Time Series Research Assignment

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Abstract

Abstract to be written here.

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1. Introduction

The aim of this paper is to replicate the work done by 1. They analyse the determinants of the Real Effective Exchange Rate (REER) based on a collection of variables as determinants. The purpose of their study was to find a set of variables with explanatory power in determining the long term behaviour of the REER in South Africa over the period starting from the first quarter of the year 1970 until the first quarter of the year 2002. Towards this end, they made use of the Maximum Likelihood method of estimating the Vector Error Correction Model (VECM) from the paper by Johansen (1995).

- What did I do? This paper is a replication and critical evaluation of the research paper by

1.

- why did I do this?

2. Literature Review

2.1. What did the Authors do?

2.2. Motivation

- Importance
- Methods
- Novel Contribution(s)

2.3. Critical Evaluation

- Robustness checks/extensions

Replication

3. Importing and Cleaning the Data

```
full_df <- fetch_full() %>% full_clean()
full_df
```

```
## # A tibble: 129 x 20
##    date       LREERS    RIRR LRGDPPCR OPENY  FBYA NFAOFPY LPR2COMM5 LPRCOMM5
##    <date>      <dbl>   <dbl>    <dbl> <dbl> <dbl>   <dbl>     <dbl>    <dbl>
##  1 1970-03-31   4.59 -0.541      0.670  44.8 -5.62    7.41    -0.734   -0.851
##  2 1970-06-30   4.58 -0.0509     0.663  46.1 -1.94    6.92    -0.729   -0.849
##  3 1970-09-30   4.59 -0.707      0.632  47.9 -1.55    6.29    -0.747   -0.875
##  4 1970-12-31   4.59  0.906      0.637  46.8 -3.49    5.12    -0.703   -0.846
##  5 1971-03-31   4.59  1.54       0.675  47.5 -6.51    4.40    -0.690   -0.825
##  6 1971-06-30   4.60  0.628      0.651  47.3 -4.91    3.86    -0.659   -0.792
##  7 1971-09-30   4.59  1.09       0.643  46.9 -5.09    3.11    -0.675   -0.795
##  8 1971-12-31   4.56  0.301      0.624  47.4 -7.57    2.87    -0.653   -0.749
##  9 1972-03-31   4.49  0.117      0.625  45.7 -4.69    3.33    -0.591   -0.665
## 10 1972-06-30   4.50 -0.0238     0.617  47.4 -8.77    4.63    -0.407   -0.481
## # ... with 119 more rows, and 11 more variables: LPR2COMM3 <dbl>,
## #   LPRCOMM3 <dbl>, LPR2GOLD <dbl>, LPRGOLD <dbl>, SDUMC1 <dbl>, SDUMC2 <dbl>,
## #   SDUMC3 <dbl>, DUMRER1 <dbl>, DUMRER2 <dbl>, DUMFBYA <dbl>, DUMNFAOFPY <dbl>
```

3.1. Variable Names (SECTION TO BE DELETED)

```
as_tibble(names(full_df))
```

```
## # A tibble: 20 x 1
##    value
##    <chr>
##  1 date
##  2 LREERS
##  3 RIRR
##  4 LRGDPPCR
##  5 OPENY
##  6 FBYA
##  7 NFAOFPY
##  8 LPR2COMM5
```

```
##  9 LPRCOMM5
## 10 LPR2COMM3
## 11 LPRCOMM3
## 12 LPR2GOLD
## 13 LPRGOLD
## 14 SDUMC1
## 15 SDUMC2
## 16 SDUMC3
## 17 DUMRER1
## 18 DUMRER2
## 19 DUMFBYA
## 20 DUMNFAOFPY
```

4. Plotting the Variables of Interest (STEP 0.)

All variables appear as they were before their natural logarithm was determined.

4.1. Plotting the Variables:

```r
# p1 <- plot_endog1(full_df)
# p2 <- plot_endog2(df = full_df)
plot_endog1(full_df)
```

