Time series analysis of Belgium and Euro Area 10-years Government Bond Yields

Advanced Time Series Analysis - D0M63B

Presentation of the Dataset

- **Dataset published on FRED (Federal Reserve Economic Data).**
- **Belgium and Euro area 10-years Government Bond Yields*.**
- **Time series with quarterly frequency (end of period value).**
- **From the first quarter of 1970 to the last quarter of 1995.**
- **Critical value 0.05 will be applied for all tests.**

Univariate Time Series Analysis

- **Explorative Analysis of Belgian Bond Yields (BE_ts).**
- **Creation of the best Arima model for forecasting.**

Multivariate Time Series Analysis

- **Analysis of the relationship between the two series**
- **Cointegration test, ADLM(2) and VAR model**

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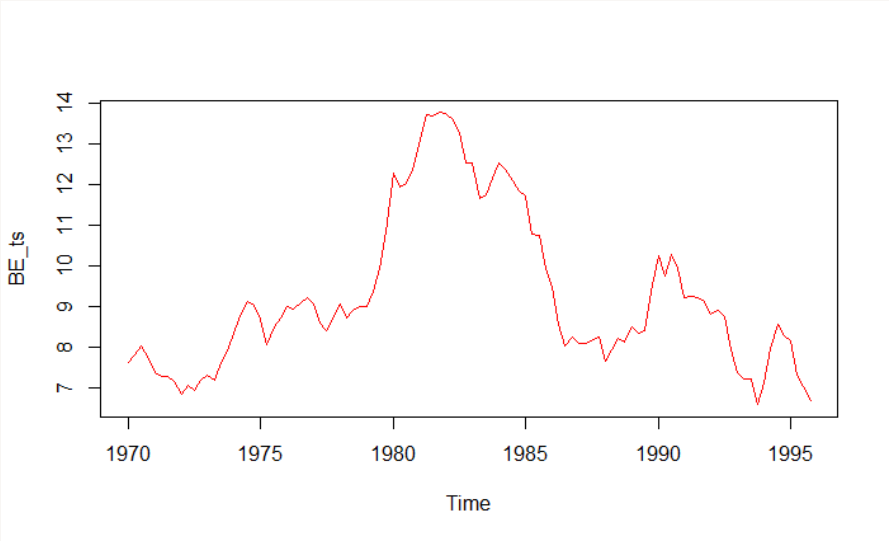
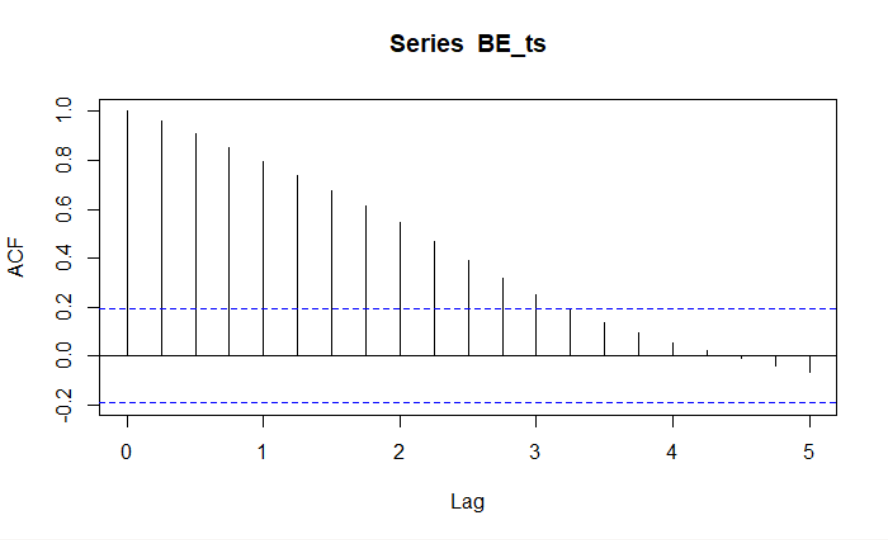
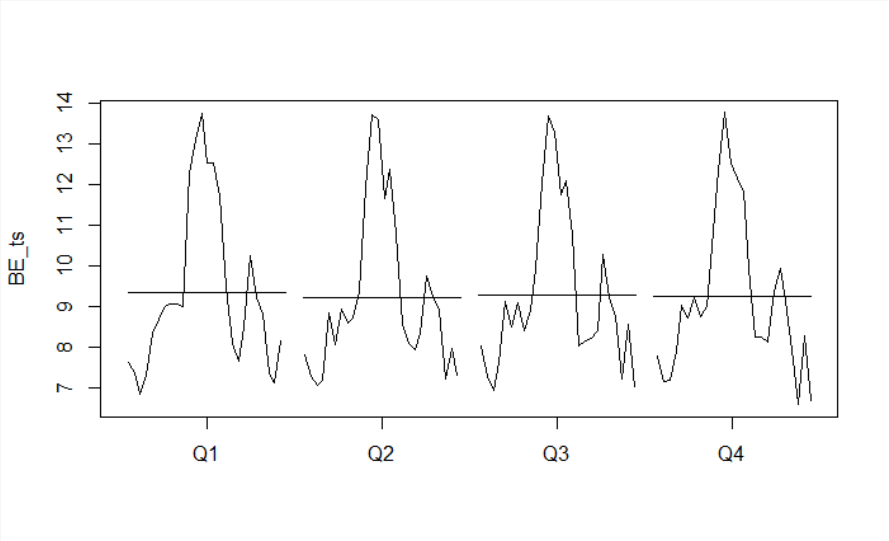
***BE: https://fred.stlouisfed.org/series/IRLTLT01BEA156N UE: https://fred.stlouisfed.org/series/IRLTLT01EZM156N#0**

