WP/16/205

IMF Working Paper

Surprise, Surprise: What Drives the Rand / U.S. Dollar Exchange Rate Volatility?

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INTERNATIONAL MONETARY FUND

 WP/16/205

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African Department and Strategy, Policy, and Review Department

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October 2016

Abstract

This paper investigates possible drivers of volatility in the South African rand since the onset of the global financial crisis. We assess the role played by local and international economic surprises, commodity price volatility, global market risk perceptions, and local political uncertainty. As a measure of rand volatility, the study uses a market-based implied volatility indicator for the rand / U.S. dollar exchange rate. Economic surprises—the difference between market expectations and data prints—are captured by Citi's Economic Surprise Index which is available for South Africa and its main economic partners. The results suggest that rand volatility is mainly driven by commodity price volatility, and global market volatility, as well as domestic political uncertainty. In addition, economic surprises originating in the United States matter, but not those originating from South Africa, Europe, or China.

JEL Classification Numbers: F31, F37, G15, G17

Keywords: Rand; volatility; macroeconomic surprises; spillovers; commodities.

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I. INTRODUCTION[1]

In a purely floating exchange rate system, currency volatility is the nature of the game. In recent years, the South African rand has been on the back foot against major currencies, with investors wary about the country's subdued growth, weak fiscal outlook, rising industrial and social tensions, and external vulnerabilities associated with the current account deficit financed largely through non-FDI inflows. In addition, economic and non-economic surprises, defined as unanticipated news—the difference between actual and expected data prints or unanticipated events; have triggered bouts of volatility, with the so-called "taper tantrum" being just one example of an external economic surprise. Domestic events like the Marikana massacre shocked markets, changing investors' perception of the country's credit risk, and triggering episodes of heightened exchange rate volatility.[2] Furthermore, commodity price volatility and global market uncertainty also caused sprouts of rand volatility (Arezki et al, 2012).

At the outbreak of the global financial crisis, the rand reached a five-year low of R11.56 against the U.S. dollar on October 22, 2008, as global liquidity dried up. The sudden depreciation was quickly reversed when the Federal Reserve loosened monetary policy. As a result, the rand appreciated for nearly three years until September 2011. From that point on, a combination of (early) signs of a recovery in the United Sates, continued problems in the euro zone, concerns over a possible slowdown in China and emerging markets, and the subsequent decline in commodity prices, coupled with an investor focus on South Africa's deteriorating fundamentals, pushed the rand to historical lows against the U.S. dollar and other major currencies (Figure 1). Neither the appreciation nor the depreciation has been smooth, and the rand zigzagged around its multi-year trend, mirroring changes in investors' risk aversion and surprises.

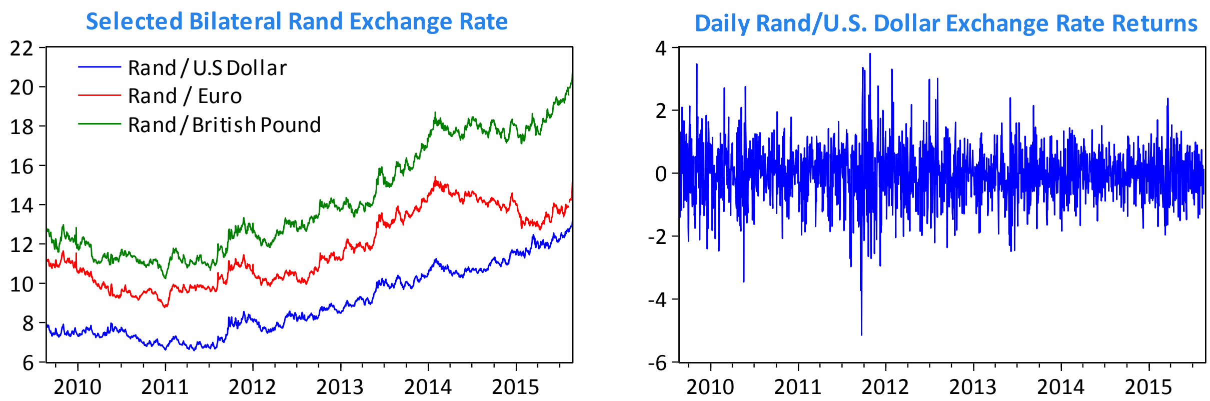
Therefore, this paper investigates the possible drivers of volatility in the South African rand / U.S. dollar exchange rate (rand volatility) since the onset of the global financial crisis. As a gauge of rand volatility, we use a market-based implied volatility indicator. First, the paper investigates the role that macroeconomic surprises play as determinants of rand volatility, using a surprise index compiled by Citi. Second, we investigate the role that commodity price volatility and global financial market risk perceptions play—both reflections of surprises in

[1] We are very grateful to Kristjan Kasikov, David Lubin, and Alexander Wolfson from Citi Bank for kindly providing the Economic Surprise Index data and for their useful comments. To Sandile Hlatshwayo and Magnus Saxegaard for allowing us to use the policy uncertainty data, to Leandro Medina, to Shakill Hassan, as well as the IMF South Africa team for their constructive comments.

[2] The Marikana massacre occurred during a strike at Lomnin in 2012, which led to the killing of 34 mineworkers, after violent clashes between striking mineworkers and the police.

key global markets. Third, we include an algorithm measure of political uncertainty in South Africa as an additional explanatory variable to gauge the effect of political uncertainty in the rand volatility.

Figure 1. Historical Trend and Daily Returns of the South African Rand, August 2009 - 2015



Source: Bloomberg and Author's calculations

The results suggest that rand volatility is mainly driven by global factors—expressed by commodity price volatility and the VIX. In addition, macroeconomic surprises originating from the United States also matter for rand volatility. On the domestic front, we find that local political uncertainty is positively associated with rand volatility. Neither domestic macroeconomic surprises nor those originating from other EMs are statistically related to rand volatility, a finding that is broadly in line with existing literature on emerging market currencies (Wong et al., 2014; Mishra et al., 2014).

The rest of this paper is organized as follows; section two gives an overview of the literature. Section three describes the data used in the paper. Section four describes our continuous time series empirical approach and discusses the results. Section five provides a sensitivity analysis performed on the continuous time series results. Section six describes our analysis in an event study framework and discusses the results. Section seven concludes.

II. LITERATURE REVIEW

The existing literature on high frequency exchange rate volatility has generally leaned on the Efficient Market Hypothesis (Fama 1970, 1991) as its basis. At its strongest level, the hypothesis contents that asset prices, at any given time, fully reflect all available and relevant information for their determination. The market usually makes prior assumptions regarding the outcome of a particular scheduled macroeconomic announcement. Thus, the set of available and relevant information should include these assumptions, and they would be reflected in the current exchange rates (e.g. Gürkaynack et al., 2005). Within this framework, exchange rate volatility is mainly caused by the arrival of unanticipated relevant information in the form of a "surprise" (Galati and Ho, 2001). In fact, as noted by Gupta and Reid (2012), using the surprise component of macroeconomic variables instead of the actual outcome reduces concerns about endogeneity in the study.

Researchers have employed different definitions of exchange rate volatility, ranging from simple exchange rate returns, as measured by the daily log change in the exchange rates, to measures of volatility of returns, including squared returns, standard deviation of returns, and volatility implied by GARCH models, inter alia. Several papers relate volatility to unanticipated (or surprise) events, including economic and political developments, in addition to other news that may be relevant for investor perception of a country's risk profile. Engel and Frankel (1984), Almeida et al (1998), Andersen and Bollerslev (1998), Pearce and Solakoglu (2007) find that domestic and external surprises are important drivers of exchange rate volatility. In emerging markets, external surprises, most notably from the United States, are particularly important.

Studies focusing on advanced economies find that domestic and external economic surprises matter for exchange rate volatility. Nevertheless, surprises originating in the United States usually have a more significant effect on volatility. Galati and Ho (2001) examined the reaction of the euro / U.S. dollar exchange rate—as measured by daily exchange rate returns—to news about the macroeconomic situation in the United States and the euro zone during the first two years of European monetary union. They find that macroeconomic surprises have a statistically significant correlation with daily movements of the euro against the dollar, with economic surprise flows from the United States having a greater impact on volatility. Laakkonen (2007) also examined the impact of U.S. and European macroeconomic surprises on the euro / U.S. dollar volatility—as measured by absolute value of the 5-minute intraday euro / U.S. dollar exchange rate returns—using the Flexible Fourier Form method, and find that while both U.S. and European surprises increased volatility significantly, nevertheless surprise flows from the United States were the most important. Interestingly, Laakkonen (2007) finds that bad surprises had a greater impact on volatility relative to good surprises.

Likewise, empirical studies for emerging markets show that exchange rate volatility is driven by economic surprises. Wong et al. (2014), examined the responsiveness of exchange rates—as measured by exchange rate returns—in the Asian-Pacific market to U.S. and domestic economic surprises. They find that regional macroeconomic shocks are as important as the U.S. macroeconomic shocks in affecting exchange rate returns. However, they also find that surprises from the U.S. Federal Reserve policy rate announcements were the most significant event among the 107 macroeconomic announcements examined. Mishra et al., 2014, analyzed the effect of the 2013–14 U.S. Federal Reserve monetary policy announcements in the aftermath of the tapering speech, on the daily bilateral exchange rates returns against the U.S. dollar, government bond yields, and stock prices for 21 emerging markets, using ordinary least squares in an event study framework. They find evidence that emerging market currencies did indeed react negatively to the Fed tapering announcements. Moreover, the study shows that emerging market countries with stronger macroeconomic fundamentals, deeper financial markets, and a tighter macro prudential policy stance in the run-up to the tapering announcements experienced smaller currency depreciations.

