The Rand, Interest Rate and Intervention by the South African Reserve Bank

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ARTICLE DETAILS

History
Received:
September 18, 2023
Revised:
November 18, 2023
Accepted:
November 30, 2023
Published:
December 31, 2023

Keywords
Rand
Interest Rate
Intervention
South African Reserve Bank
VECM

ABSTRACT

Purpose
The study has a twofold aim. The first is to assess whether the interventions explain the short-term fluctuations of the exchange rate of the rand and interest rate in South Africa. The second is to confirm whether intervention shocks transmit to the exchange rate and interest rate settings.

Methodology
Data from 1975 to 2020 was collected from the World Bank's website. The research used the Vector Autoregression (VAR) model to investigate the relationship between interventions, the exchange rate of the rand, and interest rates. FEVD was also employed to examine whether intervention shocks have discernible effects on both the interest rate and the exchange rate of the rand.

Findings
The evidence identifies that reserve growth positively and significantly influences the exchange rate, indicating that intervention causes the depreciation of the rand. However, the reserve growth has a negative and insignificant impact on the interest rate, indicating that intervention was unable to explain the interest rate set by SARB. The significance of the cumulative effects on the exchange rate is evidence that the interventions explain short-run stabilization of the exchange rate.

Conclusion
In conclusion, the findings of this analysis highlight a clear impact of interventions on exchange rates, while concurrently revealing a lack of statistically significant influence on interest rates. This research offers a policy that can inform future policy decisions related to interventions and the broader monetary framework governing the rand exchange rate.

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1. Introduction

The central bank interventions (thereafter, interventions) have always attracted attention from researchers, and participants in the foreign exchange (forex) market. Because the exchange rate incessantly exhibits volatility, the central bank intervenes by buying (selling) forex to smoothen the country's currency from appreciation (depreciation). If the central banks do not intervene, exchange rate fluctuations that 'overshoot' fundamentals may create uncertainties and generate added costs that shrink firms' profits (Viola, Klotzle et al., 2019; Connolly & Taylor, 1994). Excessive swings can cause external instability if market confidence is eroded and export is restrained. This threatens the stock market (Panda, Nanda & Paital, 2019), financial stability (Tiwary, Das et al., 2022), makes monetary policy unsustainable (Omojolaibi & Gbadebo, 2014; Neely, 2009; Adebiyi, 2007; Amato et al., 2005) and hurt the real sector (Chiliba, Alagidede & Schaling, 2019; Disyatat & Galati, 2005).

Persistent intervention is evident in crisis periods because it limits the effect of accompanied shocks on the exchange rate (Adler et al., 2019; Lízal & Schwarz, 2013). Lízal and Schwarz (2013) note that during a financial crisis, central banks in most industrialized countries embark on interventions to lessen the consequences. The global COVID-19 crisis was accompanied by the US Fed's aggressive contractionary monetary policy cycle since 2022 (Clarida, Burcu, & Chiara, 2021; Brainard, 2021). This has resulted in substantial capital flows, getting the dollar to record levels and sharp currency depreciations across countries. Regular intervention is more in emerging economies regardless of the volume in advanced economies (Frömmel & Midiliç, 2022; Menkhoff, 2012).

Literature holds that intervention is effective in stabilizing the exchange rate, and if not sterilized, it would affect the interest rates, and cause severe growth in the money supply. In this context, intervention depicts a pseudo and unconventional monetary policy to mitigate exchange rate undulations. For some studies, intervention can also be implemented with the interest rate (Odoyo, Raymond & Kenneth, 2014; Lízal & chwarz, 2013; Fatum, 2010; Canales-Kriljenko, 2003; Fatum & Hutchison, 1999). Fatum (2010) observes that if traditional monetary policies are constrained central banks wield influence over exchange rates by setting the interest rate. The interest rate works via the portfolio-balance channel and it affects the exchange rate through a direct effect on demand and supply of forex (Fatum, 2015). Increasing the interest rate would offer lenders higher returns relative to other countries, through a reduction in forex and an increase in capital flow thereby leading to the exchange rate appreciating. Most central banks of large countries slashed their interest rates after 2008 to keep the exchange rate stable. Smaller countries, particularly emerging economies in Asia become flooded with capital causing the appreciation of their currencies and a sharp fall in interest rates.

Monetary authorities in emerging economies participate in the forex markets to influence the exchange rate level, limit exchange rate volatility, and/or accumulate reserves. The South African (SA) rand is the most traded emerging currency in Africa, and for decades remains amongst the most volatile currencies that continue to experience depreciation. The South African Reserve Bank (SARB) has implemented inflation targeting since 2000 using interest rates to control money circulation and inflation. In March 2023, the apex bank set its inflation projection to 3–6 percent, the lending rate was raised to 11.25

percent and the repurchase (repo) rate to 7.75 percent. The SARB intervenes in reserve accumulation (SARB, 2023) and has achieved success has been able to respectively, accumulating gross reserves and international liquidity position of USD57 billion and USD50 billion in 2022, which contains SARB's activity in international syndicated loans to augment the reserves, since the early 2000s.

With the interventions, although the rand moves alongside short-term targets, the exchange rates remained persistently volatile and inconsistent with expectations. Some papers investigate factors causing fluctuations and recognize that the rand's volatility cannot be clarified by only movements in fundamentals (Mpofu, 2016; Maveé, Perrelli, & Schimmelpfennig, 2016; Arezki, Dumitrescu, et al., 2012). The implication of intervention for the rand and monetary policy has received less research attention (Khuntia et al., 2018). Only a few studies have been identified for South Africa, and their empirical analysis is made alongside other countries (Diniz-Maganini et al., 2023; Anjaly, 2022; Almudhaf, 2014). Analyzing the effect of the intervention, alongside its interactions with interest rates and the exchange rate level, is required.

