The Effectiveness of the SARB in Managing Bubbles in the USD-ZAR Market

Phehello M. Mkhabela

1254411

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Declaration

Declaration

I Phehello M. Mkhabela, declare that this research article is my own work except as indicated in the references and acknowledgments. It is submitted in partial fulfilment of the requirements of the degree of Master of Management in Finance and Investments, in the Graduate School of Business, University of Witswatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

PHEHELLO M. MKHABELA
Name in full

Signature

MIDRAND
Signed at

19 April 2020
Date

Dedication

I dedicate this piece of work to my son Lelihle Mehlami and my niece Mbali Nhlangisa who have allowed me the space and time to work on this article. I wish to also dedicate it to my guiding light, my grandmother Mmapula Nhlapho, my mother, my dad and my entire family.

To my doctor, Dr Bramdev, thank you for stabilising my life and giving me hope again.

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I would like to acknowledge my supervisor, Professor C. Malikane for allowing me the space and time to engage with this topic and its elementary parts as well as his guidance and patience. Without his guidance, this piece of work would have been near impossible.

Abstract

In this paper we use the monetary model to detect the presence of bubbles in the ZAR/US$ foreign exchange market. We also test if the interest rate used by the South African Reserve Bank (SARB) is an effective tool to manage bubbles in the ZAR/US$ currency pair. We first test for evidence that the money supply and real output variables are cointegrated with the exchange rate process. Our results show that there is no cointegration amongst the variables. We therefore conclude that when shocks enter the system, an equilibrium point is not restored. We thus conclude that there is evidence of a bubble in the exchange rate process. We then test the properties of the error term to confirm if the bubble decays by its own lags or not. We also test for evidence that the interest rate decays the bubble as intended by the SARB. We conclude that the bubble term and the interest rate decay the bubble in lag 2 but in an insignificant manner. We thus draw the conclusion that the bubble is explosive as it grows exponentially.

Our overall conclusion from our tests is that there is evidence of a bubble in the ZAR/US$ exchange rate and the instrument used by the SARB is not effective in managing it. The continued depreciation of the ZAR against the US$ can therefore be said to be unrelated to the economic fundamentals of an exchange rate. There is a need for the SARB to relook its monetary policy to address the inefficiencies in the economy as a result of this bubble.

Key words: Bubble; Economic Fundamentals, Monetary Model.

1. Introduction

In a free-floating currency regime, it is widely held that the forex market works on the basic economic principles of demand and supply (Blanchard & Watson, 1982). This assumption leads to an expectation that any shocks in the market will always be corrected toward equilibrium in the long run. Despite this expectation, the history of finance is characterised by asset market crashes – implying a disequilibrium not corrected. Scholars such as Flood and Garber (1980); Blanchard and Watson (1982); et al have sought to understand market crashes. The common argument has been that crashes are explained by a disequilibrium caused by an asset price bubble. Earlier arguments were that the crashes are indicative of irrational behaviour by investors.

In a later paper, Blanchard and Watson (1982) argued that bubbles do exist even with rational behaviour. R. Shiller (1984) has done a lot of work in understanding how traders may act rationally to drive and sustain a bubble. Johansen, Ledoit, and Sornette (2000) argued that a bubble doesn't always burst. This brings an interesting dynamic to the understanding of bubble behaviour. The existence of a bubble may lead to misallocation of resources and a burst may have devastating effects on the economy (Rudebusch, 2005). The presence of a bubble is therefore critical to identify and manage even if there is no eventual crash. Policy interventions in industrial economies often lead to capital flows into emerging economies putting pressure on the value of domestic fiat money (Carstens & Governor, 2015). Scholars such as Mishkin (2000); (B. S. Bernanke & Mishkin, 1997) continue to drive policy shifts in industrial and emerging economies.

The South African Rand (ZAR) has continually depreciated against the American Dollar (US$) since the introduction of the free float in 1998. In that period, it moved from a low of R5,04/US$ to a high of R16,04/US$ with a median of R8,21/US$ and an average of R9,45/US$. On the face of it, it may appear that the ZAR is undervalued relative to the US$ or simply reflective of its true value relative to the US$. However, a sound conclusion requires a statistical analysis. It is possible that a financial asset following a random walk may, purely by chance, resemble such abnormal price movement. The SARB have always maintained that the interest rate is an adequate instrument to maintain financial stability in the economy (Mminele, 2013). The interest rate is that seen as an effective tool to manage any mispricing (bubbles) in the exchange rate. The objective of this study is to examine if movements in the ZAR/US$ exchange rate exhibit the existence of a bubble or not. Our null hypothesis is that there are bubbles in the ZAR/US$ currency pair. The alternative hypothesis is that there are no bubbles. Additionally, we test if the interest rate used by the SARB is effective in managing bubbles in the ZAR/US$ market. Our null hypothesis is that if rational bubbles exist, the tool used by the SARB does not reduce the bubble or its effects.

Chapter 2 of this paper reviews academic literature on asset bubbles - the definition of a bubble and its formation. Chapter 3 explores and explains the economics of the monetary model to exchange rate determination and explains the mechanics of a bubble identification. Chapter 4 has the empirical data analysis and presentation of results. The last chapter is dedicated to conclusion on the two key hypothesis.