In the case of South Africa, a number of studies examine the determinants of exchange rate volatility.[3]

- Fedderke and Flamand (2005) look at the period from June 2001 to June 2004, using ordinary least squares (OLS) in an event study framework. They measure volatility of exchange rate returns expressed as daily rand / U.S. dollar exchange rate returns, and look at domestic and U.S. macroeconomic surprises. To investigate whether there is asymmetry between surprise types, they model the rand volatility as a function of dummy variables for good and bad surprises in each country. They find that macroeconomic surprises from the United States drive changes in rand volatility, and that there is an asymmetry between good and bad surprises, with only good surprises from the United States having a significant impact.

- Farrell et al (2012) examine the high-frequency response of the rand / U.S. dollar exchange rate returns within ten-minute intervals around (five minutes before, five minutes after) official inflation announcements between January 1997 to August 2010 using OLS. They show that the rand appreciates (depreciates) on impact when inflation is higher (lower) than expected – evidence that "bad" surprises about inflation is a "good" surprise for the currency under the inflation targeting monetary policy framework.

- Hassan and Paul (2014), investigate rand movements at half-second intervals during the March 2014 Monetary Policy Committee Statement by the South African Reserve Bank, to illustrate how the rand reacts to information on macro fundamentals at very high frequency. Their results show that the rand responds significantly to changes in expectations of future macro fundamentals (domestic and international) as outlined in the South African Reserve Bank's monetary policy committee statement.

[3] While not looking at exchange rate volatility *per se*, Gupta and Reid (2012) explore the sensitivity of industry-specific stock returns in South Africa to monetary policy and to various unanticipated macroeconomic shocks.

- Arezki et al (2012) contend that commodity exporting countries, such as South Africa, face large terms of trade fluctuations which render their exchange rate volatile. They investigate the relationship between the volatility of commodity prices—particularly the gold price—and the volatility of the South African rand both in the short- and long-run for the period 1980-2010. They find that gold price volatility—as measured by the twelve month rolling window of the standard deviation of the International Monetary Fund (IMF) international gold price index, plays a key role in explaining excessive rand exchange rate volatility—as measured by the twelve month rolling window of the standard deviation of real effective exchange rate—particularly since the liberalization of capital controls in 1995, pointing to the importance of commodity prices in an economy where commodities represent over 60 percent of exports.

- Hassan (2015) shows that global market volatility as measured by the VIX drives short-term rand volatility, as periods of high rand volatility follow episodes of high VIX volatility, since the 2007 US sub-prime crisis to 2014.

- Following Campbell et al (1997) seven step event study framework, Mpofu and Peters (2016) investigate the presence of abnormal returns in the daily rand exchange rate (measured as the absolute percentage changes of the daily rand exchange rate against the U.S. dollar, the Euro, and the British pound) following a number of selected monetary policy announcements—which did not coincide with other macroeconomic or non-economic announcements or releases—and political events (including the Marikana massacre, the release of Nelson Mandela banknotes, and the African National Congress (ANC)—South Africa's ruling party elective—conferences) using daily data over the period 1 March 2000 to 31 December 2014. Their research, finds the presence of significant cumulative abnormal returns for all three exchange rates on the days surrounding the selected monetary policy announcements, the Marikana massacre on 16 August 2012 and the release of Nelson Mandela banknotes on 6 November 2012. The ANC elective conferences only have significant cumulative abnormal returns using the rand / U.S. dollar in 2007 and 2012.

- Mpofu (2016) examines real and nominal exchange rate volatility using both bilateral (rand / U.S. dollar) and effective exchange rates from 1986 to 2013. His paper relies on a GARCH (1,1) which is augmented with macroeconomic determinants of exchange rate volatility. Mpofu finds output volatility and gold price volatility are

> positively associated with rand volatility, while that trade openness; coupled with changes in foreign exchange reserves and money supply decrease volatility.[4]

The literature mainly relies on the event study methodology to investigate the drivers of volatility. In this framework, the series usually consists of only the instance an economic data point is released and a surprise may be observed, and a window surrounding the data release; the time unit could be seconds, minutes, hours or days. As such, the event study approach models the relationship between economic surprises and volatility conditional on a surprise having taken place. Alternatively, in this paper we use a continuous-time framework to model the relationship between exchange rate volatility and other covariates such as global volatility or commodity price volatility. Almost by design, this should reduce the impact of economic surprises which now have a lower frequency of occurring in the sample. However, using the economic surprise index compiled by Citi—a 3-month moving average of economic surprises—complements this approach by allowing for a cumulative or lasting effect of economic surprises. For comparability with the literature—which uses a daily surprise matter, to analyze whether domestic inflation surprises matter, and to assess sensitivity to the econometric approach, we also use an event study framework.

In addition, this paper adds to the literature in 4 ways: firstly, we focus on the period since the onset of the global financial crisis, a time during which South Africa's fundamentals have deteriorated relative to peers. Secondly, we use a market-based rand / U.S. dollar implied volatility measure to assess to impact of different sources of volatility. Thirdly, we use the economic surprise index compiled by Citi, available for a number of advanced and emerging markets, which gives us a broadly consistent surprise metric for domestic and external economic surprises. This allows us to consider external news surprises from countries other than the United States that have important linkages with South Africa, namely China and the euro zone. Fourthly, we combine the effect of macroeconomic surprises, commodity price volatility, global financial market volatility and local political uncertainty as determinants of the rand / U.S. dollar exchange rate volatility.

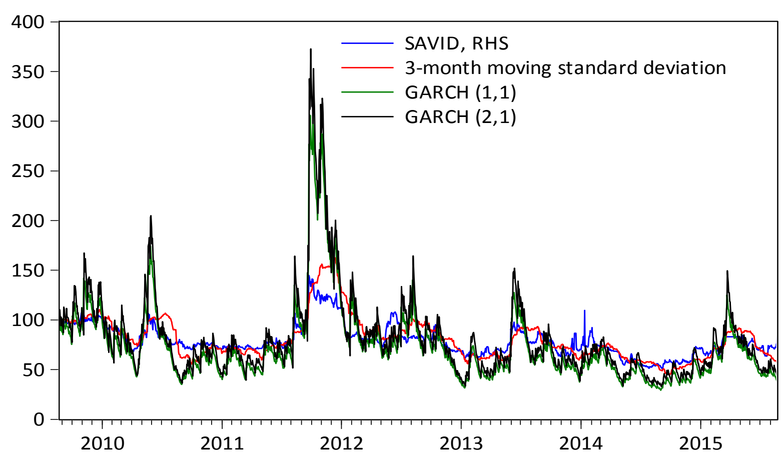
[4] However these results—output volatility only increases exchange rate volatility—only hold when using bilateral exchange rate, but not when using the real effective exchange rate.

III. DATA

A. Volatility Metrics

Our analysis is carried out based on daily data from August 24, 2009 to August 24, 2015. The use of daily data avoids loss of information between discrete events of macroeconomic news releases, and allows for surprises to slowly find their way into exchange rate volatility (Gupta and Reid, 2012). While there is no consensus over the most appropriate measure of exchange rate volatility, the literature leans towards the use of implied measures of volatility. Clark et al (2004) argue that if the focus is on countries with well developed financial markets such as South Africa, then one should take into account forward markets—or currency option market—to obtain a measure of implied exchange rate volatility. In this paper we use the Johannesburg Stock Exchange (JSE) measure of implied rand / U.S. dollar exchange rate – the South African Volatility Index for the rand / U.S. dollar exchange rate (SAVID). The SAVID is a forecast of the 90 day implied volatility of the rand against the U.S. dollar derived from actual options traded data.[5] A high value for the SAVID corresponds to a more volatile market and therefore more risk of currency value change, while a low value is indicative of a less volatile market and therefore less risk. For example, when daily currency market returns are sufficiently volatile, the SAVID will tend to spike upward, reflecting a higher level of expected risk.

Figure 2. Selected Measures of Volatility, August 2009 – 2015



*All series are set equal to 100 at the beginning
Source: JSE, Bloomberg, Author's own calculations

[5] Investment houses are polled regarding whether they are prepared to price Rand / U.S. dollar currency options in the market and their views are then averaged out. These investment houses price options higher when they expect a high risk of a change in prices as they require a greater premium from traders to insure against such moves.

As a sensitivity analysis, we employ three alternative common measures of historical exchange rate volatility (in Appendix II); (i) the daily rand / U.S. dollar exchange rate returns—widely used in studies of the impact of macroeconomic surprises on exchange rates; and two common realized or historical volatility approximations: (ii) a three-month moving average standard deviation of the daily return of the rand / U.S. dollar exchange rate; and (iii) a generalized autoregressive conditional heteroscedasticity (GARCH) model of the daily return of the rand / U.S. dollar rate. All volatility measures are plotted in Figure 2.

B. Macroeconomic Surprises

A common approach used to quantify the surprise component of macroeconomic data announcements takes the difference between the actual and the market expectation (the average or the median of all analysts' opinions) providing a survey-based measure of macroeconomic announcement surprises (e.g. Balduzzi et al., 2001). This assumes that analysts' opinions are a good reflection of investor opinions, an assumption that should hold over a longer horizon, but may not be true at every point in time.

