# PORTUGAL

**30413-Econometrics**
Assignment, Bemacs


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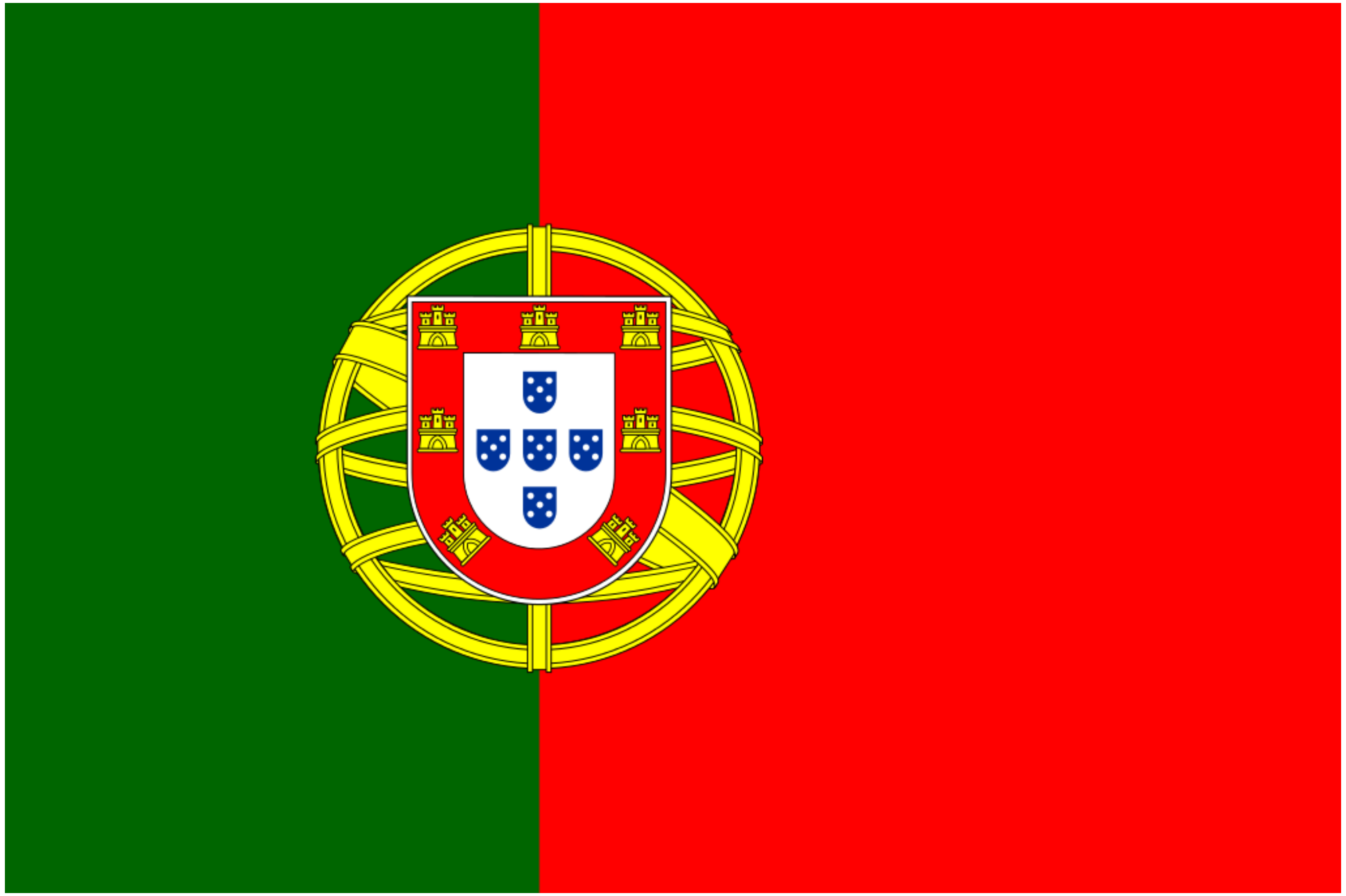
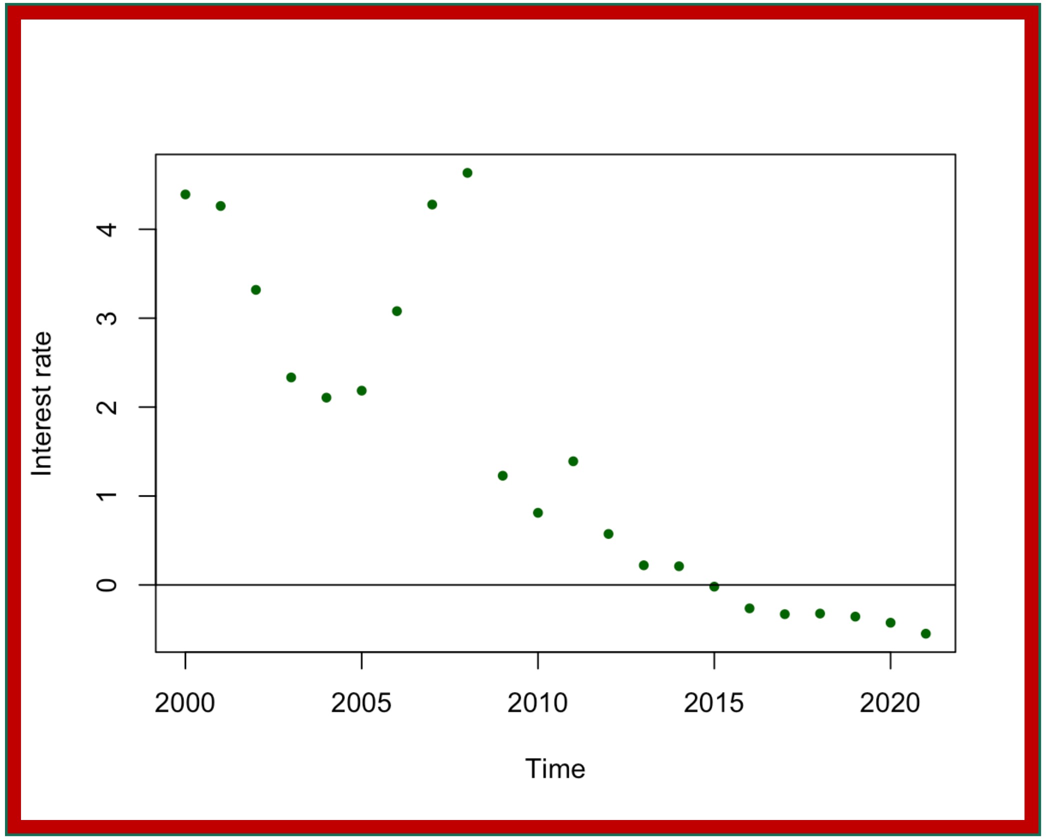