Research for emerging economies identifies how monetary shock affects the effect of intervention affects the exchange rates (Choi & Limnios, 2022; Adler & Mano, 2021; Dua & Suri, 2018; Hoshikawa, 2017). Because for South Africa, monetary policy conduit is more focused on the interest rate, I examine the efficacy of intervention on the exchange rate, through an integrated interaction with the interest rate. The objectives of this study are twofold. The first step is to test the impact of the intervention on both the exchange rate and the interest rate. To do this, integrative interaction based on the vector autoregression specification is analyzed. The second finds how the exchange rate and interest rate react to intervention shocks, and as such the dynamic system is diagnosed for the impulse response and forecast error variance decomposition. The finding shows robust macroeconomic evidence that intervention affects the fluctuation exchange rate. According to the specification, a positive intervention leads to a depreciation of the exchange rate and a fall in the interest rate. The result implies stabilizing the exchange rate (rand), monetary policy, and conduct of future intervention by the SARB. The paper's remainder is organized to include sections 2, 3, 4, and 5, for literature, methodology, results, and conclusions, respectively.

2. Literature Review

The ultimate objectives of interventions include stabilizing undulated exchange rate volatility and sometimes, increasing reserve. Literature dichotomizes intervention into two depending on whether its implementation has implications for current monetary policy and the instruments. In this context, the intervention is sterilized, when the effect leaves no short-run growth on the money supply (Adler & Mano, 2021; Omojolaibi & Gbadebo, 2014; Neely, 2009; Kim, 2003). Otherwise, it is an unsterilized (non-sterilized) intervention, which happens when the effect creates expansionary or contractionary impacts on the monetary base (Ponomarenko, 2019; Benes, Berg et al., 2013). The unsterilized intervention could apply as a (unconventional) monetary policy for inflation targeting and to smoothen exchange rate swings (Cho & Limnios, 2022; Heintz & Ndikumana, 2011; Kamil, 2008).

Intervention theories propose the portfolio balance and signaling mediums as channels in which interventions affect exchange rates. Portfolio balance models argue that in the presence of incomplete markets, if the domestic and foreign assets are imperfect substitutes, then intervention can affect the exchange rate (Montoro & Ortiz, 2023; Dominguez & Frankel, 1993; Branson & Henderson, 1985). The intervention is sterilized, and it causes growth in the relative supply of domestic assets, drives risk premia up, and causes the exchange rate to depreciate (Choi & Limnios, 2022; Ponomarenko, 2019; Gabaix & Maggiori, 2015). The signaling channel discloses that sterilized intervention affects the exchange rate by releasing information about monetary policy intention. The channel suggests that the central bank backs intervention with the expected change in policy since any change in the expected interest rate would impact the exchange rate (Montoro & Ortiz, 2023; Fatum, 2015; Gosh, 1992).

Numerous researchers have conducted studies concerning the efficiency, intervention, and effectiveness of interventions. These studies depend on the portfolio balance or signaling channels as support to assess empirical data. The conclusions from available studies on the effectiveness of interventions in mitigating exchange rate volatility are mixed. Authors have revealed that intervention is effective in undoing the volatility of the exchange rates and leads to reducing the volatility of the exchange rates (Viziniuc, 2021; Rishad et al., 2021; Akdogan, 2020; Adler et al., 2019; Viola et al., 2019; Dua & Suri, 2018; Hoshikawa, 2017; Fatum, 2015; Omojolaibi & Gbadebo, 2014; Moura, Pereira & Attuy, 2013; Vargas, González & Rodríguez, 2013; Hisali, 2007; Baillie & Osterberg, 1997). Baillie & Osterberg (1997) note that although the Fed's purchase of the US dollar is correlated with the USD depreciation, the intervention has no direct impact on the exchange rate. Hisali (2012) argues that seasonal forces are the causes of the movement in short-term exchange rates, and finds that intervention reduces the likelihood of the exchange rate process remaining in a state space with disruption. Vargas et al. (2013) show that supply money volatility is higher under a more efficient allocation with intervention than under a regime without intervention.

Hoshikawa (2017) studies the rebounds in the exchange rate after intervention and finds that when intervention is effective, the rebound is the next day. Moreover, the external transaction adds to the money growth despite the sterilization that thrived in stabilizing interest rates. Viola et al. (2019) examined the effects of the intervention on exchange rate volatility in Brazil and found different impacts along the distribution of exchange rate volatility. Akdogan (2020) evaluates the response of central banks to the volatility of exchange rates in advanced and emerging economies and finds that central banks respond more to exchange rate appreciation. Viziniuc (2021) argues that in an open economy where intervention is made through reserve, it dampens exchange rate volatility when currency mismatch is high. However, intervention creates winners and losers when the volatility is due to domestic developments. Moura et al. (2013) found that interventions in Mexico and Brazil were only effective for a short period.

Several studies investigated the potential impact of the intervention on the exchange rate, including works by (Montoro & Ortiz, 2023; Fatum, 2015; Behera, Narasimhan, & Murty, 2008; Bhaumik & Mukhopadhyay, 2000; Dominguez & Frankel, 1993). According to Adler et al. (2019), forex purchases and sales have a symmetric and persistent effect on the exchange rate, providing robust evidence of the significant impact of an intervention. Shulgin (2018) observed that central bank interventions have an asymmetric effect on the exchange rate of Ruble in Russia. Kubo (2017) verified the efficacy of the intervention in Thailand and showed that the reserve is the key determinant of exchange rate movement, and that intervention affects the inflation via the exchange rate. Lahura and Vega (2013) examine the asymmetric behavior of forex interventions for the Central Reserve Bank of Peru during 2009 and 2011 and find that interventions through selling the dollar are more effective than interventions via purchase.

