EXCHANGE-RATE DYNAMICS IN SOUTH AFRICA DURING THE GLOBAL COVID-19 PANDEMIC

.

by

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DECLARATION

I declare that Exchange-rate dynamics in South Africa during the global Covid-19 pandemic: Quantitative analysis of the causes of Exchange-rate volatility in South Africa during the global Covid-19 pandemic and the role of fiscal and monetary policy is my own work. All sources that I have used or quoted have been indicated and acknowledged, making use of complete references.

I further declare that I have submitted my dissertation to originality checking software and it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work. or any part of it, for examination at Unisa for another qualification or at any other higher education institution.

KC Young

Signature

20 February 2024

Date

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DEDICATION

This dissertation is dedicated to my husband, Janico Bester, who has been my anchor throughout this endeavour. Your faith in me has fuelled my determination and sustained me through any challenges I faced.

I also dedicate this work to my parents, Alan and Antoinette Young. It is through your unwavering support, love and sacrifices that I stand where I am today. For which I am forever grateful.

Lastly, I dedicate this work to my siblings, Michaela, Courtney and Reegan, who have served as an endless source of laughter and joy, which has made the challenges more bearable and the success more joyful.

ABSTRACT

This study examines the volatility of the USD/ZAR exchange rate in South Africa during the Covid-19 pandemic. Covid-19 was a global pandemic that affected all countries across the globe, placing limits on the mobility between cities and countries in terms of the movement of goods, services, and individuals. During this period more economically vulnerable countries, such as South Africa, were more predisposed to the effects of this and thus experienced increased levels of volatility within various markets. This research aims to take a closer look at the volatility of the foreign-exchange market, between the South African rand and United States dollar, during the period, to determine if Covid-19 resulted in increased volatility within this market.

Furthermore, this study takes a close look at the drivers of volatility during this period, to determine if the monetary and fiscal policies implemented by the South African government were successful in restricting the level of volatility.

In order to determine the volatility of the USD/ZAR exchange rate, an EGARCH model is generated for the prior period, as well as for the period where covid was considered national state of disaster. This model revealed that, overall, there is volatility and specifically volatility clustering within the market, as both tests yielded significant results. However, it was noted that, during the Covid-19 period, the persistence of volatility as viewed in the GARCH variable was increased, meaning there was more persistent volatility during this period. When viewing the descriptive statistics of this model, it was noted that there was a larger period of volatility in prior periods, which indicated that monetary or fiscal policy may have been able to restrain this to an extent. To test this, the error correction model was estimated based on the monthly exchange rate, real interest rate, broad money supply and government spending. This estimation revealed that, while monetary policy tools, real interest rates and broad money supply were significant factors in the determination of the USD/ZAR exchange rate during this period, the fiscal-policy tool government spending did not. Lastly, this study determined that in the event of a global crisis, measures such as; decreasing the repo rate, are effective and should be utilised. As these measures assist borrowers in managing their financial obligations. An alternate SARB policy recommendation that proved to be fruitful is enhancing the liquidity in the banking sector, increased money supply assisted in maintaining exchange rate stability, by limiting volatility in the foreign

exchange market. A final policy recommendation determined is that fiscal policies should not be used with the intention of affecting the exchange rate dynamics.

Key words: Exchange rate, Volatility, Covid-19 pandemic, Fiscal policy, Monetary Policy, EGARCH

KAKARETŠO

Nyakišišo ye e latelago e ka ga phetogophetogo ya kelo ya neeletšano ya USD/ZAR ka Afrika Borwa nakong ya leuba la Covid-19. Covid-19 e bile leuba la lefase ka bophara leo le amilego dinaga ka moka lefaseng ka bophara, le le beago mellwane ya mosepelo gare ga ditoropokgolo le dinaga go ya ka tshepelo ya dithoto, ditirelo le batho. Mo lebakeng le dinaga tšeo di nago le ikonomi ya go fokola, go swana le Afrika Borwa, di amilwe kudu ke dikhuetšo tše gomme ka go realo di itemogetše maemo ao a oketšegilego a phetogophetogo ka gare ga mebaraka ya go fapana. Maikemišetšo a dinyakišišo tše ke go lebelela ka kelohloko go phetogophetogo ya mmaraka wa neeletšano ya dinaga tša ka ntle gare ga ranta ya Afrika Borwa le tolara ya United States mo lebakeng le, go bona ge eba Covid-19 e feleleditše ka phetogophetogo ye e oketšegilego ka gare ga mmaraka wo.

Go feta fao, nyakišišo ye e lebelela ka kelohloko dihlohleletši tša phetogophetogo mo lebakeng le, go bona ge eba dipholisi tša ditšhelete le ikonomi tšeo di phethagaditšwego ke mmušo wa Afrika Borwa e atlegile go thibela maemo a phetogophetogo.

Go laetša phetogophetogo ya kelo ya neeletšano ya USD/ZAR, mmotlolo wa EGARCH o tšweleleditšwe lebaka le le fetilego, go tloga ka la 1 Febereware 2018 go fihla ka la 29 Febereware 2020 gammogo le lebakeng la Covid gare ga la 1 Matšhe 2020 le mafelelo a kgwedi a maemo a bosetšhaba a masetlapelo ka Aporele 2022. Mmotlolo wo o utolotše gore, ka kakaretšo, go na le phetogophetogo le phetogophetogo ye e kgobokanego fela ka gare ga mmaraka, ka ge diteko ka bobedi di tšweleditše dipoelo tše bohlokwa. Le ge go le bjalo, go lemogilwe gore lebakeng la Covid-19, phegelelo ya phetogophetogo bjalo ka ge go bonwe ka gare ga phetogo ya GARCH go oketšegile, mo go šupago gore go bile le phetogophetogo ye e phegeletšego kudu mo lebakeng le. Ge go lebelelwa dipalopalo tše di hlalošago tša mmotlolo wo, go lemogilwe gore go bile le lebaka le letelele la phetogophetogo mo mabakeng ao a fetilego, yeo e laeditšego gore pholisi ya ditšhelete goba ya ikonomi e ka ba e kgonne go thibela se go fihla bokgoleng bjo itšego. Go leka se, mmotlolo wa tokišo ya diphošo o akanyeditšwe go ya ka kelo ya neeletšano ya kgwedi le kgwedi, kelo ya tswala ya nnete, kabo ya tšhelete ye e nabilego le tšhomišo ya tšhelete ya mmušo. Kakanyetšo ye e utolotše gore, le ge e le gore didirišwa tša pholisi ya ditšhelete, dikelo tša tswala ya nnete le kabo ya tšhelete ye e nabilego e be e le

mabaka a bohlokwa mo go laetšeng kelo ya neeletšano ya USD/ZAR mo lebakeng le, tšhomišo ya tšhelete ya mmušo ya sedirišwa sa pholisi ya ditšhelete ga se go be le khuetšo ye kgolo godimo ga kelo ya neeletšano.

Mantšu a bohlokwa: Kelo ya neeletšano, phetogophetogo, leuba la Covid-19, Pholisi ya ditšhelete, Dipeelano tša mmušo, EGARCH

OPSOMMING

Die volgende studie oorweeg die wisselvalligheid van die USD/ZAR-wisselkoers in Suid-Afrika gedurende die Covid-19-pandemie. Covid-19 was ’n wêreldwye pandemie wat alle lande regoor die wêreld geraak het, en beperkings geplaas het op mobiliteit tussen stede and lande wat betref die beweging van goedere, dienste en individue. Gedurende hierdie tydperk was ekonomies kwesbare lande, soos Suid-Afrika, meer vatbaar vir hierdie nadelige gevolge van die pandemie, en het die lande dus verhoogde vlakke van wisselvalligheid in verskeie markte ervaar. Hierdie navorsing se doel is om die wisselvalligheid van die buitelandse-valutamark tussen die Suid Afrikaanse rand en die Amerikaanse dollar gedurende hierdie tydperk van nader te ondersoek, om te bepaal of Covid-19 verhoogde wisselvalligheid in hierdie mark tot gevolg gehad het.

Verder kyk hierdie studie ook van naderby na die dryfvere van wisselvalligheid gedurende hierdie tydperk, om te bepaal of die monetêre en fiskale beleide wat deur die Suid-Afrikaanse regering geïmplementeer is, suksesvol was om die vlak van wisselvalligheid te beperk.

Om die wisselvalligheid van die USD/ZAR-wisselkoers te bepaal is ’n EGARCH-model geskep vir die tydperk voor die Covid-19 pandemie, asook vir die Covid-tydperk tot die einde van die maand van die nasionale ramptoestand in Suid-Afrika. Hierdie model het onthul dat daar, oor die algemeen, wisselvalligheid en spesifiek wisselvalligheidsvorming in die mark is, aangesien albei toetse beduidende resultate gelewer het. Daar is egter agtergekom dat die voortduur van wisselvalligheid soos beskou in die GARCH-veranderlike toegeneem het gedurende die Covid-19-tydperk, wat beteken dat daar meer voortdurende wisselvalligheid gedurende hierdie tydperk was. Wanneer daar gekyk word na die beskrywende statistieke van hierdie model is daar opgelet dat daar ’n groter tydperk van wisselvalligheid in vorige tydperke was, wat aangedui het dat monetêre of fiskale beleid dit tot ’n mate kon beperk het. Om hierdie te toets is die foutregstellingsmodel beraam gebaseer op die maandelikse wisselkoers, reële rentekoers, breëgeldvooraad (broad money supply) en owerheidsbesteding. Hierdie beraming het onthul dat hoewel monetêre beleidshulpmiddels, reële wisselkoerse en breëgeldvoorraad beduidende faktore was in die bepaling van die USD-ZAR-wisselkoers gedurende hierdie tydperk, het

owerheidsbesteding, ’n fiskale-beleidshulpmiddel, geen beduidende impak op die wisselkoers of die wisselvalligheid daarvan gehad nie.

Sleutelterme: wisselkoers, wisselvalligheid, Covid-19-pandemie, fiskale beleid, owerheidsbeperkings, EGARCH

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ACRONYMS

AC	Autocorrelation
ADF	Augmented Dickey Fuller
ARCH	Autoregressive Heteroskedasticity
ARCH-LM	Autoregressive Heteroskedasticity La Grange Multiplier
ARMA	Autoregressive Moving Average
BOP	Balance of Payments
Covid-19	Coronavirus 2019
ECM	Error Correction Model
ECT	Error Correction Term
EGARCH	Exponential Generalised Autoregressive Heteroskedasticity
FDI	Foreign Direct Investment
FGLS	Feasible Generalised Least Squares
GARCH	Generalised Autoregressive Heteroskedasticity
GS	Government Spending
IMF	International Monetary Fund
IRP	Interest Rate Parity
M3	Broad Money Supply
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
OLS-PCSE	Panel-Corrected Standard Errors
PAC	Partial Autocorrelation
POLS	Pooled Ordinary Least Squares
PPP	Purchasing Power of Parity

PROB	Probability
RIR	Real Interest Rate
SARB	South African Reserve Bank
Stats SA	Statistics South Africa
USD	United States Dollar
USD/ZAR	United States Dollar vs South African Rand
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
WHO	World Health Organisation
ZAR	South Africa Rand

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1. ORIENTATION OF THE STUDY

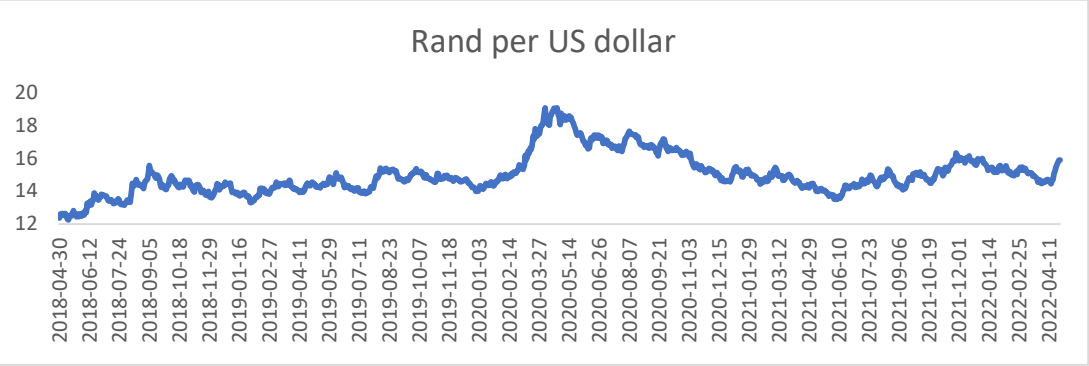
1.1. Introduction

On the 11th of March 2020, the World Health Organisation (WHO) officially declared the Covid-19 virus a pandemic (WHO Report, 2020). By the 15th of March 2020, the South African government officially declared a national state of disaster in South Africa, the start of what would have been a 21-day lockdown then proceeded to commence on the 26th of March 2020 (Sekyere, Bohler-Muller, Hongoro & Makoae, 2020). This national state of disaster proceeded to be in effect until the 22nd of April 2022 (SARB, 2022). The restriction of the mobility of individuals, goods, and services, not only between cities, but between countries as well, created an unstable economic environment and cultivated uncertainty for businesses, as well as the global economy (WHO report, 2020). Emerging market economies, such as South Africa, are most vulnerable to shocks and instability. Thus, the pandemic has had a deep and unprecedented impact on the economic and financial markets in these economies (Harjes et al., 2020).

In South Africa, the pandemic highlighted the issues relating to the robustness and flexibility of the financial market in the country (Sekyere et al., 2020). An area of the financial system in South Africa that displayed a large amount of volatility during this period was the exchange rate (Lyke & Ho, 2021). This research takes a closer in-depth look at the effects thereof.

Figure 1.1 depicts the South African Rand to US dollar exchange rate, from the 30th of April 2018 up until the 11th of April 2022.

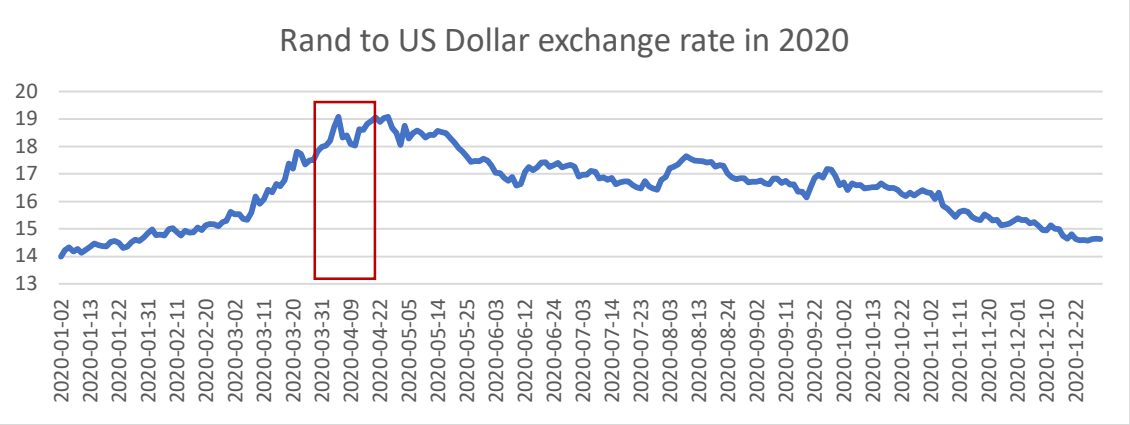
Figure 1.1: Rand per US dollar exchange rate



Source:___https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates

During this period illustrated in figure 1.1, a sharp rise in the USD/ZAR exchange rate is noticeable around 2020. A closer examination of the year 2020, as observed in the figure below (figure 1.2), reveals that the USD/ZAR exchange rate peaked concurrently with the announcement of the national state of disaster in South Africa.

Figure 1.2: Rand per US dollar exchange rate in 2020



Source:___https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates

When comparing the exchange rate over the two periods, before and during the

Figure 1.3 & 1.4: USD/ZAR prior to Covid-19 pandemic

COVID-19 pandemic, it becomes evident that during the pandemic graphically there appears to be a higher level of volatility. With the exchange rate reaching levels it had not previously reached, this may be viewed in figures 1.3 and 1.4.