2. Literature Review

A free-floating exchange rate is characterised by volatility that may lead to a currency depreciation or appreciation. Implicit in this volatility is the economic value of the currency and a possibility of other non-economic factors influencing the pricing process which lead to a price bubble forming. The volatility doesn't in itself imply the presence of a bubble. There has been an increased interest in understanding asset bubbles over the years yet the definition of an asset bubble remains a contentious issue. Flood and Garber (1980) define it as the component of an asset price not explained by the fundamental economic factors. Blanchard and Watson (1982) define it as the component of an asset price unjustified by available information – irrational expectations. A useful definition is advanced by Frankel and Rose (1996) who define a forex bubble as a larger than exponential price volatility. What is clear is that a bubble tends to drive asset prices rapidly, followed by a burst; a plateau or a sharp decline. However, Johansen et al. (2000) argue that not all bubbles burst. The larger than exponential acceleration of foreign exchange rate may lead to an overvaluation or over-depreciation of the currency causing disequilibrium in the market. Common in these definitions is that there is an economic fundamental and a non-economic fundamental component in the pricing of a currency with the latter causing an imbalance in the pricing.

A bubble represents an unjustified economic value attached to the asset. For efficient resource allocation in the economy, asset price bubbles should be effectively managed. Foreign exchange represents one of the most traded financial assets in the world. The total forex market said to be many times bigger than the stock market (Sornette, Johansen, & Bouchaud, 1996). We could try estimate the true economic value of the exchange rate and call the difference between the observed and estimated a bubble as defined. Alternatively, we can analyse the behaviour of the currency movements to see patterns synonymous with bubble formations (Sornette et al., 1996). Whichever approach is chosen, it remains difficult to estimate a market fundamental value as it is not an observable number (Van Norden, 1996). The general notion that the foreign exchange rate is determined by forces of supply and demand holds. Supply and demand are themselves influenced by the economic fundamentals. The monetary model identifies; money supply, interest rates and income as the key fundamentals that drive foreign exchange (Frenkel, 1976). Taylor and Peel (2000) argue that there is a long-run relationship between these factors. This implies that any shock to the exchange rate process will correct back to equilibrium. When equilibrium is restored, a crash is not expected.

Implicit in the exchange rate is the economic benefits expected from the asset on the spot plus the expected change in the value of the asset Flood and Garber (1980). The economic benefits on the spot can be read with ease. However, the expected change in the value of the asset in the future can be tricky as it is based on the available information about the movement of the economy. The argument for efficiencies in markets assumes that all known information about an asset is priced in. This implies therefore that there will be no under or overvalued assets. This assumption is predicated on the notion that market participants are only influenced by information relevant to the economic fundamentals. It disregards the impact of social factors in driving behaviour as argued in various articles by (R. J. Shiller, Fischer, & Friedman, 1984) . Whilst it is rational to expect market participants to only consider economic fundamentals, the reality is that there is a lot of human judgment involved in the pricing processes.

Currency traders typically hold positions in currencies expecting the market to move in their favour. This expectation should ideally be informed by an understanding of the economic fundamentals' trajectory. However, some psychological factors may influence the formation of expectations on the future price movement. A trader could receive information on the expected movement of the currency sparking a surge in demand. This information could be incorrect but the spark will have occurred (R. J. Shiller et al., 1984). This has the effect of leading to a strengthening of the one currency over the other. The demand may increase at an exponential rate, totally divorced from the economic fundamentals change. Whether the initial spark was informed by a correct analysis of the expected movement of the exchange rate or not becomes of little value, a demand surge will start. Other traders observing this increase in demand may take it as a true signal of the expected movement of the exchange rate. This may further reinforce the market belief about the direction of the currency market in the future. Other market participants may observe the market giving positive returns and decide to buy more of the currency leading to a self-fulfilling prophecy to those who bought earlier. The non-economic variable will have been priced in.

More and more participants may be drawn into the market thus strengthening the currency more as noted by Blanchard and Watson (1982). It may not be easy to confirm if any positive returns realised should be attributed to improved economic fundamentals or the psychological factors. Typically, this process may lead to a frenzy with higher than exponential changes in the exchange rate. The price can't not increase forever and as such, participants may start asking questions. If the initial information that sparked the surge in the demand is proven to have been incorrect, market dumping may occur. There would typically be a sudden sharp decline in demand and those who huge stocks may be trying to dump their holdings. Supply will thus far exceed demand and the price will drop sharply. The market may plateau, lose some significant value or simply crash. The speed of the price oscillations may determine if there will be a soft landing or a crash in the market. This is when financial losses are incurred, often leading to devastating societal suffering. Traders caught with positions in the currency more than their risk appetites, may suffer irreparable financial losses. The contagion risk across geographies is high with the increased integration between international markets and the effects felt by the wider world (Meese, 1986).

There is a significant market for currency speculators, hence the scale of the impact of psychological factors can be very big (R. J. Shiller, 2002). Currency speculators have shared values systems influencing their behaviours. This often leads to mimicking behaviours and validating personal judgments using friends and trusted persons. This process follows a pattern seen in fashion trends that follow a random walk with high unpredictability. Speculation leads to an irrational surge in demand for a currency even when traders can see that there may be a price bubble. They may hope for a soft landing or timely exit prior to a crash (Schnabl & Hoffmann, 2008). This is how price bubbles may build up with rationality. R. Shiller (1984) argues that traders are social beings just like any other society. He posits that traders' psychological factors drive speculation creating a rational bubble within irrationality. Logically, the currency price should be rallied up indefinitely, however, this is not possible as soon or later, traders will start asking questions, R. J. Shiller (2002) argues.

