

ANALYSIS OF THE DETERMINANTS OF EXCHANGE RATE VOLATILITY
IN THE SACU REGION

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Abstract

The currencies of the five SACU countries have experienced notable volatility in the last decade. The purpose of this study therefore, was to identify the determinants of exchange rate volatility in the SACU region and also to determine if there is a long run relationship between exchange rate volatility and its determinants. The study used annual time series data from 1980 to 2017. This study uses the generalised autoregressive conditional heteroscedasticity GARCH (1, 1) approach. The results from the study revealed that interest rates and inflation were both significant factors in explaining exchange rate volatility in Lesotho. Interest rates were also found to be a determinant of exchange rate volatility in Namibia. For South Africa, Swaziland and Botswana, inflation and interest rates were not significant in explaining exchange rate volatility. Policy makers in the region should therefore start considering the possibility of macro-economic policy independence going forward. In Lesotho, targeted inflation may go a long way in reducing exchange rate volatility. In Namibia and Lesotho, there is also room to explore the possibility of changing the interest rates time and again with the aim of reducing exchange rate volatility.

Table of Contents

Abstract	i
Table of Contents	ii
List of Tables.....	v
List of Figures	vi
List of Acronyms	vii
Acknowledgements	viii
Declaration	ix
CHAPTER ONE: INTRODUCTION	1
1.1 Background of the Study	1
1.2 Statement of the Problem	1
1.3 Objectives of the Study	3
1.4 Hypotheses of the Study	3
1.5 Significance of the Study	3
1.6 Limitation of the Study.....	4
1.7 Delimitations of the Study.....	4
CHAPTER 2 : LITERATURE REVIEW.....	5
2.1 Introduction	5
2.2 Theoretical Literature	5
2.3 Empirical Studies	7
2.4 Summary of Literature Reviewed	19
CHAPTER 3 : METHODOLOGY.....	20
3.1 Introduction	20
3.2 Research Design	20
3.3 Procedure.....	20
3.4.0 Data Analysis	21
3.4.1 Unit Root Tests.....	21

3.4.2 Cointegration Tests.....	22
3.4.3 GARCH (1, 1) Model.....	23
Model Specification.....	23
Mean Equation.....	24
Variance Equation.....	25
3.4.4 Diagnostic Tests	26
Serial Correlation	26
White’s Heteroscedasticity Test	27
Residual Normality Test	27
Best Model.....	28
3.5 Research Ethics	28
3.6 Summary	28
CHAPTER 4 : RESULTS AND DISCUSSION	29
4.1 Introduction	29
4.1 Unit Root Tests.....	29
4.2 Cointegration Tests.....	31
4.3 The GARCH Model	32
4.4 Diagnostic Tests	33
4.4.1 Serial Correlation	33
4.4.2 White Heteroscedasticity Test.....	34
4.4.3 Residual Normality Test.....	35
4.4.4 Stability Tests	37
4.5 Discussions of Results.....	40
4.6 Summary	43
CHAPTER 5 : CONCLUSIONS AND RECOMMENDATIONS	45
5.1 Introduction	45
5.2 Conclusions	45

5.3 Limitations of the study.....	47
5.4 Recommendations	47
References	49

List of Tables

Table 2.1:Common Determinants of Exchange Rate Volatility	16
Table 2.2: One Study Justified Determinants of Exchange Rate Volatility.....	18
Table 4.1: Unit Roots Test Results	30
Table 4.2:Cointegration Test Results	31
Table 4.3:GARCH Test Results	33
Table 4.4:LM Test Results	34
Table 4.5:White Heteroscedasticity Test Results.....	35
Table 4.6:Residual Normality Test Results	37

List of Figures

Figure 4.1:Botswana Normality Test Result	35
Figure 4.2:Lesotho Normality Test Result	36
Figure 4.3:Namibia Normality Test Result	36
Figure 4.4:South Africa Normality Test Result	36
Figure 4.5:Swaziland Normality Test Result	37
Figure 4.6:Botswana Cusum Test Result	38
Figure 4.7:Lesotho Cusum Test Result	38
Figure 4.8:Namibia Cusum Test Result	39
Figure 4.9:South Africa Cusum Test Result	39
Figure 4.10:Swaziland Cusum Test Result	40

List of Acronyms

ARCH:	Autoregressive Conditional Heteroscedasticity
ARDL:	Autoregressive Distributed Lag
CAD:	Canadian Dollar
CPI:	Consumer Price Index
ECM:	Error Correction Model
EGARCH:	Exponential Generalised Autoregressive Conditional Heteroscedasticity
EU:	European Union
GARCH:	Generalised Autoregressive Conditional Heteroscedasticity
GBP:	Great British Pound
GDP:	Gross Domestic Product
GMM:	Generalized Method of Moments
LM:	Lagrange Multiplier
PPP:	Purchasing Power Parity
PKR:	Pakistan Rupee
Q1:	Quarter 1
Q4:	Quarter 4
SACU:	Southern African Customs Union
TARCH:	Threshold Autoregressive Conditional Heteroscedasticity
USD:	United States Dollars

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CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The collapse of the Bretton Woods system of fixed exchange rates in the 1970s led to intensified nominal and real exchange rate volatility for many economies. In the first place, it is critical to define what exchange rate is: this is the price of the domestic currency in terms of another foreign currency (Copeland, 2008). Exchange rate volatility is a measure of the variations in an exchange rate (Abdalla, 2012). Developed and developing countries have all been affected by exchange rate volatility largely as a result of increased transaction costs and reduced gains to international trade (Chiaraah & Insah, 2013).

Southern African Customs Union was established between South Africa, Botswana, Namibia, Lesotho and Swaziland in 1910. South Africa, Lesotho, Namibia and Swaziland have harmonised their monetary and exchange rate policies in a quasi-monetary union since 1990. The three countries, Namibia, Swaziland and Lesotho have pegged their currencies to the South African Rand (Ikhide & Uanguta, 2010). The SACU countries have been experiencing intense exchange rate volatility and more so, they are not able to effectively hedge against exchange rate volatility risk. Firms are not exporting as much as they would with less exchange rate volatility pushing the current accounts into deficits and causing a negative blow on the growth rates of the countries (Ajao & Igbekoyi, 2013).

1.2 Statement of the Problem

Exchange rate volatility is a serious economic problem because exporters may refrain from engaging in trade as a result of increased risk. This reduces export earnings, pushing the current account into deficit which may culminate in balance of payment crises (Agboola, Tchokote, & Uche, 2015). The SACU countries get a significant

portion of their income from export earnings, implying that the stability of the exchange rate is a huge concern in these countries. Studying and understanding exchange rate volatility is thus important to inform trade and investment decisions that seek to reduce exchange rate risk. Exchange rate risk refers to the potential to lose money because of a change in the exchange rate.

There is disagreement amongst researchers regarding the significance of inflation, interest rates, trade openness, government expenditure and money supply as determinants of exchange rate volatility. The first variable is trade openness which was a major determinant in the study carried out in Nigeria by Ajao and Igbekoyi (2013). However, findings by Stancik (2007) researching on New European Union countries as well as Abubakar, Dantama and Hassan's (2017) study in Ghana contradicted this result and proved that economic openness has a calming effect on exchange rate volatility. Findings by Chipili (2012) in Zambia that monetary factors (money supply, inflation, interest rates and foreign reserves) are important determinants of exchange rate volatility were refuted by findings of Juvenal (2010) from the United States which showed that monetary shocks are insignificant sources of exchange rate volatility. This bone of contention amongst researchers shows inconsistency and the existence of unanswered questions.

The research carried out so far regarding exchange rate volatility is very informative especially for single country analysis. However, there is no research carried out that explicitly concentrates on what drives exchange rate volatility for a trade bloc in an African context. In the context of SACU countries, understanding the determinants of volatility remains limited and it has not been assessed from the perspective of inflation and interest rate dynamics. The present research therefore sought to explore the determinants of exchange rate volatility in the SACU countries.

1.3 Objectives of the Study

The main objective was to analyse the determinants of exchange rate volatility in the SACU region. The specific objectives were:

- To examine if inflation and interest rates determine exchange rate volatility in the SACU region, and
- To determine if there is a long run relationship between exchange rate volatility and its determinants.

1.4 Hypotheses of the Study

H₀: Inflation and interest rates do not determine exchange rate volatility in SACU.

H₁: Inflation and interest rates determine exchange rate volatility in SACU.

H₀: There is no long run relationship between exchange rate volatility and its determinants.

H₁: There is a long run relationship between exchange rate volatility and its determinants.

1.5 Significance of the Study

Existing studies on determinants of exchange rate volatility provide immense insights but they leave a gap that is unexplored regarding the determinants of exchange rate volatility for African countries in a trade bloc where their economies will be closely integrated. The results from the existing studies point to inflation and interest rates which are the two variables which this study concentrated on, as being among the important determinants of exchange rate volatility in the African setting for the single country analysis that was carried out. Getting consistent data for all the five countries on all the possible determinants of exchange rate volatility covering the period of the study was not possible; that is why this study confined itself to only two variables. This research adds to the existing body of knowledge by providing new empirical evidence on exchange rate volatility determinants in the SACU region. The target

beneficiaries of this study are researchers and fellow students in terms of further research areas that may emerge. Research findings may also be used by economic planners as they fine tune the exchange rate policy in the SACU region.

1.6 Limitations of the Study

The research results might have been compromised due to limited data for some of the variables included in this study.

1.7 Delimitations of the Study

The study analysed determinants of exchange rate volatility for the period 2000 to 2017. The variables included are exchange rate volatility, inflation and interest rates.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the analysis of relevant theoretical and empirical literature on the subject of the study, which is an analysis of the determinants of exchange rate volatility in the SACU region. Due to the limited number of studies conducted in the SACU countries on the area of study, other regional and international reviews were used to shed light on the subject under investigation. Existing theories were reviewed as well as empirical studies done by other researchers to gain a balanced insight into the determinants of exchange rate volatility. The purpose of reviewing theoretical and empirical literature is to assist in specifying a model for this research.

