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# Exchange rate risk and sovereign debt risk in South Africa: A Regime Dependent Approach

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**Abstract**

We provide novel evidence of the regime specific effect of exchange rate risk on sovereign debt risk in South Africa. Using monthly data from 2008 to 2021 through a Markov regime switching model with time varying probabilities for the transitions, our results show that exchange rate risk matters in determining movements in sovereign debt risk as measured by sovereign credit default swaps (CDS). The results suggest that exchange rate risk exacts a positive and significant impact on sovereign debt risk in both the high risk regime and low risk regime. However, we notice that the magnitude of the impact differs from one regime to the other, implying that sovereign debt risk responds differently to exchange rate risk bull and bear markets

**Keywords:** Sovereign debt, Exchange rate, Markov Regime Switching Model, credit default swaps

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## 1. Introduction

Although the South African economy has exhibited average annual growth of less than 2 percent over past decades, it is an upper-middle-income economy, ranked as the most important emerging economy in Africa, the only country on the continent to be ranked in the top 15 worldwide, and a key entryway to Sub-Saharan markets. Despite this, South Africa has experienced bounteous economic structural changes partly due to embracing a rather non-interventionist policy stance in the foreign exchange rate market (Takaendesa, Tsheole & Aziakpono 2006) — the currency was allowed to float. Unsurprisingly, the South African currency has undergone more persistent depreciation after allowing its currency to float. For example, the Rand lost half its value towards the end of 2003 partly as a result of high inflation (Makatjane & van Wyk 2020).

Like many other emerging economies (EME), South Africa has also experienced appreciation against major currencies (such as US Dollar, British Pound, Canadian Dollar and Australian Dollar to name a few), which in turn facilitated international investment in local currency bonds for South Africa. These trends "… seemed to be a break with the past, when EME local currency bonds had not been able to attract much foreign investment because of fears that EME currencies were inherently unstable or could easily weaken in case sentiment in global markets turned against EMEs." Needless to say, that South Africa's need for a strong and reliable local currency bond markets that can deliver a fairly stable source of funding in context of freely floating exchange rates can't be taken for granted and calls for an investigation of the effect exchange rate on South Africa's sovereign debt risk.

A sovereign's ability to meet its debt obligations is an imperative contributor to both financial stability and sustained economic growth. The European Union sovereign debt crisis showcased how sovereign credit risk can propagate from one country to another with devastating effects for the real economy. Thus, a clear understanding of the drivers of sovereign debt risk is of paramount importance. Moreover, the choice of instrument to use in measuring sovereign debt risk is very crucial as it helps in accurately determining the possibilities that a country might default on its debt. To this end, we use sovereign credit default swaps (CDS) to quantify sovereign credit risk. CDS are financial derivatives whose premiums show the cost of insuring against default. According to Longstaff et al, (2013), CDS are a direct quantifier of credit default risk and are not distorted by unrelated risk such as liquidity dry ups.

Within the South African context, rising sovereign debt in the period leading to and during the COVID-19 pandemic has generated renewed perception to the possibility of a sovereign debt crisis (Hesse and Miyajima, 2022). Hesse and Miyajima (2022) highlights the importance of managing sovereign debt risk as the risk can propagate shocks from government deficits and debt to interest rates, negatively affecting bank balance sheets. Even more concerning and a threat to financial stability is the increasing correlation between sovereign credit risk and bank credit risk. Hence, examining the drivers of sovereign credit risk in South Africa will go a long way in assisting policy makers and regulators in their attempt to managing and reducing sovereign debt risk.

Amongst the several important drivers of sovereign debt risk is exchange rates. Exchange rates are fundamental to the complex debt evolution of current international finance (Frieden, 2015). Changes in exchange rates have the ability to create sovereign debt crises. Historic evidence shows that massive devaluations and depreciations have caused sovereign debt crisis as debtors are left bankrupt by a depreciation/devaluation which increases the real cost of foreign currency liabilities. Some examples include Mexico's 'tequila crisis' of 1994, the 1997-

98 Asian currency crisis. The exposure of sovereign debt to currency movements has the potential to hamstring macro-economic objectives and national policy.

In assessing the effect of exchange rate risk on sovereign debt risk we follow an approach similar to that of BIS (2016) which links nominal effective exchange rate and sovereign debt risk. Our study departs from their work in a number of ways. Firstly, we adopt the Markov Regime Switching model to allow for the possibility of regime changes so as to accurately capture the true behavior of real-world data than standard models and to endogenise the structural breaks. Moreover, the regime dependent model will allow us to depart from existing literature by allowing us to isolate bearish and bullish markets. Secondly, our study also conducted a series of robustness checks, including estimating the Markov Regime Switching model with time varying probabilities and a quantile regression model for sovereign debt risk spreads. Quantile regression allows us to formalise the entire conditional distribution of sovereign debt risk and to explain the impact of exchange rate risk and other explanatory variables under different market conditions. By so doing, we extend the previous work by of BIS (2016) and thus provide additional evidence on the the relationship between exchange rate risk and sovereign debt risk.

The rest of this paper is structured as follows: Section 2 provides a brief overview of links exchange rate risk and sovereign debt risk. Section 3 describes empirical methodology and the data used in this paper while empirical analysis and results are presented in Section 4. Conclusions and policy implications are provided in the last section.

## 2. Literature Review

While a growing body of literature has examined the determinants of sovereign debt risk, thus far only a few studies have been examined the effect that exchange rate risk might have on sovereign debt risk in the developing regions (or emerging markets), and no studies have studied the effect on sovereign debt risk in South Africa. However, a number of studies have identified determinants of on sovereign debt risk (see Gonzalez-Rozada and Levy-Yeyati 2008); Longstaff et al 2011; Chuffart, E Hooper, 2019; Baldacci and Kumar 2010; Jaramillo and Weber (2013a, 2013b); and Peiris 2010; Stolbov (2017; Afonso,Arghyrou and Kontonikas , 2012; Laeven and Valencia 2013; Piljak 2013; Gale and Orszag 2003 and Miyajima et al 2014).
Grigoryeva (2021) investigated the various determinants (comprising of global—average of the CDS spreads and national factors--implied volatility of the rouble exchange rate and the size of foreign exchange reserves to GDP) of Russia’s sovereign risk. Using autoregressive distributed lag (ARDL) model and a cross-validation algorithm, the results show the size of foreign exchange reserves and relative to GDP reduces sovereign risk, while implied volatility of the rouble is positively related to CDS.

