Question 5: Volatility and GARCH estimates

Andrew Hyde

2022-11-26

Introduction

The South African Rand (ZAR) over the past few years has been label one of the most volatile currencies. This report seeks to investigate this claim.

Volatility of the South African Rand

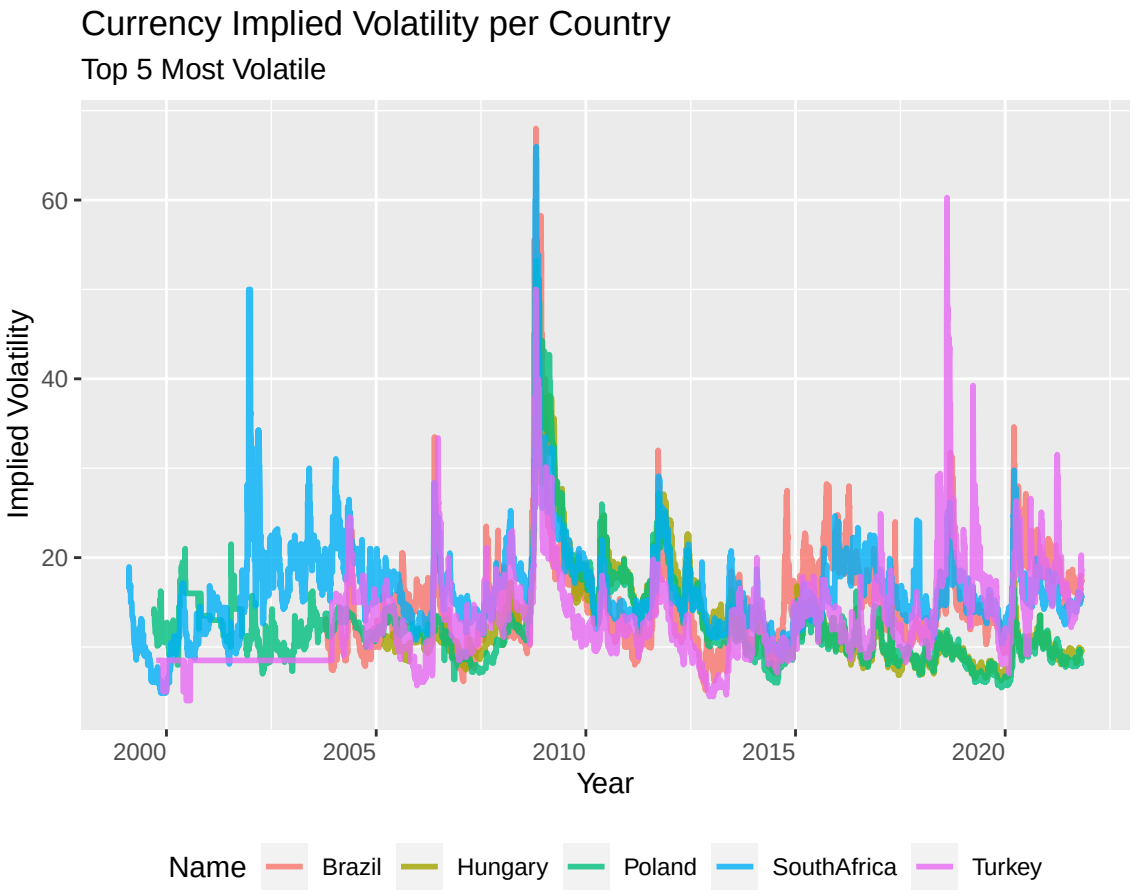
Making use of the Currency Implied Volatility data, I arrange the currencies in descending order of average implied volatility from 1933 to 2021. Implied volatility is constructed using both option premiums to gauge the market foresees higher future volatility for a currency. From the table below one can see that the South African Rand has the largest average implied volatility from the sample of all countries. The table displays the 10 currencies with the highest average implied volatility.

