ÉCONOMIE
ET MANAGEMENT
ÉCOLE UNIVERSITAIRE DE RECHERCHE

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MASTER Economie, Parcours EXPERTISE ECONOMIQUE

Introduction to R

Subject: "Empirical Analysis of Okun's Law in Eurozone Countries."

INTRODUCTION

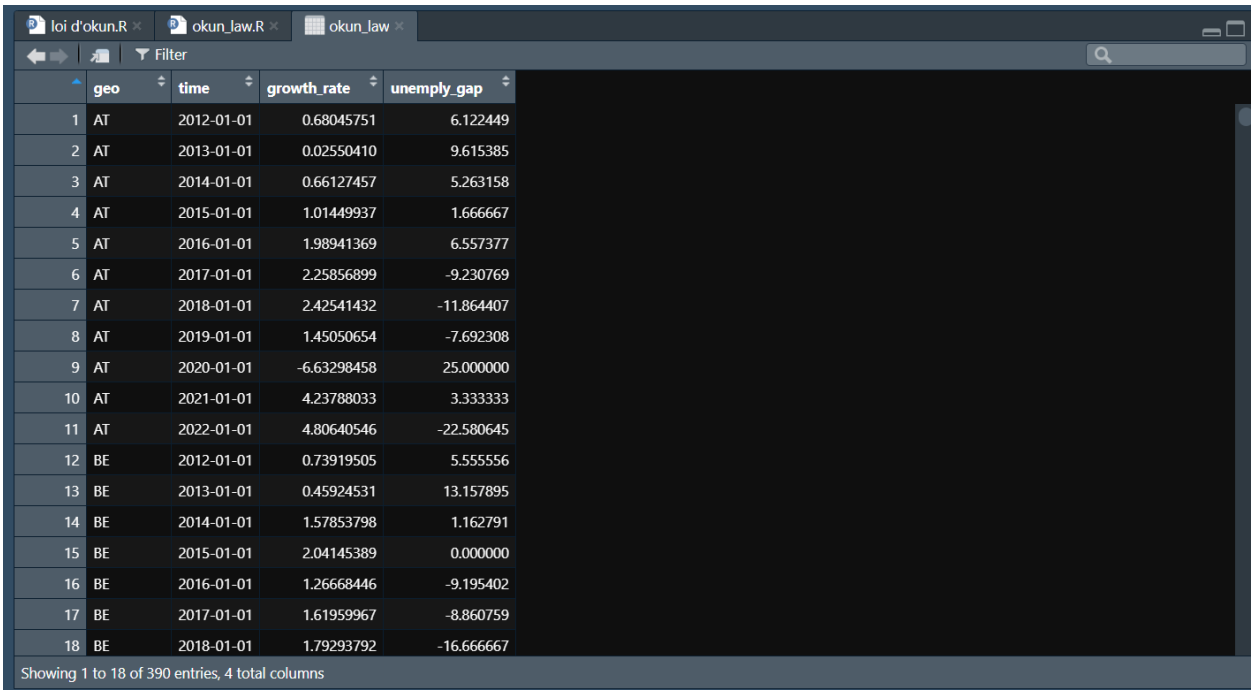
Okun's Law is an empirical relationship between the unemployment rate and economic growth, developed by the American economist Arthur Okun. This relationship is often used to study employment fluctuations in an economy. Okun's Law suggests that there is an inverse relationship between the unemployment rate and the growth of Gross Domestic Product (GDP). It states that beyond a certain threshold of growth, the unemployment rate tends to decrease, and conversely, when the unemployment rate increases the GDP by a certain percentage.

In this analysis, we endeavor to demonstrate that Okun's Law applies in real life, meaning to show that there is a negative relationship between the unemployment rate and the growth rate. To do this, we will use data on GDP and from the "Eurostat" package.