2.2 Theoretical Literature

The International Fisher Effect Theory is one of the theories guiding this study. The theory states that exchange rate changes are balanced out by interest rate changes. The Fisher theory simply argues that real interest rates across countries are equal due to the possibility of arbitrage opportunities between financial markets, which generally occurs in the form of capital flows. Currencies with higher interest rates attract large numbers of investors seeking better opportunities for their investment. This makes the currency more attractive as a form of investment and increases the demand for the currency. In the same vein, a currency's decreasing interest rates imply a decrease in the demand for that currency and thus depreciation of the exchange rate. Nominal interest rate differentials between two countries tend to reflect exchange rate fluctuations (Fisher, 2006).

The International Fisher Effect proffers that nations with lower interest rates are observed to have lower inflation rates, which ultimately results in increases in the value of the associated currency when compared to other nations. In the long-run therefore, a direct link is observed between interest rate differentials and subsequent changes in the exchange rate but with considerable deviations in the short-run (Hill, 2004). The International Fisher Effect is known for not being a reliable forecaster of short-run changes in spot exchange rates.

The exchange rate overshooting model asserts that in the short run goods prices are sticky but the prices of currencies are flexible. Prices of goods or services and wages are relatively fixed in the short run. For example, when it comes to the wage market, a lot of resistance will be faced against downward movements in workers' wages. It has thus been observed that spot exchange rates move too much given some economic shock. This implies that when an exogenous variable like money supply changes, the short-term effect of such on the exchange rate is usually greater than the long-term effect. The conclusion being that in the short term, the exchange rate overshoots its new equilibrium long-term value.

The foreign exchange market will at first overreact to a monetary adjustment, achieving a new short-term equilibrium. In the long term prices of goods will adjust, making it possible for the foreign exchange market to correct its overreaction, and the economy to reach the new long run equilibrium in all markets (Dornbusch, Fischer, & Startz, 2001). The assumption of purchasing power parity thus only holds in the long run and does not necessarily hold in the short run. One shortcoming of this model that should be noted is that this model makes no reference to specifically incorporate inflation expectations despite empirical evidence supporting the importance of inflation as a determinant of inflation (Pilbeam, 1998).

Under the asset approach, the exchange rate is viewed as adjusting to equilibrate international trade in financial assets. Exchange rates will change continuously as supply of and demand for financial assets of different countries change. The assumption behind this model is that there should be perfect capital mobility where capital moves without restrictions between countries given that there will be little transaction costs or capital controls to serve as barriers to investment. The asset-approach model comprises of two main approaches: the monetary approach and the portfolio-balance approach.

Under the monetary approach the exchange rate for any two currencies is determined by comparative demand and supply of money between the two nations. The portfolio-balance approach asserts that comparative bond supplies and demands as well as comparative money-market conditions determine the exchange rate. The monetary-approach assumes perfect substitutability between domestic and foreign bonds, whereas portfolio-balance models assume the opposite. When domestic and foreign bonds are perfect substitutes, it implies that investors are indifferent towards the currency of denomination of the bond as long as the profit margin is the same (Dornbusch et al., 2001). A typical characteristic of all the models reviewed above is that the supply and demand for money is a key determinant of exchange rate volatility.

2.3 Empirical Studies

Various researchers have come up with several causal factors that may trigger exchange rate volatility. Below are a few selected empirical studies on the subject under study. There are several studies that were conducted outside of Africa to try and establish the determinants of exchange rate volatility.

Firstly, Dungey (1999) studied the determinants of exchange rate volatility for five countries (Australia, Singapore, New Zealand, Japan and Canada). A latent factor model was used to model bilateral exchange rate changes as the weighted sum of three factors; two factors are uniquely associated with each of the currencies involved in the exchange rates and the other represented world shocks common to all exchange rates. The results showed that international factors are more important in determining exchange rate volatility for the smaller nations of Australia, Singapore, and New Zealand, than for the larger nations of Japan and Canada. This study used weekly data over the period 1990 - 1998. The result that different countries' exchange rate volatilities were differently influenced by international and domestic factors implies that there is no clear blueprint for understanding or reducing exchange rate volatility across the board.

Secondly, Stancik (2007) conducted a study to find out the determinants of exchange rate volatility for new European Union countries. In that study it was found that economic openness has a calming effect on exchange rate volatility and flexible regimes experienced higher degrees of volatility. The study used TARARCH on daily time series from the 1st of January 1999 to the 31st of December 2004.

In another study, the role of real and monetary shocks on the exchange rate behaviour using a structural vector autoregressive model of the US vis-à-vis the rest of the world was analysed. The results revealed that monetary shocks are unimportant in explaining exchange rate fluctuations. By contrast, demand shocks were found to play an important role in determining exchange rate volatility but not of the order of magnitude sometimes found in earlier studies. The study made use of quarterly data over the period 1976-2007 (Juvenal, 2010).

Ali, Khan, Razi and Shafiq (2012) explored the reasons behind the devaluation of Pakistani currency with respect to the US dollar. They used data over a period of 11 years (2001-2011) employing the multiple regression equation as the mode of estimation. Their results showed inflation differential; current account deficit, public debt and interest rate differential as the most important determinants which have a major impact on exchange rate fluctuation.

In India, Mirchandani (2013) analysed the macroeconomic determinants of exchange rate volatility over the period 1991 to 2010 using Pearson's correlation analysis. It was revealed that exchange rate volatility is correlated with variables such as the interest rate, inflation rate and GDP growth rate.

Kumamoto and Kumamoto (2014) carried out another study for Indonesia, the Philippines, Czech Republic, Hungary, Poland, Argentina and Peru in 2014 employing the TARARCH to see how currency substitution affects exchange rate volatility. Monthly time series data from 2002 M1 to 2013 M12 was used. The results from this study showed that the degree of currency substitution had significant positive effects on the conditional variance of the depreciation rate of the nominal exchange rate in most sample countries.

Jabeen and Khan (2014) carried out another study to examine the determinants of exchange rate volatility in the foreign exchange market of Pakistan. The study made use of GARCH modelling using monthly data from April 1982 to November 2011. The results showed that the PKR-USD exchange rate volatility is determined by real output volatility, foreign exchange reserves volatility, productivity volatility and inflation volatility. On the other hand, the PKR-GBP exchange rate volatility is determined by foreign exchange reserves volatility and terms of trade volatility. The PKR-CAD exchange rate volatility is determined by terms of trade volatility. The

findings revealed that exchange rate volatility in Pakistan results from real shocks than nominal shocks.

Cevik, Harris and Yilmaz (2017) carried out a study on a panel of one hundred and fifteen countries. The study sought to explore how soft power variables affect exchange rate volatility. They used System Generalized Method of Moments (GMM) to study annual data from 1996 to 2015. Of the countries studied, twenty-five were advanced economies and ninety were developing countries. The results of the study showed that soft power variables such as index of voice and accountability, life expectancy, educational accomplishments, fragility of the banking sector, financial openness and the portion of agriculture relative to services are the major determinants of exchange rate volatility in the countries studied.

Bin, Chau, Keong, Khin and Yean (2017) carried out a study in Malaysia to examine the relationship between exchange rate volatility and natural rubber prices using the Engle-Granger causality test. The research was done using annual time series data for the period 2010 to 2016. The model results indicated a significant and positive short run relationship between exchange rate, consumer price index (CPI) and the lagged of the exchange rate. The results also showed a significant and negative short run relationship between exchange rate and money supply.

Calderon and Kubota (2018) carried out a study to investigate factors driving real exchange rate volatility for 82 countries for the period 1974 to 2013. The study was carried out using panel regression analysis. The results revealed that trade in manufacturing helps reduce exchange rate volatility while non-manufacturing trade may contribute to higher exchange rate volatility. The results also showed that

financial openness mitigates exchange rate volatility in a country with a higher share of foreign equity versus foreign debt liabilities.

Kilicarslan (2018), in another study carried out in Turkey explored the determinants of exchange rate volatility. Annual time series data from 1974 to 2016 was used in the study which made use of the GARCH model to calculate real exchange rate volatility. The research results showed that the rise in domestic investment, money supply and trade openness increases real exchange rate volatility. The results also showed that the rise in foreign direct investment, output and government expenditure reduces real exchange rate volatility.

Great insight can be obtained from the studies cited above. An important factor to note however is that the settings in a developing nation are often very different from that of a developed nation. Besides that, there are many economic factors at play which may have a significant impact on African states as opposed to countries in other continents. As a result of this several studies carried out in Africa are also be analysed below.

Chipili (2012) examined the sources of volatility of the Zambian kwacha using the GARCH models (GARCH, TARARCH and EGARCH). The study revealed that both monetary factors including money supply, inflation, short-term domestic interest rate, and foreign reserves are the main determinants of exchange rate volatility. The study examined annual time series data from 1964 to 2016.

Chiaraah and Insah (2013) conducted another study to find out the drivers of exchange rate volatility in Ghana. They found that government expenditure was a major determinant of exchange rate volatility in Ghana. Their study adapted the GARCH to

estimate the sources of real exchange rate volatility using annual time series data from 1980 to 2012.

Ajao and Igbekoyi (2013) also analysed the determinants of real exchange rate volatility in Nigeria. The period that they studied was 1981 to 2013 employing the GARCH and ECM. The study results showed that that openness of the economy, government expenditure, interest rate movements as well as the lagged exchange rate are among the major variables that influence exchange rate volatility.

Aigheyisi and Oaikhenan (2015) carried out a study to examine the determinants of exchange rate volatility in Nigeria for the period 1970 – 2013. They used the EGARCH model and their results showed that government expenditures, interest rate movements as well as the lagged exchange rate are among the major significant variables that influenced real exchange rate volatility during this period.

