks are primarily driven by the increased global demand (Juvenal & Petrella, 2015).

The extent to which the currency depreciates also depends on the elasticity of demand for imports (Salehi-Isfahani, 1989). The elasticity of demand for imports refers to the responsiveness of the countries' import volumes to changes in their import prices. The demand for imports is said to be elastic (inelastic) if the import good demand changes by more (less) than the change in prices (Kin & Courage, 2014). The authors argue that exchange rates respond stronger to oil price increases if domestic demand responds less to changes in prices. For instance, an increase (decrease) in oil prices will cause the oil-importing country's currency to depreciate (appreciate) if demand for import is inelastic (elastic). Ziramba (2010) found the import demand price elasticity to be -0.147, indicating that Crude oil demand in South Africa is price inelastic. This supports the argument made by Kin & Courage (2014), that is, since South Africa is an oil-importing country, we expect their currency to depreciate when oil prices increase.

There has been a great debate on how oil prices affect a country's growth and how each oil price shock affects a country's growth. The effect of oil prices on a country's economic growth depends on whether there is an increase or a decrease in oil prices. An increase in oil prices slows down economic activities and aggregate supply, which further reduces productivity (Ftiti et al., 2016). Gbatu et al. (2017) argue that a negative oil price shock does not have a significant effect on a small oil-importing country, Liberia, and this is due to increased corruption. Furthermore, Charfeddine et al. (2020) attest to this as they conclude that the effect that negative oil price shocks have on the GDP is limited to certain periods. In the South African case, Essama-Nssah et al. (2007) show that an increase in oil prices increases the disparity between the rich and the poor. Positive oil price shocks increase the South African unemployment rate, GDP, and household consumption. High-skilled households benefit, while low and medium-skilled households (service sector) are left worse off. The pass-through of the effect of oil prices is through exchange rate transmissions.

Exchange rate pass-through (ERPT) refers to the responsiveness of domestic prices to changes in the exchange rates (Kabundi & Mbelu, 2018). The authors identify two stages of the ERPT, the first stage being the responsiveness of import prices to changes in the exchange rate, and the second stage being the responsiveness of domestic goods prices to changes in import prices. Ding et al. (2023) prove how the ERPT plays a mediating role between oil prices and the inflation rate. Several authors (mentioned above) have proven how a change in oil prices will result in a change in the exchange rate; however, since some domestic goods are produced using imported goods it is expected that a change in oil prices will affect the domestic inflation rate through increased production cost. An increase in oil prices will result in a depreciation of an oil-importing country. Akinsola & Adhiambo (2020) argue that this results in an increase in the price of imported goods, making it expensive to purchase goods from other countries. According to Mert (2018), producers seek to maximise their profits while minimising their costs, while doing so, they tend to pass on their costs to consumers through price increases thus inflation rate increase (Jongwanich et al., 2019). This proves how oil prices can lead to a higher domestic inflation rate. However, Balcilar et al. (2018) argue that the ERPT to inflation rate in South Africa is incomplete. Thus, this might imply that changes in the country's inflation rate after an increase in oil prices may not fully reflect the effect of oil prices.

Real interest rate differentials between countries also play an important role in determining the country's real exchange rate. Therefore, they can determine the extent to which oil prices affect the exchange rate (Chen & Chen, 2007). A higher domestic interest rate means greater returns, thus resulting in capital inflows (Haque et al., 1997). An increase in capital flows results in an increase in demand for domestic currency since investors need to convert their money holdings to domestic currency. This mechanism, therefore, results in an appreciation of the domestic currency. High oil prices result in a depreciation of the oil-importing country's currency (Qiang et al., 2019). However, in response, monetary authorities can increase interest rates, which will result in currency appreciation (Hnatkowska et al., 2013). Hence, in examining the effect of oil prices on exchange rates, it is essential to also look at other factors contributing to the change in exchange rate so that the results are not overestimated or underestimated. This includes considering the different exchange rate regimes as it is argued that to some extent, they also play a significant role in determining the nature of the relationship between oil prices and the exchange rate. Huang et al. (2020) contest this as they use four major exchange rates of currencies included in the Special Drawing Rights against the US dollar – Japanese Yen, Euro, Chinese Yuan, and the British Pound. They conclude that for markets under the floating exchange rate regime, unexpected oil price decreases may have a huge influence on the exchange rate. Many authors, including Al-Abri (2014), Kakanov et al. (2018), and Habib & Strasky (2008) have supported the claim that a fixed exchange rate regime is the optimal regime for oil-exporting countries when oil prices are increasing. By fixing their currency to a stable currency like the dollar, oil-exporting countries are less vulnerable to oil price fluctuations. Fixed exchange rates ensure stability, which, therefore, results in an increase in investment (Frankel, 2003).

There exist different definitions of the real exchange rate; Grennes (2018) defines it as the price ratio of tradeable and non-tradeable goods. However, some authors, Coughlin & Koedijk (1990), define real exchange rate as the price of one country's currency expressed against another country's currency multiplied by the ratio of the price level. It is considered the more reliable exchange rate compared to the nominal exchange rate, which shows the amount of domestic currency required to acquire foreign currency. This is because the real exchange rate guides the allocation of domestic and foreign goods in the domestic country (Takaendesa, 2006). However, the study will use the nominal effective exchange rate since it shows how the amount of dollars required changes when oil prices change. There are several factors that affect

the South African nominal exchange rate which may need to be studied since they may influence the underlying relationship that this study aims to reveal.

In February 2000, South Africa adopted the free-floating exchange rate regime – that is, the South African exchange rate is determined by the market forces of demand and supply - as one of the measures to target the inflation rate (Boateng et al., 2020). Dubas (2009) argued that developing countries would benefit under a floating exchange rate regime as it would prevent exchange rate misalignments. However, according to some studies by Miyajima (2020) and Aron et al. (1997), the floating exchange rate in South Africa resulted in high exchange rate volatility. Among the emerging and advanced economies, the rand is the most volatile. South African rand acts as a shock absorber (Miyajima 2020); hence, it is subject to foreign and domestic distractions.

Turning the focus to South Africa, the country is one of the most industrialised and developing economies in Africa (Udi, 2020; Schneider, 2000). As an industrialised country, it is highly dependent on energy. Most of its energy supply comes from coal, accounting 71% of the total energy sources (Scholvin, 2014). After 1994, the country experienced an increase in crude oil demand and consumption. In 2000, crude oil demand accounted for 17% of energy demand, following 70% of coal demand (Ziramba, 2010). One of the reasons that led to an increase in crude oil consumption includes the economic development the country has experienced recently (Ziramba, 2015). The increase in consumption also stems from the different uses of crude oil. According to the Petroleum Industry Quarterly Review of 2024: Q1 and Wabiri & Amusa (2010), there has been an increase in the consumption of petroleum products, including petrol and diesel – for transportation and the mining sector - in recent quarters. South Africa's oil consumption accounts for almost a quarter of Africa's total oil consumption (Wabiri & Amusa, 2010). Evidence shows that this increase in oil consumption has a positive impact on South African economic growth in the long run (Lin & Wesseh, 2014; Ziramba, 2015). Oil consumption allows for economic activities to take place, which in turn leads to an improvement in the country's GDP (Odhiambo, 2023). The South African Petroleum Industry Association (SAIPA) argued that the oil industry in South Africa has contributed to job creation and capital investment in 2019.

According to the Department of Minerals and Energy (2006) cited in Ziramba (2010), oil in South Africa is scarce; hence, about 95% of its crude oil demand is imported from the Middle East and Africa. In 2022, South Africa imported \$4.34B of Crude Oil and exported \$108M. This proves that South Africa does produce oil; however, it is unable to produce enough to settle domestic Crude Oil demand. South Africa has four Crude Oil refineries Natref, Enref, Sapref, and Calref (Bergh, 2012). The primary countries that these refineries import oil from include Nigeria, Saudi Arabia, the Republic of Congo, Angola, Ghana, and Iran. Even though most of these countries are African countries, when South Africa imports Crude Oil, they use the US dollar since the oil price is quoted in dollars. Therefore, despite the positive impact that oil consumption has in South Africa, it is still vulnerable to oil price shocks from foreign countries. For instance, political tension in oil-exporting countries can lead to a reduced supply of oil, thus affecting South Africa's access to oil (Mohaddes & Pesaran, 2016). In 2019, Saudi Arabia experienced an attack on their oil plant, which led to an increase in oil prices (Krauss & Reed, 2019). When oil prices increase, the South African Rand loses its value as more Rands are required to purchase oil (Kin & Courage, 2014).

South Africa imports crude oil and other petroleum products; however, its reliance on crude oil is 20%, which is less than its dependence on coal (71%) although it is used more than coal (Ziramba, 2010). This confirms the argument made by Nzimande & Msomi (2016). Even if that is the case, evidence shows how the South African rand was affected as oil prices surged after the Ukraine and Russia war in 2022. In 2022, crude oil prices peaked at \$122.72 in June, and the rand/dollar exchange rate depreciated to and peaked at R18.12 per dollar in October, (South African Energy Price Report, 2023). Miyajima (2020) looked at core and headline inflation rate in South Africa and concluded that fuel prices are the most volatile and are affected by oil prices and exchange rates.

Given the increase in the consumption of oil in the country, several studies, including Holtsmark (2003), Solaymani (2021), and Bergstrom (1982) have presented how the state might intervene to ensure that the pass-through of changes in oil prices does not severely affect the country. Furthermore, according to the Helen Suzman Foundation (2024), the usage of oil is one of the major causes of water pollution in South Africa which calls for government

intervention. The states intervene by regulating the market through price controls – taxes and subsidies - environmental regulation and trade policies. Although these regulations aim to ensure efficiency in the oil market and environmental quality, they vary across countries and regions. Oil prices are usually subsidised in oil-exporting countries like Iran and Malaysia Solaymami (2021), and this results in inefficiencies and an increase in consumption. However, recently, as per the Paris Climate Agreement, most countries, including Iran, have resorted to reducing subsidies. Reducing subsidies makes it expensive to produce oil for oil producers, thus increasing the price of oil and further reducing consumption.

To import crude oil, South African companies need to hold a permit issued by the International Trade Association Commission (ITAC); furthermore, only licensed manufacturers may apply for the permit (Department of Minerals and Energy, 2006). This controls the level of crude oil imported to the country. Since South Africa use most of its imported crude oil to produce fuel, Ziramba (2010) states that to control consumption, the South African government imposes taxes and levies on fuel. Evidence shows that most of the South African government's subsidy on fuel goes to oil and gas consumption (Geddes & Schmidt, 2024). However, the implications of this phenomenon are unfavourable. Since oil is crucial for production and manufacturing, changes in oil prices, according to Chitiga et al. (2012) will influence the country's income distribution and poverty status. Subsidising oil prices reduces the price of oil, which might increase volumes of oil imports, thus pressuring the currency to depreciate. This, therefore, is proven to increase the number of people living below the poverty line and further benefit the wealthier more (Solarin, 2022).

Amidst the effects of oil prices mentioned above, Gbatu et al. (2017) reveal how substitution between oil and other energy supply factors may neutralize the impact of oil prices. When oil prices increase, resources are reallocated from energy-intensive to less energy-intensive production processes – labour-intensive production processes - due to the increase in energy costs. Although this results in high unemployment rates, it is believed that it reduces production costs. When oil prices increase, South Africa may move towards using coal (Chitiga et al., 2012).

Several authors have stressed how interest rate differentials between South Africa and its trading partners affect the South African exchange rate (Raputsoane & Todani, 2009). Musa et al. (2021) found a long-run relationship between the exchange rate and interest rate differential in South Africa. They further reveal that the South African exchange rate responds asymmetrically to changes in interest rate differential. A positive interest rate differential means that the South African interest rate is greater than that of the foreign country. Therefore, this leads to the Rand gaining value – (that is, appreciation).

The difference between the price levels of the two trading countries also influences the exchange rate. A high level of inflation rate in South Africa relative to its trading partner reduces its competitiveness in exports since it increases export prices, resulting in a depreciation. The theory that explains the relationship between the exchange rates and price levels of two countries is referred to as the Purchasing Power Parity (PPP) (Vo & Vo, 2023). The theory suggests that the purchasing power of one unit of a country's currency should be equal to that of the foreign currency when it has been converted (Taylor, 2003). Hence, the PPP in the context of the oil market requires that oil prices should be the same across countries after considering currency differences.

As a small oil-importing country, oil price fluctuations leave South Africa worse-off. Moreover, the value of the rand relative to the value of the dollar is weak (according to statistics, the dollar is usually stronger than the rand. Therefore, due to the share of their oil consumption, when oil prices increase, the South African economy is negatively affected (Chitiga et al., 2012; Kin & Courage, 2014). This is seen by a reduction in GDP since import bills increase, and the capital account worsens. Both the rich and the poor South Africans are affected by an increase in the cost of living and an increase in transportation costs, respectively (Nkomo, 2006; Fofana et al., 2009).

In March 2020, South Africa recorded its first case of COVID-19, by that time, in some countries, the pandemic had already spread. This means that they had already implemented some measures to minimise the spread, including closing their borders. Trade slowed down because of the pandemic (Arndt et al., 2020). Due to global businesses shutting down, global

supply chains were disrupted (see Villarreal-Samaniego 2020); as there was a reduction in the demand, which then resulted in the depreciation of the South African Rand while oil prices dropped below \$0. In July 2012, the United States imposed sanctions on Iran, one of the major oil suppliers – 98 000 barrels per day to South Africa (Habibi, 2013; Daly, 2012). Sanctions on Iran disrupted the supply of oil, hence, putting upward pressure on oil prices (Katzman, 2015). This resulted in South Africa reducing its imports from Iran and finding other alternative suppliers. Hence, there exists a spillover effect from foreign countries where South African oil-dependence sectors are affected by reduced oil supply.

In summary, the study of the relationship between oil prices and exchange rates has conflicting conclusions. The effect of oil prices on the exchange rate is also reflected in the economic state. However, there is no consensus regarding the extent to which oil prices affect the exchange rates in South Africa. Hence, this study aims to estimate whether oil prices asymmetrically affect the exchange rate in South Africa.