01

Univariate Time Series analysis | Belgium bond: BE_ts







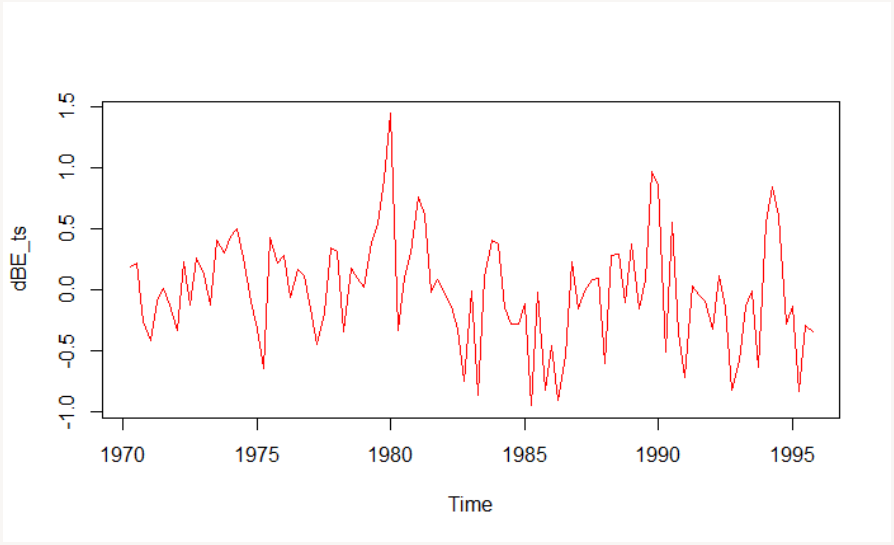
Comments

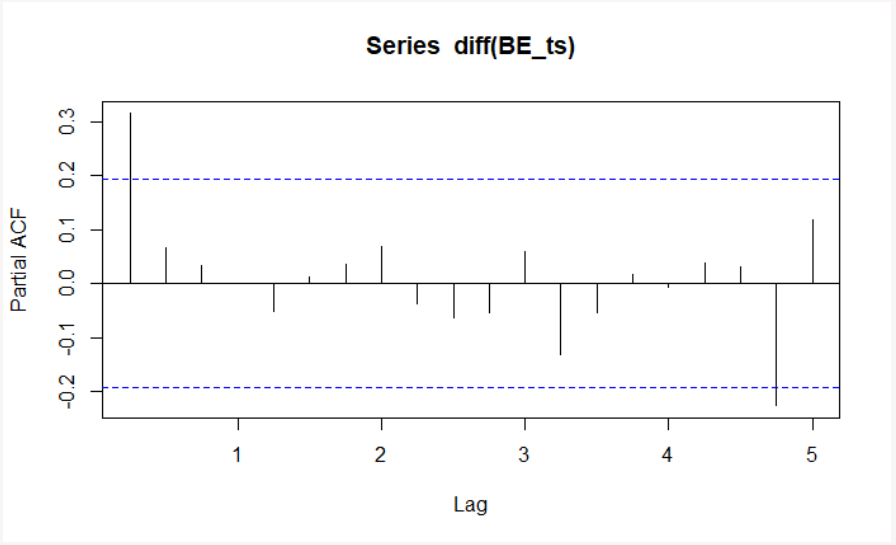
- ADF test: p-value = 0.51, the TS is not stationary.
- Ljung-Box test: p-value = 0, the TS is not white noise.