When a market crashes, the role of the central bank becomes the target of many an analyst, with hindsight the best teacher. Mishkin (2000) underscores the responsibility of central banks to ensure stability of their financial markets. Other than the central bank's monetary policy, the effectiveness of its market supervision becomes a hot topic. Fiat currency's value is backed by its issuing authority, the Reserve Bank. When the foreign exchange market crashes, the Reserve Bank has a duty to step-in and recapitalise the markets. Once again, these are resources which could be best allocated to other needs of the country. Central banks have two options to counter mispricing in assets in their economies. They can pursue standard monetary policy aimed at controlling inflation with an indirect effect on forex pricing. Alternatively they can pursue policy that directly affects price of a currency (Rudebusch, 2005). Standard monetary policy through inflation targeting has received much support in recent years (B. S. Bernanke & Gertler, 2001). They advise that central banks should not respond to changes in prices as its difficult to attribute them to a bubble or not. Admittedly. B. S. Bernanke and Gertler (2001) argue that monetary policy is not adequate to prevent financial bubbles.

A bubble policy recognises the weaknesses of a standard policy and targets the formation of a bubble. Proponents of it argue that due to the self-reinforcing nature of a bubble, early prevention can avoid later excesses (Rudebusch, 2005). There is clearly an argument for a deliberate policy to aim at managing bubbles directly as the standard policy may not be adequate. A standard policy is expected to influence the fundamental component of a price without an effect on the bubble component which forms purely out of psychological factors. B. S. Bernanke, Laubach, Mishkin, and Posen (2018) suggest increases in regulations as a response to bubbles. In their paper they suggest tight regulations, increased transparency, etc as necessary complimentary interventions to ensure price and financial stability. However, qualitative factors such as tight supervision cannot be scientifically proven to counter bubbles (B. Bernanke & Gertler, 2000). The need to detect bubbles and intervene in time in the foreign exchange market cannot be overemphasised.

3. Methodology

We use the monetary model to exchange determination explained by (Frenkel, 1976) as a predictor of the movement of the exchange rate. The model posits that there is a long run relationship between a set of economic fundamentals and the exchange rate. This suggestion is important in testing our first hypothesis on the existence of other factors in the ZAR/US$ currency pairing. It gives us a methodology to analyse the exchange rate process and identify if there are other factors involved in the exchange rate determination. However, the model has not been without criticism. Existing literature on its suitability has yielded mixed results. Meese and Rogoff (1983) found it to be weaker than a naïve random walk model in predicting exchange rates. Mark (1995) rekindled the usefulness of the monetary model. He showed that deviations from a simple set of monetary fundamentals are useful in predicting the US. Dollar exchange rate over longer horizons. Recent studies by Groen (2000) and Mark and Sul (2001) actually found evidence of a cointegrating relationship between nominal exchange rates, money supply and real output. Particularly for the ZAR/US$ currency pair, studies by scholars such as Casteleijn (1999), Ziramba (2007), and (Nell, 2003) found the model not suitable for to predict the behaviour of the exchange rate. These studies had focused largely on the period before the free float. Studies by Dube (2008), Brink (2000) and Chinn (1999) have found some long run relationship in the ZAR/US$ and the economic fundamental variables.

The model provides a long-run benchmark for the exchange rate, proving a good criterion for currency valuation (Rapach & Wohar, 2002). Its key underpinnings are represented by the following equations

$$(m_t - p_t) = \alpha_1 y_t - \alpha_2 i_t \tag{1a}$$
$$(m_t^* - p_t^*) = \alpha_2 y_t^* - \alpha_2 i_t^* \tag{2b}$$
$$(i_t - i_t^*) = \Delta s_t^e = (s_{t+1}^e - s_t | \text{I}) \tag{2}$$

Where m_t is the money supply differential; p_t is the price level, y_t is the real income differential and $(i_t - i_t^*)$ is the nominal interest rate differential. The subscript e denotes expectations and s is the exchange rate expressed as the ZAR/US$. The differentials are RSA minus USA. All variables except for interest rate, are in natural logarithms. The income elasticity α_1 and interest rate semi-elasticity, $-\alpha_2$ are equal in a money demand equation

(Woo, 1985). In equations (1a) and (1b) we have the common monetary equilibrium conditions between the domestic and foreign country. Equation (2) is the first assumption of the monetary model, Uncovered Interest Parity (UIP) possible under a perfect capital mobility condition. It has been rejected by multiple studies (Meese, 1986). The UIP assumption generally holds for high income countries de Bruyn, Gupta, and Stander (2013). Kryshko (2006) found that it holds for South Africa when using a non-parametric cointegration approach allowing for non-linearity in the short run dynamics. However, no study has rejected large mean deviations from UCIP. We therefore use equation (2) as a reasonable approximation. The Real Interest Rate Differential monetary model developed by Frankel (1979) refines the Flexible Price Monetary Model proposed by himself in Frenkel (1976) and the Sticky Pricing Model of Dornbusch (1976). This model assumes that the Purchasing Power Parity (PPP) condition holds in the long-run such that we have

$$e_t = (m_t - m_t^*) - \alpha_1(y_t - y_t^*) + \alpha_2(\Delta p_t^e - \Delta p_t^{*e}) + u_t \tag{3}$$