Chuffart, E Hooper,(2019) using data for Russia and Venezuela covering 2008 to 2015 and a Time Varying Transition Probabilities Markov Switching model, find that the crude oil price and its volatility are critical determinants of sovereign credit default swaps. Through the application of a GARCH Copula-CoVaR model, Jun et al (2020) investigated the behavior of sovereign CDS spreads under extreme oil price movements G7 and BRICS countries and found that first that ‘the upside/downside CoVaR values of sovereign CDS spreads are very different from VaR values in the sample of countries under study. They also found that impact of extreme oil returns on oil importers vary from one country to another based on the economic stability of each country.

Naifar, *et al* (2020) adopt various econometric approaches (quantile regression analysis, the rolling quantile regression, and finally, the Quantile-on-quantile) to capture the influence of different credit market conditions on CDS in oil-rich countries of the Gulf Cooperation Council (GCC) and other important oil-exporting countries. They found that oil price returns reduces sovereign credit risk premium for non-GCC oil-exporting countries under study, while an unnoticeable effect on the sovereign credit risk premium is observed for Saudi Arabia, UAE and Norway.

Augustin and Tedongap (2016) looked at various factors that influence Sovereign Credit Risk in 38 sovereign countries, over the period May 9th, 2003, until August 19th, 2010, using a probit specification model. They found evidence to suggest that "growth and consumption volatility in the U.S. contain information to account for 75% of the variation of the first two principal components in the term structure of CDS spreads". Reaching a somewhat similar conclusion Pan and Singleton 2008 for Mexico, Turkey, and Korea, found that CDS in these countries is captured by first main component. Similarly, following Pan and Singleton (2008), Longstaff et al. (2011), use the model to sovereign CDS prices and estimate the model via maximum likelihood for 26 developed and less-developed countries. They find that CDS is once again captured by the first component (which explains 64 percent of the variation) during the 2000–2010 sample period. Interestingly, the authors also found that using a different sample period (i.e., from 2007–2010 crisis period) increases the value to 75 percent.

Other important factors such as global monetary conditions, (usually proxied by US short or long term interest rates), have been acknowledged by extant literature (Gonzalez-Rozada and Levy-Yeyati (2008), Hartelius et al (2008), Dailami et al (2008) and Miyajima et al (2014). More recent work argued that the low term premia on US Treasuries has strong influence on offshore US dollar credit creation (McCauley, McGuire and Sushko (2014)) or on fixed investment and financing decisions in EMEs (Turner (2014)).

From the reviewed literature, one may be tempted say that sovereign risk is indeed influenced by national and global level factors, with growth and consumption volatility producing strong predictive effect on sovereign risk among all these factors (Longstaff et al. (2011). However, from the reviewed extant literature, there are very few studies (for example, Miyajima et al (2014) and Gadanecz, et al (2014) exploring the effect of exchange rate on sovereign debt risk in developing regions. Moreover, a considerable number of studies have used a linear approach in examining the determinant of sovereign debt risk, thus neglecting the effects of changing economic dynamics and its effect on the relationship between different macroeconomic variables and sovereign debt risk. Thus, it is pertinent not only to analyse the impact of exchange rate risk on sovereign debt risk in emerging markets but also to cater for the non-linear aspect of sovereign debt risk – exchange rate risk nexus as the analysis may provide deeper insights for policymakers to derive sound policy tools. Therefore, this study intends to build upon these few studies and to contribute to existing studies in this field by investigating the impact of exchange rate on sovereign debt risk in South Africa by using the Markov regime switching approach

## 3. Methodology

In this work we employ the Markov regime switching model to examine the relationship between sovereign debt risk and exchange rate risk. Markov Regime Switching models characterize time series properties in different states of the world (regimes). In these models the regimes are determined by an unobservable state or regime variable that follows a discrete state Markov process.

### 3.1 Model Specification

The baseline model for this study with a set of control variable (identified from the literature as factors that influence sovereign debt risk) is specified as follows:

$$Y_t = f(X_t, M_t) \tag{1}$$

where $Y_t$ is represents sovereign debt risk, $X_t$ is a vector of is the exchange rate risk measures at time t and $M_t$ is the set of control variables. Equation (1) implies that sovereign debt risk is a function of exchange rate risk and a set of common factors. To measure sovereign debt risk, we use credit default swaps (CDS) as in Grigoryeva (2021). CDS are financial derivates that allow bold holders to take out insurance against default on bonds. Basically, CDS spreads reflect the cost of insurance on default with higher spreads indicating an increase in the probability of default. According to Culp et. al (2014) 5-year CDS are the most liquid in the sovereign debt market, hence in the study we chose to use 5-year sovereign CDS spreads. In our attempt to quantify exchange rate risk, we follow the study of BIS (2016) who two measures namely, nominal effective exchange rate and exchange rate volatility. Nominal effective exchange rates measure the rate with which a given currency is depreciating with higher values indicating an increase in exchange rate risk. Equation (1) can be expanded as follows:

$$Y_t = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + \alpha_3 ER_t + \alpha_4 IN_t + \alpha_5 IR_t + \alpha_6 BS_t + \alpha_7 VIX_t + \alpha_8 SV_t + \alpha_9 TS_t + \alpha_8 BR_t + \alpha_9 TED_t + \varepsilon_t \tag{2}$$

Where $X_{1t}$ is the nominal effective exchange rate, $X_{2t}$ is exchange rate volatility, $IN_t$ represents inflation at time, $ER_t$ is the return on equity markets at time t, $IR_t$ represents interest rates, $BS_t$ represents banking sector stability, $VIX_t$ represents the volatility index in the United States of America, $SV_t$ is the domestic stock market volatility and $EV_t$, $BR_t$ is the banking sector equity returns and $TED_t$ represents the TED spread at time t.

While linear models remain at the forefront of academic research, it has been found that they leave certain aspects of economic and financial timeseries unexplained. Hence, to model non-linear behavior in economic and financial timeseries it seems natural to allow for the existence of different states of the world.