# Taylor Rule




The Taylor Rule is an explanatory function that target monetary policy used by central
banks. Introduced in 1993, it follows the equation:

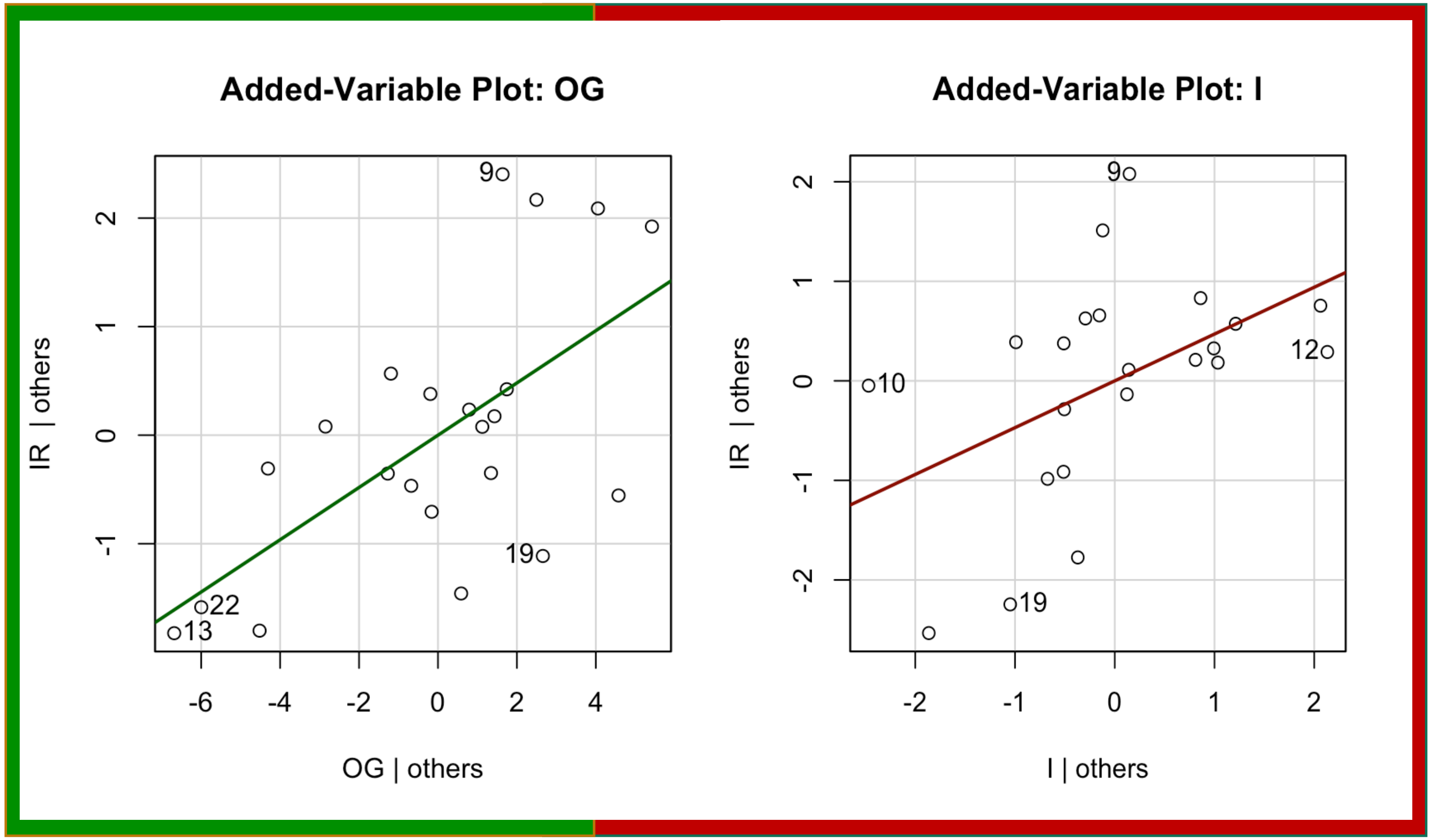
$$i_t = r^* + f_\pi(\pi - \pi^*) + f_y y_t$$

In the graph is represented the trend of the inflation over time which is described by the relationship above for the country of Portugal in the years from 2000 to 2021. It is clear from the graph that with time the interest rate in the European country has been decreasing. The choice of the years after the introduction of the Euro in Portugal is strategic since data before that date were unprecise and oscillating

# Taylor Rule

Starting from the equation, it is possible through a linear regression to estimate the parameters of output gap and inflation, which are the two explanatory variable in the model. Once this is done, it is possible to observe from the partial graphs:

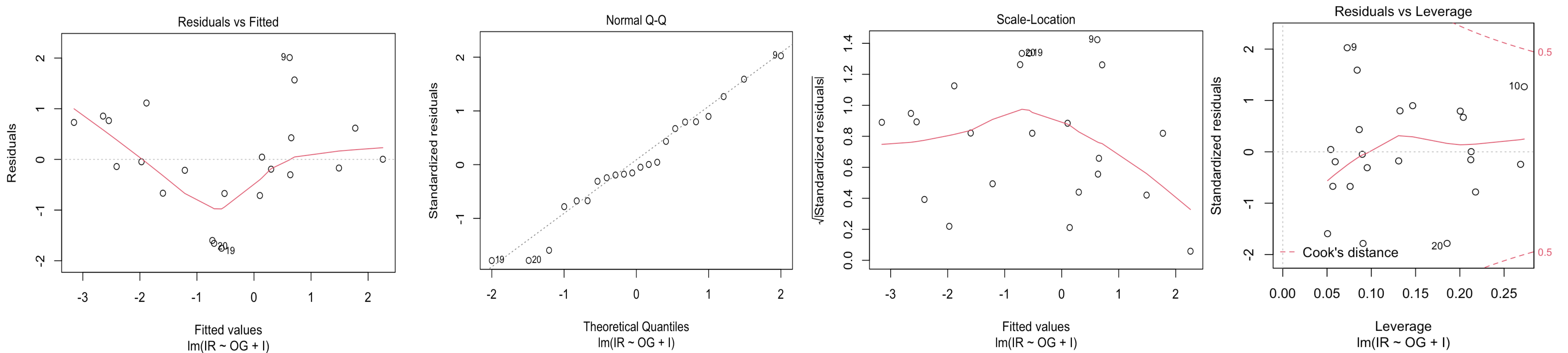
- Output Gap and Interest Rate are directly proportional
- Inflation and Interest Rate are directly proportional