Almudhaf (2014) examined the weak form efficiency hypothesis for selected countries, including South Africa, and found efficiency evidence for the rand. Anjaly (2022) and Diniz-Maganini et al. (2023) analyze the forex market efficiency of BRICS countries. Anjaly (2022) observed that reserve banks deter appreciation rather than depreciation and find asymmetric intervention. South Africa's intervention was found to significantly increase exchange rate volatility, whereas Brazil's intervention was found to be insignificant, to control market volatility. Diniz-Maganini et al. (2023) find substantial differences in countries' efficiency, with South Africa shown to be the most efficient.

3. Methodology

3.1. Methods

To analyze the relationship between intervention interest rates and the rand-dollar exchange rate in the SA system, a dynamic system that accommodates multi-policy shock, multi-variables, and multi-equations was constructed using VAR/VECM. The model captures the dynamic interdependencies present in the data using a minimal set of restrictions (Canova & Ciccarelli, 2013). Shock identification can then transform these reduced-form models into structural ones, allowing typical exercises, such as impulse response analyses or policy counterfactuals to be constructed in a straightforward way (Canova & Pina, 2005; Canova & Perez-Forero, 2015).

A pre-test unit testing uses the Augmented-Dickey-Fuller (ADF) test to establish the stochastic characterization for three variables. A generic process is assumed for the variable by ADF:

$$y_t = a_0 + \varphi y_{t-1} + \sum_{i=1}^{p-1} \delta_i \Delta y_{t-i} + \Omega_t;\ i = 1,2,\ldots,p-1 \quad (1)$$

$\delta_i = -\sum_{j=i+1}^{p-1} \varphi_j$, and a_0, Ω_t and are the respective drift, white noise, and lag length. The ADF test statistic is:

$$\tau_\mu = \hat{\varphi}_T - 1/se(\hat{\varphi}_T) \quad (2)$$

Where $se(\hat{\varphi}_T) = \hat{\varphi}_T'$'s standard error, and τ_μ is compared with the ADF critical value (τ_a). The test is performed with the null of non-stationarity ($H_0: \varphi = 1$) and alternative ($H_1: \varphi > 1$). The test identifies the series as *I(0)*, for stationarity at level or as $I(d$, order of integration), for d-differenced stationarity. The procedure must select the optimal lag (p) to obtain a parsimonious parameterization of the cointegration, and white noises model. f y_t's are confirmed integrated [e.g., $I(1)$], the study applies the Johansen cointegration (Hamilton, 2020). The VAR model is useful for the study because it allows multi-policy shock, multi-variables, and multi-equations (i.e., policy reaction functions) for the system's variables within the same framework. The Johansen test is used to establish the existence of cointegration. The test requires that if at least vector $\boldsymbol{y}_t = (y_{1t}, y_{2t}, \cdots, x_{nt})'$ in the system is $I(d)$ and $\Delta \mathbf{y}_t$ is $I(0)$, then any linear combination of the elements of $\mathbf{y}_t$ in (1), such as $\boldsymbol{w}_t = \boldsymbol{\alpha}'\mathbf{y}_t$, where matrix $\boldsymbol{\alpha}\ (n \times r\ ) = [\alpha_1, \alpha_2, ., \alpha,]$ will be $I(0)$.

$$\Delta \mathbf{y}_t = \sum_{i=1}^{k-1} \boldsymbol{D}_i \Delta \mathbf{y}_{t-i} + \boldsymbol{\pi} \mathbf{y}_{t-k} + \boldsymbol{e}_t \quad (3)$$

The test verifies rank (r) of the cointegrating space of matrix $\boldsymbol{\pi} = \boldsymbol{\gamma}\boldsymbol{\alpha}'[\alpha$ and $\boldsymbol{\gamma}$ are $n \times r]$, where Vector $\boldsymbol{\pi}\mathbf{y}_{t-k}$ contains $I(0)$ and $I(1)$. If there exist vectors $\boldsymbol{\alpha}_i$, such that $\boldsymbol{w}_t = \boldsymbol{a}_i'\mathbf{y}_t \sim I(0)\ [i = 1,2, \ldots, r]$, then the components of $\mathbf{y}_t$ are co-integrated (Hamilton, 2020). The Trace statistic (η_r) used to determine the rank, where $\lambda_{i+1}, \ldots, \lambda_n$ are $n + r$ smallest squared canonical correlations between y_{t+k} ($k = 1, 2, \ldots, n$) and y_t is:

$$\eta_r = T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \quad (4)$$

The VAR, with the $VAR(p)$-process, holds set of K endogenous variables $y_t = (y_{1t}, \ldots, y_{kt}, \ldots, y_{Kt})$, to examine the interconnectedness.

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \quad (5)$$

Where, A_i ($i = 1, \ldots, p$) represent ($K \times K$) coefficient matrices, u_t is a K-dimensional process. The VAR(p)-process has empirical features of 'stability' analyzed by the eigenvalues of A of the VAR(p) compact moving average (MA) form (6).

$$\xi_t = A\xi_{t-1} + v_t \qquad [\xi_{t(KP\times 1)}, A_{(KP\times 1)}, v_{t(KP\times 1)}] \quad (6)$$

$$\xi_{t(KP\times1)} = \begin{bmatrix} y_t \\ \vdots \\ y_{t-p+1} \end{bmatrix}, A_{(KP\times1)} = \begin{bmatrix} A_1 & A_1 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{bmatrix}, v_{t(KP\times1)} = \begin{bmatrix} u_t \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

If the variables are cointegrated, the empirical process procedure becomes appropriate to depict the VECM. VECM reveals the long- and short-term dynamics of the relationship. Based on Pfaff (2006), (6) is transformed (7) to show the cumulative 'long-run' impacts.

$$\triangle y_t = \alpha\beta^T y_{t-p} + \Gamma_1 \triangle y_{t-1} + \cdots + \Gamma_{p-1} y_{t-p+1} + \boldsymbol{u}_t \quad (7)$$

Where $\Pi = \alpha\beta^T = -(I - A_1 - \cdots - A_p)$, $\Gamma_i = -(I - A_1 - \cdots - A_i)$, $i = 1, \ldots, p-1$, Γ_i enclose the cumulative 'long-run' impacts, and $\Pi = \alpha\beta^T$ is of reduced rank (r). α and β has dimensions ($K \times r$). α is loading matrix, while estimates of the long-run equilibrium are loaded in β.