Table 1: Implied Volatility

Name	Value
SouthAfrica	16.30
Brazil	15.12
Hungary	12.89
Turkey	12.87
Poland	12.58
Columbia	12.25
Russia	12.21
NZ	11.98
Mexico	11.49
Norway	11.37

Averages may be misleading, therefore I plot the the implied volatility of the top 5 most volatile currencies to get a sense of if the Rand has been consistently been the most volatile or the average is high because of historically high period with in the full data set.

From the graph below it appears that the Rand experienced large price swings in the early 2000's compared to its counter parts, but since then has had relatively similar performance to the other plotted currencies.



I therefore reduce the sample period to the last 5 years in order to determine if currency has been one of the most volatile in recent years. Below display a table of the currency implied volatility data set from 2016 to 2021 and arrange the currencies in descending order of average implied volatility.

Table 2: Implied Volatility

Name	Value
Turkey	16.54
SouthAfrica	15.93
Brazil	15.67
Columbia	13.12
Mexico	13.06
Russia	12.30
Chile	10.98
Norway	9.89
Hungary	9.20
NZ	9.11

From both tables and graph, the South African Rand appears to be the most volatile according to how the market foresees the Rand will behave.

Q5.2 GARCH estimates

The question therefore becomes how much of the Rand's volatility is actually volatility related to the information and market forces at a particular time and not on the momentum of previous periods of volatility momentum from previous periods, given that periods of volatility tends to cluster and may not give an accurate measure of volatility at that point in time due this persistence.

I therefore make use of a GARCH model to calculate volatility estimates by decomposing the residuals of currency into its structural volatility estimates and noise.

I begin by testing the for stationary and find as expected the Rand-Dollar exchange rate is non stationary, as the absolute value of the test statistic does not exceed the absolute value of the critical value.

```
##
## ###############################################
## # Augmented Dickey-Fuller Test Unit Root Test #
## ###############################################
##
## Test regression none
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 - 1 + z.diff.lag)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.78612 -0.03347 -0.00043  0.03007  1.52714
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## z.lag.1     0.0001139  0.0001171   0.972    0.331
## z.diff.lag -0.0074499  0.0109781  -0.679    0.497
##
## Residual standard error: 0.09566 on 8301 degrees of freedom
## Multiple R-squared:  0.0001661,  Adjusted R-squared:  -7.482e-05
## F-statistic: 0.6894 on 2 and 8301 DF,  p-value: 0.5019
##
##
## Value of test-statistic is: 0.9723
##
## Critical values for test statistics:
##       1pct  5pct 10pct
## tau1 -2.58 -1.95 -1.62
```