Mpofu (2016) conducted a study which explored the determinants of exchange rate volatility in South Africa. The study used monthly time series data from 1986 - 2013 and the GARCH technique was used for data analysis. The study revealed that switching to a floating exchange rate regime had a substantial positive effect on rand volatility. The results also indicated that trade openness significantly reduced rand volatility only when bilateral exchange rates are used but found the opposite when multilateral exchange rates were used. The study also found that volatility of output, commodity prices, money supply and foreign reserves significantly influenced ZAR volatility.

Another study in Ghana examined the sources of exchange rate volatility. The results of the study showed that factors such as government expenditure, money supply growth, terms of trade and output shocks are important determinants of exchange rate

volatility. Time series data from 1980 -2013 was analysed using GARCH (1,1) model (Alagidede & Ibrahim, 2016).

More recently Abubakar, Dantama and Hassan (2017) carried out another study to explore the determinants of exchange rate volatility in Nigeria. They analysed the determinants of exchange rate volatility in Nigeria from 1989 to 2015 using the Autoregressive Conditional Heteroscedasticity (ARCH) technique. The study made use of quarterly time series. The findings from that research showed that net foreign asset and interest rate have a positive and statistically significant impact on exchange rate volatility while fiscal balance, economic openness and oil prices have a positive and statistically insignificant impact on exchange rate volatility.

Adetan and Oke (2018) examined determinants of exchange rate volatility in Nigeria using Autoregressive Distributed Lag (ARDL) Bounds test approach to cointegration and the Error Correction Model (ECM) for the period 1986 to 2016. Their results showed that the Gross Domestic Product (GDP), interest rate and inflation have a positive effect on exchange rate volatility while the degree of openness recorded a negative effect on exchange rate volatility in Nigeria.

ARCH models have been widely used in volatility modelling because it is not likely in financial time series that the variance of the errors will be constant over time, and hence it makes sense to consider a model that does not assume that the variance is constant, and which describes how the variance of the errors evolves (Brooks, 2008). Another advantage is that ARCH models can account for volatility clustering which is common in financial time series. However, one major limitation of an ARCH model is that it is difficult to determine the appropriate number of lags of the squared residual to be included.

The popularity of the GARCH model comes from the fact that the GARCH (1, 1) model, containing only three parameters in the conditional variance equation, is a very parsimonious model that permits countless past squared errors to impact the current conditional variance” (Brooks, 2008, p. 394). Due to only containing three parameters, the GARCH model is thus also not as likely to break non-negativity restraints. The GARCH model is also deemed beneficial due to its sufficiency in capturing volatility clustering in financial time series data (Brooks, 2008). This volatility clustering suggests that some time periods may experience large bursts in volatility, whilst others are associated with little or no volatility whatsoever. Ordinary time series analysis techniques would be incompatible in such cases.

According to Brooks (2008), the GARCH model also has its own limitations. Firstly, the non-negativity conditions may be violated by the estimated model. The GARCH models cannot account for leverage effects, although they can account for volatility clustering and leptokurtosis in a series. Finally, the model does not allow for any direct feedback between the conditional variance and the conditional mean.

Other researchers who chose to use ARDL may have been influenced by the fact that the model has the benefit of being applicable irrespective of whether the series under investigation are stationary at I(0) or I(1) or a mixture of both. Another advantage is that it provides robust and high quality results even if the sample size is small or large. It is also beneficial in that it takes into account the error correction model. The analysis of error correction and autoregressive lags fully covers both long-run and short-run relationships of the variable under study (Hassan, 2017).

The exponential GARCH model is an extension of the GARCH model. The model has several benefits over the pure GARCH specification. First, since the $\log(\sigma^2_t)$ is

modelled, then even if the parameters are negative, σ^2_t will be positive. There is thus no need to artificially impose non-negativity constraints on the model parameters. Asymmetries are also allowed for under the EGARCH modelling, since if the relationship between volatility and returns is negative, γ , will be negative (Hassan, 2017).

Most empirical studies have also utilised the standard deviation of the moving average of the logarithm of the exchange rate to measure exchange rate volatility. The main criticism for such a measure is that it fails to capture the potential effects of high and low peak values of the exchange rate. The other common measure is one which captures high and low fluctuation above the average values of volatility, utilizing a dummy variable capturing high and low peak values of the real exchange rate (Serenis, & Tsounis, 2012).

The literature reviewed shows that there are researches where the results show the same variables to be important determinants of exchange rate volatility. Such determinants are highlighted in Table 2.1 below.

Table 2.1: Common Determinants of Exchange Rate Volatility

Volatility Determinants	Researchers	Countries	Method	Year of Publication
Flexible exchange rate regimes	Stancik	New EU countries	TARCH	2007
	Mpofu	South Africa	GARCH	2016
Interest rate	Mirchandani	India	Pearson's correlation analysis	2013
	Chipili	Zambia	GARCH	2012
	Ajao and Igbekoyi	Nigeria	GARCH and ECM	2013
	Ali, Khan, Razi and Shafiq	Pakistan	Multiple regression equation	2012
	Adetan and Oke	Nigeria	ECM	2018
	Oaikhenan and Aigheyisi	Nigeria	EGARCH	2015
Inflation	Mirchandani	India	Pearson's correlation analysis	2013
	Chipili	Zambia	GARCH	2012
	Ali, Khan, Razi and Shafiq	Pakistan	Multiple regression equation	2012
	Adetan and Oke	Nigeria	ECM	2018
Money supply	Chipili	Zambia	GARCH	2012
	Mpofu	South Africa	GARCH	2016
	Alagidede and Ibrahim	Ghana	GARCH	2016
Foreign reserves	Kilicarslan	Turkey	GARCH	2018
	Chipili	Zambia	GARCH	2012
Government expenditure	Mpofu	South Africa	GARCH	2016
	Abubakar, Dantama and Hassan	Nigeria	ARCH	2017
	Chiaarah and Insah	Ghana	GARCH	2013
	Ajao and Igbekoyi	Nigeria	GARCH and ECM	2013
Demand/Output shocks	Alagidede and Ibrahim	Ghana	GARCH	2016
	Juvenal	United States	Structural vector autoregressive model	2010
		Ghana	GARCH	2016

Source: Author's compilation

From Table 2.1 above, it is clear that interest rate, inflation, money supply, foreign reserves and government expenditure come out strongly as the overarching determinants of exchange rate volatility for African countries. In all these studies the GARCH was the common method of modelling for exchange rate volatility. However, most of the studies carried out were for single country analysis and the outcome of the research may be different when considering a group of countries in a trade bloc.

There are other determinants which were found to be significant in specific studies but refuted as insignificant in other studies. The first such variable is trade openness which was a major determinant in the study carried out in Nigeria by Ajao and Igbekoyi (2013). However, findings by Stancik (2007) (New European Union countries) as well as Abubakar, Dantama and Hassan (2017) (Ghana) contradicted this result and proved that economic openness has a calming effect on exchange rate volatility. Findings by Chipili (2012) in Zambia that monetary factors (money supply, inflation, interest rates and foreign reserves) are important determinants of exchange rate volatility were refuted by findings of Juvenal (2010) (United States) which showed that monetary shocks are insignificant sources of exchange rate volatility.

Some of the determinants were only found to be statistically significant by one research of those reviewed including degree of currency substitution, lagged exchange rate, GDP growth rate and terms of trade. Such determinants and the studies where they were found are detailed in Table 2.2 below.

Table 2.2: One Study Justified Determinants of Exchange Rate Volatility

Volatility Determinants	Researchers	Countries	Method	Year of Publication
Terms of trade	Alagidede et al.	Ghana	GARCH	2016
GDP growth rate	Mirchandani	India	Pearson's correlation analysis	2013
Lagged exchange rate	Ajao and Igbekoyi	Nigeria	GARCH and ECM	2013
Degree of currency substitution	Kumamoto and Kumamoto	Indonesia, Philippines, Czech Republic, Hungary, Poland, Argentina, Peru	TARCH	2014
Current account deficit	Ali, Khan, Razi and Shafiq	Pakistan	Multiple regression equation	2012
<i>Public debt</i>	<i>Ali, Khan, Razi and Shafiq</i>	<i>Pakistan</i>	<i>Multiple regression equation</i>	<i>2012</i>

Source: Author's compilation

The inconsistencies in research findings highlighted in the analysis above leave a lot of unanswered questions, especially a) Whether the determinants of exchange rate volatility vary when analysing a trade bloc as opposed to a single country analysis, and b) Whether determinants of exchange rate volatility differ for developing versus developed countries?

It is evident that empirical literature specifically looking at exchange rate volatility is still limited. This is due to the fact that most studies carried out in the SACU region on the subject of exchange rate volatility concentrated on the effects of exchange rate volatility on chosen variables. One such study was in Swaziland where quarterly time series data ranging from 1995 Q1 to 2005 Q4 was used to explore the effects of exchange rate volatility on exports (Mtembu & Motlaleng, 2010). Other studies concentrated on finding the determinants of the exchange rate or on analysing the impact of volatility on various economic factors.

Only one study could be found from those reviewed by Mpofo (2016) in South Africa specifically looking at finding determinants of exchange rate volatility of all the five

countries in the SACU trade bloc. However, no study has been carried out for SACU as a trade bloc to empirically determine the factors that drive exchange rate volatility in this grouping. This raises interesting questions as to what may be influencing exchange rate volatility in the SACU region where there are developing countries whose economies are closely linked. There is definitely a gap in knowledge that needs to be filled.

2.4 Summary of Literature Reviewed

Theoretical literature points to interest rate differential and inflation rate differentials being determinants of exchange rate volatility. This is in line with the bulk of empirical study findings. As informed by the literature review, this study analysed inflation and interest rates to see if they are also determinants of exchange rate volatility in the SACU region. This study did not look at the other determinants of exchange rate volatility because of resource constraints.

CHAPTER 3 : METHODOLOGY

3.1 Introduction

This chapter explains the model and provides a background evaluation of various econometric estimation techniques that were employed in the study to analyse the determinants of exchange rate volatility in the Southern Africa Customs Union. This chapter also elaborates on the research design and methodology used to gather and analyse the information that was needed for completing the study. Variables used in the study are defined and data sources are also explained.

