Regional differences in the Okun's Relationship: New Evidence for Spain (1980-2015)

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Abstract

This paper provides new empirical evidence on the relationship between the unemployment rate and the output growth in Spain at the regional level. The "gap version" with the output growth on the left-hand side of the equation is our benchmark model. We observe in our estimates that all coefficients are significant and show the expected negative sign. Significant regional differences in the Okun's relationship, both for the short run and the long run, are found. These results are robust to two different specifications for the gaps: the HP filter and the QT procedure. In the final part of the paper, we also find that the OLS and the GMM estimates for panel data exhibit a similar pattern and that there is a clear asymmetry in the Okun's relationship in booming and recession phases of the Spanish business cycle.

Keywords: Okun's Law, unemployment, GDP, Spanish regions.

JEL codes: J64, E23, C23, R11, R23

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1. Introduction

This paper provides new empirical evidence on the relationship between the unemployment rate and the business cycle in Spain at the regional level. The so-called Okun's Law predicts a negative and stable relationship between a country's or region's jobless rate and the cyclical component of GDP growth, even though the existing empirical literature has shown that the magnitude of such relationship can vary widely across countries and regions. Thus, this paper also offers novel empirical evidence for the Spanish regional labour market, which is characterised by large and persistent employment growth disparities. Our main results are three-fold. Firstly, we find that the Okun's relationship is significant for all of the 17 Spanish regions and that coefficient shows a large degree of regional heterogeneity, regardless of the chosen approach to approximate the business cycle. The northern regions of The Basque Country and Navarre have the strongest link between the unemployment rate gap and the output gap, while Extremadura and the Balearic Islands exhibit the lowest values. Secondly, we split the Spanish regions into two groups (according to the individual estimated value of the Okun's coefficient), and re-estimate the Okun's relationship for each, finding that there is a significant difference in the value of the coefficient across regions, which is consistent with employment growth patterns. Finally, we evaluate whether the Okun's relationship is asymmetric along the business cycle or not by estimating separately the model for the period 2000-2008 and 2009-2015. Our results show a substantial degree of asymmetry in the relationship, with greater coefficients in absolute values for the booming period than for recession periods.

The paper is organised as follows. Section 2 summarises the theoretical framework. Section 3 reviews the related literature and the main empirical findings found in it. Section 4 presents our empirical results, while Section 5 concludes.

2. Theoretical framework

In a nutshell, the Okun's law might be conceptualized as the inverse, and statistically significant, relationship between the unemployment and output in macroeconomic terms. It was established in the seminal work by Okun (1962), a study for US data (1947:2 - 1960:4). In his original paper, Okun made use of three econometric specifications and drew the conclusion that in the three cases the unemployment rate was reduced about 0.3 percentage points for every percentage point of GDP growth over its normal rate (i.e. the growth rate that leaves the unemployment rate unchanged). Two of those specifications have become rather popular among the economic research, the so-called "first difference model" and the "gap model". The first difference model relates the first difference of the observed unemployment rate (u_t) to the first difference of the natural log of observed real output (y_t), i.e. to the growth rate of the aggregate output[1]. In formal terms, the first difference model might be represented according to expression (1):

$$\Delta u_t = a_0 + a_1 \Delta y_t + \varepsilon_t \qquad (1)$$

[1] Time sub-indexes ought to be interpreted as usual.

where a_0 is the constant of the regression (the intercept), a_1 is Okun's coefficient and should take negative values ($a_1 < 0$). It measures the sensitivity of changes in output on changes in the unemployment rate. Finally, ε_t stands for the disturbance term[2].

On the other hand, the gap model could be formalized according to expression (2):

$$u_t - u_t^* = b_0 + b_1(y_t - y_t^*) + \varepsilon_t \quad (2)$$

where u_t^* represents the natural rate of unemployment, y_t^* is the natural log of potential output, and the rest of the symbols should be interpreted in a similar way as in equation (1). The name of this econometric specification comes from the fact that the left-hand side term of (2) is the unemployment gap, whereas $(y_t - y_t^*)$ is the output gap. To put it another way, $u_t - u_t^*$ denotes the cyclical level of unemployment, that is, the difference between the observed and natural rate of unemployment. Similarly, the difference between the observed and potential real GDP represents the cyclical level of output.

The main problem with the gap model is that neither u_t^* nor y_t^* are observable variables, and thus a procedure to estimate them is required. In his original work, Okun deemed, rather arbitrarily, that the natural rate of unemployment was $u_t^* = 4\%$, and relatively constant across time. As for the y_t^* term, he employed a simple linear trend to model it. In the subsequent research, diverse time series methods have been used so as to estimate u_t^* and y_t^*. Researchers quite often have made use of some deterministic procedures such as the HP filter (e.g. Marinkov and Geldenhuys, 2007, or Moosa, 2008) or the Baxter-King filter (e.g. Villaverde and Maza, 2009) in order to obtain values for u_t^* and y_t^*. Other authors have employed stochastic methods with the same aim. For example, Lee (2000) applies the Beveridge-Nelson decomposition, and Moosa (1997) and Silvapulle et al (2004) exploit the unobserved components model estimated with a Kalman filter algorithm[3]. The last group of works would be made up by those that estimate u_t^* and y_t^* with an auxiliary model to obtain these equilibrium figures. Two examples of this technique are Prachowny (1993) are Marinkov and Geldenhuys (2007).

The strong empirical regularity that Okun found (and its interpretation) had a great impact because it provided, on the one hand, an approximate measure of the cost in terms of output losses of having a high level of unemployment and, on the other hand, a tool to assess macroeconomic policies in terms of their impact on unemployment. The reason for this duality is that Okun himself interpreted the relationship in both ways, that is, from the unemployment to the output and the other way round, from the output to the unemployment. He even used the inverse of the estimated coefficient to state that for every percentage point over the natural rate of unemployment (that he considered to be 4%), the output moved approximately 3 percentage points away from its potential level.

This twofold interpretation caused that in the subsequent research many authors followed the same path and made use of the estimated relationship in both directions. Due to this, some authors have estimated directly the inverse relationship, i.e. taking the output

[2] The first difference model has been popularized by the textbook of Blanchard (1997) and its subsequent editions. In this textbook, and after making some little notational arrangements, the following relationship is established: $\Delta u_t = \beta(\Delta y_t - \Delta\bar{y})$. It is easy to prove that departing from equation (1) $\beta = a_1$, and the so-called normal growth rate (i.e. $\Delta\bar{y}$) could be computed easily by just dividing (minus) the intercept by the slope (which is negative, $a_1 < 0$). Putting it another way: $\Delta\bar{y} = (-a_0/a_1) > 0$.

[3] See Harvey (1989).

growth as the dependent variable and the changes in the unemployment rate as the explanatory variable. We align ourselves to this strand of literature. The theoretical rationale for that might be a macroeconomic production function linking aggregate real output to a set of aggregate inputs such as labor, capital and technology[4]. In this way, and supposing that the equilibrium output is achieved when simultaneously all the inputs are in their respective equilibrium levels, it is possible to build a gap version of Okun's law from the aggregate production function. In this version, we should take into account the idle resources coming from each input in the modeling process. A formal view of this idea is equation (3):

$$y_t - y_t^* = c_0 + c_1(u_t - u_t^*) + c_2(Z_t - Z_t^*) + \varepsilon_t \quad (3)$$

where the term $(Z_t - Z_t^*)$ stands for a vector that expresses the difference between the equilibrium levels and actual values of inputs other than labor. In this paper we take equation (3) as the background but make two modifications. The first one is that we assume that the rest of the inputs are close to their equilibrium levels, so $(Z_t - Z_t^*) \approx 0$ and thus we totally focus on the output-unemployment relationship. The second change is that we include a lag structure of the dependent variable so as to take into account the dynamic effects affecting the output gap that might influence the estimate the Okun's law relationship. In formal terms, our baseline econometric model could be written as equation (4) shows:

$$y_t - y_t^* = \alpha + \beta(u_t - u_t^*) + \sum_{j=1}^{p} \gamma_j\left(y_{t-j} - y_{t-j}^*\right) + \varepsilon_t \quad (4)$$

where β is our parameter of interest in this research. The remaining terms in (4) are easily to interpret from the discussion above.