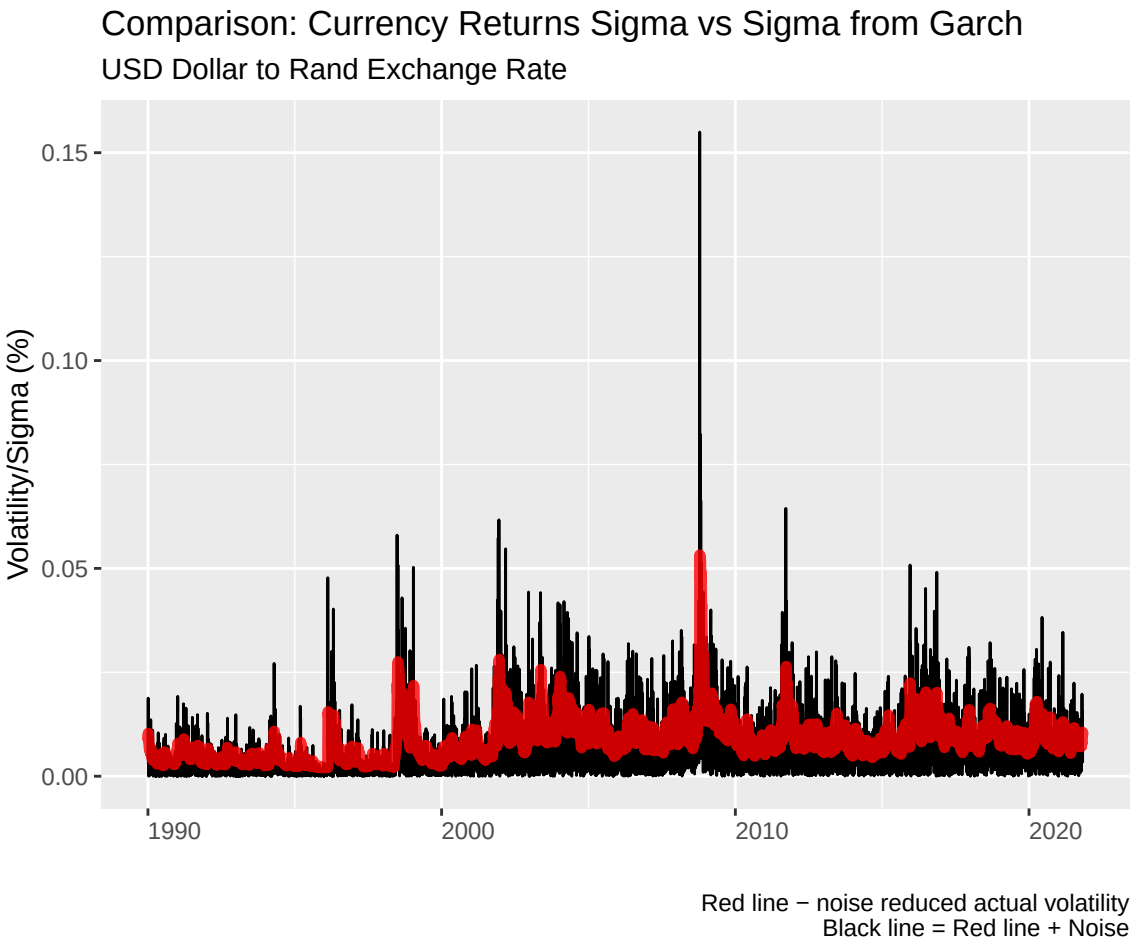
I make use of the Rand-Dollar exchange rate begin by wrangling, scale and calculating the log first differences of the Rand data to make the data stationary so I can make can accurately determine GARCH estimates.

I then test for stationary again and find as expected the transformed Rand-Dollar exchange rate stationary, as the absolute value of the test statistic does exceed the absolute value of the critical value. Therefore, the errors are now white noise.

```
##
## ###############################################
## # Augmented Dickey-Fuller Test Unit Root Test #
## ###############################################
```

```
##
## Test regression none
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 - 1 + z.diff.lag)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.066516 -0.004618 -0.000208  0.004098  0.153965
##
## Coefficients:
##            Estimate Std. Error t value Pr(>|t|)
## z.lag.1    -1.03747    0.01564 -66.324   <2e-16 ***
## z.diff.lag  0.02124    0.01097   1.935    0.053 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009462 on 8300 degrees of freedom
## Multiple R-squared:  0.5082, Adjusted R-squared:  0.508
## F-statistic:  4288 on 2 and 8300 DF,  p-value: < 2.2e-16
##
##
## Value of test-statistic is: -66.3237
##
## Critical values for test statistics:
##       1pct  5pct 10pct
## tau1 -2.58 -1.95 -1.62
```

I amend some code from the practicals and nested it within a graphing function to render a comparison between the currency returns sigma, which contains noise and is plotted on the graph in black, and the noise reduced Sigma estimate from the GARCH model plotted in red. Therefore, the volatility of the Rand maybe be overstated before controlling for noise.


Comparison: Currency Returns Sigma vs Sigma from Garch
USD Dollar to Rand Exchange Rate
Volatility/Sigma (%)
0.15
0.10
0.05
0.00
1990
2000
2010
2020
Red line − noise reduced actual volatility
Black line = Red line + Noise