### 3.2. The Markov Regime Switching Model

The present study adopts the Markov Regime Switching model to investigate the impact of exchange rate risk on sovereign debt risk along with above mentioned stated control variables. Before attempting to implement the Markov switching models, one must ensure that all the variables being used are stationary. In the Markov Switching model, unlike the Threshold Autoregressive models the regimes are determined by an unobservable parameter that follows the discrete state Markov process. Given equation (2) the Markov model can be presented in this case as follows:

$$Y_t = \mu_{s_t} + \beta_{s_t} X_t + \delta_{s_t} M_t + \varepsilon_t \quad for\ t = 1,2 \tag{3}$$

Where $Y_t$ represents sovereign debt risk, $X_t$ is the exchange rate risk, $M_t$ is the set of control variables, $\delta_{s_t}$ is the vector of switching coefficients. $\mu_{s_t}$ follows a normal distribution with mean 0 and variance $\sigma^2_{s_t}$ and $s_t$ is the hidden state variable and follows a two a regime Markov chain process. In this model we assume two states of the world (two regimes), with regime one being associated with low levels of sovereign debt risk and regime two capturing times of high sovereign debt risk.

The model switches between different regimes according to its previous value and transition probabilities. Using a two-state regime, the Markov probability of switching regime at time *t* can be formulated as follows:

$$P(S_t = j \text{ I } S_{t-1} = i) = P_{ij} \ \text{ for } i, j = 1,2 \ \ (2\ possible\ states)$$
$$\sum_{j=1}^{2} P(S_t = j \text{ I } S_{t-1} = i) = 1 \tag{4}$$

For better visualization the transition probabilities can be stacked together into a matrix as follows:

$$P = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} = \begin{bmatrix} p & 1-p \\ 1-q & q \end{bmatrix} \tag{5}$$

where $p_{11}$ is the probability of remaining in state one given that in the previous period the model was in state one and $p_{22}$ represents the probability of remaining in state 2 given that in the previous period the model was in state two. $p_{12}$ gives the probability of moving to state two given that the process was in state one in the previous period and $p_{21}$ shows the probability of moving to state one given that the process was originally in state two.

## 4. Empirical Results

### 4.1. Data Description

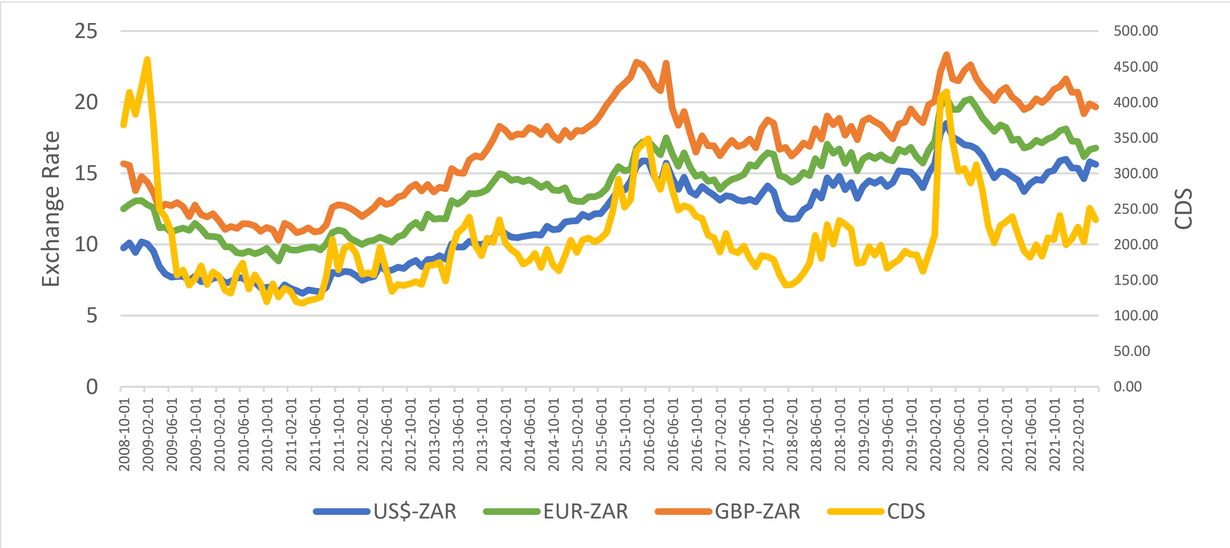
The data on variables used in the study are collected on a monthly frequency basis from October 2008 through to June 20122. Both the frequency and the length of the sample size are determined by the availability of data. We collect our data from various sources such as Thomson Reuters, South African Reserve Bank, and the St Louis Federal Reserve (FRED Database). Table 1 below presents the summary statistics for the all the variables used in the study. CDS spreads show a maximum value of 460 basis points and a minimum of 117 basis points. These two figures when compared to the leading economies in the world prove to be very high, showing that there is high likelihood of a sovereign default in South Africa compared to the leading economies. The rate of depreciation as measured by nominal effective exchange rate has an average value of 111.7 which quite high when compared to other emerging markets. This also proven by the way the South African Rand has been losing value (depreciating) against major currencies since 2008 (see Figure 1). Looking at the rest of the variables we notice that all the variables with exception of equity returns have a positive skewness value. This is not surprising as it a well know characteristic of financial assets data to have a fatter left tail.

TABLE 1: DESCRIPTIVE STATISTICS

| | Mean | Standard Deviation | Kurtosis | Skewness | Range | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| ***CDS*** | 207,126 | 65,484 | 2,701 | 1,564 | 342,706 | 117,294 | 460,000 |
| ***Nominal_Effective_Exchange_Rate*** | 111,074 | 25,066 | -0,894 | 0,668 | 90,390 | 74,300 | 164,690 |
| **Exchange_Rate_Volatility** | 0,520 | 0,141 | -0,786 | 0,233 | 0,535 | 0,283 | 0,818 |
| ***ALSI_Returns*** | 0,701 | 4,086 | 0,816 | -0,109 | 26,076 | -13,730 | 12,346 |
| ***Inflation*** | 5,275 | 1,478 | 5,647 | 1,502 | 10,000 | 2,100 | 12,100 |
| ***Interest_Rates*** | 6,143 | 1,524 | 3,040 | 0,8384 | 9,017 | 3,333 | 12,350 |
| ***Banking_Sector_Stability*** | -15,778 | 2,351 | 2,115 | -1,644 | 10,023 | -23,365 | -13,342 |
| **VIX** | 20,341 | 9,062 | 4,080 | 1,850 | 50,380 | 9,510 | 59,890 |
| ***Stock_Market_Volatility*** | 21,178 | 6,299 | 6,412 | 2,180 | 38,620 | 12,820 | 51,440 |
| ***TED_Spread*** | 0,030 | 0,235 | 10,248 | 1,912 | 1,945 | -0,525 | 1,420 |
| ***Banks_Returns*** | 0,729 | 6,651 | 9,848 | -1,553 | 60,138 | -42,328 | 17,810 |