3.2 Research Design

The quantitative research approach was used for this study since it involves an econometric modelling approach. The quantitative research methodology was appropriate for this study because econometric models which have a strong mathematical basis are the methodology of data analysis. Quantitative method was used through the econometrics analysis to analyse the determinants of exchange rate volatility in the Southern Africa Customs Union. Secondary data was collected and used in the analysis to verify the research hypotheses. The analysis was done for each of the five countries separately and then the results were assimilated into one combined viewpoint when commenting on the results of the study.

3.3 Procedure

The data used in this study covers 38 years from 1980 - 2017. The data was collected from the World Bank Development Indicators online database. Annual time series data for the five countries was analysed.

3.4.0 Data Analysis

Data was analysed using the Econometric software E-views. Annual time series data on interest rates, inflation, and exchange rates for the five countries was analysed. The study applied various econometric tests in the process of analysis as detailed below:

3.4.1 Unit Root Tests

The Augmented Dickey Fuller (ADF) unit root test was used to test whether the variables are stationary or not. The Phillips Perron unit root test was used as a confirmatory test. The null hypothesis of the test is that the variable contains a unit root or that the variable is not stationary. If the computed absolute value of the t-statistics exceeds the critical value, then the null hypothesis will be rejected. This will be an indication that the time series is stationary. In the same light, if the computed absolute value of the t-statistics does not exceed the critical value, then the null hypothesis cannot be rejected. If the ADF tests were to confirm the existence of a unit root in the series, it would then be necessary to calculate as to how many times the series may need to be differenced in order to make it stationary (Brooks, 2008). Once the level of differencing required has been established, the regression may be run in differenced form. If no unit roots were found to exist pointing to the stationarity of variables, differencing would not be necessary.

Unit root tests are critical to determine if the distribution of the variables will remain unchanged when changing the time period. The order of integration to be used was determined from the unit root test results. Carrying out unit root tests is very important as regressing non-standard distributions could produce spurious or misleading regression results (Gujarati, & Porter, 2009).

3.4.2 Cointegration Tests

Cointegration is the statistical expression of the nature of the long run equilibrium relationships among variables. Cointegration implies that the variables may drift away from each other in the short run but may not divert from each other in the long run co-movements. From the unit root test results, if the variables are integrated of different order it may imply that they may be cointegrating variables. The ARDL approach using the bounds test is used to test for cointegration when variables are integrated of different orders. The bounds test was used to test for the existence of a long run relationship between exchange rate volatility and its determinants. The model used in the bounds test was specified as follows:

$$D\text{LnVOL} = C D(\text{LnVol}(-1)) D(\text{LnVol}(-2)) D(\text{LnINF}(-1)) D(\text{LnINF}(-2)) D\text{LnIR}(-1) \\ D\text{LnIR}(-2)) \text{LnVol}(-1) \text{LnINf}(-1) \text{LnIR}(-1)$$

The Wald test (F-statistic) was calculated to establish the long-run relationship between the concerned variables. The Wald test is run by imposing restrictions on the estimated long-run coefficients of exchange rate volatility, inflation and interest rates. The null and alternative hypotheses are as follows: $H_0=B_1=B_2=B_3=0$ (no long-run relationship) against the alternative hypothesis $H_0 \neq B_1 \neq B_2 \neq B_3 \neq 0$ (a long-run relationship exists). The computed F-statistic value was evaluated with the critical values tabulated in Table CI (iii) by Pesaran, Shin and Smith (2001). According to these authors, the lower bound critical values assumed that the explanatory variables are integrated of order zero, or $I(0)$, while the upper bound critical values assumed that they are integrated of order one, or $I(1)$. Therefore, if the computed F-statistic is less than the lower bound value, then the null hypothesis cannot be rejected and the conclusion is that there is no long-run relationship between exchange rate volatility and its determinants. In the same light, if the computed F-statistic is greater than the

upper bound value, then exchange rate volatility and its determinants share a long-run level relationship. Conversely, if the computed F-statistic falls between the lower and upper bound values, then the results are inconclusive. Results from this test show whether the variables share a common stochastic trend, that is, to test whether two or more variables have a long run association.

The decision rule that is used to explain the results from this test is that if the Wald F statistic falls above the upper critical value there is cointegration. If it falls between the lower bound and the upper bound critical value the results are inconclusive. If it falls below the lower bound critical value the decision is that there is no cointegration.

Cointegration testing also identifies and hence avoids spurious regressions generated by the non-stationary time series. Taking into account that one of the specific objectives of this study was to determine the long-run relationship between exchange rate volatility and its determinants, co-integration testing presents a fundamental component of the required estimation techniques.

3.4.3 GARCH (1, 1) Model

Model Specification

Exchange rate volatility is not observable; therefore it had to be generated. Following the available literature, the GARCH (1,1) by Bollerslev (1990) was used to generate the volatility series as it allows variances of errors in the exchange rate to be time dependent. The GARCH (1,1) modelling process begins with a mean equation which expresses changes in the exchange rate as a function of its lagged value. The variables to be included in the model include exchange rate, inflation and interest rates. According to the World Bank Development Indicators database:

- Interest rate was defined as the bank lending rate that usually meets the short- and medium-term needs of the private sector,
- Inflation was defined as the annual inflation as measured by the consumer price index reflecting the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals,
- The exchange rate was defined as the exchange rate determined by each country's central bank or to the rate determined in the legally authorised foreign exchange market in each country. The exchange rate is expressed against the US dollar and for all countries in the common monetary union the exchange rate was that of the rand against the US dollar, and
- Previous period exchange rate is the exchange rate of each country lagged by one period.

The GARCH (1, 1) model was done in two stages, that is, mean equation and variance equation.

Mean Equation

The mean equation was specified as follows:

$$D(\text{LNEX}) = C1 + C2 * D(\text{LNPEX}) + e$$

In this equation:

- LNEX is the natural logarithm of exchange rate. The data is transformed into logarithm form to make it more interpretable and to help meet the assumptions of inferential statistics.
- C1 is a constant
- C2 is the coefficient of the logarithm of previous period exchange rate (lagged once). Since this is an autoregressive process current period exchange rate will be influenced by previous period exchange rate.

- e is the error term

Using the mean equation variables an equation was estimated. From this equation residuals were generated. If in the residual distribution periods of high volatility are followed by periods of high volatility and periods of low volatility, they are also followed by periods of low volatility; this will be suggesting that the residual is conditionally heteroscedastic and it can be represented by the GARCH model.

Variance Equation

The variance equation is specified as follows:

$$\sigma_t^2 = \text{GARCH} = C(3) + C(4) * \text{RESID}(-1)^2 + C(5) * \text{GARCH}(-1) + C(6)D(\text{IR}) + C(7)D(\text{INF})$$

The residual derived from the mean equation was used in deriving the variance equation. In the variance equation:

- σ_t^2 is the variance of the error term (residual). It is also known as volatility or current period volatility,
- $C(3)$ is a constant,
- $\text{RESID}(-1)^2$ is the ARCH term which denotes the previous period's squared residual variance or volatility,
- $\text{GARCH}(-1)$ is the GARCH term. The GARCH term is the previous period's residual variance or volatility,
- $C(6)$ and $C(7)$ are coefficients of the independent variables interest rates and inflation which are the exogenous variables in this equation.

The variance equation is the GARCH (1, 1) model as it has 1 ARCH term and 1 GARCH term. It refers to first order ARCH term and first order GARCH term. The conditional variance (volatility) determined through GARCH model is a weighted

average of past squared residuals. The conditional variance method is a good proxy for uncertainty because it contains an unpredictable component of volatility. GARCH models are able to model and forecast time-varying variance. The coefficients of the determinants of exchange rate volatility in the variance equation were analysed to see if they are statistically significant.

3.4.4 Diagnostic Tests

It is important to analyse the behaviour of the model so as to determine the extent to which its results can be relied on. The necessity of diagnostic testing involves checking residuals of the series for any problems. Should problems be present, this may indicate that the model is inefficient, and that parameter estimates may be biased. Diagnostic checks included for the purposes of this particular research are tests for serial correlation, heteroscedasticity, normality and testing for stability by means of the cusum test.

Serial Correlation

Serial correlation or autocorrelation occurs when the error term observations in a regression are correlated. This error term represents a random “shock” to the model, or something that is missing from the model. If the error term observations follow a pattern, this pattern will be evidence of autocorrelation. For each observation, the error term represents the distance between the actual value of the dependent variable and the predicted value. In the presence of serial correlation, then there will most likely be room to improve the model so that the regression does a better job of predicting the dependent variable.

Engle’s Lagrange Multiplier test was used to test for the presence of autocorrelation, with Ordinary Least Squares (OLS) methodology requiring that the error terms in a time series need to be uncorrelated (Gujarati, & Porter, 2009). An uncorrelated time

series can still be serially dependent due to a dynamic conditional variance process. The null hypothesis of the LM test is that there is no serial correlation in the residuals. Serial correlation is present when residuals are shown to have correlations with past values. The null hypothesis may not be rejected if the probability value exceeds the 5% level of significance, meaning that there will be no autocorrelation in the series.

White's Heteroscedasticity Test

A further assumption of the classical regression model is that homoscedasticity is present, which implies that the variance of the error terms is constant (Brooks, 2008). Should the variance not be constant, heteroscedasticity is thus deemed to exist. In such a case ordinary regression technique would not be compatible. To test for the presence of homoscedasticity, the Whites test was utilised. The null hypothesis of White's test is that the error terms are homoscedastic, whilst the alternative hypothesis is that the error terms are heteroscedastic (Brooks, 2008). The null hypothesis may not be rejected if the probability value exceeds the 5% level of significance, meaning that the error terms will be homoscedastic. A time series that is homoscedastic is said not to contain arch effects.