3. State of the art

3.1. The Okun's law at the country level

After the pioneering work by Okun a huge amount of bibliography about the topic has been yielded. The important implications, from an economic policy point of view, of an accurate estimation of the Okun's law relationship may have triggered this volume of research. Moreover, the Great Recession, with its devastating effects on unemployment in many countries, has raised the interest for this subject in the recent years. Some papers in this line are Daly and Hobijn (2010), Cazes et al. (2013), Ball et al. (2013) or Daly et al. (2014). An in-depth review of the whole literature is out the scope of this paper. An interesting (and recent) article that reviews some of this literature in order to carry out a meta-analysis on this subject is Perman et al. (2015).

Nonetheless, it can be stated that two major strands of literature have emerged in the recent years concerning the Okun's law at the country level. Firstly, some papers aim to measure the differences in the Okun's coefficient among a set of countries and try to explain why such differences exist. The second thread of literature seeks to test whether

[4] See, for instance, Gordon (1984).

the Okun's law coefficient is stable both throughout time and across the different phases of business cycle. As a matter of fact, several papers often test discrepancies among several countries and, at the same time, check the stability of the parameters over time. Thus, it could be said that both research fields are closely related. Most of the literature points out that labor institutions, and particularly the employment protection legislation (EPL), are major factors to understand cross-country differences in Okun's coefficient. In general terms, it is considered that the higher is the EPL index the lower (in absolute value) is the Okun's parameter[5]. The theoretical rationale is easy to grasp: a high value of the EPL index entails higher labor adjustment costs for the firms[6], which in turn implies a smoother evolution of the employment levels throughout the business cycle (i.e. a high EPL index produces the so-called "labor hoarding" phenomenon)[7].

An example of this kind of works is Moosa (1997), which compares the Okun's coefficients for the G-7 countries within the period 1960-1995 and concludes that there is an evident disparity among them. A similar conclusion is drawn by Sögner and Stiassny (2002) in a study for 15 OECD countries in the period 1960-1999. Another example is the work by Lee (2000), where the author evaluates robustness of the Okun's relationship for 16 OECD countries and finds mixed evidence of asymmetries and strong evidence of structural breaks in the relationship around the 1970s. Two papers that also find asymmetries throughout the business cycle are Harris and Silverstone (2001) and Virén (2001). In the same line, Crespo-Cuaresma (2003) detects, for US data within the period 1965-1999, that the Okun's coefficient is higher (in absolute value) in the recessions than in the economic expansions. Other two papers more focused on the evolution of Okun's coefficient over time are Perman and Tavera (2005) and Knotek (2007), which make use of rolling regression estimates to draw their conclusions, the former for a group of 17 European countries and the latter for US data. Perman and Tavera (2005) find evidence of convergence of Okun's law coefficients among northern European countries, and among countries with centralized wage bargaining, but they do not find any convergence in other groups of countries. Knotek (2007), on the other hand, concludes that Okun's law is not a tight relationship. To put it in other words, he states that it is only a rule of thumb, not a structural feature of the economy, and not very stable over time. Surprisingly, Ball et al. (2013) reach the opposite conclusion, that is, that Okun's law is a strong and stable relationship in most countries. To finish this subsection, we could mention the recent work by Huang and Yeh (2013), as representative of the articles that try to find not only the short run tradeoff between unemployment and output growth, which was implicitly the Okun's main goal as a Keynesian economist, but a long run relationship between the above mentioned variables. They analyze two panel data sets, one made up of 53 countries for the 1980 to 2005 period, and the other with the 50 US states over the 1976 to 2006 period. By means of the Pooled Mean Group (PMG) estimator and making use of cointegration techniques, the authors affirm that apart from the "traditional" Okun's law relationship (in the short run) there is a similar tradeoff in the long run.

[5] There are some well-known exceptions to this rule like the Spanish case precisely, with a relatively high EPL index and a huge Okun's coefficient (in absolute value). The "standard" explanation for this empirical fact is that the elevated percentage of salaried workers with a fixed-term contract within the workforce in Spain makes the Spanish labor market much more flexible than what the EPL index reflects.

[6] We are referring here to the firing costs. It is generally admitted that hiring costs are more important than firing costs in the United States (see Hamermesh, 1996, for a review of some studies), whereas the opposite is true for continental Europe (e.g. Abowd and Kramarz, 2003, and Goux et al., 2001, for French data).

[7] This idea can be found even in macroeconomics textbooks (see, for instance, Blanchard, 1997). For a more formal development of this view it is necessary to fall back on the dynamic labor demand literature. See Nickell (1987) and Hamermesh and Pfann (1996) for two early surveys on this topic.

3.2. The Okun's law at the regional level

At the regional level, the number of works focused on the analysis of the Okun's law is much lower, although it is also worth mentioning that it is an active research field nowadays. One of the pioneering papers on this topic is Freeman (2000). He focused on eight regions in the United States and concluded that whereas the Okun's law was estimated as a solid empirical regularity in all of them, he did not found significant differences in the coefficients for the period 1977-1997. Nonetheless, in a more recent paper, also using US data, Guisinger et al. (2015) significant differences in the Okun's law relationship are found when the 50 States are considered. These authors conclude that weak differences found in Freeman (2000) are a consequence of the high level of regional aggregation adopted in that paper. Also regarding North America, the Canadian case is studied in Adanu (2005). The author takes into consideration 10 regions and the Okun's law is found to be statistically significant in all of them. The main result drawn from this research is that the cost of unemployment, in terms of product lost, is estimated to be higher for those larger and more industrialized regions.

In Europe, some studies have also adopted a regional perspective. Binet and Facchini (2013) analyze the French case. In 14 out of 22 French regions that they examine the Okun's law was statistically significant. A common factor in those regions whose Okun's coefficient is not significant is the high weight of the public employment in their labor markets. The Greek case has also attracted some attention. In the work of Apergis and Rezitis (2003), the authors take into account 8 regions and find that in only two of them the coefficients are significantly different from the rest. On the other hand, Christopoulos (2004) confirms the validity of the law for 6 out of the 13 Greek regions. Moreover, this author observes important divergences among the estimated coefficients. It is likely that these dissimilarities are a consequence of the different methodological approach. The work by Durech et al. (2014) is focused on 14 regions of the Czech Republic and 8 of the Slovakia. They obtain mixed results that can be summarized in three basic ideas: (1) there are regions in which the Okun's law is valid independently of the estimation procedure; (2) there are regions in which the law is weak or not valid in any case; (3) there are regions showing mixed evidence. From these outcomes, the authors state that the Okun's law seems to be non significant in those regions where the long-term unemployment is relatively high and the average growth rate is low. These regions tend to show low levels of both domestic and external investment too.

The previous works verify that there exist important differences among the Okun's coefficients within the regions of some countries. In addition to this literature, there is another group of works that have tried to explain the reason for those differences by means of some kind of regression analysis. An example of this is Herwartz and Niebuhr (2011), in which the authors, in a first step, estimate the Okun's coefficients for 192 regions of the European Union and, in a second step, take those coefficients as the dependent variable in a regression analysis where they include both national and regional explanatory covariates so as to account for the dissimilarities. The variables that seem to have the highest explanatory power are those related to different laws and labor institutions at the national level and those associated with the structural change in employment among industries at the regional level. In the above mentioned work by Guisinger et al. (2015), the authors, after measuring significant discrepancies among the Okun's coefficients in 50 States of the US, carry out several regressions, with such coefficients as the dependent variable, in order to ascertain which factors could be behind them. To do so, they make use of a set of explanatory variables regarding the labor market flexibility and the demographic characteristics of the labor force. However, their main findings are that the results are not very robust to different econometric specifications which, in turn, might drive to imprecise estimates of the potential determinants of the Okun's coefficients. Finally, the paper by Palombi et al. (2015) analyzes the existence of a medium-run Okun's law relationship between regional output and regional unemployment rate in UK regions. By means of cointegration techniques, the authors draw the conclusion that this medium-run link is important in order to better understand the relationship and, in addition, that it is slightly asymmetric.

