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# Is Okun’s law still valid in France?

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## Abstract

This paper analyzes the Okun’s law in France, over the 1982-2021 period. We find that the variation in Gross Domestic Product (GDP) implies a variation in unemployment with a coefficient of 1 : 3. We furthermore analyze the impact of a GDP shock on unemployment with a VAR model.

## 1 Introduction

This paper is interested in analyzing the relationship between unemployment and GDP, according to the notorious Okun’s law. The so called Okun’s law was named after Arthur Okun in 1962, and highlights a relationship of 1 : 3; this means that when the GDP increases by 3%, unemployment drops by 1%.

**Contributions** We analyze the 1982-2021 period. The first objective is to determine the optimal model for the fit. The second is to analyze Okun’s coefficient over the period from 1992 to 2021, in order to observe the trend modification of this coefficient and during crises.

This paper is organized as follows: Section 2 will review all the literature on Okun’s law necessary to develop this paper. Section 3 will present the data and their sources. Section 4 will present the methods used in the development of the model. Section 5 will present the results. Finally, Section 6 concludes the paper.

## 2 Related work: Okun’s law

The seminal paper is entitled ”Potential GNP: its measurement and significance” and is by Arthur Okun in 1962; he develops a correlation model between GDP and unemployment in the United States. He finds a coefficient of 1:3, a 3% increase in GDP corresponds to a 1% decrease in unemployment [6].

In 1993 Prachowny analyzed the theoretical foundations of Okun’s law and the validity of Okun’s coefficient, he concluded that the ratio 1:3 is actually 1:1.5. ”Changes in weekly hours and capacity utilization have independent effects on the output gap” [7].

In 2000, Lee measures the robustness of Okun’s law after the war in 16 OECD countries. Okun’s law is statistically valid for most countries. Quantitative estimates –as opposed to qualitative estimates– are far from uniform [5].

In 2007, Knotek performed a dynamic analysis of Okun’s law and showed that Okun’s coefficient was not stable over time [4].

In 2013, Binet analyzes Okun’s law in the regions of France, he concludes that Okun’s law is valid for the 14 regions analyzed [2].

In 2014, Karfakis verifies Okun’s law for Greece and analyzes with a VAR model the response of unemployment to a shock on GDP [3].

In 2017, Ball analyzes Okun’s law in 20 countries on the adaptability of short-term unemployment. He finds that Okun’s law exhibits a strong relationship in most countries and quite stable over time. Okun’s coefficient varies from one country to another, depending on the country’s economic situation [1].

### 3 Data

The data we leveraged in this study comes from INSEE<sup>1</sup> and FRED DATA<sup>2</sup>. GDP and unemployment in France are in quarterly series. The first two figures illustrate the series between 1982 to 2000 and 2000 to 2021. The two following figures are the quarterly evolution of GDP and unemployment between 1982 to 2000 and 2000 to 2021.

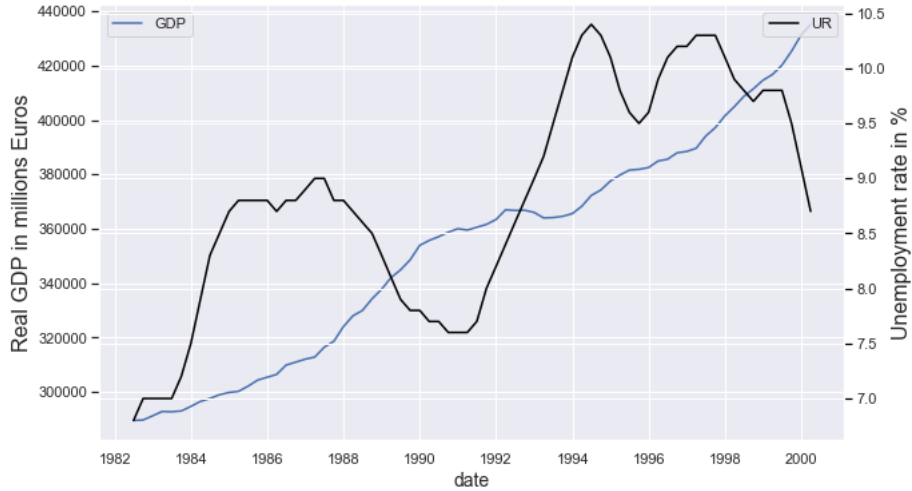


Figure 1: Real GDP and unemployment rate in France (1982:2000)



Figure 2: Real GDP and unemployment rate in France (2000:2021)

These figures present the raw data series, GDP and unemployment from 1982 to 2021. We illustrate in two figures, Figure 1 and Figure 2 for readability: The first from 1982 to 2000 and the second from 2000 to 1982.