Residual Normality Test

To test if the error terms are normally distributed, a histogram normality test is applied. The null hypothesis for the normality test is that residuals are normally distributed and the alternative is that residuals are not normally distributed. The decision rule is to reject the null hypothesis if the probability value from the test is less than 5%. In such a case, the distribution is not considered to be normal.

Best Model

The GARCH model that is derived is considered best if it meets all three desirable conditions. The desirable conditions are no serial correlation, no arch effects and residuals should be normally distributed.

3.5 Research Ethics

All information sources used in the study were acknowledged in accordance with the Harvard referencing style.

3.6 Summary

Chapter Three specified the model that was utilised in analysing determinants of exchange rate volatility in the SACU region. The chapter discussed the methodology used in carrying out the study. Included in this model are variables that are highly likely to impact on the level of volatility in the exchange rate as informed by the literature review. These variables are inflation and interest rates. The ADF and PP tests were employed as the two stationarity tests. The estimation technique utilised is the GARCH (1, 1) accompanied by co-integration analysis by means of the ARDL approach (Bounds test). Lastly, the chapter concluded with a discussion on diagnostic tests, such as the LM test, Whites Heteroscedasticity test and the histogram normality test. Ethical issues that were considered have also been discussed.

CHAPTER 4 : RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results from the unit root tests and the cointegration tests that were carried out. It goes on to the estimation of the GARCH models for the five SACU countries under study. The empirical analysis is carried out to ensure that the objectives of the study are met, that is to determine which factors are determinants of exchange rate volatility and to examine if there is a long run relationship between exchange rate volatility and its determinants. This chapter also presents the results from the diagnostic tests that were carried out.

4.1 Unit Root Tests

The Augmented Dickey Fuller (ADF) and Phillips Perron (PP) were applied to test for stationarity of the stochastic variables namely exchange rate volatility, inflation and interest rates. Table 4.1 shows results from the Augmented Dickey Fuller test and the Phillips Perron test which is used as a confirmatory test. The table also shows the order of integration that was used.

Table 4.1: Unit Roots Test Results

Country	Variable	Model Specification	ADF	PP	ADF	PP	Order of Integration
			Level	Level	First Difference	First Difference	
Namibia	LnVol	Intercept	0.720	0.769	3.647**	3.486**	1
	LnINF	Intercept	2.485	2.279	6.894**	16.428**	1
	LnIR	Intercept	1.761	1.673	5.007**	7.880**	1
South Africa	LnVol	Intercept	0.720	0.769	3.647**	3.486**	1
	LnIR	Intercept	1.086	2.110	6.061**	8.027**	1
	LnINF	Intercept	2.205	2.031	5.769**	13.252**	1
Botswana	LnVol	Intercept	1.817	1.924	4.952**	4.870**	1
	LnIR	Intercept	2.331	2.667	6.322**	6.470**	1
	LnINF	Intercept	1.644	1.529	8.447**	8.460**	1
Lesotho	LnVol	Intercept	0.720	0.769	3.647**	3.486**	1
	LnIR	Intercept	2.706	2.265	6.257**	8.344**	1
	LnINF	Intercept	3.351*	3.255*			0
Swaziland	LnVol	Intercept	0.720	0.769	3.647**	3.486**	1
	LnIR	Intercept	1.379	1.623	5.537**	4.127**	1
	LnINF	Intercept	3.616*	3.514*			0

** indicates the rejection of null hypothesis at 5%

Source: Author's compilation

In Table 4.1 it is shown that the time series variables were found to be non-stationary at level form in the three countries, South Africa, Botswana and Namibia. All three variables' exchange rate volatility, inflation and interest rates were found not to have a unit root in first difference. Therefore, the null hypothesis that there is a unit root in first difference is rejected (exchange rate volatility, interest rates and inflation). The decision is then made to accept the alternative hypothesis and conclude that the variables are stationary in first difference.

For Lesotho and Swaziland, it was found that the variables exchange rate volatility and interest rates were not stationary in level form. These variables were found to be stationary in first difference. However, the variable inflation was found to be stationary

in level form. After obtaining the unit root test results, cointegration tests were then carried out to determine the long run relationship between exchange rate volatility and its determinants.

4.2 Cointegration Tests

Cointegration is the statistical expression of the nature of the long run equilibrium relationships among variables. From the unit root test results the variables were integrated of different order implying that they may be cointegrating variables in the model. The ARDL approach (bounds test) used when variables are integrated of different orders was used to test for cointegration. The results obtained from the test are shown in Table 4.2 below.

Table 4.2: Cointegration Test Results

Country	F statistics	Probability	Level	I(0)	I(1)
South Africa	0.521565	0.6714	1%	6,140	7,607
			5%	4,183	5,333
			10%	3,393	4,410
Namibia	0.818100	0.4961	1%	6,140	7,607
			5%	4,183	5,333
			10%	3,393	4,410
Swaziland	1.141918	0.3514	1%	6,140	7,607
			5%	4,183	5,333
			10%	3,393	4,410
Lesotho	2.388883	0.0928	1%	6,140	7,607
			5%	4,183	5,333
			10%	3,393	4,410
Botswana	1.234740	0.3180	1%	6,140	7,607
			5%	4,183	5,333
			10%	3,393	4,410

Source: Author's compilation whilst I(0) and I(1) from Pesaran table CI(iii)

The decision rule used to explain the results in table 4.2 is that if the Wald F statistic falls above the upper critical value there is cointegration. If it falls between the lower bound and the upper bound critical value the results are inconclusive. If it falls below the lower bound critical value the decision is that there is no cointegration. It is clear from the results in table 4.2 that for all 5 countries at the 1%, 5% and 10% levels of

significance, there is no cointegration between exchange rate volatility, inflation and interest rates. The three variables have no long run equilibrium relationship and they do not move together in the long run.

4.3 The GARCH Model

The GARCH model is comprised of two equations, that is the mean equation and the variance equation. The mean equation that was generated is specified as:

$$D(LNEX) = C1 + C2*D(LNPEX) + e$$

From the mean equation residuals were generated. The residuals were then used to generate the variance equation for each country in the form of:

$$GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1) + C(6)*D(LNIR) + C(7) \\ *D(LNINF)$$

where

- GARCH is the variance of the error term (residual). It is also known as volatility or current period volatility,
- C(3) is a constant,
- RESID (-1) ^2 is the ARCH term which denotes the previous period's squared residual variance or volatility,
- GARCH (-1) is the GARCH term. The GARCH term is the previous period's residual variance or volatility,
- C (6) and C (7) are coefficients of the independent variables interest rates and inflation which are the exogenous variables in this equation.

The results from the GARCH models that were estimated are summarised in table 4.3 below.

Table 4.3:GARCH Test Results

Country	Variable	Meaning	Parameter Estimate	Probability
Botswana	C	Constant	0.013223	0.0339
	Resid(-1)2	Arch term	-0.033885	0.9247
	Garch(-1)	Garch term	-0.009173	0.9828
	D(LnIR)	Interest rates	0.020127	0.1263
	D(LNINF)	Inflation	0.018347	0.4412
South Africa	C	Constant	0.017913	0.0050
	Resid(-1)2	Arch term	0.082795	0.8197
	Garch(-1)	Garch term	-0.003605	0.9938
	D(LnIR)	Interest rates	-0.021938	0.0626
	D(LnINF)	Inflation	-0.033350	0.3085
Namibia	C	Constant	0.014804	0.0083
	Resid(-1)2	Arch term	-0.045127	0.8320
	Garch(-1)	Garch term	0.259889	0.3622
	D(LnIR)	Interest rates	-0.029725	0.0226
	D(LnINF)	Inflation	-0.027667	0.2933
Lesotho	C	Constant	0.013927	0.1870
	Resid(-1)2	Arch term	-0.161935	0.2113
	Garch(-1)	Garch term	0.480312	0.3369
	D(LnIR)	Interest rates	-0.014573	0.0467
	D(LnINF)	Inflation	-0.049203	0.0052
Swaziland	C	Constant	0.018348	0.0097
	Resid(-1)2	Arch term	0.281225	0.5531
	Garch(-1)	Garch term	-0.180678	0.6488
	D(LnIR)	Interest rates	-0.012306	0.2069
	D(LnINF)	Inflation	-0.042068	0.1317

Source: Author's compilation

4.4 Diagnostic Tests

Diagnostic tests were carried out to check if the residuals from the model had any problems. Four such tests were carried out to check for serial correlation, heteroscedasticity, normality and stability.

4.4.1 Serial Correlation

Serial correlation or autocorrelation occurs when the error term observations in a regression are correlated. For each observation, the error term represents the distance between the actual value of the dependent variable and the predicted value. In the presence of serial correlation, then there will most likely be room to improve the model so that the regression does a better job of predicting the dependent variable. The

Lagrange Multiplier (LM) test was used to test for the presence of autocorrelation. The null hypothesis of the LM test is that there is no serial correlation in the residuals. The null hypothesis may not be rejected if the probability value exceeds the 5% level of significance, meaning that there will be no autocorrelation in the series. The results from the LM test for serial correlation are presented in table 4.4 below.

Table 4.4:LM Test Results

Country	Test Statistic	Probability Statistic	Meaning
Botswana	1.636018	0.1886	No serial correlation
Lesotho	2.130946	0.1205	No serial correlation
Namibia	2.195785	0.1138	No serial correlation
South Africa	1.511958	0.1138	No serial correlation
Swaziland	1.636018	0.1205	No serial correlation

Source: Author's compilation

4.4.2 White Heteroscedasticity Test

If the variance of the error term is not constant, heteroscedasticity is said to exist in a model. In such a case ordinary regression technique would not be compatible. To test for the presence of homoscedasticity the White test was utilised. The null hypothesis of White's test is that the error terms are homoscedastic, whilst the alternative hypothesis is that the error terms are heteroscedastic (Brooks, 2008). The null hypothesis may not be rejected if the probability value exceeds the 5% level of significance meaning that the error terms will be homoscedastic. A time series that is homoscedastic is said not to contain arch effects. The results from the Whites test are presented in table 4.5 below.