As for the studies concerning the Spanish regions, a first article that should be cited is Pérez et al. (2003). They estimate the Okun's law for Andalusia and Spain and notice that cyclical unemployment is less sensitive to the business cycle in former than in the latter. This result suggests that there might be important differences among the whole group of Spanish regions. Precisely, the papers by Villaverde and Maza (2007, 2009) test that hypothesis. They estimate the Okun's relationship (the gap model) and conclude that there are quite important differences. These authors also point out that those differences are a consequence of the different growth rates in labor productivity among the Spanish regions. Two more recent works, although unpublished, also addressing regional differences in Spain are Ballesteros et al. (2012) and Martín-Román and Porras (2012). The work by Clar-López et al. (2014) is particularly focused on forecasting. Their goal is to assess the relative precision of forecasting models based on the Okun's law in comparison to alternative methods. They draw the conclusion that, in general terms and in most regions, the Okun's law models enhance the forecasting power, although the accuracy of the models is not good enough to provide reliable predictions. Finally, Melguizo-Chafer (2015) makes use of a higher territorial disaggregation and takes the Spanish provinces (NUTS-3 breakdown) as the observational unit. The main conclusion is that the variability found at the provincial level in the Okun's law relationship is a relevant issue that might deserve additional attention in the future research agenda.

4. Data and econometric results

4.1. Database

In this section we summarize the empirical results for the estimation of the Okun's relationship in the 17 Spanish regions. Following the discussion in Adanu (2005) and Villaverde and Maza (2009) we first need to obtain an estimate of the output and unemployment gaps. To this end, we use the BD-MORES dataset, provided by the Ministry of Finance, which is a regional dataset providing regional accounting type data on output and its components. The BD-MORES provides data for the period 1980-2008, and therefore precludes any analysis after the onset of the Great Recession. To perform such analysis, we have combined the growth rates of GDP provided by the official Regional Accounts, elaborated by the Spanish Statistical Office (INE) with the BD-MORES dataset. Specifically, we have calculated the growth rate of regional gross value added for each year from 2008 to 2015, and applied these growth rates to the existing BD-MORES data on 2008. Thus, we project the BD-MORES data to more recent periods, which allows us to take into account the effect of the recession in the Okun's relationship at the regional level.

The unemployment data is taken from the Labour Force Survey, developed by the Spanish Statistical Office (INE). Specifically, we use the regional unemployment rate for the period 1980-2015. Given that the BD-MORES data is in annual frequency, we opted to compute the annual average regional unemployment rate.

In order to obtain estimates for the output and unemployment gaps we use the Hodrick-Prescott filter (HP) and the Quadratic Trend (QT) approach. In the first case we apply the HP filter to the level output and unemployment rate series, using a value for λ of 100, as suggested by most of the literature for annual data. The resulting detrended series are regarded as the cyclical component of output and unemployment, and are afterwards used in the estimations. As regards the QT procedure, we regress each series on a quadratic trend and use the resulting residuals as the measure of the cyclical components.

Figures A1 and A2 in the appendix depict these cyclical components, and unveil a clear negative relationship between output and unemployment gaps, even though with notorious regional differences in the intensity of such relationship. Moreover, it is clear that different lag structures across regions must be taken into account in the subsequent empirical work. Interestingly, the relationship seems to be strongest among the more industrialised regions, e.g., Madrid or Catalonia, whereas the link in less developed regions, as Castilla y León or Asturias, seems to be weaker. A similar pattern was found by Adanu (2005) for the Canadian regions. Notwithstanding, the intensity of the negative relationship seems to be stronger when we use the QT rather than the Hodrick-Prescott cycles. Additionally, the Okun's trade-off seems to have vanished through time in some regions, while being reinforced in others. The negative correlation seems to be strongest in the 80's in Madrid, regions along the Ebro Axis and Catalonia, whereas is extremely low in more rural regions, as Extremadura or La Rioja. During the first years of the current century the correlation coefficient has tended to increase in those regions where it was low in the 80's, and to be reduced in the regions where it used to be relatively high. Table A1 in the appendix summarises these correlation coefficients for the whole sample and for two subsamples, namely 1980 to 2000 and 2000 to 2015. This result is a reflection of the regional heterogeneity in the relationship between output and unemployment cycles, and reinforces the motivation of this paper.

4.2. Baseline model

The empirical counterpart of the theoretical model discussed in section 2 establishes a stable relationship between the output gap and the unemployment gap, of the type:

$$ygap_t = \alpha + \beta ugap_t + \sum_{j=1}^{p} \gamma_j ygap_{t-j} + \varepsilon_t \tag{5}$$

where $ygap_t$ is the log of the output gap, $ugap_t$ is the unemployment rate gap and ε_t is an error term. We allow for a lag structure in this equation, in order to capture adequately the dynamics of the relationship between output and unemployment gaps. As we will discuss below, the optimal lag structure will be determined following standard statistical information criteria.

Given our estimates of output and unemployment gaps, the next step is to ensure that these series are stationary, or if not, whether they are cointegrated, otherwise the estimation of equation (5) would provide flawed results due to a spurious relationship between the involved variables. Therefore, we compute standard unit root tests for each of the output and unemployment gaps. Results, summarised in tables 1 and 2, suggest that all of the estimated gaps are stationary in levels, i.e., they do not exhibit a unit root. *p*-values of the ADF tests are well below 5%, whereas for the KPSS test all of the estimated t-statistics are below the corresponding 5% critical value, which is approximately 0.46. Therefore, results are robust to the type of test (ADF and KPSS tests are reported) and to the test specification.[8]

Table 1. Unit root tests. Hodrick-Prescott filter gaps

	Output gap					Unemployment gap				
Region	***ADF***	***p-value***	***lags***	***KPSS***	***Bandwidth***	***ADF***	***p-value***	***lags***	***KPSS***	***Bandwidth***
Andalucia	-3.10	0.00	1	0.057	3	-3.58	0.00	1	0.057	3
Aragon	-3.66	0.00	1	0.054	3	-3.67	0.00	1	0.057	2
Asturias	-3.26	0.00	0	0.064	3	-3.07	0.00	0	0.061	2
Balearic Islands	-3.10	0.00	0	0.057	3	-4.17	0.00	1	0.056	1
Canary Islands	-3.03	0.00	0	0.073	3	-3.5	0.00	1	0.068	2
Cantabria	-3.94	0.00	1	0.059	2	-3.33	0.00	1	0.062	2
C.-La Mancha	-2.71	0.00	1	0.051	3	-3.38	0.00	1	0.059	2
C.-León	-2.84	0.00	1	0.06	3	-3.94	0.00	1	0.058	3
Catalonia	-3.73	0.00	1	0.048	3	-4.33	0.00	1	0.04	3
Extremadura	-3.43	0.00	0	0.066	2	-3.19	0.00	0	0.062	2
Galicia	-3.63	0.00	1	0.055	3	-3.77	0.00	1	0.060	2
Madrid	-3.57	0.00	1	0.055	3	-3.34	0.00	1	0.0489	3
Murcia	-2.93	0.00	1	0.058	3	-3.45	0.00	1	0.055	3
Navarra	-3.18	0.00	1	0.054	2	-3.89	0.00	3	0.062	1
Basque Country	-3.68	0.00	1	0.055	3	-3.53	0.00	1	0.061	2
La Rioja	-3.60	0.00	1	0.057	2	-3.87	0.00	2	0.050	2
Valencia	-3.59	0.00	1	0.058	3	-3.92	0.00	1	0.051	3

Notes: ADF is the Augmented Dickey Fuller test-statistic, while KPSS is the Kwiatkowski-Phillips-Schmidt-Shin test. The 5% level critical value for the KPSS test is approximately 0.46.

[8] Given the characteristics of the time series depicted in figures A1 and A2 in the appendix, it becomes clear that none of the gap series show a trend or a constant, i.e., they evolve stationary around a zero-mean. Nevertheless, we also computed the ADF and the KPSS test under the null of a linear trend. Results, obviously, reject non-stationarity of the series. These auxiliary tests are not reported for brevity but are available from the authors upon request.