Figure 1 provides graphical analysis of the evolution of 5-year sovereign CDS spreads together with exchange rates (South African Rand against the US Dollar, Euro Great British Pound). The graph shows the that exchange rate between the South African Rand and major currencies has moved in tandem with CDS spreads. Figure 1 shows that both the exchange rate and CDS spreads exhibit a remarkable surge in 2015 and again towards the end of 2019. These latest surge can be attributed to the Covid-19 pandemic which saw huge expenditures by the government in response to the pandemic. We notice that every time the rand has lost value the CDS spreads have increased. This is also echoed by Reinhart (2002) and Reinhart and Rogoff (2009) who claim that sovereign defaults are often associated with severe currency devaluations and heightened uncertainty about exchange rates.

FIGURE 1: SOVEREIGN RISK AND EXCHANGE RATE RISK




### 3.3. Preliminary Tests

Before employing the Markov Regime Switching model, we perform a test of linearity against non-linearity to assess if indeed the relationship between sovereign debt risk and exchange rate risk is non-linear. We accomplish this by applying the BDS test of Brock, Dechart and Scheinkman (1996), which one of the most popular non-linearity tests. The BDS test has the advantage of using a test statistic that does not require one to make any assumptions about the underlying distribution. The findings are presented in Table 2, and they reveal that the null hypothesis of a linear dependence structure should be rejected. Hence, implying that it is correct to implement a non-linear technique such as the Markov Regime Switching model.

TABLE 2: BDS TEST RESULTS

| Dimension | BDS statistic | P-value |
|---|---|---|
| 2 | 24,781 | 0,000 |
| 3 | 23,823 | 0,000 |
| 4 | 22,848 | 0,000 |
| 5 | 22,184 | 0,000 |
| 6 | 21,945 | 0,000 |

As mentioned earlier it is imperative to ensure that all variables are stationarity before employing the Markov Switching model. In this instance we apply two popular tests for stationarity in the form of the Philip-Peron (PP) test and the Augmented Dickey Fuller (ADF) test. Tables 3a and 3b provide the results and the show that while some variables are stationary at level the rest of the variables are stationary after first differencing.

## TABLE 3A: STATIONARITY TEST RESULTS: PP TEST

| | | **with constant** | | **with constant & trend** | | **without constant & trend** | |
|---|---|---|---|---|---|---|---|
| | | **t-Statsitic** | **Prob.** | **t-statistic** | **Prob.** | **t-statistic** | **Prob.** |
| | LCDS | -3,418 | ***0,012*** | -3,751 | 0,022 | -0,462 | ***0,514*** |
| | Nominal effective exchange rate | -0,712 | ***0,840*** | -2,446 | 0,355 | -0,839 | ***0,351*** |
| | Ted Spread | -7,388 | ***0,000*** | -7,484 | 0,000 | -7,414 | ***0,000*** |
| | inflation | -4,903 | ***0,000*** | -4,197 | 0,006 | -2,087 | ***0,036*** |
| | interest rate | -4,160 | ***0,001*** | -3,787 | 0,020 | -2,307 | ***0,021*** |
| **At Level** | banking sector stability | -2,244 | ***0,192*** | -2,541 | 0,308 | 0,264 | ***0,588*** |
| | banks index returns | -13,254 | ***0,000*** | -13,236 | 0,000 | -13,157 | ***0,000*** |
| | VIX | -5,413 | ***0,000*** | -5,246 | 0,000 | -2,496 | ***0,013*** |
| | exchange rate volatility | -0,660 | ***0,852*** | -3,449 | 0,049 | 0,454 | ***0,812*** |
| | Alsi returns | -14,482 | ***0,000*** | -14,806 | 0,000 | -13,797 | ***0,000*** |
| | stock market volatilty | -4,273 | ***0,001*** | -3,845 | 0,017 | -1,807 | ***0,067*** |
| | d(LCDS) | -13,999 | 0,000 | -14,065 | 0,000 | -14,031 | ***0,000*** |
| | d(nominal effective exchange rate) | -9,997 | 0,000 | -9,929 | 0,000 | -9,996 | ***0,000*** |
| | d(ted spread) | -16,012 | 0,000 | -16,309 | 0,000 | -16,045 | ***0,000*** |
| | d(inflation) | -10,299 | 0,000 | -10,576 | 0,000 | -10,294 | ***0,000*** |
| **First Difference** | d(interest rates) | -6,783 | 0,000 | -7,133 | 0,000 | -6,659 | ***0,000*** |
| | d(banking sector stability) | -13,383 | 0,000 | -13,384 | 0,000 | -13,428 | ***0,000*** |
| | d(bank index returns) | -92,492 | 0,000 | -92,860 | 0,000 | -91,086 | ***0,000*** |
| | d(VIX) | -18,155 | 0,000 | -20,788 | 0,000 | -18,054 | ***0,000*** |
| | d(exchange rate volatility) | -12,132 | 0,000 | -12,132 | 0,000 | -12,064 | ***0,000*** |
| | d(Alsi returns) | -108,895 | 0,000 | -113,279 | 0,000 | -101,102 | ***0,000*** |
| | d(stock market volatility) | -12,816 | 0,000 | -13,124 | 0,000 | -12,802 | ***0,000*** |