The impulse response function (IRF) and forecast error variance decomposition (FEVD) diagnose the system dynamics based on the Wolds moving average (MA) representation:

$$y_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \cdots \tag{8}$$

with $\Phi_0 = I_K$ and Φ_s computed recursively using, $\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j$ (for $s = 1,2, \dots$,), whereby $A_j = 0$ for $j > p$. The forecasts for horizons $h \geq 1$ of the $VAR(p)$-process is recursively generated from:

$$y_{T+h|T} = A_1 y_{T+h-1|T} + \cdots + A_p y_{T+h-p|T}, \tag{9}$$

Where, $y_{T+j|T} = y_{T+j}$ for $j \leq 0$. The forecast error covariance matrix is:

$$Cov\left(\begin{bmatrix} y_{T+1} - y_{T+1|T} \\ y_{T+h} - y_{T+h|T} \end{bmatrix}\right) = \begin{bmatrix} I & 0 & \cdots & 0 \\ \Phi_1 & I & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \Phi_{h-1} & \Phi_{h-2} & \cdots & I \end{bmatrix}$$

$$(\Sigma_u \otimes I_h) \begin{bmatrix} I & 0 & \cdots & 0 \\ \Phi_1 & I & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \Phi_{h-1} & \Phi_{h-2} & \cdots & I \end{bmatrix}$$

Kronecker operator ($\otimes$) and matrices Φ_i are the coefficient matrices of the Wold MA decomposition.

3.2. Data & Variables

The data period is 1975 to 2020 and was sourced from the World Bank databased. In deciding the variable inclusion for the study, a major problem encounter is how to measure intervention. Central banks are always hesitant to release intervention information and when they do the data comes with lag (Gosh, 1992). Because intervention causes reserves volatility, some studies recommend to use change in reserves as proxy (Miyajima, 2014; Miyajima & Montoro, 2013; Calvo & Reinhart, 2001; Almekinders & Eijffinge, 2000). The variable retains stationarity information, and needs no data transformation or log-normalization with known limitations (Hudson & Gregoriou, 2010). The specific reserve includes gold (current USD). The SARB has been accumulating reserves largely for self-insurance, recognizing the necessity to lessen external vulnerability. The SA gross reserves stood about USD 51 billion in 2018, but has since increased by about 14 percent to the approximately USD 57 billion in 2022. The reserve bank still aims to continues the accumulation because the estimated adequacy level has not reached the level the authority deems as sufficient. The other variables for the paper include the period average of the official rand price of dollar exchange rate (USD/ZAR) and the lending interest rate (percent).

3.3. Model

To analyze the dynamic relations amongst intervention, interest rates and the rand's exchange rate, in a unified framework the empirical VAR model is: In equation (10), the

$$\begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} RESG_t \\ INTR_t \\ EXRT_t \end{bmatrix} \begin{bmatrix} e_{RESG} \\ e_{INTR} \\ e_{EXRT} \end{bmatrix} = H \begin{bmatrix} RESG_t \\ INTR_t \\ EXRT_t \end{bmatrix} + \begin{bmatrix} e_{RESG} \\ e_{INTR} \\ e_{EXRT} \end{bmatrix} \tag{10}$$

structural disturbances (e_{EXCH}, e_{GRES}, and e_{INTR}) representing shocks in exchange rate, change in reserve growth and the interest rate. The first equation is the reserve model, which is a simple version of those finds in some studies. The second equation is the interest rate model and tends to confirm if the intervention affects the interest rate (monetary policy), and by implication determines sterilization. The third equation is exchange rate model which includes interest rate, a monetary variable recognized in monetary business cycle. Figure 1– 4 depict the time-series plots for considered variables. The plots identify, at least visibly, that the reserve growth is non-trended, interest rate may be trended and the rand is drifted, since the 1970s. A pre- estimation was conducted to establish the stationarity and stochastic properties of the variable included in the autoregressive specification used to established the stabilization and sterilization objectives.

Figure (1 – 4): Time Series Plots of Considered Variables.

Panel A **Panel B**

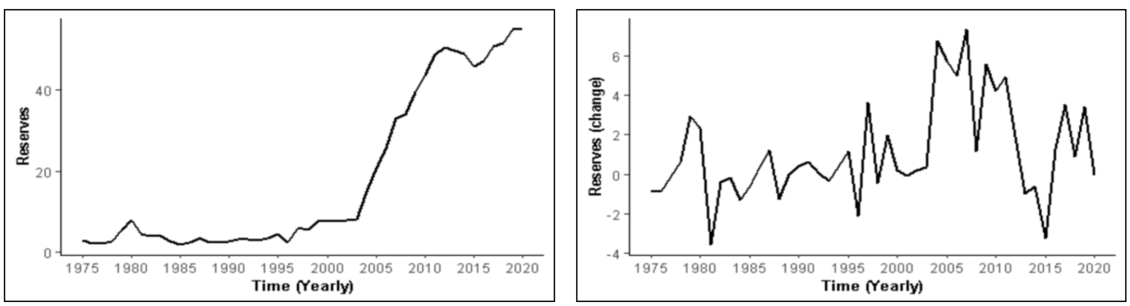

Figure.1. Reserves panel A) and reserve change (panel B)
Source: Author's own elaboration

