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# Determinants of the ZAR/USD exchange rate and policy implications: A simultaneous-equation model

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**Abstract:** This paper examines the determinants of the South African rand/US dollar (ZAR/USD) exchange rate based on demand and supply analysis. Applying the EGARCH method, the paper finds that the ZAR/USD exchange rate is positively associated with the South African government bond yield, US real GDP, the US stock price and the South African inflation rate and negatively influenced by the 10-year US government bond yield, South African real GDP, the South African stock price, and the US inflation rate. The adoption of a free floating exchange rate regime has reduced the value of the rand vs. the US dollar.

**Subjects: International Finance; Macroeconomics; Monetary Economics**

**Keywords: exchange rates; interest rates; real GDP; stock prices; EGARCH**

**JEL classifications: F31; F41**

## 1. Introduction

Multinational corporations, exporters, importers, and investors are concerned about exchange rate movements. A stronger domestic currency helps imports, hurts exports, and reduces overseas asset values measured in the domestic currency. A weaker domestic currency helps exports, hurts imports, and increases overseas asset values measured in the domestic currency. A substantial depreciation of the domestic currency is expected to cause high inflation, increase international capital outflows, reduce foreign investments, and destabilize an economy.

The South African rand/US dollar (ZAR/USD) exchange rate (units of the rand per US dollar) has been more volatile than many other currencies. During the Asian currency crisis, the South African rand was affected and had depreciated as much as 41.5% from 4.53 rand per US dollar in 1997.M6 to 6.41 in 1998.M8. In the recent global financial crisis, the South African rand had depreciated as much as 39.15% against the US dollar from 7.33 in 2008.M7 to 10.20 in 2009.M1, but it had

## ABOUT THE AUTHORS

Yu Hsing's research areas are in international economics, macroeconomics, economic development, and other related subjects. His recent publications include the J-curve hypothesis, effects of real exchange rate depreciation on aggregate output, exchange rate determination based on demand and supply analysis, comparison of the fundamental and monetary models of exchange rate determination, etc. This paper is part of his research activities studying exchange rate determination.

## PUBLIC INTEREST STATEMENT

The value of the South African rand vs. the US dollar rises with a higher US interest rate, South African output, South African stock price, or US inflation rate and declines with a higher South African interest rate, US output, US stock price, or South African inflation rate. Hence, to protect the value of the South African rand from depreciation, the government needs to reduce the interest rate, increase output, maintain a healthy stock market, and reduce the inflation rate. The adoption of a free floating exchange rate regime since February 2000 has reduced the value of the rand vs. the US dollar.

recovered most of the losses in the next few years. However, as of 4 December 2015, the South African rand had lost 24.3% of its value against the US dollar this year and ended at 14.3668.

This paper attempts to examine determinants of the ZAR/USD exchange rate based on a simultaneous-equation model. The choice of the South African rand/US dollar exchange rate as a case study is mainly because the rand has been more volatile than many other currencies and because South Africa has pursued a free floating exchange rate regime (Mtonga, 2011, pp. 2–3; Potgieter, 2005, p. 105), which provides an ideal condition for the exchange rate to be determined by market demand and supply.

## 2. Literature survey

There have been several recent studies examining the determinants of exchange rates for South Africa. Applying the efficient market hypothesis and using a daily sample during June 2001–June 2004, Fedderke and Flamand (2005) examine macroeconomic news surprises on the ZAR/USD exchange rate. Surprises originating from the US are significant whereas surprises from South Africa prove to be insignificant. Good news has a greater impact than bad news.

Potgieter (2005) presents several major findings based on a sample during 1990.Q1–2005.Q2. In the long run, a 1% increase in GDP per capita will lead to a 3.7% appreciation of the rand. If the real gold price rises 1%, the rand will appreciate about 1%. When gross reserves of the SARB increases 1%, the rand will appreciate 0.7%. There is a negative trend. In the short run, except for the dummy variables, these effects are insignificant. The actual exchange rate fluctuates around and is very close to the long-term equilibrium exchange rate, suggesting that it is positive for economic growth, stable inflation, and low unemployment.