## **CHAPTER 3: METHODOLOGY**

### **3.1 Economic Framework**

When prices of goods increase, producers of those goods tend to benefit through an increase in their revenues (Phillips, 2021). The case is the same in the crude oil market when the price of oil increases, oil producers experience an increase in their revenues. At the country level, oil-exporting countries experience an increase in the value of their currencies due to an increase in their demand. Thus, in the foreign exchange market, this leads to an appreciation of the oil-exporting country's currency. Concurrently, the currency of oil-importing countries experiences a decline in its value, thus a depreciation. The Mundell-Fleming model suggests that slight differences between foreign and domestic interest rates result in massive capital flows which alters the exchange rate (Hossain & Chowdhury, 1998). When the country experiences a depreciation due to increased oil prices, in the money market, investors look for better returns in foreign countries' financial markets, thus resulting in capital outflows. To respond to this, the central bank might increase the interest rate to attract investors. Higher interest rates result in capital inflows, which results in an increase in demand for domestic currency, thus causing the currency to appreciate (Hnatkovska et al., 2013).

### **3.2 Estimating Technique**

In addressing this study's research questions, the method used is the structural vector autoregressive model (SVAR) drawn from the work of Chen et al. (2016).

#### **3.2.1 Vector Autoregressive Model (VAR)**

Prior to estimating the SVAR model, the VAR model, also known as the reduced form VAR, should be estimated. Sims (1980) introduced the VAR model for time series data analysis, capturing bi-directional cointegration by analysing variables' present values based on their previous values and other variables. In this model, all variables are treated as endogenous. The VAR model is widely used and helps summarise and analyse the dynamic relationship between the variables under investigation (Rebucci, 2010). To observe how variables respond if there is a shock in an error term – other factors affecting the dependent variable not included in the model – impulse responses and variance decompositions are used to further interpret the VAR model.

Given a VAR model of order p, where p is the number of lags, including k variables, it can be presented as:

$$Y_t = \beta_0 + \sum_{i=1}^p \beta_i Y_{t-i} + \varepsilon_t \quad (1)$$

where  $\beta_0$  is a constant,  $Y_t$  is the dependent variable, t refers to the current period,  $\beta_i$  refers to the dependent variable's first lag parameter, that is,  $Y_{t-1}$  multiplier and  $\varepsilon_t$  refers to the error term.

The VAR model can also be written in matrix form, that is:

$$\mathbf{x}_t = \mathbf{F}\mathbf{x}_{t-1} + \boldsymbol{\varepsilon}_t \quad (2)$$

where  $\mathbf{F}$  is a matrix of parameters. The reduced form VAR can also be written in a matrix form shown below,

$$\begin{bmatrix} op_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \begin{bmatrix} op_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{op_t} \\ \varepsilon_{neer_t} \\ \varepsilon_{ird_t} \end{bmatrix} \quad (3)$$

$$\begin{bmatrix} op^-_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \hat{f}_{11} & \hat{f}_{12} & \hat{f}_{13} \\ \hat{f}_{21} & \hat{f}_{22} & \hat{f}_{23} \\ \hat{f}_{31} & \hat{f}_{32} & \hat{f}_{33} \end{bmatrix} \begin{bmatrix} op^-_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{op^-_t} \\ \varepsilon_{neer_t} \\ \varepsilon_{ird_t} \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} op^+_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \check{f}_{11} & \check{f}_{12} & \check{f}_{13} \\ \check{f}_{21} & \check{f}_{22} & \check{f}_{23} \\ \check{f}_{31} & \check{f}_{32} & \check{f}_{33} \end{bmatrix} \begin{bmatrix} op^+_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{op^+_t} \\ \varepsilon_{neer_t} \\ \varepsilon_{ird_t} \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} op^-_t \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \hat{f}_{11} & \hat{f}_{12} & \hat{f}_{13} & \hat{f}_{14} \\ \hat{f}_{21} & \hat{f}_{22} & \hat{f}_{23} & \hat{f}_{24} \\ \hat{f}_{31} & \hat{f}_{32} & \hat{f}_{33} & \hat{f}_{34} \\ \hat{f}_{41} & \hat{f}_{42} & \hat{f}_{43} & \hat{f}_{44} \end{bmatrix} \begin{bmatrix} op^-_{t-1} \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{op^-_t} \\ \varepsilon_{opv_t} \\ \varepsilon_{neer_t} \\ \varepsilon_{ird_t} \end{bmatrix} \quad (6)$$

$$\begin{bmatrix} op^+_t \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \check{f}_{11} & \check{f}_{12} & \check{f}_{13} & \check{f}_{14} \\ \check{f}_{21} & \check{f}_{22} & \check{f}_{23} & \check{f}_{24} \\ \check{f}_{31} & \check{f}_{32} & \check{f}_{33} & \check{f}_{34} \\ \check{f}_{41} & \check{f}_{42} & \check{f}_{43} & \check{f}_{44} \end{bmatrix} \begin{bmatrix} op^+_{t-1} \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{op^+_t} \\ \varepsilon_{opv_t} \\ \varepsilon_{neer_t} \\ \varepsilon_{ird_t} \end{bmatrix} \quad (7)$$

where  $op_t$ ,  $op^-_t$ ,  $op^+_t$  represents the world oil price, the negative oil price shock, and the positive oil price shock, respectively.  $opv_t$  represents oil price volatility,  $neer_t$  represents the South African nominal effective exchange rate, while  $ird_t$  represents the interest rate differential between South Africa and the United States.

Since South Africa is a small oil-importing country, oil prices are exogenous. This simply means that only changes in oil prices can affect the value of the rand, changes in the value of the rand will not affect the global oil price.

The reduced form VAR model has limitations, one of those limitations is the inability to observe where the shock originates from since  $\epsilon_t$  is a combination of  $\epsilon neer_t$ ,  $\epsilon op_t$ ,  $\epsilon op^-_t$ ,  $\epsilon op^+_t$  and  $\epsilon ird_t$ . This is known as the identification problem (Gottschalk, 2001). Each represents the error term in the nominal exchange rate equation, negative oil price shock equation and the interest rate equation, respectively. Therefore, to tackle this problem the model is extended to a structural vector autoregressive model (SVAR).

### 3.2.2 Structural Vector Autoregressive Model (SVAR)

The SVAR model estimates the dependent variable by imposing restrictions on the parameters, which are supported by economic theory (Akram, 2009). This is motivated by the belief that macroeconomic variables do not respond to a shock similarly. The model solves the identification problem by identifying the true structure of the economy, this involves ordering the structural shocks in a manner that tends to affect the dependent variable. Some variables respond to a shock with a lag or simultaneously. Lutkepohl (2010) supports SVAR as he states that identifying restrictions is important to discover the unique impulses of interest that represent the true response of the system to shocks. Chisadza et al. (2016) argued that the SVAR assists in estimating contemporaneous shocks of one variable on another variable.

The SVAR model is written as:

$$\mathbf{A}x_t = \mathbf{B}x_{t-1} + u_t \quad (8)$$

where  $\mathbf{A}$  and  $\mathbf{B}$  are  $(k \times k)$  matrix of coefficients, where  $k$  is the number of variables,  $\mathbf{A}$  captures the contemporaneous relationship between the other variables,  $\mathbf{B}$  is a matrix of parameters,  $x_t$  is a  $(k \times 1)$  vector, and  $\epsilon_t$  is also a  $(k \times 1)$  vector of the error terms.

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} op_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} op_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (9)$$

$$\begin{bmatrix} \dot{a}_{11} & \dot{a}_{12} & \dot{a}_{13} \\ \dot{a}_{21} & \dot{a}_{22} & \dot{a}_{23} \\ \dot{a}_{31} & \dot{a}_{32} & \dot{a}_{33} \end{bmatrix} \begin{bmatrix} op_t^- \\ neer_t^- \\ ird_t^- \end{bmatrix} = \begin{bmatrix} \dot{b}_{11} & \dot{b}_{12} & \dot{b}_{13} \\ \dot{b}_{21} & \dot{b}_{22} & \dot{b}_{23} \\ \dot{b}_{31} & \dot{b}_{32} & \dot{b}_{33} \end{bmatrix} \begin{bmatrix} op_{t-1}^- \\ neer_{t-1}^- \\ ird_{t-1}^- \end{bmatrix} + \begin{bmatrix} uop_t^- \\ uneer_t^- \\ uird_t^- \end{bmatrix} \quad (10)$$

$$\begin{bmatrix} \ddot{a}_{11} & \ddot{a}_{12} & \ddot{a}_{13} \\ \ddot{a}_{21} & \ddot{a}_{22} & \ddot{a}_{23} \\ \ddot{a}_{31} & \ddot{a}_{32} & \ddot{a}_{33} \end{bmatrix} \begin{bmatrix} op_t^+ \\ neer_t^+ \\ ird_t^+ \end{bmatrix} = \begin{bmatrix} \ddot{b}_{11} & \ddot{b}_{12} & \ddot{b}_{13} \\ \ddot{b}_{21} & \ddot{b}_{22} & \ddot{b}_{23} \\ \ddot{b}_{31} & \ddot{b}_{32} & \ddot{b}_{33} \end{bmatrix} \begin{bmatrix} op_{t-1}^+ \\ neer_{t-1}^+ \\ ird_{t-1}^+ \end{bmatrix} + \begin{bmatrix} uop_t^+ \\ uneer_t^+ \\ uird_t^+ \end{bmatrix} \quad (11)$$

$$\begin{bmatrix} \hat{a}_{11} & \hat{a}_{12} & \hat{a}_{13} & \hat{f}_{14} \\ \hat{a}_{21} & \hat{a}_{22} & \hat{a}_{23} & \hat{a}_{24} \\ \hat{a}_{31} & \hat{a}_{32} & \hat{a}_{33} & \hat{a}_{34} \\ \hat{a}_{41} & \hat{a}_{42} & \hat{a}_{43} & \hat{a}_{44} \end{bmatrix} \begin{bmatrix} op_t^- \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \hat{b}_{11} & \hat{b}_{12} & \hat{b}_{13} & \hat{b}_{14} \\ \hat{b}_{21} & \hat{b}_{22} & \hat{b}_{23} & \hat{b}_{24} \\ \hat{b}_{31} & \hat{b}_{32} & \hat{b}_{33} & \hat{b}_{34} \\ \hat{b}_{41} & \hat{b}_{42} & \hat{b}_{43} & \hat{b}_{44} \end{bmatrix} \begin{bmatrix} op_{t-1}^- \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^- \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} \check{a}_{11} & \check{a}_{12} & \check{a}_{13} & \check{a}_{14} \\ \check{a}_{21} & \check{a}_{22} & \check{a}_{23} & \check{a}_{24} \\ \check{a}_{31} & \check{a}_{32} & \check{a}_{33} & \check{a}_{34} \\ \check{a}_{41} & \check{a}_{42} & \check{a}_{43} & \check{a}_{44} \end{bmatrix} \begin{bmatrix} op_t^+ \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \check{b}_{11} & \check{b}_{12} & \check{b}_{13} & \check{b}_{14} \\ \check{b}_{21} & \check{b}_{22} & \check{b}_{23} & \check{b}_{24} \\ \check{b}_{31} & \check{b}_{32} & \check{b}_{33} & \check{b}_{34} \\ \check{b}_{41} & \check{b}_{42} & \check{b}_{43} & \check{b}_{44} \end{bmatrix} \begin{bmatrix} op_{t-1}^+ \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^+ \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (13)$$

The ordering of the variables is supported by the theoretical framework. Firstly, according to Saidu et al. (2021), changes in the world price of oil affect the South African exchange rate, and the interest rate (Gupta & Kotze, 2017). Secondly, some studies have found the existence of a bi-directional causal relationship between interest rates and exchange rates in some countries (Liu & Lee, 2022; Kayhan et al., 2013). However, this study follows the work of Ndlovu & Ndlovu (2024) where exchange rates are found to affect interest rates. Lastly, both the exchange rate and interest rates do not affect the world prices of oil, and this is the case because, as emphasized, South Africa is a small oil-importing country.

These matrix equations (see for instance equation 9) can also be written as systems of linear equations as follows:

$$a_{11}op_t + a_{12}neer_t + a_{13}ird_t = b_{11}op_{t-1} + b_{12}neer_{t-1} + b_{13}ird_{t-1} + uop_t \quad (14)$$

This structure of the model introduces endogeneity, where the dependent variable is correlated with the error term, in equation (14),  $(COV(neer_t, uop_t) \neq 0)$ . Therefore, the contemporaneous

dependence of  $neer_t$  on  $uop_t$  is removed by pre-multiplying both sides of equation 8 by  $A^{-1}$  (the inverse of the  $A$  matrix), as shown by equation 11 below.

$$A^{-1}Ax_t = A^{-1}Bx_{t-1} + A^{-1}u_t \quad (15)$$

This equation therefore reduces to the reduced form VAR:

$$x_t = Fx_{t-1} + \varepsilon_t \quad (16)$$

The reduced form residuals:

$$\varepsilon_t = A^{-1}u_t \quad (17)$$

Restrictions are then imposed on the reduced form VAR residuals based on the theory, such that:

$$\varepsilon_t = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix} \begin{bmatrix} uop_t^- \\ uneer_t \\ uird_t \end{bmatrix} \quad (18)$$

$$\begin{bmatrix} op_t \\ neer_t \\ ird_t \end{bmatrix} = F(x) \begin{bmatrix} 1 & 0 & 0 \\ a_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} uop_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (19)$$

The zero restrictions imply the absence of a contemporaneous effect of shocks on the dependent variable. An increase in oil prices results in an increase in the price of other goods and services. However, this mechanism runs from a change in the exchange rate, therefore, this creates a lag between changes in oil prices and the inflation rate. Since the central bank uses the interest rate to control the effects of oil prices on inflation, it is expected that interest rates will respond with a lag to oil prices (Balcilar et al., 2018). This mechanism is represented by the zero in the third row, first column. Exchange rates (interest rate) do not respond simultaneously to interest rate shocks (exchange rate shock) (Omolade et al., 2019). The first case is represented by the zero restriction in the second row, third column, while the second case is represented by the zero restriction in the third row, second column. Real exchange rate and interest rate differential do not affect the world price of oil, while oil price shocks affect exchange rates simultaneously. The same restrictions are applied in the negative and positive oil price shock equations.

To examine the asymmetry of oil prices, the model further allows the study to compile impulse responses and forecast error variance decomposition (FEVD). The impulse response observes how a variable behaves given a shock in one variable, whereas the FEVD observes how a

variable varies given a shock in one of the variables. According to Lutkepohl (2010), impulse responses are suggested as mechanisms to interpret the VAR model since it is difficult to directly observe the relationship between variables from matrices. Therefore, they will show whether the exchange rate responded similarly to positive oil price shocks and negative oil price shocks.

