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Instability and Asymmetric Behaviors of Okun coefficients in the Eurozone: A Markov-Switching Autoregressive Model

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Abstract

Purpose - This study investigates the stability over time, the disparity across countries and the asymmetry in behavior in different regimes of the relationship between unemployment and output for the Eurozone and its twelve historical members over the quarterly period 2001Q1-2017Q2.

Design/Methodology/Approach - Based on a revised version of the augmented Okun's law, we use a Markov-switching autoregressive model that allows for gradual adjustment after a regime change.

Findings - Results are threefold: first, there is an asymmetric and switching behavior of Okun coefficient in both cases of positive and negative changes in cyclical unemployment. Second, the Eurozone output is less sensitive to movement in cyclical unemployment in the recessionary regime than in the expansionary one. Third, most countries' outputs are systematically less sensitive to movement in cyclical unemployment when this latter is positive, than when it is negative.

Research limitations/implications - This study while showing that there is no evidence of jobless recovery in the Eurozone could have been conducted to the 28 EU member states.

Originality/Value: This study provides a holistic approach of Okun's law for the Eurozone and considers non-linearity of the employment-production nexus over the business cycle through the use of switching models.

Paper type: Original paper

Keywords: *Okun's law, Markov-switching model, Great Recession, European Union.*

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1. Introduction

Researchers by using standard linear regression models for stationary time series, commonly implicitly assume that the parameters of the model –the mean and the variance- remain constant over time or over business cycles. However, recent evidence shows that time series are often characterized by structural breaks that affect cross-relationships among different variables. As a consequence, ignoring slope heterogeneity while investigating relationships between time series can have two major impacts. First, if time series data exhibit state shifts and structural breaks then a model assuming constant parameters over the sample period is likely to yield misleading results. Second, the empirical results exploring the relationship may significantly depend on the selection of the sample period due to the structural breaks in the series. In other words, modeling the relationship between different series within a nonlinear framework appears more suitable to deal with such instabilities and to model the changing causality patterns over the sample period when the inconstancy of the model parameters is clear to the researcher (Kocaaslan, 2013).

As many other macroeconomic time series, output and unemployment series may exhibit nonlinear behavior due to several factors, like policy changes and economic crises. However, originally, the first strand of literature on output and unemployment nexus captured by Okun in 1962 and 1970 considers homogeneity of the slope (Moosa, 1999; Attfield and Silverstone, 1997; Lee, 2000 among others). Most of these findings highlight an empirical evidence of a negative relationship between output and unemployment, but exhibit great heterogeneity in Okun coefficient estimates. While Okun's law associates a 1-percentage point reduction in the unemployment rate with a reward of 2 to 3-percentage-point rise in real GDP, findings can vary greatly over space (Moosa, 1999; Malley and Molana, 2008; Sögner and Stiassny, 2002; Villaverde and Maza, 2009; Durech et al., 2014). The observation of a horizontal heterogeneity across countries has been recently complemented by the observation of a vertical one that refers to non-linearity in the estimates. In that sense, outcomes from Sögner and Stiassny (2002), Knotek(2007), Huang and Lin(2008), Meyer and Tasci (2012) and Chinn et al. (2014) point outthenon-linearity of Okun coefficient estimates over time, while Cuaresma (2003), Silvapulle et al. (2004), Holmes and Silverstone (2006) and Valadkhani and Smyth (2015) underline their variation over business cycle. For example, Valadkhani and Smyth (2015) examined the stability and the asymmetry in behavior in boom and bust periods of Okun coefficients in the United States (U.S.) from 1948 to 2015 using a Markov-switching model. Authors find that the Okun relationship has weakened over time and explain that jobs have not

recovered after the Great Recession in 2008 because of high structural unemployment, confirming previous results (Cuaresma, 2003, Holmes and Silverstone, 2006 and Chen et al., 2011). Besides, by employing a Markov-switching model, the authors reveal that the extent of within-regime asymmetry is much stronger than across-regime asymmetry.
Such empirical exercise has never been done for the Eurozone area yet. In the literature, studies so far remain limited at evaluating the non-linearity over the business cycle without considering switching models (Jardin and Stephan, 2012).
Our study attempts to go beyond by providing with a holistic approach of Okun's law for the Eurozone. First, it confirms cross-country disparity in Okun coefficient estimates already shown in the literature (Syed Zwick and Syed, 2016; Perman and Tavera, 2005). It investigates disparity across Eurozone members, and asymmetric behavior in recessions and in expansions. It appears reasonable to examine whether or not the output-unemployment relationship within the Eurozone exhibits asymmetric behavior in boom and bust periods. Asymmetry occurs when a symmetric response of unemployment to output depends on whether or not the economy is in an expansionary or in a recessionary regime (Holmes and Silverstone, 2006). To account for nonlinearities, we follow their methodology by using a Markov-switching autoregressive (MSAR) model in which we allow for asymmetries within and across regimes for each country and a gradual adjustment after the process changes regime. In that sense, we obtain two Okun coefficient estimates for each regime corresponding to the position of cyclical output relative to the trend (above or below trend). On this basis, and contrary to Valadkhani and Smyth (2015) or Cuaresma (2003), we do not only focus on one country but we compare Okun coefficients across the twelve historical member states (MS) of the Eurozone within the switching regime.
In that sense, the Great Recession in 2007 raised the issues of structural imbalances within the Eurozone, which are sources of a lack of competitiveness and performances. National structural disparities in labour market responses to changes in output have broader implications for labor market policies at the national and European levels. This study helps better understanding the cross-national differences in the relationship between unemployment and output within two different regimes, the recessionary one and the expansionary one.
The rest of the paper is organized as follows. Section 2 describes the methodology and data while section 3 estimates and analyzes the main results. We conclude in the last section.