Figure 1.4: USD/ZAR exchange rate prior to the Covid-19 pandemic

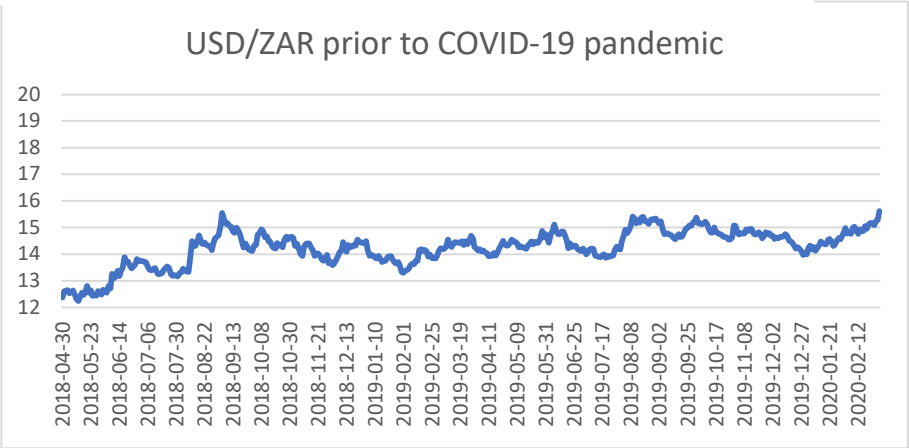
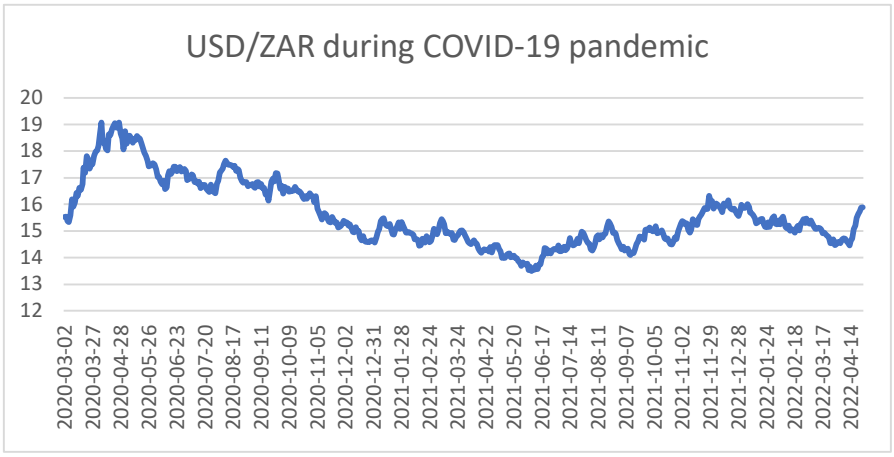


Figure 1.3: USD/ZAR exchange rate during the Covid-19 pandemic



Source:___https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates

During a financial crisis, it is generally accepted that the central bank of the country plays a critical role (Harje et al. 2020). Thus, this study considers if, in South Africa, the South African Reserve Bank (SARB) played a significant role, by implementing monetary policies in the form of interest-rate adjustments and monetary easing (Harjes et al., 2020). In response to the COVID-19 pandemic the SARB undertook the following monetary policy changes; firstly the SARB substantially reduced the repo rate from 6.75% in January 2020 to 3.75% in May 2020 (South African Reserve Bank, 2020). This reduction aimed to ease the financial burden on borrowers by lowering

interest rates, thus reducing the cost of borrowing (South African Reserve Bank, 2020). To ensure the stability and smooth functioning of financial markets, the SARB increased liquidity within the banking sector. This was achieved through the purchasing of government bonds and the expansion of the size and duration of repo facilities, with the aim of maintaining financial stability and liquidity in the banking system (South African Reserve Bank, 2020). The SARB also introduced loan guarantee schemes, to provide support to small and medium-sized enterprises (South African Reserve Bank, 2020). These allowed small and medium-sized enterprises easier access to loans to cover operating expenses (South African Reserve Bank, 2020). Lastly, the SARB implemented regulatory relief measures that allowed banks to provide capital relief to customers with previously good-standing loans (South African Reserve Bank, 2020). By allowing banks a lower liquidity cover ratio and lower capital requirements, easing their operational pressures and supporting continued lending (South African Reserve Bank, 2020). Bearing this in mind this study considers the impact of monetary policy actions on exchange-rate dynamics (South African Reserve Bank, 2020).

In addition to this, during this period, the government implemented additional social grants and made relief funds accessible to struggling businesses. Thus, this study, also seeks to determine if the South African government was able to restrict exchange-rate volatility by implementing fiscal policies during this period. This is achieved by examining the role of fiscal policies in exchange-rate dynamics. This study aims to assist in the determination of the appropriate fiscal-policy response to be taken by the South African government in the event of a similar crisis in the future, as well as appropriate monetary policy responses to be taken by the SARB.

1.2. Problem statement

The COVID-19 pandemic is a globally experienced issue. This COVID-19 virus resulted in, not only psychological and physical suffering for individuals, but economic and financial suffering for most countries across the globe (Feng et al., 2021). The extent of the lasting impact on the global economy and its various markets has yet to be determined.

During the height of this pandemic, most, if not all, economic indicators in the South African economy experienced a shock of instability (Lyke & Ho, 2021). As illustrated in figure 1.1, one such factor was the exchange rate. In South Africa, the exchange rate has a vast effect on the price of imports and exports, due to the free-floating nature thereof (Ngondo & Khobai, 2018). Therefore, a change in the exchange rate affects the community at large (Cravino & Levchenko, 2017). However, the most marginalised in the country often feel the greatest effect thereof (Cravino & Levchenko, 2017). This is often referred to as the distributional effect of currency devaluations (Cravino & Levchenko, 2017).

To stabilise the value of the rand during the pandemic, economic authorities, namely the SARB and South African government, implemented both monetary and fiscal-policy measures, respectively (International Monetary Fund, 2021). To date there has been limited research done to determine the success of these fiscal and monetary measures implemented in maintaining the value of the South African Rand during COVID-19. This study focuses on these measures, to determine the effectiveness thereof.

The value of investigating the overall effect of the pandemic on exchange-rate volatility experienced in South Africa, as well as how the South African government and SARB were able to restrain this by making use of fiscal-policy measures, lies in understanding the phenomenon. Specifically, for future reference, if researchers and the necessary monetary and fiscal authorities have a greater understanding of the effect of such shocks, it may assist them in their decision-making process in the future, thereby allowing them to react in the most optimal manner.

1.3. Research questions

In this study the following research questions will be considered.

1. How did the Covid-19 pandemic affect the volatility of the South African rand when compared to the United States dollar?
2. Was the South African government able to restrict exchange-rate volatility by implementing fiscal policy as and when it did?

3. Was the SARB able to restrict exchange-rate volatility by implementing monetary-policy measures as and when it did?

1.4. Justification and purpose of the study

The purpose of this research is to determine the role that financial and global crises play in the volatility of the exchange rate in South Africa.

Many studies have been performed on previous financial crises, which have offered valuable insight into the appropriate steps that should be taken in such a situation. One such example in Kohler's 2010 study on the 2008/2009 global financial crises and how this effected exchange rates during this period, more studies based on this are discussed in depth in the research. Thus, this study aims to take a close look at the most recent global crises, the global Covid-19 pandemic, so as to determine the effect thereof on the South African exchange rate market. Furthermore, this study would offer insight into the reaction of the government and the SARB, in terms of policy actions, during this period and assist in determining the success thereof.

1.5. Aim and objectives of the study.

1.5.1. Research aim

The aim of this research is to quantitatively determine the level of exchange-rate volatility observed in the value of the South African rand when compared to the United States dollar, due to the Covid-19 pandemic.

1.5.2. Primary objective

The primary objective of the study is to make use of the Exponential Generalised Autoregressive Heteroskedasticity model (EGARCH), so as to determine the level of volatility experienced between the ZAR and USD, as a result of Covid-19.

1.5.3. Secondary objectives

In order to successfully achieve the primary objective, the following secondary objectives are also thoroughly pursued.

1. To examine the extent to which fiscal-policy actions taken by the South African government restrict exchange-rate volatility in South Africa.

2. To examine the extent to which monetary-policy actions taken by the SARB restrict exchange-rate volatility in South Africa.
3. To examine the implication of fiscal- and monetary-policy actions, taken during a global crisis, on exchange-rate dynamics in the country.

1.6. Hypothesis statements

1.6.1. Primary Hypothesis

H_0: There exists no relationship between the Covid-19 pandemic and the volatility of the South African exchange rate, between March 2020 and April 2022

H_A: There exists a relationship between the Covid-19 pandemic and the volatility of the South African exchange rate, between March 2020 and April 2022.

1.6.2. Secondary Hypothesis:

H_0: Fiscal-policy actions taken by the government during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate.

H_A: Fiscal-policy actions taken by the government during the Covid-19 pandemic were successful in constraining the volatility of the South African exchange rate.

H_0: Monetary-policy actions taken by the SARB during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate.

H_A: Monetary-policy actions taken by the SARB during the Covid-19 pandemic were successful in constraining the volatility of the South African exchange rate.

1.7. Significance of the study

The researcher believes the value of the study lies in its ability to assist researchers and policymakers in the decision-making process, should similar global crises occur in the future. In addition to this, it should be considered that South Africa is still recovering from the shock and confines of the pandemic. Thus, the conclusion of this study may assist economic agents in the understanding of current occurrences and volatility, as the economy continues to attempt to regain stability.

1.8. Delimitations

For convenience, the study is limited to the relationship between the South African rand and the United States dollar. However, considering this was a global pandemic that affected all countries, future studies should consider the effect of more than the USD, for example, the Euro, as some of the volatility experienced in the South African rand may be as a result of worsening or improving conditions in countries apart from the United States. In addition to this, this study is only able to accommodate the volatility between the ZAR and USD. In order to test the relative strength of the rand, a recommendation for future studies would be to perform this study in comparison to other developing countries' currencies.

1.9. Definition of key terms

1.9.1. Exchange rate vs exchange-rate volatility

The exchange rate is often defined as the price of one currency in terms of another currency, expressed by making use of the domestic currency (Catão, 2020). This is, however, the nominal definition. To thoroughly understand the concept of the exchange rate, one should consider the real definition thereof (Catão, 2020). The real exchange rate is defined as the relative price of one currency in terms of another. This means economists rather consider the amount of (domestic) currency a country would have to convert (to foreign currency) to purchase the same value of goods in another country with a different currency (Catão, 2020).

The exchange rate can be influenced by many factors. Some of the most common are the rate of economic growth experienced in the relevant country, the interest rate, the relative inflation rate, the level of confidence, and the competitiveness of the countries' labour and goods market, as well as the relative strength of other currencies. The current account balance on the balance of payments also plays a key role (Anthony, 2003).

When exchange rates change unexpectedly, the risk associated with the movement is referred to as the exchange-rate volatility (Ozturk, 2006). These movements or changes are often attributed to being a direct result of movements in the balance of payments, inflation rate, interest rate and so forth (Ozturk, 2006). The volatility of a country's exchange rate is especially important with regard to international trade, as

well as investments (Ozturk, 2006). As volatility creates uncertainty, a more stable exchange-rate environment encourages trade and investment (Erdal, 1997).

1.9.2. Method of determination of exchange rates

Countries manage their exchange-rate systems in different ways, depending on the exchange-rate regime they have chosen to follow (Williamson, 2018). This regime is often intricately linked to their economic policy and determines countries exchange rate (Visser, 2004). There are two core exchange-rate regimes, namely, the fixed system and the floating (flexible) system (Visser, 2004). Under the floating exchange-rate regime, the exchange rate is determined within the foreign-exchange market by the market powers, demand and supply. There is no intervention by authorities within this market (Williamson, 2018). Under the fixed exchange rate regime, authorities set the exchange rate at a specific level relative to another currency (Blanchard & Johnson, 2018). However, Williamson (2018) explains further that the ways in which the fixed system is implemented can differ. The exchange rate can be set under a fixed system with a soft peg or with a hard peg (Williamson, 2018). A soft peg implies that the exchange rate is secured relative to another currency for a period of time, but it is not restricted in the long run (Williamson, 2018). Thus, this system allows the exchange rate to be revalued, either positively or negatively (Williamson, 2018). Under this version of the fixed exchange rate regime, countries are often, in the short run, committed to maintaining the value of their currency within a specific range (Williamson, 2018). On the contrary, under the hard-pegged fixed exchange rate system, a country will fix its exchange rate relative to another currency permanently (Williamson, 2018).

1.9.3. Role of government intervention and its fiscal-policy implications

When the government intervenes in the market via taxation and government spending, with the aim of reducing poverty and promoting growth and stability in the economy, it is referred to as fiscal policy (IMF, 2020). Feng et al. (2020) conducted a study on the response of the exchange-rate volatility to Covid-19 and government intervention in 20 various countries, where they determined that government policies implemented in response to the pandemic restrained the volatility of the exchange rate. This included fiscal-policy changes, additional income support such as stimulus checks and social grants, as well as aid received from the international community (Feng et al., 2020). Therefore, the researcher proposes to include the effect of fiscal changes in this study,

such as increased government spending and, in this way, determine how much of the volatility of the exchange rate was able to be restrained by the South African government.

1.9.4. Monetary-policy goals and the implication thereof

Monetary policy is a means by which monetary authorities are able to regulate and influence the overall economic activity of an economy (Friedman, 2000). This policy has two main objectives: firstly, to ensure there is stability with the overall prices of goods and services and thus to control inflation (Friedman, 2000). Second, this policy aims to ensure that both employment and output are maximised (Friedman, 2000). Supplementary goals of monetary policy that are often deemed appropriate are also to ensure there is stability within a country's financial market and to maintain a balance in international trade (Freidman, 2000).

In South Africa, the South African reserve bank (SARB) implements monetary policy (South African Reserve Bank, 2022). The SARB primarily makes use of the repo rate in order to succeed in achieving its monetary-policy goals (South African Reserve Bank, 2022). By reducing the repo rate, the SARB is able to reduce the short-term interest rate in the country. This in turn makes debt, specifically existing debt, more affordable for both individuals and businesses (Sekyere et al., 2020). However, for statistical purposes, economists commonly make use of the real exchange rate when examining monetary policy (Sekyere et al*.,* 2020). The real interest rate is defined as the interest rate at which banks lend, adjusted for inflation (World Bank Group, 2023).

Another method used is the restriction of the supply of monetary reserves (South African Reserve Bank, 2022). A study performed on data from various developing countries determined that monetary policy has a major, if not the largest, impact on exchange rates (Dilmaghani & Tehranchian, 2015). However, his effect does vary depending on the countries' chosen economic system (Dilmaghani & Tehranchian, 2015: 187). The variable most commonly considered when analysing this is the broad money supply (m3). This is the sum of all the demand deposits, as well as currency outside of the banks. It also includes bank and travellers' checks, deposit and commercial paper security certificates and lastly the foreign currency deposits, time and savings of local sectors not included in the central government (World Bank Group, 2023).

1.10. Chapter outline

This research study is comprised of five chapters, as follows.

Chapter 1: Outlines the background, purpose of the study and research problem. It also details the research, questions, aim and objectives, as well as describes the hypothesis of the study. This chapter also discusses the significance, limitations and recommendations of the study and lastly defines the important terms relevant to the study,

Chapter 2: Takes an in-depth view of the literature available on this topic. This includes empirical literature.

Chapter 3: Is a detailed description of the research design, methodology and data analysis.

Chapter 4: Is the data analysis. This chapter also reviews the findings of the data analysis.

Chapter 5: Discusses the results and implications of the data analysis, draws conclusions regarding the analysis, and makes recommendations based on the conclusions, as well as highlights the limitations and recommendations for future studies.

2. LITERATURE REVIEW

2.1. Introduction

As outlined above, there is a general consensus that the 2019 Coronavirus pandemic (COVID-19) created a global economic crisis with far-reaching effects, with the financial market, specifically the exchange rate market being one of the affected areas (Fent et al., 2021). There is a diverse array of research regarding the volatility of exchange rates during the previous 2008/2009 global financial crises, however, there are critical gaps and unresolved questions in current research regarding the exchange rate dynamics during the most recent COVID-19 pandemic.

This literature reviews aims to provide a comprehensive overview of existing research on exchange rate dynamics and the volatility thereof, focusing on the various exchange rate regimes, theories and how countries choose a specific regime, with an emphasis on the South African exchange rate regime. By examining research based on the 2008/2009 global financial crisis as well as more recent studies based on the COVID-19 pandemic. The purpose of the literature review is to clearly establish a clear understanding of the current state of research and to pinpoint areas where further investigation is needed.

2.2. Theoretical literature review

2.2.1. How exchange-rate regimes are chosen

Exchange-rate regimes are chosen bearing both internal and external balance in mind (Krugman, Obstfield & Melitz, 2018). In order for there to be internal balance, there must first be price-level stability, meaning inflation should be stable, but there should also be full employment (Krugman et al*.,* 2018). External balance occurs when a country's current account is balanced, meaning it should not have an extreme deficit or surplus that would prevent it from paying its debt or prevent another country from servicing its debt to them (Krugman et al*.,* 2018). Ultimately, when choosing their exchange-rate system, authorities consider the main economic focus areas, while also taking into consideration their unique circumstances (Yagci, 2001). However, the exchange rate only forms part of the intermediate target for economic policymakers, with the ultimate goal being inflation stability (Ingham, 2010).

Recent studies have shown that cultural factors play a role in the determination of a country's exchange-rate regime, with the greatest cultural influence being individualism (Cao et al., 2020). In this social-analysis study, it was determined that countries that place more emphasis on the needs of individuals, above that of society as a whole, tend to opt more towards free-floating exchange-rate regimes (Cao et al., 2020). These countries show evidence of being willing to take larger risks and increased confidence levels. Agents in the economy also tend to be more independent (Cao et al., 2020). Furthermore, democratic countries have a higher tendency to opt for a free-floating exchange rate. These countries generally have fewer capital controls and are often viewed as advanced in terms of financial development (Cao et al., 2020).

Members of the International Monetary Fund (IMF) have to adhere to three main principles (Carbaugh, 2017). First, competitive advantages between members should remain equal. Therefore, members should avoid manipulating exchange rates to the extent that effective balances of payments are not possible (Carbaugh, 2017). Second, members should attempt to maintain order in the exchange-rate market in both the short and long term (Carbaugh, 2017). Lastly, all members should consider the way in which their actions within the market could potentially affect other members (Carbaugh, 2017).

2.2.2. Historical overview of exchange-rate regimes

Throughout history, there are various periods of exchange-rate regimes. They are defined as follows:

1) The (Classical) International Gold Standard

This exchange-rate regime was based on the historical use of gold coins in exchange (Krugman et al., 2018). Under this exchange-rate regime, the value of a currency was backed by the amount of gold that the country held, making gold the international store of reserves (Krugman et al., 2018). During this period, banks in countries making use of the Gold Standard were compelled to exchange local currency for gold. There were no limitations on the export or import of gold. Thus, gold operated in a free market (Krugman et al., 2018). Central banks were required to maintain parity between the currency and the amount of gold held (Krugman et al., 2018).

Under this system, there was a fixed exchange rate that existed between all currencies (Krugman et al., 2018). However, the exchange rate was determined by the supply

and demand for gold. Therefore, the value of gold could fluctuate, resulting in a change in the exchange rate (Krugman et al*.,* 2018). Support for the Gold Standard centred on the access it granted countries to the international market (Krugman et al*.,* 2018). Other benefits include the symmetric monetary adjustment it offers (Krugman et al*.,* 2018). Under the Gold Standard all banks share the balance of payments re-adjustment that results from arbitrage, due to the fixed exchange rate (Krugman et al*.,* 2018). Another advantage included the fact that monetary policies' effects on price levels are limited, as money supply is unable to grow at a faster rate than money demand (Krugman et al*.,* 2018).