Based on a sample during 1984–2006, Frankel (2007) examines the real exchange rate for South Africa. The lagged dependent variable is positive and highly significant. A higher mineral and metal price increases the value of rand vs. the US dollar. A higher real interest rate differential between South Africa and the US makes the rand stronger. A dummy variable was used to represent the liberalization of the capital market in South Africa since 1995.Q2. The interactive dummy variable with the real interest rate differential reduces the slope.

Applying time series techniques and using a quarterly sample during 1986.Q1–2005.Q4, Raputsoane and Todani (2008) compare different versions of the monetary model of the rand/dollar exchange rate. There is a long-term relationship between the rand/dollar exchange rate, the interest rate, the income, and the money differentials. Rising commodity prices and current account balance as a percent of GDP cause the rand to depreciate. A higher inflation differential leads to an appreciation of the rand, which is in contrast with the theory.

Using a monthly data during 1997–2008, Grandes, Peter, and Pinaud (2010) examine the currency premium for the South African rand vs. the US dollar. They find that the currency premium is determined by the long-term expected inflation differential, risk aversion, and exchange rate volatility. The results are robust and stable when different sample periods are used.

Mtonga (2011) shows that the trade-weighted rand exchange rate has a positive relationship with the relative money supply, the short-term interest rate differential and a negative relationship with the relative real income and the long-term interest rate differential. The impact of the inflation rate differential or the current account balance may be positive, negative or insignificant depending upon model specifications and sample periods. He concludes that monetary policy regime change to inflation targeting has a significant impact on the currency value.

Égert (2012) studies the rand exchange rate by adding openness to the stock-flow approach, share prices, and country risk premium to variants of the monetary model. The results improve the

fitness of the models during large rand depreciations in 2002 and 2008. Large depreciations cannot be explained by real commodity prices. However, out-of-sample forecasts are poor.

Using a sample during 1988–2007, Gossel and Biekpe (2012) investigate whether the relationship between the rand/dollar exchange rate and several independent variables may have changed due to financial market liberalization in 1995. Before liberalization, the interest rate differential, equity and bond purchases by non-residents, the gold dollar price and political risk were statistically significant. After liberalization, only the interest rate differential and net purchases of stock shares by non-residents were statistically significant.

Based on an annual sample during 1910–2010 and applying time series techniques, De Bruyn, Gupta, and Stander (2013) analyze whether the monetary model of exchange rate determination may apply to South Africa. According to their findings, evidence supporting the monetary model is mixed, and theoretical restrictions specified by the monetary model can be rejected. Although the monetary model exhibits relatively low predictive and explanatory power over the short run, the monetary model outperforms the random walk model in the out-of-sample forecast.

To the author's best knowledge, few of the previous studies have examined the ZAR/USD exchange rate based on demand and supply analysis. Monetary models of exchange rate determination (Bilson, 1978; Dornbusch, 1976; Frankel, 1979; Frenkel, 1976) are based on the validity of purchasing power parity in the long run and may not hold in the short run. The assumption of the same coefficient for the money supply, income, interest rate, or inflation rate differential may need to be tested.

## 3. The model

We can express the demand for and supply of the US dollar vs. the South African rand in the foreign exchange market as:

$$D = W\underset{-}{(\varepsilon}, \underset{?}{Y^{SA}}, \underset{?}{R^{US}}, \underset{+}{S^{US}}, \underset{-}{\pi^{US}}) \tag{1}$$

$$S = X\underset{+}{(\varepsilon}, \underset{?}{Y^{US}}, \underset{?}{R^{SA}}, \underset{+}{S^{SA}}, \underset{-}{\pi^{SA}}) \tag{2}$$

where

$D$ = demand for the US dollar,

$S$ = supply of the US dollar,

$\varepsilon$ = the ZAR/USD (South African rand/US dollar) exchange rate measured as units of the rand per US dollar,

$Y^{US}$ = US real GDP,

$R^{US}$ = the real interest rate in the US,

$S^{US}$ = the real stock price in the US,

$Y^{SA}$ = real GDP in South Africa,

$R^{SA}$ = the real interest rate in South Africa,

$S^{SA}$ = the real stock price in South Africa,

$\pi^{US}$ = the inflation rate in the US, and

$\pi^{SA}$ = the inflation rate in South Africa.