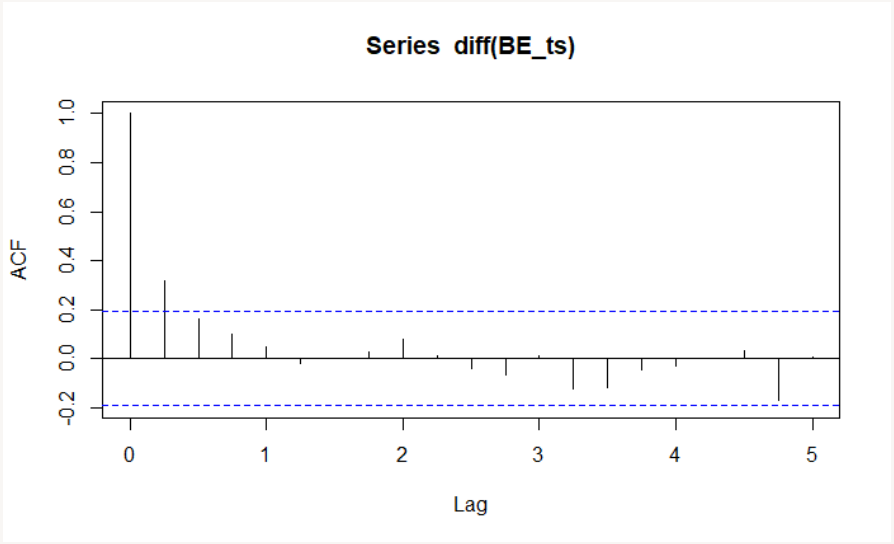
- No seasonal pattern is visible in the plot by quarter.
- The series shows strong persistency
- To fit a Arima model, is required a stationary series, so a new TS is created using the differences.

01

Univariate Time Series analysis | Belgium bond: dBE_ts







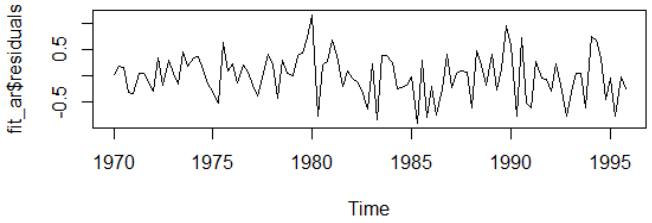
Comments

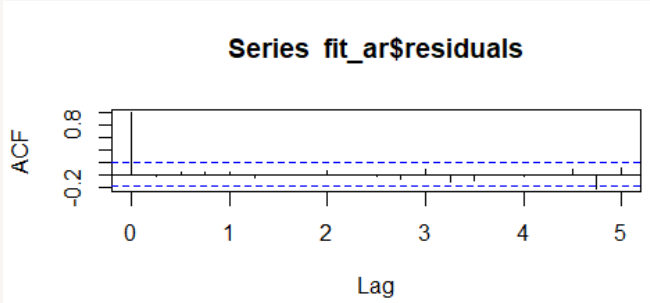
- ADF test: p-value = 0, the TS in differences is stationary.
- Ljung-Box test: p-value = 0.11, the TS seems to be white noise.

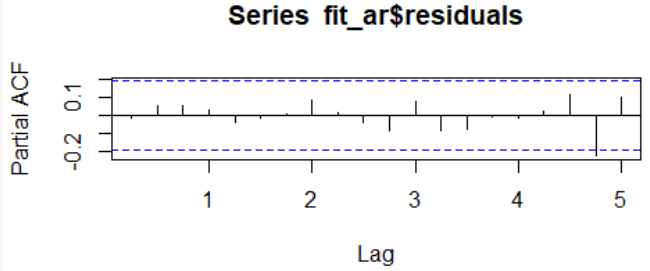
- A significant correlation can be seen in the ACF and one in the PACF.
- It was chosen to fit and compare two different models, an MA(1) and an AR(1).

