STABILITY AND ASYMMETRY IN OKUN'S LAW EVIDENCE FROM A SPANISH REGIONAL PANEL

Preliminary version

Antonio Cutanda Tarín*

D-2018-01

Mayo, 2018

* University of Valencia, Spain.

e-mail autor: antonio.cutanda@uv.es

Correspondence: Antonio Cutanda Tarín
Departamento de Análisis Económico Facultad de Economía
Avda. de los Naranjos, s/n 46022-Valencia
Phone: 96 382 82 35. Fax: 96 382 82 49

Preliminary version. Comments are welcome

Abstract

In this paper, it is estimated the Okun's Law with a Spanish regional database. We obtain a relatively high Okun's coefficient at country level in international standards, and we confirm an important degree of regional heterogeneity in this respect. On the other hand, we find an outstanding stability in the estimated coefficient with panel data techniques. Finally, we obtain mixed results about cyclical asymmetry in the Law, confirming it with panel data techniques, but rejecting it for some particular regions.

Keywords: Unemployment; Okun's Law; Economic Cycles; Regional Growth.
JEL Codes: E24, E32, R11.

1. Introduction.

In 1962 Okun gave recognition to an important empirical macroeconomic regularity: the negative relationship between output and unemployment. Despite its a-theoretical nature, this relationship has consolidated both in teaching of Macroeconomics and in the empirical research, and nowadays we have a huge number of studies about it, both with different types of data and for a big sample of countries.

Until very recently, it was widely extended the idea that Okun's Law is structurally unstable, at least for the United States, given the evidence of a break in the relationship between output and unemployment around early 70's (Lee, 2000)[1]. On the other hand, the turn of the century has witnessed the emergence of the hypothesis of asymmetry in the cyclical behavior of the Law, after checking empirically changes in Okun's coefficient throughout the cycle. Related to this, and also for the United States, the idea that the reduction of unemployment in the expansions of the last three cycles has been lower than usual has arisen and extended.

In this context, Ball, Leigh and Loungani (2013) has become a serious shake-up over this status of the matter, since, after examining evidence for the United States and 20 other developed countries, including Spain, they conclude that "Okun's Law is a strong and stable relationship in most countries". These authors argue that it is not that more recent recoveries have generated less employment than usual in the United States, as is often believed, but they have been characterized by lower output growth than before. So, this work has raised an intense debate around the subject, and some contributions supporting its results, such as Daly, Fernald, Jordà and Nechio (2014), are already available.

The present paper is part of this framework, to which it contributes with the empirical analysis of the Law with panel data techniques on a Spanish regional database. In this sense, according to Freeman (2001), the first work that estimates the Law with panel data, this kind of data have clear advantages over time series in this respect. In principle, it presents more degrees of freedom and can therefore lead to more efficient estimates. At the same time, it mitigates the frequent problems of multicollinearity in time series data. In addition, it may allow a better control of omitted variables whose changes can explain instability of the estimated parameters. Finally, panel data techniques can also lead to lower predictive errors

[1] However, the evidence about this subject is not unanimous, See, for example, Weber (1995).

than time series estimates, even when the regressors show individual variability, provided that this is more than offset by the reduction in the variance of the estimates.

In particular, in this work we estimate Okun's Law with the BDMORES database, treated both as a panel and as a set of time series. On the other hand, the issues of their stability and cyclical asymmetry have also been addresssed[2]. As for the results obtained, these confirm a high Okun's coefficient for the Spanish economy in international standards, reflecting an also high degree of flexibility in the adjustment of unemployment to changes in output, while it shows an important degree of regional heterogeneity. While panel data estimates show an outstanding stability, what is very remarkable given that the analyzed period includes the first years of the crisis, the results are not, on the whole, firmly conclusive as to the issue of cyclical asymmetry of the Law, given that we confirm it with panel data techniques, although finding some regions were the hypothesis is rejected.

The work is structured as follows: section 2 presents the different versions of the Okun's Law to be considered; section 3 examines the used data and their suitability for estimating purposes; in section 4, the results obtained are presented and commented, and the stability of the estimated parameters is analyzed; section 5 addresses the issue of cyclical asymmetry; finally, section 6 concludes.

2. The Okun's Law.

Basically, we follow the model in Okun (1962) and Ball, Leigh and Loungani (2013), hereinafter BLL. According to these authors, fluctuations in aggregate demand change output with respect to its potential level, changing both employment and unemployment. Within the framework of a set of aggregate regional units within any country, denoted by subscript *i*, the above mentioned relationships are reflected by the following expressions:

$$e_{it} - e_{it}^{*} = \gamma(y_{it} - y_{it}^{*}) + \theta_i^e + \eta_{it} \qquad (1)$$

$$U_{it} - U_{it}^{*} = \delta(e_{it} - e_{it}^{*}) + \theta_i^u + \mu_{it} \qquad (2)$$

where e_{it} is the logarithm of employment, y_{it} is the logarithm of output, U_{it} is the unemployment rate and the asterisk indicates long-term, or natural, levels. On the other hand, $\gamma > 0$ and $\delta < 0$. The terms θ_i^j, $j=e,u$, reflect regional fixed effects, whereas η_{it} and μ_{it} are error terms with the usual properties. These fixed effects pick up the influence of any

[2] Recently, there have been some attempts to analyze Okun's Law stability using semiparametric o non-parametric econometric techniques. We can mention, in this sense, Huang and Lin (2007) and Zanin and Marra (2011).

element or regional characteristic conditioning the relationship between the cyclical deviations of output and employment, or between those of employment and unemployment, depending on the equation.

From here, the so-called Okun's Law is obtained by substituting (1) into (2):

$$U_{it} - U_{it}^{*} = \beta(y_{it} - y_{it}^{*}) + \theta_i^{y} + \varepsilon_{it} \quad (3)$$

where $\beta=\gamma\delta<0$, $\theta_i^y = \delta\theta_i^e + \theta_i^u$ and $\varepsilon_{it}=\mu_{it}+\delta\eta_{it}$. Note the regional fixed effect on the relationship between output and unemployment cyclical components, derived from fixed effects in (1) and (2), and which should be adequately taken into account in subsequent empirical work.

As BLL show, taking into account the evidence on inputs shares in aggregate income and assuming that the elasticity of output to employment amounts to around 2/3, its consideration in any standard production function produces a value γ = 1.5. However, BLL also points out, at the same time, that when firms consider labor a quasi- fixed factor, so that the adjustment of employment entails costs, they will tend to not adjust it before changes in output. In this case, the firms will try, for example, to change the hours per worker and/or the intensity of work effort, giving rise to procyclical movements in productivity. For all these reasons, these authors expect an employment response to changes in output lower than the 1.5 value previously noted.

On the other hand, BLL expect a value of δ in equation (2) less than unity in absolute value, considering that changes in employment vary the incentives to participate in the job search process, giving rise to movements in and out of labor force, which produces the said result. Therefore, the coefficient of Okun's Law, $\beta = \gamma\delta$, should be lower in absolute value than the coefficient γ, which should be less than 1.5, as we have seen.

Nevertheless, given the model simplicity, it is worth noting that it obviously does not reflect the effect of any circumstance modifying the relationship between unemployment and output, not mentioned so far, as could be exogenous changes in productivity, or in labor participation.

In order to estimate Okun's Law, there are two approaches proposed by Okun (1962) himself. The first is to directly estimate expression (3), the equation "in levels", or the output-gap model, while the second strategy is to estimate the same expression in differences. Note that differentiation produces the following result:

$$\Delta U_{it} - \Delta U_{it}^{*} = \beta(\Delta y_{it} - \Delta y_{it}^{*}) + \omega_{it} \qquad (4)$$

where $\omega_{it} = \Delta\varepsilon_{it}$. From here, BLL take a set of assumptions conditioning the equation to estimate. First, they consider a constant natural rate of unemployment, which implies that the dependent variable in (4) is, directly, the increase in unemployment. On the other hand, they assume that the growth rate of potential output is also constant, which implies that the explanatory variables are the effective rate of growth and a constant. These assumptions make it possible to estimate (4) without estimating the trends of the involved series, which undoubtedly explains the greater use of this version of the Law in the empirical analysis[3].

In our case, and for different reasons, we are not going to follow this strategy. First, it seems very inappropriate to assume a constant natural rate of unemployment in the Spanish economy in the particular period analyzed, from the late 1970s to 2011. Second, in the same way it does not seem reasonable consider that Spanish potential growth rate had been constant along this period[4]. We have then estimated equation (4) with Spanish regional data without adopting such assumptions, but regressing the cyclical deviation of the increase in unemployment over the cyclical deviation of the output's growth rate. Our approach is very close to Crespo (2003) and Holmes and Silverstone (2006), who suggest the existence of different regimes in the analysis of Okun's Law depending on whether the output gap is above or below its trend.