Table 2. Unit root tests. Quadratic trends gaps

	Output gap					Unemployment gap				
Region	***ADF***	***p-value***	***lags***	***KPSS***	***Bandwidth***	***ADF***	***p-value***	***lags***	***KPSS***	***Bandwidth***
Andalucia	-2.57	0.01	1	0.083	4	-2.75	0.00	1	0.090	4
Aragon	-2.67	0.00	1	0.082	4	-2.84	0.00	1	0.090	4
Asturias	-1.67	0.08	0	0.091	4	-2.01	0.04	0	0.090	4
Balearic Islands	-2.12	0.03	1	0.083	4	-3.26	0.00	1	0.080	4
Canary Islands	-1.93	0.05	1	0.100	4	-2.42	0.01	1	0.103	4
Cantabria	-2.87	0.00	1	0.093	4	-2.13	0.03	1	0.100	4
C.-La Mancha	-2.29	0.02	1	0.072	4	-2.49	0.01	1	0.090	4
C.-León	-1.73	0.07	1	0.076	4	-2.87	0.00	1	0.090	4
Catalonia	-3.14	0.00	1	0.088	4	-3.52	0.00	1	0.080	4
Extremadura	-1.79	0.06	2	0.073	4	-1.78	0.07	0	0.090	4
Galicia	-2.79	0.00	1	0.089	4	-2.71	0.00	1	0.090	4
Madrid	-2.39	0.01	1	0.091	4	-0.87	0.00	1	0.080	4
Murcia	-2.16	0.03	1	0.081	4	-2.58	0.01	1	0.090	4
Navarra	-2.5	0.01	1	0.092	4	-2.67	0.00	3	0.090	4
Basque Country	-2.58	0.01	1	0.095	4	-2.33	0.02	1	0.100	4
La Rioja	-2.57	0.01	1	0.090	4	-2.72	0.00	1	0.090	4
Valencia	-2.91	0.00	1	0.091	4	-3.04	0.00	1	0.090	4

Notes: ADF is the Augmented Dickey Fuller test-statistic, while KPSS is the Kwiatkowski-Phillips-Schmidt-Shin test. The 5% level critical value for the KPSS test is approximately 0.46.

Once we have established the dynamic properties of the time series involved in the estimations, the next step is to estimate the model in equation (5). The empirical strategy consists in estimating equation (5) for each region in the sample period 1980-2015, allowing for different lag structures, i.e., each regional equation will include an optimal number of lags. This strategy is the same as in Adanu (2008), but contrary to Villaverde and Maza (2008), who impose a similar dynamic structure to their regional equations.

The optimal number of lags has been selected using the standard statistical information criteria, i.e., the Akaike and the Schwarz criteria. We estimate each model, using both versions of the gaps, including up to 5 lags in each equation, and decide on the optimal lag structure maximizing the criteria. In general, both criteria suggest a similar lag structure for each equation. The coefficient on the unemployment gap provides the Okun's coefficient, i.e., the output gap variation after an unemployment gap variation. We expect this coefficient to be negative, while the wide divergence of results in the existing literature precludes any prior as regards the value that should exhibit. Nevertheless, the Okun's coefficient can be interpreted as the short run elasticity of the output gap with respect to the unemployment gap. We also report the long run solution of each model, which provides the long run impact of a unit change in the unemployment gap on the output gap, i.e.,. the long run Okun's coefficient.

Equation (5) is therefore estimated by OLS for each of the 17 Spanish regions using the dataset described above. The sample period is 1980-2015, and a number of misspecification tests have been conducted after estimation to ensure a proper setup of the model. Results are summarised in Table 3 for the HP gap and in Table 4 for the QT version of the gap.

Table 3. Regional OLS estimates. HP gap

Region	Okun's Coefficient	t-stat	p-value	N. of lags	LR solution
Andalucia	-0.504	-6.40	0.00	1	-0.87
Aragon	-0.524	-4.60	0.00	1	-1.00
Asturias	-0.562	-4.12	0.00	1	-0.80
Balearic Islands	-0.425	-4.33	0.00	1	-0.72
Canary Islands	-0.522	-6.34	0.00	1	-0.73
Cantabria	-0.524	-3.07	0.00	2	-0.83
C.-La Mancha	-0.652	-4.50	0.00	2	-1.35
C.-León	-0.457	-3.55	0.00	1	-0.84
Catalonia	-0.607	-7.75	0.00	1	-0.98
Extremadura	-0.399	-2.71	0.00	4	-0.59
Galicia	-0.729	-6.49	0.00	1	-1.18
Madrid	-0.528	-4.7	0.00	2	-0.70
Murcia	-0.614	-5.95	0.00	1	-1.10
Navarra	-1069	-6.04	0.00	1	-1.51
Basque Country	-0.955	-7.19	0.00	1	-1.31
La Rioja	-0.555	-5.11	0.00	1	-1.52
Valencia	-0.617	-12.14	0.00	1	-1.20
Spain	-0.495	-15.28	0.00	5	-0.79

Notes: author's elaboration. OLS estimates of the regional models. Fourth column indicates the optimal lag length suggested by the AIC and the SBC.

Table 4. Regional OLS estimates. Quadratic trend gap

Region	Okun's Coefficient	t-stat	p-value	N. of lags	LR. Solution
Andalucia	-0.412	-7.53	0.00	1	-0.87
Aragon	-0.459	-5.54	0.00	1	-1.21
Asturias	-0.598	-5.52	0.00	1	-1.11
Balearic Islands	-0.409	-4.86	0.00	1	-0.97
Canary Islands	-0.496	-7.47	0.00	1	-0.98
Cantabria	-0.538	-3.96	0.00	2	-1.06
C.-La Mancha	-0.466	-5.67	0.00	1	-1.06
C.-León	-0.439	-5.75	0.00	1	-1.1
Catalonia	-0.565	-8.00	0.00	1	-1.16
Extremadura	-0.318	-8.86	0.00	4	-0.83
Galicia	-0.601	-4.70	0.00	1	-1.09
Madrid	-0.616	-5.81	0.00	2	-1.1
Murcia	-0.457	-5.11	0.00	1	-1.18
Navarra	-0.894	-7.36	0.00	1	-1.81
Basque Country	-0.758	-6.38	0.00	1	-1.25
La Rioja	-0.561	-8-09	0.00	1	-1.75
Valencia	-0.603	-6.36	0.00	1	-1.22
Spain	-0.425	-17.49	0.00	5	-0.97

Notes: author's elaboration. OLS estimates of the regional models. Fourth column indicates the optimal lag length suggested by the AIC and the SBC.

In both tables we observe that all estimated coefficients are significant and show the expected negative sign. Also, there is a wide range of values for the optimal lag structure. The last row in each table provides the coefficient obtained for the whole Spanish economy, estimated by pooling all of the regional observations and including a regional fixed effect. The general picture that emerges from Tables 3 and 4 is that the degree of variation in the relationship between output and unemployment gaps is quite large. This implies that the use of regional data will be helpful in identifying the magnitude of the relationship. The estimated coefficients at the aggregate level are -0.495 and -0.425 for the HP and the QT gaps respectively. However, these coefficients hide enormous regional disparities. For instance, using the HP gap, we find the northern regions of Navarra and the Basque Country show the largest coefficients of -1.06 and -0.955 respectively, i.e. more than twice the national average. Regions as Galicia or Valencia show also relatively high coefficients (-0.729 and -0.617). At the same time, other regions show lower coefficients as, e.g., the Balearic Islands (-0.425) or Extremadura (-0.399). This variation in the short run coefficients is somewhat translated to the long run coefficients, i.e., once that dynamics are settled down. Thus, 5 out of 17 regions show a coefficient greater than 1 in absolute value (La Rioja, -1.52; Navarre, -1.51; Basque Country, -1.31; Castilla-La Mancha, -1.35 and Galicia, -1.18). On the other side of the spectrum there are a number of regions exhibiting lower values, as Madrid (-0.70), the Baleric Islands (-0.72) or Extremadura (-0.59).

When the QT gap is considered a similar conclusion holds[9]. As regards short run coefficients, again the northern regions of Basque country and Navarra show the highest values (-0.758 and -0.894, respectively,), while the Balearic Islands and Extremadura remain as the regions with the lowest values (-0.409 and -0.317 respectively). Nevertheless, the estimated slope coefficients are in general lower for the QT specification than those in the HP gap version. Once we allow the short run dynamics to settle down and consider the long run coefficient, we find that La Rioja and Navarre have the greatest elasticities (-1.75 and -1.81 respectively), while the southern regions of Andalucia and Extremadura have the lowest values for such coefficient (-0.87 and -0.83). Thus, in spite of differences in the magnitudes of the estimated coefficients, the image that emerges from these results is that there is a large degree of heterogeneity in the regional response of output to the unemployment gap.