However, the disadvantages thereof are as follows: limiting the use of monetary policy has the added effect that economic agents are unable to use monetary policy as a tool to fight unemployment (Krugman et al*.,* 2018). In order to ensure there is stability within the price level, the price of gold and other goods and services must also be stable (Krugman et al*.,* 2018). Evidence from this period made it apparent that, during this time, there was a large amount of volatility within the overall price of goods and services, as a result of the fluctuating price of gold and the relative price of gold (Krugman et al*.,* 2018). Furthermore, countries were not able to increase their reserves held. This meant that, unless there was a continual increase in the amount of gold processed, countries would not be able to enjoy increased economic growth (Krugman et al*.,* 2018). Lastly, countries which had more natural gold available to them had an advantage (Krugman et al*.,* 2018). The disadvantages of the Gold Standard make it impractical to use in today's economy (Krugman et al*.,* 2018).

In terms of the central bank, they had control over economic policy decisions throughout this period. The government had no role in these decisions (Ingham, 2010). Central banks under this system prioritised exchange-rate stability over all other economic policy objectives (Ingham, 2010). This included prioritising domestic economic goals rather than external goals, in the international market (Ingham, 2010).

2) Gold exchange standard during interwar years

During the First World War, the need for a change to this system emerged as a result of unusual effects caused by the war (Burnage & Ranadive, 2011). It emerged that gold could be purchased in South Africa at a lower price and sold in London at a higher

price, thereby restricting the banks' ability to service their commitments (Burnage & Ranadive, 2011). Therefore, many countries abandoned the Classical gold standard, during the war. This, however, meant that these countries' exchange rates were no longer fixed to the value of gold reserves held (Wandshneider, 2008). Thus, this resulted in volatile, free-floating exchange rates (Wandshneider, 2008). Many countries financed war spending by printing more money, resulting in increasing inflation (Krugman et al*.,* 2018).

After the conclusion of the war, in an effort to regain pre-war stability within this market, economic agents looked towards reinstating the Gold Standard. However, many officials were dubious about returning to this system, in fear of creating a worldwide gold shortage, which would further negatively impact the global economy (Wandshneider, 2008). In addition to this, as a result of inflated price levels, due to the war, many countries' currencies were determined to be overvalued. A return to the classical Gold Standard would have implied a devaluation (Wandshneider, 2008). This would in turn have resulted in deflation, further hindering economic growth (Wandshneider, 2008). Under the guidance of Britain, the new interwar Gold standard slowly developed, also known as the Gold Exchange Standard (Wandshneider, 2008).

The Gold Exchange Standard made use of key currencies, as well as gold as reserves (Wandshneider, 2008). In essence, most countries agreed to peg the value of their currency to a fixed price of gold. Alternatively, they linked their currency to a country that had done so (Krugman et al*.,* 2018). This system, much like the previous one, also restricted monetary growth (Krugman et al*.,* 2018). This system was set up predominantly based on the currencies of both the United States and the United Kingdom (Krugman et al*.,* 2018). Internationally the United Kingdom and United States currencies became the primary source of reserves. This made them carry more responsibility in terms of maintaining price levels (Krugman et al*.,* 2018).

This new system was riddled with instability as a result of deflation and market turbulence, making it a fragile system that only lasted approximately six years (Cowen, 1997). This system is often credited with contributing to the great depression (Cowen, 1997). More recently, it has been hypothesised that this system failed largely due to the current political environment (Wandshneider, 2008). During these interwar years and years following World War I, there was an rise in the demand for democracy. The

Gold Exchange Standard system and democracy were not well aligned (Wandshneider, 2008). After this system, the idea of a fixed exchange rate was abandoned. This led to the development of the Bretton Woods system (Wandshneider, 2008).

3) Bretton Woods system

Amidst the chaos of World War II, a new international monetary system emerged. This included a new method of exchange-rate determination (Krugman et al*.,* 2018). This system was designed based on the Bretton Woods Conference that took place in the United States in 1994 (Krugman et al*.,* 2018). The ultimate goal of the said conference was to develop a monetary system for all countries, based on price stability and the encouragement of full employment, without limiting their independence, especially in terms of international trade, to such an extent that they are unable to attain external balance (Krugman et al*.,* 2018). Thus, the Bretton Woods system promoted economic stability, as well as encouraging free trade and economic integration in the international market.

During the war, the need for a hybrid system became apparent. A system was required that allowed both stability, as offered by fixed exchange rates, and independence offered by floating exchange rates (Krugman et al*.,* 2018). Due to the level of political and economic dominance the United States maintained, its currency, the US dollar, became the centre of this system (Krugman et al*.,* 2018). This system fixed the price of gold per ounce in terms of US dollars. It should be noted this price was constant and unchanging (Krugman et al*.,* 2018). All other currencies then had a fixed exchange rate to the US dollar (Krugman et al*.,* 2018). All members of the system could hold their reserve assets in both gold and/or US dollars, including US dollar assets (Krugman et al*.,* 2018). Furthermore, this system allowed them to purchase gold in exchange for dollars from the US federal reserve, at the fixed price of gold per ounce (Krugman et al*.,* 2018). Thus, this made this system similar to the Gold Exchange Standard, however, with US dollars replacing gold as the main reserve asset (Krugman et al*.,* 2018). The US federal reserve was therefore responsible for fixing the price of gold and ensuring that price stability was maintained (Krugman et al*.,* 2018). This period was one of rapid growth for many economies (Krugman et al*.,* 2018).

The issue with the Bretton Woods exchange-rate system became known as the "confidence problem" (Krugman et al*.,* 2018). The US federal bank was required to exchange gold for US dollars, which resulted in an issue in the long term, as the stock of gold was not increasing at the same rate as the demand for currency (Krugman et al*.,* 2018). Thus, at any point, any country could be required to convert all their dollars to gold, resulting in the US possibly not being able meet its obligations (Krugman et al*.,* 2018). Thus, should there have been a lack of confidence in the dollar, resulting in countries converting their reserve assets from US currency to gold, the entire system would collapse (Krugman et al*.,* 2018). In order to overcome this, there were various theories, one being to increase the price of gold in terms of dollars. However, this would have had inflationary effects and resulted in further confidence issues (Krugman et al*.,* 2018).

The ultimate collapse of the Bretton woods system is attributed to the unequal distribution of power, with the US holding economic dominance (Krugman et al*.,* 2018). This power allowed the US to control inflation across the globe (Krugman et al*.,* 2018). Furthermore, many economies required discrete exchange-rate adjustments in order to maintain internal as well as external balance. Operating under the rules of this system, such changes were not possible (Krugman et al*.,* 2018), thereby creating a dilemma between individual countries' monetary goals and the ultimate goals of price and economic stability (Krugman et al*.,* 2018). However, governments experienced increased pressure to rather focus on the economy at a domestic level, prioritising monetary goals. Thus, the need for fixed exchange rates was abandoned (Krugman et al*.,* 2018). The US first moved away from the conversion of gold to US dollars. With this they set a new price for what was then referred to as monetary gold. This resulted in the devaluation of the US dollar (Ingham, 2010). This shift gave way to floating exchange rates similar to those that are used in modern-day economies (Krugman et al*.,* 2018).

2.2.3. Modern exchange-rate regimes

The following section outlines the exchange-rate regimes used in today's modern society, following the abandonment of the Bretton Woods exchange-rate system (Krugman et al*.,* 2018).

There are three main exchange-rate regimes used across the globe, that being the flexible regimes, fixed regime, or a combination of the two, namely, a managed-floating regime (Williamson, 2018). Under each one of these regimes there are various sub-categories.

1. Floating exchange-rate regimes

First, there is the flexible exchange-rate regime, which may be divided into two sub-categories, namely, the independent floating regime and the lightly managed floating regime (Yagci, 2001). For the independent floating regime both the fiscal- and monetary-policy authorities have no obligation to influence the exchange rate. They do not intervene in the market, with the goal of maintaining a specific exchange rate (Williamson, 2018). The exchange rate is purely determined by the market forces, demand and supply (Yagci, 2001). The lightly managed exchange-rate regime is built around the same concept as the independent floating regime, with the only difference being that there may be occasional monetary-policy interventions. This may be either a direct or an indirect intervention (Yagci, 2001). The aim of this intervention is merely to restrain any effect from large shocks and is more focused on rectifying the local economy (Yagci, 2001).

The basis of a floating exchange-rate regime was built on four cornerstones. Firstly, the main advantage of this regime lies in the autonomy it offers monetary policy (Krugman et al*.,* 2018). Monetary-policy authorities are able to focus on other goals, rather than maintaining the exchange rate. They may rather focus more on internal and external balance (Krugman et al*.,* 2018). Second, this regime is not pegged to a specific currency, which means no country has ultimate control over another's currency, thus allowing countries to determine their own money supplies (Krugman et al*.,* 2018). It is also believed that exchange rates when free floating acts as automatic stabilisers (Krugman et al*.,* 2018). In the event of a change in the economy, the exchange rates should theoretically be able to adjust swifty so as to bring the economy back into equilibrium. This would help maintain internal and external balance (Krugman et al*.,* 2018). Lastly, if exchange rates move automatically, theory states they should be able to prevent large current-account surpluses or deficits, thereby further ensuring external balance (Krugman et al*.,* 2018). The main disadvantage of a floating exchange-rate regime is the higher volatility that is experienced in the short-

term, especially since overall central banks, as well as the local government, are not able to influence volatility to a large extent (Ingham, 2010). An added disadvantage, as well as the possibility of inflationary bias, is if authorities have an excessive amount of discretion in monetary policy (Ingham, 2010).

2. Fixed exchange rate regimes

On the other hand, there is fixed exchange rate regimes, also often referred to as hard-peg regimes (Williamson, 2018). The basic idea of a fixed exchange rate regime is that authorities commit to maintaining a constant exchange rate that is pegged to a specific currency (Krugman et al*.,* 2018). Under this exchange-rate regime, the relevant country's monetary authorities make a long-term commitment to a fixed nominal exchange rate that is pegged to another country's currency (Williamson, 2018). In order to maintain this exchange-rate, authorities have little to no control over their monetary policy, as their interest rates are pegged to those of the country which is serving as the anchor currency (Stone, Anderson & Veyrune, 2008).

There are three different methods with which fixed exchange rates can be implemented (Williamson, 2018). First is the dollarisation of a currency (Stone et al*.,* 2008). In this scenario, a country would discontinue the use of its local currency and another country's currency would become its national method of exchange (Williamson, 2018). In this situation, the local monetary authorities would have almost no autonomy in their monetary policy (Yagci, 2001). Second, there is the currency board. Here the central bank of the country is obligated to maintain foreign assets that are equal to the value of the local currency that is in economic circulation. This country is then further obligated to exchange a specified currency with the anchor currency at a fixed rate, so as to maintain the exchange rate, thereby also limiting monetary-policy autonomy (Stone et al*.,* 2008). Lastly, this may also occur via mutual agreements (Williamson, 2018). One such example is the European Monetary Union, in which all member countries in Europe make use of one common currency.

The advantage thereof lies in the credibility it provides the economic policy regime along with the decreased risk of inflationary bias (Yagci, 2001). Policies such as these also often result in disinflation coupled with low and stable interest rates. The stability thereof also means that these currencies are not easily affected by currency crises (Yagci, 2001).

However, in the domestic economy the local authorities have no autonomy over their monetary policy. This also means that the local central bank is unable to act as a lender of last resort. In the event of a crisis, these countries have a higher propensity for a liquidity crisis (Yagci, 2001). Additionally, any shock to the economy can not be absorbed by changes in the monetary policy of the exchange rate. Thus, economic activity bears the brunt of this shock (Yagci, 2001).

3. Managed-floating exchange-rate regimes

A managed-floating exchange-rate regime is a combination of the two systems mentioned above (Williamson, 2018). It is similar to the fixed exchange rate in the sense that a stable exchange rate is maintained by pegging the local currency to a foreign anchor currency (Stone et al*.,* 2018). However, authorities are not compelled to make a long-term commitment (Williamson, 2018). Under this system, a specific exchange rate is also often not chosen, but rather a band, where the exchange rate is to remain within a specified range (Stone et al*.,* 2018). It should also be noted that the peg may be revalued or devalued over a period (Williamson, 2018). This system allows for a degree of monetary-policy autonomy, especially in the event of a shock to the economy (Stone et al*.,* 2018). This form of an exchange-rate regime may also be implemented in terms of a crawling broad band (Yagci, 2001). In this system, monetary authorities aim to keep the exchange rate within a certain band, in order to ensure the exchange rate remains competitive. This band is altered periodically, at a fixed rate that is announced ahead of time (Yagci, 2001).

Research shows that this type of regime is often more susceptible to a financial crisis (Stone et al*.,* 2018). During a financial crisis, a country which makes use of a managed-floating system often experiences increased volatility and devaluation, which results in the abandonment of the chosen peg (Stone et al*.,* 2018). However, the advantage thereof is that monetary-policy authorities are able to maintain competitiveness and stability within the market and shocks to the economy can in part be absorbed (Yagci, 2001).

2.2.4. South Africa's exchange-rate regime

The chosen exchange-rate regime in South Africa has evolved over the years, with the influence of economic and domestic events that have occurred (Joale, 2011). However, post-1995, South Africa has maintained a floating currency regime

(Oseifuah, 2018). The following takes a brief look at the history of the South African exchange-rate regimes. The floating nature of the South African exchange-rate regime means that political, economic and social factors all have an influence on the level of volatility experienced (Oseifuah, 2018). Thus, the SARB does not intervene directly in the foreign-exchange market (Oseifuah, 2018). However, policy actions from the SARB still have an influence on the exchange rate (Oseifuah, 2018). The better the economy performs, especially in terms of economic growth and development, influences the performance of the rand in the foreign-exchange market (Oseifuah, 2018). It should be noted that the SARB does have exchange controls that it implements (SARB, 2023). These exchange controls are regulations that individuals and businesses must adhere to when transacting with a foreign currency (SARB, 2023). These restrictions include restrictions on the type of transactions that may be made, as well as a limit on the amount of currency that may be transferred in and out of the country (SARB, 2023).

2.2.5. Why the USD/ZAR exchange rate?

A safe-haven currency is defined as a currency that investors seek out in times of instability, with the aim of decreasing the risk of investing (Todorova, 2020). There are currently three main safe-haven currencies, those being the USD, Swiss franc (CHF) and the Japanese yen (JPY) (Todorova, 2020). In both the medium and short term, the USD is seen as the best safe-haven currency (Todorova, 2020).

The USD plays a role internationally, as the global currency (Bertaut, Von Beschwitz & Curcuru, 2021). This is predominantly due to the stability of the currency, which is in turn supported by the size and strength of the United States economy (Bertaut, Von Beschwitz & Curcuru, 2021). The USD is often used as a store of international reserves and a currency anchor (Bertaut, Von Beschwitz & Curcuru, 2021.) Therefore, this study compares the ZAR with the USD, due to the general stability thereof.

2.2.6. Exchange rate theories

There is little consensus regarding the factors affecting exchange-rate volatility. However, there are three main theories that have become generally accepted to be the theories explaining the determinants of the exchange rate (Bilson & Marston, 1984). They are as follows.

1. Purchasing Power of Parity (PPP)

The PPP is the currency conversion rate that attempts to eliminate price-level differences between countries, with the goal of bringing the purchasing power of various currencies into equilibrium (OECD, 2012). This theory centres on the fact that the ratio of two countries' price levels should be equal to their exchange rate (Krugman, Obstfield & Melitz, 2018). The PPP is determined by considering a standardised basket of goods and services in terms of the monetary price (Krugman, Obstfield & Melitz, 2018). If the PPP declines via an increase in domestic price levels, according to the PP theory, this results in a depreciation of the local currency (Krugman, Obstfield & Melitz, 2018). This depreciation should be proportional to the increase in the price level (Krugman, Obstfield & Melitz, 2018). Likewise, a decrease in the price level of the standardised basket of goods would ultimately result in a proportional appreciation of the local currency (Krugman, Obstfield & Melitz, 2018). Therefore, PPPs are often considered price-level deflators (OECD, 2012).

2. The monetary approach

This is a long-run theory to exchange-rate determination that incorporates the theory put forth by the PPP theory, but combines it with the money demand and supply framework (Krugman, Obstfield & Melitz, 2018). In this theory, any factors that do not affect the demand or supply of money are not included. Furthermore, this theory does not accommodate the rigidity in prices that is often essential for short-run explanations (Krugman, Obstfield & Melitz, 2018).

In essence, this theory states that changes to the supply of money cause a change in the price level of goods and services right away. This allows for full employment (Krugman, Obstfield & Melitz, 2018). The change in prices results in a change in the exchange rate (Krugman, Obstfield & Melitz, 2018). It should be noted that this theory states that exchange rates adjust full employment, so that it can be maintained to the same extent with this approach as it can in the PPP theory (Krugman, Obstfield & Melitz, 2018).

An important theory that arises in the monetary approach is the Fisher effect (Krugman, Obstfield & Melitz, 2018). This theory states that there is a long-run relationship between interest rates and inflation. This in turn affects the exchange rate (Krugman, Obstfield & Melitz, 2018). The basis of this effect is that, when the inflation

expectations change, for example increase, it will eventually result in an equal change, in this scenario increase, in the interest rate (Krugman, Obstfield & Melitz, 2018). For an open economy, the international Fisher effect arises. This theory states that the difference in nominal interest rates between two currencies should be approximately the same as the expected difference in their exchange rate (Teall, 2023). This effect concludes that there is a relationship between inflation and interest rates, as well as exchange rates (Krugman, Obstfield & Melitz, 2018).