## TABLE 3B: STATIONARITY TEST: ADF TEST

| | | *with constant* | | *with constant & trend* | | *without constant & trend* | |
|---|---|---|---|---|---|---|---|
| | | *t-statistic* | *Prob.* | *t-statistic* | *Prob.* | *t-statistic* | *Prob.* |
| | *LCDS* | *-3,468* | *0,018* | *-3,825* | *0,018* | *-0,445* | *0,521* |
| | *Nominal effective exchange rate* | *-0,776* | *0,224* | *-2,737* | *0,224* | *-0,778* | *0,378* |
| | *Ted spread* | *-5,609* | *0,000* | *-5,504* | *0,000* | *-5,648* | *0,000* |
| | *Inflation* | *-4,961* | *0,002* | *-4,496* | *0,002* | *-1,862* | *0,060* |
| *At Level* | *Interest rates* | *-3,570* | *0,059* | *-3,369* | *0,059* | *-2,006* | *0,043* |
| | *banking sector stability* | *-2,318* | *0,276* | *-2,610* | *0,276* | *-0,311* | *0,572* |
| | *banks index returns* | *-13,259* | *0,000* | *-13,237* | *0,000* | *-13,159* | *0,000* |
| | *VIX* | *-5,591* | *0,000* | *-5,447* | *0,000* | *-2,332* | *0,020* |
| | *exchange rate volatility* | *-0,579* | *0,055* | *-3,400* | *0,055* | *0,491* | *0,820* |
| | *Alsi returns* | *-14,242* | *0,000* | *-14,330* | *0,000* | *-13,818* | *0,000* |
| | *stock martket volatility* | *-4,359* | *0,008* | *-4,070* | *0,008* | *-1,753* | *0,076* |
| | *d(LCDS)* | *-13,930* | *0,000* | *-13,970* | *0,000* | *-13,964* | *0,000* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | *d(nominal effective exchange rate)* | *-9,975* | *0,000* | *-9,973* | *0,000* | *-9,975* | *0,000* |
| | *d(ted spread)* | *-13,633* | *0,000* | *-13,795* | *0,000* | *-13,668* | *0,000* |
| | *d(inflation)* | *-8,487* | *0,000* | *-8,813* | *0,000* | *-8,472* | *0,000* |
| *First Difference* | *d(interest rates)* | *-6,755* | *0,000* | *-6,981* | *0,000* | *-6,669* | *0,000* |
| | *d(banking sector stability)* | *-13,289* | *0,000* | *-13,276* | *0,000* | *-13,330* | *0,000* |
| | *d(banks index returns)* | *-10,804* | *0,000* | *-10,778* | *0,000* | *-10,844* | *0,000* |
| | *d(VIX)* | *-15,363* | *0,000* | *-15,447* | *0,000* | *-15,391* | *0,000* |
| | *d(exchange rate volatility)* | *-12,058* | *0,000* | *-12,147* | *0,000* | *-12,061* | *0,000* |
| | *d(alsi returns)* | *-10,102* | *0,000* | *-9,981* | *0,000* | *-10,044* | *0,000* |
| | *d(stock market volatility* | *-12,756* | *0,000* | *-12,963* | *0,000* | *-12,752* | *0,000* |

### 3.4 Estimation Results

The impact of exchange rate risk on sovereign debt risk was analyzed by employing the Markov switching model which we limited to only two regimes. We opted for only two regimes as a result of our relatively short sample period. First, we note that the estimated coefficients for the means (P11-C and P22-C) are statistically significant for both regime 1 and regime 2. In term s of magnitude, the mean is higher in regime 2 compared to regime 1. When comparing the volatility coefficients, Table 4 shows that there is more uncertainty in regime 1 compared to regime 2. Results presented in Table 4 reveal that exchange rate risk as proxied by nominal effective exchange rate exerts a significant and positive influence on sovereign debt risk in both regime 1 and regime 2. Its impact in regime 1, the higher sovereign debt risk is almost similar in magnitude to that in the lower regime. In regime 1, a one basis point increase in the nominal effective exchange rate leads to a 14 basis points increase in CDS spreads whereas in regime 2 a similar increase in the exchange rate risk leads to a 15 basis points increase in sovereign debt risk.  This finding conforms to Liu and Morley (2012) who examine the relationship between the macroeconomic variables as represented by interest rates and the exchange rate on sovereign CDS spreads and find that there is a strong positive relation relationship between the rate of depreciation and sovereign debt risk.

More importantly, we also examine the effect of exchange rate volatility as a second quantifier for exchange rate risk and find that it has a positive and significant impact on sovereign debt risk in both regimes. The results show that a 1 percent increase in exchange rate volatility, increases sovereign debt in by 4.5 percent and 4.8 percent in regime 1 and regime 2 respectively. An implication of this is that greater uncertainty about the future path of exchange rates would prompt a rise in sovereign debt risk.

Turning to the control variables in our model, we find that inflation has an insignificant impact on sovereign debt risk in regime 1, however that changes in regime 2 with inflation having a positive and significant coefficient. This confirms that inflation plays no role in dictating the direction of CDS spreads in regime 1, whereas if inflation increases during times of low sovereign debt risk, sovereign debt tends to rise also. In particular, a one percent increase in inflation leads to a 1.2 percent increase in CDS spreads. Rising inflation would normally trigger monetary tightening (higher interest rates) which would have an impact on the sustainability of public debt. These results resemble those of Balima et al. (2017) who find that based on a sample of more than 30 countries, inflation targeting reduces sovereign debt risk.

Interest rates are found to have a significant and positive impact on sovereign debt risk in both regime 1 and regime 2. Interestingly, the magnitude of the impact of interest rate on sovereign risk differs significantly between the two regimes with a 1 percent increase in interest rates being associated with a 1.2 percent increase in CDS spreads in the regime 1. In regime 2 that number is cut by half, with a 1 percent increase in interest rates leading to only a 0.6 percent surge in CDS spreads.