In this paper, macroeconomic surprises are approximated by the Citi's economic surprise index (ESI), which is computed in a broadly consistent manner across individual countries and country groupings.[6] The ESI is defined as weighted historical standard deviations of the difference between the actual data releases and Bloomberg survey median. Specifically, the index is based on surprises from economic growth as measured by GDP, manufacturing production, mining production, retail sales, purchasing manager index (PMI), vehicle sales, private sector credit, unemployment, trade balance, fiscal balance, inflation, and money supply, inter alia. The weights of each macroeconomic variable surprise are determined with reference to historical surprise impacts on exchange rates.

The surprises in these individual series are combined in a three-month rolling average, where older values receive smaller weights. An index value greater (smaller) than zero, denotes a stronger (weaker) than expected data print. A value near zero indicates that the data come in largely as expected. Given that volatility does not have a direction, we take the absolute value of the ESI.[7] The ESI is available for South Africa its main economic partners—the

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[6] We are grateful to Kristjan Kasikov David Lubin, and Alexander Wolfson from Citi group for supplying us with this data.

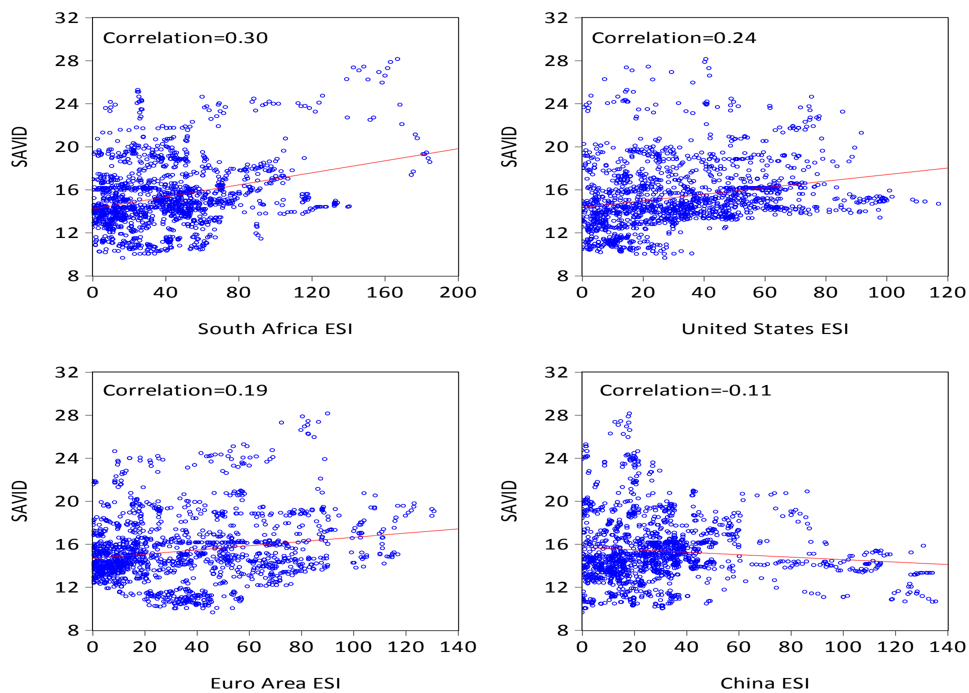
[7] In the sensitive analysis in Appendix III, we explore the question of whether there is a significant asymmetry in the response of rand volatility to positive (good) and negative (bad) surprises. To so this, we then include a dummy interaction with the ESI, where the dummy takes on the value 1 for positive surprises and zero otherwise.[7]

United States, the Euro Area, China, as well as country groupings—the G10 and the emerging market countries (EMs).[8]

It is worth noting that the ESIs for South Africa, China, and all other emerging markets do not include any inflation surprise measures. This is because the EMs ESIs typically cover far fewer releases than developed markets, and including inflation would therefore have a disproportionately large impact on the index. Meanwhile, the ESIs for developed markets do include inflation, where higher than expected inflation causes the ESI to increase. This is because higher inflation typically increases local interest rate expectations leading to an appreciation of the local currency. For South Africa, we consider the impact of inflation surprises—the difference between market consensus and the actual CPI print on the day of the release—directly in the event study framework.

Figure 3 plots the ESIs for South Africa, the United States, China, and the Euro Area against the SAVID volatility measure.

Figure 3. Selected ESIs against the SAVID, August 2009 - 2015



Source: Citi Bank, JSE and Authors' calculations

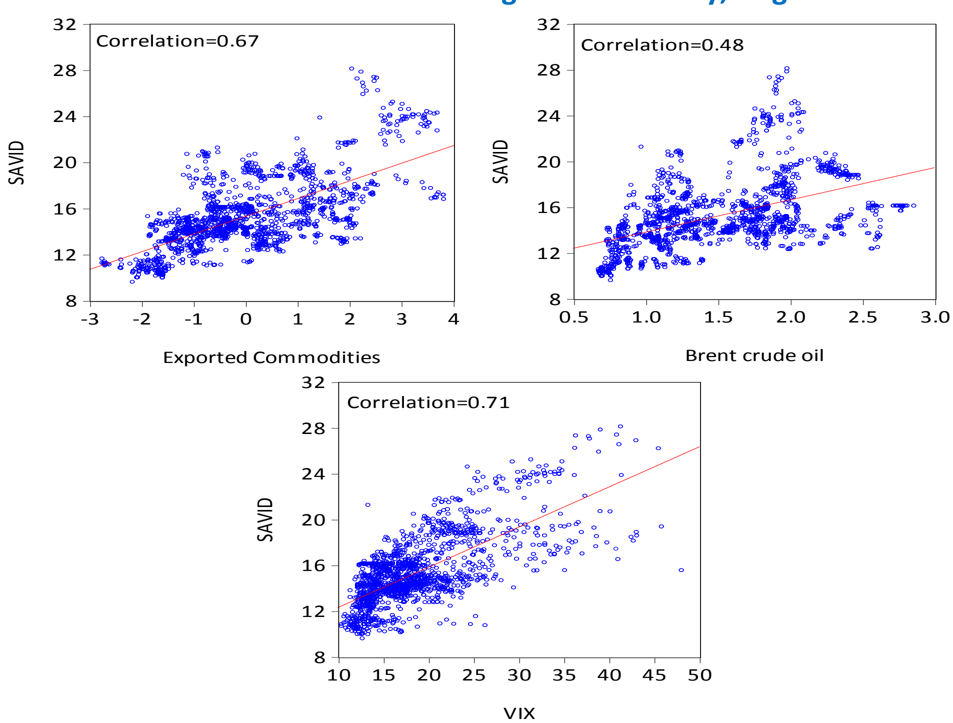
[8] The G10 is made up of following ten developed markets economies – United States, Euro-Zone, Japan, United Kingdom, Canada, Australia, Switzerland, Norway, New Zealand and Sweden - a collection chosen based on the liquidity of their financial instruments and currencies rather than size. The all Emerging Markets ESI composite covers: China, Hong Kong, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Brazil, Mexico, Chile, Colombia, Peru, Turkey, South Africa, Poland, Czech Republic, Hungary, Russia, and Ukraine. The country grouping analysis is included in the sensitivity analysis in Appendix III.

The surprise indices broadly have a zero mean, but exhibit modestly persistent swings; which is an inherent characteristic of the series given that it is constructed as a smoothing 3-month average of daily surprises. Looking at bivariate correlations, the SAVID is moderately to weakly correlated with the economic surprise indices (Table A2).

C. Commodity Price Volatility and the VIX

Given the importance of commodities for the South Africa economy, commodity price volatility may translate into rand volatility. Indeed, Arezki et al (2012) found that the volatility of commodity prices—particularly the gold price—plays a key role in explaining excessive rand volatility. We consider price volatility in South Africa's four main exported commodities (gold, coal, platinum, iron ore), and the main imported commodity (Brent crude oil) as additional explanatory variables in our analysis. As a measure of commodity price volatility, we use the 3-month rolling standard deviation of the daily commodity price returns. For the export commodities, we estimate the common factor principal component, given the multicolinearity among the exported commodity price volatility indicators (particularly between gold and platinum). Figure 4, and the bivariate correlation matrix in Table A2 show that the SAVID is highly correlated with the principal component standard deviation of the selected export commodities and oil price volatility.

Figure 4. SAVID and Global Factors Driving Rand Volatility, August 2009 – 2015



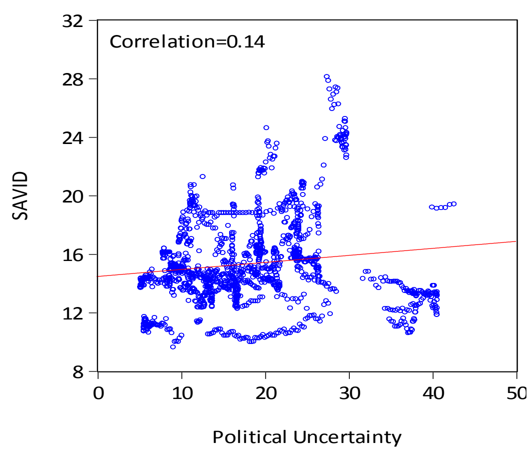
Source: JSE, Bloomberg and Authors's calculations

The daily Chicago Board Options Exchange (CBOE) Volatility Index (VIX), which measures global financial market volatility, is also found to be highly correlated with the SAVID (Figure 4 and Table A2). This would be consistent with the view that the South African rand is subject to global risk-on / risk-off sentiments Hassan (2015).