3. Interest Rate Parity (IRP) Condition

The IRP states that the expected shift in exchange rates is proportional to the relative interest rates of countries (Teall, 2023). This theory suggests that the returns anticipated from investing in domestic assets should be equal to the expected return on foreign-currency assets, once it has been adjusted for the exchange rate, irrespective of their interest rates (Krugman, Obstfield & Melitz, 2018). This is an essential theory that dictates the way in which exchange rates and interest rates interact with one another (Krugman, Obstfield & Melitz, 2018). Future exchange rates are determined via future contracts, which in turn rely on interest rates (Teall, 2023).

4. Balance of payments (BOP) theory

The BOP is a summary of all international transactions made between a specific country and all other countries across the globe (Reserve Bank of Australia, 2023). This includes transfer payments and the export and import of both goods and services, as well as financial assets (Reserve Bank of Australia, 2023). The BOP and exchange rates are linked in two specific ways, the first being it serves as the market to the international market regarding all financial transactions (Reserve Bank of Australia, 2023). Second, the BOP determines the demand for and supply of a specific currency (Reserve Bank of Australia, 2023).

The BOP theory, in terms of the exchange rate, is limited to free-floating exchange-rate systems, in countries that have an open economy (Krugman, Obstfield & Melitz, 2018). This theory suggests that exchange rates are established via the movement of the demand and supply of financial assets among countries, with the purpose of reaching equilibrium (Krugman, Obstfield & Melitz, 2018).

There are two main accounts into which BOP payments fall, the current account and the capital account (Reserve Bank of Australia, 2023). The current account includes the flow of money in the economy, as a result of international trade (Reserve Bank of Australia, 2023). In contrast, the capital account captures the changes in ownership of assets and liabilities (Reserve Bank of Australia, 2023). According to this theory, the exchange rate of a country is linked to the current account (Reserve Bank of Australia, 2023).

2.2.7. Historical evidence: From the 2008/2009 financial crisis

During the previous 2008 global financial crisis, many developing countries experienced a major depreciation of their currency (Kohler, 2010). In her 2010 study on 'Exchange rates during financial crises', Kohler determined that much of this movement could be attributed to the appreciation of safe-haven currencies, such as the US dollar. She attributed this phenomenon to investors' appetite for risk. Risk-averse investors under these pressing circumstances prefer to make investments deemed 'safer 'in terms of profit (Kohler, 2010). In addition to this, as overall economic stability becomes more unpredictable and the global economic environment more uncertain, many investors experience an increasing aversion to risk (Kohler, 2010). Kohler determined that more developed countries with a history of prosperity were thus viewed as safer (Kohler, 2010).

Similarly, in a study conducted by the Reserve Bank of New Zealand, it was determined that, during periods of uncertainty, specifically in this instance the 2008 global financial crisis, investors and traders alike tend to refrain from making riskier investments. Thus, they opt for more-liquid currencies (Wallis, 2010). In which case, currencies deemed to be 'safe haven' currencies experienced increased demand (Wallis, 2010). Hence, Wallis states that, during the peak of a crisis, foreign-exchange markets, and specifically riskier currencies, such as those in developing markets, experience increased volatility (Wallis, 2010). According to the Reserve Bank of New Zealand, during the crisis they experienced that, as risk sentiment and overall market confidence improved, the foreign-exchange market was able to stabilise (Wallis, 2010). However, Wallis also emphasised the significant role of monetary policy easing undertaken by central banks during this period (Wallis, 2010). This significantly helped in providing markets with liquidity measures, which supported economies in their efforts to recover (Wallis, 2010).

Morales-Zumaquero and Sosvilla-Rivero, in their 2013 study on the 'Real exchange-rate volatility, financial crises and nominal exchange regimes', determined, based on the 2008 financial crisis, that there exists a positive relationship between global crises and the volatility of the exchange rate. Furthermore, they observed that the level of flexibility in a country's chosen exchange-rate regime and the volatility of the real exchange rate have an inverse relationship (Morales-Zumaquero & Sosvilla-Rivero. 2013).

In a study conducted on sub-Saharan African countries, it was observed that, by mid-2008, emerging countries in this area experienced subsiding levels of trade and financial flows. This led to large gaps in the countries' balance of payments, thereby triggering increased rapid depreciation. This in turn resulted in increased exchange-rate volatility (Ltaifa, Kaendera & Dixit, 2009.) Much of this volatility was depreciation of the local currencies (Ltaifa, Kaendera & Dixit, 2009). However, according to this study, the losses experienced varied vastly, with some currencies observing up to 40% depreciation when compared to the USD, while others only 10% (Ltaifa, Kaendera & Dixit, 2009.) Ltaifa et al. (2009) determined that, of the five currencies they examined (the Nigerian naira, Ugandan shilling, Ghanian cedi, and the Rwandan and Tanzania currencies), when compared to the USD, three of these currencies experienced significantly increased levels of exchange-rate volatility during the global financial crisis, when compared to the pre-crisis volatility levels. However, when compared to the Euro, this volatility was lower (Ltaifa, Kaendera & Dixit, 2009). The last two currencies experienced either the same or lower levels of exchange-rate volatility (Ltaifa, Kaendera & Dixit, 2009.) Furthermore, this study stipulates that this volatility can be attributed to three main factors, namely, external factors, which affected volatility via transmission-mechanism channels, such as trade (Ltaifa, Kaendera & Dixit, 2009). Second were policy choices, such as the chosen exchange-rate regime, as well as the countries' various monetary and fiscal stances (Ltaifa, Kaendera & Dixit, 2009). Lastly were structural factors. These refer specifically to the flexibility of the various countries' financial markets (Ltaifa, Kaendera & Dixit, 2009).

When testing the drivers of volatility in the South African rand during the global financial crisis, Maveé, Perrelli and Schimmelpfennig (2016) determined that volatility in the global market, local commodity market and political uncertainty resulted in volatility of the South African rand. Furthermore, they determined that economic

shocks originating from the United States had the greatest effect, in comparison to those originating from within the local market, as well as Europe and China (Maveé et al., 2016). In concluding this study, they determined that South Africa's flexible exchange-rate system was a vital element to managing external shocks, as this enabled policymakers to make necessary adjustments (Maveé et al., 2016). They claimed that maintaining volatility was especially important in upholding investments. Uncertainty in investors may lead to delayed investment decisions, thereby negatively affecting economic growth (Maveé et al., 2016). Lastly, this study states that, to determine the role of economic policies in reducing volatility during a crisis, policymakers first need to understand and determine the drivers of volatility in exchange rates (Maveé et al., 2016).

2.3. Theoretical framework

This research aims to investigate the ways in which Covid-19 affected exchange-rate volatility in South Africa, specifically by considering monetary- and fiscal-policy changes implemented by local authorities. When considering the argument for monetary-policy implementation, the notion that external factors can indirectly affect key variables within the economy is rooted in Keynesian economics, specifically the Keynesian transmission mechanism (Jahan, Mahmud & Papageorgiou, 2014). On the other hand, fiscal-policy intervention during times of economic downturn is deeply rooted in the Keynesian view of the business cycle (Jahan et al., 2014).

2.4. Monetary-policy theoretical framework

Therefore, the theoretical framework that takes into consideration the effect of monetary policy is centred on the transmission mechanism, as explained in the Keynesian school of thought. The transmission mechanism explains empirically how changes in monetary-policy instruments are able to affect the economy via aggregate demand and the level of inflation (Mukherjee & Bhattacharya, 2015).

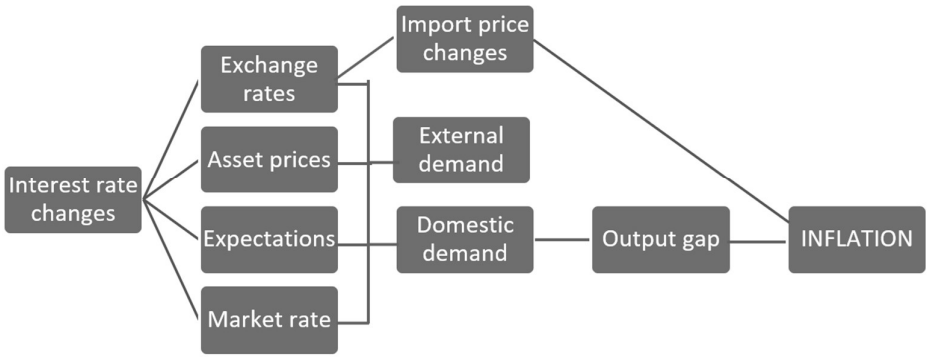
There are four channels through which this mechanism works (Choi, Willems & Yoo, 2022). According to the Keynesian school of thought, these are the interest-rate channel, exchange-rate channel, credit channel and lastly the asset-cost channel (Choi, Willems & Yoo, 2022). According to Keynesian theory, the interest-rate channel

is the prevailing channel through which monetary-policy actions flow (Babatunde & Olatunji, 2017). In this theory, they emphasise that the real interest rate, specifically in the short term, is the dominant variable affecting decisions of participants in the economy (Babatunde & Olatunji, 2017). Therefore, for the purpose of this study, the theoretical framework of the transmission mechanism centres on the interest-rate channel.

2.4.1. Keynesian view of the interest-rate channel of the transmission mechanism

The Keynesians believe that this channel of transmission is able to influence the economy in both the short and long term, largely due to the change in expectations that accompanies a change in the short term (Choi, Willems & Yoo, 2022). When considering the interest-rate channel of the transmission mechanism, the flow thereof can be summarised as follows: the relevant central bank makes changes in its monetary policy via changes in the interest rate (Reserve Bank of Australia, 2023.) The change in the interest rate then flows through the economy and affects various economic activities and inflation (Reserve Bank of Australia, 2023). The diagram below details this flow.

Figure 2.1: The flow of the Keynesian transmission mechanism



Source: https://www.economicsonline.co.uk/managing_the_economy/monetary-policy.html/

For the sake of this research, how this interest rate change flows through the exchange-rate channel are discussed more in depth.

In an economy with a floating exchange rate, the exchange rate is sensitive to investors' decisions. Investors tend to shift their resources to countries (and thereby

currencies) that offer them the highest return on investment (Reserve Bank of Australia, 2023). This implies a decrease in the demand for the local currency, thereby resulting in a depreciation of the local currency (Reserve Bank of Australia, 2023). This effect further affects the economy, as a lower exchange rate results in an increase in the cost of imported goods and services, adding to the level of inflation (Reserve Bank of Australia, 2023). However, on the contrary, a depreciation of the local currency also implies that locally produced goods become more attractive, thereby increasing exports as well as economic activity in the local market (Reserve Bank of Australia, 2023).

2.5. Fiscal-policy theoretical framework

According to traditional Keynesian theory, government intervention is required, as the economy is not self-regulating. Without the assistance of fiscal policies, the economy is not be able to maintain full employment or price stability (Jahan et al., 2014). As previously mentioned, Keynes stressed the importance of aggregate demand in maintaining a healthy economy. During a recession, aggregate demand by consumers often decreases, as they decrease their spending (Jahan et al., 2014). This effect transmits to business investment, as businesses respond to a decreased demand for their products by lowering output and investments (Jahan et al., 2014). Therefore, Keynesians believe, in such a situation, it is the local government's responsibility to increase output by intervening in the economy via fiscal policy (Jahan et al., 2014). The flow of economic activity over time is referred to as the business cycle (Jahan et al., 2014). The Keynesian view of the business cycle forms the theoretical framework for fiscal-policy intervention for this research.

The Keynesian business cycle theory is demand-induced, meaning, as previously stated, demand is the driver of economic activity (Snowdon, 2005). In this theory, demand is largely dependent on the expectations of business, especially concerning future profit and sales (Snowdon, 2005). Furthermore, this theory maintains that, in the event of a contraction in the economy, in the short-run the economy moves to a point that is below full-employment, as well as below the optimal level of gross domestic product (GDP). It then stays there for a prolonged period of time unless there is a form of fiscal intervention (Snowdon, 2005). Furthermore, Keynes stated that

pessimistic expectations would intensify this initial effect, resulting in a further decrease in aggregate demand. This led to the role of the government in restoring expectations by increasing investment and consumer spending (Snowdon, 2005). In the long run, given there is no intervention, what Keynes coined as 'animal spirts' will eventually initiate a change in expectations that will initiate the movement of investment and spending to their initial levels (Snowdon, 2005).

2.6. Empirical literature review

2.6.1. Exchange rate correlation

Dias and Santos (2020) stated that financial markets are experiencing increased correlation internationally, specifically during times of crisis, due to the increasing globalisation taking place across the world. Therefore, they determined that many countries experience interrelated financial stability within their stock markets (Dias & Santos, 2020). Developing countries, such as South Africa, tend to be more reliant on the experiences of larger, more developed countries. Thus, they often experience increased levels of volatility within their financial markets, as a result of this phenomenon (Beckmann & Czudaj, 2022). Similarly, Wen and Wang (2020) determined that, during financial crises, currencies become more connected in their level of volatility. In addition to this, during periods of turmoil and instability, exchange rates are highly likely to display higher volatility, largely as a result of an unstable financial and macroeconomic environment (Konstantakis et al., 2021).

A study performed on the dynamics of the euro to US dollar exchange rate, during the Covid-19 period, determined that the pandemic had a definite effect on the relationship between these two currencies (Konstantakis et al*.,* 2021). Making use of the Markov-Switching model, these researchers studied the change in the euro to USD dollar exchange rate for both periods, before and during the pandemic (Konstantakis et al*.,* 2021). Their conclusion was that the fundamental factors that determine exchange rates and the regimes countries implement changed as a result of the pandemic (Konstantakis et al*.,* 2021).

Across different countries, there are several factors that affect the level of volatility within the exchange rate, such as stock return, trade and economic openness, current world affairs and the flexibility of exchange-rate regimes (Hung, Nguyen & Vo, 2022).

In a study on exchange-rate connectedness during the pandemic, it was determined that overall extreme volatility in the foreign-exchange market results in an overall decrease in economic performance (Hung, Nguyen & Vo, 2022). However, crises such as the pandemic offer economists a unique view of the effect of certain economic shocks, created via various economic activities, on the economy (Hung, Nguyen & Vo, 2022). Hung, Nguyen and Vo (2022) made use of the univariate GARCH model to assess the dynamic of the volatility of exchange rates during the Covid-19 period, as well as the period prior to the pandemic. Here they determined that, for all six currencies they tested, there was a persistence in volatility before and after the pandemic. However, foreign-exchange markets proved to be more susceptible to spillover effects during the Covid-19 pandemic. Furthermore, there is evidence of increased volatility, as well as a correlation among all the exchange rates tested (Hung, Nguyen & Vo, 2022).

According to a study done by Hsing (2016), determined by making us of the EGARCH model, the factors affecting the USD/ZAR exchange rate, specifically, include variables such as the bond yields of the South African government and both the real GDP and stock price in the United States and South Africa, as well as the South African and US inflation rates.

2.6.2. Covid-19 and exchange-rate volatility research from countries outside the borders of South Africa

More recently, Benzid and Chebbi (2020), conducted a study on the impact of the Covid-19 virus on exchange-rate volatility. They made use of the GARCH (1,1) estimation technique, using daily exchange-rate volatility data regarding the US dollar in comparison to the euro, yuan and pound sterling (Benzid & Chebbi, 2020). Herein they determined, that the United States dollar (US dollar) appreciated in comparison to other currencies, given an increase in the number of Covid cases and deaths. It was also concluded that, in terms of Covid-19 and exchange-rate volatility, there is a significant and positive relationship, meaning that an increase in the number of cases resulted in increased volatility within the foreign-exchange market (Benzid & Chebbi, 2020).

In a similarly orientated study, Narayan et al. (2018) investigated the effect of terrorist attacks on the foreign exchange rate in 21 countries, via the GARCH (1,1). They

determined that an unexpected occurrence in one country significantly affects the exchange rate of all countries. The observed effect, however, differs from country to country, in terms of the duration and direction of the impact. Some countries experienced an appreciation of their local currency while others experienced a depreciation thereof (Narayan et al., 2018). In this study, researchers also observed that the duration for which this effect was experienced differed and was even permanent in some instances (Narayan et al*.,* 2018). For reoccurring or continuous shocks, the initial effect of the shock declines. However, it will still persist as markets readjust (Narayan et al*.,* 2018).

In a study done by Beckmann and Czudaj (2022) on the exchange rate between more than 50 currency pairs, they determined that the factor with the largest effect on exchange rates during the height of the global pandemic was in fact expectations. In their study, they are referring specifically to policy expectations, in terms of governments' and financial authorities' policy response to the pandemic (Beckmann & Czudaj, 2022). An important finding of their study was that the currency of the developing countries they studied, termed *minor currencies* by Beckmann and Czudaj, was to a large degree influenced by the response policies of the United States (US), as well as global factors (Beckman & Czudaj, 2022). Therefore, in this study, they attributed most of the movement in exchange rates to expectations of policies in response to the global Covid-19 pandemic, rather than the actual pandemic itself (Beckmann & Czudaj, 2022). This study was performed based on currency data from 50 currency pairs, making use of both and event study analysis as well as a cumulative abnormal returns approach (Beckmann & Czudaj, 2022).

Similarly, a study performed, focusing on the effect of the pandemic on Papua New Guinea, determined that overall, when comparing the Kina (Papua New Guinea's currency) to the US dollar, there is little evidence of a response (Odhuno, 2020). The relationship between the Kina and USD remained relatively stable throughout the first stages of the pandemic (Odhuno, 2020). This is attributed to the country's economic and social response policy (Odhuno, 2020). Financial authorities in Papua New Guinea targeted inflation and the exchange rate, with the goal of maintaining stability and smoothing any fluctuations that may arise (Odhuno, 2020). They did this by implementing both fiscal and monetary policies in conjunction with an economic stimulus package sanctioned by their government (Odhuno, 2020). However, when

comparing the Kina to the Australian dollar, Odhuno (2020) found that there was increased volatility. This volatility also coincided with increased uncertainty regarding the effects of Covid-19, as well as countries' reporting thereof (Odhuno, 2020). Oduno (2020) determined this not based on a an intensive regression analysis, but by comparing the trends of the Kina against the Australian Dollar on a daily basis.