<sup>1</sup><https://www.insee.fr>

<sup>2</sup><https://fred.stlouisfed.org>

Let us briefly analyze the evolution of GDP and unemployment. GDP is a series with a positive trend, we can easily imagine a straight line representing the trend component of GDP and see the differences. Between 1989 and 1993, we observe that the GDP shifts positively from its trend, it is exactly over this same period that we observe the drop in unemployment. Thereafter, in 1993 to 1995 the GDP resumes its level of equilibrium, there is a return to the trend. Yet, unemployment reacts to this variation with an increase. The same thing can be observed during the periods of financial crisis 2009 and covid crisis in 2020.

We can say just by looking at these two figures, Figure 1 and Figure 2 that when GDP increases unemployment decreases. But there is an important point if we look at stable periods, the GDP increases due to its positive trend, but the unemployment does not vary or varies little. It is for this reason that we will do stationary transformations the series thereafter to have only the effect of the variation and not the effect of the trend.

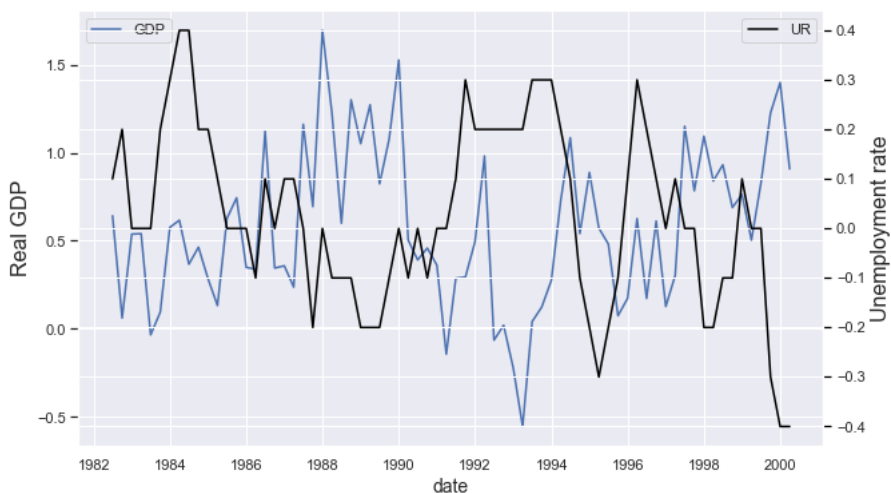


Figure 3: Changes in France's Real GDP and unemployment rate (1982:2000)

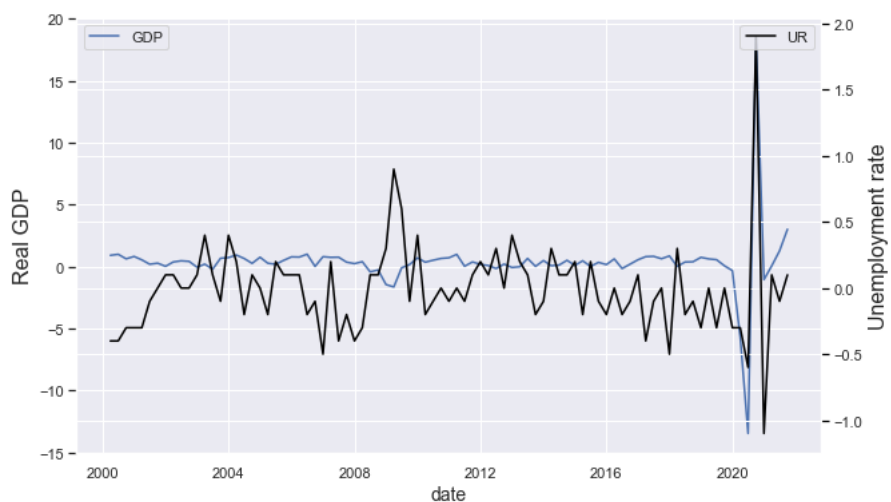


Figure 4: Changes in France's Real GDP and unemployment rate (2000:2021)