D. Local Political Uncertainty

The empirical literature on exchange rate volatility suggests political uncertainty can also increase exchange rate volatility (Leblang and Bernhard (2006); Krol (2014)). There are a number of possible transmission channels. For example, political uncertainty can weigh on investment and thus growth which in turn is one determinant of how investors see a country's creditworthiness. While political uncertainty is an unobservable variable, a recent, and growing literature, constructs "news chatter" measures of uncertainty (e.g., Baker et al (2015); Redl (2015); Hlatshwayo and Saxegaard (2016)).[9]

Figure 5. SAVID and South Africa's Political Uncertainty Index, August 2009 – 2015



Source: JSE, Hlatshwayo and Saxegaard (2015)

In this paper we use a political uncertainty index for South Africa based on a news-based search algorithm constructed by Hlatshwayo and Saxegaard (2016). The algorithm counts the number of articles mentioning at least three words related to government, politics, and uncertainty in connection with South Africa and a higher frequency of such mentions is assumed to be associated with the degree of political uncertainty. We interpolate the

[9] Other methods to gauge political uncertainty rely on surveys. In South Africa, the Bureau of Economic Research (BER) constructs a quarterly survey based measure of political uncertainty which questions a number of manufacturers to rate the political climate as a constraint on business conditions.

quarterly political uncertainty index into a daily frequency, and include this daily political uncertainty index as an additional regressor in our econometric model. Figure 5 shows that the country's local political uncertainty is moderately correlated with the SAVID.

IV. CONTINUOUS TIME APPROACH

We model the implied volatility of the South African rand / U.S. dollar (SAVID) as a function of macroeconomic surprises, commodity price volatility, the VIX, and domestic political uncertainty:

$$\sigma_{ERR_t} = \alpha + \sum_{i=1}^{n} \beta_i \left|ESI_{i,t}\right| + \sum_{c=1}^{n} \delta_i COM_t + \varphi VIX_t + \theta PU_t + u_t$$

where σ_{ERR_t}denotes the SAVID at time t, the $\left|ESI_{i,t}\right|$ denotes the absolute value of Citi economic surprise indices (ESI) of trading partner i at time t, $\sum_{i=1}^{n} \delta COM_t$ refers to the sum of common factor and oil commodity price volatility, as measured by the 3-month rolling standard deviation of commodities price daily returns series, VIX_t refers to the CBOE Volatility Index, PU_t denotes domestic political uncertainty, α is the intercept and β_i, δ_i, φ, and θ represent the parameters to be estimated and u_t is the white noise error term.

Statistical tests indicate that all variables are stationary (see Table A1). To accommodate the long memory and the daily periodicity that characterize the rand volatility data, we use heteroskedasticity and serial-correlation robust (HAC) standard errors. The results are summarized in Table 1. We group the regressors into macroeconomic surprises, global volatility, and domestic political uncertainty. Initially, we analyze the impact each of these groups has on rand volatility on its own, and then combine them into a general model.

In column A, we model rand volatility as a function of local and external macroeconomic surprises. The results suggests that increase in macroeconomic surprises originating from South Africa, the United States and the Euro Area are associated with heightened rand volatility. In contrast, an increase in macroeconomic surprises originating from China decreases rand volatility.

Table 1: Results of All Selected Specifications

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	A	B	C	D	E	F
Constant	13.104*	12.542*	8.887*	14.490*	8.511*	8.550*
SA ESI (#)	0.024*				0.001	
USA ESI	0.033*				0.013*	0.014*
EU ESI	0.015**				-0.004	
China ESI	-0.010***				0.002	
Exported Commodities		1.326*			1.034*	1.040*
Brent crude		1.850*			0.992*	1.000*
VIX			0.351*		0.221*	0.211*
Political uncertainty				0.048**	0.048*	0.051*
R-squared	0.18	0.54	0.50	0.02	0.73	0.73
Adjusted R-squared	0.18	0.54	0.50	0.02	0.73	0.73
S.E. of regression	2.74	2.04	2.14	2.99	1.56	1.56
Sum squared resid	11696.3	6531.12	7160.86	13974.65	3787.84	3814.31
Log likelihood	-3796.5	-3340.22	-3412.30	-3935.83	-2913.66	-2919.11
F-statistic	84.9	922.48	1546.24	29.74	537.07	852.82
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Prob(Wald F-statistic)	0.00	0.00	0.00	0.09	0.00	0.00
Akaike info criterion	4.86	4.27	4.36	5.03	3.73	3.74
Schwarz criterion	4.87	4.28	4.37	5.04	3.76	3.76
Hannan-Quinn criter.	4.86	4.27	4.36	5.03	3.74	3.74

All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

In column B, we model rand volatility as a function of commodity price volatility. An increase in the volatility of South Africa's main export and import commodity prices increase rand volatility. Column C assesses the role of global volatility as expressed by the VIX. An increase in the VIX leads to an increase in rand volatility, a finding similar to Hassan (2015). We note that compared to column A, the goodness of fit improves in columns B and C.

In column D, we then investigate whether political uncertainty on its own might be a driver of rand volatility. The estimated coefficient is positive and significant; suggesting that increased political uncertainty is associated with increased rand volatility. However, the poor goodness of fit suggests that this is far from the whole story.

Column E combines all selected regressors. Commodity price volatility, the VIX, and political uncertainty enter significantly with the expected sign, all contributing to increased rand volatility. For the economic surprise indices, the picture is mixed. Only U.S. economic surprises are a significant driver of rand volatility. The other surprise indices, including the South African one, become insignificant, and in the case of the European Union, surprises carry an unexpected negative sign.[10] In Column F, we drop the insignificant regressors from column E based on an F-test for omitted variables. In this specification, U.S. economic surprises, commodity price volatility, global volatility, and political uncertainty contribute to higher rand volatility, with all coefficients significant. These results suggest that rand volatility is mainly driven by global factors, but also by domestic political uncertainty.

Taken together, the findings suggest that rand volatility is positively associated with economic surprises originating in the United States, with heightened export and import commodity price volatility, with global volatility as approximated by the VIX, and with elevated political uncertainty in South Africa.

V. Sensitivity Analysis

These results presented above hold when looking at different sensitivity analysis (Appendix III). Firstly, we test whether using economic surprises for country groupings (G10 and EMs) makes a difference. Again, economic surprises for South Africa drop out, but those from the G10 and EMs are significant, with EM surprises carrying an unexpected negative sign. Secondly, we re-run the model for alternative volatility measures, namely, the daily returns of the rand / U.S. dollar exchange rate; a three-month rolling standard deviation of these daily returns; and a generalized autoregressive conditional heteroscedasticity (GARCH) model of the daily returns, with the results being broadly robust.

Thirdly, we test whether the relationship between the explanatory variables and rand volatility differs during periods of sustained appreciation and periods of sustained deprecation, and find that the impact is broadly the same. Fourthly, allowing for a different impact from positive and negative U.S. surprises in column F, shows that the impact is symmetric, and there is no difference between positive and negative surprises.

In addition, testing for persistence of volatility, we include a lagged dependent variable in all selected specifications (column A through F) which turns all regressors but the VIX insignificant. These results generally point to a strong autoregressive component in rand volatility. While at odds with the theory of Efficient Market Hypothesis, this can partly be explained by the notion of the persistence of shocks to exchange rate volatility, as explained by Hassan (2012) and Mpofu (2016). In essence, by examining the persistence in the volatility of major exchange rates (US Dollar against the British Pound and the Euro) due to

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[10] In essence this means that an increase in economic surprises from the EU generally decrease rand volatility. However, one is likely to have expected the direct relationship—an increase in economic surprises from the EU to increase rand volatility—since unexpected news (at least in absolute value) should cause an adjustment of the exchange rate to reflect the news and thus increase exchange rate volatility.

exogenous shocks, Hassan (2012) presents significant evidence of high volatility persistence and clustering, suggesting that periods of high (low) volatility are usually followed by periods of high (low) volatility, a finding consistent with Duncan and Liu (2009).

Lastly, we allow for time-varying coefficients which shows that the relationship changes over the sample period, though there are no common breaks.

VI. EVENT STUDY ANALYSIS

The results of the analysis above generally found little evidence that local macroeconomic surprises matter for rand volatility. One reason for this could be that, unlike for advanced markets, the surprise index for South Africa does not include inflation surprises which would arguably be an important economic surprise when thinking about exchange rate volatility. Simply including an inflation surprise series (expressed as a difference between market consensus and the actual CPI print on the day of the release) in the continuous time model, does not improve our model, since inflation surprises occur only on a monthly basis – creating lack of data variation in the series compared to the rest of the variables in the model. Thus an event study, which uses daily surprise data on the day of the actual surprise and the immediate days around it, is ideal to ease this shortcoming. A second reason for using an event study framework is to allow us to compare our results which cover a more recent time window with the previous literature. Similarly we use OLS with robust standard errors to estimate the following equation:

$$\sigma_{ERR_t} = \alpha + \beta\left|ESI_{SA,t}\right| + \omega\left|CPIS_{SA,t}\right| + \sum_{c=1}^{n} \delta_i COM_t + \varphi VIX_t + \theta PU_t + u_t$$

where σ_{ERR_t}denotes the SAVID at time t, the $\left|ESI_{SA,t}\right|$ denotes the absolute value of Citi economic surprise indices (ESI) for South Africa at time t; $\left|CPIS_{SA,t}\right|$ is the absolute value of South Africa's CPI surprises; $\sum_{i=1}^{n} \delta COM_t$ refers to the sum of common factor and oil commodity price volatility, as measured by the 3-month rolling standard deviation of commodities price daily returns series, VIX_t refers to the CBOE Volatility Index, PU_t denotes domestic political uncertainty; α is the intercept; β, ω, δ_i, φ, and θ represent the parameters to be estimated; and u_t is the white noise error term.