However, in assessing the results obtained, it should be taken into account that both the relationship between aggregate output and unemployment, expression (3), and the model in differences with the BLL assumptions, are very different from expression (4). While in one case it is analyzed the impact of the output gap on cyclical unemployment, or of the output's growth rate on the increase of unemployment, it is the effect on this last variable in relation to its trend of the difference of the output's growth rate with respect to its trend in the other. Therefore, it should not be a surprise to obtain different results estimating so different equations.

---

[3] Traditionally, and taking into account that Okun (1962) himself considered both approaches comparable in the empirical analysis, both have been widely used in the estimation of the Law. Additionally, note that both are equivalent, if it is assumed that the economy starts from its long-term equilibrium.

[4] Additionally, a first attempt to estimate the model under these assumptions did not yield good results.

On the other hand, although the individual effect in equation (3), θ_i^y, has vanished from equation (4) when differencing, we consider that regional effects cannot be ruled out, at a first glance, in the relationship between the cyclical deviations of the increase in the unemployment rate and the output's growth rate with respect to their trends, so that the empirical version of this equation we are going to estimate includes such effects through $\theta_i^{\Delta y}$:

$$\Delta U_{it} - \Delta U_{it}^* = \beta(\Delta y_{it} - \Delta y_{it}^*) + \theta_i^{\Delta y} + \omega_{it} \quad (5)$$

After Okun (1962), Gordon (1984) verified empirically a dynamic version of the Law and took into account the inertia in the series, estimating the trends of output and a set of relevant variables. After this work, using delays and the VAR methodology has been a frequent practice in the estimation of the Law[5]. Subsequently, Prachowny (1993) showed that the traditional version of the Law can be considered as a special production function where cyclical deviations in the capacity utilization, hours worked and the labor force do not affect to the output gap, although he finds that data reject this assumption[6]. Since then, it is often considered that, while equations (3) and/or (4) are short-term versions of Okun's Law, Prachowny's methodology characterizes the long-run equilibrium relationship between output and unemployment[7].

3. Data and estimation.

Our aim is to estimate the two versions of Okun's Law, expressions (3) and (4), with a Spanish regional database, the BDMORES. First, it should be noted that this requires using unobservable variables, specifically y_{it}^* and, U_{it}^* and their differences. At this end, it is generalized the use of some procedure to detrend the series. In this sense, although empirical evidence for the United States has shown that the results are sensitive to the filter used (see Lee, 2000), Villaverde and Maza (2009) obtain very similar results estimating the Law for the Spanish autonomous communities with three different detrending methods. In any case, the Hodrik and Prescott filter remains the most widely method used, and it is the procedure applied in BLL and in the present work; however, given that any of them show problems in

[5] Examples include Blanchard (1989), Evans (1989) and Weber (1995).
[6] Prachowny (1993) found evidence that not including such variables in the analysis produces estimates of β biased upwards, while Attfield and Silverstone (1997) obtained the opposite result.
[7] Recently, Kangasharju, Tavéra and Nijkamp (2012) to the Finnish regions, and Palombi, Perman and Tavéra (2015) to the UK regions, apply spatial analysis to Okun's Law. This technique aims to model spatial and spillover effects between regions. Usually, they obtain lower Okun coefficients than in previous studies, attributing it to the said effects. Villaverde and Maza (2015) apply this technique to the Spanish case.

one way or another, and replicating BLL, it has been checked how affect the results by several mechanisms, without finding evidence in this sense[8].

With regard to data used, the BDMORES collects data of many different variables from the 17 Spanish autonomous communities between 1955 and 2013, at best. In our case, we have taken from it the series of the gross domestic product in constant euros and the unemployment rate between 1980 and 2011[9]. Also the participation rate, *a*, that we use as instrument in the empirical analysis, was also obtained from it.

It is important to highlight a relevant characteristic of BDMORES for the empirical analysis of the Okun's Law, which is the coherence and homogeneity of their data of the labor market[10], given that one of the main problems in previous studies with annual aggregate Spanish data is the lack of homogeneous series of these variables for all the period considered. As it is pointed out by Belmonte and Polo (2004), this could explain, to a large extent, the unsatisfactory and heterogeneous results found.

As we have already mentioned, estimating the model with a regional panel requires using adequate econometric techniques to treat unobservable individual heterogeneity. In this sense, the two equations are estimated both by the fixed effects estimator and by the generalized method of moments, GMM, over the differentiated model. In the second case, we avoid the problems associated with hypothetical endogeneity of regressors by using instrumental variables. In both, following usual practice, it is analyzed how the results change when introducing lags of the explanatory variable.

On the other hand, Okun's Law has also been estimated for each of the autonomous communities and for the case of Spain, treating them as time series and not as a panel of regions, as until now.

[8] First, it has been checked that the results did not change when modifying the filter's smoothing parameter. Secondly, given the known problems with the filter in final observations of the sample, it has also been verified that the results did not change when, instead of applying the filter to the whole sample period, it was only done until 2007, last year before the crisis, keeping constant the value of the trend after it. As BLL points out, this is equivalent to consider transitory any change in unemployment or in output from that year on.
[9] Some subsequent observations available labeled as "provisional" and/or "first estimates" were discarded in the empirical analysis, given their low reliability. The BDMORES is available in http://www.sepg.pap.minhap.gob.es/
[10] In this sense, in the making of the BDMORES, these properties have received special attention. First, the series have not been extended back beyond 1976, given that these years are troublesome in the Spanish case; and second, it has been taken into account the linkage of the labor series carried out by the INE itself after changing the definition of unemployment in 2002, to adapt it to the European normative. See INE (2005).

For the GMM estimates, the results have been checked by the Sargan test of overidentifying restrictions, to verify that the instruments and the errors are not correlated. Additionally, it has been checked the orthogonality of the residuals by a LM test.

However, before estimating the model, it is important to analyze the order of integrability of the series. As is well known, to discard spurious regressions, the cyclical deviations of output and unemployment, or their differences, should be stationary; or, if they were not, they must be cointegrated. For these purposes, the results of the panel unit root tests of Im, Pesharan and Shin, of Levin, Lin and Chu and of Hadri are shown in Table 1 for the cyclical deviations of output and unemployment and for their differences. In the first two mentioned tests, the null hypothesis is the presence of a unit root, while in the third it is the stationarity, finding that all the series analyzed are stationary. Only the output gap in the case of the Hadri test offers a more debatable result.

Given that we also perform time series analysis for the autonomous communities, in Appendix A we present the results of the augmented Dickey-Fuller test and of the stationarity test of Kwiatkowski, Phillips, Schmidt and Shin. As can be seen, all series are stationary for all autonomous communities, according to these results.

4. The stability of the Okun's Law in Spain.

In Table 2 the results of both estimating methods of the two approaches to Okun's Law are presented, confirming previously available empirical evidence. In particular, the Okun's coefficient is always less than unity, both in the fixed effects and in the GMM estimation, being higher in this last case. As can be checked, the estimates of the model in differences are smaller than the estimates of the model in levels[11]. On the other hand, GMM estimates display a high goodness of fit, as is measured by the Sargan test and the test of orthogonality of residuals, especially for the model in differences. It should be noted that, in principle, our results cannot be compared with those obtained by Villaverde and Maza (2007 and 2009), Freeman (2001) or Bande and Martín-Román (2017), given that, in their models, the dependent variable is the output gap[12]. On the other hand, our within groups estimates of the

[11] Melguizo (2015) also finds a smaller value for the Okun's coefficient, very similar to our within groups estimates, when estimating the model in differences with the sample of provinces, and he attributes it to the fact that the panel data techniques used give the same weight to each province, when in fact they are very different, which would bias the estimated parameters to be lower.

[12] Plosser and Schwert (1979) point out that the Okun's coefficient in a regression of output on unemployment will only be the reciprocal of the regression of the second on the first if both variables are perfectly correlated.

equation in levels are similar in value, although somewhat lower, to those obtained by Ballesteros, Núñez and Usabiaga (2012), although, at the same time, our estimates of the equation in differences are different to those obtained by Martín-Román and Sylvina (2012), although it must be taken into account the particular econometric exercise performed by these authors, quite different from the one presented here.

In the same table we present the results of including delays of the explanatory variable. Specifically, a lag of the output gap or their difference, as the case may be, is included. It has been the only significant lag in our analysis, and not in all cases. In the model in levels, adding this lag reduces the estimate of the Okun's coefficient, although the evidence is mixed in the model in differences. The coefficient of determination of the within groups estimation improves very little with the lag. As expected, their inclusion, when it is maintained the set of instruments, reduces the significance level of Sargan's test, although marginally for the model in differences, and improves a little, or it does not in practice, the test of orthogonality of the residuals.