2. Methodology and Data

We first present the econometric specification and then discuss the data used in our study.

2.1 Empirical modeling methodology

Okun (1970) proposed two different specifications of the output-unemployment nexus: a first-difference model and a gap model. According to the first difference model, the relationship between the the natural log of observed real output y_t and observed unemployment rate u_t is given by the following expression:

$$(y_t - y_{t-1}) = \alpha + \beta(u_t - u_{t-1}) + \mu_t \quad (1)$$

Where α is the intercept, μ_t is the error term and β is the Okun coefficient that measures by how much changes in the unemployment produce changes in output.

In comparison, the initial equation representing the gap model is given by:

$$y_t - y_t^* = \alpha + \beta(u_t - u_t^*) + \mu_t \quad (2)$$

Wherey_t represents the natural log of observed real output, y_t^* is the log of potential output, u_t is the observed unemployment rate, andu_t^* is the natural rate of unemployment. $\alpha$is the intercept and μ_t is the disturbance term. The left-hand side term represents the output gap, while right-hand side captures the unemployment gap.

In this study, we opt for the gap model. However, its original specification does not allow for instability or asymmetry in behavior of the Okun coefficient. Therefore we use an augmented version of this original specification, which can also be found in Sheehan and Zahn (1980), Prachowny (1993) and Lee (2000). We follow a three-step approach through the specification of three models to appreciate the stability and the asymmetric behavior in recessions and in expansions of Okun coefficients. Assuming that the series are stationary, equation (2) is augmented by a dynamic fourth-order autoregressive error process to obtain well-behaved residuals (Valadkhani and Smyth, 2015):

$$Model\ 1: \begin{cases} Q_t = \alpha + \beta u_t^c + \mu_t \\ \mu_t = \sum_{i=1}^{p=4} \rho_i \mu_{t-1} + e_t \end{cases} \quad (3)$$

Where $Q_t = 100 \times (y_t - y_t^*)/y_t^*$ denotes the percentage deviation of actual output Y_t from the potential output Y_t^*; $u_t^c = (u_t - u_t^*)$ is the cyclical unemployment rate defined as the difference between the actual unemployment rate u_t and the natural rate u_t^*; α is the intercept term capturing the mean cyclical growth rate. Both variables u_t and u_t^* are also expressed as percentages. The no observable data y_t^* and u_t^* are estimated through the use of de-trending techniques to separate our two time series into trend and cyclical components. In that sense, we apply the Hodrick-Prescott (HP, 1997) filter and in order to test for the robustness of the Okun coefficients, the Baxter-King (BK, 1995) filter.

To address the asymmetric behavior in recession and in expansion, Model 2 decomposes the cyclical unemployment rate into its positive and negative values, denoted u_t^+ and u_t^- respectively:

$$Model\ 2: \begin{cases} Q_t = \alpha + \beta^+ u_t^+ + \beta^- u_t^- + \mu_t \\ \mu_t = \sum_{i=1}^{p=4} \rho_i \mu_{t-1} + e_t \end{cases} \tag{4}$$

The positive and negative values of the cyclical unemployment rate are defined as below:

$$u_t^+ = \begin{cases} u_t^c\ if\ u_t^c > 0 \\ 0\ if\ u_t^c \leq 0 \end{cases} \text{and } u_t^- = \begin{cases} u_t^c\ if\ u_t^c < 0 \\ 0\ if\ u_t^c \geq 0 \end{cases} \tag{5}$$