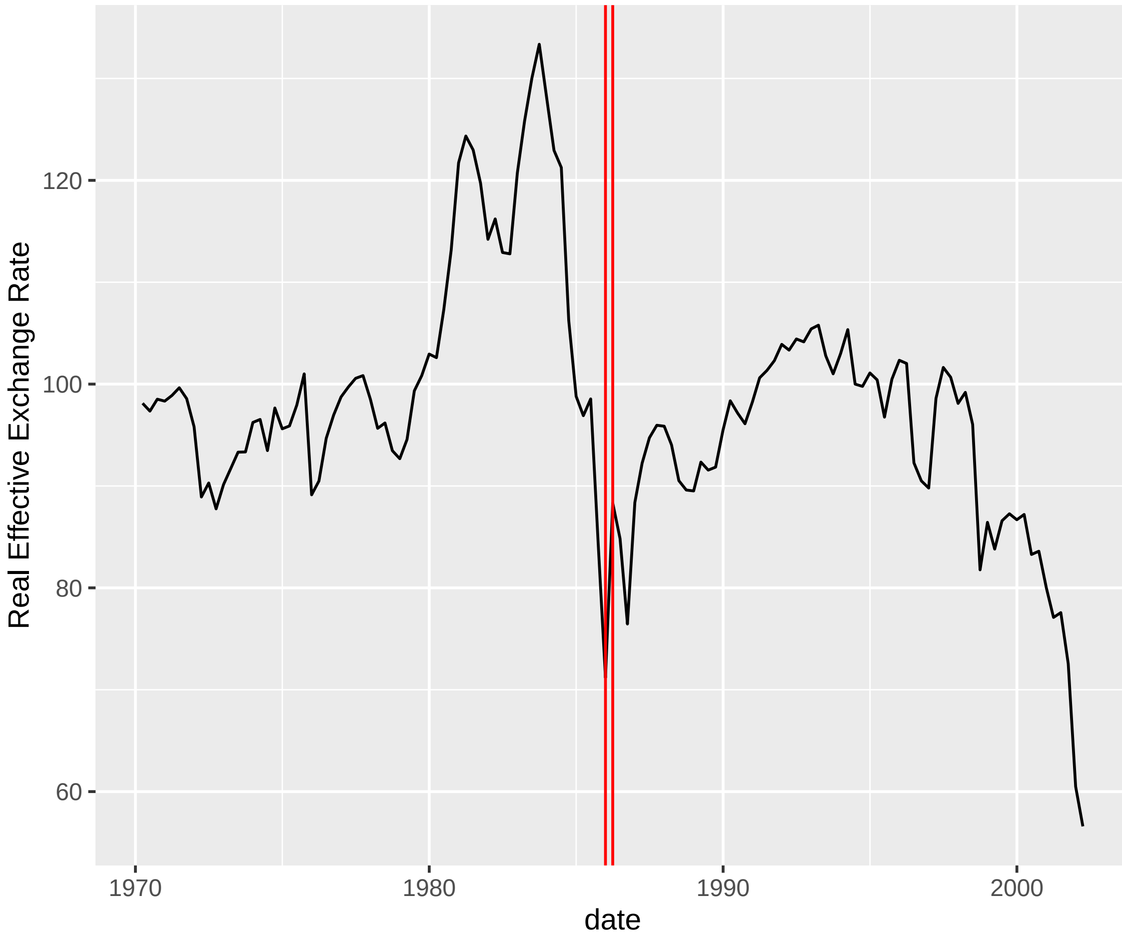


Figure 4.1: The South Africa Real Exchange Rate

```
# grid.arrange(p1, p2, nrow=2)
```