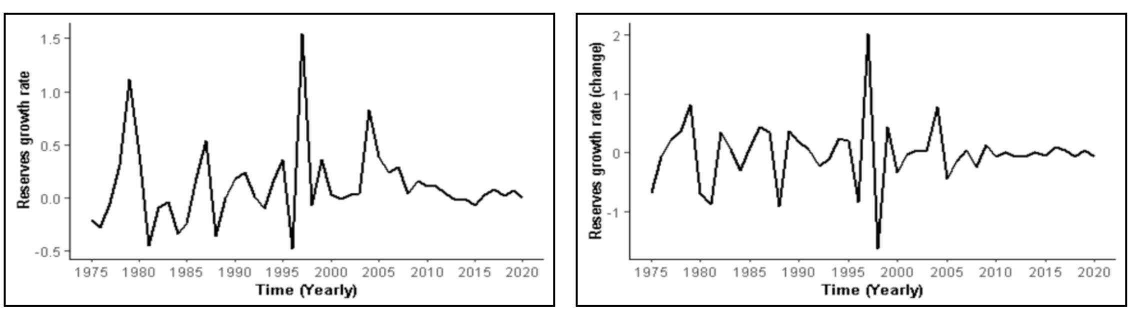

Figure.2. Reserves growth (panel A) and reserve growth change (panel B) in percent
Source: Author's own elaboration

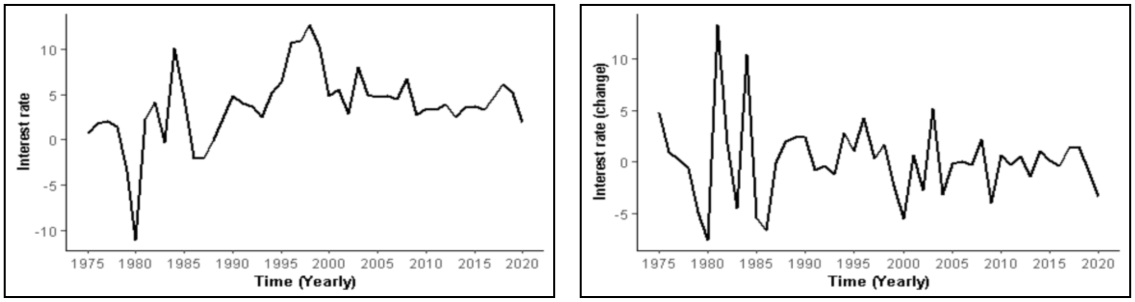

Figure.3. Interest rate (panel A) and interest rate change (panel B) in percent
Source: Author's own elaboration

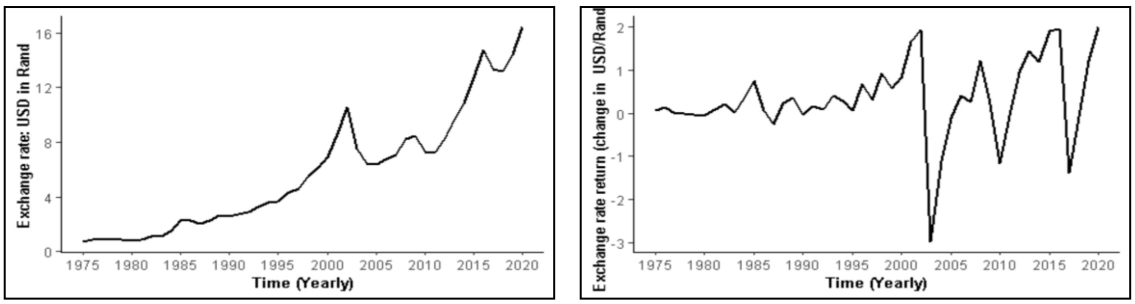

Figure.4. Exchange rate USD (panel A) and Exchange rate change Rand (panel B)
Source: Author's own elaboration

4. Results and Discussions

4.1. Pre-Estimation

Table 1 reports the pre-estimation details. The data identify positive relationship amongst considered variables. The correlation between interest rate and exchange rate (0.256) is higher and significant, since both are consistent targets of conventional monetary policy. With the correlation, intervention relates to contained information, and may drive interest rate and the rand. Specific intervention shocks may control for the trended rand and non-stationary episodes of the interest rate. The tests implemented at levels fail to reject the null of non-stationarity for exchange rate and interest rate ($\tau_\mu < \tau_\alpha$), but reject the null for change in reserve growth ($\tau_\mu > \tau_\alpha$). The change in reserve growth is level-stationary, i.e., I(0), whilst the interest rate is trend stationary and rand's exchange rate is differenced stationary, i.e., ($I(1)$). However, interest rate is differenced to be used in the integrated form for the autoregressive system. Table 2 reports the estimation completed for the optimal lag of the system. The key lag selector (HQ, AIC and SC) unanimously involves optimality at lag 2 for parsimonious parameterization of the cointegration. The Johansen test reported in Table 3 identifies that Trace statistic is not significant (p-value=95percent) at the cointegration rank of 6. Thus, the system supposes 6 co-integrating combinations (r = 6), at which the Trace statistics (η_r = 1.869) is much lower than the respective critical value (5.481). Since cointegrating ranks exist amongst the intervention, interest rates and rand, the VECM depicted system interdependence for an integrative interaction is suitable.