DATABASE CONSTRUCTION

Importing Databases

We are creating the “okun_law” database from two datasets on GDP and unemployment rate for our analysis.


loi d'okun.R | okun_law.R | okun_law

Filter

	geo	time	growth_rate	unemply_gap
1	AT	2012-01-01	0.68045751	6.122449
2	AT	2013-01-01	0.02550410	9.615385
3	AT	2014-01-01	0.66127457	5.263158
4	AT	2015-01-01	1.01449937	1.666667
5	AT	2016-01-01	1.98941369	6.557377
6	AT	2017-01-01	2.25856899	-9.230769
7	AT	2018-01-01	2.42541432	-11.864407
8	AT	2019-01-01	1.45050654	-7.692308
9	AT	2020-01-01	-6.63298458	25.000000
10	AT	2021-01-01	4.23788033	3.333333
11	AT	2022-01-01	4.80640546	-22.580645
12	BE	2012-01-01	0.73919505	5.555556
13	BE	2013-01-01	0.45924531	13.157895
14	BE	2014-01-01	1.57853798	1.162791
15	BE	2015-01-01	2.04145389	0.000000
16	BE	2016-01-01	1.26668446	-9.195402
17	BE	2017-01-01	1.61959967	-8.860759
18	BE	2018-01-01	1.79293792	-16.666667

Showing 1 to 18 of 390 entries, 4 total columns

The construction of the database is now complete, and we begin our analysis.

DATA ANALYSIS

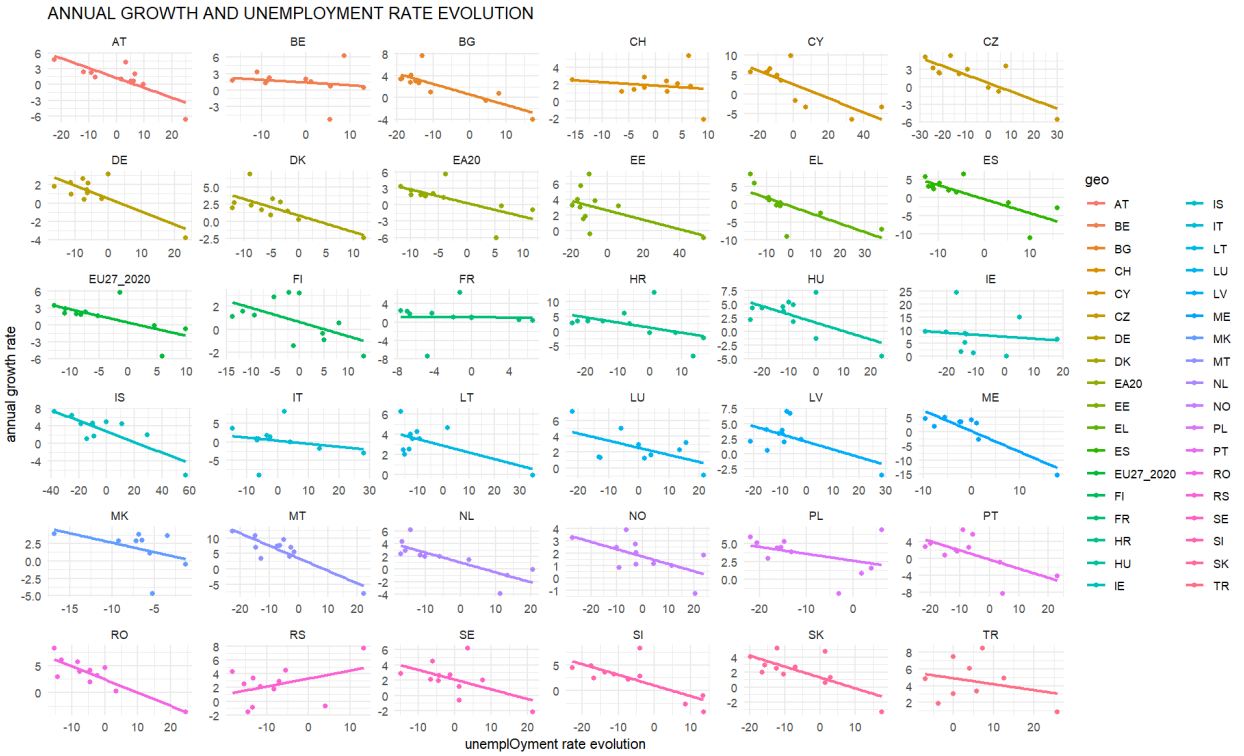
Description of data

The database ("okun_law") is a panel containing 4 variables:

- geo: The different countries. There are 33 of them.
- time: Starting from 2012 to 2022.
- growth_rate: The annual GDP growth rate.
- unemply_gap: The annual unemployment rate growth.