```
plot_endog2(df = full_df)
```

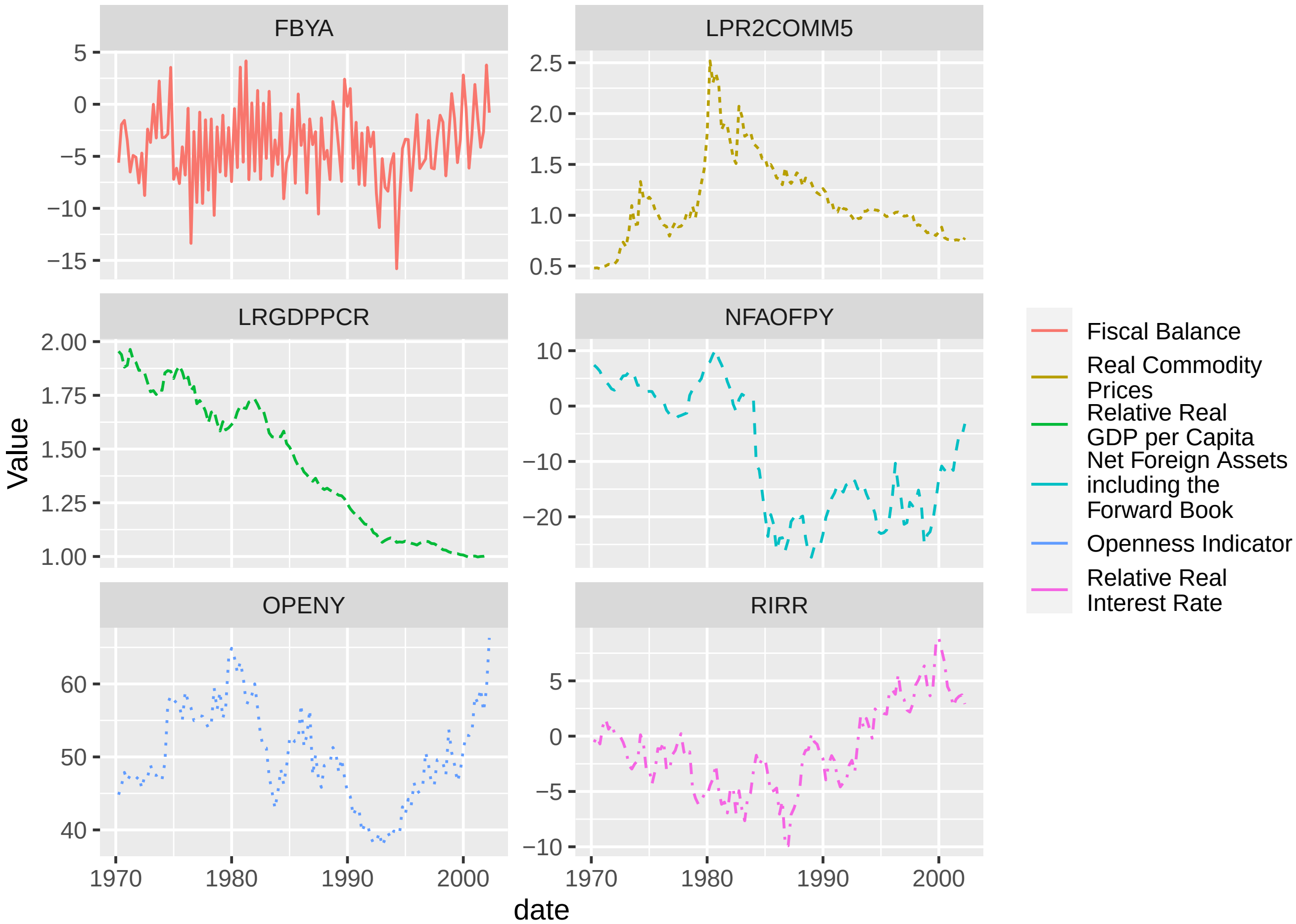
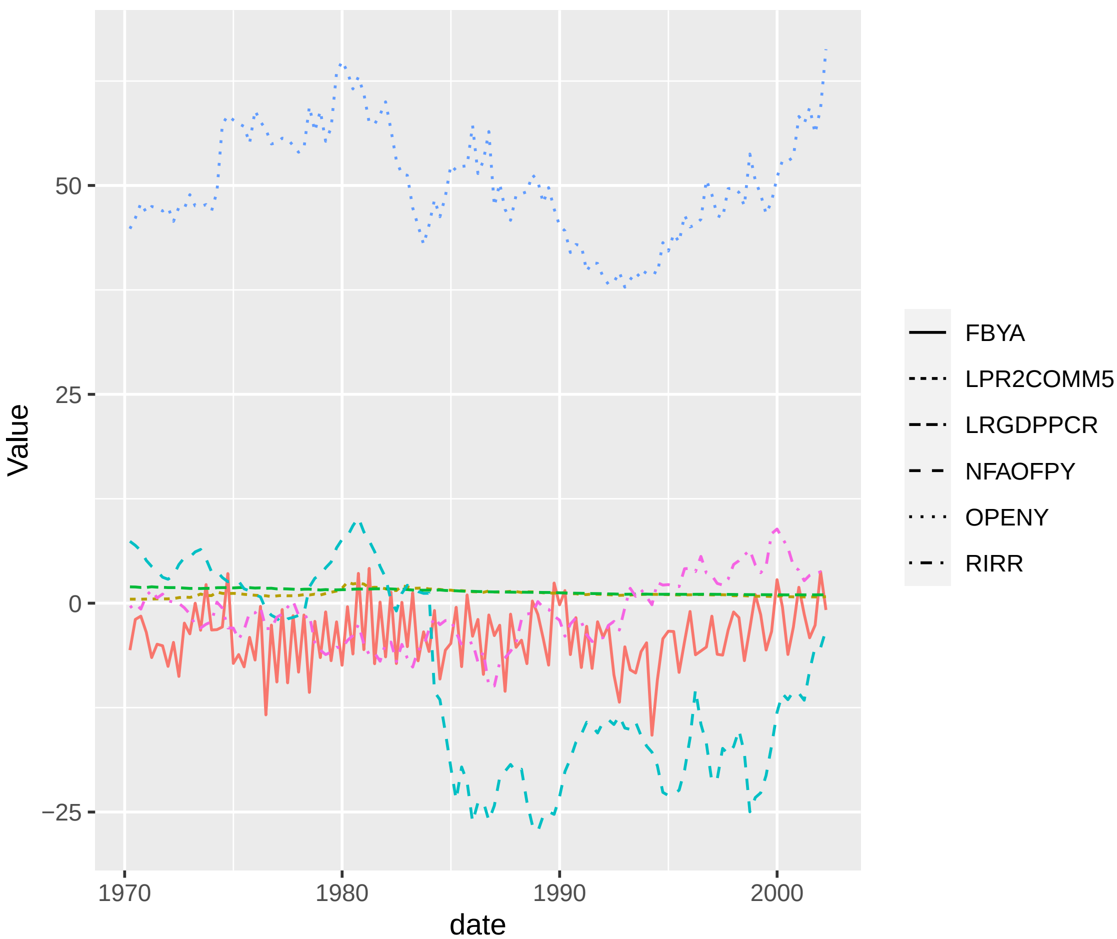