01

ARIMA(1,1,0)

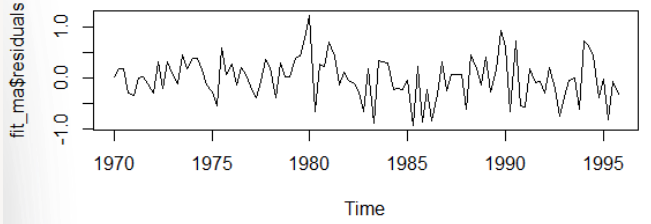


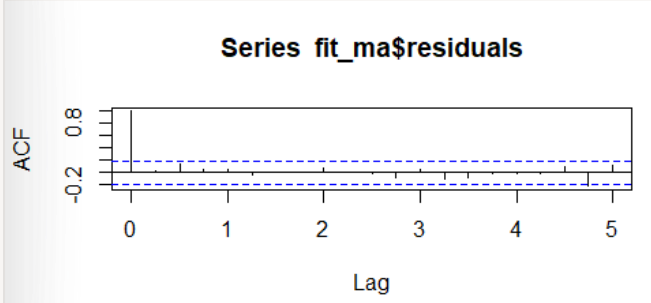


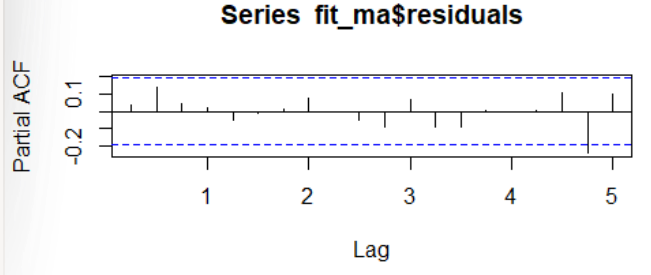


- Ljung-Box test: p-value= 0.9982, the residuals are white noise
- Since we created the CI using 5% significance level, a significant correlation is acceptable.
- Is possible to say that the model is valid
- The AR term is significant
- AIC: 115.7366
- SIC: 121.0254

ARIMA(0,1,1)