To remove the effect of the trend, the GDP is transformed into a growth rate, and unemployment is

Variable	ADF	KPSS
$\Delta GDP$	-12.313703	0.202515
	p-value: 0.0000001	p-value: 0.1
	Critical Values:	Critical Values:
	1% : -3.473	1% : 0.739
	5% : -2.880	5% : 0.463
	10%: -2.577	10%: 0.347
$\Delta unemployment$	-4.955604	0.135499
	p-value: 0.000017	p-value: 0.1
	Critical Values:	Critical Values:
	1% : -3.474	1% : 0.739
	5% : -2.881	5% : 0.463
	10%: -2.577	10%: 0.347

Table 1: Unit root tests

transformed into a change in percentage points. We can see these transformed series in Figure 3 and Figure 4. Figure 4 is not too readable because of the two crises that have taken place which lead to extreme variations. But in Figure 3 we can very well observe the interaction between the two series when the growth rate of GDP is high (i.e. GDP increases more than its trend) the change in unemployment is negative (i.e. unemployment decreases) and when the growth rate is low (i.e. GDP increases less than the trend or falls) the change in unemployment is positive (unemployment is increasing).

## 4 Methodology

After the transformations carried out on the GDP and unemployment series, detailed in the previous paragraph. We observe in Figure 3 and Figure 4 that the series is stationary, that is to say that they have no trend. We check the presence of a unit root in the series, which amounts to checking if the series have a trend.

We test the unit root of the series, that is to say if the series is stationary and have no trend. In Table 1, we use the augmented Dickey Fuller test and the Kwiatkowski-Phillips-Schmidt-Shin test. These tests confirm the stationarity.

Details of the tests :

- ADF : The null hypothesis for the ADF test is that there is a unit root, i.e. non-stationary series. The P - value is less than 5% for  $\Delta GDP$  and  $\Delta unemployment$ , we reject the H0 hypothesis so the series has no unit root and they are stationary, with no trend.
- KPSS : The null hypothesis for the KPSS test is that there is no unit root, i.e. a stationary series (the reverse of the ADF test). P-value is greater than 5% for  $\Delta GDP$  and  $\Delta unemployment$ , we accept the H0 hypothesis so the series has no unit root and they are stationary, with no trend (same result with two different tests).

Correlated variables means they are dependent, here we calculate the correlation coefficient i.e. the degree of dependence. A correlation coefficient is between -1 and 1. A correlation coefficient equal to -1 means a perfect negative dependence, 1 means perfect dependence, and 0 means no dependence. So the greater the absolute value of the correlation coefficient, the greater the dependence between the variables concerned. We choose the lag for the GDP, in the Table 2 we have the correlation values between  $\Delta u$  and  $\Delta GDP_{t+i}$  i ranging from -4 to 4. We select lag  $q = 2$  for  $\Delta GDP$  because it is the highest correlation value. The correlation value between GDP and unemployment and negative is in line with Okun's theory

$\Delta GDP_{t-4}$	$\Delta GDP_{t-3}$	$\Delta GDP_{t-2}$	$\Delta GDP_{t-1}$	$\Delta GDP_t$
-0.291830	-0.360521	<b>-0.666203</b>	-0.552782	0.462601
$\Delta GDP_{t+1}$	$\Delta GDP_{t+2}$	$\Delta GDP_{t+3}$	$\Delta GDP_{t+4}$	
-0.140414	-0.034988	-0.020162	0.13383	

Table 2: Cross correlations of unemployment with GDP

$\Delta u_{t-4}$	$\Delta u_{t-3}$	$\Delta u_{t-2}$	$\Delta u_{t-1}$
0.057445	0.174961	<b>0.294040</b>	0.243801
$\Delta u_{t+1}$	$\Delta u_{t+2}$	$\Delta u_{t+3}$	$\Delta u_{t+4}$
0.013995	0.296894	0.141647	0.089200

Table 3: Cross correlations of unemployment with GDP

and our graphical analyzes carried out in the data part. This means that the more GDP increases, the more unemployment decreases.