### 3.2.3 Stationarity

Stavarek (2015) and Cellini & Cuccia (2011) argue that exchange rates suffer from seasonality and cyclical components, and this tends to overestimate or underestimate the nature of the variables. Therefore, to deal with this, the study employs the stationarity test, which is consistent with the work of many scholars (Chen & Chen, 2007; Kumar, 2019, and Fasanya et al., 2022). The stationarity test is an essential test to conduct when analysing time series data (Ali et al. 2015). The test simply means that the statistical properties generating the time series do not change over time and they do not depend on the specific time at which they are observed (Palachy, 2019). A stationary time series has a constant mean, constant variance, and autocorrelation (Milionis, 2004). This ensures unbiased and consistent estimates. The different tests that are used to do stationarity testing include the Augmented Dickey-Fuller (ADF) test Dickey & Fuller (1981), the Phillips Perron test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test (1992). These methods test whether the variance of the time series is zero (Kwiatkowski et al., 1992), and whether there is a presence of unit root (Dickey & Fuller, 1981). For the first two tests, the null hypothesis of unit root is rejected if test statistic values – quantifies how much your sample diverges from the null hypothesis - are less than the critical values – threshold of significant values, therefore conclude that the series is stationary. The KPSS test rejects the null hypothesis of zero variance – stationary- if the test statistic is greater than the critical values, then conclude that the series is not stationary. A non-stationary time series is then differenced to obtain its stationary state. Some authors oppose differencing data to make it stationary because they argue that it might eliminate any long-term relationships between the relevant variables (Beard et al., 2019; Hossain et al., 2019). They refer to this as over-differencing, and Elmesmari et al. (2022) argue that it might increase the variance. According to Ca'Zorzi et al. (2007), if there is a cointegrating link between the variables, using a first differenced VAR model is likely to provide findings that are inaccurately described.

### 3.2.4 Cointegration

A cointegration test is used in statistical analysis to test whether two or more time series are cointegrated. Cointegration between two or more variables indicates whether there are and how many long-term relationships between variables, and that is shown by the linear equation. The different methods that can be applied to test for cointegration include the Johansen test, the Engle-Granger test, and the bound test. The Johansen test includes the maximum eigenvalue test and trace test which both indicate the number of long-term relationships. Given that the variables are cointegrated, causality will be further tested using the Granger causality test. This is because the theory suggests a bi-directional relationship between oil prices and exchange rates, (Beckmann et al., 2020; Jahan-Parvar & Mohammadi, 2011; Chen & Chen, 2007 Al Rasasi, 2018).

### 3.3 Model Specification

Several authors have argued that most macroeconomic variables respond symmetrically to changes in oil prices (Saidu et al., 2021; Huang et al., 2020; Kisswani et al., 2018). Therefore, to account for this symmetric response, the study aims to estimate the dynamics between oil prices and exchange rates; in doing so, it seeks to examine whether exchange rates respond symmetrically to oil price shocks. Since positive oil price shocks are said to affect the exchange rate differently from negative oil price shocks, the study, therefore, decomposes oil prices into these two sets of categories. It further includes the volatility of oil prices, to see how it affects the exchange rate. Since the study is based on a small economy, oil prices are exogenous. The model is specified (in matrix form and linear equation) as follows:

$$\begin{bmatrix} op_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \begin{bmatrix} op_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix} \begin{bmatrix} uop_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (20)$$

$$neer_t = f_{11}op_{t-1} + f_{12}neer_{t-1} + f_{13}ird_{t-1} + a_{21}uop_t + a_{22}uneer_t \quad (21)$$

$$\begin{bmatrix} op^-_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \dot{f}_{11} & \dot{f}_{12} & \dot{f}_{13} \\ \dot{f}_{21} & \dot{f}_{22} & \dot{f}_{23} \\ \dot{f}_{31} & \dot{f}_{32} & \dot{f}_{33} \end{bmatrix} \begin{bmatrix} op^-_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \dot{a}_{11} & 0 & 0 \\ \dot{a}_{21} & \dot{a}_{22} & 0 \\ 0 & 0 & \dot{a}_{33} \end{bmatrix} \begin{bmatrix} uop^-_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (22)$$

$$neer_t = \dot{f}_{11}op^-_{t-1} + \dot{f}_{12}neer_{t-1} + \dot{f}_{13}ird_{t-1} + \dot{a}_{21}uop^-_t + \dot{a}_{22}uneer_t \quad (23)$$

$$\begin{bmatrix} op^+_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \ddot{f}_{11} & \ddot{f}_{12} & \ddot{f}_{13} \\ \ddot{f}_{21} & \ddot{f}_{22} & \ddot{f}_{23} \\ \ddot{f}_{31} & \ddot{f}_{32} & \ddot{f}_{33} \end{bmatrix} \begin{bmatrix} op^+_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \ddot{a}_{11} & 0 & 0 \\ \ddot{a}_{21} & \ddot{a}_{22} & 0 \\ 0 & 0 & \ddot{a}_{33} \end{bmatrix} \begin{bmatrix} uop^+_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (24)$$

$$neer_t = \ddot{f}_{11}op^+_{t-1} + \ddot{f}_{12}neer_{t-1} + \ddot{f}_{13}ird_{t-1} + \ddot{a}_{21}uop^+_t + \ddot{a}_{22}uneer_t \quad (25)$$

$$\begin{bmatrix} op^-_t \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \hat{f}_{11} & \hat{f}_{12} & \hat{f}_{13} & \hat{f}_{14} \\ \hat{f}_{21} & \hat{f}_{22} & \hat{f}_{23} & \hat{f}_{24} \\ \hat{f}_{31} & \hat{f}_{32} & \hat{f}_{33} & \hat{f}_{34} \\ \hat{f}_{41} & \hat{f}_{42} & \hat{f}_{43} & \hat{f}_{44} \end{bmatrix} \begin{bmatrix} op^-_{t-1} \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \hat{a}_{11} & 0 & 0 & 0 \\ \hat{a}_{21} & \hat{a}_{22} & 0 & 0 \\ \hat{a}_{31} & 0 & \hat{a}_{33} & 0 \\ 0 & 0 & 0 & \hat{a}_{44} \end{bmatrix} \begin{bmatrix} uop^-_t \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (26)$$

$$neer_t = \hat{f}_{31}op^-_{t-1} + \hat{f}_{32}opv_{t-1} + \hat{f}_{33}neer_{t-1} + \hat{f}_{34}ird_{t-1} + uneer_t \quad (27)$$

$$\begin{bmatrix} op^+_t \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \check{f}_{11} & \check{f}_{12} & \check{f}_{13} & \check{f}_{14} \\ \check{f}_{21} & \check{f}_{22} & \check{f}_{23} & \check{f}_{24} \\ \check{f}_{31} & \check{f}_{32} & \check{f}_{33} & \check{f}_{34} \\ \check{f}_{41} & \check{f}_{42} & \check{f}_{43} & \check{f}_{44} \end{bmatrix} \begin{bmatrix} op^+_{t-1} \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} \check{a}_{11} & 0 & 0 & 0 \\ \check{a}_{21} & \check{a}_{22} & 0 & 0 \\ \check{a}_{31} & 0 & \check{a}_{33} & 0 \\ 0 & 0 & 0 & \check{a}_{44} \end{bmatrix} \begin{bmatrix} uop^+_t \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (28)$$

$$neer_t = \check{f}_{31}op^+_{t-1} + \check{f}_{32}opv_{t-1} + \check{f}_{33}neer_{t-1} + \check{f}_{34}ird_{t-1} + uneer_t \quad (29)$$

The literature introduces the wealth effect, which illustrates that when oil prices increase (decrease), the oil-importing country's currency depreciates (appreciates). Therefore, this implies that  $\ddot{f}_{11}$  and  $\hat{f}_{11}$  should be both positive, indicating a positive relationship between both the positive and the negative oil price shock and the exchange rate. Furthermore, uncertainties have an adverse effect on the economy; hence, it is expected that  $\hat{f}_{32}$  and  $\check{f}_{32}$  will be positive, implying that oil price volatilities result in depreciation.

### 3.4 Data

To estimate the dynamics between oil prices and exchange rates, the study uses South African monthly time series data, from the Federal Reserve Bank of St. Louis and the World Bank (Global Economic Monitor (GEM)) for the period of 2000M1 to 2023M12. Throughout this period, there have been several different global events that affected the global oil price, which further affected the South African exchange rate, for instance, the recent COVID-19 and the

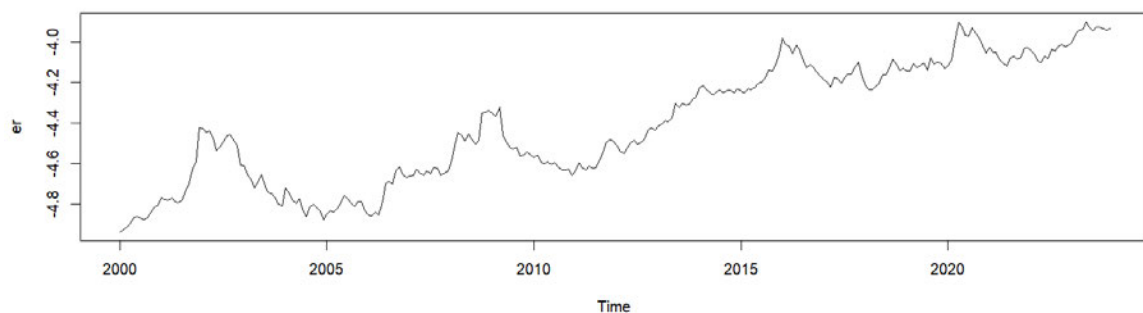
Russia-Ukraine war. Therefore, the significance of the specified period lies in the ability to examine the dynamics between the two factors during these global disturbances.

**Nominal effective exchange rate (NEER)** – When oil prices increase(decrease), South Africa requires more(less) dollars to purchase the same barrel of oil. Hence using a nominal effective exchange rate is more reliable since it reflects the actual amount of foreign currency that is required when oil prices change. It is a trade-weighted proxy for the exchange rate. The data is in indirect form and, therefore is transformed to direct form according to the following expression:

$$Direct\ NEER = \frac{1}{Indirect\ NEER} \quad (30)$$

This is done to explain an increase in the NEER as a depreciation and a decrease as an appreciation. Given that global disturbances also play a crucial role in determining the relationship between oil prices and exchange rates, the period allows the study to look at the effect of the rand crisis of September 2001 and June 2015 (Nowack & Ricci, 2006) by computing impulse responses.

Figure 3.1 below shows how the nominal effective exchange rate has been behaving for the past 24 years:



*Source: Author's compilation (2024)*

**Figure 3.1: Nominal Effective Exchange Rate (ZAR/USD) (2000M1 – 2023M12)**

Regardless of the volatilities in the exchange rate, the South African nominal effective exchange rate has been averagely depreciating against the US dollar. The country implemented

the inflation targeting policy in February 2000 to maintain price stability (Ftiti & Hichri, 2014). However, Figure 3.1 shows that during the early 2000s, the South African rand started to depreciate. In 2001 the rand depreciated abruptly against the dollar (LiPuma & Koelble, 2009; Bhunida & Gottschalk, 2003; Ricci, 2005); this is known as the Rand crisis that took place end of September. This resulted in inflation rate hikes, thus slower economic growth. Bhundia & Gottschalk (2006) argue that to some extent, the financial market developments are also an explanation. The ZAR remained stable until mid-2007 when it depreciated slightly; however, due to the GFC between mid-2008 and 2009, it further depreciated (Ndou et al., 2024). Thereafter, during late 2015 and early 2020, it depreciated and quickly regained its strength.

**Global price of Brent crude oil prices** – South Africa is a net oil importer; therefore, it uses the global price of oil. It is quoted in the US dollar per barrel of oil. Since the study aims to estimate the asymmetric effect of oil prices, this data is decomposed into positive values (increase in oil prices) and negative values (decrease in oil prices). This is done by following the work of Nzimande & Msomi (2016) and Gupta & Kotze (2017):

$$OP_t = OP_o + OP_t^+ + OP_t^- \quad (31)$$

where  $t = 1, 2, 3, \dots, T$ .  $OP_t$  refers to the complete time series index,  $OP_o$  refers to the starting values, the initial value of oil price.

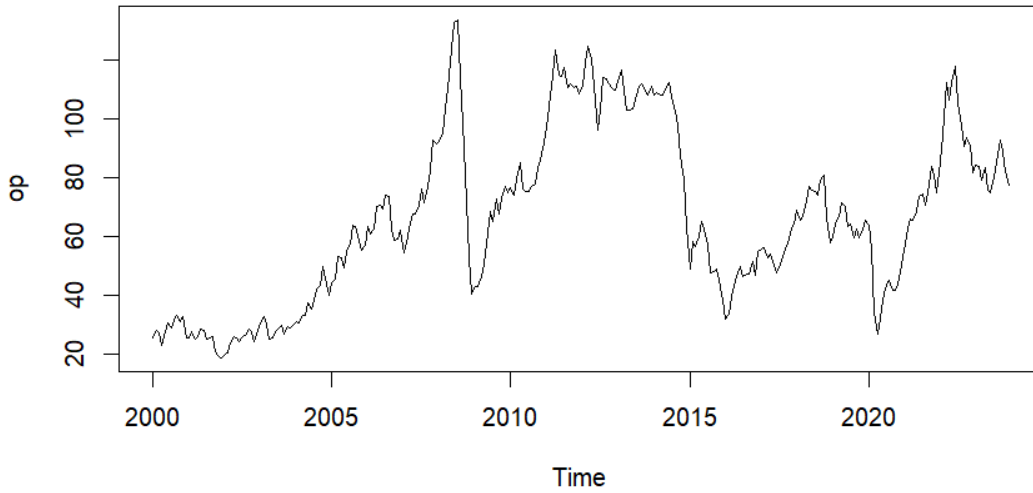
$$OP_t^+ = \sum_{i=0}^{t-1} 1\{\Delta OP_t^{-1} \geq 0\} \Delta OP_t^{-1} \quad (32)$$

and

$$OP_t^- = \sum_{i=0}^{t-1} 1\{\Delta OP_t^{-1} < 0\} \Delta OP_t^{-1} \quad (33)$$

$OP_t^+ = \sum_{t=1}^T OP_t^+$  and  $OP_t^- = \sum_{t=1}^T OP_t^-$  are cumulative positive and negative shocks, respectively.