TABLE 4: MARKOV REGIME SWITCHING MODEL RESULTS

| **Variable** | **Regime 1** | **Regime 2** |
|---|---|---|
| Nominal_Effective_Exchange_Rate | 0,0145*** | 0,0150*** |
| | (0,0000) | (0,0000) |
| Ted_Spread | -0,3677*** | 0,2747** |
| | (0,0000) | (0,0222) |
| Inflation | -0,0137 | 0,1255*** |
| | (0,4071) | (0,0000) |
| Interest Rates | 0,1655*** | 0,0648*** |
| | (0,0000) | (0,0075) |
| Banking_Sector_Stability | 0,0054 | 0,0106 |
| | (0,6472) | (0,6345) |
| Banks Index Returns | 0,0049* | 0,0023 |
| | (0,0806) | (0,4950) |
| VIX | 0,0069** | 0,0139*** |
| | (0,0273) | (0,0005) |
| Exchange Rate Volatility | 4,5256*** | 4,8802*** |
| | (0,0000) | (0,0000) |
| Equity Market Returns | 0,0021 | 0,0045 |
| | (0,5994) | (0,4336) |
| Stock Market Volatility | 0,0045 | 0,0032 |
| | (0,3786) | (0,6475) |
| Log (Sigma) | -2,3456*** | -1,8445*** |
| | (0,0000) | (0,0000) |
| P11-C | 3,4757*** | |
| | (0,0000) | |
| P22-C | | -3,6585*** |
| | | (0,0000) |

*Note: ***, **and * respectively shows statistical significance at 1% ,5% and 10 % level. The values in parenthesis are standard errors*

TABLE 5: TRANSITION PROBABILITIES MATRIX

| | | $S_t = 1$ | $S_t = 2$ |
|---|---|---|---|
| Mean | $S_t = 1$ | 0.9699 | 0.0300 |
| | $S_t = 2$ | 0.0251 | 0.9748 |
| | | | |

As regards to international factors, the VIX is included to capture the volatility in US equity markets. The VIX is found to have a significant and positive effect on CDS spreads, implying that as uncertainty in US markets increases, South African sovereign debt risk also increases. This is consistent with Miyajima et al. (2015) who find that prior to the global financial crisis, uncertainty in US equity markets tended to increase sovereign bond yields in emerging markets. This finding conforms to Merton's structural model and appears to be similar to the results of Naifar (2020) who document strong positive relation between the sovereign credit risk and the VIX index.

Concerning banking sector stability, banking sector returns, and stock market returns our evidence indicates that these have statistically insignificant coefficients in both regime 1 and regime 2. This finding confirms that equity market returns and level of stability in the banking sector are unable to provide valuable information in predicting South African CDS spread in both regimes

We control for perceived economic credit risk and financial stability by using the TED spread. The results show a very interesting situation. In regime 1 the TED spread coefficient is found to be statistically significant with a negative sign while in regime 2 it is still significant albeit with a negative sign. This shows that the effect of economic credit risk on sovereign debt risk has an inflexion point where the effect changes from negative to positive and these results appear to be similar to those of Naifar (2020) who document that the TED spread has an asymmetrical impact on CDS spreads depending on whether the market is bullish or bearish.

A look at the duration in different regimes, we find that there is strong persistence with the probability of remaining in regime 1 and regime 2 being 96.9 percent and 97.4 percent respectively. The corresponding expected durations are 33.3 and 39.8 in regime and regime 2 respectively. The smoothed probabilities graph presented in figure 2 confirms that there is strong persistence in both regimes. The PACF graphs presented in figure 3 and shows that there is little to no autocorrelation remaining in the residuals which indicates that the Markov switching model of order 2 estimated in this scenario is a good fit. The diagnostic based on residuals show that the normal distribution is a good fit for the data as shown by the QQ plots. The plots show that there are only a few discrepancies at the tails of the distribution, which is expected of financial time series data.

FIGURE 2: SMOOTHED PROBABILITIES

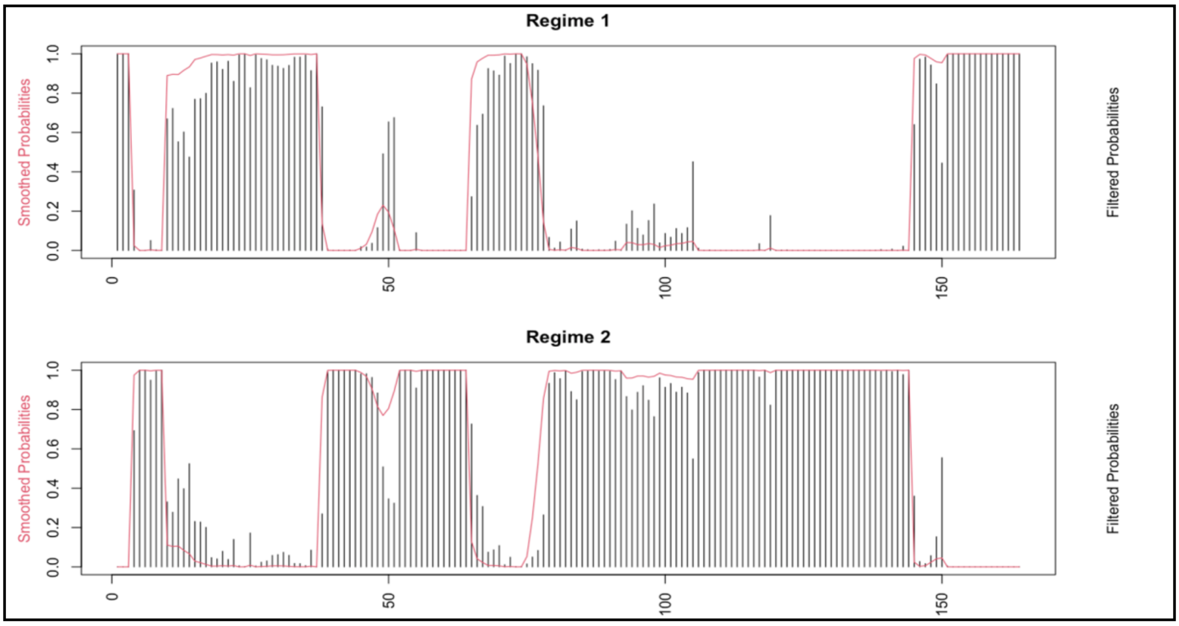
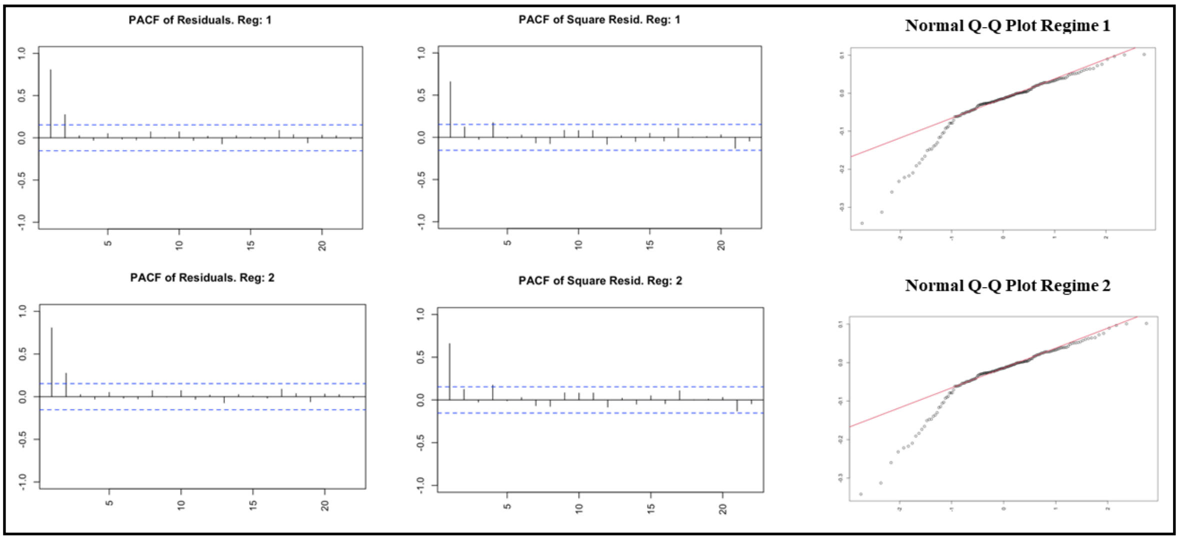