Autocorrelation measures the correlation of a variable with itself, when the observations are considered with a time lag. Autocorrelation makes it possible to detect regularities, repeated patterns in a signal such as a periodic signal disturbed by a lot of noise, or a fundamental frequency of a signal which does not actually contain this fundamental. We calculate the auto-correlation of unemployment, the highest correlation value is  $\Delta u_{t-2}$  so we choose a lag  $p = 2$ . Unemployment has an autocorrelation coefficient equal to 0.29 for a lag  $p = 2$ . This means that unemployment is self-fulling, the rise in unemployment in the past will induces the rise in unemployment in the present and in the future. The highest correlation is to lag  $p = 2$ , our data being quartered, this means that the effect of the variation in unemployment impacts unemployment over the next 6 months.

We define a model with  $q$  lag for GDP and  $p$  lag for unemployment and the dummies for the crash : Lag  $q$  for GDP is equally at 2 and lag  $p$  for unemployment is also equal at 2. We implement two dummy variable, DFC for dummy financial crisis and DCC for the dummy covid crisis. The regression equation is :  $\Delta u_t = \alpha_0 + \beta_1 \Delta u_{t-1} + \beta_2 \Delta u_{t-2} + \gamma_1 \Delta GDP_{t-1} + \gamma_2 \Delta GDP_{t-2} + DFC_{2009} + DCC_{2020} + \epsilon_t$

	coef	std err	t	P> t
const	0.0586	0.018	3.279	0.001***
$\Delta GDP_{t-1}$	-0.1023	0.009	-11.233	0.0001***
$\Delta GDP_{t-2}$	-0.0306	0.015	-2.103	0.037**
$\Delta u_{t-1}$	0.1943	0.081	2.413	0.017**
$\Delta u_{t-2}$	0.3679	0.072	5.125	0.0001***
$DFC_{2009}$	0.4627	0.146	3.166	0.002***
$DCC_{2020}$	1.1253	0.288	3.910	0.0001***

Table 4: Regression

Omnibus	50.853	p=0.0001
Durbin-Watson	1.955	
Jarque-Bera	262.654	p=9.24e-58
Skewness	-1.046	
Kurtosis	9.002	
Condition number	30.5	

Table 5: Tests on residuals

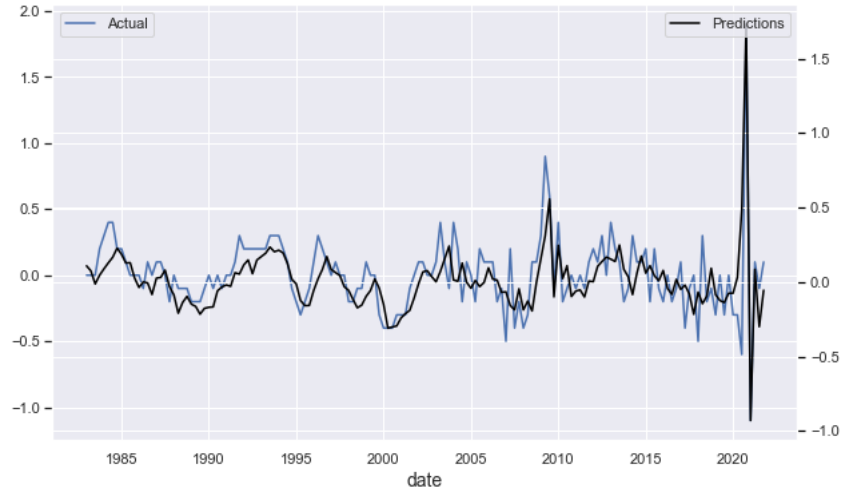


Figure 5: Actual and predicted unemployment change (in sample)

In the Table 5 we have some statistic and test on residuals :

- Omnibus p-value  $< 0.05$  means the data does not follow a normal law. A linear regression approach would probably be better than random guessing, but likely not as good as a nonlinear approach.
- Durbin Watson is a test for homoscedasticity, statistic close to 2 means there is no linear auto-correlation on residuals.
- Jarque-Bera p-value  $< 0.05$  means the data does not follow a normal law, it tests more precisely if the Skewness and the Kurtosis are respectively different from 0 and 3.
- Condition number value is larger than 30, the multicollinearity is regarded as strong.

In the Figure 8 we can see a distribution plot of residuals, residues appear to be white noise. The tests in Table 5 we can draw this conclusion, part of the variance is unexplained, by using other exogenous variables we could have a more powerful predictive capacity, but in the context of the GDP and unemployment relationship we have a robust model.