Table.1. Basic Statistics and Unit Root Test

Panel A: Basic Information

	Statistical Descriptions					Correlation		
y_t	μ	σ	$\tilde{\mu}_3$	$\tilde{\mu}_4$	JB	$RESG_t$	$INTR_t$	$EXRT_t$
$RESG_t$	-0.010	0.534	0.442	7.470	39.792	1	0.010	0.007
$INTR_t$	3.770	4.004	-0.732	6.067	22.129		1	**0.256**
$EXRT_t$	5.770	4.411	0.708	2.523	4.280			1

Panel B: ADF stationarity test

	Level			Difference			
y_t	τ_μ	C.V.(τ_a).	Lag	τ_μ	C.V.(τ_a).	Lag	Remarks
$RESG_t$	-11.749	-3.585	2	-7.599	-3.597	2	*I(0)*
$INTR_t$	-3.533	-3.585	2	-7.981	-3.589	1	*I(1)*
$EXRT_t$*	-2.205	-4.181	3	-5.020	-3.592	1	*I(1)*

Note: The Bold figure displays significance based on the probability $p|t| = 0$, and it indicates significance at 1percent, 5percent or 10percent.

***Implies the test is conducted with trend and intercept. For others, only the intercept is considered as indicated by plots. $\mu \equiv$ mean of the pooled data y_i, $\sigma \equiv$ Standard deviation, $\tilde{\mu}_3$ $\equiv$ Skewness and $\tilde{\mu}_4$ $\equiv$Kurtosis, JB $\equiv$Jarque-Bera**

Source: Author's own elaboration

Table.2. Optimal Lag Choice for Cointegration Parameterization

Lag	Lag Length		
Selector	**1**	**2**	**3**
AIC(n)	-15.531	-16.231*	-14.168
HQ(n)	-14.782	-15.888*	-13.258
SC(n)	-10.867	-12.825*	-10.010
FPE(n)	0.0000	0.0000	0.0000

Note: Final Prediction Error (*FPE*), Akaike Information Criterion (AIC), Schwarz Criterion (SC) and Hannan Quinn (HQ) Criterion.
*** Selected lag. The selector, HQ, AIC and SC, supposes lag 2 as optimal.**

Source: Author's own elaboration

Table.3. Unrestricted Cointegration Rank (Trace) Test

Hypothesized No. of CE(s)	Eigen Value	Trace Statistic	Critical Value (5percent)	P-Value
None *	8.568	316.662	46.231	0.000
At most 1 *	6. 859	114.620	40.077	0.000
At most 2 *	5.688	57.231	33.876	0.000
At most 3 *	4.864	37.731	27.584	0.001
At most 4 *	3.381	23.519	21.131	0.022
At most 5 *	2.042	17.031	14.264	0.018
At most 6	0. 812	1.869	5.481	0.625

Note:*denotes rejection of the hypothesis at the 0.05 level. The test use lag 2, and implements linear trend.

Source: Author's own elaboration

4.2. Integrative Dynamics

Table 4 reports the estimate parameters for the model. The report is used to consider the study's first objective, which tends to access how intervention affects the exchange rate and interest rate in the autoregressive specification. The dynamic system shows a number of significant interactions. For instance, the exchange rate equation ($DEXCH_t$) identifies positive significant coefficient for the change in reserve growth ($GRESG_{t-1}$), which supposes that intervention causes depreciation, and indication that intervention has significant contemporaneous effect on the exchange rate. The intervention by SARB, although aimed at building the international reserve, has cause increase the depreciation of the rand. The intervention had no significant contemporaneous effect on the exchange rate. With respect to the second lag, the joint test shows small economic magnitude (0.0095). The coefficient of interest rate ($DINTR_{t-1}$) is negative and would cause exchange rate appreciation. This implies that monetary policy causes appreciation pressure. Any increase in the interest rate offers domestic lenders higher returns, and this creates increase in capital flow and leads the exchange rate to appreciate. The evidence is consistent with prior studies (Galati, Melick & Mini, 2005), including research on intervention on the G3 exchange rates (Fatum & Hutchison, 2005).

The interest rate equation ($DINTR_t$) shows that intervention has a negative impact on the interest rate, although the effect was not significant. The joint significant test of both the one and two lag periods of the change in reserve growth is not significant, hence, no cumulative effect on interest rates exists. This is a signal for sterilization of the intervention because the intervention does not affect the interest rate, hence, monetary stock is unaffected (Omojoliabi & Gbadebo, 2014).

The evidence shows that SARB's intervention influence exchange rate but does not significantly affect the interest rate. More inference is made regarding the stabilization of intervention (exchange rate policy) and the sterilization of intervention (monetary policy). The exchange rate equation addresses the stabilization issue, whether intervention dampens the exchange rate fluctuations. Since the combined impact of the two intervention lags identify cumulative effect, albeit weak, the evidence supports the stabilization issue. The intervention, funded with monetary growth and debt issuance (SARB, 2019) drives short run exchange rate stabilization. The interest rate equation addresses the sterilization issue and its implication for monetary policy. The evidence supports that intervention by SARB has no significant effects on interest rates and by implication on money supply growth. Though a clear implication may not be possible, by comparing the impact of intervention shocks and the interest rate policy shocks in the impulse response, the study infers the effects to some extent (Kim, 2003). Thus, the intervention is perceived sterilized. The sterilized intervention shocks have significant effects on the rand's exchange rate.