FIGURE 3: POST ESTIMATION DIAGNOSTICS




To check the validity of our results, we conducted a series of robustness checks, including estimating the Markov Switching model with time varying probabilities and a quantile regression model for sovereign CDS spreads. The Markov switching model with time varying parameters is presented in Table 6 and the results are mainly consistent with those obtained in the baseline model. The two measures for exchange rate are found to be statistically significant with similar signs (signs) as in the model presented in Table 4.

TABLE 6: MARKOV REGIME SWITCHING WITH TIME VARYING PROBABILITIES

| Variable | Regime 1 | Regime 2 |
|---|---|---|
| Nominal Effective Exchange Rate | 0,0145*** | 0,0150*** |
| | (0,0000) | (0,0000) |
| Ted Spread | -0,3677*** | 0,2747*** |
| | (0,0000) | (0,0222) |
| Inflation | -0,0137** | 0,1255 |
| | (0,4071) | (0,0000) |
| Interest Rates | 0,1655** | 0,0648*** |
| | (0,0000) | (0,0075) |
| Banking Sector Stability | 0,0054*** | 0,0106*** |
| | (0,6472) | (0,6345) |
| Banks Index Returns | 0,0049 | 0,0023** |
| | (0,0806) | (0,4950) |
| VIX | 0,0069 | 0,0139 |
| | (0,0273) | (0,0005) |
| Exchange Rate Volatility | 4,5256*** | 4,8802*** |
| | (0,0000) | (0,0000) |
| Equity Market Returns | 0,0021 | 0,0045 |
| | (0,5994) | (0,4336) |
| Stock Market Volatility | 0,0045** | 0,0032 |
| | (0,3786) | (0,6475) |
| Log(Sigma) | -2,3456*** | -1,8445*** |
| | (0,0000) | (0,0000) |
| P11-C | 3,4757*** | |
| | (0,0000) | |
| P22-C | | -3,6585*** |
| | | (0,0000) |

*Note: ***, **and * respectively shows statistical significance at 1% ,5% and 10 % level. The values in parenthesis are standard errors*

The summary statistics for the time varying transition probabilities are provided in Table 7. We notice that the average probability for remaining in regime 1 is 91 percent which is quite similar to the corresponding constant probability shown in Table 5. The average probability of staying in the regime 2, given that regime the model was in regime 2 in the previous period is 88 percent compared to 97 percent obtained in the model with constant transition probabilities.

TABLE 7: TRANSITION PROBABILITIES MATRIX

| | | $S_t = 1$ | $S_t = 2$ |
|---|---|---|---|
| Mean | $S_t = 1$ | 0.913314 | 0.086686 |
| | $S_t = 2$ | 0.120636 | 0.879364 |
| | | | |
| | | $S_t = 1$ | $S_t = 2$ |

| | | | |
|---|---|---|---|
| Std. Dev. | $S_t = 1$ | 0.067760 | 0.067760 |
| | $S_t = 2$ | 0.134147 | 0.134147 |
| | | | |

Naifar (2020) predicts that changes in economic variables have asymmetrical effects on CDS spreads. To capture the asymmetric impact of country-specific financial variables and global uncertainty factors on CDS spreads, we also apply quantile regression model introduced by Koenker and Bassett (1978). We estimate the quantile regression model of the sovereign CDS spreads states for six quantiles (0.025, 0.05, 0.10, 0.90, 0.95, 0.975) adding the different control variables one at a time. We find that as we change quantiles and use different control variables the relationship between sovereign debt risk and exchange rate risk also changes. In the first part we only use the measures of exchange rate risk, and we find that both the nominal effective exchange rate and exchange rate volatility are significant, and a surge is either of the variables causes CDS spreads to increase at higher quantiles whereas as the relationship is negative for nominal effective exchange rate at lower quantiles. When we begin adding control variables, we notice a few changes with exchange risk as measured by nominal effective exchange rate's sign changing from negative to positive at lower quantiles regression in some cases and being completely insignificant. The results from the quantile which show how results change at different quantiles re-affirm the existence of a non – linear relationship that exists between sovereign debt risk and exchange rate risk. This highlights the importance of distinguishing the relationship between sovereign debt risk and exchange rate risk during bearish and bullish market times.