We expect that the demand for the US dollar has a negative relationship with the ZAR/USD exchange rate and the US inflation rate and a positive relationship with the stock price in the US. The

supply of the US dollar is expected to be positively associated with the ZAR/USD exchange rate and the stock price in South Africa and negatively influenced by the South African inflation rate.

A higher US real GDP would increase US imports from South Africa and the supply of the US dollar and reduce the ZAR/USD exchange rate. However, if the increase in US real GDP involves an increase in import–substitute goods, US imports from South Africa may decline. Monetary models of exchange rates suggest that a higher real GDP would increase the demand for money, raise the US interest rate, attract capital inflows, and increase the ZAR/USD exchange rate. Hence, the sign of $Y^{US}$ is unclear. This analysis applies to a change in real GDP in South Africa.

According to the traditional view, a higher interest rate in the US tends to attract South African people to invest in US financial assets and to increase the demand for the US dollar and the ZAR/USD exchange rate. However, according to the revisionist view, a higher US interest rate may reduce the demand for the US dollar and cause the US dollar to depreciate due to a higher default probability, a weaker financial position, and a higher exchange rate risk premium (Dekle, Hsiao, & Wang, 2002; Huang, Hueng, & Yau, 2010). This analysis applies to a change in the interest rate in South Africa.

Solving for the equilibrium values of the two endogenous variables simultaneously, we can express the equilibrium exchange rate as a function of all the exogenous variables in Equation (3). According to comparative static analysis, the sign beneath an exogenous variable shows the impact of a change in the exogenous variable on the equilibrium ZAR/USD exchange rate.

$$\bar{e} = \bar{e}\,(R^{SA},\ R^{US},\ Y^{SA},\ Y^{US},\ S^{SA},\ S^{US},\ \pi^{SA},\ \pi^{US}) \qquad (3)$$
$$\quad ?\quad ?\quad ?\quad ?\quad -\quad +\quad +\quad -$$

To test whether the adoption of a free floating exchange rate system may have caused any shift in the intercept in Equation (3), a dummy variable with a value of one during 2000.Q1–2014.Q2 and a value of zero otherwise is added to the estimated regression.

## 4. Empirical results

The data were collected from IMF's *International Financial Statistics*. The ZAR/USD exchange rate measures units of the South African rand per US dollar. Hence, an increase means a depreciation of the South African rand and an appreciation of the US dollar. The interest rate in the US is represented by the 10-year US government bond yield. The interest rate in South Africa is represented by the South African government bond yield. Real GDP in the US is measured in billions at the 2009 price, and real GDP in South Africa is measured in billions at the 2005 price. The stock price in the US or South Africa is represented by the share price index with 2005 as the base year. Except for the government bond yields and the inflation rates, other variables are transformed to the log scale to avoid a potential multicollinearity problem.

The sample consists of quarterly data ranging from 1983.Q1 to 2014.Q2 and has a total of 126 observations. The selection of 1983.Q1 as the beginning period is because South Africa pursued a managed or free float exchange rate regime, allows the exchange rate to be determined by market demand and supply. Currently, the rand is classified as independently floating. However, the Reserve Bank of South Africa reserves the right to intervene in the foreign exchange market to avoid excessive fluctuations of the South Africa rand.

The DF-GLS test on the regression residuals is employed to determine whether these time series variables in Equation (3) are cointegrated. The value of the test statistic is estimated to be −4.4609, which is greater than the critical value of −2.5837 in absolute values at the 1% level. Therefore, these variables have a long-term stable relationship.

Table 1 reports the estimated regression and related statistics. The EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedasticity) method is applied in empirical work. The

**Table 1. Estimated regression of the ZAR/USD exchange rate**

| Dependent variable: log(the ZAR/USD exchange rate) | Coefficient | *z*-Statistic |
|---|---|---|
| Constant | −12.8664 | −98.6946 |
| South African government bond yield | 0.0402 | 21.9875 |
| US government bond yield | −0.0259 | −13.4566 |
| Log(South African real GDP) | −0.5764 | −11.1956 |
| Log(US real GDP) | 2.3425 | 23.6503 |
| Log(South African stock price) | −0.0600 | −5.4706 |
| Log(US stock price) | 0.1217 | 6.4190 |
| South African inflation rate | 0.0023 | 3.0908 |
| US inflation rate | −0.0291 | −11.7559 |
| Dummy variable | 0.2010 | 20.0969 |
| $R^2$ | 0.9580 | |
| Sample period | 1983.Q1–2014.Q2 | |
| Sample size | 126 | |
| Root mean squared error | 0.9440 | |
| Methodology | EGARCH | |

Notes: The ZAR/USD exchange rate refers to the units of the South African rand per US dollar.
All the coefficients are significant at the 1% level.