Table.4. VECM estimation

Error Correction	$DRESG_t$	$DINTR_t$	$DEXRT_t$
Const.	8.0922 (0.2151)	-5.6243 (0.0016)	16.8215 (0.0174)
$DRESG_{t-1}$	-1.0085 (0.1369)	-0.0061 (0.1425)	0.0522 (0.0098)
$DRESG_{t-2}$	-0.9261 (0.0138)	-0.0052 (0.2043)	0.0095 (0.1040)
$DINTR_{t-1}$	0.6338 (0.4802)	0.0595 (0.1524)	-0.2352 (0.0423)
$DINTR_{t-2}$	-0.2727 (1.8183)	0.9157 (0.5676)	-0.3213 (0.0001)
$DEXRT_{t-1}$	0.6091 (0.5524)	-0.2267 (0.1725)	0.0786 (0.1611)
$DEXRT_{t-2}$	0.1614 (0.1570)	0.4971 (0.7220)	0.6873 (1.5583)
ECM_{t-1}	-0.0821 (0.0015)	-0.2953 (0.0014)	-0.1639 (0.0846)
$\bar{R}^2$	0.2276	0.3432	0.6845
F-stat.	2.8773	4.3313	1.4398

Source: Author's own elaboration

4.3. Shocks and Reactions

The second study objective – that seeks to demonstrate how shocks in intervention, exchange rate and interest rate perform in an integrative interaction – is examined. I examine the dynamic analysis of intervention, exchange rate and interest rate and Figure 5–7 present the dynamic impulse responses of each variable in the autoregressive specification. The plots depict the responses of the exogenous variables to corresponding shock up to tenth year. The solid lines in the graphs give point estimates, while the broken lines give one standard deviation (99 percent probability) bands.

Figure 5 shows responses of exogenous variables to the exchange rate shocks. for the intervention proxies, the foreign asset and reserves were initially sustained in responses to exchange rate shocks, but foreign asset gradual increase after the sixth innovations, while the reserve dropped after the eight-year. The money supply initially rises above the mean up to the second period, but maintain gradual fall till the sixth year. The evidence infers that 100 percent shocks on the exchange rate creates an initial increase (depreciation) impulse response for the exchange rate of around 10 percent, and the innovation was sustained for a short period but dropped after the sixth innovations. The exchange rate shocks cause initial decrease (increase) in reserve growth (interest rate) impulse response. After the second periods, the shock at 100 percent indicates a positive response for intervention up to the tenth year. The interest rate response remains low even p to the tenth year after the innovation. Figure 6 (Figure 7) shows responses of exogenous variables to the interest rate (intervention) shocks. In response to (expansionary) conventional monetary policy shocks, the rand depreciate and the depreciation gradually but remains above the zero line. However, intervention decrease initial upon the interest rate innovation, but would later rise after the second year and remains stable till the tenth. In response to intervention policy, the evidence shows that exchange rate falls initially but begins to settle after the second year. The interest rate initially falls upon the innovation but begin to rise after the second year, but later return to the initially point before the shock, indicating that the policy may be sterilized.

Table 5 presents the orthogonalized FEVD. Notably, the variables are key factor that determines own error variances over time. The decomposition of the rand shows that it's driven by self, and, by the reserve growth (intervention). The contribution of intervention to the decomposition of the exchange rate is larger than those of the monetary policy via interest rate, suggesting the need for the SARB to put intervention effects into consideration in conduct of monetary policy. The evidence identifies higher contribution of the intervention (4 percent – 7 percent) compared to the interest rate (less than 1percent) to the decomposed exchange rate variance. Reserves growth change contributes around 4-12 percent to the decomposed interest rate variance, while the exchange rate contributes higher (20 percent and 26 percent).

Figure 5-7: Response of the system to the different exogenous variables shocks

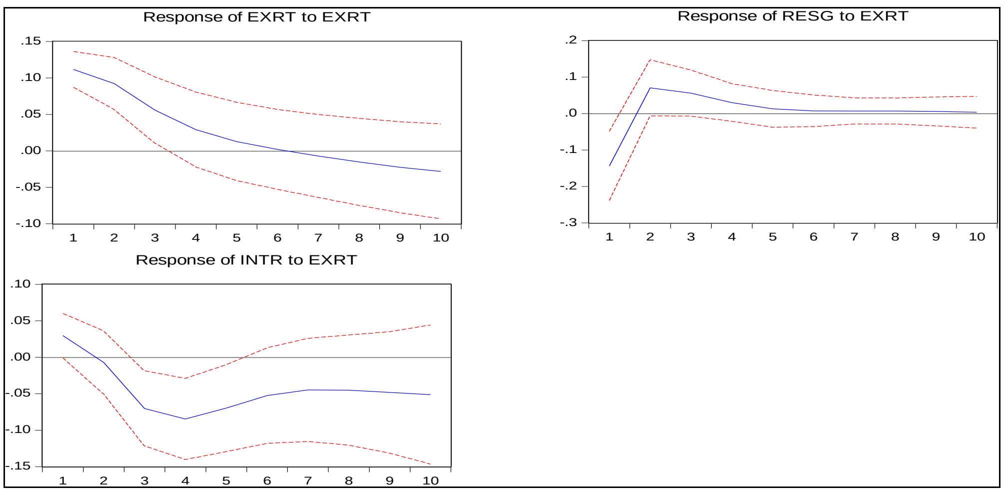

Figure.5. Response of exogenous variables to exchange rate shocks
Source: Author's own elaboration

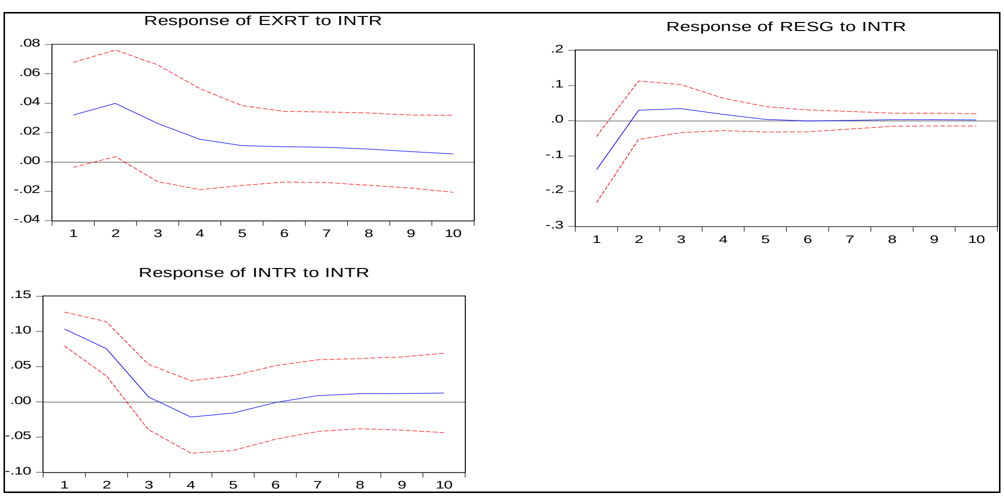

Figure.6. Response of exogenous variables to interest rate shocks
Source: Author's own elaboration