As a third step, we design a Markov-switching model with time-varying variances which allows displaying both asymmetric and switching behavior within and across different regimes. The Markov-switching model developed by Hamilton (1989) fits dynamic regression models that exhibit different dynamics across unobserved regimes using regime-dependent parameters to accommodate structural breaks. While there are two models available, Markov-switching dynamic regression (MSDR) models and Markov-switching autoregressive (MSAR) models, we opt for the second ones as they allow gradual adjustment after a regime change and are often used to model quarterly data. We assume that the transitions between the unobserved regimes follow a Markov chain. In order to have enough degrees of freedom and sufficient non-zero observations for u_t^+ and u_t^- within each regime, only two regimes ($m = 1{,}2$) are considered in model 3:

$$Model\ 3: \begin{cases} Q_t = \alpha(m) + \beta_m^+ u_t^+ + \beta_m^- u_t^- + \mu_t \\ \mu_t = \sum_{i=1}^{p=4} \rho_i \mu_{t-1} + e_t \end{cases} \tag{6}$$

The coefficients β_m^+ and β_m^- capture the asymmetric effects of positive and negative changes in cyclical unemployment on the output gap within and across $m$regimes over time, respectively. Besides, the error term e_t is also allowed to be regime dependent. That is:

$$e_t \sim nid[0, \sigma^2(m)] => \sigma^2(m) = \sigma_H^2(2 - S_t) + \sigma_L^2(S_t - 1) => \begin{cases} \sigma^2(1)\ if\ S_t = 1 \\ \sigma^2(2)\ if\ S_t = 2 \end{cases} \tag{7}$$

Where the variance in regime 2 is assumed to be significantly different from that of regime 1. After estimating model 3, a Wald test is then applied to examine the statistical significance of asymmetry in Okun coefficient within and across the two regimes. To sum up, we estimate four different Okun coefficients, $\beta_1^+, \beta_1^-, \beta_2^+$ and β_2^-.

2.2 Data

We use quarterly data over the period from 2001Q1 to 2017Q2 for the twelve historical and founding European member states of the Eurozone[2]. The series include the real GDP in millions of Euros, constant prices and constant PPP (reference year 2005) and unemployment, where unemployment is measured by the unemployment rate as per OECD database.
After generating both Y_t^p and $\overline{U}_t$ employing the Hodrick and Prescott (HP, 1997) filter, the output gap and cyclical unemployment u_t are computed. Table 1 presents the descriptive statistics of the data for the Eurozone.

[2]Austria-AT, Belgium-BE, Germany-DE, Finland-FI, France-FR, Greece-GR, Ireland-IE, Italy-IT, Luxembourg-LU, Netherlands-NL, Portugal-PT, Spain-SP.

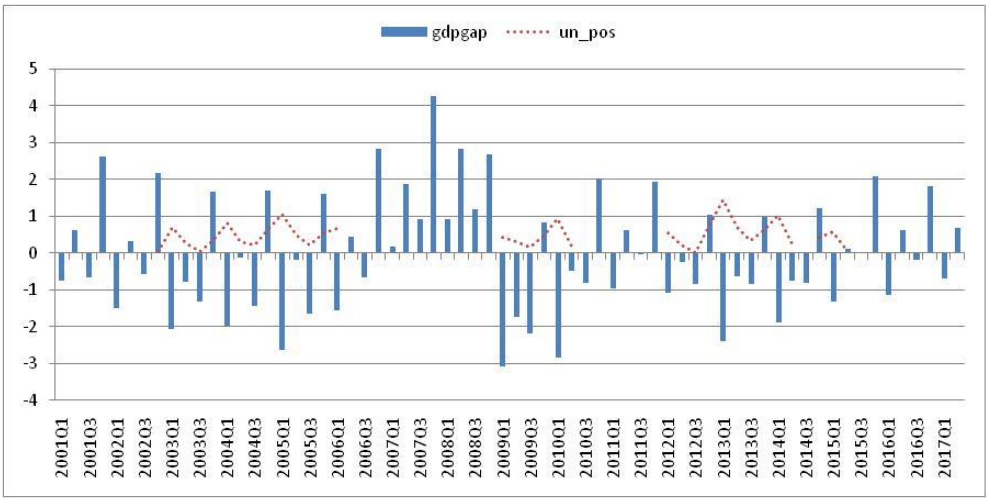
Table 1. ***Summary Statistics - Eurozone (2001Q1 - 2017Q2)***

