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# Stability and Asymmetry in Okun's Law: Evidence from Spanish Regional Data

**Summary:** This paper analyzes Okun's Law for Spain using regional data. The results confirm a very high Okun coefficient for Spain, with a high degree of regional heterogeneity. Furthermore, we find that panel data techniques provide notably more stable estimates than time series techniques applied to the same regional data. Finally, the results reveal a remarkable degree of regional heterogeneity in cyclical asymmetry in Okun's Law for the Spanish case.

**Keywords:** Unemployment, Okun's law, Economic cycles, Regional growth.

**JEL:** E24, E32, R11.

In 1962, Okun identified a relevant macroeconomic pattern: the negative relationship between output and unemployment (Arthur M. Okun 1962). Despite its a-theoretical nature, this relationship currently plays a fundamental role in macroeconomic policy. Nevertheless, evidence after the oil crisis led to a widespread belief in its structural instability (Christian E. Weber 1995; Jim Lee 2000). Recently, some authors have hypothesized that the Law displays asymmetric cyclical behavior (Thomas I. Palley 1993).

In this context, Laurence M. Ball, Daniel Leigh, and Prakash Loungani (2017) examine the evidence for different countries and confirm the stability of the Law. They argue that the relevant issue in the recent US recoveries is not the low rate of job creation, but the lower output growth, opening the door to a serious debate (see, for example, Mary C. Daly et al. 2014).

In this paper, we empirically test Okun's Law for Spain using regional data and applying both panel data and time series techniques. According to Donald G. Freeman (2001), panel data offer clear advantages in analyzing the Law, given that they provide more degrees of freedom and can yield more efficient estimates, among other aspects. We use the BDMORES database for the period 1980-2011, and we address the question of stability and cyclical asymmetry. This is a key issue for Spain, given the asymmetric cyclical behavior of the Spanish unemployment rate in recent years. Our results confirm a high Okun coefficient for Spain and a remarkable degree of regional heterogeneity across Spain, although they are not entirely conclusive on the cyclical asymmetry of the Law.

The rest of the paper is structured as follows: Section 1 describes Okun's Law, Section 2 details the data used, Section 3 presents the empirical results and analyzes

the stability of our estimates, Section 4, addresses cyclical asymmetry and Section 5 concludes.

## 1. Okun's Law

According to Okun (1962) and Ball, Leigh, and Loungani (2017), hereinafter BLL, fluctuations in aggregate demand cause changes in aggregate production with respect to potential output, simultaneously altering unemployment. We consider a set of regional units within the same country, denoted by subscript  $i$ . In this context, these relationships are given by the following expressions:

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

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

where  $e_{it}$  is log employment and  $y_{it}$  is log output in Equation (1). An asterisk after a variable indicates the long-term or natural level of that variable. In Equation (2),  $U_{it}$  is the unemployment rate, and this variable with an asterisk is the natural level of unemployment. Additionally, as is standard, we assume  $\gamma > 0$  and  $\delta < 0$ . The terms  $\theta_i^j$ ,  $j = e, u$ , reflect regional fixed effects, whereas  $\eta_{it}$  and  $\mu_{it}$  are error terms with the usual properties. These fixed effects capture the influence of any regional idiosyncratic characteristic conditioning the relationships (1) and (2).

From these expressions, 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 that  $\theta_i^y$  is a fixed effect affecting the relationship between cyclical deviations of output and unemployment.

As BLL show, using the available evidence on income shares and assuming an elasticity of output to employment of around 2/3, then  $\gamma \approx 1.5$ , for any standard neo-classical production function. However, if labor is considered a quasi-fixed factor, so that the adjustment in employment is expensive, firms will compensate for fluctuations in output by maintaining the same number of employees, but changing their working hours and/or the intensity of work effort. Thus, BLL expect the response of employment to changes in output to be lower than 1.5. Furthermore, they expect  $|\delta| < 1$  in Equation (2), given that changes in employment modify the incentives to job search. Therefore, for all these reasons, we consider that the coefficient of Okun's Law,  $\beta = \gamma\delta$ , should be lower in absolute value than  $\gamma \approx 1.5$ .