The results are similar to the ones before (Table 2). Economic surprise from South Africa, commodity price volatility, the VIX all enter significantly and with the expected sign (columns A through C).[11] However, a South African inflation surprise is insignificant (column A) and political uncertainty on its own is also insignificant (column D). Entering all regressors jointly (column E), commodity price volatility, the VIX, and political uncertainty enter significantly and with the expected sign. The economic surprise index for South Africa and the South African inflation surprise are insignificant and can be excluded (column F). We also note that including only CPI surprises or SA ESIs in specification F does not change their insignificance or signs. The event study results are thus consistent with the ones for continuous time. Rand volatility is largely driven by external factors and domestic political uncertainty.

Table 2: Event Study Results

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 736
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	A	B	C	D	E	F
Constant	14.898*	12.526*	8.997*	14.664*	8.591*	8.601*
SA ESI (#)	0.020*				0.004	
CPI Surprises (#)	1.388				-0.370	
Exported Commodities		1.206*			0.947*	0.949*
Brent crude		1.746*			1.212*	1.213*
VIX			0.336*		0.215*	0.216*
Policy uncertainty				0.019	0.0447*	0.045*
R-squared	0.01	0.52	0.48	0.00	0.71	0.71
Adjusted R-squared	0.01	0.52	0.48	0.00	0.71	0.71
S.E. of regression	2.85	1.99	2.07	2.86	1.55	1.55
Sum squared resid	5963.3	2893.62	3142.78	5991.89	1751.32	1753.62
Log likelihood	-1814.2	-1548.14	-1578.54	-1816.01	-1363.36	-1363.84
F-statistic	3.1	395.09	670.33	2.58	295.66	443.88
Prob(F-statistic)	0.05	0.00	0.00	0.11	0.00	0.00
Prob(Wald F-statistic)	0.02	0.00	0.00	0.57	0.00	0.00
Akaike info criterion	4.94	4.22	4.29	4.94	3.72	3.72
Schwarz criterion	4.96	4.23	4.31	4.95	3.77	3.75
Hannan-Quinn criter.	4.95	4.22	4.30	4.95	3.74	3.73

All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

[11] Given that the event is identified as an economic surprise in South Africa, we do not include economic surprise indices for the other countries/regions. If we were to identify an event as a domestic or external economic surprise, the sample converges to continuous time.

VII. CONCLUSION

This paper investigates the main drivers of the daily South African rand / U.S. dollar exchange rate volatility since the global financial crisis. In line with the literature, we model rand volatility as a function of local and selected international economic surprises which arise if a data print differs from expectations. In addition, for a commodity producer like South Africa, commodity price volatility can also contribute to exchange rate volatility—commodity price volatility being tantamount to a surprise in a key economic data. Similarly, global volatility can translate into local volatility when a country is impacted by investor risk-on / risk-off sentiments. Lastly, local political uncertainty can be a further source of surprises that drives exchange rate volatility.

We approximate rand volatility with the JSE South African Volatility Index for the rand / U.S. dollar exchange rate, a forecast of the 90 day implied volatility of the rand against the U.S. dollar derived from actual options traded data. Alternatively, we use the daily return of the rand / U.S. dollar rate, a rolling standard deviation, and a GARCH model. For surprises in economic data prints, we employ Citi Bank's Economic Surprise Index (ESI), a 3-month rolling average of the difference between market expectations and data prints for a list of macroeconomic fundamentals.

Looking at the whole period from 2009 onwards or four day windows around the release of South African economic data prints, the results are broadly similar. Increased commodity price volatility for South Africa's main export and import commodities and increased global volatility, as approximated by the VIX, are associated with heightened rand volatility. In addition, political uncertainty also contributes to heightened rand volatility. When it comes to economic data surprises, only U.S. surprises matter for to rand volatility. South African surprises, including inflation surprises, do not enter as significant explanatory variables.

Why should we worry about foreign exchange rate volatility in a flexible exchange rate regime? A flexible exchange rate is a powerful adjustment mechanism, and has served South Africa well to manage external shocks. Exchange rate volatility—in particular 'excess' volatility—can cause uncertainty amongst investors, delaying investment decisions, adversely affecting growth and job creation. Thus, understanding what contributes to foreign exchange rate volatility is an important first step to assess whether there is a role for economic policy to reduce this volatility within the existing foreign exchange regime. Arguably, South Africa cannot control commodity price volatility or global financial market volatility. However, South Africa can further strengthen its buffers, such as international reserves, and reduce external vulnerabilities which should reduce the susceptibility to volatility. In addition, the perception of political uncertainty is something the government can influence in the way it develops and implements economic policy, as well as the way it communicates economic policy decisions.

APPENDIX

Appendix I—Descriptive Statistics and Detailed Results

Table A1: All variables' descriptive statistics and Unit root tests

	Rand volatility	Citi ESIs (Macroeconomic Surprises)						Global factors			Local Political Uncertainty
	SAVID	SA	USA	China	Euro Area	EMs	G10	Exported com.	Oil	VIX	
Mean	15.37	40.93	32.92	30.19	34.89	18.83	20.98	0.00	1.53	18.50	18.38
Median	14.78	36.75	28.85	24.00	26.40	15.30	18.50	-0.23	1.54	16.87	17.10
Maximum	28.12	184.90	117.20	135.70	131.00	63.70	62.60	3.82	2.85	48.00	42.58
Minimum	9.63	0.10	0.00	0.00	0.00	0.00	0.00	-2.77	0.67	10.32	5.12
Std. Dev.	3.02	32.81	23.65	26.99	29.40	14.62	14.62	1.32	0.52	6.07	8.59
Skewness	1.09	1.40	0.73	1.85	0.82	0.78	0.58	0.61	0.29	1.57	0.72
Kurtosis	4.76	5.52	2.95	6.61	2.86	2.82	2.47	2.91	2.23	5.70	3.10
Jarque-Bera	513.45	925.59	140.95	1745.59	178.81	161.73	107.78	98.46	60.22	1115.00	137.34
Probability	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	24073	64101	51550	47272	54645	29467	32858	0	2396	28969	28784
Sum Sq. Dev.	14240	1684209	875267	1140431	1352840	334232	334549	2714	421	57598	115382
Observations	1566	1566	1566	1566	1566	1565	1566	1566	1566	1566	1566
Stationary tests: Null hypothesis: Series has a unit root (*MacKinnon (1996) one-sided p-values)											
Augmented Dickey-Fuller (ADF)	0.03**	0.00*	0.00*	0.00*	0.01*	0.00*	0.00*	0.01**	0.07***	0.00*	0.02**
Phillips-Perron (PP)	0.02**	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.06***	0.09***	0.00*	0.00*

Source: JSE, Citi, Bloomberg, Authors' calculations

* denotes rejection of null hypothesis at the 1%, ** at the 5% and *** at the 10% level of significance

Note: Exported Commodities (includes Gold, Platinum, Coal and Iron ore) and Oil (Brent Crude) enter our analysis expressed as daily price returns volatility

Table A2: Bivariate correlation coefficients between selected variables

	Rand volatility	Citi ESIs (Macroeconomic Surprises)						Global factors			Local Political Uncertainty
	SAVID	SA	USA	China	Euro Area	EMs	G10	Exported com.	Oil	VIX	
SAVID	1	0.30	0.24	-0.10	0.19	0.10	0.24	0.67	0.48	0.70	0.14
SA	0.30	1	0.02	-0.03	0.23	0.03	0.19	0.25	0.06	0.40	0.02
USA	0.24	0.02	1	0.06	-0.10	-0.15	0.52	0.02	0.33	0.18	-0.11
China	-0.10	-0.03	0.06	1	-0.12	0.13	0.01	-0.18	-0.04	-0.14	0.13
Euro Area	0.19	0.23	-0.10	-0.12	1	0.21	0.39	0.09	0.11	0.42	-0.02
EMs	0.10	0.03	-0.15	0.13	0.21	1	0.05	0.27	0.12	0.12	-0.04
G10	0.24	0.19	0.52	0.01	0.39	0.05	1	0.07	0.04	0.34	-0.10
Exported commodities	0.67	0.25	0.02	-0.18	0.09	0.27	0.07	1	0.29	0.38	0.00
Oil	0.48	0.06	0.33	-0.04	0.11	0.12	0.04	0.29	1	0.42	-0.23
VIX	0.70	0.40	0.18	-0.14	0.42	0.12	0.34	0.38	0.42	1	0.10
Political Uncertainty	0.14	0.02	-0.11	0.13	-0.02	-0.04	-0.10	0.00	-0.23	0.10	1