Figure 4.2: Determinants of the Real Exchange Rate for South Africa

```
plot_endog2_joint(df = full_df)
```



explain the plots above

5. The Johansen Method

explain johansen method

The Johansen (1995) method requires six steps in the estimation process, which follows as:

1. Choosing a specification for the deterministic parts of the model
2. Pre-testing the variables in the system to ensure that they are likely integrated of order one (i.e. $x_t \sim I(1)$$)
3. Estimating the unrestricted Vector Autoregressive model in levels and checking this models adequacy
4. Estimating the VECM form and determining the cointegration rank (i.e. ‘r’)
5. etc.

5.1. Plotting the Diffirenced Variables (STEP 1.)

```
diff_df <- full_df %>% mutate(across(names(.)[2:13], function(x) x-lag(x))) %>%
    filter(date > first(date))
plot_endog1(diff_df)
```

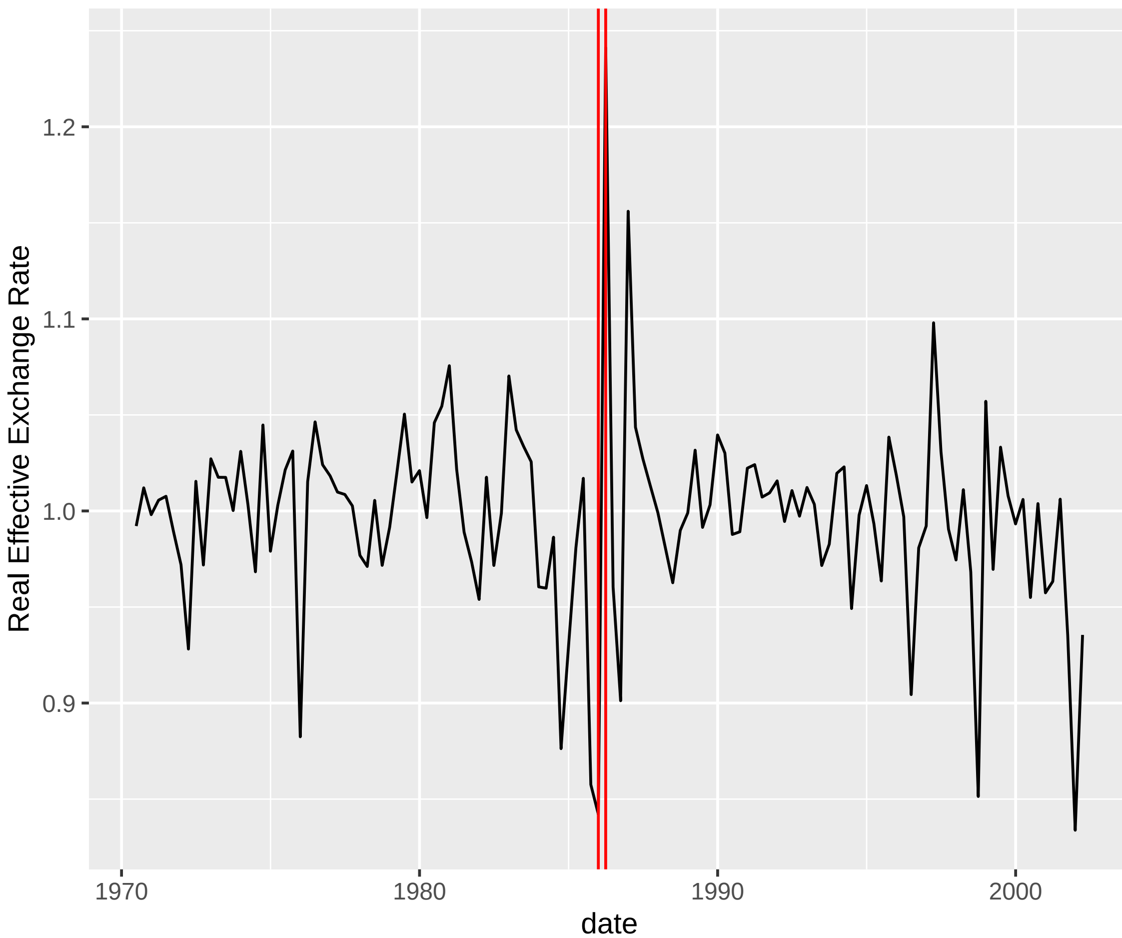


Figure 5.1: The First Difference of the Real Exchange Rate Time Series

```
plot_endog2(df = diff_df)
```

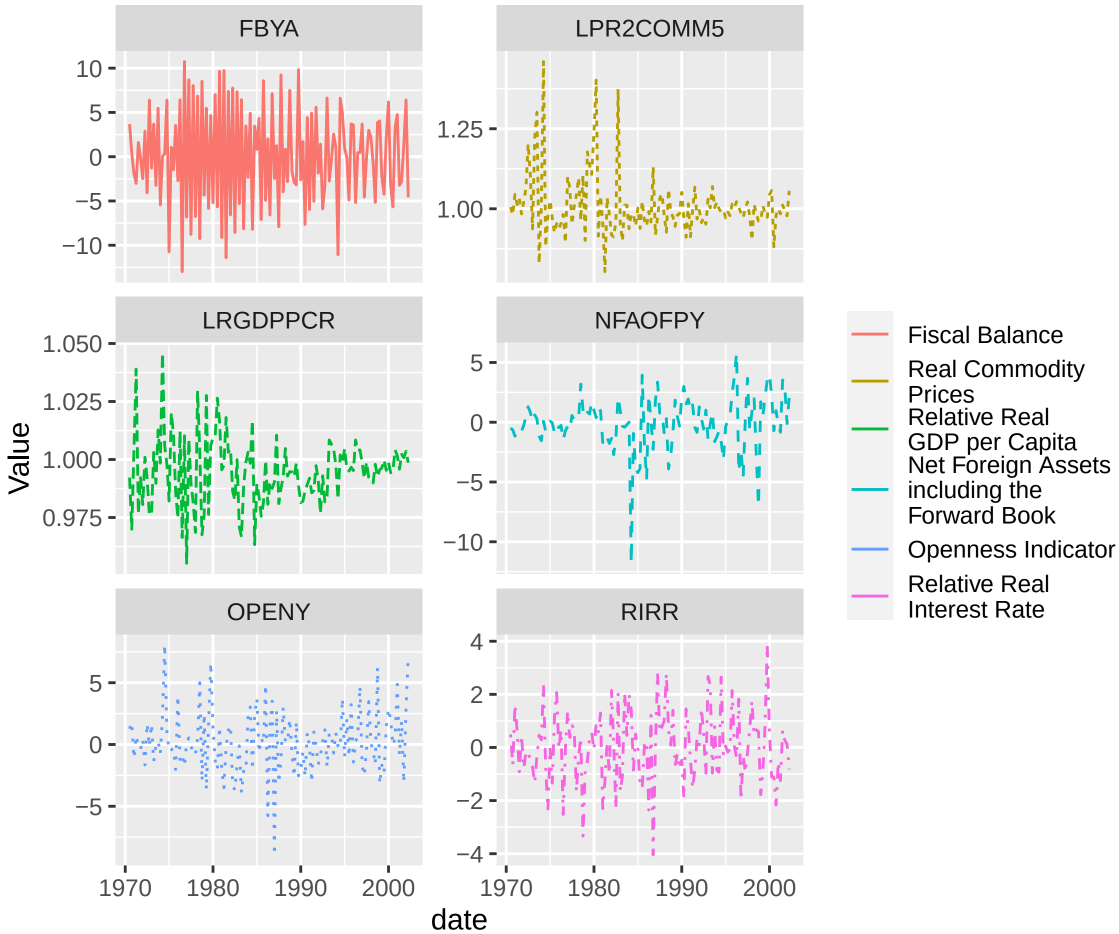


Figure 5.2: The First Difference of the Determinants of the Real Exchange Rate

figures 5.2 and 5.1 above suggests that the REER time series is most likely integrated of the first order (i.e. $REER \sim I(1)$), and includes a constant term.