# First Linear Regression

The first linear regression is done with respect to both coefficients of the output gap and the inflation.
According to the result of the regression model, both inflation and output gap are statistically significant (10%).

```
Call:
lm(formula = IR ~ OG + I, data = DF)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.75282 -0.57628 -0.09412  0.70151  2.00963 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)   
(Intercept) -0.86503    0.49969  -1.731  0.09964 . 
OG           0.24080    0.06895   3.492  0.00244 **
I            0.47024    0.19852   2.369  0.02860 * 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.03 on 19 degrees of freedom
Multiple R-squared:  0.7079,	Adjusted R-squared:  0.6772 
F-statistic: 23.03 on 2 and 19 DF,  p-value: 8.361e-06
```



# Tests Performed

After the linear first linear regression, some tests are done to check whether there is the presence of the OLS assumptions or not:

- The Breusch-Pagan test suggest, since we accept the alternative hypothesis, that we are under heteroscedasticity conditions.
- The test for uncorrelation are both failed, which implies that there is correlation between the errors.
- Lastly, the Reset test suggests that the model used is correct since there is the presence of linearity given the fact that testing a second order term would not be statistically significant.

▪ **Test for Homoscedasticity**

```
        studentized Breusch-Pagan test

data:  lr_1
BP = 4.8546, df = 2, p-value = 0.08828
```

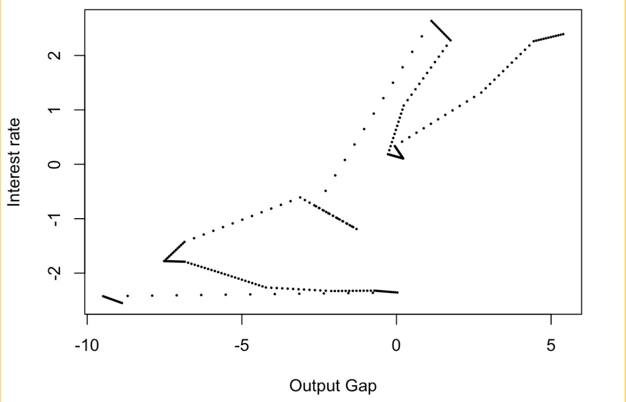
▪ **Tests for Uncorrelation**

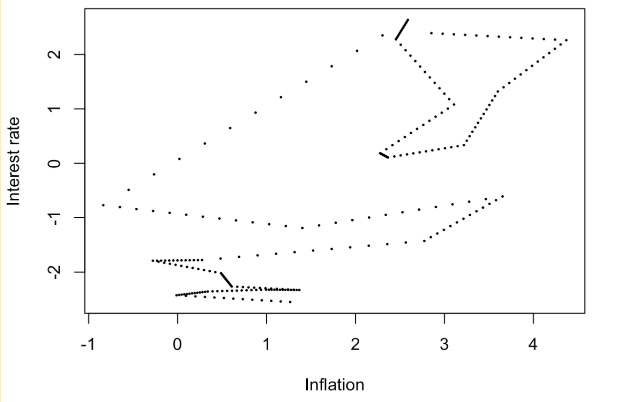
```
        Breusch-Godfrey test for serial correlation of order up to 3

data:  lr_1
LM test = 11.289, df = 3, p-value = 0.01026
        Durbin-Watson test

data:  lr_1
DW = 0.78884, p-value = 0.0002556
alternative hypothesis: true autocorrelation is greater than 0
```

▪ **Test for Linearity**

```
        RESET test

data:  lr_1
RESET = 1.4828, df1 = 2, df2 = 17, p-value = 0.2549
```