Next, the results of the estimation of the model in levels for each autonomous community are presented, exercise justified by the relevance of regional differences in the Law for economic policy, what explains the high available number of similar econometric exercises in the literature, both with regional and country data. These results confirm, first, an Okun's coefficient less than unity for the different autonomous communities, as in the available evidence with samples of countries using a similar model[13]. Second, they also confirm a wide range of values of the Okun's coefficient in the sample of autonomous communities, confirming previous results in Villaverde and Maza (2007 and 2009). Third, GMM estimates generally provide higher estimated parameters than OLS estimates, except in the cases of Madrid, Castilla-León and Aragon. As for the goodness of fit, the R^2 for OLS estimates are generally good, whereas the Sargan test for GMM estimates shows a significance level of, at least, 79%, and the test of orthogonality of residuals also offers very good results. There are two particular cases, Extremadura and La Rioja, showing a very poor fit in OLS estimation, although there is not the case in their GMM estimates[14,15]. Because of

[13] Among these studies, we can mention Moosa (1997), Sögner and Stiassny (2002), Moazzami and Dadgostar (2009) and the aforementioned BLL. The rest of works uses output as dependent variable. Additionally, Perman, Stephan and Tavéra (2015), after doing an exercise of meta-regression on 269 estimates of the Okun's coefficient, find that their true value is less than one, especially when unemployment is the dependent variable.

[14] It is not uncommon in Okun's Law studies with regional data to find some regions showing a poor econometric fit. This is the case with Christopoulos (2004), for the Greek economy, and Binet and Facchini (2013) for France, although in these cases the dependent variable is output. In the first case, 7 of the 13 regions considered show a poor econometric fit; in the second, this occurs in 8 regions of 22.

this, it has been verified that the results are robust to the exclusion of these two communities of the sample[16].

These results provide estimated coefficients very similar to those found by BLL and Schnabel (2002) for Spain, -0.852 and -0.950, respectively, when our OLS estimate is -0.894, and -0.932 our GMM estimate[17]. This is the highest value inside the sample of countries considered by these authors, who attribute it to the "high incidence of temporary employment contracts" that "make it easier for companies to adjust employment when production changes, increasing the coefficient of Okun"[18]; and this is also the case in Cazes, Verick and Al Hussami (2013)[19]. As for economic policy implications, the autonomous communities with higher values for this coefficient will also be those where aggregate demand policy will display a higher effect on unemployment. In that sense, the autonomous communities with GMM estimated Okun's coeffcient above the average in absolute value are, in that order, Catalonia, Cantabria, Canarias, Murcia, Valencia, Andalusia, Basque Country, Asturias and Balearic Islands. With respect to OLS estimates, this group is enlarged with Castilla-León, Aragón and Galicia, although this last autonomous community displays an estimate close to the average in both cases.

Given that, following BLL, we have derived the Okun's Law from the relationships between employment, unemployment and production, we estimate these together. That is, equations (1), (2) and (3) are estimated together as a system of apparently unrelated regressions (SUR), applying the Hodrik and Prescott filter to the three variables. Unfortunately, although we have estimated the data as a panel, we have not been able to treat adequately, in

---

[15] While for La Rioja one could think of a problem with data, Extremadura is more complex, especially since it is one of the autonomous communities with the higher unemployment rate in the sample along the period. On the other hand, also Martín-Román and Sylvina (2012) find problematic these same regions.

[16] Table A.2 in the Appendix presents the results of estimating Okun's Law in differences for each autonomous community. As a general conclusion, these results are similar to those obtained estimating the model in levels, although with a poor goodness of fit, both for the within groups and for the GMM estimates, obtaining also smaller Okun's coefficients. Note that the problems with Extremadura and La Rioja remain in this case.

[17] They are also very close to the results of Martín-Román (2002) and Amarelo (2009), although these authors estimate the model in differences. On the other hand, Pérez, Rodríguez and Usabiaga (2003) find a very similar value for a shorter period and using VAR techniques (when the parameters estimated for all lags of the output gap are added, you obtain -0.87). On the contrary, with the same sample, although without applying VAR techniques, Leal, Pérez and Rodríguez (2002) obtain a much lower coefficient, -0.37. Also Riera (2002), who estimates the reverse version of the Law, obtains a lower coefficient than in previous studies.

[18] Guisinguer, Hernández-Murillo, Owyang and Sinclair (2018) find that the Okun's coefficients for the states of the United States are positively related to labor market rigidity indicators. Given that the dependent variable in the model is output, their results support the increase in the Okun's coefficient with the degree of flexibility of the labor market, when the dependent variable is unemployment.

[19] These authors, after decomposing the change in unemployment in the change in output, in productivity per hour worked, in hours per worker and in the labour force conclude in favour of the hypothesis of BLL about the importance of temporary contracts. This study confirms the peculiarity of the last recession in Spain, where productivity, hours per worker and labour force increased simultaneously.

this case, the fixed effects. The results obtained, both for the model in levels and in differences, are presented in Table 4. Recall that the model imposes that γ, the parameter of the relationship between output and employment, is less than 1.5, but greater in absolute value than Okun's coefficient, β; as can be seen, this coefficient satisfies these requirements in both estimates. On the other hand, δ, the parameter of the relationship between employment and unemployment, should be, in absolute value, less than unity, as it actually occurs in both estimates. In addition, β, the Okun's coefficient, is very close in the estimation in levels to the values previously obtained, and we could explain the small differences with respect to these by the lack of treatment of the fixed effects in this case[20]. Finally, we point out that also in these results the model in differences produces lower estimated parameters than the model in levels, as we had already detected in the estimation of the single equation model.

The final question to analyze in this section is the stability of the obtained estimates. This is a long discussed subject in the empirical analysis of Okun's Law, given its reliance on constancy of variables such as productivity and/or labor participation. In that sense, we have already noted that Lee (2000) finds evidence of structural instability in their estimates for the United States and a sample of OECD countries, with time series data, finding a break in early 1970s. Sögner and Stiassny (2002) find mixed evidence of structural instability with another sample of OECD countries, while, as we have already noted, BLL concludes that "the Okun Law is a strong and stable relationship in most countries", which "does not change substantially during the Great Recession". Also for the Spanish case, they are frequent the studies where the estimates for more recent periods provide higher absolute values of the Okun's coefficient, as are Schnable (2002) and Amarelo (2009).

Recently, it has become popular a relatively simple technique to analyze this question. It was applied for the first time to the study of the Okun's Law with time series data from the G7 countries by Moosa (1997), and by Knotek (2007) to the case of the United States, and basically consists of estimating a same particular relationship over many different but consecutive sample periods. If the relationship is stable, the parameters estimated in each of the different sample periods should not change from one to another. Applying this technique, Moosa (1997) finds mixed results by country, and Knotek (2007) concludes that

[20] Table A3 in the Appendix presents the results of the estimation of the SUR model for the time series of the autonomous communities.

the Okun's Law has not been stable in the United States in the period 1948-2007. Subsequently, Owyang and Sekhposyan (2012) confirm this outcome.

In our case, we apply this technique to our panel of Spanish regions and to the Spanish time series, using within groups estimation in the first case and OLS in the second, and also GMM estimation for both[21,22]. We have decided to take a basic sample period of 21 annual observations for each regression; thus, the first "rolling regression" estimates the Okun's Law in levels from 1980 to 2000. From this point on, the sample is moving for a year, both at the beginning and at the end of the period. This procedure gives then a set of twelve different estimated parameters of the model, one for each of the sample periods considered, whose temporal evolution allows analyze its stability. Finally, the results are plotted, assigning the resulting estimated parameters to the last year of each sample period. These results are showed in Figure 1.

As can be seen in this graph, for the regional sample (AC in the Figure) both estimators show a remarkable stability along the period[23]. Regarding Spain (SP in the Figure), the estimated parameters show bigger instability; in particular, it seems clear that they have started a slow increase with the crisis, downloading their absolute value, and meaning that the effect of changes in output on unemployment has been reduced along it. This result agrees with those obtained with the same technique by Cazes, Verick and Al Hussami (2013) for Spain and by Sylvina and Martín-Román (2017) for the autonomous communities. Overall, our results support Freeman's (2001) hypothesis in the sense that panel data provide more stable estimates than time series data, due that they allow greater control of omitted variables. Our evidence is then mixed about supporting the hypothesis of stability of Okun's Law for the Spanish economy, depending on the kind of data considered. However, it should be noted that BLL confirm their hypothesis for the time series of United States, in sharp contrast to our results for the aggregate Spanish data. Finally, it is striking that the estimated Okun's coefficient is reduced in Spain simultaneously to the downfall in

[21] Previously, in the empirical analysis of Okun's Law for Spain, this technique has only been applied to the case of Andalusia by Ballesteros, Núñez and Usabiaga (2012); to Spain, altogether with other countries, by Cazes, Verick and Al Hussami (2013); and to the autonomous communities by Sylvina and Martín-Román (2017).

[22] For the GMM estimates, the set of instruments has been maintained along all the time windows. This set is the same used in Tables 2 and 3, applied in these cases over the entire time period.