To test this hypothesis, the Augmented Dickey Fuller test is employed. The p-value for each of the differenced time series is less than 0.05 and thus the null hypothesis is rejected, and we can conclude that these series are all stationary after one difference

The Augmented Dicky-Fuller tests for the differenced time series values of all the variables in the system, as well as the first difference of each of these series are displayed in figures **??** and **??** below.

```
# Better format this later
joint_adf_test <- joint_adf(full_df)
# knitr::kable(joint_adf_test)
joint_adf_test
```

```
##                                      RIRR              OPENY              FBYA
## statistic               -2.38462381354433 -1.41520930294888 -2.78464219204947
## Lag order                               5                 5                 5
## Alternative Hypothesis         stationary        stationary        stationary
## p.value                 0.416625588494009 0.819624761470709  0.25033235278204
##                                   NFAOFPY             LREERS          LRGDPPCR
## statistic               -0.726702534543652 -1.60754795387395 -2.35890115070675
## Lag order                                5                 5                 5
## Alternative Hypothesis          stationary        stationary        stationary
## p.value                  0.965806321320507 0.739666893698904 0.427318859264153
##                                 LPR2COMM5          LPRCOMM5         LPR2COMM3
## statistic               -2.41968238737432 -2.70975599360111 -2.50126679665837
## Lag order                               5                 5                 5
## Alternative Hypothesis         stationary        stationary        stationary
## p.value                 0.402051248926356 0.281463593043258 0.368135468720973
##                                  LPRCOMM3          LPR2GOLD           LPRGOLD
## statistic               -2.83555524551097 -2.47972355133744 -2.78418176316389
## Lag order                               5                 5                 5
## Alternative Hypothesis         stationary        stationary        stationary
## p.value                 0.229167084246809 0.377091297164509 0.250523759510613
```

The Augmented Dicky-Fuller tests for the differenced time series values of all the variables in the system are displayed in figure **??** below.

```
# Better format this later
joint_adf_test <- joint_adf_diff(full_df)
# knitr::kable(joint_adf_test)
joint_adf_test
```

```
##                                      RIRR               OPENY              FBYA
## statistic               -5.10084175770901  -3.76672305393889 -6.18347214444395
## Lag order                               5                  5                 5
## Alternative Hypothesis         stationary         stationary        stationary
## p.value                              0.01 0.0228622783611834              0.01
##                                   NFAOFPY             LREERS          LRGDPPCR
## statistic               -0.723559520045346 -5.21343979738062 -4.07675332825604
## Lag order                                5                 5                 5
```

```
## Alternative Hypothesis         stationary        stationary        stationary
## p.value                  0.966075042853094              0.01              0.01
##                                 LPR2COMM5          LPRCOMM5         LPR2COMM3
## statistic                -5.26358049519449 -5.69103704497667 -5.21681313467281
## Lag order                                5                 5                 5
## Alternative Hypothesis          stationary        stationary        stationary
## p.value                               0.01              0.01              0.01
##                                  LPRCOMM3          LPR2GOLD           LPRGOLD
## statistic                -5.73704796302016 -5.35199824805661 -5.81245247692998
## Lag order                                5                 5                 5
## Alternative Hypothesis          stationary        stationary        stationary
## p.value                               0.01              0.01              0.01
```

Figures **??** and **??** therefore confirm that none of the variables are stationary, and that all but `NFAOFPY` i.e. the net foreign assets are stationary after the first difference. For those that are stationary, the null hypothesis was rejected at the 1% significance level, barring the openness indicator. This might be due to the irregular behaviour created by the apartheid era sanctions (MacDonald & Ricci, 2004).

5.2. VECM Model Estimation:

paper table 1 col's:

1. Var's + Seasonal(4) + lags(4) 2. ^{Above} *+ outlier_dummies -> Trace test* $\implies$ *two CI vectors*

Multiple ways to estimate VEC models:

First approach: ordinary least squares (yields accurate result) but does not allow to estimate the cointegrating relations among the variables. The estimated generalised least squares (EGLS) approach would be an alternative.

Most popular estimator: MLE of Johansen (1995) [In R: ca.jo function of the urca package of Pfaff (2008a)] Alternatively, ***`VECM`*** *of tsDyn package of Di Narzo et al. (2020)*

Before VECM: 1. Determine lag order p -> Det. rank of CI matrix r 2. deterministic terms have to be specified. 3. Choose lag order: est. the VAR in levels 4. Choose lag specification that minimises an Information criterion

5.2.1. Determine the Lag Order

First we split the data into the additional dummies and the main variables:

6. Estimating the Unrestricted VAR in Levels and Checking Adequacy

```r
options(scipen=999)
var_aic <- VAR(endog_df[,c(2:8)], type = "const", lag.max = 8,
               ic = "AIC", season = 4)

VARselect(endog_df[,c(2:8)], type = "const", lag.max = 8, season = 4)$selection
```

```
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      2      1      1      1
```

```r
var_aic2 <- endog_df %>% dplyr::select(2:8) %>% VAR(., type = "const", season = 4,
                                                 exogen = exog_df[,"Outliers"],
                                                 lag.max = 8, ic = "AIC")

# var_aic3 <- endog_df %>% dplyr::select(2:7 | 9) %>% VAR(., type = "const", season = 4,
#                                                   exogen = exog_df[,"Outliers"],
#                                                   lag.max = 8, ic = "AIC")
#
# var_aic4 <- endog_df %>% dplyr::select(2:7 | 10) %>% VAR(., type = "const", season = 4,
#                                                   exogen = exog_df[,"Outliers"],
#                                                   lag.max = 8, ic = "AIC")
#
# var_aic5 <- endog_df %>% dplyr::select(2:7 | 11) %>% VAR(., type = "const", season = 4,
#                                                   exogen = exog_df[,"Outliers"],
#                                                   lag.max = 8, ic = "AIC")
#
# var_aic6 <- endog_df %>% dplyr::select(2:7 | 12) %>% VAR(., type = "const", season = 4,
#                                                   exogen = exog_df[,"Outliers"],
#                                                   lag.max = 8, ic = "AIC")
#
# var_aic7 <- endog_df %>% dplyr::select(2:7 | 13) %>% VAR(., type = "const", season = 4,
#                                                   exogen = exog_df[,"Outliers"],
#                                                   lag.max = 8, ic = "AIC")

# var_aic$p; var_aic2$p; var_aic3$p; var_aic4$p; var_aic5$p; var_aic6$p; var_aic7$p
```

```
var_aic$p; var_aic2$p
```

```
## AIC(n)
##      2
```

```
## AIC(n)
##      1
```

```
# normality.test(var_aic)

options(scipen=0)
```

```
stargazer(var_aic$varresult, font.size = "tiny")
```