Where e_t is the exchange rate; and $(\Delta p^e - \Delta p^{*e})$ has been substituted for the interest rate differential. If e_t is I(0) or I(1), then the Δe_t =0 in the steady state if we abstract from any deterministic trend or growth in e_t, so that we have $p_t = p_t^*$. We therefore have

$$e_t = (m_t - m_t^*) - \alpha_1(y_t - y_t^*) \tag{4}$$

This is the basic form of the monetary model. It establishes a long-run relationship between the nominal exchange rate and the monetary fundamentals Rapach and Wohar (2002). Mark and Sul (2001) add a restriction that $\alpha_1 = 1$ such that we get:

$$e_t = (m_t - m_t^*) - (y_t - y_t^*) \tag{5}$$

To test the long run relationship is essentially to test if there is a stable relationship between e_t, $(m_t - m_t^*)$, and $(y_t - y_t^*)$ i.e. to test if these variables are cointegrated. The stability tests for this model are premised on the assumption that there is cointegration amongst the variables. For the integration properties of these variables, we use the Augmented Dickey Fuller (ADF) test by Dickey and Fuller (1979). This test has been criticised for its low power where the time series process is stationary but with a root the non-stationary boundary (de Bruyn et al., 2013). To supplement our results, we also perform the variation of the ADF as proposed by Ng and Perron (2001). The Ng and Perron (2001) unit root test has the advantage of a goods size and power properties to test for stationarity. The null hypothesis is that the variables are I(1) and the alternative is that they are not I(1). The long run model will only hold if the variables are cointegrated. If $e_t, m_t - m_t^*$, and $y_t - y_t^*$ are all I(1), we can estimate the model

$$e_t = \alpha_0 + \alpha_1(m_t - m_t^*) - \alpha_2(y_t - y_t^*) + u_t \tag{6}$$

Where α_0 is a constant, α_1 is the money supply elasticity, α_2 is the real income elasticity and u_t is an error term to cater for factors that may explain the movement in e_t other than the fundamentals. The model posits that α_1=1 and α_2= -1. The distribution of u_t must be independent and identically distributed i.e. $\sim idd(0, \sigma^2)$. Equation (6) represents the cointegration equation if the error term, u_t is found to be stationary. According to Stock (1987), when e_t and its explanatory variables are cointegrated, the OLS estimates of the parameters are consistent and highly efficient. However, they suffer from asymptotic bias unless the regressors are exogenous (Rapach & Wohar, 2002). To treat for this bias, we use the Fully Modified OLS (FMOLS) estimates as suggested by Phillips and Hansen (1990). We test the residuals for stationarity using the Ng and Perron (2001) unit root test. The null hypothesis is that the residuals contain unit root and the alternative is that they contain no unit root. If the residuals are stationary, then we conclude that the long run model holds. To test for the significance of the parameters, we use the Wald Test by Wald (1943).

In order to test for the existence of bubbles we use two approaches. The first method is by Diba and Grossman (1984). According to this method, if the exchange rate and the market fundamentals are integrated of the same order, bubbles cannot exist. Essentially, this approach involves testing for unit root in the money supply, real output and exchange rate variables. We use the Augmented Dickey-Fuller (ADF) to test for unit root (Dickey & Fuller, 1981) and supplement it with the Ng and Perron (2001) test. The test is to confirm the level of integration required for each variable to be stationary. In the ADF tests, the null hypothesis is that the variables have unit root and the alternate hypothesis is that they have no unit root. If absolute value of the t-statistic is higher than the critical value at 5% confidence level and significant, we reject the null, otherwise, we fail to reject the null. For the Ng Perron test, if the absolute values of the MZa, MZt, MSB and MPT t-statistics at level, is lower than the critical value at 5%, we fail to reject the null hypothesis. Otherwise we accept the alternative hypothesis. If from both tests, all variables are integrated of the same order, we confirm that there is no evidence of bubbles' existence.

The second related method is the cointegration approach due to Granger and Engle (1985). This method has a two-step approach. To illustrate this method, the first step is to confirm if all the individual variables are I(1). If the variables are confirmed as I(1), we then estimate the cointegration regression in Equation (6) at level, using FMOLS and save the residuals as $\hat{u}_t$. No inferences are drawn on the parameter estimates of this regression. We are only interested in the estimated parameter values (Brooks, 2019, p. 378). This would confirm the existence of a cointegration relationship between the exchange rate and the market fundamentals or not. If the residuals are I(1), either one or both of the explanatory variables must be I(1) but neither can be integrated of a higher order than 1 (Rapach & Wohar, 2002). If the residuals are I(0), Granger and Engle (1985) say that the exchange rate tends towards equilibrium after a shock, confirming integration. We then use $\hat{u}_t$ obtained in estimating Equation (6) as one of the regressors to estimate the long-run equilibrium model, see Equation (7). The coefficient of the error term will give us the speed of adjustment in the system after a shock. The coefficient of the error term is expected to be negative to indicate the correction in the system. To avoid a spurious regression, we use the explanatory variables at first differences. We use the Akaike Information Criteria to determine the optimal lag length. The new regression states the short run dynamics of the exchange rate as follows:

$$\Delta e_t = \beta_1 \Delta(m_t - m_t^*) + \beta_2 \Delta(y_t - y_t^*) - \lambda \hat{u}_{t-1} + \varepsilon_t \tag{7}$$

Where β_1 is the coefficient of the change in monetary supply, β_2 is the for real income. These coefficients demonstrate the short run dynamics of the explanatory variables. The error term in equation (6), $\hat{u}_t$ is interpreted as a disequilibrium shock and is lagged by 1 in Equation (7). The term ε_t represents the white noise in the system and it must be ~ $idd(0, \sigma^2)$. The coefficients of Equation (7) can be used to make inferences. The coefficient of the error term λ, represents the speed with which any shocks are corrected back to equilibrium. The negative sign on the coefficient λ denotes the expectation that the error term will have a correcting effect. If λ is statistically significant and negative, we will conclude that there is a bubble. If the sum of the error terms is <1, the bubble is said to be non-explosive. If the sum of the errors =1, we will conclude that the bubble is stable, if greater than 1, the bubble will be said to be is explosive.