4.3. Extensions

We next explore further this relationship between the output and the unemployment gap by performing two addiditional exercises. First, we investigate whether we can estimate separately the Okun's law for different groups of regions, since previous literature has shown that different groups or clusters of regions can be considered when analysing the labour market outcomes (see *inter alia* Bande *et al*, 2008, Bande and Karanassou, 2009, 2014, Bande *et al.*, 2012, or Trivin and Sala, 2014). Secondly, given that our sample covers a period of time before and after the Great Recession, we explore if there is a cyclical asymmetry in the response of the output gap to the unemployment gap[10]. In order to perform such analysis, we use two different samples, one from 2000 to 2007 and

[9] However, point estimates of coefficients show in general lower values tan those obtained for the HP gap. In figure A3 in the appendix HP gap versus QT gap short run estimates are depicted.
[10] A large branch of the existing literature has shown that the Okun relationship is highly asymmetric along the business cycle.

another one from 2008 to 2015, and pool the regional data to exploit the cross-sectional dimension.

We first start by grouping Spanish regions depending on the value of the short run Okun's coefficient. Using the HP gap model, we compute the median of the regional distribution of estimated Okun's coefficients, and classify Spanish regions into two broad groups: first, those regions with an estimated individual slope coefficient greater than the median value (so called "High group") and those with a lower value (so called "Low group"). Table 5 summarises this information. After clustering the 17 Spanish regions into these groups, we next pool the observations for each group, and estimate the Okun's coefficient using a fixed effects panel model. In this model, and following the same methodology outlined above, we allow for specific dynamics for the output gap, and select the optimal number of lags based on the AIC and the SBC criteria. Since the model includes the lagged endogenous variable as a covariate in the fixed effects model, we report both the OLS and the GMM estimates. In any case, we do not expect the Nickell bias to be severe, since the number of cross section in each group is smaller than the number of time observations. Our results in Table 6 suggest indeed that this is the case, with similar estimates for both specifications.[11]

Table 5. Classification of Spanish regions

High Group	Low Group
Navarre	Madrid
Basque Country	Aragon
Galicia	Cantabria
C.-La Mancha	Canary Islands
Valencia	Andalucia
Murcia	C. and León
Catalonia	Balearic Islands
Asturias	Extremadura
La Rioja	

Median: -0.555

[11] For brevity, table 6 reports only estimated Okun's coefficients and the corresponding long run solutions of the model. Full results, with the estimated coefficients for the lagged endogenous are available from the authors upon request.

Table 6. Pooled estimation. OLS and GMM

	Okun's Coefficient	*p-value*	*Long run elasticity*	*lags*
		Group High		
OLS	-0.619	0.00	-1.17	1
	(-17.70)			
GMM	-0.645	0.00	-1.16	
	(-14.97)			
		Group Low		
OLS	-0.435	0.00	-0.72	4
	(-10.34)			
GMM	-0.442	0.00	-0.72	
	(-10.48)			

Notes: author's calculations. Fixed effects OLS and Arellano-Bond GMM estimator, t-statistics in parentheses.

Results in Table 6 suggest that there exist significant differences between both groups as regards the magnitude of the Okun's relationship. The point estimate for the coefficient of the High group is -0.619, 200 basis points greater than the estimate for the Low group (-0.435). Further, these differences do not vanish when we estimate the model with the Arellano and Bond GMM estimator, since the reported coefficients are virtually identical than those of the OLS estimation. Additionally, when we compute the long run solution of the model for each group, the differences become even more apparent, with long run elasticities of -1.17 and -0.72 respectively. Therefore, our analysis confirms the existence of strong differences in the relationship between output and unemployment gaps between both groups of Spanish regions.

We next turn our attention to the analysis of potential asymmetries during the business cycle. In this case, we follow the following approach. We first use all of the regional data to estimate separate models for the sub-periods 2000-2008 and 2009-2015[12]. If there is cyclical asymmetry, we should find significant different Okun's coefficients for each sub-sample. We again, report both the OLS and GMM estimations, which are summarised in table 7.

[12] The choice of this sub-periods is based on the available data for the recession period. Since the existing data at the moment of writing was 2009-2015, we decided to use a similar number of periods prior to the onset of the recession, which additionally coincide with one of the strongest booms of the Spanish economy in the last decades. Therefore, estimates in table 7 provide information for two extremely divergent moments of the recent Spanish business cycle: one in which GDP growth was one of the strongest in the European Union, and another in which Spain led the international indicators as regards job destruction and unemployment growth.

Table 7. Expansion and Recession periods. OLS and GMM

	2000-2008 Whole sample				2009-2015 Whole sample			
	Okun's Coefficient	*p-value*	*Long run elasticity*	*lags*	*Okun's Coefficient*	*p-value*	*Long run elasticity*	*lags*
OLS	-0.465	0.00	-0.95	2	-0.304	0.00	-0.28	3
	(-8.03)				(-3.92)			
GMM	-0.666	0.00	-1.37		-0.395	0.00	-0.45	
	-8.72				(-2.84)			

Notes: author's calculations. Fixed effects OLS and Arellano-Bond GMM estimator, t-statistics in parentheses.

Results in table 7 show the existence of significant and strong differences in the Okun's relationship along the business cycle. In the booming period of 2000-2008, the Okun's coefficient was of -0.465, with a long run coefficient of -0.95, i.e., for each percentage point of unemployment above (below) its trend, GDP growth was almost a half percentage point below (above) its trend. When the recession kicked in, however, this trade-off was significantly reduced, since the short run coefficient falls to -0.304, with a long run elasticity of -0.45, almost 30% of the estimated effect for the booming period. In other words, there exists a clear asymmetry in the Okun's relationship in booming and recession phases of the Spanish business cycle. Additionally, these differences do not rely on the estimation techniques, since GMM estimates provide similar estimates. In fact, for the booming period, the Okun's coefficient is larger than the OLS estimate (-0.666), with an also larger long run coefficient (-1.37)

5. Conclusions

In this paper we estimate the Okun's law for the Spanish regions, providing new empirical evidence on the relationship between the unemployment rate and the output growth at the regional level. The "gap version" with the output growth on the left-hand side of the equation is our benchmark model. We carry out several modifications in this baseline model, which may be considered the novelties of this work. First, we allow for a lag structure in the Okun's equation, in order to capture adequately the dynamics of the relationship between output and unemployment gaps. This, in turn, allows us to estimate both the short run and the long run elasticities for the Okun's law. Second, we also take into consideration two different methods so as to obtain the unemployment and output gaps, the HP filter and the QT procedure, in order to provide robustness to our analysis. Third, after the time series study, we pool the Spanish regions into two groups and perform a panel data approach. OLS and GMM estimates with panel data methodology are obtained and compared. Finally, we also take into account the potential asymmetries throughout the business cycle and estimate distinct elasticities for the boom period ranging from 2000 to 2008 and the recessionary period comprised between 2009 and 2015.

As for the results, after checking that our series are stationary, a first thing we observe in our estimates is that all coefficients are significant and show the expected negative sign. Thus, in all the Spanish regions the Okun's law seems to portray the cyclical behaviour of local labour markets to a greater or lesser extent. However, there is a wide variability in the point estimates across regions, both for the short run and the long run output-unemployment elasticities. Moreover, these outcomes are robust to the different gap specifications, i.e. HP filter or QT procedure. As an example of that, and regarding the short run coefficients estimated by means of the HP filter, our findings show that the northern regions of Navarra and the Basque Country exhibit the largest coefficients: -1.06 and -0.955 respectively. On the other hand, the Balearic Islands (-0.425) and Extremadura (-0.399) show the lowest coefficients. These huge disparities imply that the use of regional data will be helpful in identifying the magnitude of the relationship, particularly if the Okun's law is used as a rule of thumb for regional economic policy purposes.

We also carry out two different extensions from our benchmark approach. First, we pool the Spanish regions so as to obtain a single database with both time and cross-regional variability, which allows us to make use of panel data techniques. Thus, we compute both the OLS and GMM estimations for panel data and compare them. In the first exercise, we break down the Spanish regions into two blocks, according to the value of the short run Okun's coefficient. We find that there are significant differences between the "high" and "low" elasticity groups and that the OLS and GMM estimates show a similar pattern. This outcome reinforces the idea of the significance of regional analysis in order to recommend more accurate economic policy prescriptions with regard to the business cycle. In the second exercise, we test whether there are cyclical asymmetries in the Okun's coefficients. With this aim, we make use of all the regional data to estimate separate models for the sub-periods 2000-2008 and 2009-2015. It is found that the Okun's cyclical elasticity is significantly higher (in absolute terms) in the expansionary period of 2000-2008 than in the recessionary period of 2009-2015. Put in other words, a marked asymmetry in the Okun's relationship during booms and downturns is detected.