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Mon, Jun 27, 2022 - 11:59:39

Table 6.1

	Dependent variable:						
	y						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LREERS.l1	1.159***	3.255	−0.003	−13.827**	−10.886	7.550	−0.034
	(0.118)	(2.996)	(0.032)	(5.467)	(6.599)	(4.877)	(0.207)
RIRR.l1	−0.004	0.917***	0.001	0.533***	0.178	−0.043	−0.003
	(0.004)	(0.101)	(0.001)	(0.184)	(0.222)	(0.164)	(0.007)
LRGDPPCR.l1	0.291	3.652	0.892***	10.079	−17.329	−6.684	0.277
	(0.368)	(9.319)	(0.101)	(17.009)	(20.531)	(15.172)	(0.645)
OPENY.l1	0.003	−0.098	−0.0002	0.569***	0.062	0.027	0.001
	(0.002)	(0.060)	(0.001)	(0.110)	(0.133)	(0.098)	(0.004)
FBYA.l1	0.002	−0.050	−0.001	−0.020	−0.066	0.115*	−0.002
	(0.002)	(0.040)	(0.0004)	(0.073)	(0.089)	(0.065)	(0.003)
NFAOFPY.l1	−0.006**	0.039	−0.001	0.162	0.160	1.014***	0.003
	(0.002)	(0.063)	(0.001)	(0.114)	(0.138)	(0.102)	(0.004)
LPR2COMM5.l1	0.035	−1.098	0.022	4.044	3.349	1.451	0.882***
	(0.056)	(1.406)	(0.015)	(2.566)	(3.097)	(2.288)	(0.097)
LREERS.l2	−0.298**	−0.091	−0.030	5.796	0.424	−9.308*	0.023
	(0.124)	(3.140)	(0.034)	(5.732)	(6.919)	(5.113)	(0.217)
RIRR.l2	0.001	−0.077	−0.001	−0.299*	0.105	−0.104	−0.006
	(0.004)	(0.097)	(0.001)	(0.177)	(0.214)	(0.158)	(0.007)
LRGDPPCR.l2	−0.294	−6.154	0.078	−9.080	19.048	4.244	−0.360
	(0.367)	(9.279)	(0.100)	(16.935)	(20.442)	(15.106)	(0.642)
OPENY.l2	−0.004*	0.115**	−0.00001	0.298***	−0.094	0.063	−0.0002
	(0.002)	(0.057)	(0.001)	(0.104)	(0.126)	(0.093)	(0.004)
FBYA.l2	−0.001	0.008	0.001	−0.088	0.298***	0.061	−0.0004
	(0.002)	(0.041)	(0.0004)	(0.074)	(0.090)	(0.066)	(0.003)
NFAOFPY.l2	0.006**	−0.037	0.002***	−0.081	−0.104	−0.048	−0.001
	(0.003)	(0.065)	(0.001)	(0.118)	(0.143)	(0.105)	(0.004)
LPR2COMM5.l2	−0.014	−0.383	−0.012	−1.349	1.429	−3.885	0.015
	(0.059)	(1.498)	(0.016)	(2.734)	(3.300)	(2.439)	(0.104)
const	0.708	−14.683	0.168	43.635**	46.235*	4.672	0.029
	(0.433)	(10.962)	(0.119)	(20.008)	(24.151)	(17.847)	(0.758)
sd1	0.026*	−0.404	0.006	−0.512	−0.272	0.072	0.030
	(0.015)	(0.380)	(0.004)	(0.694)	(0.838)	(0.619)	(0.026)
sd2	0.007	−0.304	0.003	−0.305	−3.987***	−0.128	0.017
	(0.014)	(0.365)	(0.004)	(0.667)	(0.805)	(0.595)	(0.025)
sd3	0.007	−0.496	−0.003	0.596	0.219	0.032	0.008
	(0.016)	(0.416)	(0.005)	(0.760)	(0.918)	(0.678)	(0.029)
Observations	127	127	127	127	127	127	127
R^2	0.872	0.910	0.997	0.893	0.499	0.972	0.942
Adjusted R^2	0.852	0.895	0.996	0.877	0.421	0.967	0.933
Residual Std. Error (df = 109)	0.050	1.269	0.014	2.316	2.796	2.066	0.088
F Statistic (df = 17; 109)	43.511***	64.498***	2,058.637***	53.747***	6.391***	219.211***	104.377***