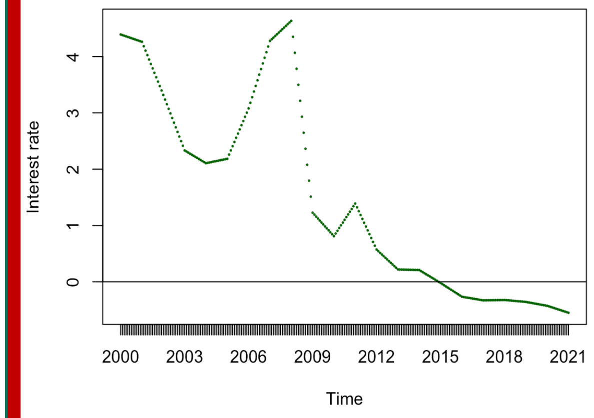
# Second Linear Regression and Interpolation



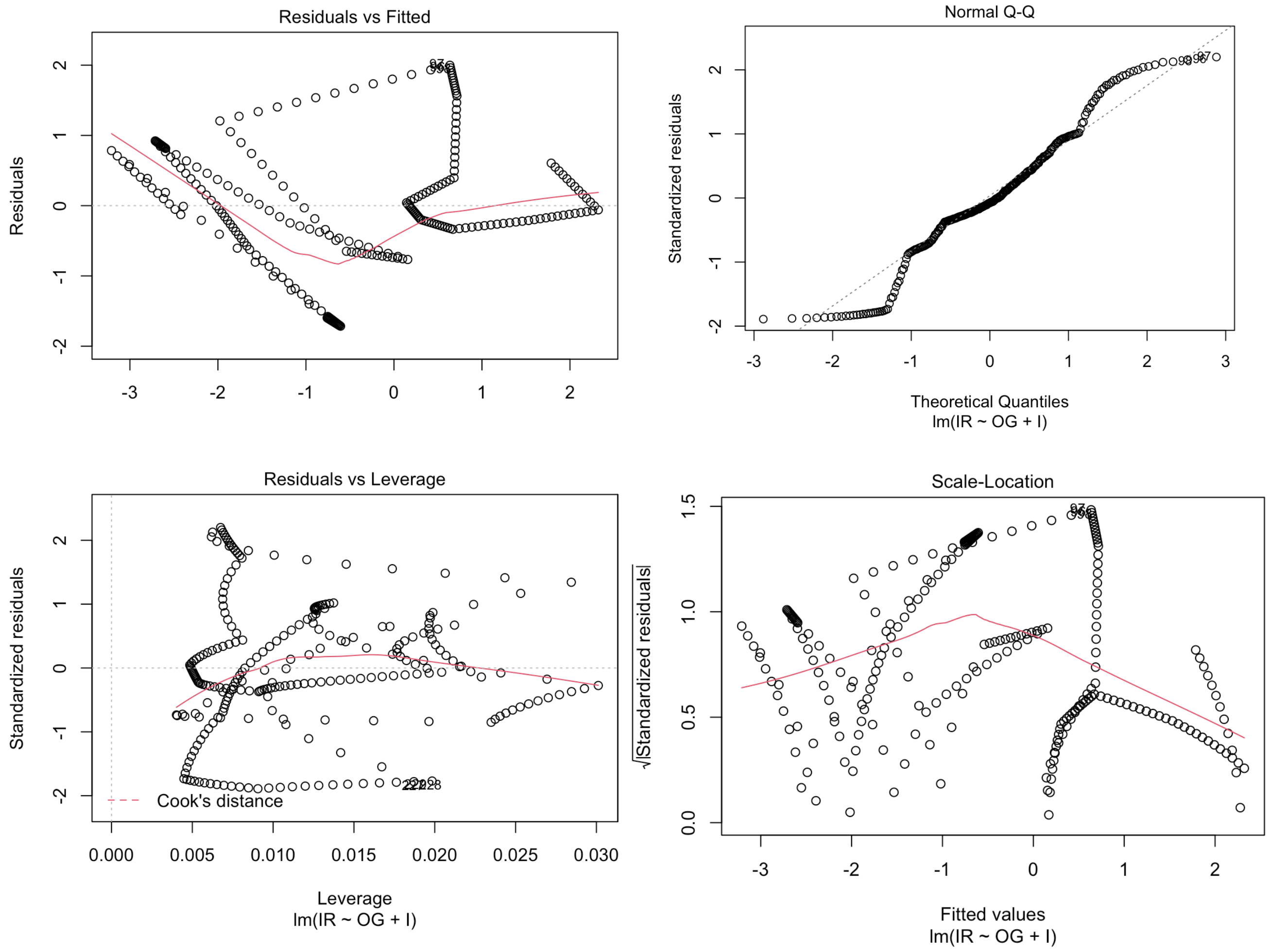

The second linear regression is done through the means of interpolation, which enables to generate more data starting from the given dataset already used in the first model to increase accuracy of the regression.

```
Call:
lm(formula = IR ~ OG + I, data = C)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.71540 -0.49469 -0.06969  0.55616  1.99849 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.93608    0.14523  -6.445 5.89e-10 ***
OG           0.23899    0.02072  11.531  < 2e-16 ***
I            0.50278    0.05825   8.632 7.16e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9115 on 250 degrees of freedom
Multiple R-squared:  0.7133,	Adjusted R-squared:  0.711 
F-statistic:   311 on 2 and 250 DF,  p-value: < 2.2e-16
```




Thanks to this process, not only the result of the previous one is confirmed, but also the result has improved

# Tests Performed




- **Test for Homoscedasticity**

```
        studentized Breusch-Pagan test

data:  lr_2
BP = 60.865, df = 2, p-value = 6.072e-14
```

- **Test for Uncorrelation**