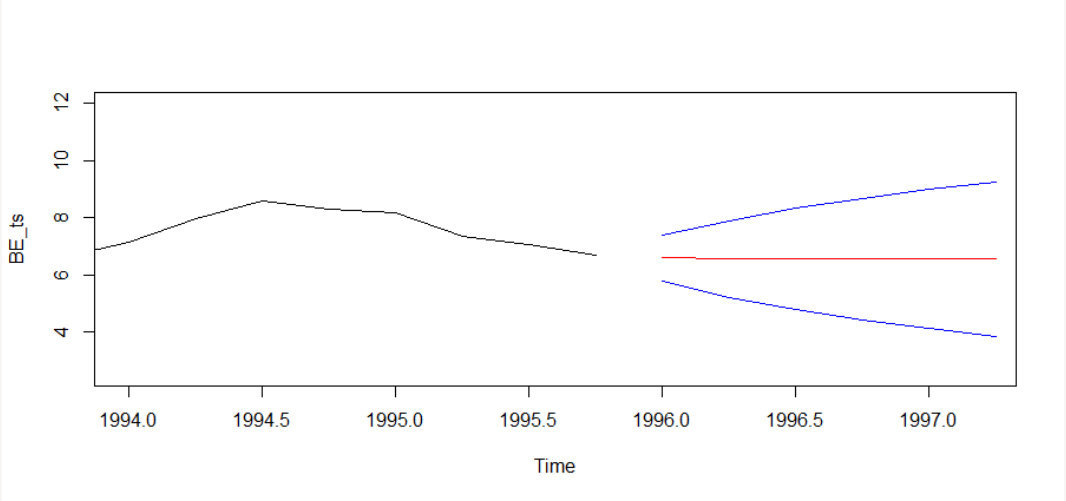




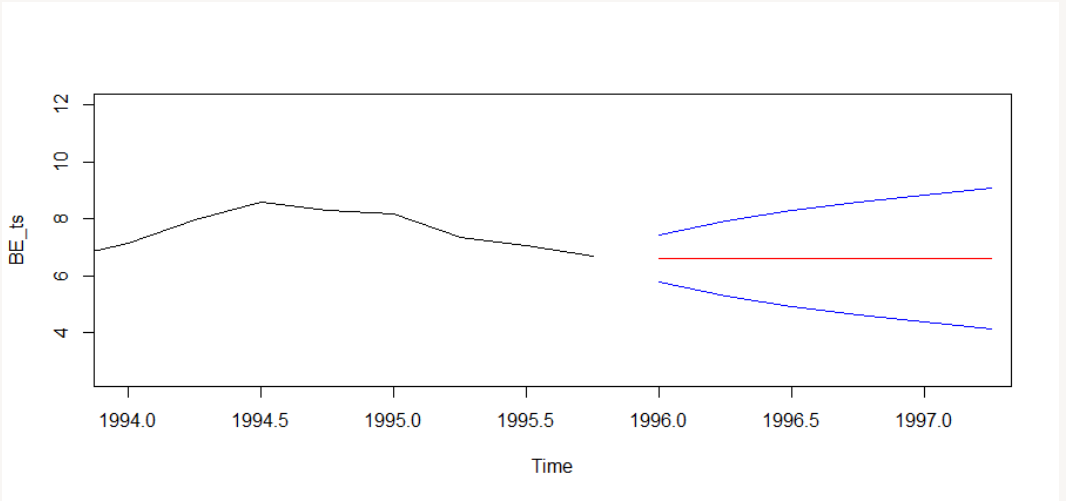
- Ljung-Box test : p-value= 0.9611, the residuals are white noise
- Since we created the CI using 5% significance level, a significant correlation is acceptable.
- Is possible to say that the model is valid
- The MA term is significant
- AIC: 117.5694
- SIC: 122.8581

01 Univariate Time Series analysis | Forecasting

ARIMA(1,1,0)



ARIMA(0,1,1)



- MAE(AR): 0.4052151
- MAE(MA): 0.405801
- Diebold-Mariano p-value = 0.953

- MSE(AR): 0.2479685
- MSE(MA): 0.2450036
- Diebold-Mariano p-value = 0.7929

Comments

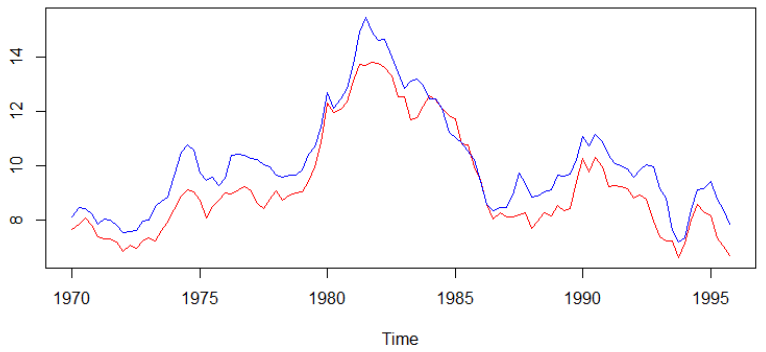
- The forecasts are very similar.
- MAE and MSE are almost the same.
- Diebold-Mariano tests: we reject the null hypothesis in both the cases. So, is possible to say that the forecast performance of the two models is not significantly different.
- Essentially, both models predict only a slight negative change in the next quarter's yields from those of time t. Forecasted values have wide prediction intervals.
- The AR(1) model is preferred because it has lower AIC, SIC, and MAE.

02

Multivariate TS analysis

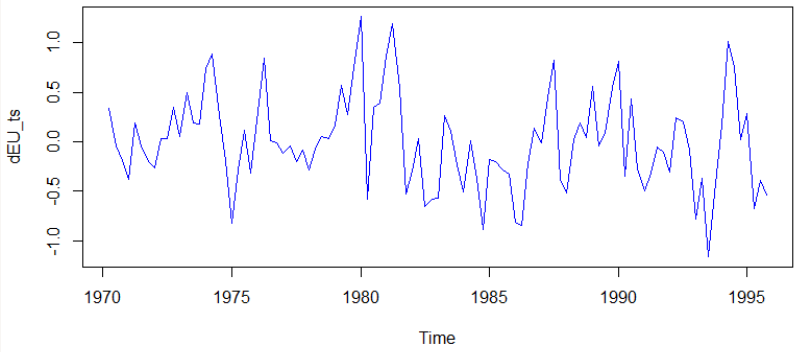
Cointegration Test

EU_ts (blue) and BE_ts (red)



- ADF test: the TS is not stationary.
- dEU_ts is created using the diff() function.

dEU_ts



- ADF test: the TS is now stationary.
- EU_ts and BE_ts are both integrated of order 1, it is possible to proceed with a cointegration test.