[23] The results for the model in differences provided similar conclusions, although the GMM estimates show greater volatility, even though its range of variation in the entire sample period never exceeded 0.05. These results are available to the interested reader.

the weight of total temporary contracts with the crisis, as is well known, especially when their high weight was, precisely, the main argument adduced for its important relative value.

5.- Asymmetry in Okun's Law in Spain.

Together with the stability issue, it has also received a great lot of attention in empirical research of Okun's Law their hypothetical asymmetry, in the sense that it changes along the cycle, operating differently in expansions than in recessions. This hypothesis tries to rationalize the observed fact that unemployment reacts in a different way to changes in output of similar size in both phases of the cycle. In the empirical field, this hypothesis is tested checking if Okun's coefficient is different in the said phases[24].

As Silvapulle, Moosa and Silvapulle (2004) point out, the explanations offered for asymmetry in the Law are very different: an initial possible explanation would be the existence of asymmetries in the substitution process of productive factors and/or technical restrictions, as well as in changes in labor participation or in employment policies along the economic cycle; also the labor market rigidity could explain a greater reaction of unemployment to output in expansions than in recessions; and, finally, the previous investment made by firms in training of workers could explain their greater reluctance to fire them in crises than to hire them in expansions.

Palley (1993) was the first study to raise this question, finding evidence of asymmetry in the Law for United States. Later, Lee (2000) finds evidence of asymmetries only in some of the countries in their sample and Viren (2001) and Harris and Silverstone (2001) find it in most of the countries examined. Both Crespo (2003) and Silvapulle, Moosa and Silvapulle (2004) confirm the existence of asymmetries in United States, with a greater effect of output growth in unemployment in recessions than in expansions, as well as a greater persistence of the effect of disturbances in unemployment on the last. Subsequently, Holmes and Silverstone (2006) confirm this conclusion, point out that the notion of jobless recovery to explain the recent experience of the United States may be an exaggeration that does not take into account the evidence of a very insensitive Okun's Law in expansions.

[24] Harris and Silverstone (2001) and Silvapulle, Moosa and Silvapulle (2004) list the reasons that make important this issue: (1) it could help to discriminate between alternative theories on the relationship between the labor and goods and services markets; (2) it is relevant for the asymmetric analysis of the Phillips curve; (3) it is useful for economic policy; and (4), ignoring asymmetry when it exists would lead to predictive errors in the application of the Law. In any case, if asymmetry exists, ignoring it entails poor model specification, generating both prediction and inference errors.

In our case, we will study the asymmetry of Okun's Law in Spain through the model in levels, equation (3), following the proposal of Silvapulle, Moosa and Silvapulle (2004), consisting of decomposing the output gap in two series according to its sign, and canceling the rest of observations. That is, $y_{it} - y_{it}^*$ is decomposed into two new variables, $(y_{it} - y_{it}^*)^+$and $(y_{it} - y_{it}^*)^-$, where $(y_{it} - y_{it}^*)^+ = y_{it} - y_{it}^*$ when $y_{it} - y_{it}^* \geq 0$ and equals zero otherwise, and $(y_{it} - y_{it}^*)^- = y_{it} - y_{it}^*$ when $y_{it} - y_{it}^* < 0$, and zero otherwise. Thus, our model to estimate, from equation (3), will be given by:

$$U_{it} - U_{it}^* = \beta^+ (y_{it} - y_{it}^*)^+ + \beta^- (y_{it} - y_{it}^*)^- + \theta_i^y + \varepsilon_{it} \qquad (6)$$

where β^+ and β^- are two parameters whose comparison allow us to test the asymmetry hypothesis[25].

Table 5 presents the results obtained in the estimation of equation (6) with our regional panel data set, comparable to Table 2, already examined and where you have the results of the estimation of the symmetrical Okun's Law, although in this case no lags are included in the equation. As can be checked, the estimated parameters show similar values and goodness of fit in both Tables. Remarkably, both parameters are statistically significant with both estimators. And curiously, while β^+ increases in the within groups estimation with respect to the estimated symmetric model, and β^- is reduced, in the GMM estimates occurs the opposite. Thus, the results do not allow conclude in favor of a greater unemployment's sensitivity to changes in output in the expansive phases of the cycle against the recessive ones, or vice versa. However, a test of the equality of the parameters in both cycle phases is strongly rejected for the within groups estimation and hardly accepted at less than 8% significance level for the GMM estimation, what constitutes evidence of asymmetry.

These results agree with those obtained previously for the Spanish economy with aggregate data by Virén (2001). Leal, Pérez and Rodríguez (2002) also maintain that they find clear evidence of asymmetry but obtain very nearby values of both coefficients, at least in some cases, without doing any formal test. Also Pérez, Rodríguez and Usabiaga (2003), evenly without making a formal test, but obtaining in this case a big difference between the parameters, conclude in favor of asymmetry. This is also the case in Cazes, Verick and Al

[25] An extended version of this equation that includes lags from both the output gap and cyclical unemployment has been estimated with time series data for the Spanish and Andalusian cases by Pérez, Rodríguez and Usabiaga (2003), finding evidence of asymmetry in Okun's Law in both cases. Also Amarelo (2009) finds evidence of asymmetry in Catalonia, and Cazes, Verick and Al Hussami (2013) find it for Spain and other countries.

Hussami (2013), although, contrary to our results, these authors find, with time series, that the Okun's coefficient is larger in recessions than in expansions.

Next, Table 6 presents the results of estimating equation (6) for each of the autonomous communities, although they are not so conclusive as previously obtained results. First of all, the goodness of fit of OLS estimates, measured by the value of R^2, is similar to that obtained in Table 3, while that of GMM estimates, measured by the Sargan and the orthogonality of residuals tests, worsens a bit with respect to the said Table 3. On one hand, the estimated parameters for Spain are very close, being somewhat higher in absolute value the OLS estimates. On the other, the test of equality of parameters presents a significance level of about 30% in both cases. Secondly, with both estimates, the most part of autonomous communities gets an estimated β^+ higher in absolute value than that estimated in Table 3, and the opposite with respect to the estimated β^-, and in line with the within groups estimates; only in the case of the OLS estimates for the Balearic and the Canary Islands and the Navarre this does not happen, and for this latter and La Rioja for the GMM estimators[26]. Third, the results of the test of equality of parameters show a high degree of heterogeneity inside the sample. While only some autonomous communities overcome 50% of significance level for the null hypothesis[27], there are some cases of test rejections at 10% significance level (Castilla-La Mancha and Galicia, in the OLS estimates, and the two Castillas and the Basque Country, in the GMM).

We have also raised the possibility of checking the asymmetry of Okun's Law with the model in differences. However, the use of this version of the model, equation (5), presents problems to make this type of exercise. In principle, the described procedure applied to this equation implies that the benchmark between expansive and contractive phases of the cycle is the potential growth rate[28]. But this means that values of output growth only slightly lower than this rate would be classified as a contractive phase, which we do not consider, in principle, adequate. On the other hand, if one decides to abandon this benchmark for a more

[26] As can be seen, the problems with Extremadura and La Rioja, already mentioned, remain, being the first the only case in which we obtain a positive value for one of the parameters.

[27] For OLS results, they are Aragon, Canarias, Madrid, Murcia, Navarre and La Rioja, to which are added the Valencian Community and Extremadura, but excluding the Balearic Islands, for GMM estimates.

[28] Holmes and Silverstone (2006), already cited, is a good example of the difficulties faced in this context. These authors find evidence of asymmetry both, during an unemployment regime in which it is always above or below its trend, and between different regimes, which differ precisely in this characteristic, existing differences in the unemployment response to output at the same stage of the cycle in two different regimes. In any case, the nature of this concrete exercise goes beyond the objective of this work.

realistic one, establishing a growth rate lower than the potential growth rate, it is not obvious what value should be taken and how it should be found[29].

Given these problems, most of the tests for asymmetry based on the model in differences rest on their version adopted by BLL, consisting in regressing the increase of unemployment on both the series of positive and negative increases of output, as are Lee (2000), Harris and Silverstone (2001) and Virén (2001). So, it is not infrequent in these exercises to find values of the relevant parameters away from their expected values (a negative one, but higher than -1).