In the aforementioned study by Feng et al (2021), research analysis on the role of government intervention and Covid-19 on exchange-rate volatility, performed on 20 different countries, determined via the Generalised Method of Moments, that there is a positive relationship between the number of Covid-19 cases and increased exchange-rate volatility. Their regression analysis determined that government intervention in the 20 sampled countries was successful in restraining exchange-rate volatility, via various channels (Feng et al*.,* 2021). These channels are as follows: the response of the government system, the government's overall response, the government's reaction to the containment of Covid-19 cases and the response of the health system, the stringency with which restrictions were implemented and lastly their level of support to the economy (Feng et al*.,* 2021). The success of these channels was attributed to two main motivations. Firstly that non-economic actions, for example, restrictions on movement, assisted in easing investor concerns and created a sense of stability by easing uncertainty (Feng et al*.,* 2021). Second, economic interventions, such as social grants and tax reductions, resulted in increased private-consumer consumption (Feng et al*.,* 2021). This in turn increased capital flows, which was successful in restraining volatility in the foreign-exchange market (Feng et al*.,* 2021).

2.6.3. Existing research on exchange rate volatility

Alagidede and Ibrahim (2016) determined, by means of the GARCH model as developed by Bollerslev in 1986, in Ghana there exists a significant, negative relationship between the real exchange rate and terms of trade. After a shock to exchange rates, they will return back to approximately their normal level. However, this often occurs over a prolonged period of time (Alagidede & Ibrahim, 2016). This shift back to normalcy is often accompanied by dire consequences in the short run, as consumers and investors alike shift both their consumption and investment expenditure respectively (Alagidede & Ibrahim, 2016). These researchers also concluded that the main driver of exchange-rate shocks is the exchange rate itself. Hence, future exchange rates are determined by current exchange rates. Thus,

exchange rates themselves result in further exchange-rate volatility (Alagidede & Ibrahim, 2016). However, they also noted that there is a significant relationship between government expenditure, money-supply growth and foreign direct investments (FDI) and exchange-rate volatility (Alagidede & Ibrahim, 2016). Lastly, they concluded that, although economic growth is negatively affected by an excessive level of exchange-rate volatility, there is also a positive effect thereof (Alagidede & Ibrahim, 2016). In the event of excessive volatility and low economic growth, countries are forced to ensure resources are allocated efficiently and are also often forced to form new innovative ways to improve economic growth. This is known as the growth-enhancing effect (Alagidede & Ibrahim, 2016).

Devereux and Lane (2003) performed a cross-country study that determined that developing countries' exchange rates tend to be less sensitive to external shocks. This is as developing countries tend to have increased external debt. This debt restricts the ability of the exchange rate to respond to external shocks (Devereux & Land, 2003). However, it is also noted that increasing external debt does negatively affect exchange-rate volatility in developing countries (Devereux & Lane, 2003). Devereux and Lane (2003) performed this study based on bilateral exchange-rate volatility, making use of the Optimal Currency Area theory.

The standard model explaining exchange-rate movements, developed by Dornbusch (1976), states that in the short run any unanticipated change in monetary policy, specifically monetary expansion, results in large fluctuations in the exchange rate (Dornbusch, 1976). The theory he put forth is as follows: in the case of monetary expansion, it results in a depreciation of the domestic exchange rate. However, due to the differential adjustment speed of markets, it occurs that in the short run, if there is monetary expansion, output will react and have a dampening effect on the aforementioned depreciation, which may in turn increase the interest rate (Dornbusch, 1976).

In the aforementioned study conducted by Benzid and Chebbi (2020), they made use of the GARCH (1,1) model to determine the exchange-rate volatility as a result of the Covid-19 pandemic. According to their research, this GARCH model allowed them to determine both the dynamic and static forecasts of the conditional variance, as well as the mean value (Benzid & Chebbi, 2020). To further improve the forecasting of their

model, the researchers employed three metric tests, namely, the Mean Absolute Error test, the Theil Inequality Coefficient and lastly the Root Mean Square Error (Benzid & Chebbi, 2020). They stated that these tests were chosen due to the ease with which they can be implemented (Benzid & Chebbi, 2020). Lastly, to ensure they received unbiased statistical results, Benzid and Chebbi (2020) tested the robustness of their results via the residual normality test, residual heteroskedasticity and residual serial correlation tests.

The experiences of emerging economies differ vastly from those of developed economies. Hence, the emphasis should be placed on studying these economies in isolation (Krol, 2014). In a paper investigating the uncertainty regarding economic policy when considering exchange-rate volatility, Krol (2020) determined the following; e*xchange-rate dynamics* expresses the mechanics and developments of exchange rates over a period (Krylova, Cappiello & De Santis, 2005). Hence, this study aims to, with the above-mentioned taken into consideration, carefully evaluate the drivers of the volatility in the exchange rate experienced in South Africa during the 2020 Covid-19 pandemic.

Chen, Lin and Reed (2005) stated that, when performing a regression analysis, the panel-corrected standard errors (OLS-PCSE) estimator was more appropriate when considering hypothesis testing, whereas, on the converse, the feasible generalised least squares (FGLS) estimator was more effective when determining the accuracy of the regression coefficients. Therefore, in Rajkovic, Bjelicb, Jacimovica and Verbic's (2020) analysis of the impact of the exchange rates of foreign-trade imbalances during a crisis, they chose to employ the FGLS estimator test. They used this test in combination with the pooled ordinary least squares (POLS) estimator, fixed effects, and random effects estimator. Furthermore, they made use of the Hausman test, in order to determine if the individual effects could in fact be modelled as random or fixed effects (Rajkovic et al., 2020). Similarly, Morina et al. (2020) made use of the Hausman test to determine the fixed and random effects when considering the volatility of the exchange rate in comparison to economic growth in Central and Eastern Europe countries. However, when testing their hypothesis, they opted to perform a panel data regression (Mornia et al., 2020). They attributed this decision to the regression's ability to reduce multicollinearity and bias issues that may arise (Mornia et al., 2020).

Engle and Patton (2007) studied the optimal model that should be used to forecast and determine volatility within financial markets. Their results indicated that the most appropriate models to use would be either the Autoregressive Conditional Heteroskedasticity test (ARCH) or the generalised version thereof, the Generalised Autoregressive Conditional Heteroskedasticity test (GARCH) (Engle & Patton, 2007). Their conclusion was; the ARCH and GARCH models were both able to present the stylised facts regarding the volatility experienced in the price of financial assets (Engle & Patton, 2007).

Atoi (2014) tested the volatility of the Nigerian stock market by making use of the GARCH model. In his model, he stressed the importance of the use of appropriate error distribution tests (Atoi, 2014). Atoi also recommended that future studies make use of error distributions such as the Root Mean Square Error in order to ensure the forecasted volatility models are robust and reflect comprehensive decisions regarding policies (Atoi, 2014).

Narayan (2020a) analysed the dynamics of exchange-rate spillover shocks during the pandemic in 2020. This was performed making use of the dynamic VAR model, using hourly data, relating to the pound, Canadian dollar, euro and yen (Narayan, 2020a). The aim of this study, that was successfully proven, was to prove that, when forecasting exchange rates, the prevailing predictor of future exchange rates is the current rate itself (Narayan, 2020a). Narayan (2020) proved that, during the Covid-19 pandemic, exchange-rate shocks were more influential in forecasting future exchange rates than the prior period.

Narayan, in another study done in 2020, explored the yen-dollar relationship, with the emphasis on the way this was affected by the Covid-19 pandemic. He made use of a time-varying unit root model in order to perform this study (Narayan, 2020b). In this study, it was determined that the yen, which started as a non-stationary variable before the Covid-19 period, became stationary throughout the pandemic (Narayan, 2020b). It was concluded that this is due to the transitory effect that Covid-19 had on the yen (Narayan, 2020b). It was argued that Covid has a transitory effect, as all other shocks during this period were considered negligible, purely due to the size and impact of the shock Covid-19 caused (Narayan, 2020b).

In a study performed relating to Ghana, researchers found that the use of a simple linear regression by means of the Ordinary Least Squares was a sufficient method (Attah-Obeng et al., 2013). This form of regression analysis allowed researchers to explore the causal relationship between the dependent and various independent variables, with relative ease (Attah-Obeng et al., 2013).

Considering the secondary objectives of the study, a more in-depth view of the relationship between monetary policy, fiscal policy and the exchange rate is essential. Many studies test relationships such as this by making use of the Ordinary Least Squares method. However, Fox and Jennings (2014) determined that, although this model was favourable in terms of simplicity when working with time series data, this model often mis specifies the data and results in insignificant variables. To overcome this, as well as to include the effect of a long-run relationship, Precious and Palesa, in their 2014 study on economic growth and monetary policy in South Africa, made use of the Vector Error Correction Model (VECM). Herein it was determined that monetary policies play a significant role in attracting investment in foreign and domestic investments, which assists economic growth (Precious & Palesa, 2014).

2.6.4. Summary of empirical literature review

Table 2.1: Summary of empirical literature

AUTHOR/S	YEAR	COUNTRY/REGION	MODEL USED	KEY RESULTS
Benzid & Chebbi	2020	United States (US)	GARCH (1,1)	There exists a positive relationship between the appreciation of the US dollar and an increase in the number of covid-19 cases and deaths, indicating a significant and positive relationship between the amount of covid cases and increased volatility with

				the foreign exchange market
Narayan et al.	2018	21 countries	GARCH (1,1)	Terrorist attacks are statistically significant in affecting the exchange rate returns.
Beckmann & Czudaj	2022	50 curreny pairs	Event study analysis & cumulative abnormal returns	Movement in exchange rates were attributed to expectations of policies in response to the Covid-19 pandemic.
Odhuno	2020	Papua New Guinea	Daily trend comparison	Economic and social policy response taken by Papua New Guinea maintained the Kina to Australian dollar ratio throughout the first stages of the Covid-19 pandemic. However, volatility increased with uncertainty regarding the effects of Covid-19.
Feng et al.	2021	20 countries	Generalised Method of Moments	There is a positive relationship between the number of Covid-19 cases and increased exchange rate volatility. Government intervention was successful in restraining exchange-rate volatility.
Alagidede & Ibrahim	2016	Ghana	GARCH	There is a significant, negative relationship

				between real exchange rate and terms of trade. The main driver of the exchange rate is the exchange rate itself.
Devereu & Lane	2003	Cross-country study om developing countries	Optimal Currency Area theory	Developing countries exchange rates tend to be less sensitive to external shocks, due to high levels of external debt.
Chen, Lin & Reed	2005		FGLS	The FGLS is the most effective theory in determining the accuracy of regression coefficients.
Rajkovic, Bjlicb, Jacimovica & Verbic	2020		FGLS and POLS	Individual effects can be modelled as random or fixed effects when considering the impact of exchange rates on foreign-trade imbalances during a crisis.
Morina et al.	2020	Central and Eastern Europe	Hausman test and panel data regression	The panel data regression is able to reduce multicollinearity and bias issues when considering the volatility of the exchange rate in comparison to economic growth.

Engle & Patton	2007		ARCH & GARCH	ARCH and GARCH models are able to present the stylised facts regarding volatility experienced in the price of financial assets
Atoi	2014	Nigeria	GARCH	In order to test the volatility of the Nigerian stock market, the GARCH model is optimal.
Narayan	2020a	Various countries (GBP, CAD, EUR, YEN)	Dynamic VAR model	When forecasting exchange rates, the prevailing predictor of future exchange rates is the current rate itself.
Narayan	2020	Japan and the United States (YEN/USD analysis)	Time-varying unit root model	Yen became stationary throughout the pandemic due to transitory effect that Covid-19 had on the Yen
Attah-Obeng	2013	Ghana	OLS	A simple linear regression allowed researchers to explore the causal relationship between the dependent and independent variables with ease.
Precious & Palesa	2014	South Africa	VECM	To overcome misspecification and include a long-run relationship when considering economic

				growth and monetary policy, the VECM is most effective. Monetary policies are essential in promoting sustained economic growth.

2.7. Literature synthesis and conclusion

The aim of this literature synthesis is to provide a comprehensive understanding of exchange rate volatility and how this was affected by the Covid-19 pandemic, based on factors affecting the volatility thereof, the response of exchange rate volatility to various monetary and fiscal policies as well as the economic consequences thereof, by considering the findings of various studies.

Exchange rates regimes are chosen based on internal end external balance, ensuring price stability and full employment as well as a balanced current account respectively. Consider their economic focal areas, while taking their unique situation into account. South Africa makes use of a maintained floating currency regime. When considering the exchange rate volatility of a currency, most studies make use of the US dollar as a comparison, this is largely due to the stability of the currency, it's role as the global currency and lastly the fact that it is considered a safe haven currency by most investors.

Theoretical evidence from the 2008/2009 global financial crisis formed an important basis of this research. Kohler (2010) provided insight on the 2008/2009 global financial crisis, concluding that many developing countries experienced a currency depreciation, due to the risk averse nature of investors during periods of crises. Wallis (2010) demonstrated that exchange rate volatility during a crisis is driven by investor sentiment, as in New Zealand investors avoided more liquid currencies, resulting in increased volatility in developing markets exchange rate markets.. Studies performed by Morales-Zumaquero and Sosvilla-Rivero (2013), Ltaifa, Kaendera and Dixit (2009), Maveé, Perrelli and Schimmelpfennig (2016) all further confirmed that during a global crisis there exists a relationship between exchange rate volatility and the relevant

crisis. This was mainly attributed to uncertainty and response to policy actions, be this monetary or fiscal policy actions.

Several studies relating to both the Covid-19 pandemic and the 2008/2009 global financial crisis have highlighted that volatility models such as the GARCH, ARCH and variations thereof, are most commonly, and successfully used, to model exchange rate volatility. Narayan et al. (2018) determined that even given a more centralised crisis, such as a terrorist attack, there is still a significant relationship between the relevant crisis and exchange rate returns of the affected country.

Overall studies presented in the literature review show that during Covid-19 the value of the US dollar appreciated, thus, there was a definite significant positive relationship between the number of covid-19 cases and exchange rate volatility in the US dollar (Benzid &Chebbi, 2020).Beckman and Czudaj said minor currencies were influenced by the US response policies and global factors, so volatility was as a result of expectations of policies changing due to Covid-19 rather than the Covid-19 pandemic itself. This indicates that the Covid-19 pandemic had a statistically significant effect on exchange rate returns, thus, exchange rate volatility.

On the other hand the role of fiscal and monetary policy in restraining exchange rate volatility is considered in the literature. Monetary policy easing provides liquidity during global crises, that supports essential recovery (Wallis, 2010). Ltaifa, Kaendrera and Dixit (2009) further confirmed that monetary and fiscal stances impacted the level of exchange rate volatility experienced in currencies during the 2008/2009 global financial crisis. When considering the Keynesian transmission mechanism it is also evident that interest changes, implemented by monetary authorities, traditionally has an effect on exchange rates. Odhuno (2020) concluded that in Papua New Guinea, both fiscal and monetary policy changes were sanctioned to maintain economic and price stability during the Covid-19 pandemic, however, Papua New Guinea still experienced increased exchange rate volatility throughout the Covid-19 pandemic. This raises the question as to whether there was increased or decreased volatility in the exchange rate market as a result of these fiscal and monetary policy changes.

The literature presented on the exchange rate volatility during times of crises revelas the complexity and multifaceted nature of currency markets. There are many factors at play, such as policy changes, including both fiscal and monetary policy changes,

increased uncertainty and shifts in investor risk sentiment. Furthermore, the research indicates that monetary and fiscal policy intervention played a critical role in various countries economies, however, the effect thereof was not uniform across different economies. The way in which these policy changes affected the dynamics of the exchange rate in South Africa still need to be studied more in depth. This literature has highlighted that ongoing research is essential in order to understand past movement as well as the future trajectory of the South African foreign exchange market.

3. RESEARCH METHODOLOGY

3.1. Introduction

The following chapter clearly defines the systematic method that is employed to solve the research problem. This chapter considers the research approach, chosen empirical approach for this study and discusses data sources, the main variables of the study, the model selection, robustness checks and limitations of the study.

3.2. Research approach and type

This research is based on a quantitative research approach, using statistical analysis, secondary data, and deductive reasoning. Deductive reasoning is also often referred to as the 'top-down' approach to research, as the research hypothesis is first decided and thereafter tested making use of data analysis (Wilson, 2010). Due to this chosen research method, the research is based on a positivism philosophy (Wilson, 2010), as reality is observed in an objective manner, based purely on statistics (Wilson, 2010).

3.3. Research design and methodology

3.3.1. Model selection

When attempting to analyse the volatility experienced in a market or variable based on time series data, a model that measures the variance has been proven to be most useful (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023). This is especially true when considering financial data that has varying volatility and non-constant variance of the error term (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023). Relevant variance models includes tests such as the Autoregressive Conditional Heteroskedasticity (ARCH) model and expanded models based on this model (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023).

The ARCH model was originally estimated by Robert F Engle (1982). Later Tim Bollerslev (1986) adapted this model to form the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model (Alberg, Shalit & Yosef, 2008). This was based on the limitations of the ARCH model (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023). This extension of the model identified a difference between the conditional and unconditional variance (Villar-Rubio, Huete-Morales & Galán-

Valdivieso, 2023). The aim of the GARCH model was to include the effect of the previous period's error term, thereby enabling the GARCH model to propagate volatility over a period (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023).

The GARCH model can be either a symmetric or an asymmetric model. The model is considered symmetric when volatility responds in the same manner to both a positive and a negative shock, whereas it is considered asymmetric when volatility reacts differently to positive or negative shocks (Bollerslev, 2008). Generally, when asymmetric reactions to shocks are observed, the Exponential GARCH model is preferred (Bollerslev, 2008).