Additionally, if the error term is not serially correlated with the exchange rate a bubble will be confirmed, otherwise there is no bubble. To test for the significance of the parameters, we use the Wald Test by Wald (1943). The null hypothesis is that the explanatory variables have no significant influence on the exchange rate process. The alternative hypothesis is that they have a significant impact on the exchange rate. We restrict the coefficients of the economic variables to 1 as per the monetary model. We use a 5% confidence level to conclude on the significance of the parameters.

To investigate the effectiveness of the SARB in managing bubbles in the ZAR/US$ exchange rate, we need to find the relationship between the SARB monetary instrument and the bubble if they exist. We have seen that rational bubbles are driven by the reinforcing effects in the system. Firstly, we expect that the error term u_{t} will follow an autoregressive process. We also expect that the influence of the interest rate may not be instantaneous, but lagged. To find the optimum lag length, we use the Akaike Information Criterion. We then run a regression of the form:

$$u_{\mathrm{t}} = \sum_{i=1}^{n}(\eta u_{t-1}) - \sum_{i=0}^{n}(\varphi_{t-1}) + \mu_t \tag{8}$$

Where u_{t} is the error term obtained from the OLS estimate of Equation (6); η is the coefficient which represents the percentage by which the lags of the error term. The variable i_t is the interest rate at time t , φ is the coefficient of the interest rate variable and μ_t is the white noise. We are expecting that the interest rate instrument should have a negative effect on the error term hence the negative sign on φ. Additionally, we don't expect the interest rate to have an instantaneous effect on the bubble, however, we want to confirm this from the model, hence we start the variable at t_0 . Lastly, we don't expect the error term to have a mean, hence there is no constant. If the coefficients η and φ is found to be statistically significant and negative, we will conclude that the variables decay the bubble. We are particularly interested in the significance and sign of φ to confirm if the interest rate is effective to manage bubbles in the ZAR/US$ exchange rate. We use the Schwarz Information

Criteria to determine the lag length. We use the Wald Test as proposed by Wald (1943) to make a decision on the significance of each of the variables. In this test, we restrict the coefficients of the bubble lags to zero and compare the probability value to our 5% confidence level. The null hypothesis is that the bubble term lags and the interest rate lags have no significant influence the bubble term process at 5% confidence level.

4. Empirical Analysis

4.1 Data Analysis

We use data that consist of seasonally adjusted quarterly observations of the money supply (M3); real gross domestic product (GDP) and the ZAR/US$ nominal exchange rate. We also use the interest rate time series is from the 90 day South African Treasury bills. The data spanned a period Q1:1998 to Q4: 2019 coinciding with the start of the free-floating period of the ZAR (Mminele, 2013). The RSA data were downloaded from the South African Reserve Bank website and USA data were downloaded from the Federal Reserve Board website. We transform the data series for all the variables into an index by using year 2010, Q3 as the base quarter for both RSA and the USA. To reduce the chances of heteroskedasticity we take a natural log of the data to smoothen the time series (Osborne, 2010), all variables We calculate the differentials $(m_t - m_t^*)$ and $(y_t - y_t^*)$ by treating RSA as a domestic country and the USA as a foreign country. Thus we subtract the USA natural log time series from the RSA natural log time series for both variables.

Figure 1- Money Supply Differential (RSA-USA)

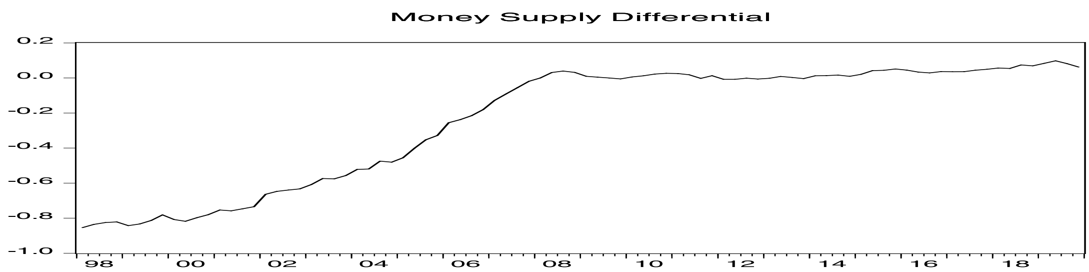


Figure 2 - Real Output Differential (RSA-USA)

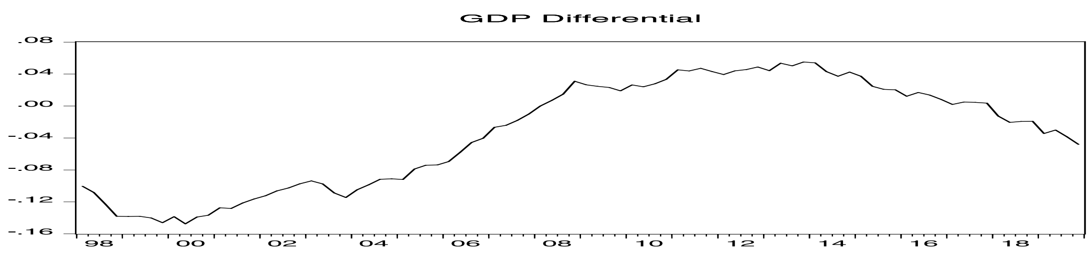


Figure 3 - ZAR/US$ Exchange Rate (1998-2019)