Table 4.5: White Heteroscedasticity Test Results

Country	Test Statistic	Probability	Result
Botswana	0.106762	0,0000	Heteroscedastic
Namibia	0.037119	0.0000	Heteroscedastic
South Africa	0.049064	0.0000	Heteroscedastic
Lesotho	0.242399	0,0000	Heteroscedastic
Swaziland	0.697274	0,0000	Heteroscedastic

Source: Author's compilation

All the five countries' results showed the presence of ARCH effects in the error term implying heteroscedasticity.

4.4.3 Residual Normality Test

To test if the error terms are normally distributed, a histogram normality test was applied. The null hypothesis for the histogram normality test is that residuals are normally distributed and the alternative is that residuals are not normally distributed. The decision rule is to reject the null hypothesis if the probability value from the test is less than 5%. In such a case, the distribution is not considered to be normal. The histograms for each country are shown below.

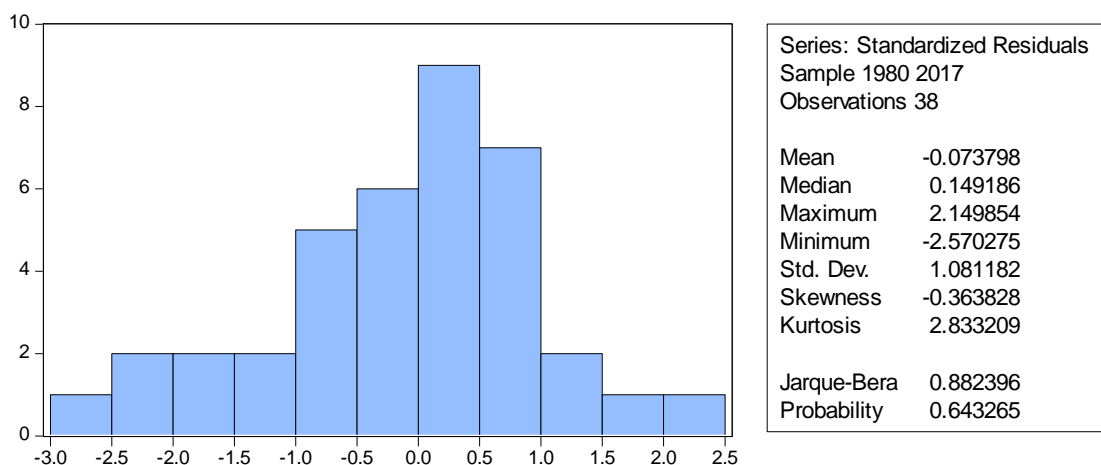


Figure 4.1: Botswana Normality Test Result

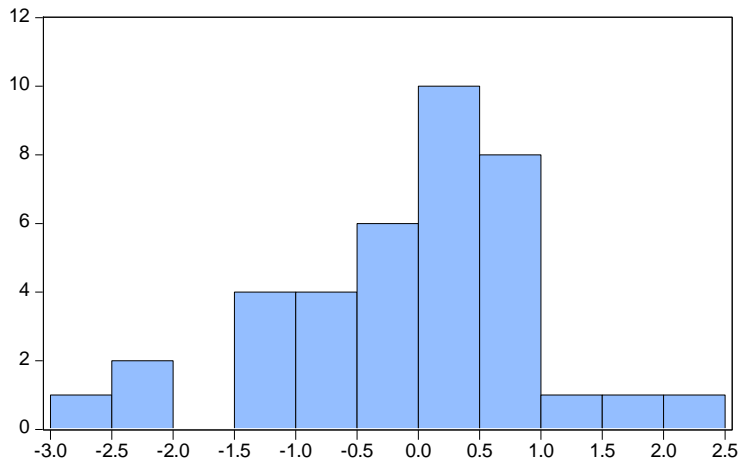


Figure 4.2:Lesotho Normality Test Result

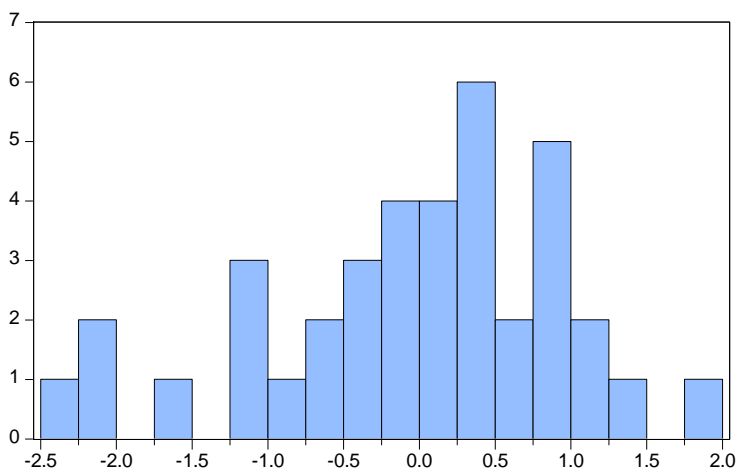


Figure 4.3:Namibia Normality Test Result

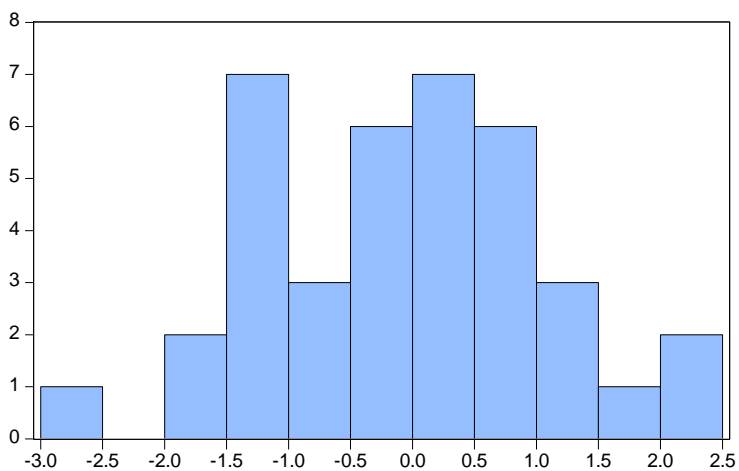


Figure 4.4:South Africa Normality Test Result

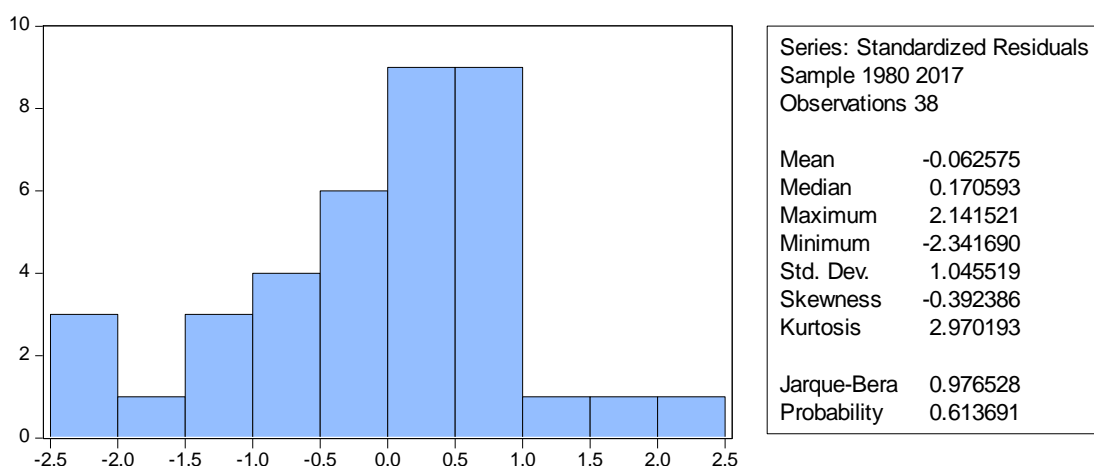


Figure 4.5:Swaziland Normality Test Result

The results from the histogram normality tests are summarised in table 4.6 below.

Table 4.6:Residual Normality Test Results

Country	Probability	Meaning
Botswana	0.6433	Normal Distribution
Namibia	0.3452	Normal Distribution
Lesotho	0.4381	Normal Distribution
South Africa	0.8685	Normal Distribution
Swaziland	0.6137	Normal Distribution

Source: Author's compilation

4.4.4 Stability Tests

The cusum test was used to test for the stability of the model. From the graphs that are generated, if the blue line falls within the two red boundary lines then the model is stable. The test was conducted for each country and the results are as presented below.

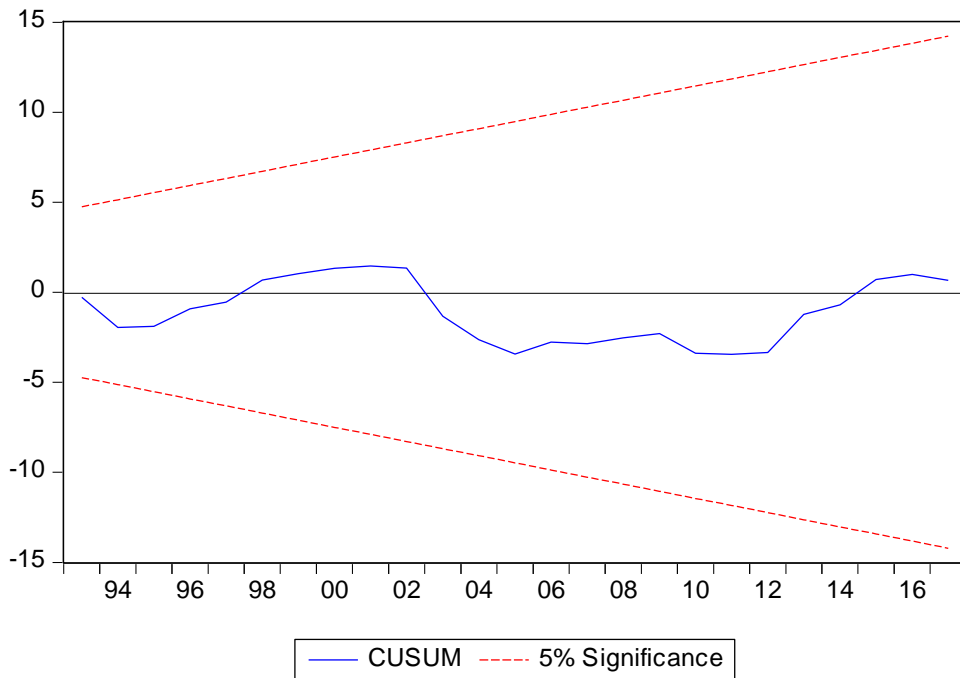


Figure 4.6: Botswana Cusum Test Result

For Botswana, the dependent variable $D(LNVOL)$ is stable because blue line falls within the two red lines.