The EGARCH model is a variation of the basic GARCH model. However, it has been adapted to be able to include asymmetric volatility (Alberg, Shalit & Yosef, 2008). The EGARCH model has been proven to be more accurate in the determination of volatility than the basic GARCH model (Alberg, Shalit & Yosef, 2008). There are two main reasons for this, the first being that both positive and negative news is able to impact volatility, in various different ways (Engle & NG, 1993). The second is that volatility is able to react differently depending on the size of the shock. Hence, bigger shocks may have a greater impact on volatility (Engle & NG, 1993). The chief advantage of this model lies in its ability to reflect both positive and negative volatility in the data series, which the basic GARCH model is not able to do (Villar-Rubio, Huete-Morales & Galán-Valdivieso, 2023). As a result of this, the parameters of the equation are without restrictions, which results in a more reliable optimisation (Bollerslev, 2008).

Taking into consideration that the aim of this study is to analyse the volatility of the foreign-exchange market, which experiences both positive and negative shocks, the model estimation technique is the Exponential Generalised Autoregressive Conditional Heteroskedasticity model (EGARCH model). The researcher believes this model most accurately answers the research questions as presented.

3.3.2. EGARCH model

When estimating the EGARCH model, daily time series data is considered to be the most accurate (Bollerslev, 2008). Therefore, it is that the estimation be based on the daily change in the South African foreign exchange rate. First there are three conditions which must be adhered to before the researcher may make use of the EGARCH. They are as follows (Bollerslev, 2008):

1. There should be evidence of volatility clustering. This implies that large shocks should be followed by more large shocks and similarly small shocks should be followed by further small shocks.
2. The ARCH effect must be evident. This the researcher should check by making use of the LM test.
3. There should be a leverage effect as measured by the gamma variable (γ).

3.4. EGARCH Model specification

This research first makes use of the EGARCH (P, Q) estimation technique, where 'P' represents the ARCH term and 'Q' includes the effect of the GARCH term. This model is illustrated with a normal distribution (Brooks, 2014).

The basic GARCH term is represented by:

Equation 3.1: EGARCH (P,Q)

$$(\sigma_t^2) = \varpi + \sum_{i=1}^{q} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^2$$

This research is based on a single time series. Therefore, this equation is adapted to form the EGARCH (1;1) model, as displayed below (Brooks, 2014). It is important to note this is based on the assumption of a normal distribution, that being the Gaussian EGARCH model (Su, 2010).

Equation 3.2: EGARCH (1,1)

$$Ln(\sigma_t^2) = \varpi + \beta \, ln(\sigma_{t-1}^2) + \gamma \frac{v_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|v_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right]$$

The use of the Gaussian distribution implies that this model does consider volatility clustering (Su, 2010).

3.4.1. Justification and explanation of suggested variables

ϖ is the constant term. This should be estimated. This term forms the variance intercept (Brooks, 2014).

α is the parameter representing the ARCH term. This is needs to be estimated (Brooks, 2014). The ARCH term refers to the way in which the degree of a shock to variance impacts volatility in the future (Brooks, 2014).

β This parameter needs to be estimated and represents the persistence that may be observed in conditional volatility, regardless of the situation in the market. It is the parameter that represents the GARCH term. If this parameter is relatively larger, it implies that it takes the market a longer period to recover from a crisis (Brooks, 2014).

γ represents the level of asymmetric volatility. This is also known as the leverage effect. Hence γ (gamma) can also be referred to as the leverage term (Brooks, 2014). The sign of the term is important in this case, as it indicates the different way returns reacts to positive and negative news (Brooks, 2014).

$\gamma \frac{\upsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}}$ represents the standardised volatility shock from the previous period (Brooks, 2014).

$\left[\frac{|\upsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right]$ This term is also a parameter, it replaces the ARCH term by considering the previous period's volatility shock in absolute terms (Brooks, 2014).

It is important to note the following regarding the gamma (leverage) term:

If $\gamma = 0$, there is no asymmetric volatility, but rather symmetry.

If $\gamma < 0$, the impact of negative shocks on volatility is greater than the effect of positive shocks.

If $\gamma > 0$, the impact of positive shocks on volatility is greater than the effect of negative shocks (Brooks, 2014).

3.5. ARMA model

When estimating an EGARCH model, a fitted model that forms the mean equation is required; this is known as the ARMA specification (Brooks, 2014). The ARMA model refers to the autoregressive (AR) moving average (MA) model. The purpose of this model is to describe the data series, where AR represents the regression of the historical data, whereas MA represents the dependent relation between the residual and the observed statistic (Brooks, 2014).

The ARMA (p,q) model is given in Brooks (2014) by:

Equation 3.3: ARMA (P,Q)

$$Yt = \phi_i X_{t-1} + \phi_2 X_{t-2} + \ldots\ldots + \phi_p X_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots\ldots + \theta_q \varepsilon_{t-q}$$

3.5.1. Justification and explanation of ARMA variables

Y_t This is the series that is created

The autoregressive (AR) process is given by:

$$\phi_i X_{t-1} + \phi_2 X_{t-2} + \ldots\ldots + \phi_p X_{t-p}$$

ϕ is referred to as the AR parameter.

X_t is dependent on the number of lags, which is denoted by p.

p is the lag term, which is referred to as the order in the AR process

The moving average (MA) process is given by:

$$\theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots\ldots + \theta_q \varepsilon_{t-q}$$

θ is referred to as the MA parameter.

ε_t this is the error term, otherwise referred to as the white noise term.

q is the lag term, which is the order of the MA process

The MA process models the moving average of both the current and past residual terms.

3.5.2. Selecting ARMA model parameters

The parameters of the ARMA model, are eventually the parameters of the EGARCH model, hence, it is essential to ensure that the optimal parameters are selected for the time series data. They define both the behaviour and structure of the model, to ensure the times series is correctly represented (Brooks, 2014). In order to select the optimal parameters, the Autocorrelation Function (ACF) is used to identify the optimal parameters for the model, by considering the autocorrelation present in the times series (Brooks, 2014).

Alternative: Akaike Information Criterion (AIC). The AIC model generates the amount of information that would be lost to estimate the relevant series, the model with the least AIC is most preferred.

Alternative: Bayesian Information Criterion (BIC). This uses the Schwarz criterion to optimise the ARMA model parameters selection. This selection is used when simplicity is prioritised. The BIC assists in finding the parameters that ensures that the model is both a good fit but balances this with the complexity thereof.

3.6. Secondary objective modelling

Another objective of this study is to determine if a relationship exists between monetary and fiscal policy and the exchange-rate volatility experienced. To test for this effect, an error correction model (ECM) is generated, making use of the following independent variables: the real interest rate and broad money supply, so as to determine the effects of monetary policy, and government spending to analyse the effect of the government intervention. The dependent variable is the monthly USD/ZAR exchange rate.

3.6.1. Error Correction Model (ECM)

Brooks (2014) gives the general form of an ECM model as the following:

Equation 3.4: ECM

$$\Delta Y_t = a + \beta \Delta X_t + yECT_{t-1} + \epsilon_t$$

Where,

$$\Delta Y_t = Y_t - Y_{t-1}$$

The two variables of interest in the equation are X_t and Y_t

a is the intercept term

β is the representative of the short-term effect on X_t and Y_t

y represents the coefficient of the ECT, this term indicates how quickly Y_t will return to its equilibrium levels after a shock

ϵ_t this term is the residual term, which may also be referred to as the error term

ECT_{t-1} is the '*Error correction term'* which considers the long-run equilibrium between Y and X, to measure the deviations. This term is given by the following equations:

The ECT is a derived formula, firstly the long-term cointegration must be considered, this is given by the following equation:

$$Y_t = \theta_0 + \theta_1 X_t + u_t$$

$$where\ u_t\ is\ the\ long-term\ regression\ residual, thus:$$

$$ECT_{t-1} = u_{t-1}$$

The advantage of the ECM model is its ability to incorporate the dynamics of both the short-term and long-term equilibrium, clearly indicating the relationship and adjustment process between variables.

3.7. Data and data sources

The required data is data pertaining to the South African daily and monthly USD/ZAR exchange rate, monthly real interest rate, monthly broad money supply figures, and government expenditure, as well as the dates and various stages of the lock-down regulation levels. Data used is data collected between the 1st of March 2020, to include the effect that the level 5 announcement on the 26th of March had on the exchange rates, till the end of April 2022, as South Africa's national state of disaster officially ended on the 22nd of April 2022 (South African Government, 2021). Then for a separate analysis so as to determine if Covid-19 influenced volatility, data was

collected for the same period length between the 30th of April 2018 till the 29th of February 2020.

The data collected to perform this quantitative research is cleaned and published data, that has already been published by various reliable sources, such as Statistics South Africa (Stats SA), the International Monetary Fund (IMF), SARB, WHO, the World Bank, the Organisation for Economic Cooperation and Development (OECD) and so forth.

The data relating to the USD/ZAR exchange rate in the financial market, specifically, the daily movement thereof, was obtained from the SARB's list of historical data, freely available at the following site: https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics/selected-historical-rates.

Data on the real interest rate and broad money supply (M3) in South Africa, may be obtained from the Organisation for Economic Cooperation and Development (OECD), as well as data pertaining to the South African government's monthly government spending. This data is publicly available at: https://stats.oecd.org/.

3.8. Data verification

Before an empirical analysis may be performed the validity of the data must first be checked (Brooks, 2014). This ensures that the data set is complete and has been correctly transferred (Brooks, 2014). In order to test this the following tests are used;

3.8.1. Normality test

In most cases, before modelling data, the normality of the residuals must be tested (Epaphra, 2017). However, it is important to note that, when estimating the EGARCH model, the assumption of normality is disregarded, as volatility models such as these tend to not have a normal distribution, but are skewed with fat tails (Tsay, 2013).

This test measures the level of kurtosis and skewness within the data (Epaphra, 2017).

3.8.2. Test for serial correlation

If there is evidence of serial correlation, it would result in an inaccurate forecast of the actual volatility within the markets (Epaphra, 2017). In order to test for serial correlation, also known as autocorrelation, the Ljung-box Q statistic is used.

3.8.3. Stationarity test

It may occur that time series data that is not necessarily related may show a relationship irrespective of whether one variable is dependent on the other or not (Wooldridge, 2019). This is known as spurious regression (Wooldridge, 2019). To ensure there is no spurious regression within the variables, the variables should be stationary (Wooldridge, 2019). To test for stationarity, the researcher makes use of the Augmented-Dickey Fuller test (ADF).

3.8.4. Lagrange multiplier for ARCH (ARCH-LM) models

A specification test, used to test for no conditional heteroskedasticity in the EGARCH model, the ARCH-LM test is used (Wooldridge, 2016). In this test, the squared error is regressed on its lag terms, to test for the presence of the ARCH effect (Yasar, 2021). This test must first come back with positive results before the EGARCH model may be used.

3.9. Residual diagnostics

In order to ensure that the model has been correctly specified and may be deemed a good fit, the following residual test must be performed:

3.9.1. ARCH-LM for the residuals

To test that the variance model has not been incorrectly specified, the standardised residual of the EGARCH model must be tested for any remaining ARCH effects (Minović, 2008). If there is no existence of ARCH effects within the residuals, the variance equation may be accepted as correctly specified (Minović, 2008).

3.9.2. Autocorrelation of residuals

The autocorrelation of the squared residuals of the model should also be considered when viewing the model as a good fit (Minović, 2008). This test also tests for the existence of any remaining ARCH effects, which should no longer be present if the model is correctly specified (Minović, 2008). Once again, autocorrelation was tested by making use of the Ljung-Box Q statistic test (Minović, 2008).

3.10. Chapter Summary

To summarise the above has clearly outlined the approach to be followed in the data analysis. The research is of a quantitative nature, making use of deductive reasoning, it was determined that the optimal model to determine the volatility of the USD/ZAR exchange rate is the EGARCH (1,1) model, as the research is based on a single time series, wherein both positive and negative shocks were experienced. To establish whether a relationship exists between fiscal and monetary policy and exchange rate volatility during the COVID-19 pandemic, the ECM model was selected. Robustness checks are essential to ensure that the analysis are reliable and credible, hence, in this chapter the normality test, test for stationarity, the test for serial correlation and lastly the Lagrange multiplier for ARCH models were selected to serve as robustness checks for this research. Lastly, it was concluded that the ARCH-LM and autocorrelation of residuals test are used to ensure that the model was correctly specified.

4. DATA ANALYSIS AND INTERPRETATION

4.1. Introduction

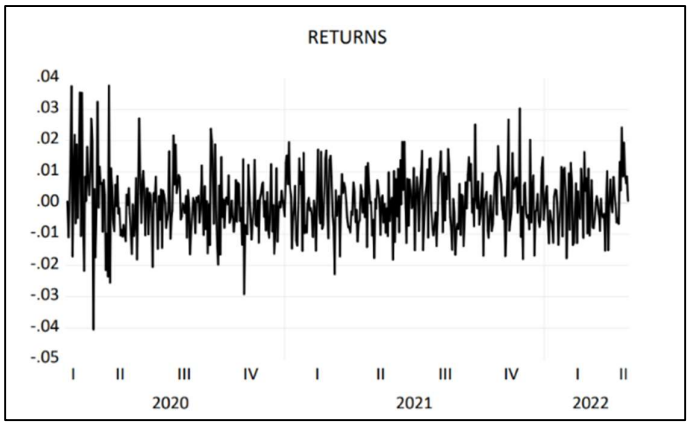
The data collected to perform the EGARCH model pertains to the daily USD/ZAR exchange rate between the 1st of March 2020 and the 29th of April 2022, signalling the end of the South African National state of disaster, as well as the 1st of February 2018 till the 29th of February 2020, representing the pre-Covid period. This data is based on a five-day week, as markets are not open on weekends or special holidays (South African Reserve Bank, 2023). Given the fact that this data is to be used in the EGARCH modelling process, the data has been changed into the returns on the USD/ZAR exchange rate. EViews is used for the purpose of this research.

4.2. Graphical representation of the data

The below graphs are a visual indication of the trend of the returns data for the two periods.

Figure 4.1: Return on exchange rate during the Covid-19 pandemic.

Return = log (exchange rate/exchange rate (-1))

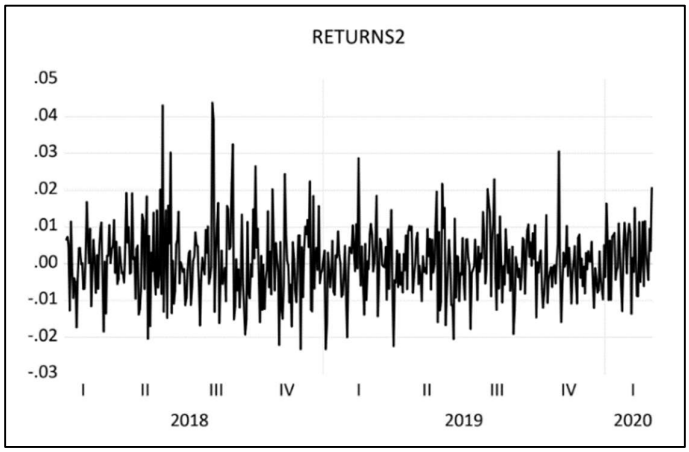


Data available at: https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics

Here it can be viewed that there is constant variance over the chosen time period. However, there are periods of extreme volatility that are often followed by periods of further volatility, thus suggesting there is evidence of volatility clustering.

Figure 4.2: Return on exchange rate before the Covid-19 pandemic.

Return2 = log (exchange rate/exchange rate (-1))



Data available at: https://www.resbank.co.za/en/home/what-we-do/statistics/key-statistics

Similarly to the period during the pandemic, there is also evidence of volatility clustering in the variable. However, from observing the graph, it appears that the period prior to the pandemic had a higher level of volatility.

In order to further view this, the descriptive statistics of the two periods are observed.

4.3. Descriptive statistics of the USD/ZAR returns series

Table 4.1: Descriptive statistics for RETURNS and RETURNS2

	RETURNS	RETURNS2
Mean	0.0000428	0.000529
Median	-0.000428	-0.0000175
Maximum	0.037640	0.043847
Minimum	-0.040441	-0.023177
Standard deviation	0.010258	0.009724
Skewness	0.387388	0.630347
Kurtosis	4.069053	4.677380
Jacque-Bera	39.22097	95.03042
Probability	0.0000	0.0000
Sum	0.023137	0.274015
Sum Sq. Deviation	0.056722	0.048886

From the above, it may be concluded that both data sets are not normally distributed, as evident in their Jacque-Bera statistic, kurtosis, and skewness statistic. The kurtosis of a normally distributed data set should be approximately 3, while the skewness of a normally distributed data set should be close to 0 (Brooks, 2014). A higher kurtosis statistic implies that there is a higher probability that there are significant deviations from the mean value (Brooks, 2014). Therefore, it is observed from the descriptive statistic that the period prior to Covid-19 pandemic (evident in *RETURNS2*) ha a higher probability of significant deviations from the mean. A skewness statistic of 0.387388 (*RETURNS*) implies that during the Covid-19 pandemic the return of exchange rate was relatively symmetrical (Brooks, 2014). Whereas the period prior to the Covid-19 pandemic displayed a value of 0.630347, which implies that the return on exchange rate during this period was moderately skewed (Brooks, 2014).

A good measure of the level of volatility experienced is the standard deviation of the data, a higher standard deviation value indicates a higher level of volatility (Gujarati & Porter, 2010). From the above data it can be seen that RETURNS, for the period of the COVID-19 pandemic, had a slightly higher standard deviation than that of the prior period before the COVID-19 pandemic.

4.4. Stationarity testing

The first step in determining if the EGARCH model can be estimated is ensuring that the data is stationary, by determining if this data has unit roots. The Augmented Dickey Fuller (ADF) test is used for the purpose of this study, the result generated are as follows:

Table 4.2: ADF Unit roots test results for RETURNS and RETURNS2

H_0: The times series contains a unit root and is non-stationary.