Scatter Plot

We create a scatter plot to visualize the relationship between the unemployment rate and the growth rate. We create a plot from the "okun_law" data frame with the unemployment rate change (unemply_gap) on the X-axis and GDP growth rate (growth_rate) on the Y-axis for each country.



This graph allows us to see the relationship between the GDP growth rate and unemployment rate change with a separate graph for each country. We can observe a negative relationship between the growth rate and the unemployment rate change for most countries in general. However, we notice that some countries have data close to the regression line, while others are further away. We will perform a regression to confirm the strength of the relationship between unemployment rate change and GDP change.

REGRESSION

We are now entering the regression phase to analyze the relationship between the growth rate and the unemployment rate in more depth.

Global regression for the entire dataset

```
> global_lm <- okun_law %>% lm(growth_rate ~ unemply_gap, data = .)
> summary(global_lm)

Call:
lm(formula = growth_rate ~ unemply_gap, data = .)

Residuals:
     Min       1Q   Median       3Q      Max
-14.2989  -1.4651  -0.3873   1.2661  20.2773

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.66627    0.17004   9.799   <2e-16 ***
unemply_gap -0.15064    0.01274 -11.821   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.204 on 388 degrees of freedom
Multiple R-squared:  0.2648,    Adjusted R-squared:  0.2629
F-statistic: 139.7 on 1 and 388 DF,  p-value: < 2.2e-16

>
```

Results of regression

- Intercept: The intercept estimate is 1.66627 with a standard error of 0.17004. The p-value of the intercept is significant (p-value < 0.05). This means that for a 1% decrease in unemployment, GDP would, on average, increase by 1.67%.
- Multiple R-squared: The multiple R-squared is 0.2648, which means the model explains about 26.48% of the variation in the "growth_rate" variable. This means that a significant portion of GDP variation is not explained by the model, contained in other variables. The adjusted R-squared is 0.2629, slightly lower than the multiple R-squared because it considers the number of predictors in the model.
- F-statistic: The p-value associated with the F-statistic is extremely low (< 2.2e-16), indicating that the model is statistically significant.
- Finally, the residual standard error is 3.204, indicating the dispersion of residuals.

In summary, the correlation coefficient for the entire dataset remains quite low. Let's see country by country what is happening.

REGRESSION BY COUNTRY

Explanation Of Results:

- **Point 1**

From a general perspective, we observe a reasonably good relationship for some countries (around 60% on average) with significant parameters. This is the case for countries such as Germany, Spain, or Montenegro.

Example of Montenegro

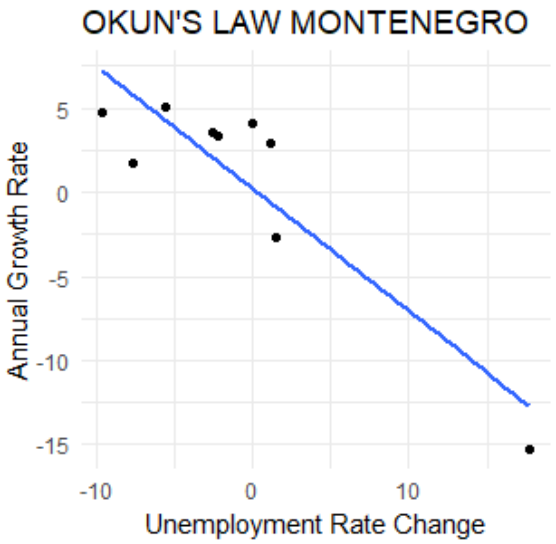
Database and scatter plot for Montenegro:

loi d'okun.R | okun_law.R* | okun_me | okun_law

Filter

	geo	time	growth_rate	unemply_gap
1	ME	2012-01-01	-2.724737	1.522843
2	ME	2013-01-01	3.549919	-2.500000
3	ME	2014-01-01	1.784890	-7.692308
4	ME	2015-01-01	3.389267	-2.222222
5	ME	2016-01-01	2.947713	1.136364
6	ME	2017-01-01	4.718214	-9.550562
7	ME	2018-01-01	5.077987	-5.590062
8	ME	2019-01-01	4.063299	0.000000
9	ME	2020-01-01	-15.308477	17.763158

Showing 1 to 9 of 9 entries, 4 total columns



Regression for Montenegro

```
> me_data <- okun_me %>% select(growth_rate, unemply_gap) # Selecting Montenegro data
> lm_me <- lm(growth_rate ~ unemply_gap, data = me_data) # Creating the regression model
> summary(lm_me) # Display the regression model summary

Call:
lm(formula = growth_rate ~ unemply_gap, data = me_data)

Residuals:
    Min      1Q  Median      3Q     Max
-4.0955 -2.5215  0.7354  1.5103  3.8099

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.2534     1.0224   0.248  0.81137
unemply_gap  -0.7315     0.1356  -5.396  0.00101 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.05 on 7 degrees of freedom
Multiple R-squared:  0.8062,    Adjusted R-squared:  0.7785
F-statistic: 29.12 on 1 and 7 DF,  p-value: 0.001012

>
```

The model is significant (F-statistic) and explains 80% of the GDP variation.

- **Point 2**

However, we notice that for some countries, the relationship between growth and the unemployment rate is constant or even increasing. Why is that?

To understand why Okun's law doesn't work in certain cases, we will examine the case of Serbia with an increasing regression line, illustrating this anomaly.

Scatter plot of Okun's law (Serbia)

We can observe on this graph an increasing regression line with points that deviate from it.