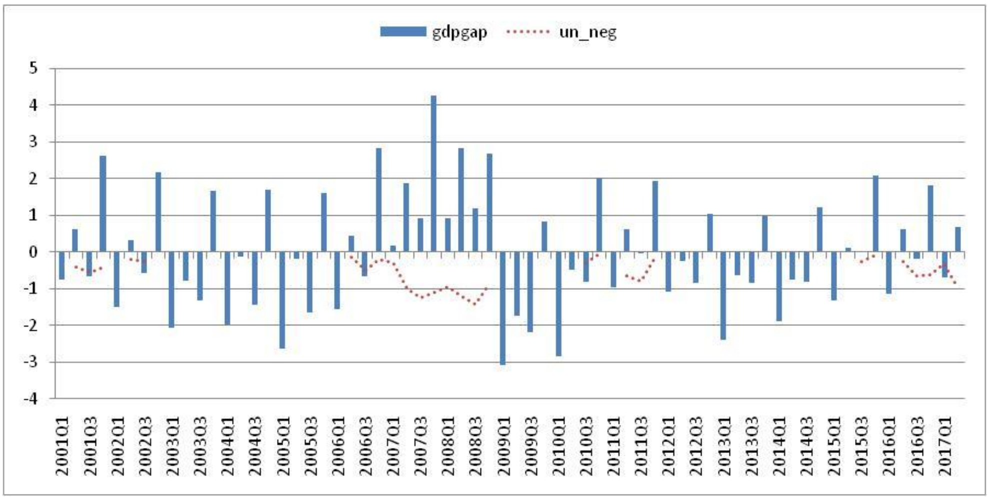
Description	Output gap Q_t	Cyclical U u_t^c	Positive cyclical unemployment u_t^+	Negative cyclical unemployment u_t^-
Mean	-0.0003	0.004	0.49	-0.54
Max.	4.24	1.43	1.43	-1.42
Min.	-3.06	-1.42	0.91	-0.03
Std. Dev.	1.57	0.6	0.33	0.40
Skewness	0.31	-0.26	0.91	-0.61
Kurtosis	2.57	2.74	3.56	2.18
No. of obs.	66	66	37	29

Notes: in%. Std. Dev.=Standard Deviation. No. of obs.= Number of non-zero observations.

The plot of the cyclical components of output and unemployment series gives a pictorial evidence of an inverse relationship between cyclical unemployment and cyclical output during the sample period (Figure 1). The maximum (4.24) and minimum (-3.06) output gap are observed in 2007Q4 and 2009Q1, corresponding to the beginning and the worse period of the Great Recession, respectively. Moreover, the maximum (1.43) and minimum (-1.42) cyclical unemployment rates are recorded in 2013Q1 and 2008Q3. Looking at the standard deviations, we can also observe that the cyclical output (1.56) exhibits greater variability than cyclical unemployment (0.60). One can also notice that positive cyclical unemployment u_t^+ (0.33) and negative cyclical unemployment u_t^- (0.40) show a relatively similar variability.

Figure 1. Inverse relationship between output gap and positive/negative cyclical unemployment





Sources: Author's calculations

As our series need to be stationary, we conducted three different unit root tests: Augmented Dickey-Fuller (DF, 1981), Phillips and Perron (PP, 1988) and Kwiatkowski et al. (KPSS, 1992). Results indicate that both cyclical output and unemployment are stationary[3].

[3] Results of unit root tests are available upon requests.

3. Empirical Results

3.1 Eurozone level

We apply first our three-step methodology to the Eurozone. Table 2 presents the estimation results of models 1 and 2 using ordinary least squares (OLS). Apart from the intercept, all the coefficients have the expected sign and are statistically significant at the 1% level. The corresponding Okun coefficients in models 1 and 2 are consistently negative and highly significant, offering strong evidence that the output gap is inversely related to the cyclical unemployment rate. Asymmetric behavior of Okun coefficient in recession and in expansion is also confirmed: during expansion periods (β^{+} =-2.6), the adjustment is slightly more important than during recession periods (β^{-} =-2.1). Diagnostic tests (Durbin-Watson test and Breusch-Godfrey test) conducted therefore indicate that there is no autocorrelation in the residuals. Besides, the Ramsey RESET test indicating whether non-linear combinations of the fitted values help explain the response variable, is rejected for model 1 while it cannot be rejected for model 2. Testing for the presence of asymmetry, results of the Wald statistics[4] under the null hypothesis of an equality between β^{+} and β^{-} (H_0: $\beta^{+} = \beta^{-}$ $versus$ H_1: $\beta^{+} \neq \beta^{-}$) reject H_0 at the 1% level. These results in RRESET test and Wald test confirm the relevance of investigating the asymmetric behavior in Okun coefficient for the Eurozone.

[4]Results of Wald test are available upon requests.

Table 2. ***Fixed and asymmetric Okun coefficients – Eurozone***

Description	**Model 1**		**Model 2**	
	Coef.	*t Stat.*	*Coef.*	*t Stat.*
α	-0.03	-0.32	0.01	0.03
β	-2.25***	-10.26		
β^{+}			-2.6***	-6.21
β^{-}			-2.1***	-5.29
ρ_1	0.18***	2.74	0.19**	2.68
ρ_3	-0.65***	-9.58	-0.64***	-9.44
R^2	0.83		0.83	
Diagnostic tests				
DW	1.86		1.87	
BG(2)	25.86		25.88	
BG(4)	31.51		31.43	
RRESET	F(3,56)=1.32*		F(3,55)=1.36	

*Notes: *** represents significance at 1%. DW= Durbin-Watson test. BG(2) and BG(4)= Breusch-Godfrey serial correlation LM test with 2 and 4 lags. RRESET=Ramsey RESET test.*

The estimation results for model 3 are shown in table 3. It appears that all the switching and non-switching coefficients have the expected sign and are statistically significant at the 1% level. Results of testing the absence of asymmetry within and across the two specified regimes from estimating model 3 (table 4) allows us reject the null hypotheses at the 1% level. In that sense, they provide evidence of asymmetry within the two regimes and across them. These outputs validate the use of model 3.