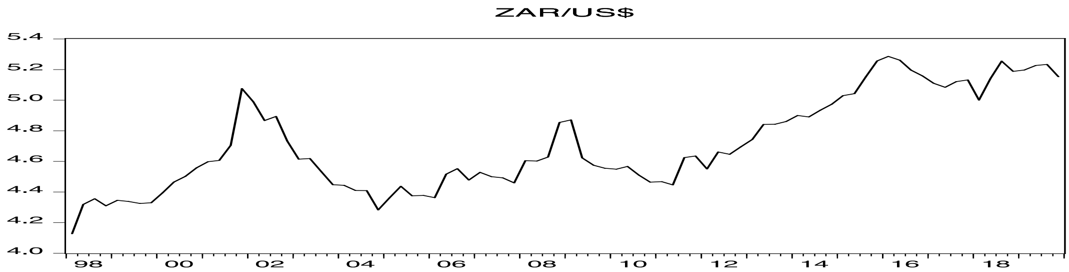


Figure 1 shows that the money differential between South Africa and the USA was increasing in the period 1998 to 2008 then it plateaued ever since. The Real Output graph in Figure 2 shows that the real GDP differential between the two countries was declining in the period 1998 to 2000. It then increased to a peak in 2014 before declining until 2019. In this period, the exchange rate has been consistently going up, the ZAR depreciating. We note about 6 times when it depreciated sharply and gained some value in the period 1998. The behaviour of the ZAR/US$ has been somewhat volatile quarter by quarter. Using the monetary model, we will analyse if the movements in the exchange rate have been determined by the economic fundamentals.

4.2 Cointegration tests

Our tests are essentially to test if there is any (bubble) influence on the exchange rate other than the economic fundamentals. To do this, we test if there is cointegration in the relationship between the exchange rate and the economic fundamentals using two approaches. Our first approach is the Diba and Grossman (1984) which argues that if cointegration is confirmed, bubbles cannot exist. To confirm cointegration we analyse the properties of the variables so see if they are integrated of the same order and not a higher order than 1. We first use the ADF test by Dickey and Fuller (1981) to perform the unit root tests. The null hypothesis; H0: Series contains unit root versus H1: series is stationary. The variables tested were e_t, $(m - m_t)$, and$(\boldsymbol{y} - \boldsymbol{y_t})$. The tests were done at level and with first differencing. The ADF results in Table 1 show that all the variables are I(1). At level, the t-statistic, in absolute terms for e_t and $(m - m_t)$ and $(\boldsymbol{y} - \boldsymbol{y_t})$ are lower than the ADF critical values at all confidence levels and insignificant. With first differencing, the t-statistics are greater than the ADF critical values at all confidence intervals and significant.

Table 1-Unit Root Test Results:

	Augmented Dickey-Fuller Test			
Variables	**Level**		**First Difference**	
	$\mathbf{t-statistic}$	$\mathbf{p-value}$	$\mathbf{t-statistic}$	$\mathbf{p-value}$
e_t	-1,636*	0,460	-8,675**	0,000
$(m - m_t)$	-2,037*	0,271	-3,940**	0,003
$(\mathbf{y} - \mathbf{y_t})$	-1,153*	0,692	-6,694**	0,000
Critical Values				
1%	-3,508			
5%	-2,896			
10%	-2,585			

Notes:
*-Non-stationary at 5% confidence level.
**- Stationary after first differencing

We then use the Ng and Perron (2001) test to because of its superiority to the ADF test, to confirm if we get the same results. As shown on Table 2, the T-Statistics, at level, on the MZa and MZt show that variables are not stationary. The T- Statistics absolute values are smaller than the critical values at the 5% confidence level. The MSB and MPT T- Statistics are bigger than the critical values at the 5% confidence level. This further confirms that the variables are non-stationary at level. After first differencing, the absolute values of the MZa and MZt metrics are still lower than the critical values at the 5% level. Under the MSB and MPT, the t-Statistics are higher than the critical values at 5% level. This confirms that the variables are not I(1), instead they are integrated of a higher order. We thus can confirm that there is no cointegration amongst the variables.

The ADF tests show that the variables are integrated of the same order. According to the Diba and Grossman (1984) hypothesis, we should conclude that there is no evidence of bubbles in the exchange rate. However, we place reliance on the results of the Ng Perron test which indicate that the variables are integrated of an order higher than 1 which violates the cointegration condition (Rapach & Wohar, 2002). We thus we can conclude that there is evidence of bubbles as per Diba and Grossman (1984) hypothesis. The sum of the residuals is 1,525 which implies that the bubble is explosive.

Table 2- Ng-Perron Unit Root Test

Ng Perron Unit Root								
Variables	At Levels				First Differences			
	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT
e_t	-0,193*	-0,104*	0,539*	20,385*	-4,007**	-1.257**	0,314**	6,285**
$(m - m_t)$,	0,406*	0,406*	1,000*	61,634*	-23.213**	-3,305**	0,142**	1,400**
$(\mathbf{y} - \mathbf{y_t})$.	-0,640*	-0.542*	0,848*	35,787*	-3,832**	-1,361**	0,355**	6,412**
1%	-13,800	-2,580	0,174	1,780				
5%	-8,100	-1,980	0,233	3,170				
10%	-5,700	-1,620	0,275	4,450				

Notes:
*-series is non-stationary at level
**-series is non-stationary at first differences