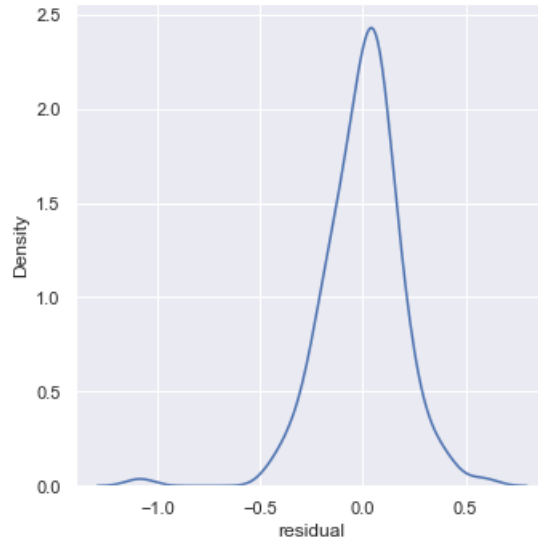


Figure 6: Distribution of residuals of the regression model

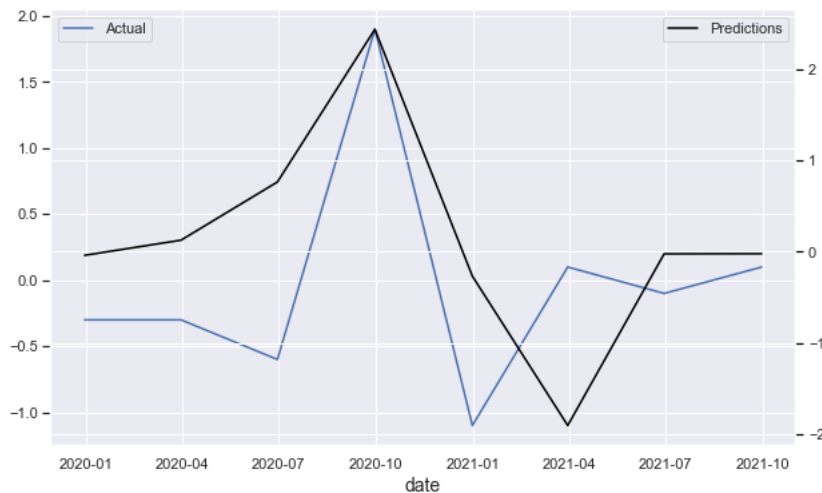


Figure 7: Actual and predicted unemployment change (out sample : Covid crisis period)

To do the out sample prediction we split into train and test data set at the fourth quarter of 2019. The model is trained on 1982:2019 data and tested on 2020:2021 data. You can see in the Figure 9 the comparison between the actual value and the predicted one. The prediction horizon is one quarter.

We did Granger causality test between unemployment and GDP with lag equal to 2.

Since the p-value is less than 0.05, we can reject the null hypothesis of the test and conclude that knowing the value of GDP is useful for predicting the future value of unemployment.

## 5 Results

The Okun's ratio for the period 1982 to 2021 is equal to -0.3035. Which means that when the GDP increases by 3%, unemployment drops by 1%, inversely. This ratio is composed of a short term effect equal to the sum



F test	F=55.1666	p=0.00001
Chi2 test	chi2=113.9866	p=0.00001
Likelihood ratio test	chi2=85.5686	p=0.00001

Table 6: Granger causality test

of the GDP coefficients, -0.1328. And a long-term effect which is the sum of the unemployment coefficients, 0.5622. The short-term effect is the direct effect of GDP on unemployment, it is negative, it confirms Okun's law which highlights the negative relationship between GDP and unemployment. The long-term effect is the self-fulfilling effect of unemployment. It is positive, which means that the effect of the increase in unemployment in Q-2 and Q-1 will have a significant impact on unemployment in Q.

We calculated the Okun's ratio over 117 periods using a sliding window of 10 years (40 quarters).