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Appendix

Table A1. Correlation coefficients between output and unemployment gaps

	HP Gap			QT Gap		
Region	1980-2015	1980-2000	2000-2015	1980-2015	1980-2000	2000-2015
Andalucia	-0,85	-0,86	-0,79	-0,9	-0,81	-0,91
Aragon	-0,71	-0,77	-0,62	-0,78	-0,79	-0,76
Asturias	-0,69	-0,68	-0,65	-0,87	-0,87	-0,86
Balearic Islands	-0,63	-0,54	-0,71	-0,71	-0,59	-0,74
Canary Islands	-0,8	-0,85	-0,79	-0,92	-0,96	-0,89
Cantabria	-0,73	-0,63	-0,83	-0,9	-0,81	-0,94
C.-La Mancha	-0,7	-0,73	-0,65	-0,79	-0,7	-0,8
C.-León	-0,63	-0,51	-0,66	-0,82	-0,72	-0,83
Catalonia	-0,84	-0,89	-0,78	-0,89	-0,92	-0,87
Extremadura	-0,66	-0,07	-0,69	-0,73	-0,18	-0,82
Galicia	-0,81	0,8	-0,82	-0,92	-0,89	-0,93
Madrid	-0,84	-0,91	-0,68	-0,91	-0,93	-0,89
Murcia	-0,78	-0,79	-0,73	-0,82	-0,7	-0,85
Navarra	-0,84	-0,9	-0,75	-0,88	-0,92	-0,84
Basque Country	-0,88	-0,86	-0,85	-0,94	-0,92	-0,94
La Rioja	-0,53	-0,32	-0,62	-0,76	-0,67	-0,79
Valencia	-0,84	-0,87	-0,8	-0,9	-0,93	-0,88

Source: Own calculations

Figure A1. Output and unemployment gaps. Hodrick-Prescott filter

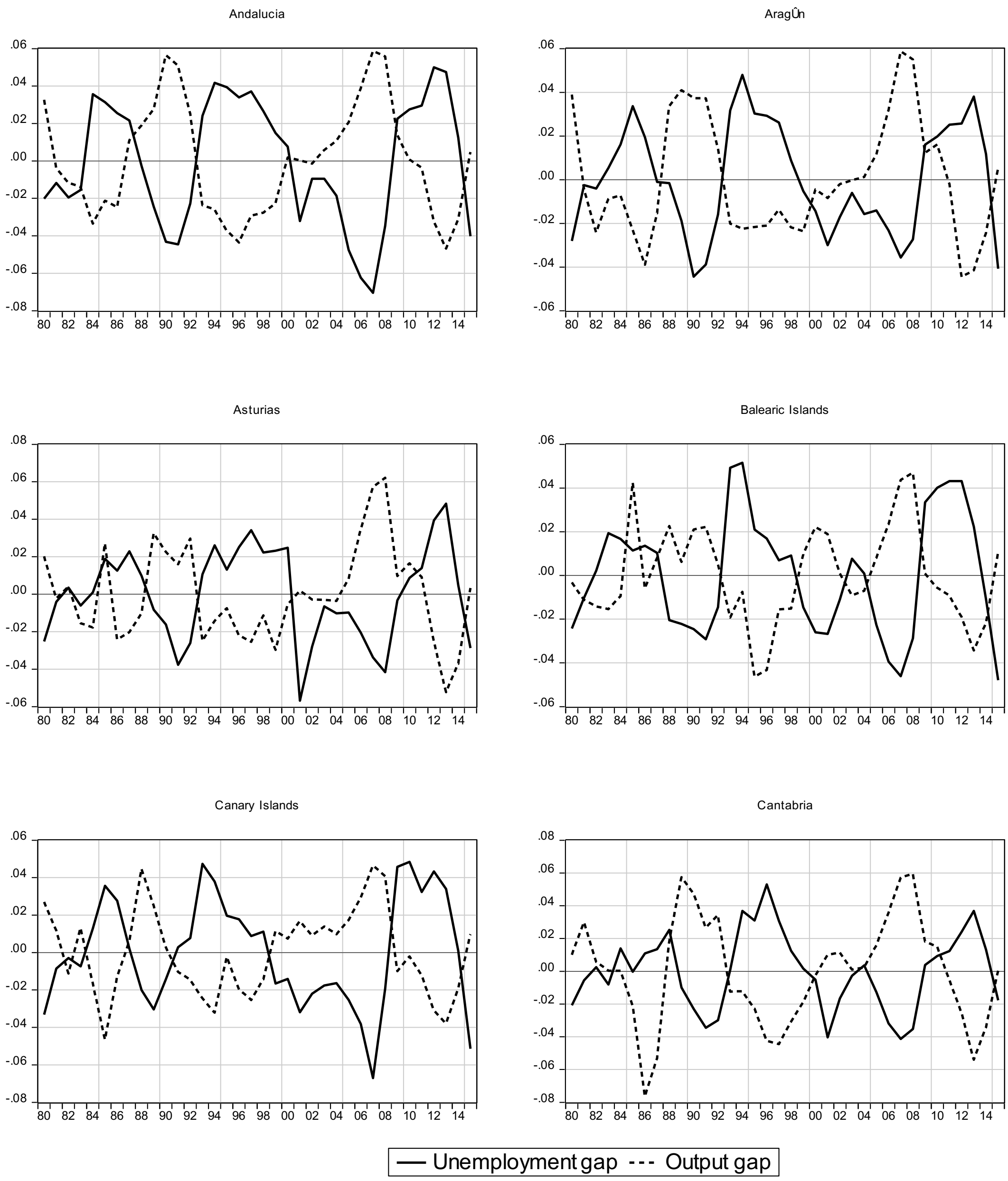

Figure A1. (continued)

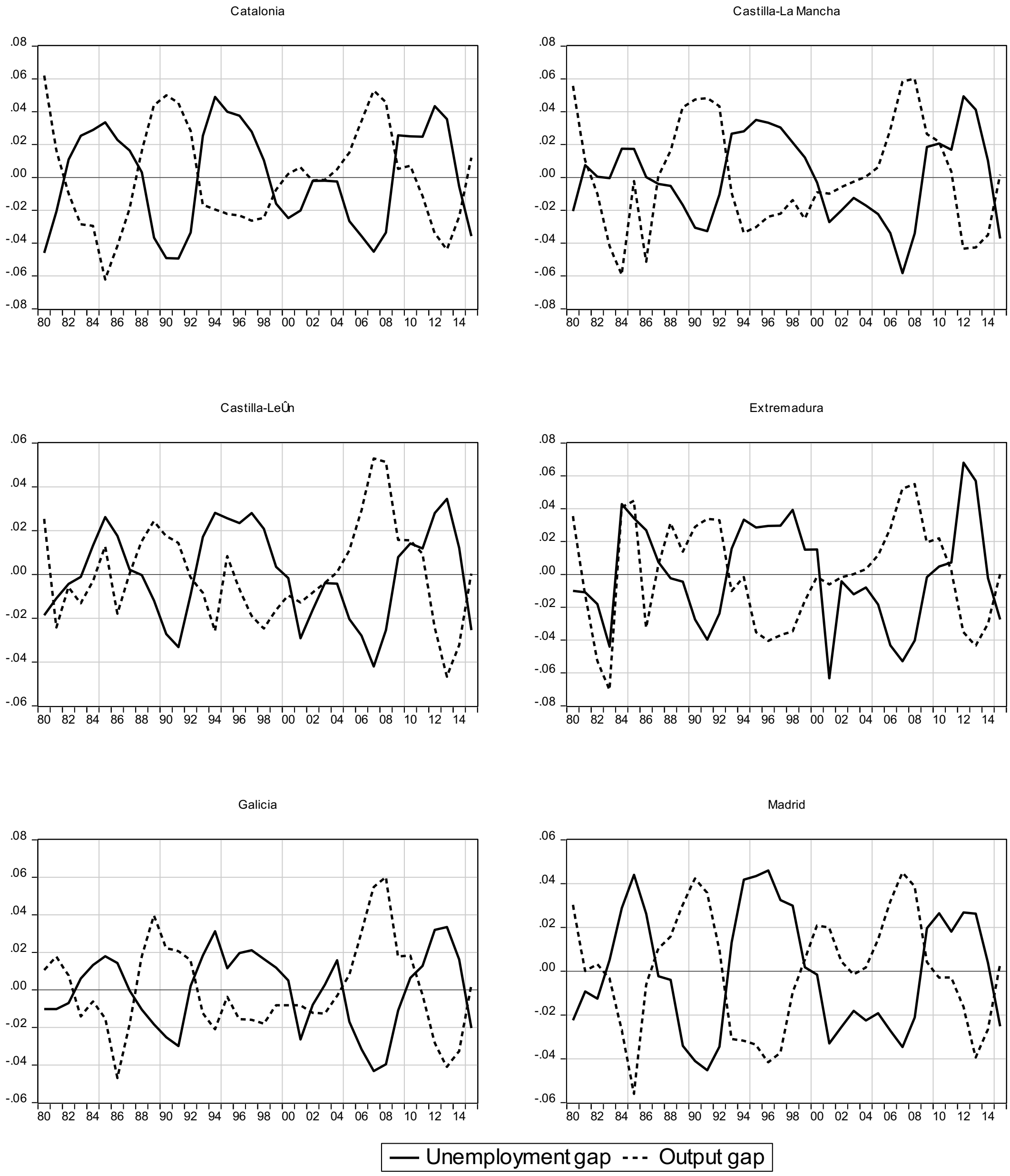

Figure A1. (continued)