Finally, and despite all these conditioning factors, we have done a test of asymmetry with the model in differences, whose results are presented in Table 7. In this case, we decompose $\Delta y_{it} - \Delta y_{it}^*$ into two new variables, $(\Delta y_{it} - \Delta y_{it}^*)^+$and $(\Delta y_{it} - \Delta y_{it}^*)^-$, where $(\Delta y_{it} - \Delta y_{it}^*)^+ = \Delta y_{it} - \Delta y_{it}^*$ when $\Delta y_{it} - \Delta y_{it}^* \geq 0$ and zero otherwise, and $(\Delta y_{it} - \Delta y_{it}^*)^- = \Delta y_{it} - \Delta y_{it}^*$ when $\Delta y_{it} - \Delta y_{it}^* < 0$ and zero otherwise. Thus, the model to estimate, from equation (3), is given by:

$$\Delta U_{it} - \Delta U_{it}^* = \beta^+ (\Delta y_{it} - \Delta y_{it}^*)^+ + \beta^- (\Delta y_{it} - \Delta y_{it}^*)^- + \theta_i^{\Delta y} + \omega_{it} \qquad (7)$$

The main conclusion obtained from the results, presented in Table 7, is that there is asymmetry in Okun's Law in Spain, given both the differences in the estimated values for the parameters and the results of the tests of equality. Moreover, these results must be taken carefully, given the above-mentioned problems. In any case, note that, according to them, it is confirmed a higher Okun's coefficient in absolute value in recessions than in expansions; in fact, Okun's Law would only works in Spain in crises, since only β^- is statistically significant.

6. Conclusions.

In this paper it has been estimated the Okun's Law with panel techniques on a data sample of the Spanish autonomous communities between 1980 and 2011. In this respect, it is worth highlight the consistency and homogeneity of the labor series in our database, given that the lacking of these characteristics has been determinant for the previously obtained empirical results, according to different studies. In any case, our results support some of them, both

[29] In this sense, although using the model in levels, Crespo (2003) raises the possibility that asymmetry does not occur when the benchmark is a zero output gap, but a different value, and he finds that an estimation of the confidence interval of it contains the zero, concluding that this result endorse the exogenous imposition of a zero value, as it has been done in both previous and later works.

those obtained with Spanish time series data and for some autonomous communities, considered in isolation, as well as previous results obtained with the less frequently applied panel data techniques.

Firstly, our results confirm a negative Okun's coefficient lower than unity when the endogenous variable is cyclical unemployment, both with the model in levels and with the model in differences. On the other hand, the results confirm a higher value of this coefficient for the Spanish economy in international standards. It has been advanced in previous studies the hypothesis that this result is due to the heavy weight of temporary contracts in the Spanish labor market, compared to other economies.

Second, our results also confirm a high degree of heterogeneity in the value of the Okun's coefficient inside the sample of the autonomous communities, being possible identify a group of them in which there is a higher sensitivity of unemployment to changes in output, which makes them especially suitable for aggregate demand policies aiming to reduce it.

Third, we have tested the stability of the estimated parameters by rolling regressions techniques. This methodology has shown a very high stability of panel data estimates, and simultaneously the contrary for time series estimates, what agrees with is usually considered in this field. We believe that these results support Freeman (2001), in the sense that panel data present superior features in front of time series data to analyze this subject. In any case, the results obtained with the Spanish time series contradict sharply with BLL results with US time series, although using a different technique.

It should also be noted that the estimated Okun's coefficient with Spanish time series has been reduced in absolute value with the crisis, at least in their first years, notably at the same time that the weight of temporary labor contracts in total has experienced a significant fall, what is relevant given the recently association made between both variables. Everything indicates that we are dealing with a particularly complex issue requiring further research.

Finally, panel data techniques have allowed us find evidence of asymmetry in Okun's Law for the Spanish economy, confirming available previous results with aggregate data. Nevertheless, the tests of asymmetry for autonomous communities cast a shadow on this result, appearing also a high degree of heterogeneity in this field, with a group of regions for which asymmetry is firmly rejected. Although we found problematic the model in differences to test this hypothesis, a first attempt made using it confirms the existence of asymmetry.

References

Amarelo, C. (2009): "La Relació entre el Creixement Econòmic i la Taxa d'Atur en el Cas Català", *Papers de Treball*, Direcció General d'Analisi, Politica Econòmica, Generalitat de Catalunya, 3/2009.

Attfield, C.L.F. and B. Silverstone (1997): "Okun's Coefficient: a Comment", *The Review of Economics and Statistics 79*, 326-329.

Ball, L.M., Leigh, D, and P. Loungani (2013): "Okun's Law: Fit at Fifty?", *National Bureau of Economic Research*, *Working Paper 18688*.

Ballesteros, J.A., Núñez, F. and C. Usabiaga (2012): "La Ley de Okun para las Regiones Españolas: Distintas Aproximaciones Econométricas", *Instituto de Estadística y Cartografía de Andalucía, Documento de Trabajo 4/2012*.

Bande, R. and A.L. Martín-Román (2017): "Regional Differences in the Okun's Realtionship: New Evidence for Spain (1980-2015)", Mimeograph.

Belmonte, A. and C. Polo (2004): "Formulaciones de la Ley de Okun y Resultados para España", Mimeograph.

Binet, M. and F. Facchini (2013): "Okun's Law in the French Regions: A Cross-Regional Comparison", *Economics Bulletin 33*, 420-433.

Blanchard, O. (1989): "A Traditional Interpretation of Macroeconomic Fluctuations", *American Economic Review 79*, 1146-1164.

Cazes, S,; Verick, S. and F. Al Hussami (2013): "Why Did Unemployment respond so Differently to the Global Financial Crisis across Countries? Insights from Okun's Law", *IZA Journal of Labor Policy 2*.

Christopoulos, D.K. (2004): "The Relationship between Output and Unemployment: Evidence from Greek Regions", *Papers in Regional Science 83*, 611-620.

Crespo, J. (2003): "Okun's Law Revisited", *Oxford Bulletin of Economics and Statistics 65*, 439-451.

Daly, M.C., Fernald, J.G., Jordà, O. and F. Nechio (2014): "Output and Unemployment Dynamics", *Working Paper Series*, Federal Reserve Bank of San Francisco, 2013-32.

Evans, G.W. (1989): "Output and Unemployment Dynamics in the United States: 1950-1985", *Journal of Applied Econometrics 4*, 213-237.

Freeman D.G. (2001): "Panel Tests of Okun's Law for Ten Industrial Countries", *Economic Inquiry 39*, 511-523.

Gordon, R.J. (1984): "Unemployment and Potential Output in the 1980s", *Brookings Papers on Economic Activity 2*, 537-586.

Guisinguer, A.Y., Hernández-Murillo, R., Owyang, M.T. and T.M. Sinclair (2018): "A State-Level Analysis of Okun's Law", *Regional Science and Urban Economics 68*, 239-248.

Harris, R. and B. Silverstone (2001): “Testing for Asymmetry in Okun’s Law: A Cross-Country comparison”, *Economics Bulletin 5*, 1-13.

Huang H. and S. Lin (2007): “Smooth-time-varying Okun’s Coefficients”, *Economic Modelling 25,* 363-375.

Holmes, M.J. and B. Silverstone (2006): “Okun’s Law, Asymmetries and Jobless Recoveries in the United States: A Markov-Swuitching Approach”, *Economic Letters 92*, 293-299.

INE (2005): “Enlace de las series de paro 1976-2000 según la definición EPA-2002”, *Documento de Trabajo*. Subdirección de Estadísticas del Mercado Laboral.

Kangasharju, A., Tavera, C. and P. Nijkamp (2012): “Regional Growth and Unemployment: The Validity of Okun’s Law for the Finnish Regions”, *Spatial Economic Analysis 7*, 381-395.

Knotek, E.S. (2007): “How Useful is Okun’s Law?”, *Federal Reserve Bank of Kansas City Economic Review, Fourth Quarter 2007*, 73-103.

Leal, T., Pérez, J.J. and J. Rodríguez (2002): “Pautas Cíclicas de la Economía Andaluza en el período 1984-2001: Un Análisis Comparado”, *Documento de Trabajo, CentrA: Fundación Centro de Estudios Andaluces*, E2002/18.

Lee, J. (2000): “The Robustness of Okun’s Law: Evidence from OECD Countries”, *Journal of Macroeconomics 22*, 331-356.

Martín-Román, A.L.: (2002): “Ley de Okun, Paro Registrado y Paro EPA”, *Boletín Económico del ICE*, Ministerio de Industria, Turismo y Consumo, 2728.

Martín-Román, A.L. and M. Sylvina (2012): “La Ley de Okun en España ¿por qué existen diferencias regionales?”. Mimeograph.

Melguizo, C. (2015): “An Analysis of the Okun’s Law for the Spanish Provinces”, *Institut de Recerca en Economia Aplicada Regional i Pública, Document de Treball 2015/01*.

Moazzami, B. and B. Dadgostar (2009): “Okun’s Law Revisited: Evidence from OECD Countries”, *International Business and Economics Research Journal 8*, 21-24.

Moosa, I.A. (1997): “A Cross-Country Comparison of Okun’s Coefficient”, *Journal of Comparative Economics 24*, 335-356.

Okun, A.M. (1962): “Potential GNP: Its Measurement and Significance”, *Cowles Foundation Paper 190*.