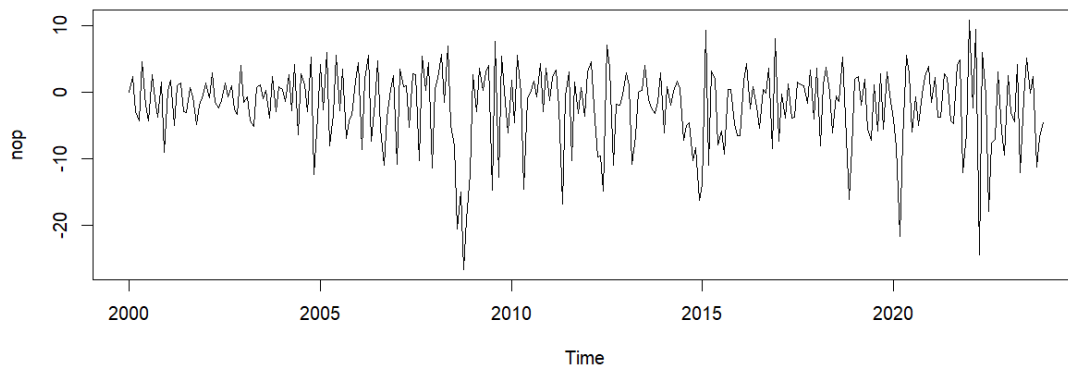
Figures 3.2, 3.3, and 3.4 below show how oil prices, the negative and positive shocks of oil prices have behaved from January 2000 to December 2023.



*Source: Author's compilation (2024)*

**Figure 3.2 Brent Crude Oil Prices (2000M1 – 2023M12)**

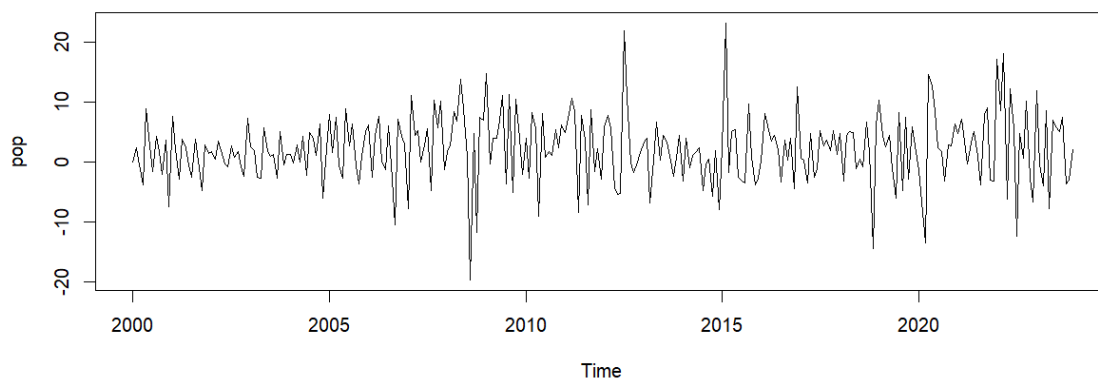
Bhar & Malliaris (2011) studied oil prices and the impact of the GFC of 2007-2008. They support Figure 3.2, as they mention that from 2004 to 2007, oil prices increased dramatically, and this was due to an increase in global demand for oil and supply disruptions. Ural (2016) also shows how the GFCs also caused high volatilities in oil prices, as seen by the huge spikes. During the COVID-19, it is also seen that oil prices were affected as they decreased. Several studies have looked at this phenomenon and have found a common conclusion of how the pandemic led to reduced demand and supply thus leading to in oil price volatilities (Bourghelle et al., 2021; Jawadi & Sellami, 2022; Gil-Alana & Monge, 2020).



*Source: Author's compilation (2024)*

**Figure 3.3: Negative Oil Price Shock (2000M1 – 2023M12)**

Figure 3.3 supports the work of the authors previously mentioned (Bourghelle et al., 2021; Jawadi & Sellami, 2022; Gil-Alana & Monge, 2020), on how volatile oil prices are. Negative oil price shocks were less volatile before 2005; however, after 2005 they started to be highly volatile. This is due to economic disturbances, such as the GFC in 2000-2008 and COVID-19 in 2020, which caused drastic changes in oil demand and supply. The drastic decline in 2008 was caused by the GFC, which resulted in a decrease in global demand; oil prices dropped from \$150 per barrel of oil in mid-2008 to \$30 per barrel of oil late 2008 (Bhar & Milliaris, 2011).



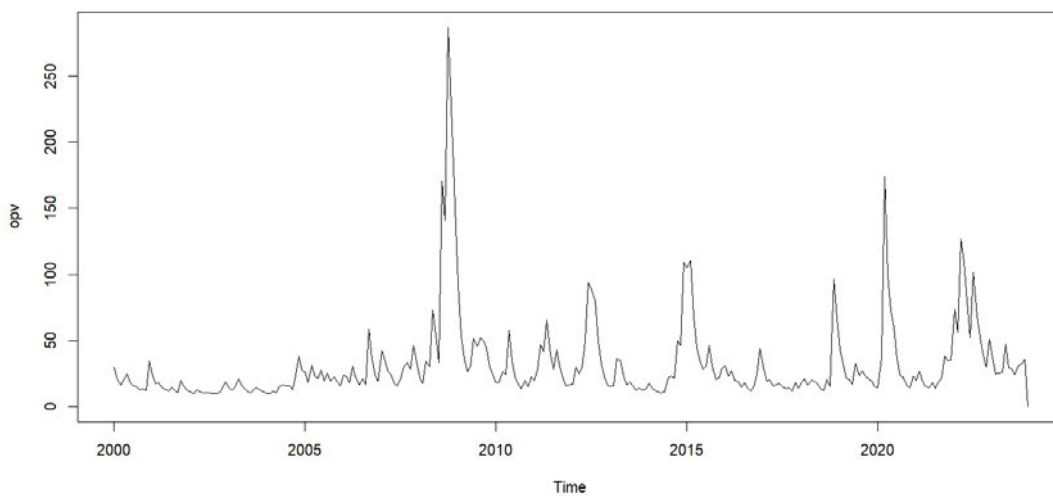
*Source: Author's compilation (2024)*

**Figure 3.4 Positive Oil Price Shock (2000M1 – 2023M12)**

Positive oil price shocks behave similarly to negative shocks in terms of their volatilities. For the period from mid-2008 until late 2009, oil prices were highly volatile; this is shown by the

huge spikes during this period. After the period of the GFC, they returned to being stable; however, they were more volatile as compared to the periods prior to the GFC.

**Oil Price Volatility (OPV)** – The literature has shown the role that is played by oil price volatility in determining the dynamics between macroeconomic variables, including exchange rates. Hence, this study will also examine its role in explaining the symmetric response of exchange rates to oil price changes. Figure 3.5 below shows the volatility of oil prices.



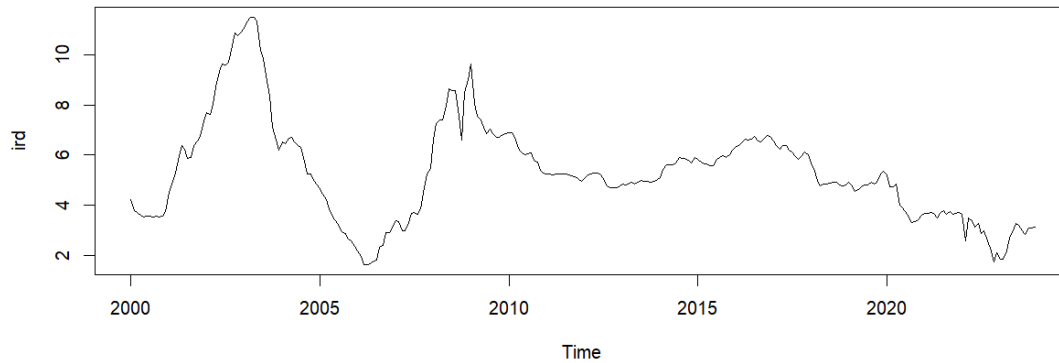
*Source: Author's compilation (2024)*

**Figure 3.5: Oil Price Volatility (2000M1- 2023M12)**

Figure 3.5 shows that oil prices are indeed volatile as seen by the consistent ups and downs. Furthermore, they support Bourghelle et al. (2021), as they show they are subject to geopolitical disturbances. Two spikes are noticeable in Figure 3.5, one is during mid-2008 which could be attributed to the GFC, and the second one is during mid-2020 which could be attributed to COVID-19. Yu et al. (2022) prove that these spikes were caused by these two crises.

**Interest rate differential (IRD)** – Interest rate differentials refer to the difference in interest rate between home country and foreign country. It is one of the country's determinants of exchange rate through capital mobility. A higher domestic interest rate relative to foreign countries leads to exchange rate appreciation; in contrast, if the domestic interest rate is

relatively low, the exchange rate will depreciate (Msomi & Ngalawa, 2024). Figure 3.6 below shows the differential in interest rates between South Africa and the United States.



*Source: Author's compilation (2024)*

**Figure 3.6: Interest Rate Differentials for SA and USA (2000M1 – 2024M12)**

From mid-2000 to late 2008, the interest rate differentials were wide, where after increasing from the 3<sup>rd</sup> quarter of 2000 to 2003, it declined rapidly until mid-2006. After that, the interest differentials increased until 2008. After 2008 it remained stable, however, was averagely declining. This shows that the interest rate between these two countries is significantly changing over time, with the South African interest rate exceeding that of the United States.

## CHAPTER 4: RESULTS ANALYSIS

### 4.1 Introduction

This study aims to estimate the dynamics between oil prices and exchange rates. Its main objectives are to estimate the underlying relationship between the two macroeconomic variables and further examine whether exchange rates respond asymmetrically to oil price shocks. This chapter employs the methods specified above to achieve these objectives. It first tests for stationarity, then further tests for cointegration. Subsequent sections contain the two models, VAR and SVAR, where the study will be able to obtain the estimates specifying the magnitude of the effects. Since the study creates partial sums by decomposing oil prices, each test and estimate will consist of five results, one from the original oil price shocks, one from each of the oil price shocks, and one with oil price volatility with each oil price shock.

### 4.2 Lag Selection Criteria

Since the study uses quarterly time series data to achieve its objectives, it is therefore crucial to know the significant lags to use when estimating the model. The selection is based on four criteria namely, Akaike's information criterion (AIC), Hannan-Quinn criterion (HQC), Schwarz information criterion (SIC), and final prediction error (FPE). Many scholars, Mazerolle (2006), Kuha (2004), and Yamashita et al. (2007) have used these criteria; Liew (2004) argues that AIC and FPE are more reliable in time series data with up to 60 observations, furthermore, recommended for estimating an autoregressive lag length. In each of the four criteria, the lag with the smallest value is the chosen lag. The tables below show the results obtained from estimating the lag selection criteria with the oil price shock equation (see equations 20 & 21), the negative oil price shock equation (see equations 22 & 23), the positive oil price shock (see equations 24 & 25), and the oil price volatility equations (see equations 26 – 29), respectively.

**Table 4.1 Lag Selection Criteria (Oil Price Shock)**

| Number of lags | 1            | 2            | 3            | 4            |
|----------------|--------------|--------------|--------------|--------------|
| AIC(n)         | -5.741198350 | -5.745136411 | -5.713989084 | -5.703552147 |
| HQ(n)          | -5.662024864 | -5.618459932 | -5.539807413 | -5.481866384 |
| SC(n)          | -5.543919927 | -5.429490933 | -5.279976552 | -5.151172561 |
| FPE(n)         | 0.003362886  | 0.003198456  | 0.003299907  | 0.003334982  |

*Source: Author's computation (2024)*

The AIC criteria and the FPE indicate 2 lags as the maximum number of lags – that is AIC (-5.745136411) and FPE (0.003198456), while the HC and SC indicate 1 lag, -5.662024864 and -5.543919927, respectively. According to Asghar & Abid (2007) and Liew (2006), the SC and HQ criteria work best for large samples; hence, for this reason, the study will make use of 1 lag in estimating the relationship between the nominal exchange rate and oil prices.

**Table 4.2 Lag Selection Criteria (Negative Oil Price Shock)**

| Number of lags | 1            | 2            | 3            | 4            |
|----------------|--------------|--------------|--------------|--------------|
| AIC(n)         | -5.537838875 | -5.540360030 | -5.507084529 | -5.495136555 |
| HQ(n)          | -5.458882028 | -5.414029075 | -5.333379466 | -5.274057384 |
| SC(n)          | -5.341077958 | -5.225542563 | -5.074210513 | -4.944205988 |
| FPE(n)         | 0.003935069  | 0.003925305  | 0.004058435  | 0.004107769  |

*Source: Author's computation (2024)*

Based on Table 4.2, equation 4 criteria also indicate a maximum number of lags as 1 lag, HQ (-5.458882028), and SC (-5.341077958).

**Table 4.3 Lag Selection Criteria (Positive Oil Price Shock)**

| Number of lags | 1            | 2            | 3            | 4           |
|----------------|--------------|--------------|--------------|-------------|
| AIC(n)         | -5.655971719 | -5.672866624 | -5.656604438 | -5.65760309 |
| HQ(n)          | -5.577014872 | -5.546535670 | -5.482899375 | -5.38914981 |
| SC(n)          | -5.459210802 | -5.358049158 | -5.223730421 | -4.98861597 |
| FPE(n)         | 0.003496615  | 0.003438163  | 0.003494805  | 0.00349251  |

*Source: Author's computation (2024)*

Based on Table 4.3, equation 5 criteria also indicate a maximum number of lags as 1 lag, HQ (-5.577014872), and SC (-5.459210802). For all the models VAR and SVAR, the study will use 1 lag.