Table 3. Asymmetric and switching Okun coefficient for the Eurozone

	Coef.	z Stat.
Switching coefficients		
Regime 1: Expansionary regime		
β_1^+	-2.58***	-8.92
β_1^-	-2.32***	-8.32
AR(4)	0.79***	9.15
α_1	-1.50***	-1.72
Regime 2: Recessionary regime		
β_2^+	-1.87***	8.45
β_2^-	-1.33***	-5.24
AR(4)	1.01***	43.83
α_2	-3.68***	-1.83
Non-switching coefficients		
ρ_1	0.45	0.22
ρ_3	-0.56	-1
Transition matrix probabilities		St. err.
$P11$	0.92	0.05
$P21$	0.04	0.03
Average duration (in quarters)		St. err.
Expansionary regime	14	11.06
Recessionary regime	23	17.70

*Notes: *** indicates significance at 1%. St. err. = Standard error.*

We can now describe our two regimes. Regime 1 is characterized by a positive mean cyclical output (α_1= 1.50%) while the second regime is characterized by a negative one (α_2 =-3.68%). The first regime is called expansionary as the mean cyclical output is above the trend output, while the second is called recessionary as the mean cyclical output is below the trend output. In expansion, both adjustments for positive and negative unemployment are higher in absolute value than in recession. During expansion, the absolute Okun coefficient estimate for positive cyclical unemployment ($|\beta_1^+| = 2.58$) is higher than the one for negative cyclical unemployment ($|\beta_2^-| = 2.32$). This indicates an asymmetry *within* the regime, confirmed by the statistics of the Wald test shown in table 5, significant at the level of 1%. Also, in recession, the absolute Okun coefficient estimate for positive cyclical unemployment ($|\beta_2^+| = 1.87$) is higher than the one for negative cyclical unemployment ($|\beta_2^-| = 1.33$). This asymmetry during recessionary cycles suggests that a given increase in cyclical unemployment where output is below the trend has a smaller impact on the cyclical output than a decrease in cyclical unemployment of equal magnitude. Again, the statistics of the Wald test shown in table 5 confirms the significance of this result at the level of 1%.

Table 4. Four Okun coefficient estimates–Eurozone

	Cyclical unemployment negative $(u - u_t < 0)$	Cyclical unemployment positive $(u - u_t > 0)$
Regime 1: Expansionary Expansion in output	$\beta_1^+ = -2.58$	$\beta_1^- = -2.32$
Regime 2: Recessionary Recession in output	$\beta_2^+ = -1.87$	$\beta_2^- = -1.33$

Table 4 summarizes our results regarding the four Okun coefficient estimates for the Eurozone. There is also an asymmetry *across* regimes. Our results show that $|\beta_1^+| > |\beta_2^+|$ and that $|\beta_1^-| > |\beta_2^-|$. This means that the output is less sensitive to movement in cyclical unemployment in the recessionary regime.

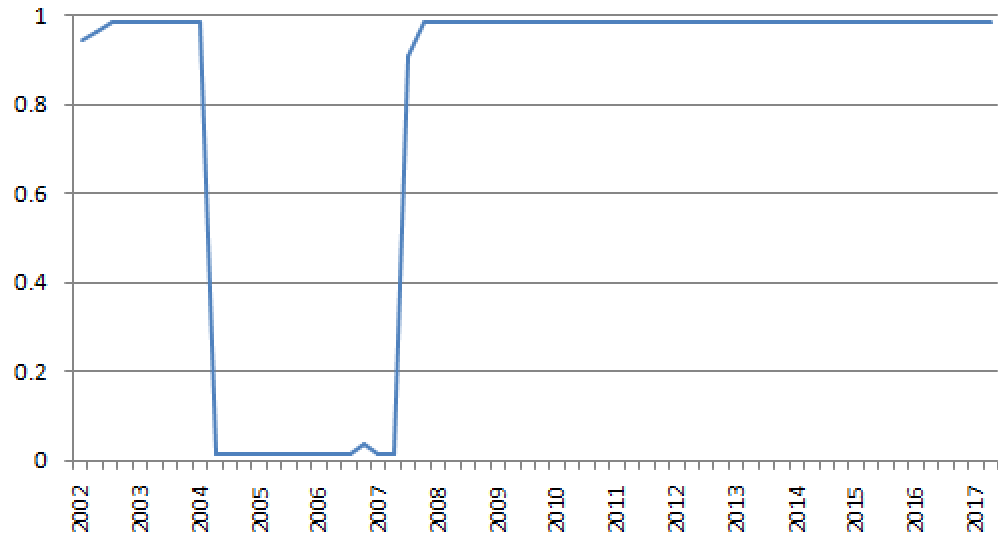
Table 5. Testing for asymmetries within and across regimes for the Eurozone (model 3)