We then proceed to employ our second approach to confirm cointegration using the Engle-Granger two step approach and compare our results to the first test. The Engle-Granger approach uses the ADF test to confirm if the variables are I(1) as a first step. Having confirmed above that all the variables are I(1), we move to the second step and estimate Equation (6) using the FMOLS method and save the residuals as $\hat{u}_t$.

$$= 4{,}869 + 0{,}985(m_t - m_t^*) - 11{,}258(y_t - y_t^*) + u_t$$
$$\text{S.E} \quad (0{,}057) \qquad (0{,}353) \qquad (7{,}102)$$

We then test the $\hat{u}_t$ for stationarity using the ADF and Ng Perron unit root tests. At 5% confidence level, the we fail to reject the null hypothesis that $\hat{u}_t$ has unit root, refer to Table 3. Thus we conclude that there is no cointegration between the variables as the residuals are confirmed as not I(0) on both the tests, see Table 3. This result is consistent with our conclusion under the first hypothesis by Diba and Grossman (1984).

The monetary model posits that the coefficients of money supply and real output are 1 and -1 respectively and the constant is zero. We then test for the probability that these coefficients could have some significant influence on the exchange rate determination using the Wald test. We restrict the coefficients to the values of the monetary model. For both the Money Supply and Real Output variables, we reject the null hypothesis that α_1=1 and $\alpha_2 = -1$ as the F-Statistics are lower than the critical value at 5%. The results of the regression therefore are incongruent with our expectations. The results are consistent with the findings by (Nell, 2003) who finds that M3 provides little information about future prices. He had studied the predictive power of M3 on future prices in the period 1968-97. For the period 1970-2002, Tlelima and Turner (2004) also found money supply to have unstable predictive power. On our expectation on the constant, we fail to reject the null hypothesis that α_0=0. Both the F-Statistic and T-Statistic with probabilities values lower than 5% critical values. This result also shows that the ZAR has a long run average rate of about 4,87. The money supply and real output variables are however, weak to predict the movement of the exchange rate. In summary, we conclude that the monetary model does not hold for the ZAR/US$ currency pair. This conclusion implies that there is no long run relationship between the economic fundamentals and the exchange rate. When a shock occurs in the system, there system does not return to equilibrium. This means that the ZAR/US$ rate is determined largely by factors outside of the economic fundamentals. Graph, shows the recursive residuals graph within the 5% confidence level. We perform a residuals recursive test to confirm that the economic fundamentals are not stable predictors of the ZAR/US$ exchange rate. Graph 6, shows that there is no stability in the model as it wanders off the 5% standard error bounds. We can see five quarters in which the model is outside the bounds. This result seems consistent with the finding by Tlelima and Turner (2004) who found 3 quarters of instability in the money supply in the period 1980-93.

Table 3 - ADF and Ng Perron Unit Root Tests

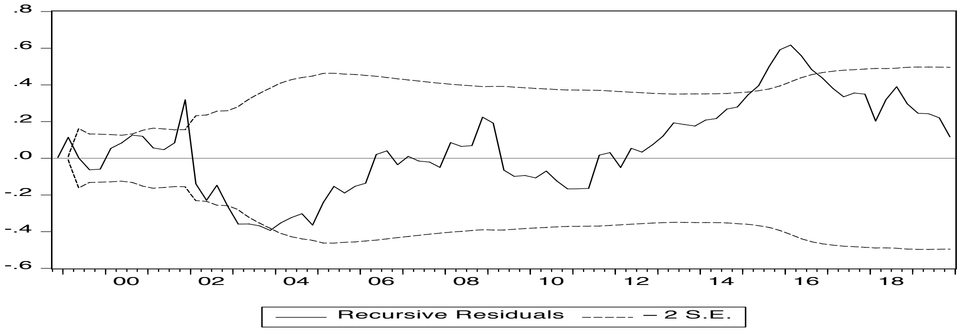
Augmented Dickey-Fuller Test				
Variables	**Level**		**First Difference**	
	$\mathbf{t-statistic}$	$\mathbf{p-value}$	$\mathbf{t-statistic}$	$\mathbf{p-value}$
u_t	-1,758*	0,399*	8,645*	0,000*
Critical Values				
1%	-3,508			
5%	-2,896			
10%	-2,585			

Ng Perron Test								
Variables	**At Levels**				**First Differences**			
	MZa	**MZt**	**MSB**	**MPT**	**MZa**	**MZt**	**MSB**	**MPT**
u_t	-5,960*	-1,712*	0,287*	4,155*	-42,300*	-4,581*	0,108*	0,627*
Critical Values								
1%	-13,800	-2,580	0,174	1,780				
5%	-8,100	-1,980	0,233	3,170				
10%	-5,700	-1,620	0,275	4,450				

Notes:

*- Residuals are non-stationary at levels

Figure 4 - Recursive Residuals Graph



4.3 Effect of Interest Rates on the Bubble

Our results from the Diba and Grossman (1984) test and the Engle-Granger show that there is no cointegration amongst the variables. We have thus confirm that the ZAR/US$ does not return to equilibrium after a shock to the system. Our second test shows that the economic fundamentals have poor predictive power on the exchange rate. We then analyse the properties of the bubble and the effect of the interest rate variable. This will help us understand if the bubble does adjust downwards by itself and/or by the effect of the interest rate. To do this, we run the regression in Equation (8). For the optimal lag length, we use the Schwarz Criteria as it gives the least number of lags for both variables. The error term optimal lag length is 2.