```
        Durbin-Watson test

data:  lr_2
DW = 0.0065824, p-value < 2.2e-16
alternative hypothesis: true autocorrelation is greater than 0
        Breusch-Godfrey test for serial correlation of order up to 3

data:  lr_2
LM test = 252.09, df = 3, p-value < 2.2e-16
```

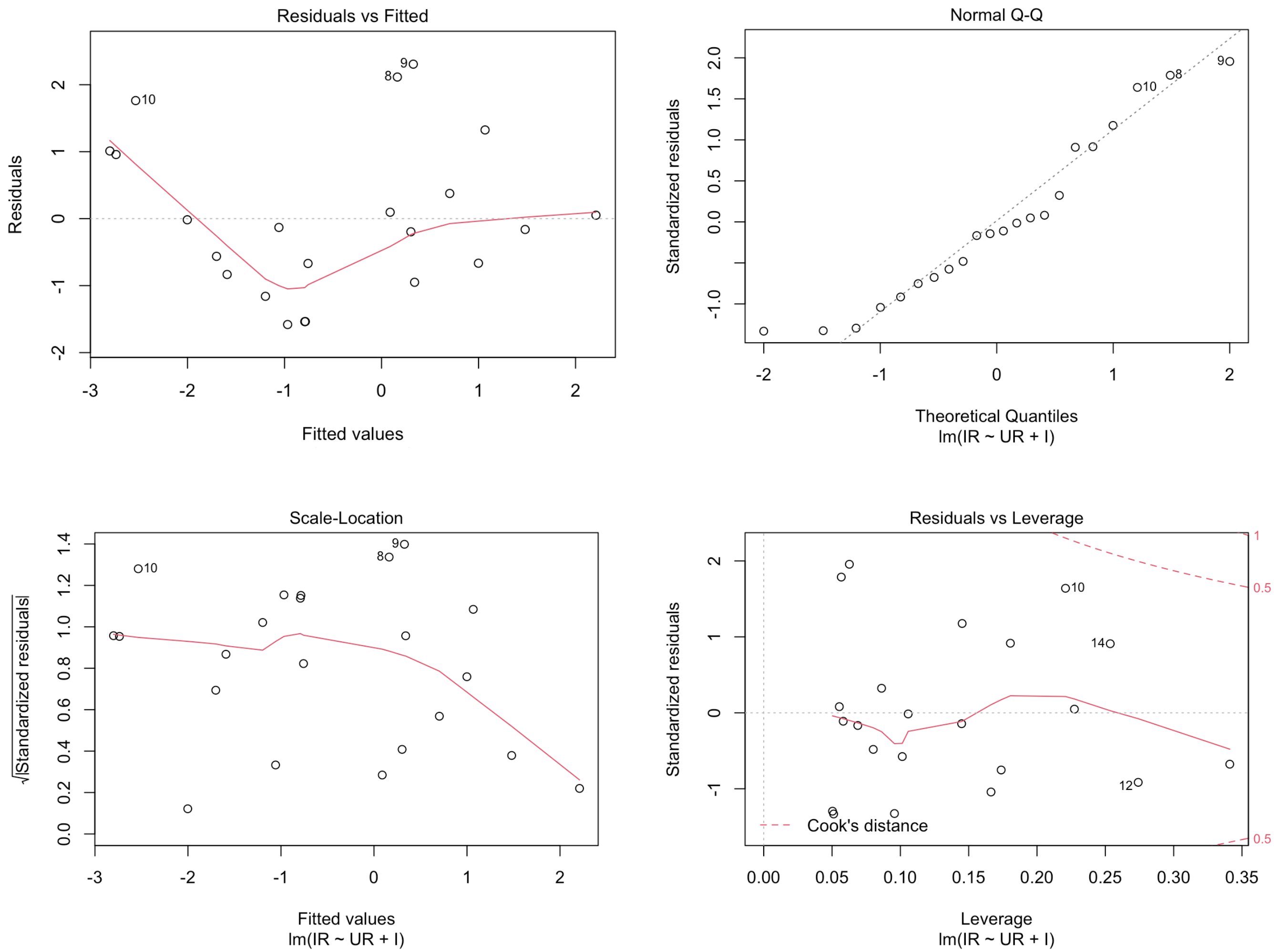
- **Hac-Robust standard errors**

```
> #HAC-robust standard errors
> coeftest(lr_2, vcov = vcovHAC)

t test of coefficients:

             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.936077   0.644286 -1.4529 0.147508
OG           0.238986   0.075866  3.1501 0.001831 **
I            0.502784   0.185387  2.7121 0.007150 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

# Analysis

- The Breusch-Pagan test is passed, meaning there is presence of homoscedasticity in the dataset.
- The tests for uncorrelation are both failed, which suggests correlation between the errors.
- Running the Hac-Robust Test it is shown that the estimate do not differ much from the standard regression model and thus can be considered a proof of correctness of the model.
- This is in line with the economic theory of the Taylor Rule.

# Third Linear Regression