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

```r
vec <- ca.jo(full_df[,2:8], type = "trace", ecdet = "const", spec = "transitory",
             K = 2, season = 4)

summary(vec)
```

```
##
## ######################
## # Johansen-Procedure #
## ######################
##
## Test type: trace statistic , without linear trend and constant in cointegration
##
## Eigenvalues (lambda):
## [1]  3.226452e-01  3.056645e-01  1.957155e-01  1.380763e-01  1.252489e-01
## [6]  6.903593e-02  5.055723e-02 -3.763868e-17
##
## Values of teststatistic and critical values of test:
##
##             test  10pct   5pct   1pct
## r <= 6 |   6.59   7.52   9.24  12.97
## r <= 5 |  15.67  17.85  19.96  24.60
## r <= 4 |  32.67  32.00  34.91  41.07
## r <= 3 |  51.54  49.65  53.12  60.16
## r <= 2 |  79.20  71.86  76.07  84.45
## r <= 1 | 125.53  97.18 102.14 111.01
## r = 0  | 175.00 126.58 131.70 143.09
##
## Eigenvectors, normalised to first column:
## (These are the cointegration relations)
##
##                 LREERS.l1      RIRR.l1   LRGDPPCR.l1     OPENY.l1      FBYA.l1
## LREERS.l1     1.000000000  1.000000000  1.0000000000  1.000000000  1.000000000
## RIRR.l1      -0.028700319 -0.024832003 -0.0495351536  0.021426382 -0.032714540
## LRGDPPCR.l1   0.036839401 -0.370381932 -0.4847935498  0.295296964 -0.705186836
## OPENY.l1      0.007083864  0.015689214 -0.0202890136  0.008264062  0.024737869
## FBYA.l1       0.004686594  0.062055423  0.0416485377  0.003981405 -0.023526482
## NFAOFPY.l1   -0.010493007 -0.007671979  0.0186247167 -0.011039635 -0.003311103
```

```
## LPR2COMM5.l1 -0.433148353 -0.541501295 -0.0003179585  0.075812986 -0.459041247
## constant     -4.937606070 -5.068744743 -3.2353710895 -5.156065474 -5.757600576
##                NFAOFPY.l1 LPR2COMM5.l1    constant
## LREERS.l1      1.000000000   1.00000000  1.00000000
## RIRR.l1        0.022186671   0.00613396  0.06235873
## LRGDPPCR.l1    0.055693378  -9.61680383  3.43526556
## OPENY.l1       0.012034159  -0.21501124 -0.05679878
## FBYA.l1       -0.004572458   0.02671456 -0.01887175
## NFAOFPY.l1     0.003215153   0.13330577 -0.05313833
## LPR2COMM5.l1 -0.298025061   0.43627745 -0.80240394
## constant     -5.115763263  10.93501505 -3.70871207
##
## Weights W:
## (This is the loading matrix)
##
##               LREERS.l1      RIRR.l1  LRGDPPCR.l1    OPENY.l1      FBYA.l1
## LREERS.d    -0.00286803 -0.002602126  0.012393665 -0.06876437 -0.009481427
## RIRR.d       2.12912596 -0.433127933  0.457821314 -0.65467733  1.972233716
## LRGDPPCR.d  -0.05402128  0.007310749  0.007383926 -0.01353346  0.017934595
## OPENY.d     -2.03071208 -1.949346974 -0.819573151 -2.11279742 -2.898615836
## FBYA.d      -3.31500289 -9.478800392 -1.690391800  0.20254767  4.016673670
## NFAOFPY.d   -0.93652609  4.589800555 -1.683084324 -3.35243843  1.148575527
## LPR2COMM5.d  0.09410192 -0.007165251  0.013707118 -0.23704970  0.059333145
##               NFAOFPY.l1  LPR2COMM5.l1      constant
## LREERS.d    -0.065372441 -0.0020741294 -2.289277e-15
## RIRR.d      -0.402231684  0.0949009978  3.398530e-14
## LRGDPPCR.d   0.002045853  0.0005199018 -2.959589e-16
## OPENY.d      1.617659874  0.1617752611 -8.358618e-14
## FBYA.d      -0.167185039 -0.0303707385 -1.366319e-13
## NFAOFPY.d   -1.486675095 -0.0375826127 -1.510753e-14
## LPR2COMM5.d  0.068474560 -0.0026400075  7.148635e-16
```

```r
vec2 <- ca.jo(full_df[,2:8], type = "trace", ecdet = "const", #spec = "transitory",
             K = 4, season = 4)

summary(vec2)
```

```
##
```

```
## ######################
## # Johansen-Procedure #
## ######################
##
## Test type: trace statistic , without linear trend and constant in cointegration
##
## Eigenvalues (lambda):
## [1] 2.741384e-01 2.056177e-01 1.997777e-01 1.202430e-01 1.111450e-01
## [6] 6.313826e-02 4.743264e-02 8.789624e-17
##
## Values of teststatistic and critical values of test:
##
##             test  10pct   5pct   1pct
## r <= 6 |   6.07   7.52   9.24  12.97
## r <= 5 |  14.23  17.85  19.96  24.60
## r <= 4 |  28.95  32.00  34.91  41.07
## r <= 3 |  44.97  49.65  53.12  60.16
## r <= 2 |  72.83  71.86  76.07  84.45
## r <= 1 | 101.60  97.18 102.14 111.01
## r = 0  | 141.65 126.58 131.70 143.09
##
## Eigenvectors, normalised to first column:
## (These are the cointegration relations)
##
##                  LREERS.l4      RIRR.l4  LRGDPPCR.l4    OPENY.l4       FBYA.l4
## LREERS.l4      1.000000000  1.000000000  1.000000000  1.00000000  1.0000000000
## RIRR.l4       -0.034477285 -0.063811357 -0.009346723  0.13402907  0.0005436228
## LRGDPPCR.l4   -0.230930452 -1.979972815  0.220425455  1.21783849  0.1933115316
## OPENY.l4       0.008764965  0.058750655  0.034174450 -0.01896788  0.0092309447
## FBYA.l4        0.018668473  0.038031301 -0.063011996  0.50306497  0.0190210726
## NFAOFPY.l4    -0.005434018 -0.004171023 -0.036568269 -0.03361502 -0.0127952636
## LPR2COMM5.l4 -0.479741162 -1.216902985 -0.584758148 -0.99438252 -0.0630707443
## constant      -4.888234747 -6.999166718 -6.698582220 -1.81614163 -5.1579047707
##                 NFAOFPY.l4 LPR2COMM5.l4     constant
## LREERS.l4      1.00000000  1.000000000  1.000000000
## RIRR.l4        0.02712490  0.006444232  0.023024728
## LRGDPPCR.l4    0.93836513 -0.448950307  0.576574119
## OPENY.l4       0.03025468  0.012413433 -0.007913675
## FBYA.l4       -0.01188010 -0.007032678 -0.013589504
```

```
## NFAOFPY.l4   -0.01613723  0.002262130 -0.011528765
## LPR2COMM5.l4 -0.30291162 -0.127398851 -0.183636782
## constant     -6.53786889 -5.026297709 -4.525355672
##
## Weights W:
## (This is the loading matrix)
##
##                 LREERS.l4      RIRR.l4 LRGDPPCR.l4      OPENY.l4      FBYA.l4
## LREERS.d     -0.03905540  0.009542747  0.02039254 -3.016394e-03  0.056264052
## RIRR.d        2.85186904  0.672316964  0.55505618 -9.518194e-02 -0.620548723
## LRGDPPCR.d   -0.03738182  0.012467654 -0.01100385  4.345389e-05 -0.008292489
## OPENY.d      -4.11197066 -0.971890116 -0.27421153  2.471038e-01 -6.750016203
## FBYA.d      -14.32992479  0.677115272  1.52182656 -3.805992e-01 -1.127317608
## NFAOFPY.d     0.50573233  1.705655623  1.46584329  3.250713e-01 -0.405973425
## LPR2COMM5.d   0.16445725  0.039012790 -0.02156001 -8.125198e-03 -0.241502261
##               NFAOFPY.l4 LPR2COMM5.l4      constant
## LREERS.d     0.001401803 -0.087318974 -8.897356e-15
## RIRR.d      -1.192751656  0.720502337  9.019749e-14
## LRGDPPCR.d  -0.006841840  0.001697689 -6.117938e-15
## OPENY.d     -1.236150400  0.836600047 -6.321306e-13
## FBYA.d       0.690078812  1.881228636 -5.040780e-13
## NFAOFPY.d    0.560346240 -1.969193524  8.207158e-13
## LPR2COMM5.d  0.036485387 -0.033810781  7.318486e-14
```

```r
mod1 <- tsDyn::VECM(full_df[,2:8], lag = 4, estim = "ML", include = "const",
                    r=1, exogen = exog_df$season_dum)

summ <- mod1$model
```

```r
#
#
#
# mod <- VECM(data = endog_df[,2:8], lag = 4, r = 1,
#             include = "const", estim = "ML", exogen = exog_df[,2:4])
#
# mod_summ <- summary(mod)
```

```
# mod <- dynlm(full_df$LREERS ~ full_df$RIRR + full_df$LRGDPPCR + full_df$OPENY
#             + full_df$FBYA + full_df$NFAOFPY + full_df$LPR2COMM5
#             + full_df$DUMNFAOFPY + full_df$DUMRER1
#             + full_df$DUMRER2 + full_df$DUMFBYA + full_df$SDUMC1
#             + full_df$SDUMC2 + full_df$SDUMC3,
#             lag = 4,
#             include = "const", estim = "ML", exog
#             exogen = exog_df[,2:8])
```

```
stargazer(summ, header = FALSE)
```