Cointegration Test

- The test statistics is -3.6296, which is smaller that the Engle-Granger ADF test statistics for one explanatory variable −3.41. Therefore, we reject the H0 hypothesis of no cointegration and conclude that BE_ts and EU_ts are cointegrated.
- Since they are cointegrated, an error correction model (ECM) can now be constructed and estimated.
- Automatic lag selection will also be used to select the order of a VAR model.

02

Multivariate TS analysis

ECM and VAR selection

```
Call:
lm(formula = dBE_ts ~ dEU_ts + ECT)

Residuals:
     Min       1Q   Median       3Q      Max
-0.90731 -0.17119  0.00488  0.19259  0.73247

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.00652    0.03004  -0.217 0.828650
dEU_ts       0.66574    0.06431  10.351  < 2e-16 ***
ECT         -0.21808    0.06005  -3.632 0.000446 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3049 on 100 degrees of freedom
Multiple R-squared:  0.5305,    Adjusted R-squared:  0.5212
F-statistic: 56.51 on 2 and 100 DF,  p-value: < 2.2e-16
```

- 53% of the variance of dBE_ts is explained by the regressors in the ECM model.
- All the variables are significant (except the intercept)
- Ljung-Box test : p-value=0.07 so H0 is not rejected, the model is valid. However, the decision to reject H0 in the test could be debated given the low p-value.

- The parameter ECT measures the speed of adjustment towards equilibrium.
- This model captures both the short-term and long-term relationship between the two TS in differences, which is significant.

VAR selection

```
$selection
AIC(n)  HQ(n)  SC(n) FPE(n)
     1      1      1      1

$criteria
               1           2           3           4           5           6           7           8           9          10
AIC(n) -3.7535439 -3.72116286 -3.66304975 -3.60982313 -3.57738747 -3.57830038 -3.52855526 -3.5229081 -3.52875955 -3.51739786
HQ(n)  -3.6875703 -3.61120682 -3.50911129 -3.41190225 -3.33548417 -3.29241466 -3.19868712 -3.1490575 -3.11092657 -3.05558247
SC(n)  -3.5901504 -3.44884034 -3.28179821 -3.11964258 -2.97827791 -2.87026181 -2.71158768 -2.5970115 -2.49393395 -2.37364325
FPE(n)  0.0234356  0.02421083  0.02566879  0.02708953  0.02801088  0.02802621  0.02951455  0.0297598  0.02968551  0.03015034
```

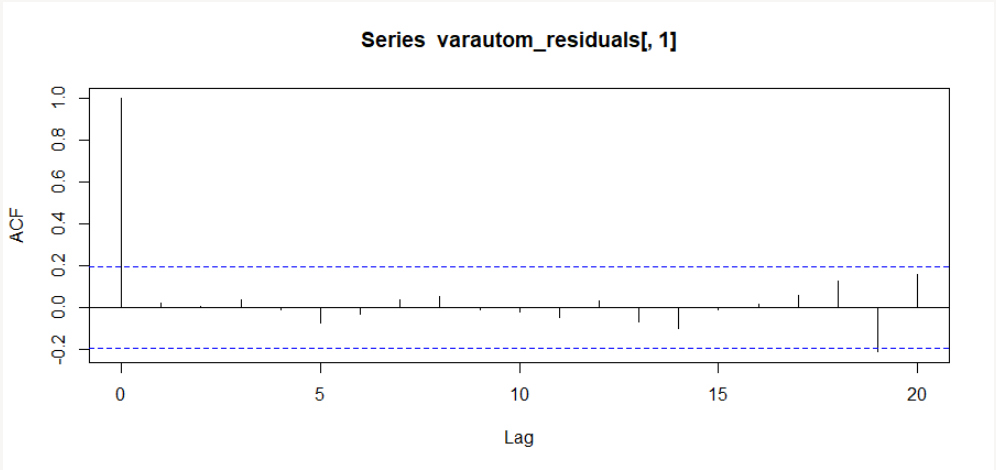
- The selectvar() function was used with dBE_ts and dUE_ts.
- The order of the VAR model selected by Schwarz's information criterion is 1, so a VAR(1) was estimated.