	Hypotheses	*Type of asymmetry*	*Wald test*
1	$H_0^1: \beta_1^+ = \beta_1^-$ $H_1^1: \beta_1^+ \neq \beta_1^-$	Within – 1/1	314.7*
2	$H_0^2: \beta_2^+ = \beta_2^-$ $H_1^2: \beta_2^+ \neq \beta_2^-$	Within – 2/2	454.8***
3	$H_0^3: \beta_1^+ = \beta_2^+$ $H_1^3: \beta_1^+ \neq \beta_2^+$	Across – 1+/2+	391.6***
4	$H_0^4: \beta_1^- = \beta_2^-$ $H_1^4: \beta_1^- \neq \beta_2^-$	Across – 1-/2-	257.6***

Notes: *** indicates significance at 1%.

Transition probabilities that are of greater interest for a Markov process are shown also in table 3. The probability of staying in an expansion phase in the next period given that the process is in this phase in the current period ($P11$) equals 0.92 and therefore indicates that regime 1 is highly persistent. Similarly the estimate of 0.96 ($P22$) indicates that regime 2 corresponding to recessionary cycles is also highly persistent. Finally, the average duration in regime 1 (regime 2) is 3 years and a half (6 years and a half). Figure 2 displays the probability of switching to a recessionary regime (regime 2) and suggests that the economy is most likely in a recessionary regime since 2004 with a significant average Okun coefficient estimate of -2.25.

Figure 2. Inferred probabilities for being in Regime 2 – Recessionary Regime



3.2 Disparity for the Eurozone countries within the two regimes

We then apply our three-step methodology to our twelve historical Member States. Tables 1A and 2A in appendix display Okun coefficient estimates of models 1 and 2. If we do not consider the intercept α, eleven out of the twelve estimated coefficients have the expected sign and are statistically significant at the 1% level. The case of Luxembourg is specific as Okun coefficient estimates are not significant neither in model 1 nor in model 2. We therefore skip its case from the analysis that follows. In model 1, Portugal has the lowest estimate ($|\beta_{PT}| = 1.33$) in absolute value, while Spain has the highest estimate ($|\beta_{SP}| = 2.85$). For both models,ρ_1 and ρ_3 that indicate the AR coefficient estimates, indicate that none of the roots lie outside the unit root. The estimated goodness-of-fit statistics R^2 varies from 0.50 for Germany and 0.95 for Spain for both models. However, the statistics remains very high. The DW statistics allows us to indicate that there is no evidence of first-order serial autocorrelation in the disturbance when all the regressors are strictly exogenous in any of the two models, for any of our twelve countries. The BG statistics with 2 and 4 lags testing for higher-order serial correlation, points out that there is no higher-order serial correlation in the residuals, for any of the two models, and any of our twelve countries. Moreover, the statistics of the Ramsey RESET test is not significant for model 1 but significant for model 2 for ten countries - Luxembourg is not included in our discussion anymore due to the non-significance of Okun coefficient estimates in models 1 and 2- confirming the relevance of our non-linear approach. The case of the Ramsey RESET statistics for Belgium indicates that there is no statistical reason to expect an asymmetry in behavior of the Okun coefficient between expansions and recessions. For Belgium, a symmetric Okun coefficient is appropriate.

We now focus on the amplitude in asymmetry shown in model 2. The estimated $\hat{\beta}$, $\hat{\beta}^{+}$ and $\hat{\beta}^{-}$ confirm the presence of asymmetric behavior in boom and bust periods. Our results also indicate that there is a clear diversity within the Eurozone. Model 2 reveals two groups of countries. The first group, that gathers Austria, Germany, France, Italy and Portugal, is characterized by a higher$\left|\hat{\beta}^{+}\right| > \left|\hat{\beta}^{-}\right|$. This implies that a change in the positive cyclical unemployment has a larger impact on cyclical output than the same absolute change in the negative cyclical unemployment. On the opposite, the second group, consisting of Finland, Greece, Ireland, Netherlands and Spain is characterized by $\left|\hat{\beta}^{+}\right| < \left|\hat{\beta}^{-}\right|$. For each country, we conducted a Wald test to assess the significance of this difference between $\hat{\beta}^{+}$ and $\hat{\beta}^{-}$ by designing $H_0: \beta^{+} = \beta^{-}\ versus\ H_1: \beta^{+} \neq \beta^{-}$. Our results allow us reject the null hypothesis at the 1% level for all of the eleven countries, except for Belgium, for which referring to the asymmetric behavior in Okun coefficient is not appropriate.