Table 6.2

Statistic	N	Mean	St. Dev.	Min	Max
LREERS	129	4.573	0.129	4.036	4.893
RIRR	129	−1.137	3.896	−9.909	8.880
LRGDPPCR	129	0.324	0.231	−0.004	0.675
OPENY	129	50.200	6.575	37.826	66.305
FBYA	129	−3.984	3.653	−15.805	4.168
NFAOFPY	129	−8.683	11.484	−27.309	10.234
LPR2COMM5	129	0.073	0.352	−0.747	0.924
ECT	124	4.968	0.100	4.725	5.231
Intercept	124	1.000	0.000	1	1
LREERS -1	124	−0.004	0.052	−0.182	0.216
RIRR -1	124	0.023	1.345	−4.047	3.865
LRGDPPCR -1	124	−0.005	0.015	−0.046	0.045
OPENY -1	124	0.101	2.489	−8.939	8.067
FBYA -1	124	0.059	5.603	−12.986	10.748
NFAOFPY -1	124	−0.084	2.258	−11.802	5.779
LPR2COMM5 -1	124	0.003	0.089	−0.219	0.378
LREERS -2	124	−0.002	0.050	−0.172	0.216
RIRR -2	124	0.035	1.353	−4.047	3.865
LRGDPPCR -2	124	−0.005	0.015	−0.046	0.045
OPENY -2	124	0.067	2.477	−8.939	8.067
FBYA -2	124	−0.009	5.576	−12.986	10.748
NFAOFPY -2	124	−0.093	2.260	−11.802	5.779
LPR2COMM5 -2	124	0.004	0.089	−0.219	0.378
LREERS -3	124	−0.002	0.049	−0.172	0.216
RIRR -3	124	0.027	1.354	−4.047	3.865
LRGDPPCR -3	124	−0.005	0.015	−0.046	0.045
OPENY -3	124	0.107	2.465	−8.939	8.067
FBYA -3	124	−0.018	5.575	−12.986	10.748
NFAOFPY -3	124	−0.121	2.244	−11.802	5.779
LPR2COMM5 -3	124	0.004	0.089	−0.219	0.378
LREERS -4	124	−0.002	0.049	−0.172	0.216
RIRR -4	124	0.026	1.353	−4.047	3.865
LRGDPPCR -4	124	−0.005	0.015	−0.046	0.045
OPENY -4	124	0.101	2.462	−8.939	8.067
FBYA -4	124	0.035	5.578	−12.986	10.748
NFAOFPY -4	124	−0.153	2.220	−11.802	5.779
LPR2COMM5 -4	124	0.004	0.089	−0.219	0.378

7. Directly from (MacDonald & Ricci, 2004)

7.1. Section 3 Data and Methodology

- Plotting the exp(LREER) and the rest of the variables
- Showcase the vector of interest
- Investigate LR CI Rel's amongst var's in vector
  - Method: MLE of Johansen (1995)
  - Why? Corrects for Autocorr and ednog parametrically using VECM specif.
  - Key Advantage: the estimated coefficient - the β vector - can be used to provide a measure of the equilibrium real exchange rate and therefore a quantification of the gap between the prevailing real exchange rate and its equilibrium level. The methodology also derives estimates of the speed at which the real exchange rates converges to the equilibrium level.

8. Old Stuff

9. References

10 Johansen, S. 1995. *Likelihood-based inference in cointegrated vector autoregressive models*. OUP Oxford.

MacDonald, R. & Ricci, L.A. 2004. Estimation of the equilibrium real exchange rate for south africa 1. *South African Journal of Economics*. 72(2):282–304.

Appendix