In order to estimate the Law, Okun (1962) proposed two alternative approaches. The first one consists of directly estimating Expression (3), the equation "in levels" or the output gap model; while the second consists of estimating Equation (3) after taking first differences. Both approaches have been frequently used in empirical research. Note that differentiating (3) we get:

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

where  $\omega_{it} = \Delta\varepsilon_{it}$ . From here, BLL assume that the natural rate of unemployment and the natural output growth rate are constant, which considerably simplifies Expression (4). These assumptions make it possible to estimate the Law without detrending the

series, which is why this version is the most widely used in empirical analysis. However, in this work we do not follow this empirical strategy, given that it does not seem appropriate to assume the natural rate of unemployment and the potential output growth rate in Spain as constants during our sample period, which includes much of the impact of the oil crisis.

In our approach, we directly estimate Equation (4). This procedure is very close to that employed by Jesús Crespo (2003) and Mark J. Holmes and Brian Silverstone (2006), who consider different behavior of Okun's Law over the cycle depending on the sign of the output gap.

Additionally, although the fixed effect  $\theta_i^y$  has disappeared from Equation (4), we consider that regional effects cannot be ruled out in the empirical analysis, given previous evidence on regional differences in Spanish unemployment (see Inmaculada García-Mainar and Victor M. Montuenga-Gómez 2003 and Roberto Bande and Ángel Martín-Román 2018). We thus expand Equation (4) to include such effects through the term  $\theta_i^{\Delta y}$ :

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

Furthermore, Robert J. Gordon (1984) empirically tested a dynamic version of the Law, assuming the presence of inertia in the relevant series, and estimating the trends in output and other variables. Since then, VAR methodology has frequently been used in empirical research on the Law (see, for example, George W. Evans 1989 and Weber 1995). Additionally, Martin F. J. Prachowny (1993) showed that Okun's Law can be considered as a special production function where cyclical deviations in capacity utilization, hours worked and workforce do not affect the output gap, although the data do not support the model. Nowadays, Equations (3) and (4) are often considered short-term versions of Okun's Law, whereas Prachowny's methodology analyzes the long-run equilibrium relationship between output and unemployment.

## 2. Data and Estimation

We estimate the two approaches of Okun's Law, Equations (3) and (4), using Spanish regional data sourced from the BDMORES (2019)<sup>1</sup> database, which provides data for the 17 Spanish autonomous communities over the period 1955-2013. From this data set, we have taken the gross domestic product in constant euros and the unemployment rate between 1980 and 2011, as well as the participation rate,  $a$ , which is used as an instrument in the empirical analysis.

The estimation of Equations (3) and (4) requires estimating two unobservable variables,  $y_{it}^*$  and  $U_{it}^*$ . We estimate these variables using a detrending procedure. The empirical evidence for the United States has shown that the results are sensitive to the filter (detrending procedure) used (Lee 2000). For the case of Spain, José Villaverde and Adolfo Maza (2009) use three different detrending methods with Spanish regional

<sup>1</sup> **BDMORES**. 2019. Base de datos regionales de la economía española BD.MORES. <https://www.sepg.pap.hacienda.gob.es/sitios/sepg/es-ES/Presupuestos/DocumentacionEstadisticas/Documentacion/paginas/basesdatos estudiosregionales.aspx> (accessed July 21, 2019).

data and report very similar results. Following BLL, we have applied the Hodrick-Prescott filter, the most widely-used method, and we have checked that the results we obtain are not sensitive to the use of different procedures. First, we have checked that the results do not change when the filter smoothing parameter does. Second, given the problems of the filter with observations at the end of the sample, we have verified that the results do not change when it is applied only until 2007, the last year before the crisis, keeping constant the trend from then on. In addition, we have also checked that the results do not change with alternative detrending methods; namely, the Baxter-King filter and a quadratic trend filter. These results are available to the interested reader on request.

It is worth mentioning that the labor variables from BDMORES present a high degree of homogeneity over time, as the breaks in these series (over long periods) have been considered a serious handicap of previous research on Okun's Law for Spain. Notably, in the update of BDMORES, the change in the definition of unemployment in 2002 (according to the European standard) has been carefully addressed to avoid a break in the series (see National Statistics Institute - INE 2005). As pointed out by Ana Belmonte and Clemente Polo (2004), this could largely explain previous unsatisfactory empirical results.

As mentioned above, we need to deal with unobservable heterogeneity when estimating the model with regional data. Thus, we apply both the fixed effects and the generalized method of moments estimators (WG and GMM, respectively). For the GMM case, we difference the model and use instrumental variables to deal with endogeneity problems. Also, following standard practice, in both cases we include lags of output gap and its difference in the model. Additionally, we estimate Okun's Law separately for each autonomous community and for Spain as a whole. Finally, we check that the GMM estimates pass the Sargan test of overidentifying restrictions, and the LM test for the orthogonality of residuals.