Table 4 – Bubble and Interest Rate Regression Results

Variable	Coefficient	Standard Error
u_{t-1}	1,032*	0,041
u_{t-2}	-0,048*	0,041
i_{t-0}	0,044	0,052
i_{t-1}	0,061**	0,096
i_{t-2}	-0,104**	0,062

* - Significant at 5%

**- Not Significant at 5%

We use the Wald Test to test of the parameters are statistically significant to explain the movement in the bubble. Our null hypothesis is that the variables are not significant. For the first lag of the bubble term, the is a positive 1, 031 which means that the bubble in $\boldsymbol{t+1}$ is increases by 3,2% from its $\boldsymbol{t_0}$ values. From Wald test critical F-statistic and T-Statistic values, we reject the null hypothesis that the first lag is not significant to influence the bubble term process at 5%. The second lag of the bubble term is a negative 0,048 which shows that by the second lag, the bubble decays returning the system towards equilibrium. The Wald test F-Statistic and T-Statistics critical values indicate that we fail to reject the null hypothesis, at 5% that the second lag of the bubble term is not significant. The Interest rate at $\boldsymbol{t_0}$ is a positive 4,4% which should that the interest rate leads to an increase in the bubble. The Wald test shows that we fail to reject the null hypothesis of this effect being insignificant. The first lag of the Interest Rate variable has a positive coefficient of 0,061 which shows that the bubble in $\boldsymbol{t+1}$ is influence positively by the $\boldsymbol{t_0}$ value of the Interest Rate variable. From the Wald test F- Statistics and T-Statistics critical values, at 5%, we fail to reject the null hypothesis of no significant influence. The second lag of the Interest Rate variable has a negative coefficient of 0,104 which shows that the bubble decays. The Wald test F-Statistics and T-Statistics critical values indicate that at 5% we fail to reject the null hypothesis of an insignificant influence on the bubble process.

We therefore conclude that the second lags of the bubble term and the interest rate decay the bubble but in an insignificant way. This indicates that once a shock comes into the exchange rate system, the bubble keeps growing and adjusts in an insignificant manner by itself and the effects of the interest rate changes. This brings us to the conclusion that the interest rate instrument used by the SARB to manage bubbles is not effective. This implies that the continued depreciation of the ZAR against the US$ has a component of a bubble.

5. Conclusion

Summary conclusion:

Our first research question is if there are bubbles in the ZAR/US$ Exchange Rate. To perform this test, we use the monetary model for exchange rate determination by Frenkel (1976). The theory of assets bubbles states that an asset price comprises two components, an economic value and a non-economic value. The true economic value of an asset is equal to the discounted economic benefits expected to be derived from it. The ZAR is an asset held bother for current consumption and capital appreciation. Since 1998, the ZAR floats freely with the ZAR/US$ exchange rate determined by the forces of demand and supply. The asset bubble formation theory posit that the expectations on the future change in the value of the asset influence its price (Flood & Garber, 1980). We use the monetary model to exchange rate determination to analyse the factors that influence the exchange rate process. Frenkel (1976) argues that the exchange rate is determined by economic fundamentals such as money supply and real gross domestic product in a long run relationship. This model assumes purchasing power parity and uncovered interest parity between the two countries. By definition, a bubble in the exchange rate would be evidenced by the presence of factors other than the money supply and real gross domestic product. Our second research question is on whether the interest rate used by the SARB is an effective tool to manage bubbles in the ZAR/US$, if they exist.

There has been mixed conclusions on the suitability of the monetary model to determine the exchange rate processes from around the world and in the ZAR/US$ currency pair. The span of data has been identified as the main reason why the model may not hold. We employ this model in the floating period using quarterly data with a total sample size of 88 observations. We test for the existence of a long run relationship between the ZAR/US$ exchange rate and the economic fundamentals. To do this, we use the finding by Diba and Grossman (1984) which states that if there is cointegration in the OLS estimates of the monetary model, a bubble cannot exist. We use the ADF and Ng Perron unit root tests to understand the stationarity properties of the variables. Our ADF results confirm that the variables are all I(1), however, the Ng Perron results show that the variables are integrated of an order higher than 1. This is indicative of variables that are not cointegrated. We then use a second method, the

Engle-Granger two step approach to test for cointegration (Granger & Engle, 1985). Our results are consistent with the first test. We then test for the significance of the coefficients in the model, after applying theoretical restrictions, we conclude that the Real Output and Money Supply are not significant in the exchange rate determination. The residuals recursive test confirms this.

Having confirmed the exchange rate doesn't return to equilibrium after a shock, the presence of a bubble, we tested the properties of the bubble together with the interest rate to confirm if the bubble decays or not. Our results show that the second lags of the bubble term and the interest rate decay the bubble but in an insignificant way. This indicates that once a shock comes into the exchange rate system, the bubble keeps growing and adjusts in an insignificant manner by itself and the effects of the interest rate changes. This brings us to the conclusion that the interest rate instrument used by the SARB to manage bubbles is not effective. This implies that the continued depreciation of the ZAR against the US$ has a component of a bubble.

Overall conclusion:

Our overall conclusion is that the first hypothesis of a presence of bubble in the ZAR/US$ exchange rate cannot be rejected. Our second hypothesis of the Interest Rate being an ineffective tool in managing bubbles can be rejected. We therefore can conclude that there are bubbles in the ZAR/US$ exchange rate and the interest rate is an effective tool to manage bubbles.

Recommendation:

The key recommendation is that the SARB should revise their approach to the management of bubbles in the ZAR/US$ currency pair. The risks inherent in a currency that is mispriced can be can cause dire losses to the economy.

Limitations:

Our paper did not look into the likelihood of a burst in the bubble.

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