Multivariate TS analysis

VAR(1)

VAR(1) for equation dBE

```
VAR Estimation Results:
=========================
Endogenous variables: dBE, dEU
Deterministic variables: const
Sample size: 102
Log Likelihood: -84.302
Roots of the characteristic polynomial:
0.4651 0.07444
Call:
VAR(y = data, p = 1, type = "const")


Estimation results for equation dBE:
====================================
dBE = dBE.l1 + dEU.l1 + const

       Estimate Std. Error t value Pr(>|t|)
dBE.l1  0.10225    0.12677   0.807   0.4218
dEU.l1  0.29446    0.11859   2.483   0.0147 *
const  -0.01119    0.04073  -0.275   0.7841
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Residual standard error: 0.4112 on 99 degrees of freedom
Multiple R-Squared: 0.1529,     Adjusted R-squared: 0.1358
F-statistic: 8.936 on 2 and 99 DF,  p-value: 0.0002706
```



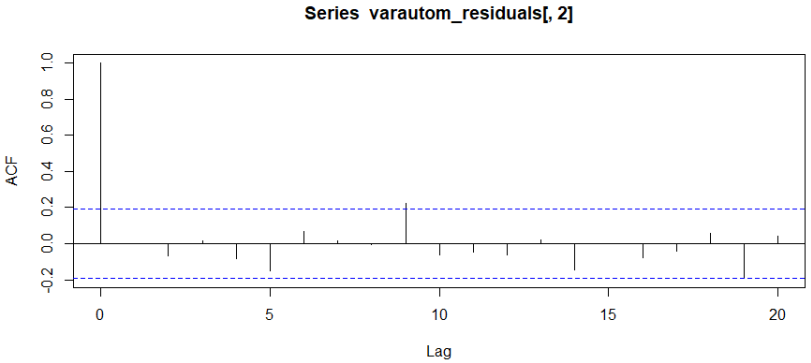
- The regressors are jointly significant, but only one regressor is significant (dEU.l1).
- The model explain 15.29% of the variance of dBE.
- Correlogram: there is only one significant residual.
- Ljung-Box test: p-value = 0.991, the residuals are white noise, the model is valid.

Multivariate TS analysis

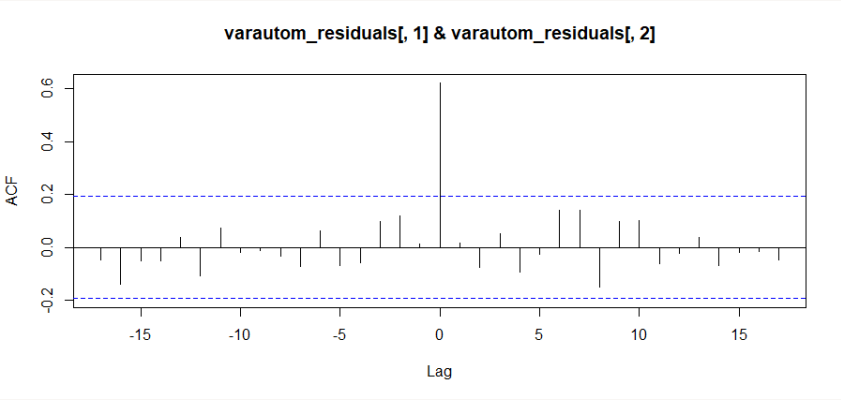
VAR(1)