Before proceeding with our estimation strategy, we need to verify the order of integrability of the series. To avoid spurious regressions, the output gap and cyclical unemployment - in levels or in differences - should be stationary; alternatively, they should be cointegrated. For this purpose, we have applied the panel unit root tests of Im, Pesaran, and Shin (Kyung So Im, M. Hashem Pesaran, and Yongcheol Shin 2003); Levin, Lin, and Chu (Andrew Levin, Chien-Fu Lin, and Chia-Shang J. Chu 2002); and Hadri (Kaddour Hadri 2000). Table 1 displays these results. For the first two tests, the null hypothesis is the existence of a unit root, whereas for the third test it is stationarity. The results presented in Table 1 indicate that all series are stationary. Likewise, we have carried out a similar analysis for each autonomous community and for Spain, in this case applying the augmented Dickey-Fuller (David A. Dickey and Wayne A. Fuller 1979) and the Kwiatkowski, Phillips, Schmidt, and Shin tests (Denis Kwiatkowski et al. 1992). These results are presented in the Appendix.

**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

**Notes:** Ipshin: Im, Pesaran, and Shin test; Levinlin: Levin, Lin, and Chu test; Hadri: Hadri test. In Ipshin and Levinlin the null hypothesis is the existence of a unit root, while in Hadri it is stationarity. For each test, we present the statistics and the significance level.

**Source:** Author's calculations.

### 3. Okun's Law in Spain and Its Stability

In Table 2, we present the estimation results of both approaches to Okun's Law for our regional panel. In general, we confirm previous empirical evidence for Spanish regional data, with all the estimated Okun coefficients below one. As can be seen, the model in differences provides lower estimates (in absolute value) than the model in levels. Nonetheless, estimates are larger than those obtained by Celia Melguizo (2017), and very similar to those obtained by Villaverde and Maza (2021), who find that regional spillover effects can play an important part in Okun's Law. We do not compare our results with those obtained by Freeman (2001) or Villaverde and Maza (2007, 2009), because said authors use the output gap as the dependent variable, and the Okun coefficient from a regression of output on unemployment will only be the reciprocal of the coefficient from the inverse regression when the two variables are perfectly correlated (see Charles I. Plosser and William Schwert 1979). The GMM estimates are larger than those obtained with the WG approach and they also show better goodness of fit (using various tests).

**Table 2** Okun's Law in Spain: Panel Data

	$U_{it} - U_{it}^* = \beta_0(y_{it} - y_{it}^*) + \beta_1(y_{it-1} - y_{it-1}^*) + \theta_i^y + \varepsilon_{it}$				$\Delta U_{it} - \Delta U_{it}^* = \beta_0(\Delta y_{it} - \Delta y_{it}^*) + \beta_1(\Delta y_{it-1} - \Delta y_{it-1}^*) + \theta_i^{\Delta y} + \omega_{it}$			
	(WG)		(GMM)		(WG)		(GMM)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\beta_0$	-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)
$\beta_1$		-0.079 (0.035)		-0.056 (0.179)		-0.128 (0.031)		-0.043 (0.130)
$\bar{R}^2$	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
Orthog.			0.849 0.931	0.700 0.951			1.146 0.992	1.236 0.990

**Notes:** Standard errors in parentheses. Columns (1), (2), (5) and (6) present within-group estimates (WG), while columns (3), (4), (7) and (8) present GMM estimates in first differences. In this last case, the instruments are second to fourth lags of  $y_{it} - y_{it}^*$  and  $\Delta U_{it}$  for columns (3) and (4), second to fifth lags of  $\Delta a_{it}$  and third to fifth lags of  $\Delta U_{it} - \Delta U_{it}^*$  for the other columns.

**Source:** Author's calculations.

Table 2 also shows that the results in the two specifications do not change when a lag of the output gap is included, or its difference. Our results thus show a very small effect, if any, of the lagged output gap on cyclical unemployment. However, the  $R^2$  for the WG estimates improves a little and, as expected, the significance level of the Sargan test for the GMM estimates worsens, albeit only slightly, for the model in differences. This is not surprising, given that we keep the same set of instruments. Finally, the test of orthogonality of the residuals improves slightly.