Owyang, M.T. and T. Sekxposyan (2012): “Okun´s Law over the Business Cycle: Was the Great Recession all that Different?”, *Federal Reserve Bank of St. Louis Review, September/October 2012*, 399-418.

Palley, T.I. (1993): “Okun’s Law and the Asymmetric and Changing Cyclical Behaviour of the USA Economy”, *International Review of Applied Economics 7,* 144.162.

Palombi, S.; Perman, R. and C. Tavéra (2017): “Commuting Effects in Okun’s Law among British areas: Evidence from Spatial Panel Econometrics”, *Papers in Regional Science 96*, 191-209.

Pérez, J.J.; Rodríguez, J. and C. Usabiaga (2003): “Análisis Dinámico de la Relación entre Ciclo Económico y Ciclo del Desempleo: Una Aplicación Regional”, *Investigaciones Regionales 2*, 141-162.

Perman, R.; Stephan, G. and C. Tavéra (2015): “Okun’s Law-A Meta-Analysis”, *The Manchester School 83*, 101-126.

Plosser, C.I. and W. Schwert (1979): “Potential GNP: Its Measurement and Significance. A Dissenting Opinion”, *Carnegie-Rochester Conference Series on Public Policy 10*, 179-186.

Prachowny, M.F.J. (1993): “Okun’s Law: Theoretical Foundations and Revised Estimates”, *The Review of Economics and Statistics 75*, 331-336.

Riera, M.C. (2002): “La Llei d’Okun. Una Aplicació per Espanya”, *Revista Econòmica de Catalunya 43*, 27-36.

Schnabel, G. (2002): “Output Trends and Okun’s Law”, *BIS Working Papers*, Bank for International Settlements, 111.

Silvapulle, P.; Moosa, I.A. and M.J. Silvapulle (2004): “Asymmetry in Okun’s Law”, *The Canadian Journal of Economics 37*, 353-374.

Sögner, L. and A. Stiassny (2002): “An Analysis on the Structural Stability of Okun’s Law-A Cross-Country Study”, *Applied Economics 34*, 1775-1787.

Sylvina, M. and A.L. Martín-Román (2017): “Self-employment and Okun’s Law relationship: the Spanish Case”, Mimeograph.

Villaverde, J. and A. Maza (2007): “Okun’s Law in the Spanish Regions”, *Economic Bulletin 18*, 1-11.

Villaverde, J. and A. Maza (2009): “The robustness of Okun’s Law in Spain, 1980-2004. Regional Evidence”, *Journal of Policy Modeling 31*, 289-297.

Villaverde, J. and A. Maza (2015): “Okun’s Law among the Spanish Regions: A Spatial Panel Approach”, Mimeograph.

Virén, M. (2001): “The Okun Curve is Non-Linear”, *Economics Letters 70,* 253-257.

Weber, C.E. (1995): “Cyclical Output, Cyclical Unemployment and Okun’s Coefficient: A New Approach”, *Journal of Applied Econometrics 10*, 433-445.

Zanin, L. and G. Marra (2012): “Rolling Regression versus Time-Varying Coefficient Modelling: An Empirical Investigation of the Okun’s Law in Some Euro Area Countries”, Bulletin of Economic Research 64, 91-108.

Table 1: Panel Unit Root Tests

	$U_{it} - U_{it}^{*}$	$y_{it} - y_{it}^{*}$	$\Delta U_{it} - \Delta U_{it}^{*}$	$\Delta y_{it} - \Delta y_{it}^{*}$
Ipshin	-8.394	-5.696	-9.586	-10.039
	0.000	0.000	0.000	0.000
Levinlin	-16.699	-14.192	-18.427	-21.213
	0.000	0.000	0.000	0.000
Hadri	-0.558	1.105	-1.292	-1.385
	0.711	0.134	0.901	0.917

Note: Ipshin shows the result of the Im, Pesharan and Shin test, while Levinlin shows that of the Levin, Lin and Chu test and Hadri the result of the Hadri test. In the first two cases the null hypothesis is the existence of a unit root, while in the latter is the stationarity. We present the statistics and the significance level of the tests.

Table 2: Okun's Law in _Spain. Panel Data.

	$U_{it}-U_{it}^{*}=\beta_0(y_{it}-y_{it}^{*})+\beta_1(y_{it-1}-y_{it-1}^{*})+\theta_i^{y}$				$\Delta U_{it}-\Delta U_{it}^{*}=\beta_0(\Delta y_{it}-\Delta y_{it}^{*})+\beta_1(\Delta y_{it-1}-\Delta y_{it-1}^{*})+\theta_i^{\Delta y}+\omega_{it}$			
	(WG)		(GMM)		(WG)		(GMM)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_0	-0.564 (0.026)	-0.541 (0.034)	-0.715 (0.066)	-0.647 (0.213)	-0.325 (0.031)	-0.336 (0.031)	-0.516 (0.148)	-0.496 (0.154)
β_1		-0.079 (0.035)		-0.056 (0.179)		-0.128 (0.031)		-0.043 (0.130)
$\overline{R}^2$	0.456	0.483			0.175	0.209		
Sargan			0.705 0.872	0.866 0.648			1.471 0.961	1.372 0.927
Ortog.			0.849 0.931	0.700 0.951			1.146 0.992	1.236 0.990

Note: In brackets, the standard errors. Columns (1), (2), (5) and (6) present the within groups estimates while columns (3), (4), (7) and (8) the GMM estimates in first differences. In this last case the instruments have been from second to fourth lags of $y_{it}-y_{it}^{*}$ and ΔU_{it} for columns (3) and (4) and from second to fifth lags of Δa_{it} and from third to fifth lags of $\Delta U_{it}-\Delta U_{it}^{*}$.

Table 3: Okun's Law in Spain: Time Series. Model in Levels.

$$U_t - U_t^* = \beta\left(y_t - y_t^*\right) + \varepsilon_t$$

	(OLS)		(GMM)		
	β	$\overline{R}^2$	β	Sargan	Ortog.
Andalusia	-0.857 (0.083)	0.772	-0.854 (0.217)	0.089 0.956	0.029 0.998
Aragon	-0.627 (0.104)	0.536	-0.596 (0.118)	0.527 0.912	0.540 0.969
Asturias	-0.502 (0.099)	0.451	-0.822 (0.235)	0.328 0.848	0.228 0.972
Balearics	-0.627 (0.134)	0.412	-0.782 (0.185)	0.995 0.910	0.517 0.971
Canary Islands	-0.795 (0.091)	0.709	-0.975 (0.080)	4.005 0.856	4.468 0.812
Cantabria	-0.405 (0.088)	0.401	-0.979 (0.180)	0.518 0.914	0.433 0.979
Cast.Leon	-0.649 (0.148)	0.380	-0.546 (0.204)	2.808 0.832	2.786 0.904
Cast.Man.	-0.392 (0.090)	0.376	-0.545 (0.130)	1.887 0.864	1.905 0.862
Catalonia	-0.882 (0.099)	0.716	-1.102 (0.097)	1.490 0.828	1.784 0.775
Valencian Com.	-0.843 (0.097)	0.706	-0.937 (0.096)	0.590 0.898	0.879 0.927
Extremadura	-0.081 (0.132)	0.012	-0.498 (0.199)	2.904 0.893	5.262 0.627
Galicia	-0.585 (0.093)	0.559	-0.753 (0.129)	3.855 0.796	3.802 0.802
Madrid	-0.733 (0.080)	0.726	-0.617 (0.146)	3.117 0.794	3.813 0.800
Murcia	-0.708 (0.083)	0.700	-0.975 (0.263)	0.036 0.847	0.036 0.981
Navarre	-0.466 (0.068)	0.599	-0.698 (0.082)	0.118 0.942	0.239 0.971
Basque Country	-0.608 (0.096)	0.563	-0.840 (0.197)	0.211 0.899	0.436 0.932
The Rioja	-0.068 (0.129)	0.008	-0.569 (0.173)	1.090 0.895	2.801 0.730
Spain	-0.894 (0.066)	0.852	-0.932 (0.068)	0.304 0.858	0.816 0.845

Note: In brackets, the standard errors. The instruments for the GMM estimations are different sets of lags of $y_t - y_t^*$, $U_t - U_t^*$, ΔU_t, Δy_t and, sometimes, a constant for the different autonomous communities.

Table 4

$$e_t - e_t^* = \gamma(y_t - y_t^*) + \eta_t$$
$$U_t - U_t^* = \delta(e_t - e_t^*) + \mu_t$$
$$U_t - U_t^* = \beta(y_t - y_t^*) + \varepsilon_t$$

(SUR)		
γ	δ	β
0.849 (0.077)	-0.259 (0.009)	-0.354 (0.021)

$$e_t - e_{t-1} = \gamma(y_t - y_{t-1}) + \eta_t$$
$$U_t - U_{t-1} = \delta(e_t - e_{t-1}) + \mu_t$$
$$U_t - U_{t-1} = \beta(y_t - y_{t-1}) + \varepsilon_t$$

(SUR)		
γ	δ	β
0.237 (0.002)	-0.081 (0.003)	-0.019 (0.000)

Note: In brackets, the standard errors.