TABLE 8: QUANTILE REGRESSION RESULTS

| | Q(0,025) | Q(0,05) | Q(0,10) | Q(0,90) | Q(0,95) | Q(0,975) |
|---|---|---|---|---|---|---|
| Intercept | 2,0315*** | 2,1067*** | 2,2281*** | 1,8124*** | 1,0474** | 0,7851** |
| | (0,1050) | (0,1430) | (0,1350) | (0,3540) | (0,4280) | 0,3890 |
| Nominal Effective Exchange Rate | -0,0004 | -0,0008 | -0,0014** | 0,0009 | 0,0051** | 0,0065*** |
| | (0,0010) | (0,0010) | (0,0010) | (0,0020) | (0,0020) | (0,0020) |
| Exchange Rate Volatility | 0,3733*** | 0,3349*** | 0,2438** | 0,9963*** | 1,7122*** | 1,9992*** |
| | (0,0910) | (0,1250) | (0,1200) | (0,2910) | (0,3560) | (0,3200) |
| Intercept | 2,1558*** | 2,1887*** | 2,3626*** | 1,8129*** | 1,4930*** | 1,1587*** |
| | (0,1370) | (0,1460) | (0,1340) | (0,2590) | (0,3790) | (0,3570) |
| Nominal Effective Exchange Rate | 0,0012* | 0,0013* | -0,0021*** | 0,0007 | 0,0032 | 0,0045** |
| | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0020) | (0,0020) |
| Exchange Rate Volatility | 0,3029** | 0,2774** | 0,1506 | 0,9820*** | 1,1928*** | 1,6352*** |
| | (0,1280) | (0,1380) | (0,1260) | (0,2240) | (0,3040) | (0,2930) |
| TED Spread | 0,1333*** | 0,1079*** | 0,1275*** | 0,2424*** | 0,1117 | 0,1683 |
| | (0,0170) | (0,0160 | (0,0190) | (0,0790) | (0,1430) | (0,1680) |
| Intercept | 1,9272*** | 2,0345*** | 2,0391*** | 1,6248*** | 1,1851*** | 1,4873*** |
| | (0,1030) | (0,0950) | (0,1300) | (0,2150) | (0,2720) | (0,2280) |
| Nominal Effective Exchange Rate | -0,0006 | -0,0009** | -0,0010* | 0,0006 | 0,0023 | 0,0009*** |
| | (0,0000) | (0,0000) | (0,0010) | (0,0010) | (0,0010) | (0,0010) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Exchange Rate Volatility | 0,2898*** | 0,2566*** | 0,2647** | 0,9334*** | 1,3851*** | 1,1273*** |
| | (0,0890) | (0,0890) | (0,1220) | (0,1830) | (0,2190) | (0,2010) |
| Inflation | 0,0348*** | 0,0259*** | 0,0277*** | 0,0413*** | 0,0545*** | 0,0564*** |
| | (0,0020) | (0,0020) | (0,0030) | (0,0080) | (0,0100) | (0,0110) |
| Intercept | 2,1762*** | 2,2661*** | 2,3586*** | 2,9937*** | 3,1289*** | 3,2572*** |
| | (0,1560) | (0,1570) | (0,1700) | (0,1010) | (0,1080) | (0,1040) |
| Nominal Effective Exchange Rate | -0,0022*** | -0,0031*** | -0,0037*** | -0,0065*** | -0,0075*** | -0,0081*** |
| | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) |
| Exchange Rate Volatility | 0,1686 | 0,0677 | -0,0313 | -0,4824*** | -0,6241*** | -0,7205*** |
| | (0,1480) | (0,1480) | (0,1610) | (0,0990) | (0,1060) | (0,0990) |
| Stock Market Volatility | 0,0085*** | 0,0116*** | 0,0138*** | 0,0164*** | 0,0191*** | 0,0190*** |
| | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) |
| Intercept | 1,9857*** | 1,6393*** | 1,7811*** | 1,9100*** | 1,8207*** | 2,1287*** |
| | (0,0940) | (0,1060) | (0,1230) | (0,3540) | (0,3210) | (0,3190) |
| Nominal Effective Exchange Rate | -0,0003 | 0,0009 | 0,0002 | -0,0007 | -0,0002 | -0,0024** |
| | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) | (0,0010) |
| Exchange Rate Volatility | 0,4087*** | 0,6757*** | 0,5755*** | 0,6192** | 0,6783** | 0,5158** |
| | (0,0820) | (0,0980) | (0,1060) | (0,2880) | (0,2630) | (0,2580) |
| Interest Rate | 0,0013 | 0,0167*** | 0,0176*** | 0,0431*** | 0,0472*** | 0,0563*** |
| | (0,0030) | (0,0030) | (0,0030) | (0,0120) | (0,0110) | (0,0110) |

*Note: ***, **and * respectively shows statistical significance at 1% ,5% and 10 % level. The values in parenthesis are standard errors*

## 5. Conclusion

This study analyses the regime specific relationship between sovereign debt risk and exchange rate risk in South Africa for the period 2008 – 2022. The investigation employs a two state Markov regime switching model to take into account the non-linearities that may exist in the aforementioned relationship. Using credit default swaps data to represent sovereign debt risk and nominal effective exchange rate and exchange rate volatility to represent exchange rate risk we show that exchange rate risk matters in determining movements in sovereign debt risk. The results suggest that exchange rate risk exacts a positive and significant impact on sovereign debt risk in high and low risk regimes. However, we notice that the magnitude of the impact differs from one regime to the other, implying that that sovereign debt risk responds differently to exchange rate risk in high and low sovereign debt risk regimes.

We also included some control variables, which were selected based on previous literature and these include inflation, TED spread, interest rates, VIX, banking sector stability, domestic stock market volatility, and equity returns. The impact of inflation on sovereign debt risk is found to be insignificant in regime 1, however in regime 2 it is positive and significant. Interest rates are found to have a significant and positive impact on sovereign debt risk in both regime 1 and regime 2. Banking sector stability and equity returns prove to be statistically insignificant in both regimes. Moreover, the probabilities duration in different regimes and the smoothed probabilities shows that there is strong persistence in different regimes.

From the results we obtained, we can deduce some important policy implications. The results show that exchange rate risk does indeed influence sovereign debt risk and this relationship is non-linear. Therefore, policy makers and regulators have to be aware that when they institute policies that are aimed at tackling sovereign debt risk, they have to consider the importance of exchange rate risk and be aware that the relationship between the two is not symmetric but changes with different economic environments. This study extends the understandings of the relationship between sovereign debt risk and exchange rate risk; however, this study only uses two regimes in its analysis. Thus, it would possible be insightful to extend this study by employing multiple regimes to see how the relation will change.

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