Source: JSE, Citi, Bloomberg, Authors' calculations

Note: Exported Commodities (includes Gold, Platinum, Coal and Iron ore) and Oil (Brent Crude) enter our analysis expressed as daily price returns volatility

Appendix II—Alternative Measures of Exchange Rate Volatility

The simplest measure of historical volatility is the standard deviation. In this case, the 3-month moving average standard deviation provides a good indication of historical volatility. However the standard deviation does not capture the dynamic effects of the volatility – assuming that it remains constant over time. To remedy this Bollerslev's GARCH models are a convenient approach to estimate the volatility of an exchange rate, specifically the time-varying standard deviation of the daily returns.[12] In this model, the conditional variance of the rand / U.S. dollar exchange rate returns depends not only on lagged disturbances, but also on its own lagged values, such that the conditional variance or exchange rate volatility can be expressed in the following set of equations:

$$y_t = \mu + u_t \tag{1}$$

$$u_t = \varepsilon_t h_t^{1/2}, \qquad \varepsilon_t / I_{t-1} \sim N(0,1)$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-1}^2 + \sum_{j=1}^{p} \beta_j \, h_{t-j}, \quad t=1,.... \tag{2}$$

Where y_t is equal to the log of the difference of the rand / U.S. dollar exchange rate and μ is the mean of y_t. Assuming $\varepsilon_t \sim N(0,1)$ for all t gives $u_t \sim N(0, h_t)$ so that y_t conditional on the past information I_{t-1} is normal, but heteroskedastic. Estimating Equation 2 by maximum likelihood we obtain estimates of the parameters μ, α_0, α_i, $(i = 1, \dots, p)$ and β_j $(j = 1, \dots, q)$ and hence also the conditional variance (h_t).

The conditional variance must be nonnegative, which requires that $\alpha_0 \geq 0$, $\alpha_i \geq 0$, $(i = 1, \dots, p)$ and $\beta_j \geq 0$ $(j = 1, \dots, q)$. The values of p and q may be selected on the basis of likelihood ratio tests. According to standard information criteria, a lag length of GARCH (2,1) seems best suited to the data.[13] Since the GARCH(1,1) is mostly used in the literature,

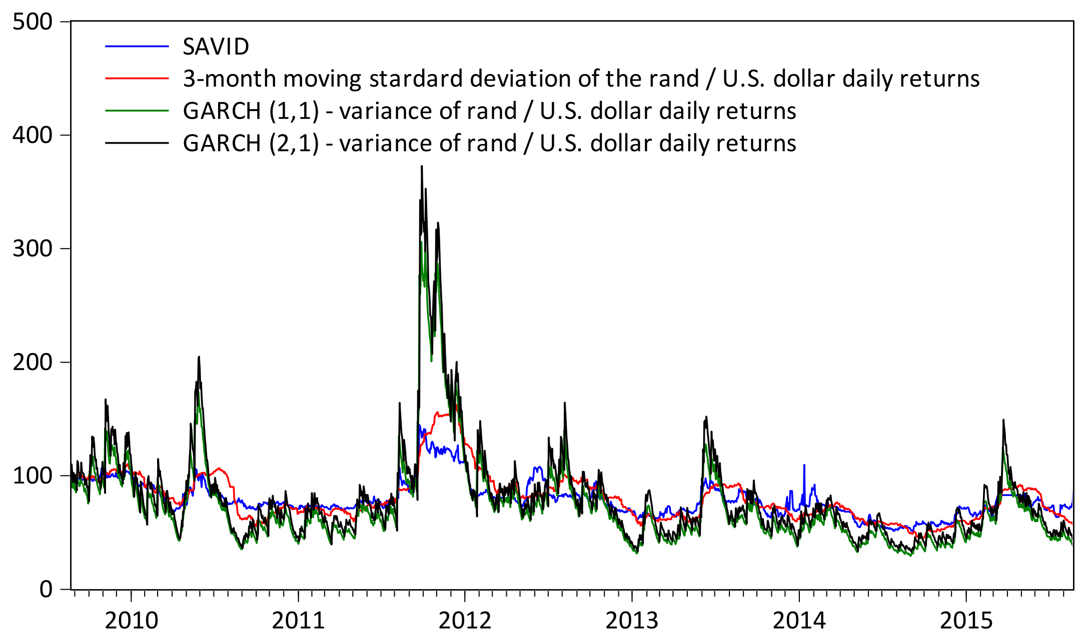
[12] As pointed in Cheong et al., 2007, a GARCH model is able to capture the non-constant time varying conditional variance such as excess kurtosis and fattailedness. Herwartz (2003) mentions that recently there has emerged some consensus that the GARCH model introduced by Engle (1982) and Bollerslev (1986) is suitable to capture stylized facts of log foreign exchange rate processes such as the martingale property, volatility clustering and leptokurtosis.

[13] We use the Aikaike Information Criterion, the Schwarz Information Criterion, and the Hannan-Quinn Information Criterion.

our analysis reports estimated based on both the GARCH (1,1) and GARCH(2,1) for sensitivity analysis purposes. Alternative GARCH models including the integrated GARCH of Engle and Bollerslev (1986)—designed to model persistent changes in volatility—and a component GARCH model of Engle and Lee (1999) —designed to better account for long-run volatility dependencies by relaxing the assumption of a constant variance—were also estimated (Table A3 and Figure A1) for robustness or sensitivity analysis purposes.

The three volatility measures follow broadly the same trend (Figure A1). All three measures have spikes at roughly the same times, early 2010 (euro zone debt crisis), late 2011 (rand trend appreciation trend reversed to depreciation trend), mid-2012 (on a mixture of euro zone debt crisis contagion, falling commodity prices, Marikana massacre, early 2013 (taper tantrum), and beginning of 2014 (second round of taper tantrum). Compared to the SAVID and the GARCH, the moving average of the standard deviation seems smoother, but shows similar spikes.

Figure A1. Selected measures of the Rand / U.S. dollar exchange rate volatility



*All series are set equal to 100 at the beginning
Source: JSE, Bloomberg, Author's own calculations

Table A3: Alternative GARCH models of the Rand / U.S. dollar exchange rate returns

GARCH (1,1)

GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.013	0.005	2.694	0.007
RESID(-1)^2	0.051	0.008	6.155	0.000
GARCH(-1)	0.932	0.012	81.019	0.000
R-squared	0.00	Akaike info criterion		2.51
Adjusted R-squared	0.00	Schwarz criterion		2.52
Durbin-Watson stat	2.00	Hannan-Quinn criter.		2.51
Heteroscedasticity tests: ARCH LM				
F-statistic	3.120	Prob. F(1,1563)		0.078
Obs*R-squared	3.118	Prob. Chi-Square(1)		0.078

GARCH (2,1)

GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*RESID(-2)^2 + C(4)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.020	0.007	2.978	0.003
RESID(-1)^2	-0.018	0.020	-0.899	0.369
RESID(-2)^2	0.081	0.024	3.374	0.001
GARCH(-1)	0.912	0.015	61.092	0.000
R-squared	0.00	Akaike info criterion		2.51
Adjusted R-squared	0.00	Schwarz criterion		2.52
Durbin-Watson stat	2.00	Hannan-Quinn criter.		2.51
Heteroscedasticity tests: ARCH LM				
F-statistic	0.000	Prob. F(1,1563)		0.997
Obs*R-squared	0.000	Prob. Chi-Square(1)		0.997

IGARCH

GARCH = C(1)*RESID(-1)^2 + (1 - C(1))*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
RESID(-1)^2	0.044	0.005	8.364	0.000
GARCH(-1)	0.956	0.005	183.735	0.000
R-squared	0.00	Akaike info criterion		2.52
Adjusted R-squared	0.00	Schwarz criterion		2.52
Durbin-Watson stat	2.00	Hannan-Quinn criter.		2.52
Heteroscedasticity tests: ARCH LM				
F-statistic	1.090	Prob. F(1,1563)		0.297
Obs*R-squared	1.090	Prob. Chi-Square(1)		0.296

Table A3/continued: Alternative GARCH models of the Rand / U.S. dollar exchange rate returns

CGARCH

Q = C(1) + C(2)*(Q(-1) - C(1)) + C(3)*(RESID(-1)^2 - GARCH(-1))

GARCH = Q + C(4) * (RESID(-1)^2 - Q(-1)) + C(5)*(GARCH(-1) - Q(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.773962	0.112888	6.856016	0
C(2)	0.988369	0.014986	65.95086	0
C(3)	0.034633	0.061289	0.565069	0.572
C(4)	0.018755	0.059549	0.314944	0.7528
C(5)	0.938349	0.077605	12.09135	0
R-squared	0.00	Akaike info criterion		2.51
Adjusted R-squared	0.00	Schwarz criterion		2.53
Durbin-Watson stat	2.00	Hannan-Quinn criter.		2.52
Heteroscedasticity tests: ARCH LM				
F-statistic	3.282638	Prob. F(1,1563)		0.0702
Obs*R-squared	3.27995	Prob. Chi-Square(1)		0.0701

CGARCHT

Q = C(1) + C(2)*(Q(-1) - C(1)) + C(3)*(RESID(-1)^2 - GARCH(-1))

GARCH = Q + (C(4) + C(5)*(RESID(-1)<0))*(RESID(-1)^2 - Q(-1)) + C(6) *(GARCH(-1) - Q(-1))