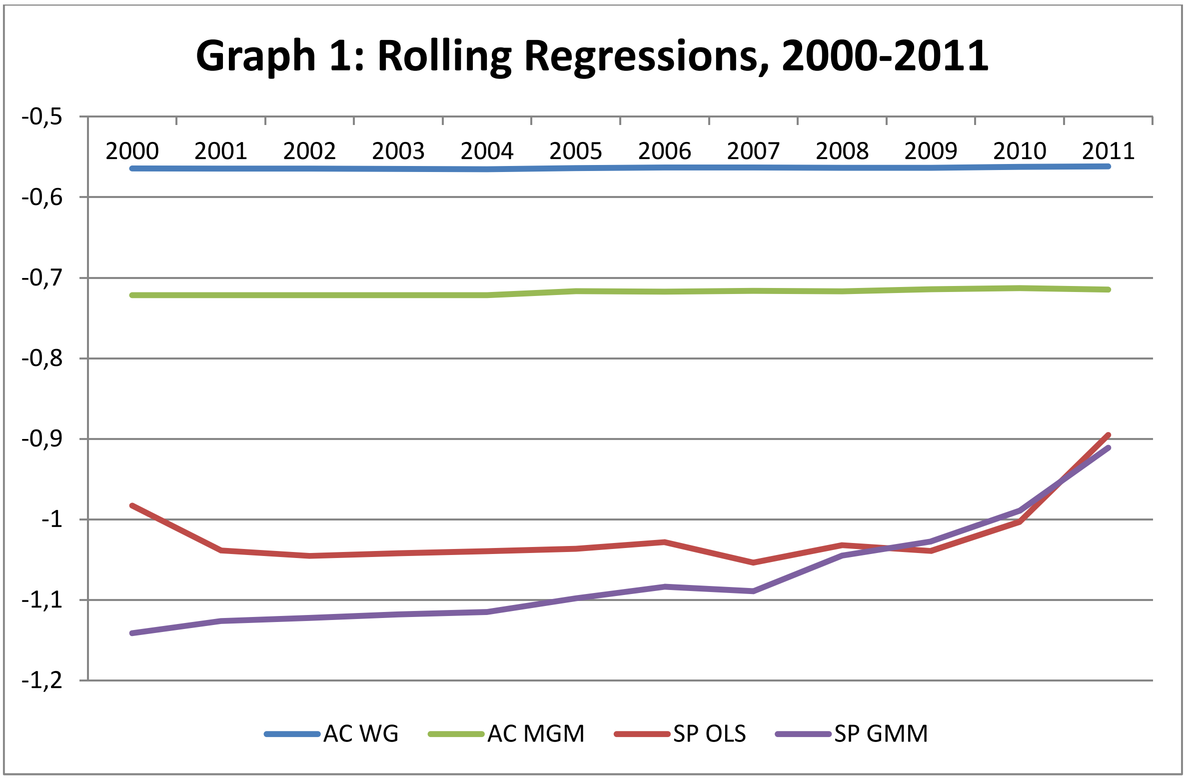
Graph 1: Rolling Regressions, 2000-2011
-0,5
-0,6
-0,7
-0,8
-0,9
-1
-1,1
-1,2
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
AC WG
AC MGM
SP OLS
SP GMM

Table 5

$$U_t - U_t^* = \beta^+ \left(y_t - y_t^*\right)^+ + \beta^- (y_t - y_t^*)^- + \varepsilon_t$$

	(WG)	(GMM)
β^+	-0.716	-0.432
	(0.072)	(0.183)
β^-	-0.413	-1.135
	(0.059)	(0.257)
$\beta^+=\beta^-$	7.261	3.106
	0.007	0.077
$\overline{R}^2$	0.406	
Sargan		1.447
		0.835
Ortog.		0.907
		0.988

Note: In brackets, the standard errors. The column (WG) presents within groups estimation, the column (GMM), these estimates in first differences. In this case, the instruments have been the first and second lags of $\Delta(y_{it} - y_{it}^*)^+$, the fifth of $(y_{it} - y_{it}^*)^-$, the second of $\Delta^2 a_{it}$, the first of Δy_{it} and a constant.

Table 6

$$U_t - U_t^* = \beta^+ \left(y_t - y_t^*\right)^+ + \beta^- (y_t - y_t^*)^- + \varepsilon_t$$

	(OLS)				(GMM)				
	β^+	β^-	$\beta^+=\beta^-$	$\overline{R}^2$	β^+	β^-	$\beta^+=\beta^-$	**Sargan**	**Ortog.**
Andalusia	-0.943	-0.752	1.368	0.766	-0.973	-0.746	1.671	0.745	0.533
	(0.123)	(0.106)	0.242		(0.136)	(0.149)	0.196	0.862	0.990
Aragon	-0.657	-0.589	0.146	0.510	-0.929	-0.881	0.043	0.344	0.544
	(0.110)	(0.142)	0.702		(0.319)	(0.394)	0.835	0.841	0.968
Asturias	-0.573	-0.413	0.528	0.447	-0.967	-0.407	1.834	0.281	0.312
	(0.191)	(0.108)	0.467		(0.498)	(0.193)	0.175	0.868	0.988
Balearics	-0.494	-0.795	0.609	0.419	-0.640	-0.509	0.219	7.551	7.015
	(0.333)	(0.194)	0.435		(0.169)	(0.211)	0.639	0.871	0.957
Canary Islands	-0.748	-0.843	0.139	0.698	-0.965	-0.880	0.165	2.779	4.639
	(0.234)	(0.100)	0.708		(0.165)	(0.104)	0.684	0.835	0.795
Cantabria	-0.519	-0.327	1.122	0.414	-0.656	-0.507	0.504	2.687	5.740
	(0.147)	(0.104)	0.289		(0.153)	(0.223)	0.477	0.846	0.676
Cast.Leon	-0.770	-0.491	1.302	0.389	-0.930	-0.400	22.719	6.075	6.506
	(0.184)	(0.161)	0.253		(0.065)	(0.097)	0.000	0.912	0.952
Cast.Man.	-0.532	-0.232	3.579	0.409	-0.620	-0.385	2.908	7.462	14.753
	(0.122)	(0.101)	0.058		(0.079)	(0.104)	0.088	0.760	0.323
Catalonia	-0.914	-0.847	0.085	0.667	-0.932	-0.815	0.149	1.112	0.965
	(0.185)	(0.134)	0.770		(0.190)	(0.193)	0.698	0.952	0.995
Valencian Com.	-0.944	-0.756	1.934	0.686	-0.838	-0.732	0.196	1.284	1.632
	(0.078)	(0.109)	0.164		(0.174)	(0.148)	0.657	0.732	0.897
Extremadura	-0.218	0.047	0.542	0.043	-0.656	-0.519	0.105	0.127	0.073
	(0.320)	(0.167)	0.461		(0.307)	(0.336)	0.745	0.938	0.999
Galicia	-0.778	-0.342	13.037	0.630	-0.924	-0.703	0.700	2.437	3.668
	(0.069)	(0.098)	0.000		(0.154)	(0.262)	0.402	0.785	0.817
Madrid	-0.754	-0.716	0.055	0.690	-0.578	-0.553	0.021	2.586	4.352
	(0.115)	(0.116)	0.814		(0.148)	(0.128)	0.883	0.858	0.824
Murcia	-0.757	-0.663	0.371	0.692	-0.835	-0.682	0.452	0.720	0.558
	(0.126)	(0.091)	0.542		(0.217)	(0.087)	0.501	0.868	0.989
Navarre	-0.458	-0.474	0.011	0.513	-0.534	-0.551	0.015	1.017	0.996
	(0.131)	(0.059)	0.913		(0.126)	(0.120)	0.902	0.907	0.985
Basque Country	-0.703	-0.520	1.245	0.524	-0.670	-0.385	9.420	2.220	1.546
	(0.090)	(0.136)	0.264		(0.092)	(0.102)	0.002	0.973	0.998
The Rioja	-0.069	-0.067	4.940	0.008	-0.102	-0.349	0.667	7.505	16.359
	(0.247)	(0.124)	0.994		(0.236)	(0.110)	0.413	0.756	0.230
Spain	-0.968	-0.815	0.941	0.826	-0.989	-0.903	1.188	5.845	10.236
	(0.069)	(0.141)	0.331		(0.055)	(0.060)	0.275	0.923	0.744

Note: In brackets, the standard errors. The instruments for GMM estimation are different sets of lags of ΔU_t,y_t,Δy_t, $\Delta(y_t - y_t^*)$, $(y_t - y_t^*)^+$, $(y_t - y_t^*)^-$, $\Delta(y_t - y_t^*)^+$, $\Delta(y_t - y_t^*)^-$, and, sometimes, a constant for the different autonomous communities.