Test for unit root at level:

Augmented Dickey Fuller test			
Series	**Intercept**	**Intercept & Trend**	**None**
RETURNS	-23.92604 ***	-23.90448 ***	-23.94789***
RETURNS2	-21.96915***	-21.95124 ***	-21.92985***

Note: p < 0.001 ***, p < 0.05 **, p < 0.01 **

The volatility observed in the study variable is high, thus, in order to accommodate heteroskedasticity within the error terms as well as accommodate any structural breaks in the data, both the Phillips-Perron (PP) and the Zivot-Andrews tests are employed to ensure stationarity.

Table 4.3: PP unit roots test result for RETURNS and RETURNS 2

H_0: The times series contains a unit root and is non-stationary

Test for unit root at level:

Phillips-Perron Test			
Series	**Intercept**	**Intercept & Trend**	**None**
RETURNS	-23.92069 ***	-23.90021 ***	-23.94143***
RETURNS2	-21.95497***	-21.93625***	-21.91522***

Note: p < 0.001 ***, p < 0.05 **, p < 0.01 **

From the above analyses, it is concluded that the null hypothesis of a unit root and hence non-stationarity may be rejected at the 1% level of significance for both variables, the implication hereof is that the time series does not contain a unit root and is stationary. Thus, the return on the USD/ZAR exchange rate, at level, for the period during the Covid-19 pandemic and prior to the pandemic is stationary and may be used in the EGARCH analysis.

4.5. ARMA mean equation

4.5.1. ARMA equation for the Covid-19 pandemic period

The parameters of the ARMA model are first estimated via the BIC, before the model may be estimated. The BIC makes use of the Schwarz criterion, the result of which is as follows:

Table 4.4: Schwarz criterion results for RETURNS

BIC	MA				
AR		1	2	3	4
	1	**-6.301618**	-6.277831	-6.280564	-6.256280
	2	-6.278069	-6.288395	-6.280190	-6.282458
	3	-6.278204	-6.278692	-6.283005	-6.270721
	4	-6.285144	-6.299932	-6.283521	-6.271797

The optimal model is the one in which the Schwarz criterion is at its lowest value, hence, for this model the optimal ARMA equation for this data set, is the ARMA (1,1) model. The model output is as follows.

Table 4.5: ARMA (1,1) model output

ARMA conditional least squares (Marquardt – EViews legacy)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Probability**
C	0.0000730	0.000442	0.165281	0.8688
AR (1)	-0.988413	0.004778	-206.8589	0.0000
MA (1)	0.997182	0.002648	376.5481	0.0000

4.5.2. ARMA equation for the period prior to Covid-19 pandemic

Similarly to the previous model, the ARMA parameters were first determined via the BIC test. The Schwarz criterion statistics revealed the following results:

Table 4.6: Schwarz criterion results for RETURNS2

BIC	MA				
AR		1	2	3	4
	1	**-6.393766**	-6.383759	-6.374042	-6.356579
	2	-6.382441	-6.391983	-6.380720	-6.368625
	3	-6.371966	-6.388347	-6.374366	-6.329046
	4	-6.366601	-6.374148	-6.371335	-6.381123

The optimal model is the one in which the Schwarz criterion is at its lowest value, hence, for this model the optimal ARMA equation for this data set, is the ARMA (1,1) model. The output is as follows.

Table 4.7: ARMA (1,1) model output

ARMA conditional least squares (Marquardt –EViews legacy)				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
C	0.000517	0.000431	1.199248	0.2310
AR (1)	0.002500	1.574843	0.001587	0.9987
AR (2)	0.002500	1.575631	0.001587	0.9987

4.6. Testing for ARCH effects

Before performing the actual EGARCH estimation, it must first be tested that the data presents evidence of ARCH effects, making use of the ARCH heteroskedasticity test, based on the squared residuals of the ARMA model that has already been estimated.

The test reveals the following:

Table 4.8: Heteroskedasticity test: ARCH for RETURNS

H_0: There exist no ARCH effects.

Heteroskedasticity Test ARCH – RETURNS			
F-statistic	12.13733	Prob F	0.0000***
Obs* R-Sqaured	23.34960	Prob Chi-squared	0.0000***
Lag length: q = 2			
***1% level of significance **5% level of significance *10% level of significance			

Table 4.9: Heteroskedasticity test: ARCH for RETURNS2

H_0: There exist no ARCH effects.

Heteroskedasticity Test ARCH – RETURNS2			
F-statistic	18.13998	Prob F	0.0000***
Obs* R-Squared	17.58979	Prob Chi-squared	0.0000***
Lag length: q=1			
***1% level of significance **5% level of significance *10% level of significance			

From the above it can be confirmed that the regression coefficients for the return on the USD/ZAR exchange rate for both periods are significant. It can also be noted that the period between 2018 and 2020 shows evidence of ARCH effect at the first lag, as opposed to the period between 2020 and 2022, which only reveals ARCH effects at the second lag. The null hypothesis may be rejected, as there is evidence of ARCH effects in both time series. Therefore, the EGARCH models may be estimated.

4.7. EGARCH model output estimation

4.7.1. Estimating the EGARCH (1,1) model

The framework used in the analysis of this model is the normal Gaussian framework.

Table 4.10: EGARCH (1,1) model output

Dependent variable: **Returns**

Method: ML ARCH

Sample adjusted 03/04/2020 04/29/2022.

	EGARCH (1,1)	Estimate	Std error term	Z-statistic	P-value
C (4)	Constant term ($\boldsymbol{\varpi}$)	-1.161224	0.388539	-2.113851	0.0028**
C (5)	ARCH term ($\boldsymbol{\alpha}$)	0.185399	0.060019	3.089017	0.0020**
C (6)	Leverage effect ($\boldsymbol{\gamma}$)	0.053147	0.029087	1.827192	0.0677*
C (7)	GARCH term ($\boldsymbol{\beta}$)	0.890411	0.039783	22.38175	0.0000***
***1% level of significance p<0.001 **5% level of significance p<0.05 *10% level of significance p<0.10					

The constant and ARCH terms are significant at the 5% level of significance, the leverage is significant at the 10% level of significance, while the GARCH is statistically significant at the 1% level of significance. Thereby indicating that past volatility in the exchange rate influences the current volatility of the exchange rate.

C (4) is the constant term. This value is significant at the 5% level of significance, as it has a probability of 0.0028. This term is also a positive value.

C (5) is the ARCH term, represented by alpha, and has a probability of 0.0020. This indicates that, during the Covid-19 pandemic, the size of the shock had a significant effect (at the 1% level of significance) on the volatility of the USD/ZAR exchange-rate returns. This term is a positive value, meaning current and past variance have a positive relationship (Brooks, 2014). Therefore, the degree of the shock to variance has an impact on volatility. In conclusion, there is evidence of volatility clustering in the data.

The parameter representing the leverage effect, c (6), is statistically significant, with a probability of 0.0677. Thus, the model exhibits the leverage effect at the 10% level of significance. C (7) is greater than 0, which means that $\boldsymbol{\gamma} > 0$, so asymmetric volatility is confirmed, indicating that positive and negative shocks affect exchange-rate volatility differently (Brooks, 2014). The fact that this term is positive, indicates that volatility reacted more strongly to positive news than it did to negative news (Brooks, 2014).

C (8) is Beta, which is the representative for the GARCH term, and is significant at the 1% level of significance. This indicates the persistence of past volatility. The significance of this variable further indicates that past volatility plays a role in determining the volatility of exchange rates in the future.

The EGARCH (1,1) equation is given by the following equation:

Equation 4.1: EGARCH (1,1) for RETURNS

$$\boldsymbol{Ln(\sigma_t^2) = -1.161224 + 0.890411 ln(\sigma_{t-1}^2) + 0.053147 \frac{v_{t-1}}{\sqrt{\sigma_{t-1}^2}} + 0.185399 \left[\frac{|v_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right]}$$

4.7.2. Estimating the EGARCH model

This analysis also makes use of the normal Gaussian distribution framework.

Table 4.11: EGARCH (1,1) model output

Dependent variable: Returns2

Method: ML ARCH

Sample adjusted 02/05/2018 02/28/2020

	EGARCH (1,1)	Estimate	Std. Error Term	Z-statistic	P-value
C (4)	Constant term ($\boldsymbol{\varpi}$)	-1.409140	0.572750	-2.460304	0.0139***
C (5)	ARCH term ($\boldsymbol{\alpha}$)	0.076983	0.045503	1.691803	0.0907*
C (6)	Leverage effect ($\boldsymbol{\gamma}$)	0.147970	0.036597	4.043206	0.0001***
C (7)	GARCH term ($\boldsymbol{\beta}$)	0.854813	0.059056	14.47449	0.0000***
***1% level of significance p<0.001 **5% level of significance p<0.05 *10% level of significance p<0.10					

The constant term is significant at the 5% level of significance, the leverage and GARCH terms are statistically significant at the 1% level of significance, and the ARCH term is significant at the 10% level of significance. Thereby indicating that past volatility in the exchange rate influences the current volatility of the exchange rate for the period prior to the pandemic.

The constant term C (4) is significant at the 5% level of significance, as it has a probability of 0.0139. The test statistic for the term also has a negative value.

C (5), the alpha term, has a probability of 0.0907. This indicates that, during the period prior to the Covid-19 pandemic, the size of the shock had a significant effect (at the 10% level of significance) on the volatility of the USD/ZAR exchange-rate returns. Hence, this model also has evidence of volatility clustering. Similarly to the EGARCH (1,1) for the period during the Covid-19 pandemic, the ARCH term has a positive value, meaning current and past variance have a positive relationship (Brooks, 2014). Therefore, the degree of the shock to variance has an impact on volatility.

The leverage effect (C (6)) of this model is also a positive value, indicating again that positive shocks have a greater impact on volatility than negative shocks and asymmetric volatility may be confirmed (Brooks, 2014). The probability of 0.001 indicates that this effect is highly significant at the 1% level of significance.

Beta (C (7)) is also significant at the 1% level of significance, and thus this model also illustrates the persistence of past volatility that influences future volatility.

The EGARCH (1,1) equation is given by the following equation:

Equation 4.2: EGARCH (1,1) for RETURNS 2

$$\boldsymbol{Ln(\sigma_t^2) = -1.409140 + 0.854813\, ln(\sigma_{t-1}^2) + 0.147970 \frac{v_{t-1}}{\sqrt{\sigma_{t-1}^2}} + 0.076983 \left[\frac{|v_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right]}$$

4.8. Residual diagnostics

4.8.1. ARCH-LM test

To test the validity of these tests, first the ARCH-LM test, as previously specified, must be performed. This determines if the residuals still show evidence of the ARCH effect.

Table 4.12: ARCH-LM output for EGARCH (1,1) with dependent variable returns

Considering the RETURNS variable was originally tested at a lag length of 2, both lag lengths are tested in the following ARCH-LM test, to ensure there are no further ARCH effects in the model.

H_0: There exist no ARCH effects.

Heteroskedasticity Test ARCH - RETURNS			
F-statistic	0.050184	Prob F	0.8228
Obs* R-Squared	0.050366	Prob Chi-squared	0.8224
Lag length: q =1			
F-statistic	0.233185	Prob F	0.7921
Obs* R-Squared	0.468581	Prob Chi-squared	0.7911
Lag length: q = 2			

Table 4.13: ARCH-LM output for EGARCH (1,1) with dependent variable returns2

H_0: There exist no ARCH effects.

Heteroskedasticity Test ARCH – RETURNS2			
F-statistic	0.455074	Prob. F	0.5002
Obs*R-squared	0.456440	Prob.Chi-Square	0.4993
Lag length: q = 1			

As shown above, the Chi-square value is larger than the LM test statistic. This means the EGARCH model eliminates the ARCH effect, hereby accepting the null hypothesis of no ARCH effect for the ARCH-LM test.

4.8.2. Correlation test statistic

Next it should be determined whether autocorrelation remains within the model estimation output. This further determines if both of the models have been estimated correctly.

Table 4.14: Ljung-Box test for serial correlation

H_0: There is no serial correlation of any order up to p.

Lag Length	AC	PAC	Q-stat	Prob*
1	-0.010	-0.010	0.0501	0.823
2	0.024	0.024	0.3620	0.834
3	-0.019	-0.019	0.5620	0.905
4	0.080	0.079	4.0376	0.401
5	-0.077	-0.075	7.2752	0.201
6	-0.049	-0.054	8.5922	0.198
7	0.015	0.021	8.7104	0.274
8	-0.048	-0.056	9.9909	0.266
9	-0.011	-0.002	10.061	0.346
10	0.033	0.039	10.645	0.386
11	0.104	0.094	16.670	0.118
12	-0.023	-0.016	16.958	0.151
13	0.024	0.016	17.288	0.186
14	-0.026	-0.035	17.671	0.222
15	0.004	-0.009	17.680	0.280

The result of this residual diagnostic indicates that there is no autocorrelation in the variables. The null hypothesis is not rejected, confirming that this EGARCH model correctly represents the volatility of the USD/ZAR exchange-rate returns.

Table 4.15: Ljung-Box test for serial correlation

H_0: There is no serial correlation of any order up to p.

Lag Length	AC	PAC	Q-stat	Prob*
1	0.030	0.030	0.4579	0.499
2	0.009	0.008	0.4963	0.780
3	-0.053	-0.054	1.9794	0.577
4	-0.029	-0.026	2.4140	0.660
5	0.024	0.027	2.7122	0.744
6	0.012	0.008	2.7897	0.835
7	-0.012	-0.016	2.8626	0.897
8	-0.019	-0.016	3.0450	0.932
9	-0.041	-0.037	3.9254	0.916
10	-0.017	-0.016	4.0809	0.944
11	0.101	0.101	9.5340	0.573
12	0.006	-0.004	9.5515	0.655
13	0.022	0.017	9.8208	0.709
14	0.035	0.046	10.462	0.728
15	0.029	0.033	10.898	0.760

The residual of the EGARCH (1,1) for *returns2* shows no evidence of autocorrelation. Hence, the null hypothesis may be accepted, as may the model.

4.9. EGARCH model conclusion

The results of the two EGARCH models can be concluded as follows: both estimated models had all their variables significant at the 1% level of significance and both removed all ARCH effects from their residuals, making both estimations significant and proving that there is overall volatility clustering within the foreign-exchange market.

To consider the effect of the Covid-19 pandemic, the differences between these models should be studied. One way in which the strength of the model can be tested is by considering the sum of the ARCH and GARCH coefficients (Gabriel, 2013). For the period prior to the Covid-19 pandemic, the sum of these is approximately 0.2478 (0.187859 + 0.059915), whereas, during the Covid-19 pandemic the sum of these coefficients is 1.0573 (0.187859 + 0.869434). The closer this value is to 1, the more persistent the shocks were towards the conditional variance (Gabriel, 2013); hence,

there was more persistence in volatility and higher levels of volatility clustering were evident during the Covid-19 pandemic time period.

However, as viewed in the descriptive statistics, the period prior to the Covid-19 period experienced periods of higher levels of volatility. Although our estimation output indicates that there was more volatility clustering during the global pandemic, this is still an indication that there exists a relationship between the Covid-19 pandemic and the volatility of the South African exchange rate between March 2020 and the end of the national state of disaster in April 2022. Therefore, it may be concluded that the null hypothesis, that there exists no relationship between the Covid-19 pandemic and the volatility of the South African exchange rate, may be rejected.

4.10. Determining the impact of monetary and fiscal-policy tool

In order to assess the impact of monetary policy and fiscal policy, the monthly real interest rate (RIR) , broad money supply (M3) and government spending (GS) are taken into consideration, along with a monthly aggregate for the USD/ZAR exchange rate.

4.10.1. Descriptive statistics of the monthly variables

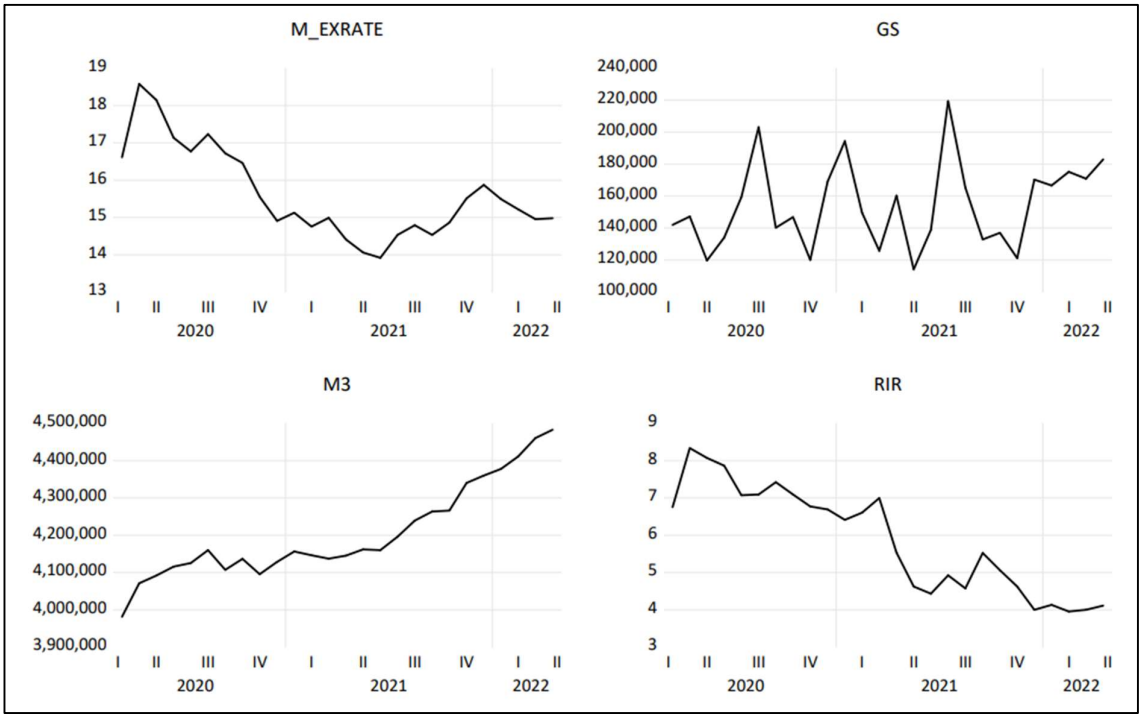
Table 4.16: Descriptive statistic for monthly government spending, broad money supply, the real interest rate and USD/ZAR exchange rate, during the Covid-19 pandemic.