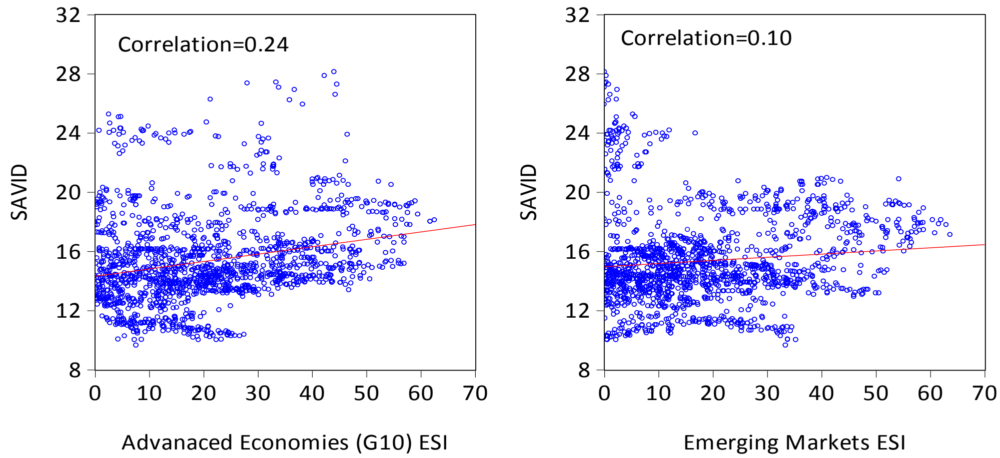
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.752	0.082	9.197	0.000
C(2)	0.974	0.009	104.907	0.000
C(3)	0.061	0.010	6.100	0.000
C(4)	-0.121	0.032	-3.800	0.000
C(5)	0.072	0.041	1.749	0.080
C(6)	0.077	0.342	0.224	0.822
R-squared	0.00	Akaike info criterion		2.51
Adjusted R-squared	0.00	Schwarz criterion		2.53
Durbin-Watson stat	2.00	Hannan-Quinn criter.		2.51
Heteroscedasticity tests: ARCH LM				
F-statistic	0.001	Prob. F(1,1563)		0.982
Obs*R-squared	0.001	Prob. Chi-Square(1)		0.982

Appendix III—Sensitivity Analysis - Robustness checks

A. Analysis using country grouping ESIs as explanatory variables

We estimated specifications A through G, using country grouping ESIs versus the domestic ESI – namely ESIs from Advanced Economies (G10) and Emerging Market economies (plotted in Figure A2).

Figure A2. SAVID versus selected ESIs



Source: JSE, Citi Bank, and Authors' calculations

Similarly to the results with individual country ESIs, Table A4, Colum A, associates rand volatility only to local macroeconomic surprises and surprises from Advanced Economies (G10) and selected Emerging Markets (EMs). The results show that, on average, an increase in local and international macroeconomic surprises—originating from Advanced Economies leads to an increase in rand volatility.

Column B, C and D are as before, with global volatility factors, including South Africa's main exported and imported commodity price volatility, and the global market risk perceptions (VIX), having a large positive and significant effect on rand volatility. In addition, an increase in local political uncertainty is also associated with an increase in rand volatility.

Pooling all selected variables into a single specification, Column E shows that rand volatility does not respond to local macroeconomic surprises, but responds positively to ESI from the G10 and negatively to surprises from EMs. As before, increases in Commodity price volatility, the VIX and local political uncertainty are associated with an increase in rand volatility.

Column F expresses a more parsimonious specification of all selected variables, where the ESIs for South Africa do not belong, according to the F-test for omitted variables. On average these results are consistent with the previous finding that, rand volatility is mainly driven by macroeconomic surprises originating from the international sources, commodity price volatility and global market risk perception. While local only news related to political uncertainty seem to have a significant effect on rand volatility.

Table A4. Analysis with Country Groupings: Results of estimations A through G

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	A	B	C	D	E	F
Constant	13.236*	12.542*	8.887*	14.490*	8.786*	8.781*
SA ESI (#)	0.024*				0.000	
G10 ESI	0.038*				0.017**	0.017**
EMs ESI	0.018				-0.020**	-0.020**
Exported Commodities		1.326*			1.083*	1.082*
Brent crude		1.850*			1.290*	1.293*
VIX			0.351*		0.199*	0.198*
Political uncertainty				0.048**	0.052*	0.052*
R-squared	0.13	0.54	0.50	0.02	0.74	0.74
Adjusted R-squared	0.13	0.54	0.50	0.02	0.73	0.73
S.E. of regression	2.81	2.04	2.14	2.99	1.56	1.55
Sum squared resid	12318.8	6531.12	7160.86	13974.65	3765.11	3765.23
Log likelihood	-3835.1	-3340.22	-3412.30	-3935.83	-2907.59	-2907.61
F-statistic	81.0	922.48	1546.24	29.74	618.54	722.06
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Prob(Wald F-statistic)	0.00	0.00	0.00	0.09	0.00	0.00
Akaike info criterion	4.91	4.27	4.36	5.03	3.73	3.72
Schwarz criterion	4.92	4.28	4.37	5.04	3.75	3.75
Hannan-Quinn criter.	4.91	4.27	4.36	5.03	3.74	3.73

All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

B. Alternative measures of volatility

For robustness purposes, we run specification F using the above alternative measures of volatility (discussed in Appendix II). In addition we also run the analysis in the commonly used daily returns series of the rand / U.S. dollar exchange rate. On average the results (Table A5 and A6) are quite robust. We observe that selected commodities' price volatility, global market risk perceptions and political uncertainty play a significant role in driving rand volatility. In addition macroeconomic surprises (mainly those originating from the United States, Advanced economies and EMs) also have an influence on driving rand volatility although the evidence is less significant.

Table A5. Specification E using alternative measures of volatility

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	SAVID	Standard Deviation	GARCH (1,1)	GARCH (2,2)	Component GARCH with a trend	Returns
Constant	8.511*	0.369*	0.037	0.068	0.074	-0.064*
SA ESI (#)	0.001	0.001***	-0.001	-0.002**	-0.002**	0.000
USA ESI	0.013*	0.002*	-0.001	-0.001	-0.001	0.000
EU ESI	-0.004	-0.001***	-0.001	-0.001	-0.001	0.001*
China ESI	0.002	0.000	0.000	0.000	0.000	0.000
Exported Commodities	1.034*	0.092*	0.136*	0.131*	0.125*	-0.020*
Brent crude	0.992*	0.101*	0.121*	0.119*	0.114*	0.036*
VIX	0.221*	0.010*	0.026*	0.025*	0.026*	-0.003*
Political uncertainty	0.048*	0.005*	0.006*	0.006**	0.006*	0.001*
R-squared	0.73	0.74	0.62	0.56	0.55	0.31
Adjusted R-squared	0.73	0.74	0.61	0.56	0.55	0.31
S.E. of regression	1.56	0.12	0.25	0.27	0.27	0.07
Sum squared resid	3787.84	21.37	99.30	117.33	114.73	7.70
Log likelihood	-2913.66	1140.46	-62.43	-193.08	-175.52	1940.02
F-statistic	537.07	550.62	208.51	165.61	161.32	58.50
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Prob(Wald F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Akaike info criterion	3.73	-1.45	0.10	0.26	0.24	-2.46
Schwarz criterion	3.76	-1.41	0.14	0.31	0.29	-2.42
Hannan-Quinn criter.	3.74	-1.43	0.11	0.28	0.26	-2.44

All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

Table A6. Analysis with Country Groupings: Using alternative measures of volatility

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	SAVID	Standard Deviation	GARCH (1,1)	GARCH (2,2)	Component GARCH with a trend	Returns
Constant	8.786*	0.451*	0.168*	0.184**	0.186*	-0.089*
SA ESI (#)	0.000	0.000	0.000	0.000	0.000	0.000
G10 ESI	0.017**	0.001***	0.000	0.000	0.000	0.001
EMs ESI	-0.020**	-0.003*	-0.007*	-0.007*	-0.007*	0.001*
Exported Commodities	1.083*	0.106*	0.152*	0.144*	0.137*	-0.022*
Brent crude	1.290*	0.124*	0.092*	0.086*	0.081*	0.036*
VIX	0.199*	0.007*	0.028*	0.028*	0.028*	-0.003*
Political uncertainty	0.052*	0.007*	0.006*	0.005*	0.005*	0.001***
R-squared	0.74	0.75	0.64	0.57	0.56	0.17
Adjusted R-squared	0.73	0.74	0.64	0.57	0.56	0.16
S.E. of regression	1.56	0.12	0.25	0.27	0.27	0.08
Sum squared resid	3765.11	20.77	93.88	114.25	112.30	9.33
Log likelihood	-2907.59	1161.36	-18.98	-172.64	-159.20	1787.91
F-statistic	618.54	653.68	391.85	298.29	288.03	44.03
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Prob(Wald F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Akaike info criterion	3.73	-1.47	0.03	0.23	0.21	-2.27
Schwarz criterion	3.75	-1.45	0.06	0.26	0.24	-2.25
Hannan-Quinn criter.	3.74	-1.46	0.04	0.24	0.22	-2.26

All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

C. Robustness depending on whether the rand is appreciating or depreciating

One question that could rise is whether the results in Column F are robust depending on whether the rand is appreciating or depreciating. In order to investigate this question, we run specification F including a dummy variable interaction, taking the value of 1 for a period when the rand appreciating (Table A7). The results suggest that, regardless of whether the rand is appreciating or depreciating, and increase in surprises originating from the United States, exported and imported commodity price volatility, the VIX and local political uncertainty increase rand volatility. However, we find that when the rand is depreciating, and increase in the VIX lead to greater volatility compared to if the rand is appreciating.