Regression

```
> rs_data <- okun_rs %>% select(growth_rate, unemply_gap) # Selecting Serbia's data
> lm_rs <- lm(growth_rate ~ unemply_gap, data = rs_data) # Creating the regression model
> summary(lm_rs) # Display the regression model summary

Call:
lm(formula = growth_rate ~ unemply_gap, data = rs_data)

Residuals:
    Min      1Q  Median      3Q     Max
-4.4596 -1.6117  0.3852  1.6878  3.1260

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.31277    1.07704   3.076   0.0132 *
unemply_gap  0.11631    0.08955   1.299   0.2263
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.638 on 9 degrees of freedom
Multiple R-squared:  0.1578,    Adjusted R-squared:  0.06427
F-statistic: 1.687 on 1 and 9 DF,  p-value: 0.2263

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```
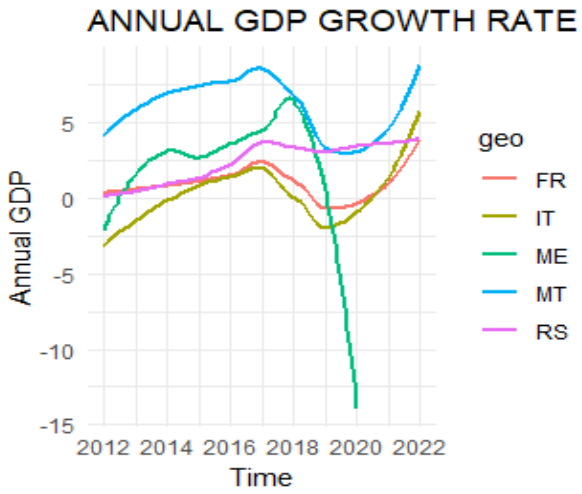

We observe that for most of these countries, the "unemployment rate" parameter is not significant, and the correlation coefficient is very low. Additionally, the model is not significant (p-value > 0.05), which explains the model's ineffectiveness. This is also the case for countries like Italy and France.

Factors

On one hand, when studying the evolution of GDP growth rates in these countries more closely, we observe a certain lethargy compared to other countries.

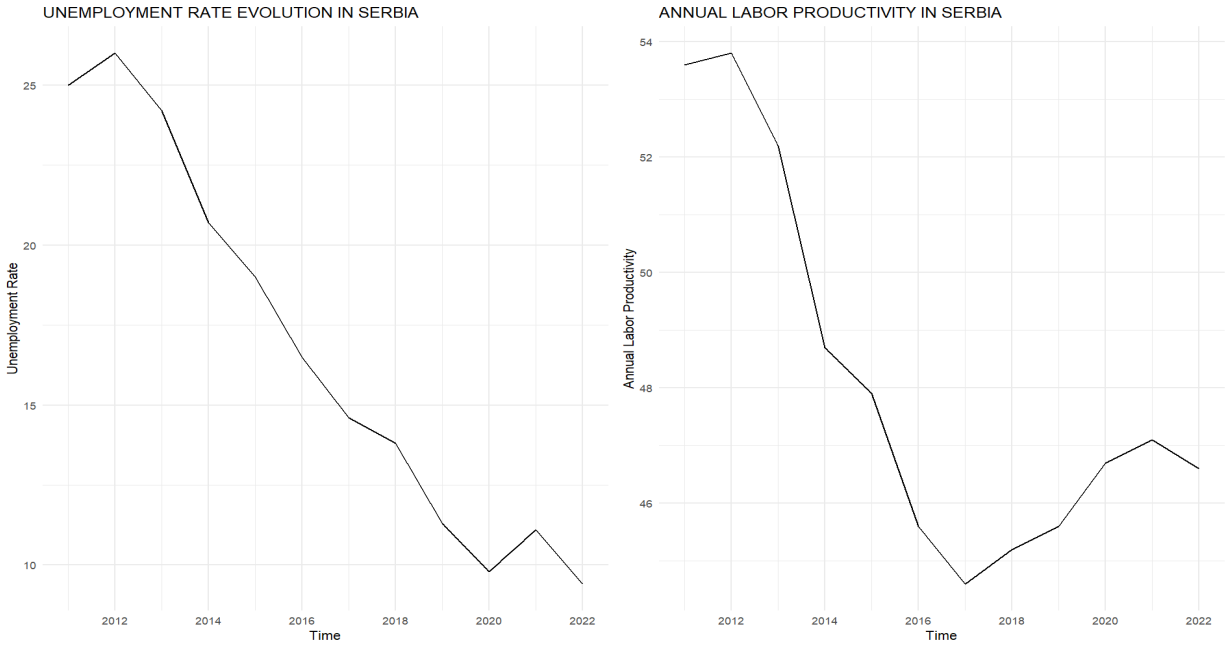
<u>Comparison of the growth rate evolution between different countries (Malta, Montenegro, Serbia, France, Italy)</u>



The observation that the growth rate curves for Malta and Montenegro are above those for France and Italy is significant. Indeed, according to Okun's law, economic growth must reach a certain threshold to trigger a decrease in the unemployment rate. This could be one reason explaining the weakness of our regression models.

On the other hand, it is noteworthy that in the case of Serbia, unemployment decreases over time in correlation with labor productivity. This trend is also evident in France, as demonstrated in the following graphs (As we can observe in the graphs below).

Unemployment Rate and Work Productivity Evolution in Serbia



In summary, the reduction in unemployment, coupled with a decline in productivity, is insufficient to trigger an increase in GDP growth. Economic growth tends to coincide with a decrease in productivity, resulting in a less productive workforce. This, in turn, leads to an increase in unemployment, as businesses hire fewer workers.

Ultimately, the anomalies observed can be attributed to the weakness in GDP growth rates, which are insufficient, and a decline in labor productivity.

CONCLUSION

In the end, Okun's Law is a useful tool for analyzing economic trends, but it can vary from one economy to another and over time due to various factors. The key element is the stability of the relationship between the unemployment rate and economic growth within the specific context being studied.