The formula of extended version (Figure 9):

Regression model :

$$\Delta u_t = \alpha_0 + \beta_1 \Delta u_{t-1} + \beta_2 \Delta u_{t-2} + \gamma_1 \Delta GDP_{t-1} + \gamma_2 \Delta GDP_{t-2} + \epsilon_t$$

$$\text{Short term effect} = \gamma_1 + \gamma_2$$

$$\text{Long term effect} = \beta_1 + \beta_2$$

$$\text{Okun's ratio} = \frac{\gamma_1 + \gamma_2}{1 - (\beta_1 + \beta_2)}$$

The formula of restricted version (Okun's correlation model):

$$\text{Regression model} : \Delta u_t = \alpha_0 + \gamma \Delta GDP_t + \epsilon_t$$

$$\text{Okun's ratio} = \gamma$$

We can indeed see that the Okun ratio is not stable over time, Figure 8 illustrates the evolution of this ratio since 1992. However, we can see -0.3 as an equilibrium level. The Okun's ratio is very strongly impacted by the crisis (2009 financial crisis and 2020 covid crisis). The impacts, according to the two crises are different. During the financial crisis of 2009 this ratio reached more than -0.6. A 1% increase in GDP reduced unemployment by 1.66%. During the covid crisis the ratio reached -0.1 which means that the 1% increase in GDP generated a 10% drop in unemployment, which is 6 times more.

We can draw this conclusion, the drop in GDP during the covid crisis had a more negative impact on unemployment than the financial crisis. But the post-crisis recovery was much more beneficial for unemployment during the covid crisis than the financial crisis.

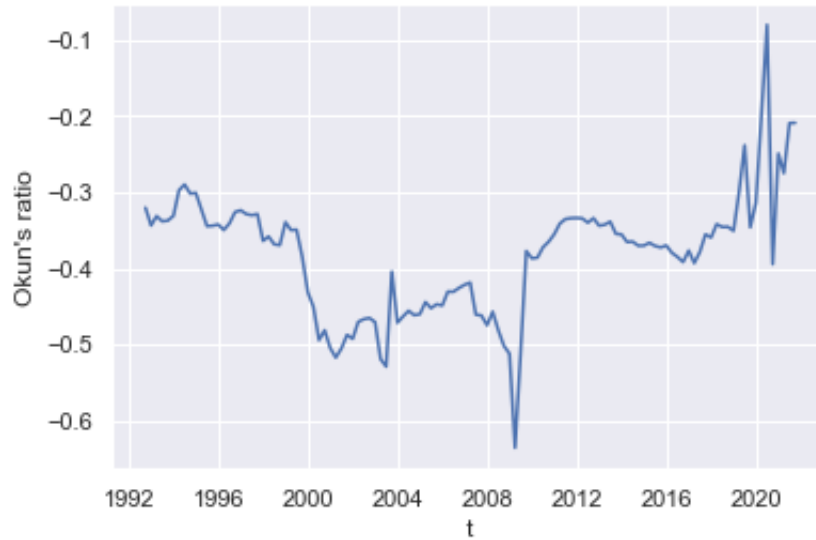


Figure 8: Okun's ratio for France between 1992 and 2021 (Extended version)

In Figure 9 we can see the components of Okun's ratio with the short term and long term component. The variation of its components is more spectacular than the variation of the Okun's coefficient, which varies little over time. So the effect of the change in GDP on the change in unemployment varies little or not at all over time. What really varies is the response time of unemployment to GDP. Which seems logical if we think in the context of a company. Depending on the nature of the event (crisis or post-crisis) the company will take more or less time to lay off or recruit, depending on its future needs.

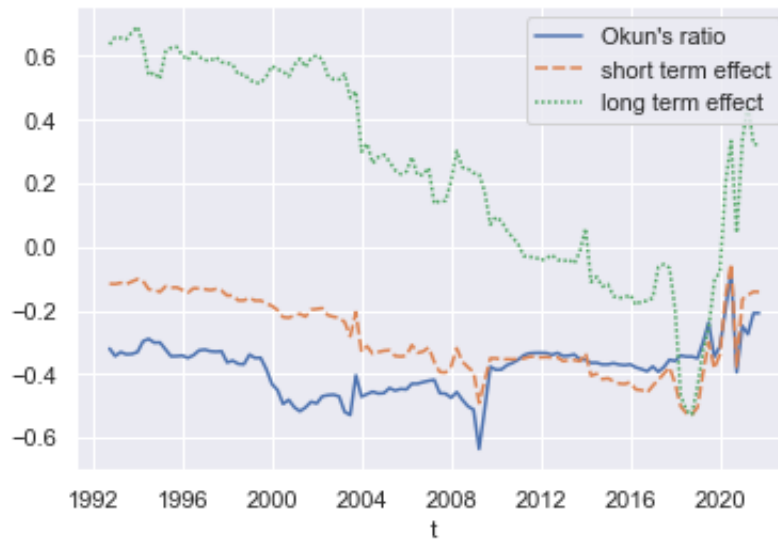


Figure 9: The Okun ratio and its components

In the Figure 10 we can see how unemployment responds to a shock to GDP. We can see that a positive shock to GDP causes unemployment to fall over the next 10 quarters. The major effect is between the first and the second quarter to come. And we do not see any inverse effect, which means that a positive shock to