In Table 3 we present the results for the model in levels for each autonomous community's time series. The aim is to check whether there are regional differences in the Law. Once again, the results consistently show an estimated Okun coefficient below one for all the regions, confirming previous time series evidence for Spain (see Imad A. Moosa 1997; Leopold Sögner and Alfred Stiasny 2002; Bakhtiar Moazzami and Bahram Dadgostar 2009, and also BLL - cross-country studies which report a wide range of values of the Okun coefficient). Furthermore, the GMM estimates are usually higher than the OLS ones, except for Madrid, Castile-Leon and Aragon. Finally, the  $R^2$  values for the OLS estimates are acceptable, while the Sargan tests for the GMM estimates reach a significance level of at least 79%, and the tests of orthogonality for the residuals also provide satisfactory results. It should be noted that Extremadura and Rioja differ from the others in that they show quite a poor fit for OLS but not for the GMM estimates. In this respect, empirical research on Okun's Law using regional data often shows a poor fit for some regions (see Dimitris K. Christopoulos 2004, for the Greek economy, or Marie-Estelle Binet and François Facchini 2013, for the French). While this could be attributable to poor quality data for Rioja, the smallest region in the sample, it is more problematic for Extremadura, as this region has the highest unemployment rate in the sample. In any case, we have verified that the results do not change when these two regions are excluded from the sample. Table A2 in the Appendix presents the results of estimating Okun's Law in differences separately for each autonomous community, confirming the results reported in Table 3, although with a worse fit and smaller estimated Okun coefficients. Likewise, Extremadura and Rioja continue to show poor results.

Our estimates for the Okun coefficient for the Spanish time series, -0.894 (OLS) and -0.932 (GMM), are very similar to those found for Spain by BLL and Gert Schnabel (2002) (-0.824 and -0.950, respectively). According to BLL, Spain's "Okun coefficient, -0.82, is substantially higher in absolute value than any other country. The natural explanation is the unusually high incidence of temporary employment contracts" (Ball, Leigh, and Loungani 2017, p. 1438). Similarly, Amy Y. Guisinger et al. (2015) find a relationship between US states' Okun coefficient and labor market indicators.

According to these results, changes in aggregate output have a large effect on Spanish unemployment. This lends support to the use of a regionally-oriented aggregate demand policy in Spain, when indicated by the value of the fiscal multipliers. In this respect, the autonomous communities with the highest coefficients (above the GMM average estimate) are Catalonia, Cantabria, Canarias, Murcia, Valencia, Andalusia, the Basque Country, Asturias and the Balearic Islands. As regards the OLS estimates, this group expands to include Castile-Leon, Aragon and Galicia.

**Table 3** Okun's Law in Spain, Time Series, Model in Levels

	$U_t - U_t^* = \beta(y_t - y_t^*) + \varepsilon_t$				
	(OLS)		(GMM)		
	$\beta$	$\bar{R}^2$	$\beta$	Sargan	Orthog.
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
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

**Notes:** Standard errors in parentheses. The instruments for the GMM estimations are different lags of  $y_t - y_t^*$ ,  $U_t - U_t^*$ ,  $\Delta U_t$ ,  $\Delta y_t$  and, occasionally, a constant.

**Source:** Author's calculations.

Following BLL, we have estimated jointly, as a system of seemingly unrelated regressions (SUR), the relationships between employment, unemployment and output: Equations (1), (2) and (3), respectively. For this purpose, we have applied the Hodrick-Prescott filter to the three variables. The results, both for the model in levels and in differences, are shown in Table 4. On the one hand, according to the model, the

absolute value of the parameter relating output and employment,  $\gamma$ , should be below 1.5, but above the Okun coefficient,  $\beta$ . As can be seen, our estimate satisfies these requirements. On the other hand, the absolute value of the parameter relating employment and unemployment,  $\delta$ , should be below one, as is the case with both estimates. Furthermore, the estimated Okun coefficient for the model in levels is very close to those previously obtained, and above the estimated coefficients for the model in differences, as in Table 2.