EGARCH model has several advantages. There is no restriction on the parameters. The conditional variance is a multiplicative function of lagged error terms. Volatility can react to the bad and good news asymmetrically. As shown, approximately 95.80% of the change in the equilibrium ZAR/USD exchange rate can be explained by the nine right-hand side variables. All the coefficients are significant at the 1% level. The equilibrium ZAR/USD exchange rate is positively associated with the South African government bond yield, US real GDP, the US stock price, the South African inflation rate, and the dummy variable representing a free floating exchange rate regime since February 2000. It is negatively affected by the 10-year US government bond yield, South African real GDP, the South African stock price, and the US inflation rate.

Specifically, a one percentage-point increase in the 10-year US government bond yield would reduce the log of the ZAR/USD exchange rate by 0.0259 whereas a one percentage-point increase in the South African government bond yield would raise the log of the ZAR/USD exchange rate by 0.0402. According to the Wald test, the null hypothesis that the coefficients of the 10-year US government bond yield and the South African government bond yield are the same in absolute values can be rejected at the 1% level.

A one unit increase in the log of US real GDP would raise the log of the ZAR/USD exchange rate by 2.3425 whereas a one unit increase in the log of South African real GDP would reduce the log of the ZAR/USD exchange rate by 0.5764. According to the Wald test, the null hypothesis that the coefficients for the log of US real GDP and the log of South African real GDP in absolute values are the same can be rejected at the 1% level.

A one unit increase in the log of the US stock price would increase the log of the ZAR/USD exchange rate by 0.1217 whereas a one unit increase in the log of the South African stock price would reduce the log of the ZAR/USD exchange rate by 0.0600. The null hypothesis that the coefficients of the US stock price and the South African stock price in absolute values are the same can be rejected at the 1% level.

The positive significant sign of the South African inflation rate suggests that a higher inflation rate would cause the rand to depreciate. The negative significant coefficient of the US inflation rate implies that a higher inflation rate would cause the US dollar to depreciate. The impact of a higher US inflation rate is much greater than that of a higher South African inflation rate in absolute values. The null hypothesis that the coefficients of the US inflation rate and the South African inflation rate in absolute values are the same can be rejected at the 1% level.

## 5. Summary and conclusions

This paper has examined the determinants of the ZAR/USD exchange rate based on a simultaneous-equation model consisting of the demand for and supply of the US dollar vs. the South African rand. A reduced-form equation is estimated by the EGARCH method. The paper finds that a higher South African government bond yield, US real GDP, US stock price or South African inflation rate would raise the ZAR/USD exchange rate whereas a higher 10-year US government bond yield, South African real GDP, South African stock price or US inflation rate would reduce the ZAR/USD exchange rate. The free floating exchange rate regime adopted since February 2000 has caused the rand to depreciate vs. the US dollar.

There are several policy implications. Demand and supply analysis appears to apply to the study of the ZAR/USD exchange rate because it can explain approximately 95.80% of exchange rate movements. Interest rates, real GDP, stock prices, and inflation rates in the US and South Africa play significant roles in exchange rate movements. Holding other factors constant, the recent decline of the 10-year US government bond yield would cause the rand to depreciate where the recent decline of the South African government bond yield would cause the rand to appreciate. The rising trends of real GDP in the US and South Africa would have the opposite impacts on the exchange rate though the effect of an increased US real GDP is much larger than that of an increased South African real GDP. Although plunging stock prices in South Africa during the global financial crisis had depreciated the rand significantly, the rapidly rising stock prices in South Africa after the global financial crisis have caused the rand to appreciate. A higher inflation rate in South Africa is expected to result in a weaker rand. The use of the differential form for the interest rate, real GDP, the stock price or the inflation rate between two countries may need to be tested in advance because the null hypothesis that the two coefficients in absolute values are the same which can be rejected.

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