**Table 4.4 Lag Selection Criteria (Negative Oil Price Shock and Oil Price Volatility)**

| Number of lags | 1     | 2     | 3     | 4     | 5     | 6     |
|----------------|-------|-------|-------|-------|-------|-------|
| AIC(n)         | 0.409 | 0.368 | 0.257 | 0.203 | 0.149 | 0.135 |
| HQ(n)          | 0.536 | 0.579 | 0.551 | 0.582 | 0.612 | 0.683 |
| SC(n)          | 0.724 | 0.893 | 0.991 | 1.147 | 1.303 | 1.500 |
| FPE(n)         | 1.506 | 1.445 | 1.293 | 1.226 | 1.162 | 1.148 |

*Source: Author's computation (2024)*

Based on Table 4.4, the maximum number of lags is 1 lag, HQ (0.536) and SC (0.724). Therefore, to estimate equation 6, the study will use 1 lag.

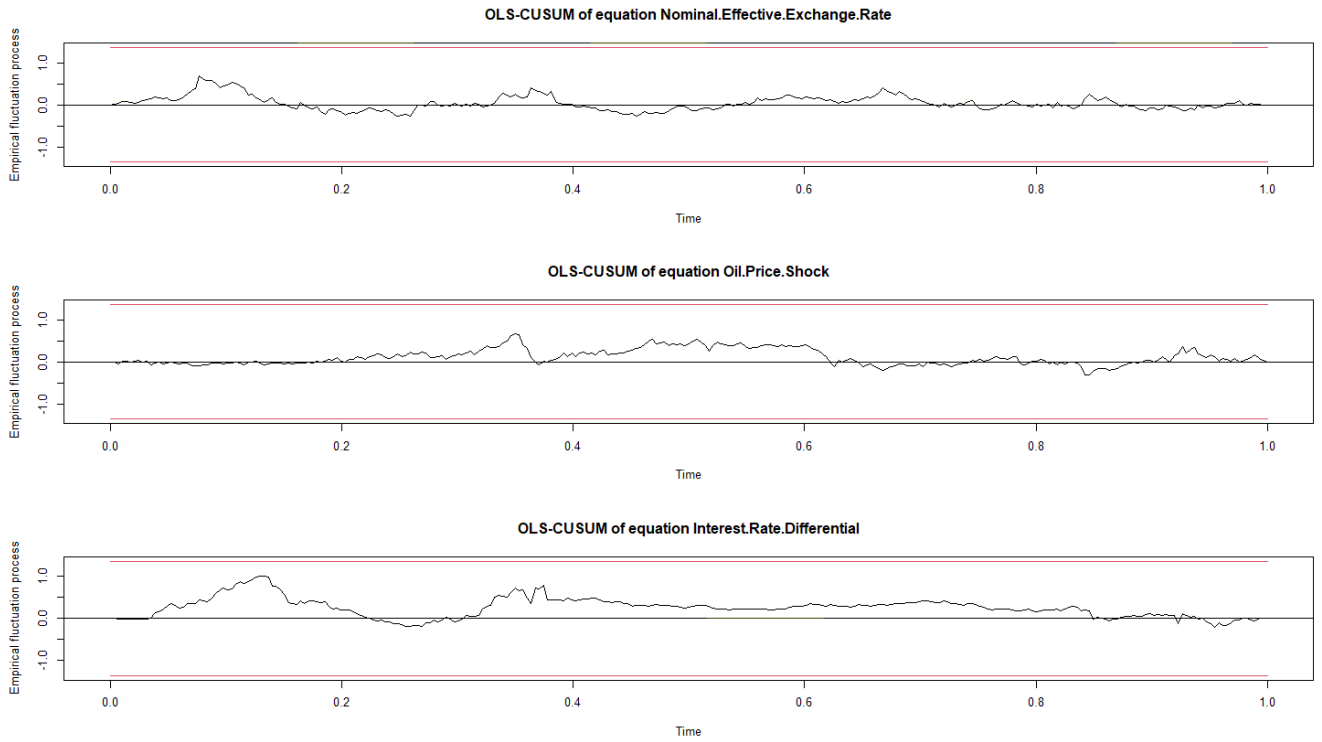
**Table 4.5 Lag Selection Criteria (Positive Oil Price Shock and Oil Price Volatility)**

| Number of lags | 1         | 2         | 3         | 4         |
|----------------|-----------|-----------|-----------|-----------|
| AIC(n)         | 0.2974530 | 0.2262626 | 0.2118879 | 0.1350919 |
| HQ(n)          | 0.4237839 | 0.4368041 | 0.5066601 | 0.5140847 |
| SC(n)          | 0.6122704 | 0.7509483 | 0.9464620 | 1.0795443 |
| FPE(n)         | 1.3464620 | 1.2540515 | 1.2364402 | 1.1454911 |

*Source: Author's computation (2024)*

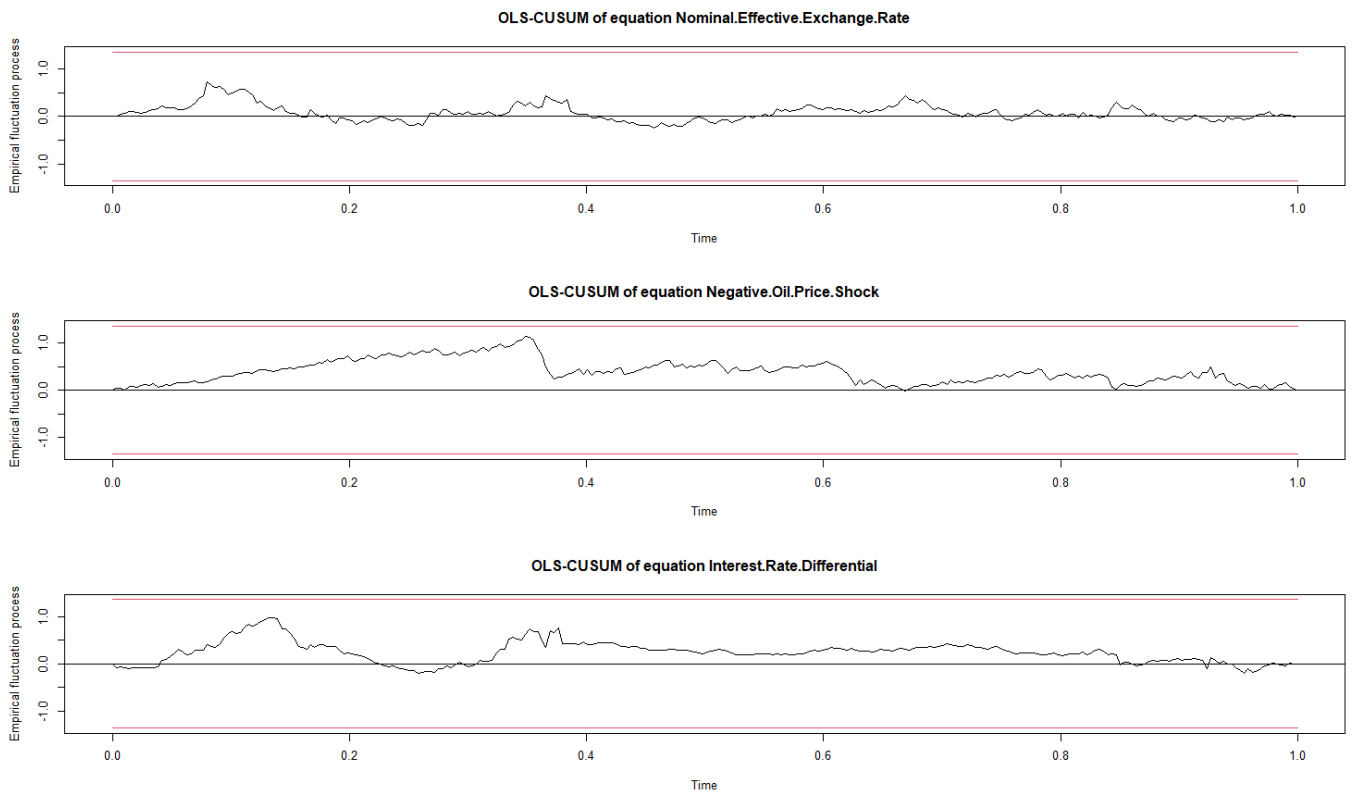
Based on Table 4.5, the maximum number of lags is 1 lag, HQ (0.536) and SC (0.724). Therefore, to estimate equation 7, the study will use 1 lag.

Since the world is subject to uncertainty, economic variables are also expected to deviate from their usual behaviour. This, therefore, affects the estimation since they tend to either overestimate or underestimate the estimations (Johnson & Fowler, 2011). The figure below shows the results obtained from testing the variables' stability using the cumulative sum of recursive residuals (CUSUM) test, which sums up the deviations of the variable and checks whether it exceeds a specific threshold.



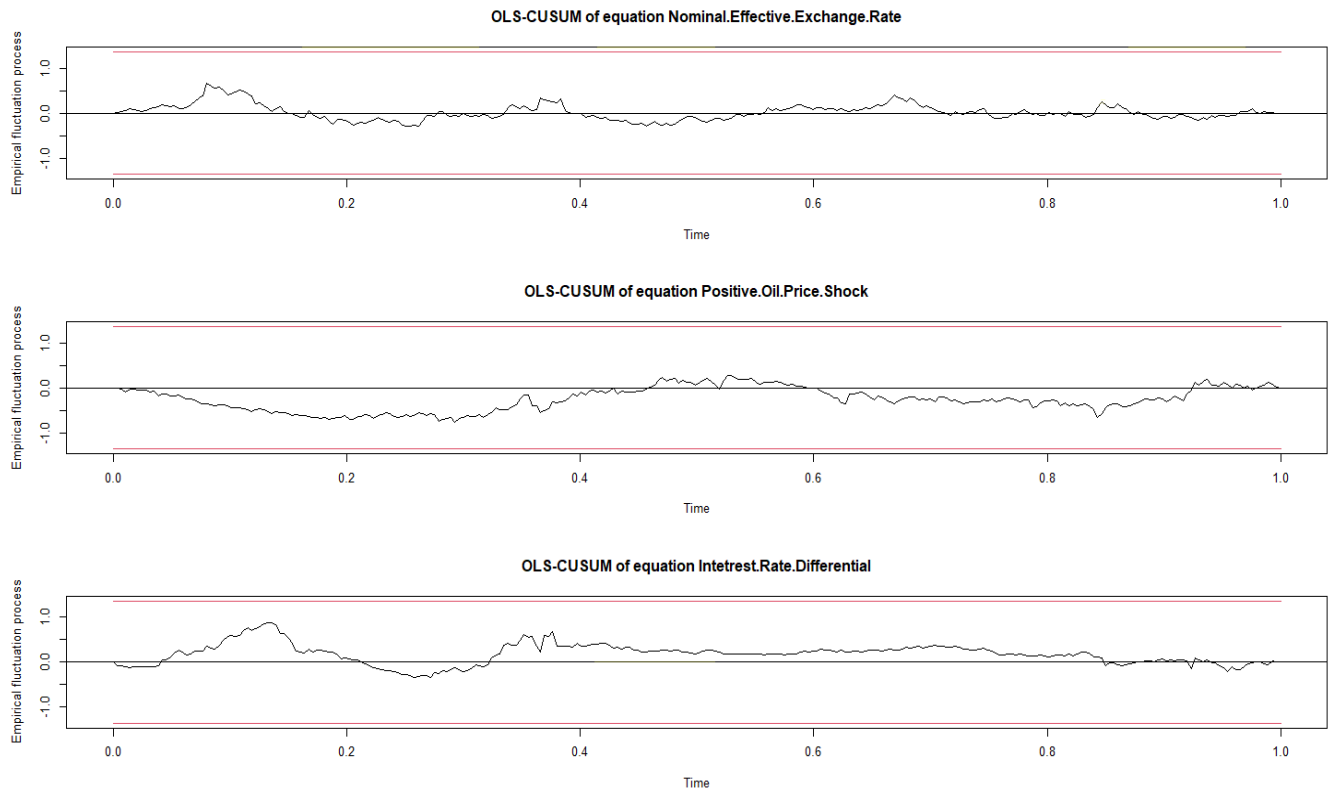
*Source: Author's computation (2024)*

**Figure 4.1 Recursive CUSUM test (Oil Price)**



*Source: Author's computation (2024)*

**Figure 4.2 Recursive CUSUM test (Negative Oil Price Shock)**



*Source: Author's computation (2024)*

**Figure 4.3 Recursive CUSUM test (Positive Oil Price Shock)**

The red lines represent the threshold, and the black line shows the sum. Therefore, with reference to the above diagrams, Figures 4.1- 4.3, it can be concluded that the five variables have been stable from January 2000 until December 2023. Some of the results are similar to Saidu et al.'s (2021) findings.

### 4.3 Stationarity

Most time series data fluctuate in an unstable and inconsistent manner; this results from the never-ending global disruptions that cause spikes in some periods. This instability and inconsistency; consequently, have a negative impact on the accuracy of the estimations since some results may not reveal the true relationships. Therefore, to ensure consistency and stability, the data is made stationary. Although it is possible to conclude whether the data is stationary by observing its behaviour over time, that method is not reliable since one cannot

observe whether the statistical properties of the data do not change over time. It can be argued that Figure 3.1 was stationary from the first month of 2000 until early 2008 and, thereafter, was nonstationary as it increased. Both oil price shocks (Figures 3.3 & 3.4) show that oil price shocks are stationary throughout the period, regardless of the spikes in 2008 and 2009. However, it cannot be agreed whether oil price shocks (Figure 3.2) are stationary or not. Figure 3.5 indicates that interest rate differentials are stationary as they tend to revert after spiking. Therefore, the ADF, KPSS, and Phillips-Perron tests were designed to further test for stationarity. Table 4.6 below shows the results obtained from the ADF test. The study only conducts the ADF test as all three tests lead to the same conclusion.

**Table 4.6 ADF Test**

| Variables                       | Coefficients |
|---------------------------------|--------------|
| Nominal effective exchange rate | -2.5824      |
| Oil price shock                 | 0.4716       |
| Negative oil price shock        | -6.8998**    |
| Positive oil price shock        | -7.0877**    |
| Oil price volatility            | -4.9426**    |
| Interest rate differential      | -3.4378**    |

\*, \*\* &\*\*\*, respectively mean 10%, 5% & 1%

*Source: Author's computation (2024)*

All variables are stationary at levels, at a 5% level of significance except for the nominal effective exchange rate and oil price shock. The nonstationary variables were then differenced once and further tested for the 1<sup>st</sup> difference stationarity (results shown by the table below).