Table 7

$$\Delta U_{it} - \Delta U_{it}^{*} = \beta^{+}(\Delta y_{it} - \Delta y_{it}^{*})^{+} + \beta^{-}(\Delta y_{it} - \Delta y_{it}^{*})^{-} + \theta_i^{\Delta y} + \omega_{it}$$

	(WG)	(GMM)
β^{+}	-0.073	0.893
	(0.054)	(0.848)
β^{-}	-0.541	-1.958
	(0.049)	(0.568)
$\beta^{+}=\beta^{-}$	6.461	4.681
	0.011	0.030
$\overline{R}^2$	0.189	
Sargan		1.077
		0.982
Ortog.		1.296
		0.995

Note: In brackets, the standard errors. The column (WG) presents the within groups estimation and the column (GMM), these estimates in first differences. In this case, the instruments have been second to fifth lags of $\Delta^2 a_{it}$, first of u_{it}, fifth of y_{it}, second of $\Delta u_{it} - \Delta u_{it}^{*}$ and a constant.

Appendix

Table A1: Time Series Unit Root Tests.

	ADF				KPSS			
	$U_{it}-U^*_{it}$	$y_{it}-y^*_{it}$	$\Delta U_{it}-\Delta U^*_{it}$	$\Delta y_{it}-\Delta y^*_{it}$	$U_t-U^*_t$	$y_t-y^*_t$	$\Delta U_{it}-\Delta U^*_{it}$	$\Delta y_{it}-\Delta y^*_{it}$
Andalusia	-4.108**	-2.912**	-4.249**	-4.221**	0.076	0.077	0.040	0.055
Aragon	-3.811**	-3.831**	-4.265**	-5.523**	0.037	0.059	0.041	0.036
Asturias	-3.774**	-3.259**	-4.660**	-5.494**	0.037	0.067	0.041	0.032
Balearics	-4.402**	-3.131**	-4.532**	-5.483**	0.038	0.069	0.041	0.033
Canary Islands	-4.123**	-2.993**	-5.216**	-5.355**	0.038	0.079	0.041	0.037
Cantabria	-3.594**	-3.989**	-4.876**	-4.988**	0.038	0.060	0.041	0.033
Cast.Leon	-4.386**	-2.849**	-4.854**	-5.069**	0.038	0.066	0.041	0.037
Cast.Man.	-3.814**	-2.846**	-5.237**	-6.663**	0.037	0.063	0.041	0.052
Catalonia	-4.185**	-3.184**	-3.907**	-4.092**	0.037	0.064	0.041	0.050
Valencian Com.	-4.296**	-3.209**	-4.067**	-4.349**	0.037	0.077	0.041	0.045
Extremadura	-4.074**	-3.906**	-4.869**	-6.219*	0.038	0.065	0.041	0.034
Galicia	-4.035**	-3.307**	-4.038**	-4.990**	0.037	0.056	0.041	0.040
Madrid	-3.651**	-2.810**	-3.863**	-4.704**	0.037	0.075	0.041	0.043
Murcia	-3.720**	-2.939**	-4.039**	-5.194**	0.038	0.075	0.041	0.049
Navarre	-4.254**	-2.655**	-5.042**	-6.400**	0.036	0.064	0.041	0.043
Basque Country	-3.439**	-3.081**	-4.737**	-4.957**	0.036	0.073	0.041	0.037
The Rioja	-3.906**	-3.564**	-4.367**	-5.563**	0.037	0.049	0.041	0.042
Spain	-4.436**	-3.632**	-4.321**	-4.042**	0.037	0.071	0.041	0.049

Note: ADF is the increased Dickey-Fuller test and KPSS is the Kwiatkowski, Phillips, Schmidt and Shin test. The null hypothesis in the first is the existence of a unit root, while in the second is the stationarity. In all cases, the values of the statistics are reported. ** indicates that the null hypothesis is rejected at a 1% significance level. On the other hand, the critical significance level at 1, 5 and 10% for the KPSS test is 0.739, 0.463 and 0.347, respectively.

Table A.2: Okun's Law in Spain: Time Series. Model in Differences

$$\Delta U_t - \Delta U_t^* = \beta(\Delta y_t - \Delta y_t^*) + \omega_t$$

	(OLS)		(GMM)		
	β	$\overline{R}^2$	β	Sargan	Ortog.
Andalusia	-0.740 (0.147)	0.456	-0.672 (0.133)	5.253 0.811	5.428 0.860
Aragon	-0.396 (0.125)	0.250	-0.360 (0.138)	5.500 0.855	11.017 0.441
Asturias	-0.250 (0.100)	0.170	-0.221 (0.069)	5.722 0.891	8.410 0.752
Balearics	-0.351 (0.132)	0.189	-0.420 (0.113)	5.946 0.819	6.746 0.819
Canary Islands	-0.618 (0.128)	0.434	-0.471 (0.266)	2.752 0.839	3.754 0.807
Cantabria	-0.193 (0.107)	0.097	-0.203 (0.103)	6.783 0.871	7.098 0.896
Cast.Leon	-0.293 (0.141)	0.126	-0.488 (0.121)	8.313 0.822	10.478 0.726
Cast.Man.	-0.170 (0.096)	0.094	-0.355 (0.154)	5.172 0.879	5.060 0.928
Catalonia	-0.939 (0.128)	0.639	-1.075 (0.055)	4.887 0.898	6.039 0.870
Valencian Com.	-0.739 (0.143)	0.471	-0.879 (0.135)	7.735 0.805	7.163 0.893
Extremadura	0.202 (0.124)	0.081	-0.445 (0.096)	4.885 0.898	5.463 0.906
Galicia	-0.365 (0.114)	0.254	-0.147 (0.069)	1.924 0.926	2.135 0.951
Madrid	-0.571 (0.110)	0.470	-0.310 (0.060)	7.234 0.841	13.116 0.438
Murcia	-0.531 (0.118)	0.400	-0.753 (0.068)	2.789 0.993	1.884 0.999
Navarre	-0.325 (0.079)	0.357	-0.163 (0.052)	3.123 0.978	2.234 0.997
Basque Country	-0.523 (0.103)	0.458	-0.607 (0.079)	5.088 0.826	4.555 0.918
The Rioja	-0.007 (0.120)	0.001	-0.160 (0.160)	2.362 0.937	2.607 0.956
Spain	-0.986 (0.098)	0.769	-1.097 (0.063)	4.807 0.940	4.486 0.972

Note: In brackets, the standard errors. The instruments for the GMM estimations are different sets of lags of Δa_t, $\Delta U_t - \Delta U_t^*$, Δy_t, $\Delta y_t - \Delta y_t^*$, $\Delta^2 y_t$, a_t and a constant for the different autonomous communities.

Table A3

$$e_t - e_t^* = \gamma(y_t - y_t^*) + \eta_t$$
$$U_t - U_t^* = \delta(e_t - e_t^*) + \mu_t$$
$$U_t - U_t^* = \beta(y_t - y_t^*) + \varepsilon_t$$

	(SUR)		
	γ	δ	β
Andalusia	1.369 (0.239)	-0.454 (0.053)	-0.781 (0.079)
Aragon	1.123 (0.335)	-0.244 (0.039)	-0.429 (0.085)
Asturias	0.669 (0.438)	-0.193 (0.029)	-0.336 (0.088)
Balearics	0.824 (0.388)	-0.183 (0.041)	-0.322 (0.093)
Canary Islands	0.762 (0.340)	-0.214 (0.063)	-0.605 (0.079)
Cantabria	0.818 (0.269)	-0.256 (0.027)	-0.266 (0.071)
Cast.Leon	0.775 (0.487)	-0.238 (0.033)	-0.382 (0.125)
Cast.Man.	0.725 (0.229)	-0.266 (0.031)	-0.239 (0.066)
Catalonia	1.190 (0.307)	-0.365 (0.060)	-0.740 (0.091)
Valencian Com.	1.177 (0.325)	-0.313 (0.057)	-0.682 (0.087)
Extremadura	0.367 (0.252)	-0.340 (0.005)	-0.124 (0.086)
Galicia	1.114 (0.389)	-0.228 (0.032)	-0.444 (0.084)
Madrid	1.096 (0.268)	-0.373 (0.053)	-0.649 (0.076)
Murcia	1.198 (0.233)	-0.358 (0.052)	-0.576 (0.072)
Navarre	1.139 (0.314)	-0.199 (0.030)	-0.350 (0.059)
Basque Country	0.895 (0.375)	-0.242 (0.038)	-0.460 (0.087)
The Rioja	-0.092 (0.337)	-0.187 (0.007)	0.015 (0.064)
Spain	1.429 (0.326)	-0.354 (0.055)	-0.871 (0.065)

Note: In brackets, the standard errors.