	Government spending (GS)	Broad money supply (M3)	Real interest rate (RIR)	USD/ZAR exchange rate
Mean	154090.9	4204194.	5.869231	15.61838
Median	148405.5	4157818.	5.970000	15.16945
Maximum	219381.0	4482242.	8.330000	18.57600
Minimum	114102.0	3981097.	3.950000	13.91670
Std. Dev	27091.25	128437.9	1.435234	1.227452
Skewness	0.568299	0.749784	0.070298	0.838394
Kurtosis	2.734700	2.653917	1.586206	2.845764
Jarque-Bera	1.475758	2.565853	2.186797	3.071688
Probability	0.478127	0.277225	0.335076	0.215274
Sum	4006364.	1.09E+08	152.6000	406.0779
Sum Sq. Dev.	1.83E+10	4.12E+11	51.49738	37.66593
Observations	26	26	26	26

From the above, it is noted, based on the kurtosis as well as the Jacque-Bera statistic, that these variables are not normally distributed. The kurtosis and skewness show that

these variables have different tails and favour different distributions. This can be seen graphically below:

Figure 5.3: Data trends



When considering the government spending and broad money supply, the logged version thereof is also more manageable for the purpose of this study. However, to maintain consistency, the analysis will make use of all of the variables in their logged form.

To test the impact of monetary and fiscal-policy variables on the relevant exchange rate, an error correction model (ECM) analysis was generated. However, there were first steps to be taken before this analysis was performed.

Similarly to the estimation of the EGARCH, all variables used in the estimation were first tested for stationarity, making use of the ADF test statistic. See Addendum A. The ADF test confirmed there is evidence of stationarity within the variables. However, it was determined that the real interest rate and broad money supply variables are only stationary at their first difference, the 1(1) level, and should be used in this form to accurately perform the estimation. Whereas government spending is stationary at the 1(0) level and may therefore be used at level. Thus, there is a mixture of 1(0) and 1(1)

variables. From the above it may be stated that the null hypothesis of no stationarity may be rejected.

In order to perform the ECM, the variables should be integrated in the same order, they must be stationary, and they have to be cointegrated. Therefore, although the government spending (GS) is stationary at the 1(0) order, it will be integrated in the model at the 1(1) order. Next in order to determine if the ECM may be used, it must first be tested that there exists a long-term relationship b=between the variables, hence, the cointegration of the variables must be tested for evidence of this relationship. For this study the variables were tested via the Johansen cointegration test, for the results of this analysis refer to addendum B. From this analysis, it is determined that the null hypothesis of no cointegration may be rejected, thus there is cointegration within the variables.

Due to the evident cointegration, the long-run model was estimated, this is the error correction term (ECT.) To view the analysis of the ECT refer to addendum C. The residual series of this analysis is known at the ECT statistic and will be used in the ECM to account for the long-term relationship between the variables.

4.11. ECM model

The generated ECM model results are as follows.

Table 4.17: Error Correction Model

Dependent variable: D(LEXRATE)

Method: Least Squares

Sample Adjusted 2020M05 2022M04.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.016208	0.007122	-2.275674	0.0340
ECT(-1)	-0.198928	0.117696	-1.690180	0.1005
D(LM3)	3.116984	0.862908	3.612185	0.0017
D(LGS)	0.007190	0.026781	0.268487	0.7911
D(LRIR)	0.132817	0.062709	2.117979	0.0469
R-squared 0.523836 Mean dependent var -0.004138 Adjusted R-squared 0.428604 F-statistic 5.500595 Durbin-Watson stat 1.916885 Prob (F statistic) 0.003738				

From the above, it is noted that the model is a good fit, as indicated by the R-squared and adjusted R-squared. The R-squared value is less than the Durbin Watson statistic and is also between 0.50 and 0.90. The adjusted R-squared indicates that approximately 43% of the change in the dependent variable can be explained by the independent variables. The Durbin Watson is also a good indicator of the specification of the model, this being almost 2, which indicates that the model may be accepted.

The ECT is significant (at the 10% level of significance) and negative, thus proving the long-run relationship is viable and may be interpreted. The ECT shows the speed at which the dependent variable adjusts back to the equilibrium. For this model, the speed would be 19.89% per month. Furthermore, and most importantly for this research, it can be seen that both variables representing the monetary-policy actions yielded significant results (at the 5% level of significance), whereas the government spending representing fiscal policy did not. This means that monetary policy was able to influence the exchange rate and ultimately the changes and volatility thereof, while fiscal-policy changes did not. As this model is estimated at the first order, the

coefficient variables are not viable and were not accurate for interpretation of the effect thereof on the dependent variable, exchange rates.

4.11.1. ECM model conclusion

To conclude, from the above, it is confirmed that we may reject the null hypothesis that monetary-policy actions taken by the SARB during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate. However, the null hypothesis relating to fiscal policy may be accepted, that being that fiscal-policy actions taken by the government during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate.

5. ANALYSIS RESULTS

5.1. Introduction

This final chapter summarises the current study, firstly by presenting an overview of the study. This is done via an in-depth analysis of the results achieved in the statistical analysis, the objective hereof is to draw a conclusion regarding the proposed research questions an hypotheses. This is followed by an overview of the implications of the discussed results and how this relates to the South African foreign exchange market. The chapter concludes by presenting the researchers policy recommendations based on the statistical analysis as well as a brief discussion as to how future studies in this area can improve research on this topic.

5.2. Summary of the results of the data analysis

This research made use of statistical analysis, employing methodologies such as ARMA, EGARCH and ECM, to determine that, in the South African exchange rate market, specifically during the Covid-19 pandemic, there was evidence of volatility clustering and persistence in volatility and highlighted the asymmetrical impact of various shocks on the USD/ZAR exchange-rate volatility. This provided insight into the dynamics of the South African exchange rate, particularly in times of crisis. The results of the above-mentioned tests are discussed below.

From the onset when viewing the graphs (refer to figures 3 and 4) relating to the volatility of the relationship between the rand and dollar, the researcher was able to conclude that there was evidence of volatility clustering, as a period of volatility was followed by another period of further volatility. A point worth noting is that this graph revealed that, during the period prior to the Covid-19 pandemic, the rand experienced increased rates of volatility. This view was solidified by the higher maximum and minimum values, as well as the higher mean value, of the prior period, as indicated in Table 1. Table 1 also confirmed that the datasets were not normally distributed.

Both the returns and returns2 variables indicated that there was evidence of stationarity, via the ADF test, at the 1% level of significance, allowing for further estimation without changing the variables any further. The ARMA model was determined making use of the optimisation model. The results thereof revealed that, for the Covid-19 period, the optimal ARMA equation is the ARMA(1,1) model, for the

prior period the optimal equation is the ARMA (1,1) model. These two models showed evidence of ARCH effects, when tested making use of the ARCH heteroskedasticity test. Thus, these models were then used to estimate the two EGARCH models.

Both of the calculated EGARCH models, making use of the Gaussian framework, confirmed the evidence of volatility clustering. Refer to equations 3 and 4. The results of the EGARCH(1,1) model for the Covid-19 period are as follows. All the relevant terms, the constant, ARCH, GARCH term and leverage effect, are significant at the 1% level of significance. The ARCH term determined that the size of the shock to the foreign-exchange market had a significant effect on the level of volatility experienced. The positive nature of this term further concluded that there exists a positive relationship between past and current volatility, as evident in the volatility clustering. The GARCH term determined that there was persistent volatility; so past volatility played a role in determining future volatility during this period. The value of the leverage effect allowed the researcher to conclude that, during this period, volatility reacted differently to positive and negative shocks. As this term was a positive value, it is determined that there is a stronger relationship between positive shocks and increased volatility than there is to negative shocks and volatility.

In order to see if the Covid-19 pandemic influenced this volatility, the next EGARCH model was constructed on the period prior to this. The results of this EGARCH model (refer to table 8), based on the ARMA (1,1) equation, is as follows: again all terms are significant at the 1% level of significance. Thus, even before the pandemic, past and current volatility were intricately related. Much like the first EGARCH model, the ARCH term is a positive, significant value, allowing for the conclusion that the size of the shock had an influence on the level of volatility experienced within the market, and past and current volatility are interconnected. Again similarly, the leverage effect revealed a positive, significant value, thus confirming asymmetric volatility, whereby, for this model, positive shocks have a greater influence on volatility than negative shocks. Persistent volatility within the data is also confirmed by the significance of the GARCH term. This volatility influences the level of future volatility.

When comparing these two models with one another, it may be concluded that both periods experienced volatility clustering, where positive shocks played a larger role. However, the nature of volatility differed between the two periods. During the Covid-

19 period, the sum of the GARCH and ARCH terms yielded a value of approximately 1.05, whereas the previous period yielded a value of approximately 0.25. This allows for the conclusion that there was a higher persistence of volatility during the Covid-19 pandemic. This indicates that, during the pandemic, volatility experienced in the current period had a greater influence on volatility in the future than it did in the period prior to Covid-19.

In terms of the South African government and SARB's ability to restrict the exchange-rate volatility by implementing fiscal and monetary policy, respectively, the following was confirmed. The broad money supply, government spending and real interest rate are the three main variables used to influence monetary and fiscal policy. Therefore, these variables were compared to the ZAR/USD exchange rate, on a monthly basis, for the Covid-19 period. When studying the trends of these variables, as viewed in Table 13, it may be concluded that these variables all show evidence of very different trends.

In terms of fiscal policy, government spending showed evidence of extreme volatility, with an overall increasing trend. Whereas as monetary-policy variables displayed two different trend for the two variables, broad money supply had an overall increasing trend, whereas the real interest rate declined over time. When compared to the exchange rate, that had a decreasing trend over time. The only variable that moved similar to this was the real interest rate.

To measure the impact, if any, of these independent variables (broad money supply, real interest rate and government spending) on the dependent variable (monthly exchange rate), an ECM was generated. The results generated by the use of this model concluded the following. There is a significant relationship between the ECT and the exchange rate; hence, there is a long-run relationship between these three variables and the exchange rate. In this model, it is determined that monetary-policy actions had a significant influence on the change rate during this period, as both the broad money supply and real interest rate yielded significant results for this test. This means these variables had a meaningful impact on the ZAR/USD exchange rate. However, the variables representing government spending, an indicator of fiscal policy, did not yield significant results.

5.3. Conclusion of the data analysis

When considering the descriptive statistical analysis alongside the insights determined by the EGARCH model, in terms of the dynamics of the USD/ZAR exchange rate during the period of uncertainty of the Covid-19 pandemic, it may be concluded that there is an undeniable change in the nature of volatility.

There is an undisputable increase in the persistence of volatility. However, it is vital to note that the degree to which the exchange rate varies decreases substantially during this period, in comparison to the period prior to the pandemic. This serves as a confirmation that there exists a relationship between the volatility of the South African exchange rate and the Covid-19 pandemic. Therefore, the researcher rejects the null hypothesis that there exists no relationship between the Covid-19 pandemic and the volatility of the South African exchange rate. This answers the first research question posed in this study.

The ECM model assists in answering the second and third research questions posed in the study. Thus, the researcher concludes that the monetary-policy actions effected the volatility of the ZAR/USD exchange rate, whereas, fiscal-policy actions were not able to do so. Therefore, in terms of the hypothesis of the study, the following is concluded: the null hypothesis that monetary-policy actions taken by the SARB during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate may be rejected.

However, the null hypothesis relating to fiscal policy may be accepted, that being that fiscal-policy actions taken by the government during the Covid-19 pandemic were not successful in constraining the volatility of the South African exchange rate. When considering the results of these two different tests together, the researcher partially attributes the restraint in the level of volatility to the monetary policies implemented during this period.

5.4. Policy recommendations

When considering the possibility of a similar crisis in the future, the following policy recommendation and future actions are suggested by the researcher, based on this study. As mentioned before, monetary-policy actions implemented by the SARB play a significant and important role in determining the amount of volatility experienced

within the foreign-exchange market, in terms of the ZAR/USD exchange-rate relationship. During the Covid-19 pandemic, although there was evidence of more persistent volatility, the level thereof decreased when compared to the prior term. Thus, this researcher believes the actions taken by the SARB were effective and correctly implemented. This indicates that, for the South African economy, in the event of a major unexpected shock, it is prudent for the SARB to decrease interest rates while increasing the broad money supply. Specific policy recommendations includes measures such as; decreasing the repo rate, assisting borrowers in managing their financial obligations. Additionally, the SARB enhanced liquidity in the banking sector by expanding both the availability and duration of repo facilities for banks, via the purchasing of bonds.

Government spending showed no evidence of significance in influencing the volatility of the exchange rate. Thus, from a fiscal policy point of view, there is little local government is able to do to affect the dynamic of the exchange rate, during times of crises.

5.5. Limitations and future recommendations

In this study, the change in volatility in the USD/ZAR exchange rate from the period prior to the Covid-19 pandemic and the period during the Covid-19 pandemic was attributed to the Covid-19 pandemic. To ensure there are no other variables that could have played a more significant role, future studies should consider other factors relating to the pandemic and overall global economy that may have had a larger effect on volatility. This may include political factors, economic factors, social factors, the situation in other countries.

For simplicity and ease of testing, this study was only able to test the USD/ZAR exchange-rate relationship. Studies furthering this research in the future should also consider testing more exchange-rate relationships. A valuable test would also be to include a comparison of the exchange rate for another developing country. The circumstances and ability of these countries to react is more similar and would provide valuable insight into the reaction and stability of the South African authorities and market respectively.

5.6. Conclusion

Broadening the overall understanding of the dynamics of the foreign-exchange market in South Africa, during times of crisis is essential to not only the way in which policymakers should react now but the restoration thereof after the fact as well. The results of this research identified that, during periods of instability, as in the case of the Covid-19 pandemic, there is a definite change in the dynamics of the South African exchange rate. As determined for this specific case, volatility proved to be more persistent.

The experiences of developing countries such as South Africa vary vastly from that of developed countries and the emphasis must be placed on the way in which our government should uniquely react. This study places the emphasis on the critical role of both the SARB and the South African government. In terms of this, the results of this study determine that, in terms of the foreign-exchange market, specifically the USD/ZAR exchange rate, the South African government should not focus on exchange-rate adjustments when making ultimate policy decisions, as there appeared to be no significant relationship between exchange-rate volatility in the USD/ZAR exchange rate and government spending. However, as mentioned before, there is still a definite role for fiscal policy during such a crisis, but this is perhaps more focused on other economic variables, such as restoring economic growth and development, as well as maintaining employment.

On the contrary, monetary policy was instrumental during this global pandemic. This study determined that the constraint on the level of volatility experienced during the Covid-19 period could be attributed to the appropriate use of monetary-policy tools. By reducing the interest rate significantly, while increasing the broad money supply, the SARB and its monetary-policy actions were able to ensure that, although there was persistent volatility during this period, this volatility could be constrained to an acceptable level, so as to avoid extremely high peaks followed by extremely low troughs. As previously state in the literature review, stability in this market is essential, with the aim of maintaining inflation levels, as well as maximising output and employment.

Lastly, this chapter concludes the present research. This chapter intricately presents and discusses the finding of the research. It has served as an answer to the research

questions and research hypotheses. It has highlighted the policy recommendations in the event of a similar crisis in the future. Furthermore, it has also stipulated the limitations of the study and expressed the recommendations for future researchers. Further research on this topic is essential for the South African economy and the recovery thereof. This researcher believes this research serves as a good starting point on which to base further studies in future.

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ADDENDUMS

Addendum A: Augmented Dickey Fuller Test

Ho: The time series contains a unit root and is non-stationary

Augmented Dickey Fuller test			
Series	**Intercept**	**Intercept & Trend**	**None**
RIR	-0.741546	-4.258280**	-1.032400
D(RIR)	-6.007782***	-5.773864***	-5.562615***
M3	1.597222	-0.250532	3.314547
D(M3)	-6.006228***	-6.557417***	-2.174942***
GS	-4.122592**	-4.237240**	0.509805
D(GS)	-5.252671***	-5.173630***	-5.359181***

Note: p < 0.001 ***, p < 0.05 **, p < 0.01 **

Addendum B: Johansen cointegration

Ho: There exists no serial correlation in the variables.

	AC	PAC	Q-STAT	PROB.
1	0.707	0.707	14.560	0.000
2	0.421	-0.158	19.933	0.000
3	0.175	-0.119	20.897	0.000
4	0.087	0.119	21.147	0.000
5	0.025	-0.064	21.170	0.001
6	0.010	0.012	21.173	0.002
7	-0.093	-0.186	21.501	0.003
8	-0.287	-0.306	24.830	0.002
9	-0.377	0.034	30.930	0.000
10	-0.455	-0.238	40.361	0.000
11	-0.475	-0.169	51.296	0.000
12	-0.369	0.160	58.359	0.000

Addendum C: Error correction term (ECT) estimation

Dependent variable (LEXRATE) **Method Least squares** **Sample adjusted 2020M03 2022M04.**				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Prob.**
LM3	1.389371	0.685970	2.025409	0.0551
LRIR	0.343667	0.080959	4.244947	0.0003
LGS	0.013598	0.068718	0.197881	0.8450
C	-19.20412	10.44535	-1.838534	0.0795
R-squared 0.531541 Adjusted R-squared 0.467660 F-statistic 8.320831 Durbin-Watson stat 0.481869 Prob(F-statistic) 0.000696				

LEXRATE Logged Monthly USD/ZAR exchange rate

LM3 Logged Broad money supply

LRIR Logged Real exchange rate

LGS Logged Government Spending