GDP has a constant positive effect of unemployment.

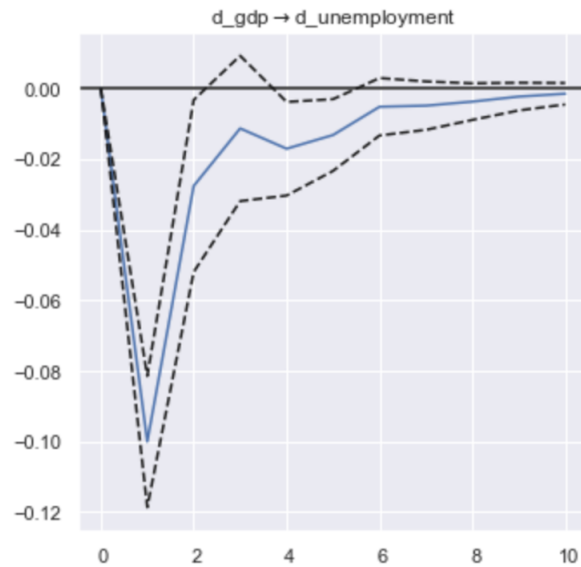


Figure 10: Response of  $\Delta unemployment$  to a shock on  $\Delta GDP$

In the Figure 11 we can see the cumulative effect. We can interpret these two curves as follows: GDP is a variable with a positive trend, i.e. GDP is constantly increasing. This trend is called potential GDP. In this context, if the real GDP goes beyond the potential GDP, then unemployment will go below its current equilibrium level.

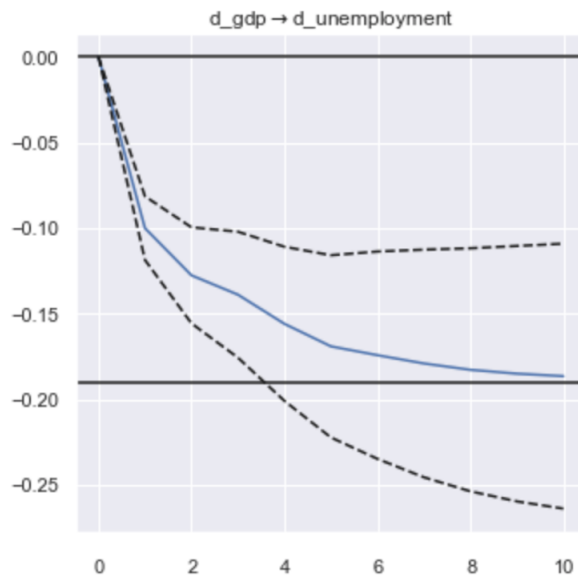


Figure 11: Cumulative response of  $\Delta unemployment$  to a shock on  $\Delta GDP$

## 6 Conclusion

The two major crises, the financial crisis and the covid crisis, have indicated us that the Okun coefficient in France is very sensitive to these. The effects are different depending on the type of economic crises: we saw Okun's coefficient being multiplied by two during the financial crisis, and divided by three during the covid crisis. Okun's law is certainly valid even during crises, but we can no longer afford to set a rate as before, as for example 1:3, and make our predictions and forecast with such a fixed ratio. It is also important to note the lasting effect on unemployment induced by a shock to GDP. For the financial crisis, unemployment in France was 7% with the crisis, unemployment reached to 9.25% after the crisis, and it never reached its pre-crisis level again (same for the covid crisis).

In conclusion, Okun's law is still valid in France, and a coefficient of 1:3 can be used in normal times to easily predict the evolution of unemployment. Yet in times of crisis, a statistical model will have to be used to calculate the effect of that crisis for deducing from the Okun's coefficient, and make a more precise prediction of unemployment.

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