**Table 4** Okun’s Law in Spain: System of Seemingly Unrelated Regressors (SUR)

$e_t - e_t^* = \gamma(y_t - y_t^*) + \eta_t$ $U_t - U_t^* = \delta(e_t - e_t^*) + \mu_t$ $U_t - U_t^* = \beta(y_t - y_t^*) + \varepsilon_t$		
(SUR)		
<b><math>\gamma</math></b>	<b><math>\Delta</math></b>	<b><math>B</math></b>
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)		
<b><math>\gamma</math></b>	<b><math>\Delta</math></b>	<b><math>B</math></b>
0.237 (0.002)	-0.081 (0.003)	-0.019 (0.000)

**Notes:** Standard errors in parentheses.

**Source:** Author’s calculations.

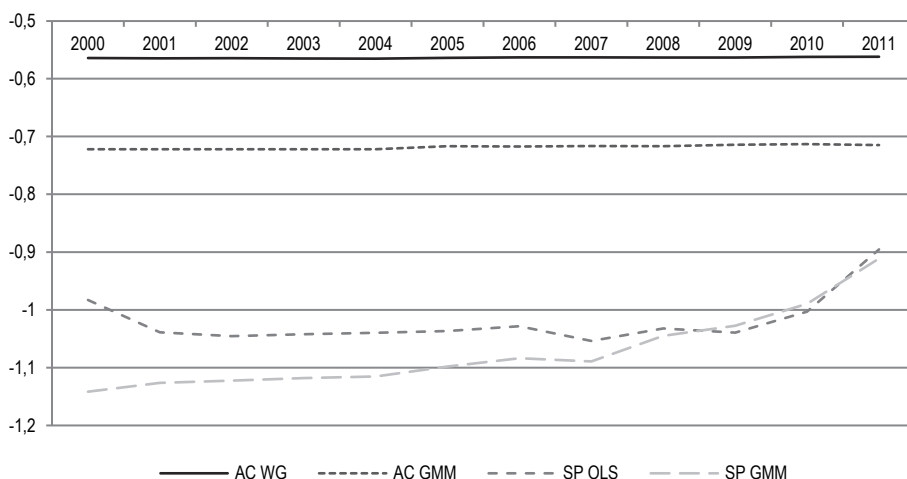
Finally, we analyze the stability of Okun’s Law in Spain. As pointed out above, Weber (1995) and Lee (2000) find evidence of structural instability in Okun’s Law for OECD countries, including the United States. In fact, they find evidence of a break in the relevant series in the early 1970s. Additionally, Sögner and Stiassny (2002) find mixed evidence of structural instability for another sample of OECD countries, while BLL conclude that Okun’s Law “is strong and stable by the standards of macroeconomics. Reports of deviations from the Law are often exaggerated” (Ball, Leigh, and Loungani 2017, p. 1439). Finally, Schnabel (2002) finds a higher Okun coefficient for Spain in more recent periods than in earlier ones, which he takes as evidence of a structural change.

In recent years, it has become customary to analyze the stability of Okun’s Law using a relatively simple technique. It consists of estimating the Okun coefficient over many different but consecutive periods, and comparing the values obtained. If these estimates are similar, the obvious implication is that Okun’s Law is stable. This technique was applied by Moosa (1997) to a sample of the G7 countries, yielding mixed results depending on the country, and by Edward S. Knotek (2007) to US data, who concludes that the Law is not stable for the period 1948-2007. More recently, Michael T. Owyang and Tatevik Sekhposyan (2012) confirm this conclusion.

In our case, we have applied this technique both to the Spanish aggregate data (OLS and GMM estimates) and to the panel of the Spanish regions (WG and GMM



estimates). For this purpose, we take a period of 21 annual observations for each regression; thus, the first rolling regression estimates the model in levels from 1980 to 2000. From this first estimation, the period moves ahead one year at a time, both at the beginning and at the end of the period. In this way, we obtain a set of 12 estimated values for the Okun coefficient, one for each sub-period, which allows us to analyze the stability of the coefficients over time. To obtain the GMM estimates, we use the same set of instruments as in Tables 2 and 3 over all the sub-periods. Finally, we plot these results in Figure 1, assigning the final year of each sub-period to each estimated coefficient.



Source: Author's calculations.

**Figure 1** Rolling Regressions, 2000-2011

As can be seen in Figure 1, the two panel data estimates (AC WG and AC GMM, in Figure 1) prove to be remarkably stable. The panel data estimates for the model in differences (not reported but available on request) show similar behavior. The same cannot be said of the time series estimates (SP OLS and SP GMM, in Figure 1), whose values increased with the crisis. This last result suggests that the effect of output changes on Spanish unemployment is smaller now than before the crisis, although it should be borne in mind that in the last year of our sample Spain had not yet reached the trough of the crisis. In relation to this, we recall that BLL find some evidence of instability for some countries, but conclude against the existence of a structural change. Our evidence for the Spanish economy seems troubling, given the disparity of the results obtained for the same data through different estimators. Nevertheless, we note that the Okun coefficient estimate shows an increase - a decline in its absolute value - at the same time as the share of temporary contracts drops (as occurred in Spain in the crisis). Taken as a whole, this evidence supports Freeman's (2001) hypothesis that panel data provide more stable estimates as it is possible to control for omitted variables.