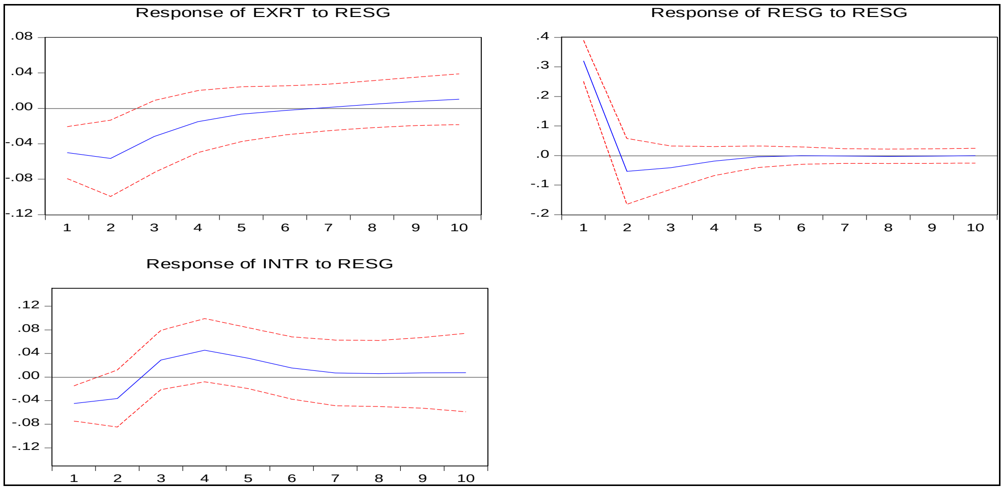

Figure.7. Response of exogenous variables to intervention shocks
Source: Author's own elaboration

Table.5.Orthogonalized Forecast Error Variance Decomposition

Year	S.E.	e_{RESG}	e_{INTR}	e_{EXRT}
Decom* of $RESG_t$				
1	0.3206	77.309	0.0000	28.190
2	0.3305	73.348	0.0713	28.410
3	0.3361	71.212	0.1980	29.756
4	0.3381	70.455	0.2126	33.644
5	0.3385	70.272	0.2131	39.138
6	0.3387	70.210	0.2155	40.544
7	0.3388	70.154	0.2153	40.610
8	0.3389	70.095	0.2172	40.396
9	0.3391	70.040	0.2204	40.179
10	0.3392	69.993	0.2226	39.905
Decom of $INTR_t$				
1	0.1034	9.0621	73.394	20.099
2	0.1450	12.603	49.198	23.433
3	0.1722	8.9625	35.401	25.406
4	0.1968	7.4800	27.131	25.898
5	0.2137	6.5031	22.997	25.972
6	0.2257	5.8365	20.791	25.991
7	0.2363	5.3837	19.303	26.011
8	0.2473	4.9782	17.967	26.028
9	0.2594	4.5738	16.665	26.032
10	0.2727	4.1875	15.438	26.024
Decom of $EXRT_t$				
1	0.1115	4.0261	0.0000	100.00
2	0.1471	4.3191	0.0767	96.722
3	0.1598	4.3371	0.0908	94.113
4	0.1645	5.2734	0.0986	92.007
5	0.1668	5.2389	0.1411	90.086
6	0.1687	6.2120	0.2651	88.062

7	0.1710	6.8149	0.4663	85.871
8	0.1741	6.8415	0.6922	83.652
9	0.1780	6.9583	0.8994	81.564
10	0.1829	6.0347	0.8731	79.660

Note: *Decom: means decomposition

Source: Author's own elaboration

5. Conclusion

Literature holds that interventions is effective in stabilizing exchange rate, and if not sterilized affects the interest rate, and cause severe growth in money supply. When this happens, intervention depicts a pseudo and unconventional monetary policy that drive the exchange rate or mitigate its undulations. Central banks are often committed to intervention in forex market in order to moderate the magnitude and pace of the domestic currency fluctuations.

Although the SARB intervention in the foreign exchange market to growth the reserve has achieved success, but the implication for exchange rate stabilization and sterilization remains a subject of contention and requires empirical scrutiny. According to the signal channel of transmission, that supposes the central bank backs intervention with expected change in policy since any change in expected interest rate would impact the exchange rate (Montoro & Ortiz, 2023; Fatum, 2015; Gosh, 1992), the paper investigates how intervention affects the exchange rate by releasing information about monetary policy.

The paper depicts a dynamic interaction amongst intervention, interest rate and the exchange rate of the SA rand in an integrated autoregressive framework. The evidence shows that intervention influence exchange rate but does not significantly affect the interest rate. This supposes that intervention drives exchange rate stabilization in the short run. In addition, the evidence supports that SARB 's intervention has no significant effects on interest rate and by implication on money supply growth. The intervention is perceived sterilized, but has significant effects on the rand's exchange rate.

Author Contributions

Adedeji Daniel Gbadebo perform conceptualization, formal analysis, data analysis, and response to reviewers' comments.

Funding

The authors received no external research grant or fund.

Conflicts of Interest

The authors declare no conflicts of interest.

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