The estimation results for model 3 and all our countries are displayed in table 3A in Appendix. We first note that the distinction between the two regimes is less obvious. The mean cyclical output is not systematically above the trend output in regime 1, but systematically inferior to the mean cyclical output in regime 2. This situation refers to France, Greece, Italy, Netherlands and Spain. Therefore, we can consider regime 1 as expansionary or low recessionary while regime 2 remains recessionary, characterized by a negative output gap. Second, a great diversity across countries characterizes Okun coefficient estimates. There is no clear pattern emerging. For example, in the recessionary regime, in case of positive cyclical unemployment, Okun coefficient estimates are lower in absolute value that in case of negative cyclical unemployment for most of the countries, but not all (Austria, Italy, and Portugal are the exceptions). The same applies for the expansionary or low recessionary regime: in most cases of positive cyclical unemployment, Okun coefficient estimates are higher than or equal to Okun coefficient estimates in negative cyclical unemployment cases. Third, differences are also noticeable when we analyze transition probabilities. The recessionary regime appears highly persistent and more persistent on average than for the expansionary or low recessionary regime for most of the countries with few exceptions (Spain, Ireland, and Greece).

4 Conclusions

By applying a Markov-switching autoregressive model, this article revisits the specification of the Okun coefficient both in the Eurozone and in its twelve historical members. This issue has not been examined in a rigorous manner, as far as we know. We estimate three models to exhibit the potential instability and asymmetry in behaviors during recession and expansion periods of Okun coefficient estimates. These models are applied for the Eurozone using quarterly data series on unemployment and output, but also to its member states to capture the potential diversity across Eurozone members.
Results are threefold. First, they have revealed the presence of asymmetries in behavior of Okun coefficient estimates in expansion and in recession both within and across regimes for the Eurozone, but also for most of the Eurozone countries. Second, at the Eurozone level, they have shown that the output is less sensitive to movement in cyclical unemployment in the recessionary regime than in the expansionary one. Third, the Eurozone and most European countries output are systematically less sensitive to movement in cyclical unemployment when this latter is positive, than when it is negative.
In terms of policy implications, our findings suggest at least two recommendations: First, as our results indicate the great heterogeneity in Okun coefficient estimates and their asymmetric behaviors in booms and bursts phases reflect extremely special features of macroeconomic structures and national labor markets. Structural reforms could be implemented to promote a more homogenous response in unemployment when equal absolute increases or decreases in output occur. It would develop a more time-consistent behavior at the Eurozone level. Second, the evidence of jobless recovery found in the United States does not seem valid in the European context. During expansionary phases, especially in the aftermath of the great recession, the US recovered with higher growth but without expected associated gains in terms of unemployment. According to our results for the Eurozone, phases of recovery since 2001 have been accompanied by a low but significant dynamic in job creation. Indeed, during expansionary phases, Eurozone real output should grow an extra 2.58% in case of positive cyclical unemployment, to reduce unemployment by 1 percentage point, while it requires an extra 1.87% during recessionary phases. Third, at the national level, the two different Okun

coefficients according to the situation within the same regime, lead to the necessity to decentralize countercyclical macroeconomic policies –the monetary policy implemented by the European central bank need to take into account this diversity while launching an expansionary policy during recession phases or a contractionary one during rapid expansion phases. The strong coordination of monetary policymakers with national fiscal authorities needs to support measures that aim at boosting the output coupled with structural reforms especially in countries with low Okun coefficients within the recessionary regime.

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Appendix 1A: *Disparity of Fixed Okun coefficient estimates within the Eurozone (model 1)*

Description	***AT***	***BE***	***DE***	***FI***	***FR***	***GR***	***IE***	***IT***	***LU***	***NL***	***PT***	***SP***
α	-0.01	0.03	-0.01	-0.02	-0.01	-0.01	0.02	0.01	-0.04	0.04	0.06	-0.01
β	-2.31***	-2.22***	-2.09***	-2.28***	-2.1***	-2.33***	-2.50***	-1.96***	NS	-1.68***	-1.33***	-2.85***
ρ_1	0.01*	0.07**	0.09**	-0.36***	0.22*	0.07**	0.13**	0.26**	0.47***	0.06**	0.01*	-0.02**
ρ_3	-0.8***	-0.28***	-0.35**	-0.39***	-0.23*	-0.06	-0.23*	-0.62***	-0.53***	-0.42***	-0.20**	-0.30***
R2	0.79	0.82	0.50	0.86	0.56	0.76	0.53	0.84	0.51	0.65	0.67	0.95
DW	1.99	1.72	1.82	1.48	1.88	1.92	1.86	1.61	1.62	1.76	1.94	1.79
BG(2)	22.79	51.62	12.99	6.63	35.81	37.28	1.03	19.7	11.93	46.24	30.59	16.85
BG(4)	27.45	53.54	17.08	12.52	36.29	41.32	6.21	21.36	13.90	46.35	35	18.62
RRESET	1.66	5.07	1.51	2.37	1.07	0.41	0.15	0.03	1.68	1.09	1.22	1.93