**Table 4.7 ADF Test**

| Variable                        | Coefficient |
|---------------------------------|-------------|
| Nominal effective exchange rate | -6.3965**   |
| Oil price shock                 | -6.6715**   |

\*, \*\* &\*\*\*, respectively mean 10%, 5% & 1%

*Source: Author's computation (2024)*

Table 4.7 shows that the first difference of the two variables is significant at a 5% level of significance; therefore, the null hypothesis of unit root is rejected and concludes that the first difference is stationary. For the purposes of conducting the cointegration test using the Johansen cointegration test, all variables, including are differenced, making them all I (1), therefore, we estimate the growth rates.

#### 4.4 Cointegration

Cointegration refers to the long-run relationship between variables. In this section, the study tests for the long-run relationship between the nominal effective exchange rate, oil price shocks, and interest rate differential. It makes use of the Johansen cointegration test, which according to Brooks (2019), compares the biggest eigenvalue or the sum of the eigenvalues to the critical values, which aids in identifying the number of cointegrating connections. The null hypothesis is that there is no cointegration ( $r=0$ ), and the alternative hypothesis is that there is cointegration between variables. The null hypothesis is rejected if the test statistic value exceeds the critical values, then concludes that there is an existence of cointegration. The rank ( $r$ ), which stands for the number of cointegrating equations and should be less than the number of variables is kept increasing until the null hypothesis is no longer rejected. The table below shows the results obtained from estimating the Johansen cointegration test.

**Table 4.8: Johansen cointegration test (Oil price shock)**

| Null hypothesis | Max-eigen test | Critical values | Trace test | Critical values |
|-----------------|----------------|-----------------|------------|-----------------|
| $r = 0$         | 38.26          | 26.81           | 83.27      | 41.07           |
| $r \leq 1$      | 32.37          | 20.20           | 45.01      | 24.60           |
| $r \leq 2$      | 12.64***       | 12.97           | 12.64***   | 12.97           |

\*\*\* Significant at 1%

*Source: Author's computation (2024)*

The null hypothesis of no cointegration ( $r = 0$ ) is rejected since the test statistic exceeds the critical value ( $38.26 > 26.81$ ); therefore, it is concluded that there is at least one cointegration.

The null hypothesis of at least one cointegration ( $r \leq 1$ ) is also rejected since the test statistic is greater than the critical value, ( $32.37 > 20.20$ ), concluding that there are two cointegrating relationships. The last null hypothesis failed to be rejected, given that the test statistic (12.64) is less than the critical value of 12.97; therefore, we conclude that there are two long-run relationships. The trace test has the same conclusion of two long-run relationships as the null hypothesis of two cointegrations failed to be rejected. These results are consistent with the conclusion of Sibanda et al. (2015), who used the same method to test for the long-run relationship between oil prices and exchange rates and found one. This also proves that, indeed, when oil prices change, the South African exchange rate is affected. The table below shows the results obtained from estimating the Johansen test for the negative oil price shock and the nominal exchange rate.

**Table 4.9: Johansen cointegration test (Negative oil price shock)**

| Null hypothesis | Max-eigen test | Critical values | Trace test | Critical values |
|-----------------|----------------|-----------------|------------|-----------------|
| $r = 0$         | 39.34          | 26.81           | 77.95      | 41.07           |
| $r \leq 1$      | 26.29          | 20.20           | 38.61      | 24.60           |
| $r \leq 2$      | 12.32***       | 12.97           | 12.32***   | 12.97           |

\*\*\*Significant at 1%

*Source: Author's computation (2024)*

The null hypothesis of no cointegration ( $r = 0$ ) is rejected since the test statistic exceeds the critical value ( $39.34 > 26.81$ ); therefore, it is concluded that there is at least one cointegration. The null hypothesis of at least one cointegration ( $r \leq 1$ ) is also rejected since the test statistic is greater than the critical value, ( $26.29 > 20.20$ ), concluding that there are two cointegrating relationships. The last null hypothesis failed to be rejected given that the test statistic (12.32) is less than the critical value of 12.97; therefore, we conclude that there are two long-run relationships. The trace test has the same conclusion of two long-run relationships as the null hypothesis of two cointegrations failed to be rejected. This shows that there is a relationship between negative oil price shocks and the nominal exchange rate, which is expected since there is a relationship with the initial oil prices.

The table below shows the results obtained from conducting the Johansen cointegration test of the positive oil price shock.

**Table 4.10: Johansen cointegration test (Positive Oil Prices)**

| Null hypothesis | Max-eigen test | Critical values | Trace test | Critical values |
|-----------------|----------------|-----------------|------------|-----------------|
| $r = 0$         | 37.79          | 26.81           | 70.75      | 41.07           |
| $r \leq 1$      | 20.54          | 20.20           | 32.96      | 24.60           |
| $r \leq 2$      | 12.42***       | 12.97           | 12.42***   | 12.97           |

\*\*\* Significant at 1%

*Source: Author's computation (2024)*

The null hypothesis of no cointegration is rejected since the test statistical value (37.79) is greater than the critical value (26.81); therefore, it is concluded that there is at least one cointegrating relationship. However, the null hypothesis of at least one cointegrating relationship is also rejected since the test statistical value (20.54) is greater than the critical value (20.20), then concludes that there are at least two cointegrating relationships. The study fails to reject the null hypothesis of at least two cointegrating relationships since the test statistic (12.42) is less than the critical value (12.97); and therefore, concludes that there are two long-run relationships. The max-eigen test supports this conclusion as the first two null hypotheses are rejected in favour of two long-run relationships.

The cointegration results reveal two long-run relationships. Since the study is based on a small economy, it can be argued that these relationships include, first, the response of the growth of nominal exchange rate to oil price shocks, and second, the response of the growth rate of interest rate differential to oil price shocks. They lay a foundation for the study to further examine the symmetric response of the nominal exchange rate to oil prices. Several studies that have found these relationships include, Chisadza et al. (2016); Chiweza & Aye (2018); Fowowe (2014); and Saidu et al. (2021), and they all used different yet similar methods.

#### **4.5 Vector Autoregressive Model (VAR)**

The table below shows the short-run relationships of the reduced form VAR.

**Table 4.11: Vector Autoregressive Model (Negative Oil Price Shock)**

|          | Dependent variable: |                     |                     |
|----------|---------------------|---------------------|---------------------|
|          | NEER                | NOP                 | IRD                 |
| NEER -1  | 0.166***<br>(0.059) | -0.392<br>(11.008)  | 1.562***<br>(0.575) |
| NOP -1   | -0.001<br>(0.0003)  | 0.011<br>(0.061)    | -0.004<br>(0.003)   |
| IRD -1   | 0.003<br>(0.006)    | -0.344<br>(1.059)   | 0.313***<br>(0.055) |
| Constant | 0.002<br>(0.002)    | 2.021***<br>(0.372) | -0.017<br>(0.019)   |

\*, \*\* & \*\*\* respectively mean 10%, 5% & 1%

*Source: Author's computation (2024)*

On average, ceteris paribus, a 1% decrease in the growth rate of oil prices in the previous month leads to a 0.1% increase in the growth of the nominal exchange rate (depreciation). This is unexpected as it contradicts the theory of some scholars, Kisswani et al., (2019), and the wealth effect, that is, when oil prices decrease, oil-importing countries are better off as they require fewer dollars to purchase the same barrel of oil, thus an appreciation. This kind of response is expected in the long run, where a decrease in oil prices results in large volumes of oil imports, thus increasing demand for foreign currency, and resulting in domestic depreciation. However, as mentioned in the literature, oil is a relatively inelastic good; hence, the country will adjust gradually to changes in its price and these results may emphasise that. A 1% increase in the growth of interest rate differentials causes a 0.3% currency depreciation, on average, ceteris paribus. An increase in interest rate differential implies either an increase in the domestic interest rate or a decrease in the foreign interest rate. Analysing the former, an increase in interest rate results in domestic depreciation. This supports the findings by Egilsson (2020), where he argues how high interest rates may discourage new investment, reduce exports, and increase funding costs, and further recommends lowering wages and specialising to compensate for higher funding costs.

**Table 4.12: Vector Autoregressive Model (Positive Oil Price Shock)**

|          | Dependent variable: |                     |                     |
|----------|---------------------|---------------------|---------------------|
|          | NEER                | POP                 | IRD                 |
| NEER -1  | 0.175***<br>(0.059) | 7.798<br>(10.357)   | 1.505***<br>(0.570) |
| POP -1   | -0.0003<br>(0.0003) | -0.111*<br>(0.060)  | -0.007**<br>(0.003) |
| IRD -1   | 0.003<br>(0.006)    | -0.024<br>(1.004)   | 0.320***<br>(0.055) |
| Constant | 0.004*<br>(0.002)   | 2.424***<br>(0.362) | 0.008<br>(0.020)    |

\*, \*\* & \*\*\* respectively mean 10%, 5% & 1%

*Source: Author's computation (2024)*

On average, ceteris paribus, a 1% increase in the growth of oil prices in the previous month leads to a 0.03% decrease in the growth of the nominal exchange rate (appreciation). This supports the theory, as proven by several authors, that when oil prices increase, the exchange rate of an oil-importing country appreciates (NEER decrease), (Lizardo & Mollick, 2010; Sanusi & Kapingura, 2022). A 1% increase in the growth of interest rate differentials causes a 0.3% currency depreciation, on average, ceteris paribus, which is a similar response as that of the negative oil price shock. Focusing on the coefficients of oil price shocks in both tables in the nominal exchange rate equation, they are not significantly different from each other, which suggests some degree of symmetry.

#### **4.6 Structural Vector Autoregressive Model (SVAR)**

The SVAR model emphasises the identification of the true structure of the economy by imposing some restrictions on the VAR model. From the previous chapter, the study specified the shortcomings of the VAR model where we cannot interpret the error as it is a combination of all the error terms from each equation (see equations 2 - 7). Furthermore, the SVAR model introduces endogeneity (see equation 8 - 13). Therefore, the study uses restrictions that are

based on the theory to overcome and identify the model. This restriction makes use of the theoretical findings by scholars to present a structural model.

In matrix form

$$\mathbf{A} \quad x_t = \mathbf{B} \quad x_{t-1} + u_t \quad (34)$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 3.905 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} op_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \begin{bmatrix} op_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (35)$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 3.813 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} op_t^- \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \dot{b}_{11} & \dot{b}_{12} & \dot{b}_{13} \\ \dot{b}_{21} & \dot{b}_{22} & \dot{b}_{23} \\ \dot{b}_{31} & \dot{b}_{32} & \dot{b}_{33} \end{bmatrix} \begin{bmatrix} op_{t-1}^- \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^- \\ uneer_t \\ uird_t \end{bmatrix} \quad (36)$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 3.539 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} op_t^+ \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \ddot{b}_{11} & \ddot{b}_{12} & \ddot{b}_{13} \\ \ddot{b}_{21} & \ddot{b}_{22} & \ddot{b}_{23} \\ \ddot{b}_{31} & \ddot{b}_{32} & \ddot{b}_{33} \end{bmatrix} \begin{bmatrix} op_{t-1}^+ \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^+ \\ uneer_t \\ uird_t \end{bmatrix} \quad (37)$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 3.732 & 1 & 0 & 0 \\ -9.469 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} op_t^- \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \hat{b}_{11} & \hat{b}_{12} & \hat{b}_{13} & \hat{b}_{14} \\ \hat{b}_{21} & \hat{b}_{22} & \hat{b}_{23} & \hat{b}_{24} \\ \hat{b}_{31} & \hat{b}_{32} & \hat{b}_{33} & \hat{b}_{34} \\ \hat{b}_{41} & \hat{b}_{42} & \hat{b}_{43} & \hat{b}_{44} \end{bmatrix} \begin{bmatrix} op_{t-1}^- \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^- \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (38)$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 3.574 & 1 & 0 & 0 \\ -9.112 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} op_t^+ \\ opv_t \\ neer_t \\ ird_t \end{bmatrix} = \begin{bmatrix} \check{b}_{11} & \check{b}_{12} & \check{b}_{13} & \check{b}_{14} \\ \check{b}_{21} & \check{b}_{22} & \check{b}_{23} & \check{b}_{24} \\ \check{b}_{31} & \check{b}_{32} & \check{b}_{33} & \check{b}_{34} \\ \check{b}_{41} & \check{b}_{42} & \check{b}_{43} & \check{b}_{44} \end{bmatrix} \begin{bmatrix} op_{t-1}^+ \\ opv_{t-1} \\ neer_{t-1} \\ ird_{t-1} \end{bmatrix} + \begin{bmatrix} uop_t^+ \\ uopv_t \\ uneer_t \\ uird_t \end{bmatrix} \quad (39)$$

The above expression implies simultaneous effects. That is, only the growth of the nominal effective exchange rate responds simultaneously to the growth of oil price shocks. Interest rate differential growth rate does not respond simultaneously to the growth of oil price shocks. According to this study and how the variables are ordered, the reason for this is that interest rate is used as a measure to control for inflation caused by increases in oil prices. Furthermore, this is supported by Balcilar et al. (2018) and Chisadza et al. (2016), who point out that inflation responds to oil prices with a lag. Hence, we would also expect interest rates to respond with a lag. Also, according to Chisadza et al. (2016), in response to inflation, the government needs to take into consideration the effect on output and other real variables. Although Donkor et al.

(2022) found a bi-directional causality between oil price volatility and the rand-dollar exchange rates, this study will apply causality running from oil price volatility to exchange rates (Chiweza & Aye, 2018). Hence, they come after oil price volatility. The authors further argue that exchange rates respond with a lag to oil price volatility. Nominal exchange rates (interest rate) respond with a lag to interest rate (nominal exchange rate) changes (Omolade et al., 2019). For the former, when the monetary authorities reduce interest rates, it takes time for investors to reallocate their capital to countries with better returns, thus resulting in a lagged response of exchange rate. Both the nominal exchange rate and interest rate do not have significant power to affect the world price of oil.

The aim is to remove the contemporaneous effects (remove the  $A$  matrix), and this is done by multiplying it by its inverse which is also a lower triangular (multiply all elements on both sides by the inverse of the  $A$  matrix). The matrices below show the results of the inverse of the  $A$  matrix of the three equations.