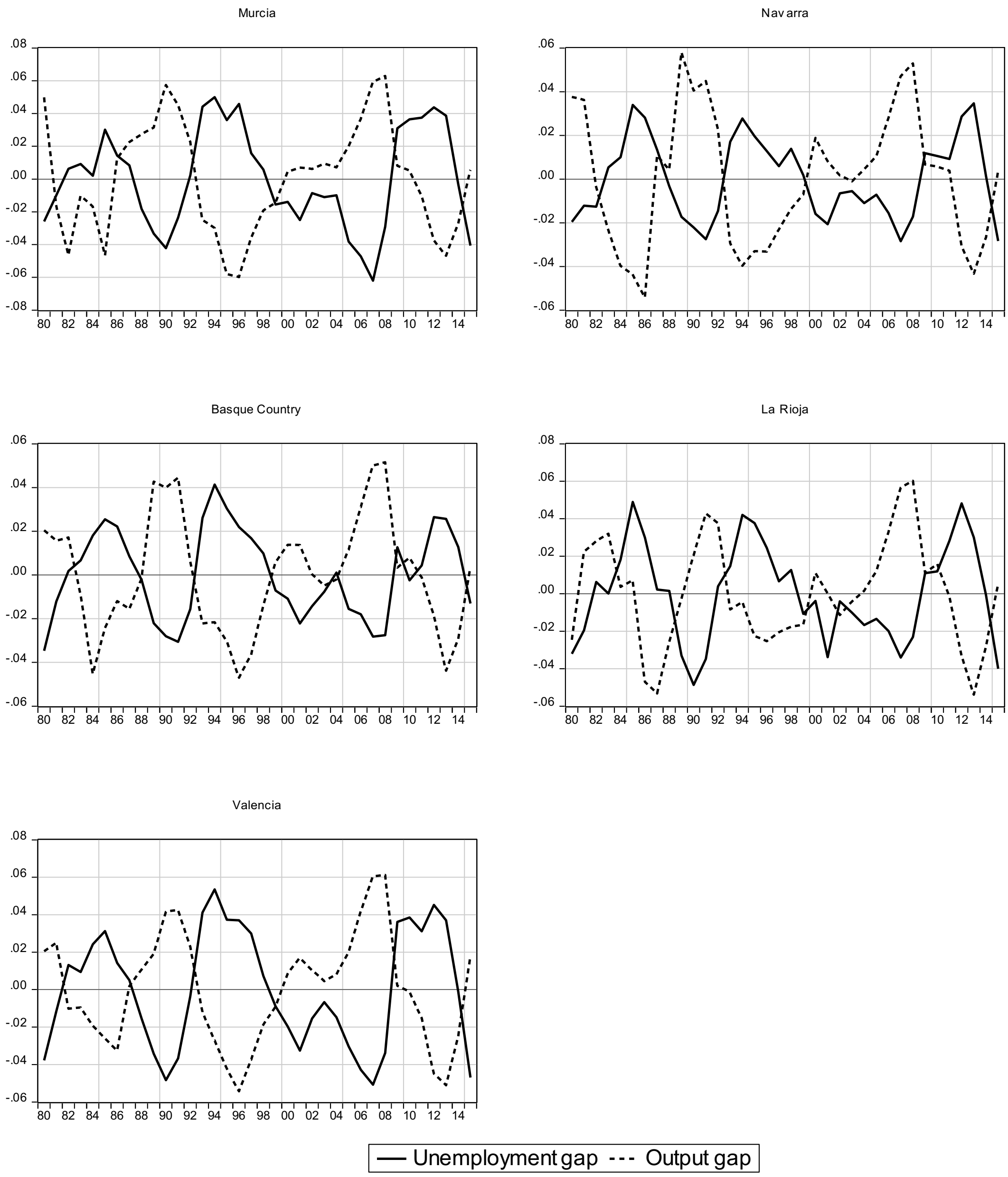

Figure A2. Output and unemployment gaps. Quadratic trend

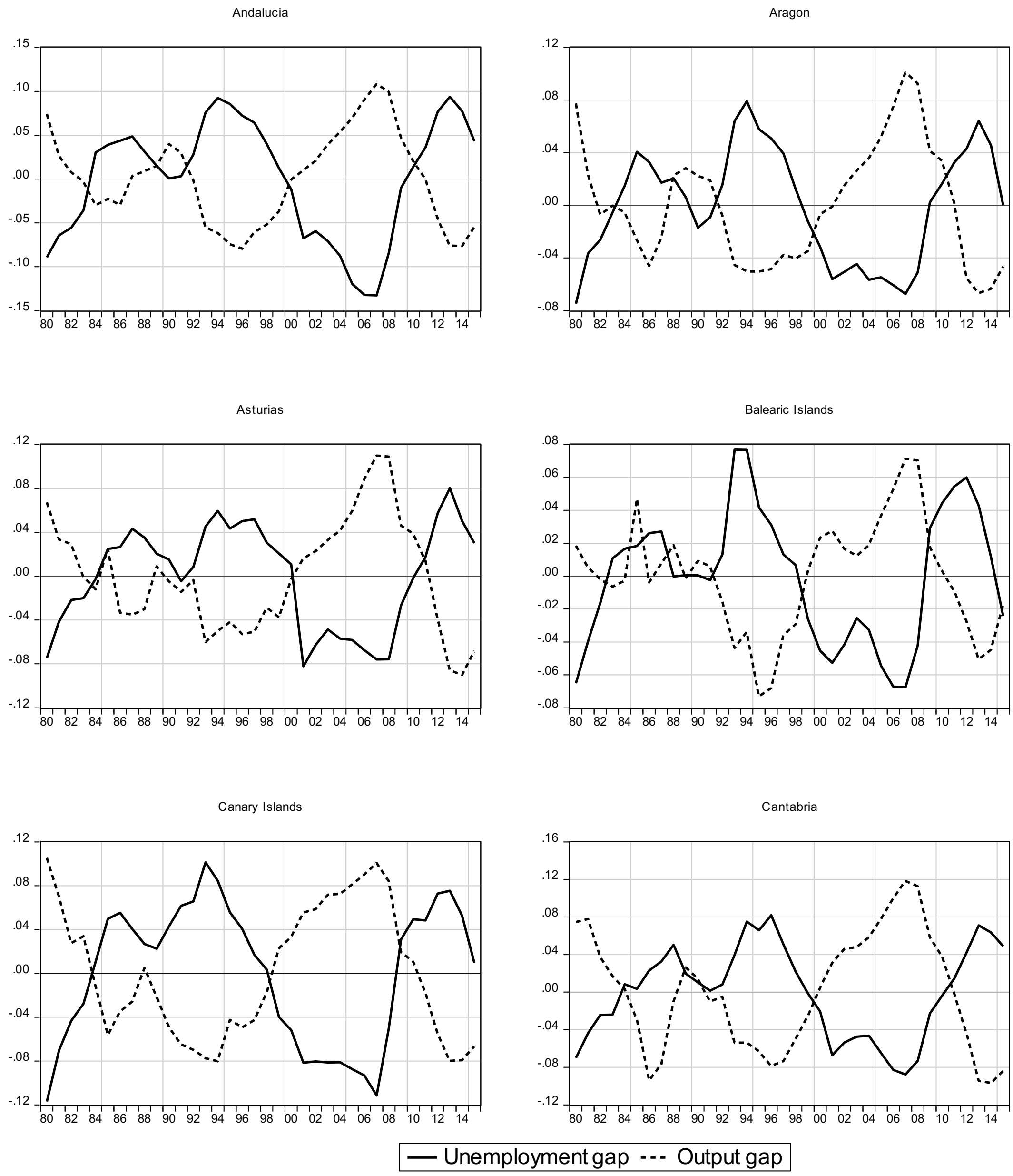

Figure A2. (continued)