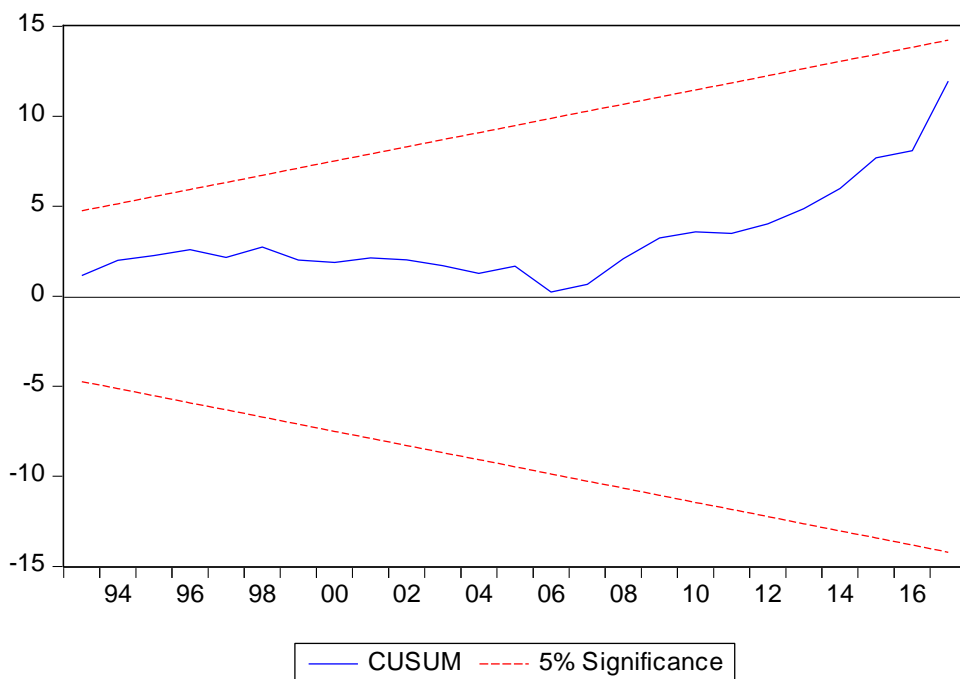


Figure 4.7: Lesotho Cusum Test Result

For Lesotho, the dependent variable $D(LNVOL)$ is stable because the blue line falls within the two red lines.

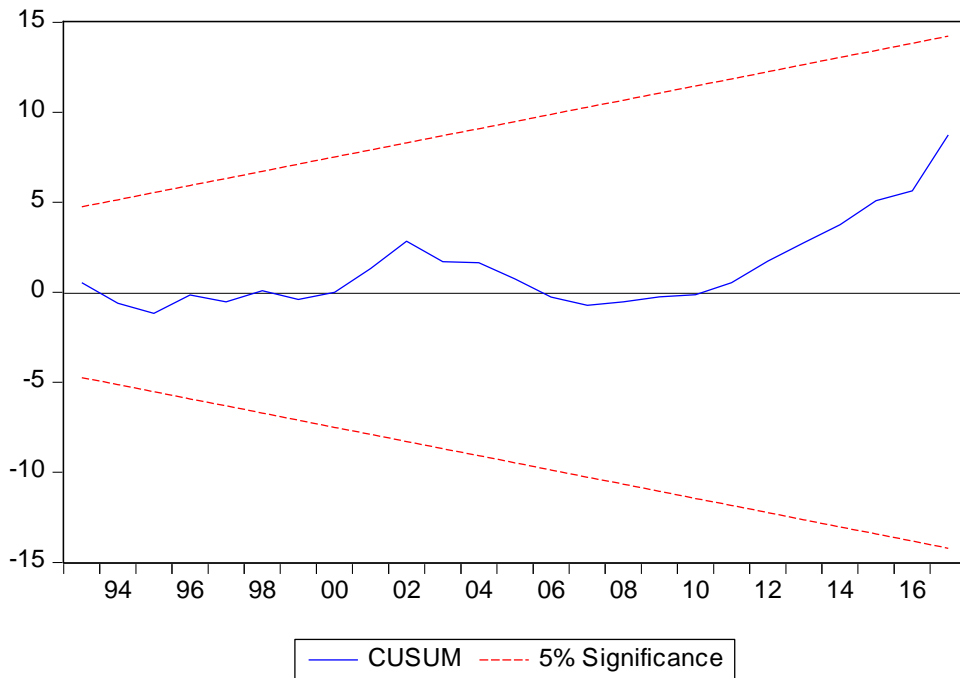


Figure 4.8: Namibia Cusum Test Result

For Namibia, the dependent variable $D(LNVOL)$ is stable because the blue line falls within the two red lines.

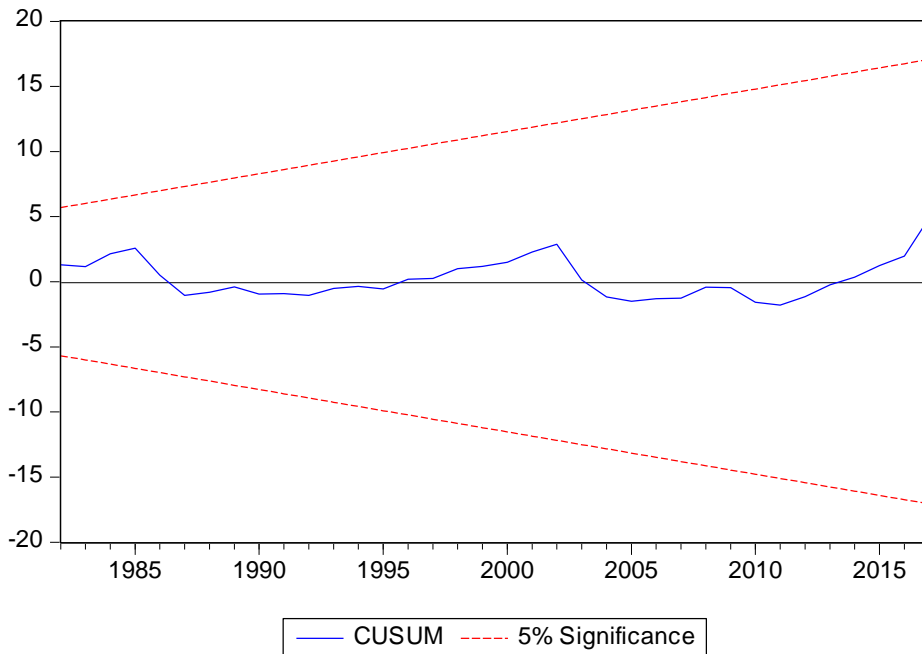


Figure 4.9: South Africa Cusum Test Result

For South Africa, the dependent variable $D(LNVOL)$ is stable because the blue line falls within the two red lines.

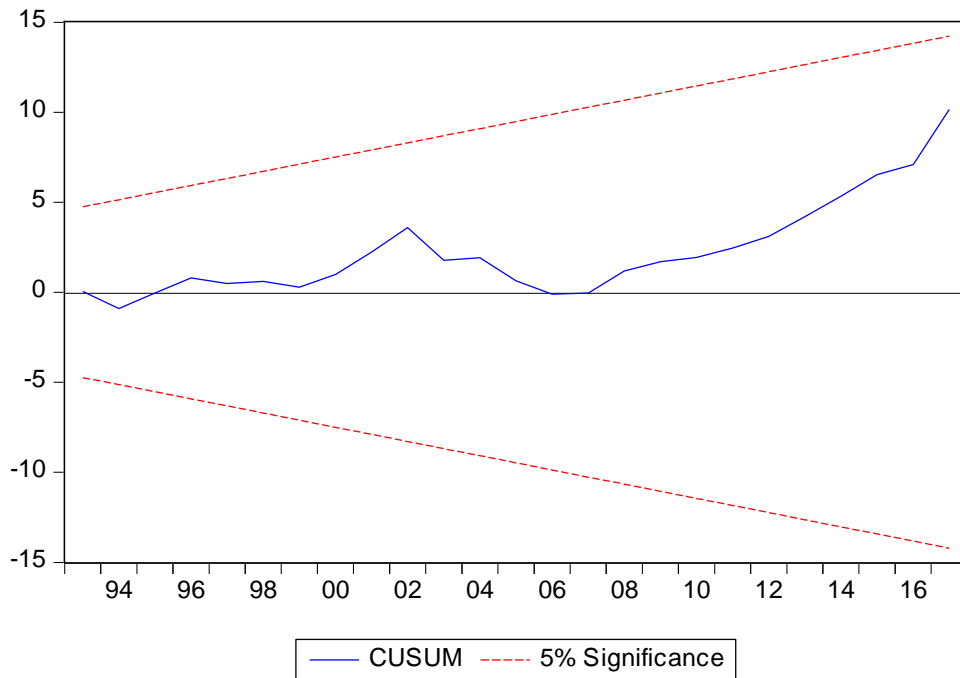


Figure 4.10:Swaziland Cusum Test Result

For Swaziland dependent variable $D(LNVOL)$ is stable because blue line falls within the two red lines.