Therefore obtaining:

$$\varepsilon_t = A^{-1}u_t \quad (40)$$

$$\begin{bmatrix} \varepsilon_{op^-}_t \\ \varepsilon_{neer}_t \\ \varepsilon_{ird}_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -3.905 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{op^-}_t \\ u_{neer}_t \\ u_{ird}_t \end{bmatrix} \quad (41)$$

$$\begin{bmatrix} \varepsilon_{op^-}_t \\ \varepsilon_{neer}_t \\ \varepsilon_{ird}_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -3.813 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{op^-}_t \\ u_{neer}_t \\ u_{ird}_t \end{bmatrix} \quad (42)$$

$$\begin{bmatrix} \varepsilon_{op^+}_t \\ \varepsilon_{neer}_t \\ \varepsilon_{ird}_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -3.539 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{op^+}_t \\ u_{neer}_t \\ u_{ird}_t \end{bmatrix} \quad (43)$$

$$\begin{bmatrix} \varepsilon_{op^-}_t \\ \varepsilon_{opv}_t \\ \varepsilon_{neer}_t \\ \varepsilon_{ird}_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -3.732 & 1 & 0 & 0 \\ 9.469 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{op^-}_t \\ u_{opv}_t \\ u_{neer}_t \\ u_{ird}_t \end{bmatrix} \quad (44)$$

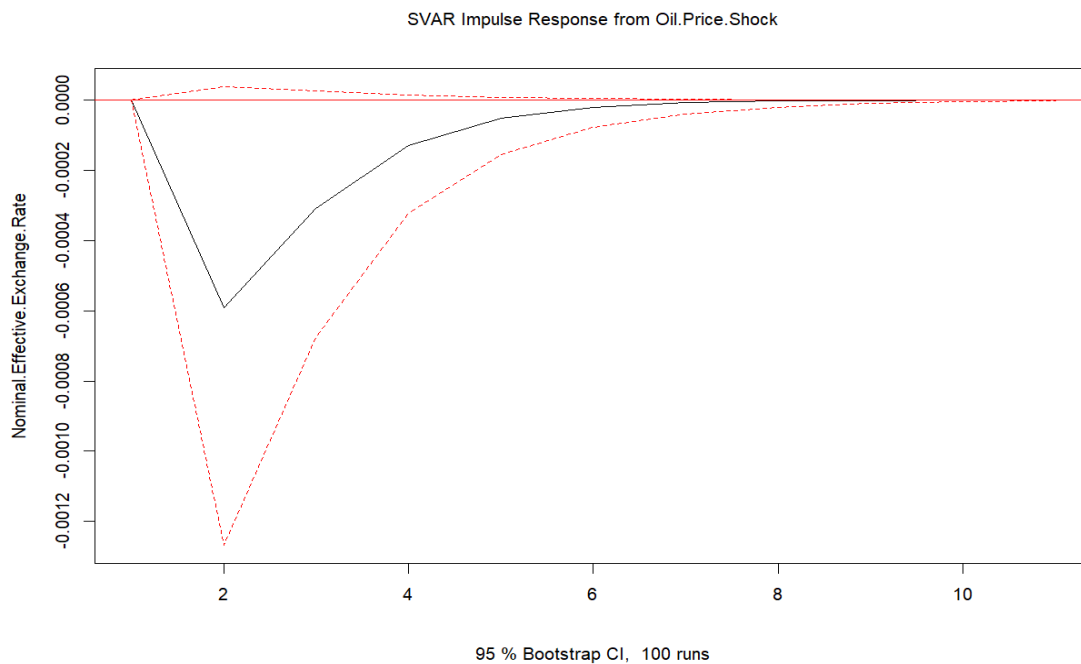
$$\begin{bmatrix} \varepsilon_{op^+}_t \\ \varepsilon_{opv}_t \\ \varepsilon_{neer}_t \\ \varepsilon_{ird}_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -3.574 & 1 & 0 & 0 \\ 9.112 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{op^+}_t \\ u_{opv}_t \\ u_{neer}_t \\ u_{ird}_t \end{bmatrix} \quad (45)$$

This therefore eliminates the endogeneity problem.

The figures (-3.905, -3.813, and -3.539) are the magnitude responses of the nominal exchange rate to an unanticipated change in oil price shocks, while -3.732 and -3.573 are the magnitude responses of oil price volatility to unanticipated changes in oil price shocks.

#### 4.7 Impulse Response and Forecast Error Decomposition (FEVD)

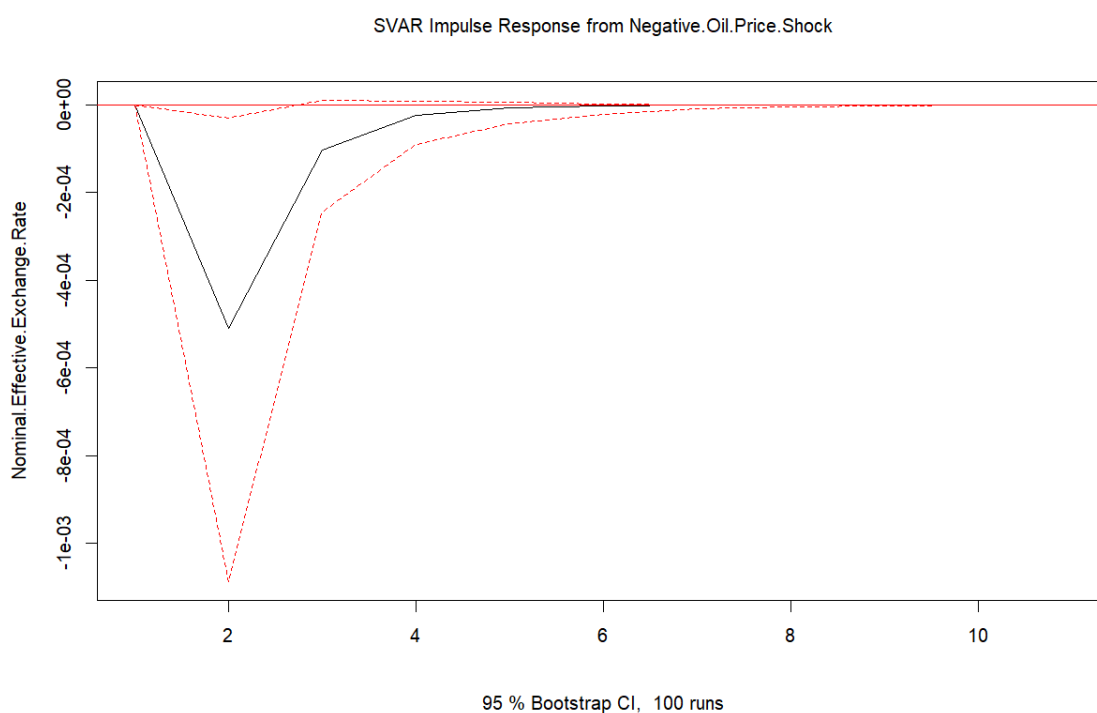
Impulse response assists in identifying the speed at which the growth rate of the nominal effective exchange rate adjusts in response to a shock in both the components of oil prices and the growth rate of interest rate differential. The figures below show the results of this response, and it can be argued that almost all of them are insignificant and depict uncertainty.



*Source: Author's computation (2024)*

#### Figure 4.4 Nominal Effective Exchange Rate Impulse Response to Oil Price Shock

Figure 4.4 is insignificant and shows a level of uncertainty. However, if the study were to explain it, it shows that when there is a shock in oil prices, the growth of the nominal exchange rate falls, indicating an appreciation, and thereafter increases.

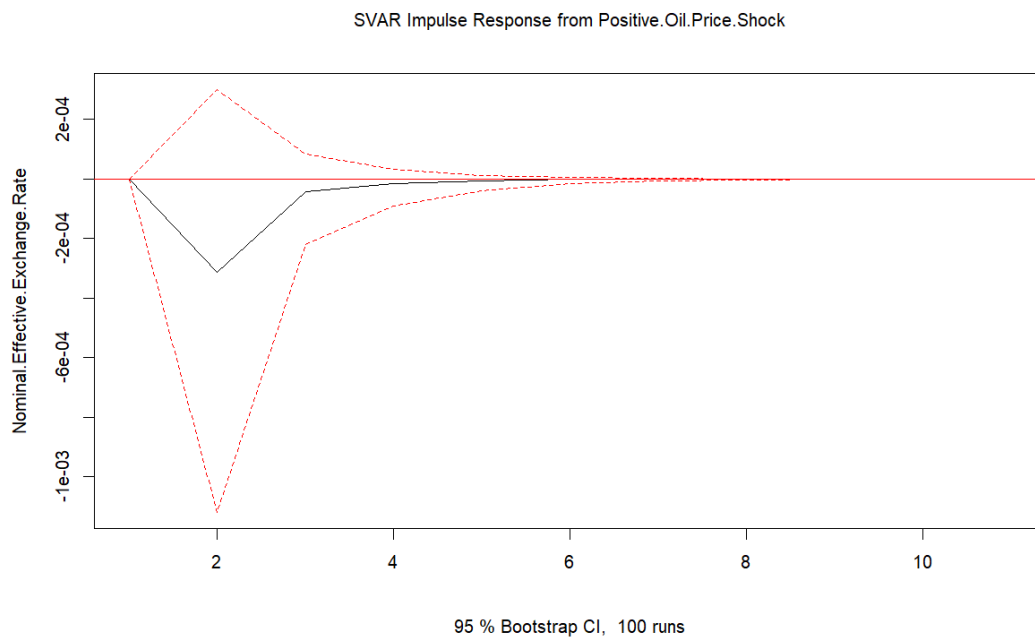


*Source: Author's computation (2024)*

**Figure 4.5: Nominal Effective Exchange Rate Impulse Response to Negative Oil Price Shock**

Figure 4.5 shows that when there is an unexpected decrease in the growth of oil prices, the rate at which the nominal exchange rate grows decreases for the first two months and after that increases. A possible explanation for this mechanism is that, when oil prices fall, it is cheap for oil-importing countries to import oil as they require fewer dollars. This, therefore, causes the oil-exporting countries' currencies to lose value. This finding is consistent with the wealth effect illustrated by Saudi et al. (2021) and Kisswani et al. (2018), which states that when oil prices drop, wealth is reallocated from the oil-exporting country to the oil-importing country. As the oil-importing countries import more and more, oil prices will increase, eventually, and the currency will depreciate since the more they buy the more they require dollars.

The figure below shows the growth of the nominal exchange rate response to the growth of positive oil price shocks.



*Source: Author's computation (2024)*

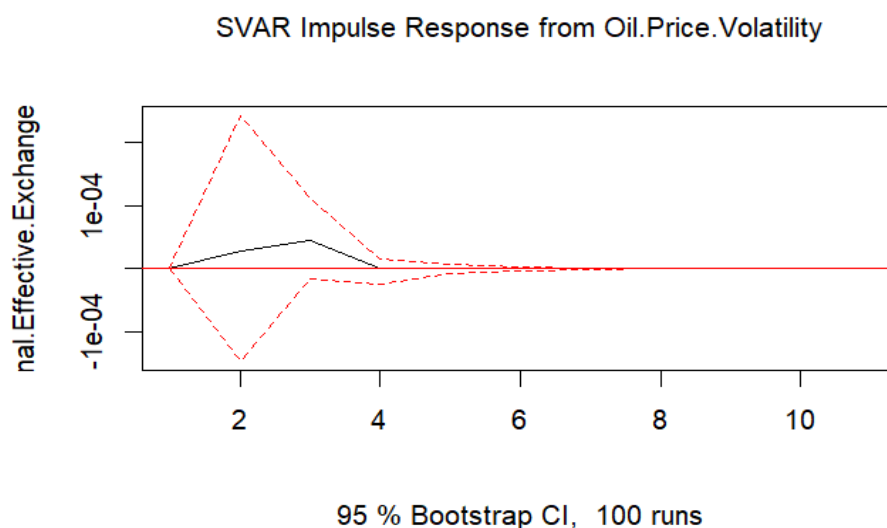
**Figure 4.6: Nominal Effective Exchange Rate Impulse Response to Positive Oil Price Shock**

Figure 4.6 shows that the growth of nominal effective exchange rates behaves similarly when oil prices increase as to when oil prices decrease. That is, when oil prices increase nominal exchange rate decreases for the first 2 months; however, by a smaller amount, and thereafter increases. When oil prices increase, the ZAR is expected to depreciate (increase in NEER). However, Figure 4.6 shows that for the first 2 months, the ZAR appreciates and then depreciates. This shows that the ZAR responds with lags to oil price increases, meaning the nominal exchange rate does not contemporaneously respond to an increase in oil price shocks, implying an asymmetric response since Figure 4.5 shows a contemporaneous response.

The growth of nominal exchange rates behaves similarly to both price shocks, that is, an increase in oil prices has the same effect on the ZAR as a decrease in oil prices, which is not expected. This then challenges policy makers as they would not know how to effectively control each shock in a manner that will directly deal with each shock. It is expected that NEER responds oppositely to each of the oil price shocks. Since they respond in the same direction but in different magnitudes, it can be concluded that ZAR does not respond symmetrically to

changes in oil price shocks. The nominal exchange rate responds differently to oil price increases and oil price decreases. Furthermore, figures 4.5 and 4.6 show that the nominal exchange rate responds more to oil price increases. This contradicts the findings of Saidu et al. (2021), as they found a symmetric response and that negative oil price shocks had a greater effect; moreover, Ngoma et al. (2016) who observed South Africa as an oil-exporting country and found a symmetric response of the ZAR to oil price changes. Moreover, this finding is consistent with the work of several authors including Yamaka (2024) who found an inverse relationship between oil prices and exchange rates for oil importing countries.

The figure below shows how the exchange rate behaves after a shock in the oil price volatility.