```
Call:
lm(formula = IR ~ UR + I, data = DF2)

Residuals:
    Min      1Q  Median      3Q     Max 
-1.5807 -0.7924 -0.1464  0.8121  2.3069 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)   
(Intercept) -1.14968    0.67088  -1.714  0.10285   
UR          -0.15349    0.08452  -1.816  0.08519 . 
I            0.75160    0.20152   3.730  0.00142 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.218 on 19 degrees of freedom
Multiple R-squared:  0.5913,	Adjusted R-squared:  0.5483 
F-statistic: 13.75 on 2 and 19 DF,  p-value: 0.0002032
```

Lastly, it is computed a third linear regression with respect to a newly introduced explanatory variable following an alternative formulation of the Taylor Rule in which is used the unemployment rate.

$$i_t = r^* + \alpha(\pi - \pi^*) + \beta(u_t - u_n)$$

# Tests Performed & Analysis

- The test for homoscedasticity is not passed, which indicates the presence of heteroscedasticity in the model.
- The test for uncorrelation are both failed, indicating correlation between the errors.
- It can be seen that the intercept is not statistically relevant since the p-value of the t-test of the intercept is too high. However, based on the join F-test result, the explanatory variables are jointly statistically significant.

- Test for Homoscedasticity

```
        studentized Breusch-Pagan test

data:  lr_3
BP = 1.1456, df = 2, p-value = 0.564
```

- Tests for Uncorrelation

```
        Durbin-Watson test

data:  lr_3
DW = 0.55865, p-value = 1.953e-06
alternative hypothesis: true autocorrelation is greater than 0
```

```
        Breusch-Godfrey test for serial correlation of order up to 3

data:  lr_3
LM test = 12.176, df = 3, p-value = 0.006805
```

# Conclusions


Three models were discussed: a first linear regression with raw data, an interpolation implemented version, and, lastly, an alternative formulation of the economic rule by Jonh Taylor.

I. The first estimate proved the direct proportionality between the interest rate and the two studied explanatoy variables, output gap and inflation. This relation found can be also be confirmed though purely economic means. In fact, as output increases above its potential level, resulting in a positive gap, would increase as well inflation, forcing the Central Bank to raise interest rate in order to bring the economy back to its originary state.
II. The second regression not only confirmed the first obtained result, but was able to better clarify in details was proved through the first test.
III. Lastly, the alternative formulation of the Taylor Rule was able to prove that there is another variable which can be used to explain the behaviour of the interest rate.

# Bibliography

All data and relevant information about Portugal are taken from:

Stats.oecd.org. 2022. *OECD Statistics*. [online] Available at: <https://stats.oecd.org/>.