Table A7. Specification F with dummy variable refereeing to appreciation of the Rand

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	Variable	Coefficient
Dummy variable interaction for appreciating Rand	Constant	8.538*
	USA ESI	0.014*
	Exported Commodities	1.029*
	Brent crude	1.086*
	VIX	0.196*
	Political uncertainty	0.056*
	USA ESI	-0.001
	Exported Commodities	0.026
	Brent crude	-0.188
	VIX	0.033**
	Political uncertainty	0.001
	R-squared	0.73
	Adjusted R-squared	0.73
	S.E. of regression	1.56
	Sum squared resid	3794.82
	Log likelihood	-2915.10
	F-statistic	428.03
	Prob(F-statistic)	0.00
	Prob(Wald F-statistic)	0.00
	Akaike info criterion	3.74
	Schwarz criterion	3.77
	Hannan-Quinn criter.	3.75

* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Note: All commodities are expressed in commodity price daily returns volatility as
Source: Authors calculations

D. Asymmetry between positive and negative surprises (ESIs)

We were also interested on finding whether there is asymmetry in the impact of good (positive) and bad (negative) surprises on rand volatility, in our preferred specification. For this purpose, we added the interaction between the absolute value of the United States ESI and dummy variable D_{ESI_i} taking the value of 1 for positive United States ESI values and the value of 0 for negative United States ESI values.

$$\sigma_{ERR_t} = \alpha + \beta\left|ESI_{US,t}\right| + \gamma D_{ESI_{US,i}} * \left|ESI_{i,t}\right| + \sum_{c=1}^{n} \delta_i COM + \varphi VIX + \varphi PU + u_t$$

The results reject the presence of such kind of asymmetry. In particular, both good and bad United States ESIs increase rand volatility equally—with the coefficient of the dummy interaction statistically insignificant.

E. Lagged dependent

As part of our sensitivity analysis, we add a lagged depended variable (rand / U. S. dollar volatility) into our preferred specification (Table A8).

Table A8. Adding a lag-dependent variable to our selected specifications

Method: Ordinary Least Squares (OLS)
Sample: 8/24/2009 8/24/2015, Included observations: 1566
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 8.0000)

	A	B	C	D	E
Constant	0.241*	0.334**	0.299*	0.238*	0.497*
SA ESI (#)	0.001				0.000
USA ESI	0.000				0.000
EU ESI	0.001				-0.001
China ESI	0.000				0.000
Exported Commodities		0.027***			0.0452*
Brent crude		0.068**			0.034
VIX			0.026*		0.030*
Political uncertainty				-0.001	0.000
SAVID (-1)	0.981*	0.971*	0.950*	0.985*	0.931*
R-squared	0.97	0.97	0.97	0.97	0.97
Adjusted R-squared	0.97	0.97	0.97	0.97	0.97
S.E. of regression	0.51	0.51	0.50	0.51	0.50
Sum squared resid	403.6	403.1	385.82	405.50	381.47
Log likelihood	-1160.4	-1159.5	-1125.14	-1164.10	-1116.26
F-statistic	10696.3	17872.3	28063.39	26663.42	6281.15
Prob(F-statistic)	0.00	0.00	0.00	0.00	0.00
Prob(Wald F-statistic)	0.00	0.00	0.00	0.00	0.00
Akaike info criterion	1.49	1.49	1.44	1.49	1.44
Schwarz criterion	1.51	1.50	1.45	1.50	1.47
Hannan-Quinn criter.	1.50	1.49	1.44	1.49	1.45

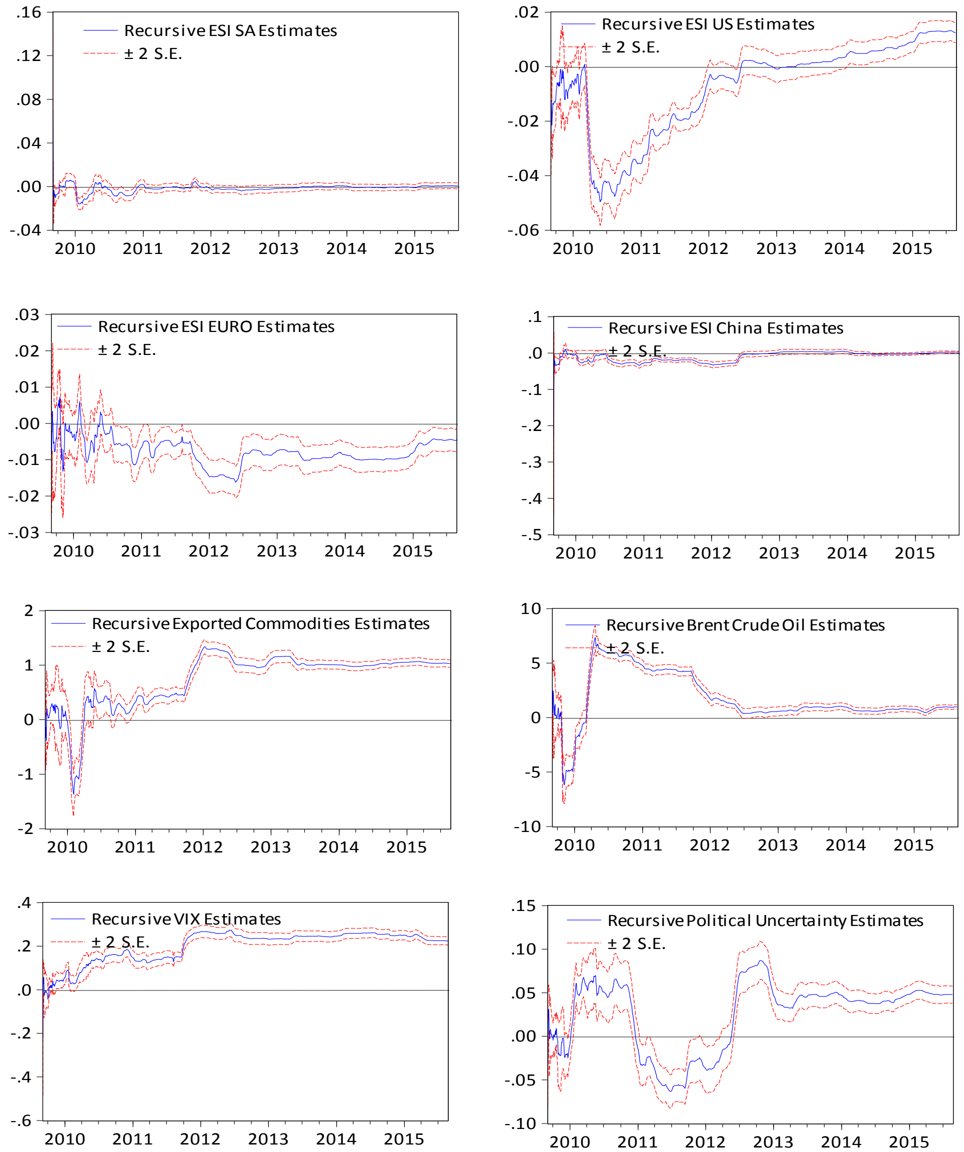
All Surprises (ESI) are in absolute values
* denotes significance at the 1%, ** at the 5% and *** at the 10% level of significance
Source: Authors calculations

We find that volatility tends to be persistent at best, such that periods of high (low) volatility are usually followed by periods of high (low) volatility; a finding consistent with Hassan (2012) and Mpofu (2016), which present significant evidence of high exchange rate volatility persistence and clustering in the US Dollar exchange rate returns following exogenous shocks a finding consistent with Duncan and Liu (2009). In general the coefficient of lagged volatility is positive and statistically significant, while most surprise indices and commodity price volatility coefficients turn insignificant. However, the effect of global volatility on the rand / U.S. dollar exchange remains statistically significant.

F. Time-varying coefficients

Similar to previous studies, we investigate whether the relationship between the rand / U.S. dollar exchange rate volatility and economic surprises has changed over the sample period under investigation. We re-estimate our preferred specification F in Tables 1, using a recursive least squares framework. Similar to other studies (Fedderke and Flamand, 2005); we find that the responsiveness of rand volatility to macroeconomic surprises, commodity price, and global volatility, has changed over time. However, we cannot identify a common break in the series.

Figure A3. Recursive Ordinary least squares estimates of preferred specification



Source: Authors' calculations

For most regressors, the estimated coefficient differs between the initial phase of the sample period (2009/2010) marked by the onset of the global financial crisis and the late period (Figure A3). A noteworthy development is the change in effect of surprises from the United States: in particular we observe that surprises from the Unites States switched from contributing to a decline on the rand volatility to increasing volatility since mid 2013, which coincides with the period of tapering of quantitative easing, as the United States showed signs of revival. This is consistent with the rationale that in the period immediately following the global financial crisis, when the global economy was under distress; surprises (mostly negative) from the United States should increase uncertainty and lead investors to emerging markets. Meanwhile, under quantitative easing surprises from the United States (which are on average mostly positive) is bad for South Africa (as an emerging market), because it means investors should relocate their funds back to safer heavens.

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