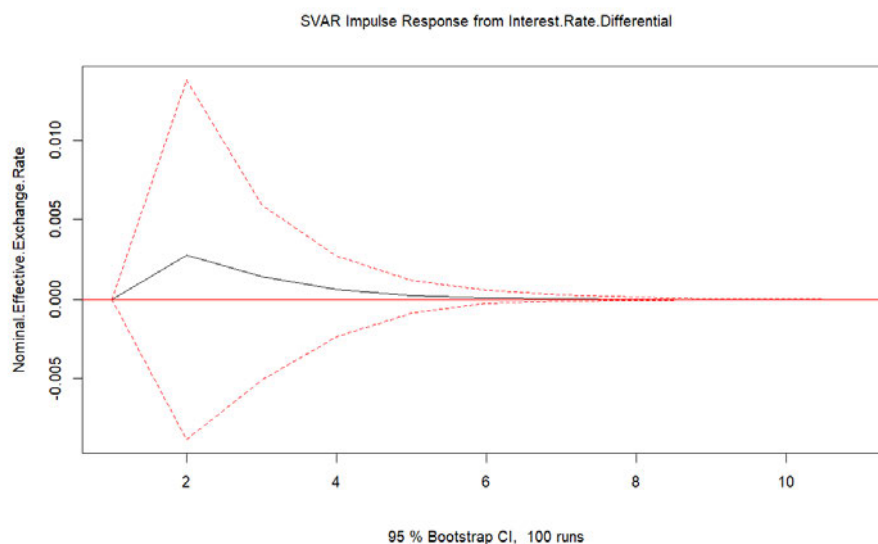
*Source: Author's computation (2024)*

**Figure 4.7: Nominal Effective Exchange Rate Impulse Response to Oil Price Volatility (Negative Oil Price Shock)**

Figure 4.7 shows that a shock in the growth of oil price volatilities caused the South African rand to depreciate for the first three months. This is in line with the theory which states that during uncertainties, oil-importing countries are likely to experience a depreciation in their currency. After three months, the currency appreciates. This supports Mumtaz & Theodoridis (2015), cited in Miyajima (2020) that uncertainties in South Africa could lead to a depreciation

of the rand as they result in the inflation rate. However, this contradicts Chiweza & Aye (2018), who found that oil price volatility causes exchange rates to depreciate only in the long run.

Most results obtained thus far contradict the findings of many scholars; the nominal exchange rate is found to be behaving in an unexpected manner. This can be justified by Mussa's (1979) finding that most changes in the exchange rates are unexpected. To some extent, there is a disconnect between economic variables and the floating exchange rate, and limited evidence of the relationship between the two causes unexpected conclusions. Msomi & Ngalawa (2024) support this argument as they mention that there are unobserved factors driving the behaviour of exchange rates; hence, in most cases, the results will be unexpected. Most existing research on the two factors is based on extreme cases such as hyperinflation (Frankel & Rose, 1995). The study argues that the growth of the nominal exchange rate responds with a lag to oil price increases, which might not be the case as we usually see a contemporaneous response. Bacchetta & Wincoop (2013) refers to the use of observed factors to explain exchange rate behaviour as a scapegoat. It is, therefore, difficult to model the behaviour of exchange rates due to the unobserved factors involved, which results in unexpected results.

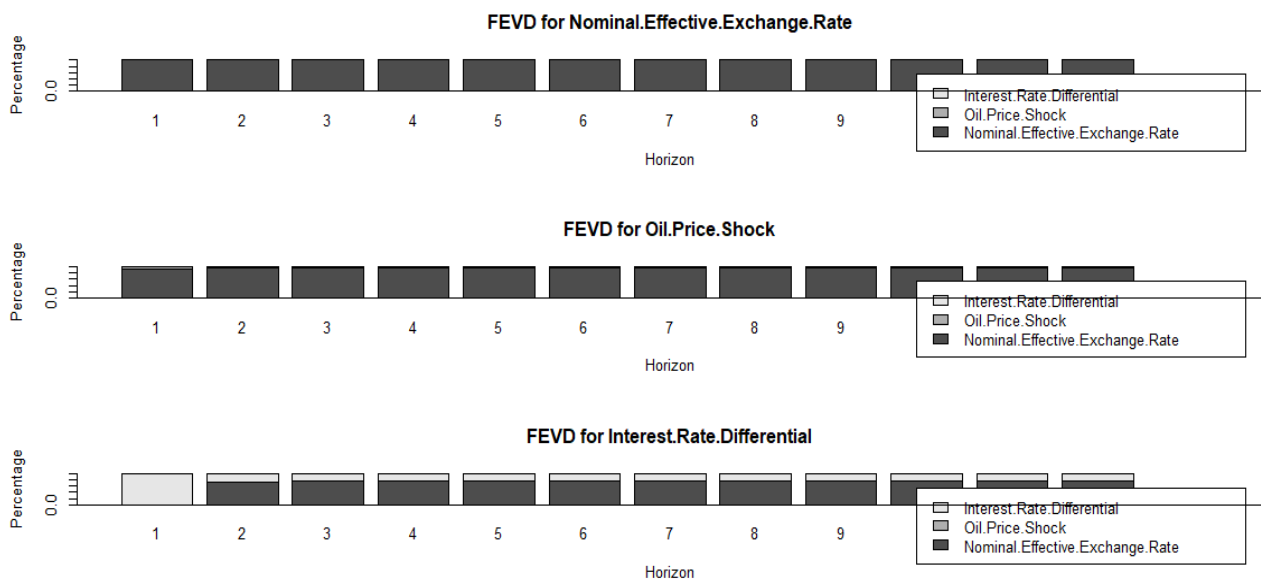


*Source: Author's computation (2024)*

**Figure 4.8: Nominal Effective Exchange Rate Impulse Response to Interest Rate Differential**

Figure 4.7 shows that when there is a shock in the interest rate differential growth, the growth of the nominal exchange rate will increase (depreciate) for the first two months, and decrease (appreciate) thereafter. A shock in the interest rate differential may refer to a sudden increase in the domestic interest rate; in that case, we would expect a depreciation in the domestic currency. Hence, Figure 4.7 implies that the exchange rate does not respond with a lag to interest rate differential, which is inconsistent with Omolade et al. (2019).

FEVD is estimated to observe how other variables explain the variance of one variable. Since oil consumption in South Africa has increased and the world has been experiencing oil price changes, it is expected that exchange rate variance is to be explained mostly by oil prices rather than interest rate differential. The figure below shows the results from the estimation of FEVD.

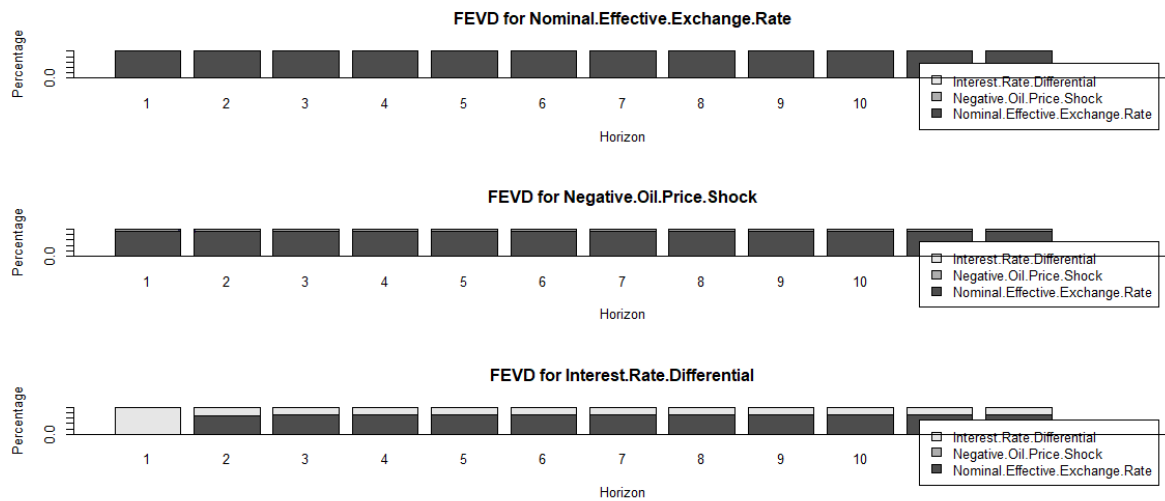


*Source: Author's computation (2024)*

**Figure 4.9: Forecast Error Variance Decomposition (Oil Price Shocks)**

Figure 4.9 shows that the growth of the nominal effective exchange rate is fully explained by itself in all periods. This implies that how the nominal exchange rate varies is not dependent on oil prices and the interest rate. This, to some extent, supports the ordering of the variables in the SVAR, where the interest rate came after the nominal exchange rate. The figure also shows that oil prices explain themselves slightly in the first month and thereafter are fully

explained by the nominal exchange rate. This is not expected in a small oil-importing country. Interest rates are explained by themselves and the exchange rate, which further supports the ordering of the SVAR.



*Source: Author's computation (2024)*

**Figure 4.10 Forecast Error Variance Decomposition (Negative Oil Price Shocks)**

Figure 4.9 is similar to Figure 4.8. It shows that the growth of the nominal effective exchange rate is explained by itself, the growth of negative oil price shocks is explained by the growth of nominal exchange rates, which is also not expected in a small oil-importing country, and interest rate differentials are explained by itself and nominal exchange rate.

#### 4.8 Conclusion

This section aimed at examining the dynamics between positive and negative oil prices and the ZAR. It achieves this by estimating a structural vector autoregressive (SVAR) model. The model allows the study to impose restrictions, based on the theoretical findings of other authors, on the mechanism that captures a clear interpretation. Furthermore, the study employs the impulse response method (Cholesky decomposition) to further examine whether the nominal exchange rates respond symmetrically to changes in oil prices. The study finds a negative

relationship between the growth of the nominal exchange rate and the growth of both oil price shocks as a 1% increase (decrease) in oil prices leads to a 0.03% appreciation (0.1% depreciation). The impulse response results were almost all insignificant; however, they show a lack of symmetry since the growth of the nominal exchange rate changes in the same direction regardless of the price shock. Moreover, the magnitude is not the same as the nominal exchange rate responds more to negative oil price shocks. This conclusion of no symmetry contradicts some researchers' conclusions, Saudi et al. (2021) and Ngoma et al. (2016); however, it reveals the significance of the role being played by the unobserved factors. However, in terms of oil price volatilities, the study implies that the South African rand depreciates in periods of uncertainty, and this is supported by (Miyajima, 2020).

## **CHAPTER 5: CONCLUSION AND RECOMMENDATION**

### **5.1 Summary**

The study analysed the dynamics between oil prices and the South African exchange rates. Its main objectives were to examine the relationship between oil prices and the exchange rate and further examine if exchange rates respond symmetrically to changes in oil prices. To achieve these objectives, the study uses monthly data from 2000M1 till 2023M12 extracted from the Federal Reserve Bank of St. Louis and the World Bank. It employed the structural vector autoregressive (SVAR) model to conduct the estimations which allows it to impose restrictions in the model using theoretical findings and further conduct impulse responses.

The study acknowledges that South Africa is a small net oil-importing country, which makes it vulnerable to oil price shocks. The main common and crucial finding in the literature was the wealth effect. The wealth effect implies that when oil prices increase, wealth is transferred from the oil-importing countries to the oil-exporting countries through revenue gains. Oil-importing countries require more dollars to import oil. Therefore, their currency depreciates, and the currency of oil-exporting countries appreciates. There exists a belief that increases and decreases in oil prices of the same magnitude do not have the same opposite effects on the exchange rates. Hence, the study decomposed oil prices into two partial sums that capture shocks, namely, the positive oil price shock and the negative oil price shock. This enabled it to estimate the asymmetry of oil prices.

After the estimations, the study, therefore, found negative relationships between both oil price shocks and the exchange rate. On average, a 1% increase in the growth of oil prices resulted in a 0.03% decrease in the growth of the nominal exchange rate implying an appreciation, holding other factors constant. Moreover, on average, a 1% decrease in the growth of oil prices resulted in a 0.1% increase in oil prices (depreciation), holding other factors constant. While there's still a debate about the symmetric response of the exchange rate, the study found results that contradict the findings of most authors, Saidu et al (2021) and Ngoma et al. (2016), that is, the exchange rate does not respond symmetrically to oil prices. The study shows insignificant impulse responses that show that the growth of the exchange rate responds similarly to changes in oil prices regardless of the shock; however, the magnitude differs such that the exchange rate responds more to negative oil prices. This finding contradicts Kumar (2019) as he finds that

the exchange rate responds more to positive oil price shocks. This proves that the understating of how exchange rates behave is far from being discovered, given the number of existing research studies around it and the still conflicting conclusions. However, oil price volatilities led to exchange rate depreciation, as expected.

## **5.2 Limitations and Recommendations**

Given the outlined economic disturbances that have affected the dynamics between oil prices and exchange rates, the study did not take into consideration the structural breaks that might cause the relationship between these two to change over time. The results showed that the variance of real exchange rates is fully explained by itself. However, the economy always observes how exchange rates change when the price level changes. Therefore, this might mean that there are other factors that explain the variance of exchange rates even more than the ones included in the model. When oil prices change, the prices of goods that are produced using oil also increase. This is because oil is an input good, and an increase in input good increases its price. Therefore, when South Africa imports, it also incurs the increments in these other goods, hence including the price level of each country, which would have assisted in controlling the extent to which oil prices affect exchange rates.

The South African state needs to implement some measures that will control the influence that oil price changes have on the South African economy. Since a positive oil price shock leads to depreciation, the state can restrict the importation of oil during these hikes in oil prices to avoid this depreciation. By doing so, they will be reducing the chances of experiencing inflation in the country. Furthermore, stabilizing the Rand could also serve as a measure to combat international spillovers, as Chikwira & Jahed (2024) argue that exchange rate stabilization assists in mitigating global shocks and uncertainties. The study did not aim to examine the extent to which imported crude oil affects the country's price level; however, this could be interesting to discover since South Africa is a highly industrialized economy. In addition, Huang et al. (2020) touches on how expectations enter crude oil modelling. Finding out how South African expectations affect the demand and further the price of oil would have a significant contribution towards the existing literature.

## 6. References

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# APPENDIX 1: Ethical Clearance Letter



30-08-2024  
Miss Nozipho Sinenhlanhla Dube (220031975)  
School Of Acc Economics&Fin  
Westville

Dear Miss Nozipho Sinenhlanhla Dube,

**Original application number:** 00025750  
**Project title:** Oil prices and exchange rates dynamics in South Africa

## Exemption from Ethics Review

In response to your application received on 30 August 2024, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW**.

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.


In case you have further queries, please quote the above reference number.

### PLEASE NOTE:

Research data should be securely stored in the discipline/department for a period of 5 years.

I take this opportunity of wishing you everything of the best with your study.

Yours sincerely,

  
Prof Claire Lauren Vermaak  
Academic Leader Research  
School Of Acc Economics&Fin

UKZN Research Ethics Office  
Westville Campus, Govan Mbeki Building  
Postal Address: Private Bag X54001, Durban 4000  
Website: <http://research.ukzn.ac.za/Research-Ethics/>

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