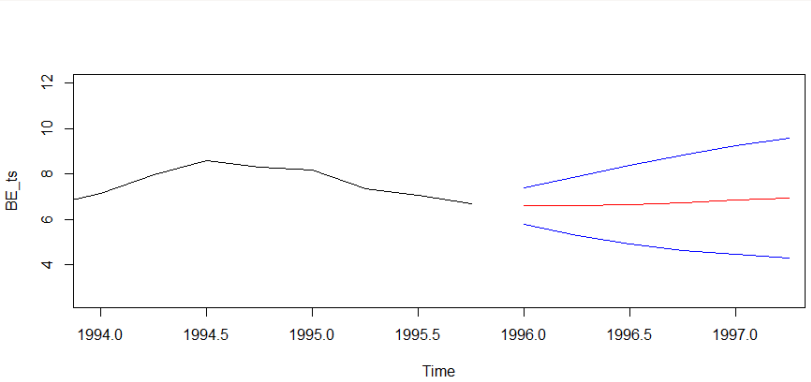
VAR(1) for equation dEU

```
Estimation results for equation dEU:
====================================
dEU = dBE.l1 + dEU.l1 + const

        Estimate Std. Error t value Pr(>|t|)
dBE.l1  0.217751   0.131701   1.653   0.1014
dEU.l1  0.288438   0.123201   2.341   0.0212 *
const  -0.005571   0.042314  -0.132   0.8955
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1


Residual standard error: 0.4272 on 99 degrees of freedom
Multiple R-Squared: 0.2033,     Adjusted R-squared: 0.1872
F-statistic: 12.63 on 2 and 99 DF,  p-value: 1.302e-05
```



- The regressors are jointly significant.
- Only one regressor is significant (dEU.l1).
- The model explain 20.33% of the variance of dEU.
- Correlogram: there is one significant residual.
- Ljung-Box test: p-value=0.3971, the residuals are white noise.
- It is possible to say that the model is valid.



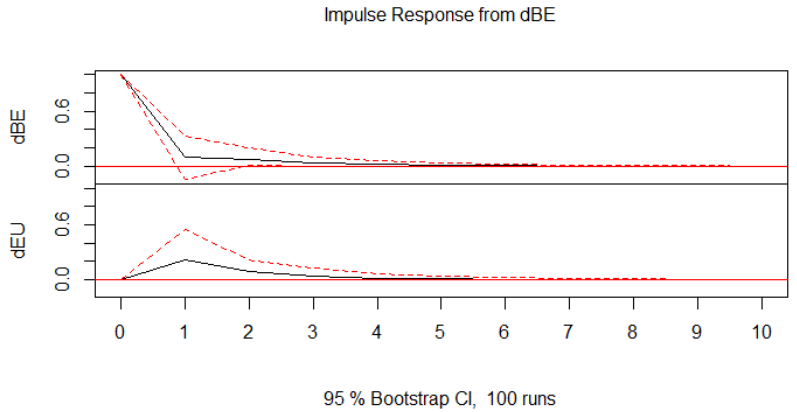


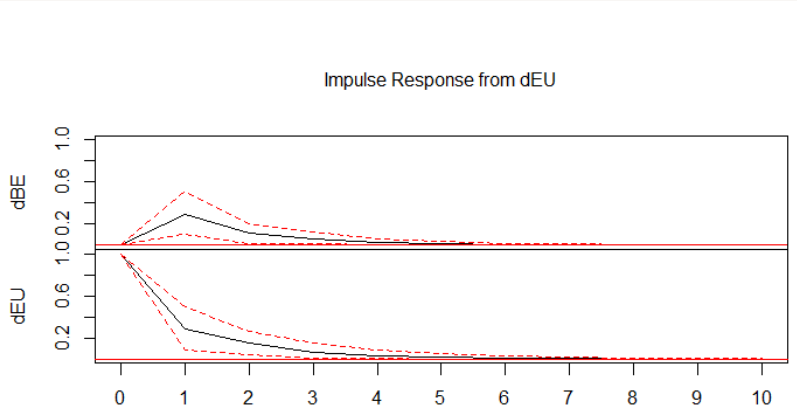
- Cross-correlogram: A strong significant cross-correlation without lag is observed. There is no problem with contemporaneous correlations in a VAR model, as it does not allow for explicit modeling of contemporaneous interdependence.
- The forecast is created using the var model. The forecast is different from the two created using the Arima models.

Multivariate TS analysis

IRF

Impulse Response Functions based on the VAR(1) estimates





- The IRFs provide a simple way to interpret the estimated coefficients of the VAR model.

- Given a unitary impulse in dBE at time t, no significant response is observed.
- Given a unitary impulse in dEU at time t, a significant positive dBE response is observed at time t + 1.

- It is possible to use this information for forecasting dBE, by predicting a response if the value of dEU changes.

- From the VAR model we can infer that the value of the Belgian bond yields (in difference) in t depends on the value of the European bond yields (in difference) in t-1.
- This positive relationship potentially allows investors to predict Belgian bond yields performance using the Euro Area bond yields, letting them adjust their strategies.