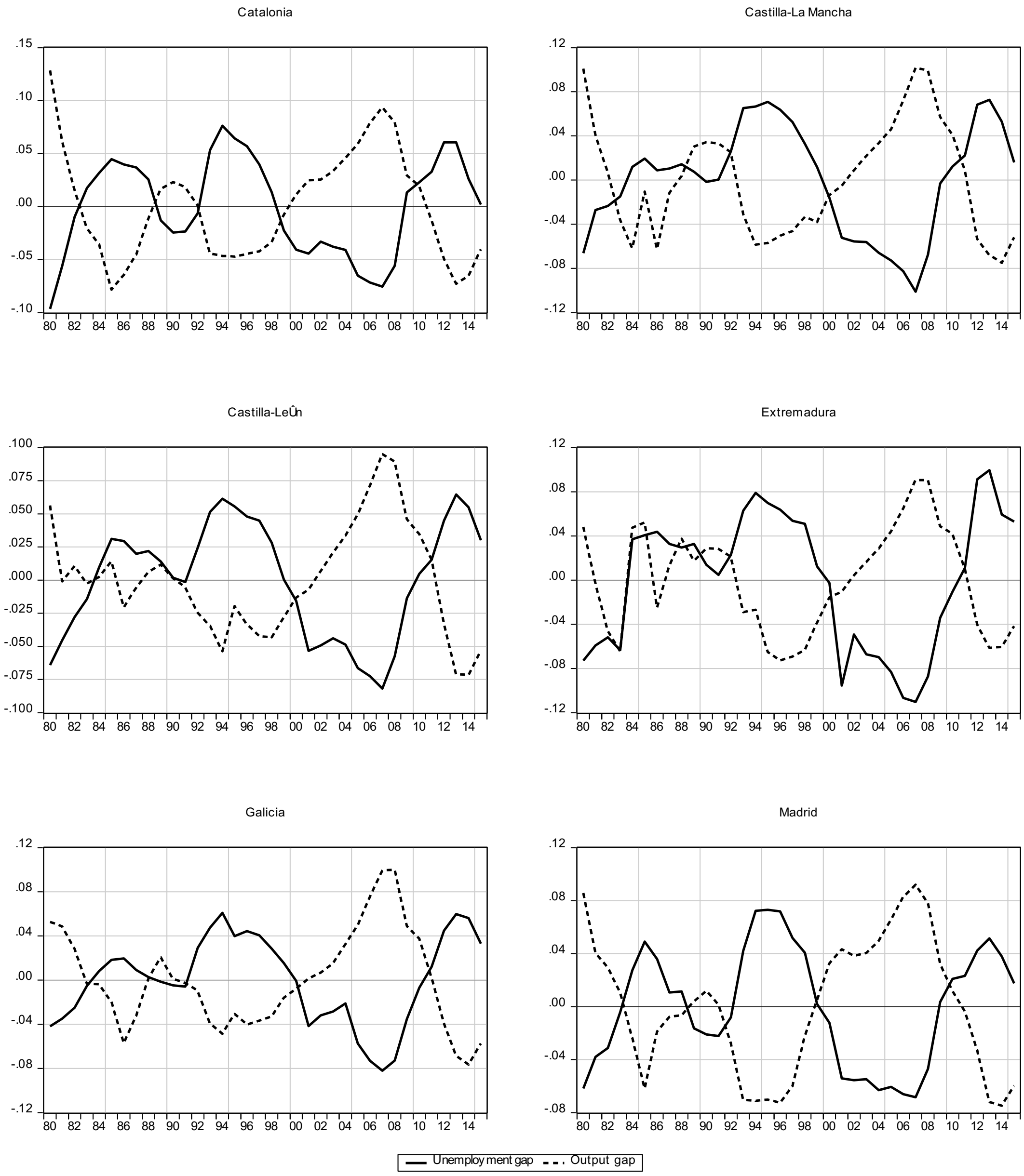

Figure A2. (continued)

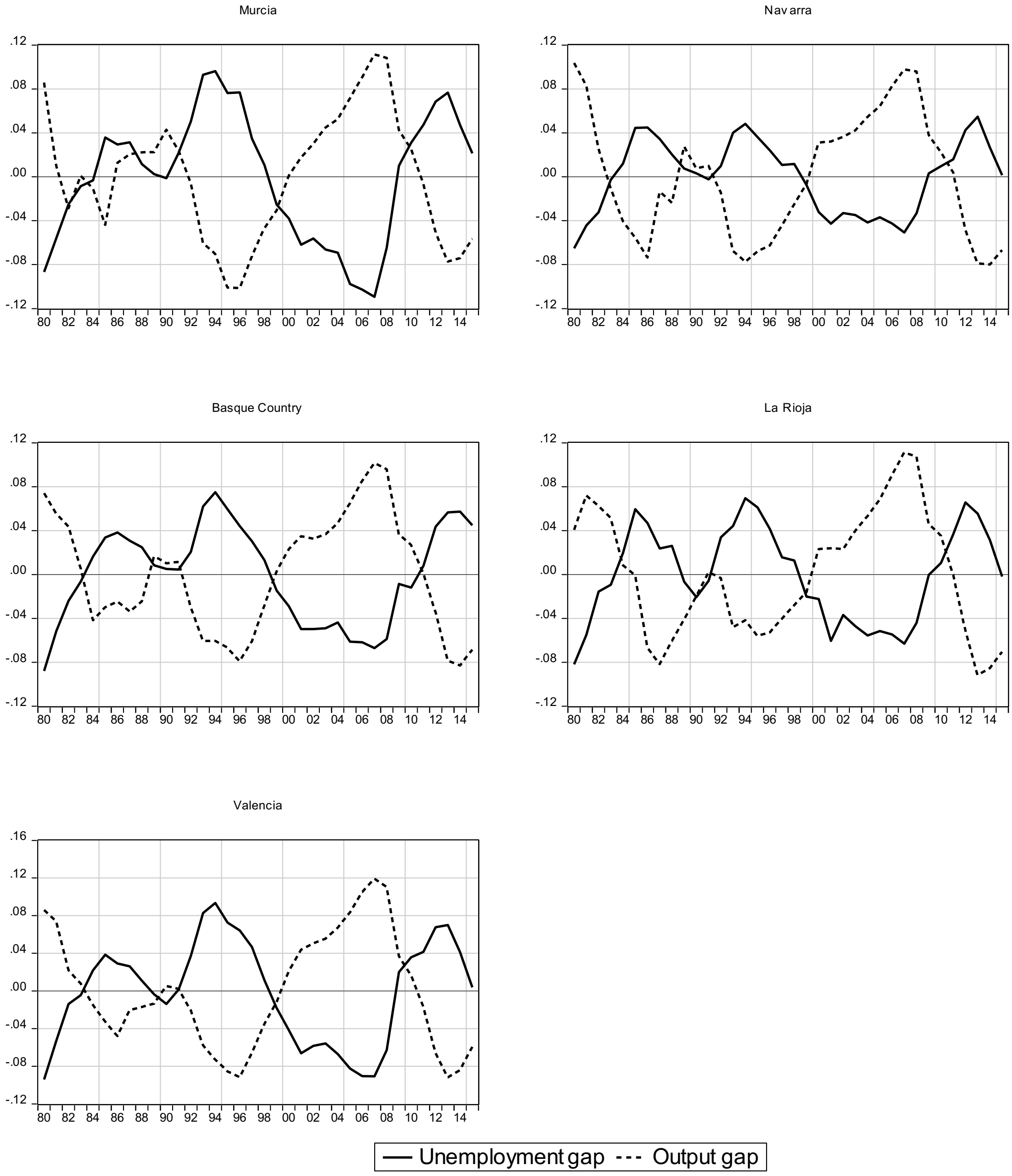

Figure A3. HP gap and QT gap short run point estimates