4.5 Discussions of Results

The study examined two variables, namely, inflation and interest rates to establish if they are determinants of exchange rate volatility in the SACU region. Secondary data obtained from the World Bank Development Indicators was used in the empirical analysis covering a period of thirty-eight years from 1980 - 2017. The first test carried out was the unit root test for the variables exchange rate volatility, inflation and interest rates for each country.

The time series variables exchange rate volatility, inflation and interest rates were found to be non-stationary at level form in the three countries South Africa, Botswana and Namibia. This meant that they were containing a unit root (non-stationary) and if used in this form, in regression modelling it could possibly lead to misleading or

spurious results. All three variables, exchange rate volatility, inflation and interest rates were differenced once and they were then found not to have a unit root in first difference. The three variables were now stationary and could thus be used in further tests.

For Lesotho and Swaziland, it was found that the variables exchange rate volatility and interest rates were not stationary in level form. These variables were found to be stationary in first difference. However, the variable inflation was found to be stationary in level form for these two countries. Variables were found to be integrated of order zero and order one respectively. Since variables were integrated of different order, it was a sign that there could be cointegrating variables in the model. This also meant that ordinary least squares modelling could not be used hence the decision to use an alternative GARCH (1, 1) modelling in the regression analysis.

Cointegration tests were then carried out to establish if there was a long run relationship between exchange rate volatility and its determinants. ARDL (bounds test) revealed that for all five countries there was no cointegration between exchange rate volatility, interest rates and inflation. These variables had no long term equilibrium relationship and would not move together in the long run. Since the second objective of the study was to establish if there was a long run relationship among exchange rate volatility and its determinants, then it is clear that there is no evidence of a long run equilibrium relationship between exchange rate volatility and its determinants.

Following the GARCH (1, 1) model that was then estimated, all variables (ARCH, GARCH, inflation or interest rates) with a probability value in the variance equation of less than 5% can be considered as determinants of exchange rate volatility. Firstly, for Botswana, South Africa and Swaziland, none of the variables had a probability

value of less than 5%. This means that internal shocks, previous period volatility (ARCH) and current period volatility (GARCH) and the two variables being tested (inflation and interest rates) are not significant in explaining the volatility of the exchange rate in the three countries. This result contradicts the results found by Chipili (2012) in Zambia, Mirchndani (2013) in India, Ajao and Igbekoyi (2013) and Ali, Khan, Razi and Shafiq (2012) in Pakistan. These studies found the two variables, inflation and interest rates to be among the most important determinants of exchange rate volatility.

The variable interest rates with a probability value of 0.0226, was the only one found to be significant in explaining exchange rate volatility in the tests that were run for Namibia. This is in line with most researchers who also found this same result in their studies. These studies include Chipili (2012), Ali et al. (2012), Micharndani (2013), Ajao and Igbekoyi (2013), Oaikhenan and Aigheyisi (2015) and Adetan and Oke (2018). All these studies found interest rates to be a significant determinant of exchange rate volatility in sync with the results found for Namibia.

Lesotho's interest rates and inflation were the two factors that were found to be significant in explaining exchange rate volatility in that country. Studies carried out in Zambia by Chipili (2012), in Pakistan by Ali, Khan, Razi and Shafiq (2012) and in India by Mirchandani (2013) also found inflation and interest rates to be important determinants of exchange rate volatility.

Diagnostic tests were then carried out to check if the residuals from the model had any problems. Four such tests were carried out to check for serial correlation, heteroscedasticity, normality and stability. For the five SACU countries, the test results

revealed that there was no problem of serial correlation among variables. The models can therefore be trusted to do a good job of predicting the dependant variable.

The White Heteroscedasticity Test showed that all the five countries had the presence of ARCH effects in the error term implying heteroscedasticity. Ordinary least squares could therefore not be used in modelling this regression. The researcher then used the GARCH (1, 1) model which is appropriate for modelling when there are ARCH effects. The third diagnostic test that was carried out was the Residual Normality Test. All five countries' results showed that the residuals were normally distributed which was another good sign of the reliability of the model.

Stability Tests were the last diagnostic tests to be carried out. These tests were necessitated to avoid problems of structural change which will occur if the coefficients in a regression model do not remain constant across all observations. To test for the stability of the model, the cusum test was used. From the graphs that were generated, all the five countries' results showed the desirable quality of stability. The GARCH models' results can therefore be relied on as the desirable characteristics of no serial correlation, normal distribution and stability were found to be characteristic of all the models.

4.6 Summary

Chapter Four presented the results from the unit roots and cointegration tests that were conducted. It also detailed how the GARCH (1, 1) models were estimated. To check on how good the model was, several diagnostic tests were conducted namely testing for serial correlation, heteroscedasticity, normality and stability. The chapter presented an empirical analysis of secondary data to check which factors are determinants of exchange rate volatility in the SACU region and to check for the presence of a long

run relationship among variables in the model. The chapter also presented discussions of the results.

CHAPTER 5 : CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents conclusions and recommendations emanating from the study.

The conclusions are given against the backdrop of the study objectives. The study sought to analyse if inflation and interest rates are determinants of exchange rate volatility in the SACU region.

5.2 Conclusions

The first objective of this study was to analyse whether or not inflation and interest rates determine exchange rate volatility in SACU. Secondly the study sought to determine if there is a long-run relationship between exchange rate volatility and its determinants. From the results it was established that only in Lesotho were the two variables inflation and interest rates confirmed to be determinants of exchange rate volatility. In Namibia only the variable interest rates proved to be a determinant of exchange rate volatility. For South Africa, Botswana and Swaziland both variables were seen not to influence exchange rate volatility.

This result was very interesting as it was expected that the same determinants would be found for all the countries especially those in the monetary union (Lesotho, Namibia, Swaziland and South Africa). South Africa, Lesotho, Namibia and Swaziland harmonized their monetary and exchange rate policies in a quasi-monetary union since 1990. The three countries, Namibia, Swaziland and Lesotho have pegged their currencies to the South African Rand (Ikhide & Uanguta, 2010). It is the usual case that whatever happens in South Africa is spilled over into these three smaller states. However, the determinants of exchange rate volatility coming from this study are totally contradictory to this usual phenomenon.

While studying the determinants of exchange rate volatility for five countries (Australia, Singapore, New Zealand, Japan and Canada), Dungey (1999), found that international factors are more important in determining exchange rate volatility for the smaller nations of Australia, Singapore, and New Zealand, than for the larger nations of Japan and Canada. This outcome may help to inform why there were mixed results in the current study. The countries in the SACU region are of different sizes and they are at different stages of economic development. In light of this, it can be acceptable to have varying determinants of exchange rate volatility for countries in the same trade bloc.

The second objective was to determine if there is a long run relationship between exchange rate volatility and its determinants. There was no evidence of cointegration found between exchange rate volatility and its determinants in all the five countries. This means that there is no long-run equilibrium relationship between exchange rate volatility and its determinants.

Lessons that comes out of this study are: first, that interest rate is a determinant of exchange rate volatility in Namibia. Second, it was also demonstrated that both interest rates and inflation influenced exchange rate volatility in Lesotho. Third, for Botswana, South Africa and Swaziland, the variables inflation and interest rate are not determinants of exchange rate volatility. The result that different countries' exchange rate volatilities were differently influenced by inflation and interest rates speaks to the fact that there is no clear blueprint for reducing exchange rate volatility across the board. Other better to do economies such as that of South Africa and Botswana may be able to use appropriately aimed domestic policies to reduce volatility given the

substantial domestic factor contributions to volatility for those countries. However, for some countries like Namibia (upper middle income country), Lesotho and Swaziland, the source of exchange rate volatility may lie largely outside their policy control.

This study was informative and a lot could be drawn from it in terms of determinants of exchange rate volatility for instance, for over a long period like a century. It would also be interesting to research for countries like South Africa, Botswana and Swaziland with regards to what drives their exchange rate volatility since inflation and interest rates were not found to be the determinants there. Could it be other factors like public debt, trade openness, money supply or even the amount of foreign reserves?

5.3 Limitations of the study

This research aimed to analyse if the macroeconomic variables inflation and interest rates were determinants of exchange rate volatility in the SACU region. The scope of the study was therefore limited to these two variables and their extent of influence on exchange rate volatility. The findings from the study can therefore, only be applied to these two macroeconomic variables. In future, further researches can consider including other macroeconomic variables into their research to widen the scope.

This study also made use of the nominal exchange rate for the five countries. Future researchers may consider working with the real exchange rate for the same group of countries to see if they will still get the same result in terms of determinants of exchange rate volatility and the presence or not of a long run relationship between exchange rate volatility and its determinants.

5.4 Recommendations

The results from this study can be used to inform the process of policy making regarding reducing exchange rate volatility in South Africa, Botswana, Namibia,

Lesotho and Swaziland. The study recommends further analysis on the determinants of exchange rate volatility and policy makers should consider the possibility of macro-economic policy independence. In Lesotho, inflation targeting may go a long way in reducing exchange rate volatility. In Namibia and Lesotho, there is also room to explore the possibility of changing the interest rates time and again with the aim of reducing exchange rate volatility. For South Africa, Botswana and Swaziland, policy makers should explore other foreign exchange intervention policies other than inflation targeting.

Overall, the GARCH (1, 1) presented in this study does provide a profound basis for further research as well as the improvements in the methodology and equations. There still exists after this study an information gap as to the determinants of exchange rate volatility especially for South Africa, Botswana and Swaziland. This study therefore, suggests that future theoretical and empirical research should further investigate the determinants of exchange rate volatility focusing on other factors that were not covered like money supply, foreign reserves, public debt and trade openness. Other researchers and students can also use the results from this study as a benchmark to compare their results.

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