Appendix 2A: *Disparity of Asymmetric Okun coefficient estimates within the Eurozone (model 2)*

Description	*AT*	*BE*	*DE*	*FI*	*FR*	*GR*	*IE*	*IT*	*LU*	*NL*	*PT*	*SP*
α	0.21	-0.03	0.23	-0.45	-0.29	-0.31	-0.47	0.06	-	-0.34	0.16	-0.03
β^{+}	-2.84***	-2.41	-2.55***	-1.13***	-2.2***	-1.08***	-1.12**	-2.07***	-	-1.27*	-1.45***	-2.83***
β^{-}	-1.77**	-2.12	-2.03**	-2.09***	-2.08***	-2.60***	-2.63***	-1.85***	-	-2.76**	-1.17***	-2.86***
ρ_1	0.02*	0.07	0.10**	-0.32***	0.20*	0.06**	0.07**	0.26***	-	0.03**	0.01*	-0.02***
ρ_3	-0.16**	-0.27***	-0.34**	-0.42***	-0.23*	-0.05**	-0.23*	-0.62***	-	-0.47***	-0.20**	-0.30***
R2	0.79	0.82	0.51	0.86	0.57	0.76	0.54	0.84	-	0.66	0.67	0.95
DW	1.8	1.72	1.94	1.65	1.92	1.92	1.88	1.6	-	1.76	1.95	1.79
BG(2)	22.1	51.5	10.5	8.6	32.0	37.4	0.41	19.7	-	45.3	30.1	17.0
BG(4)	26.2	53.4	15.1	12.4	33.0	41.6	7.9	21.5	-	45.4	34.6	18.7
RRESET	1.77**	3.55	1.86**	2.95***	1.11**	0.78*	1.44**	0.02**	-	1.30**	1.54***	1.90***

*Notes: ***, ** and * denote significance at the 1%, 5%, and 10%, respectively. DW = Durbin-Watson; BG(2) and BG(4) = Breusch-Godfrey serial correlation LM test with 2 and 4 lags, respectively. RRESET = Ramsey RESET test. NS = not significant.*

Appendix 3A: *Disparate, Asymmetric and switching Okun coefficient estimates within the Eurozone*

Description	AT	BE	DE	FI	FR	GR	IE	IT	LU	NL	PT	SP
Switching coefficients												
Regime 1: Expansionary or low recessionary regime												
β_1^+	-1.1***	-	-2.7***	-2.7***	-1.8*	-2.4***	-1.1*	-1.9***	-	-1.3***	-2.3***	-1.7***
β_1^-	-1.1***	-	-1.5***	-2.6***	-1.8***	-2.4**	-3.1***	-1.3***	-	-2.3***	-1.8***	-2.0***
AR(4)	1.0***	-	-0.02	0.7***	0.9***	0.9***	0.4***	0.9***	-	1.1***	0.8***	0.9***
$\alpha(1)$	-4.1***	-	0.07*	0.37*	-0.01*	-0.53*	-0.66	-1.2*	-	-3.1***	0.68*	-6.03*
Regime 2: Recessionary regime												
β_2^+	-2.9***	-	-2.1***	-1.9***	-1.10*	-1.6*	-1.1***	-2.9***	-	-2.1***	-1.5*	-2.52*
β_2^-	-2.0***	-	-2.9***	-4.1***	-2.5***	-2.1***	-1.91***	-2.4***	-	-2.8***	-1.05*	-2.9***
AR(4)	0.7***	-	0.8***	1.2***	0.8***	0.9***	0.38*	-0.1**	-	0.49***	1.0***	1.0***
$\alpha(2)$	-	-	-	-	-	-	-	-	-	-	-	-

	6.5***		0.01**	0.6	2.2**	4.2	0.83	1.9***		6.4***	1.42*	7.13*
Non-switching coefficients												
ρ_1	0.75	-	0.41	1.91	0.34	1.34	-0.07	0.1	-	0.24	0.72	0.36
ρ_3	0.95	-	0.92	1.21	0.63	0.67	-0.55	0.8	-	0.84	0.64	0.43
Transition matrix parameters												
P11	0.60	-	0.62	0.02	0.79	0.89	0.7	0.41	-	0.55	0.84	0.93
P21	0.05	-	0.12	0.70	0.07	0.20	0.37	0.04	-	0.04	0.06	0.13
Average duration												
Expansionary regime	2.5	-	3	1	5	9	1	2	-	2	6.5	15
Recessionary regime	20	-	8	1.5	13.5	5	2.5	20	-	20.5	15	7

*Notes: ***, ** and * denote significance at the 1%, 5%, and 10%, respectively.*

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