#### 4. Asymmetry in Okun's Law for Spain

As we mentioned above, an additional issue is the hypothesis of asymmetric behavior of the Law throughout the cycle. If true, Okun's Law would work differently in expansions than in recessions, implying different Okun coefficients in the two phases of the cycle. Paramsothy Silvapulle, Moosa, and Mervyn J. Silvapulle (2004) discuss the reasons that could explain this: first, asymmetry in the substitution of production factors and/or technical restrictions on production; second, changes in labor market participation, or in firms' employment policies throughout the cycle; third, rigidities in the labor market that could make unemployment more sensitive to output in expansions than in recessions; and, finally, firms being more reluctant to fire workers in crises than in expansions, due to previous investment in their training. Thus, Lee (2000) finds evidence of asymmetries for only some countries, while Richard Harris and Brian Silverstone (2001) and Matti Virén (2001) identify asymmetries in most of them. For the US case, Palley (1993) finds evidence of asymmetry, which is also confirmed by Crespo (2003) and Silvapulle, Moosa, and Silvapulle (2004). Finally, Holmes and Silverstone (2006) in line with all the above works, assert that it is not appropriate to use the term "jobless recovery" to describe the recent US experience, which they take as evidence of worse performance of Okun's Law in expansions.

In principle, given the cyclical behavior of the Spanish unemployment rate since the 70s, Spain seems a natural candidate to test this hypothesis. In the last three economic cycles, the Spanish unemployment rate has increased on average by 2.4% each year in contractions, while it has decreased on average by 1.4% each year in expansions. In the Great Recession, following extensive labor market reforms, rates of job creation were higher in the recovery phase, and the unemployment rate decreased by 2.1% each year, although its average yearly increase in the previous contraction had been also higher, at 3%.

In our case, we analyze the asymmetry of the Law for Spain using the model in levels - Equation (3) - as proposed by Silvapulle, Moosa, and Silvapulle (2004). Following this work, we decompose the output gap into two series according to its sign, and then we discard in each series those observations with the wrong sign, in order to regress both series on cyclical unemployment. If the resulting estimates are different, we can conclude that there is evidence of asymmetry. 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 zero otherwise. Thus, from Equation (3) we obtain:

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

with  $\beta^+$  and  $\beta^-$  being parameters to estimate. Javier J. Pérez, Jesús Rodríguez, and Carlos Usabiaga (2003) test this hypothesis for Spanish aggregate data, finding evidence of asymmetry. Unlike those authors and Silvapulle, Moosa, and Silvapulle (2004), we test the hypothesis with Spanish regional data, using both panel data and time series techniques.

Table 5 presents the results of estimating Equation (6) with the regional data as a panel, and these can be compared to the results of estimating the *symmetrical* Okun's Law, reported in Table 2. As can be seen, the estimates in both Tables are similar in

terms of fit. Estimates of both  $\beta^+$  and  $\beta^-$  are statistically significant, and while  $\beta^+$  increases and  $\beta^-$  decreases in WG estimates, with respect to Table 2, the opposite occurs with the GMM estimates. Therefore, these results do not provide support for the hypothesis of different unemployment sensitivity to changes in output in expansions than in recessions. Nonetheless, a test of the equality of  $\beta^+$  and  $\beta^-$  is strongly rejected for the WG estimates and only just accepted for the GMM ones. These results are in line with those obtained previously for Spain in studies using aggregate data by Virén (2001) or by Pérez, Rodríguez, and Usabiaga (2003). Finally, Bande and Martín-Román (2018) and Villaverde and Maza (2021), who examine this issue only for the last crisis, also conclude against asymmetry.

**Table 5** Okun's Law in Spain: Testing Asymmetry

	$U_t - U_t^* = \beta^+(y_t - y_t^*)^+ + \beta^-(y_t - y_t^*)^- + \varepsilon_t$	
	(WG)	(GMM)
$\beta^+$	-0.716 (0.072)	-0.432 (0.183)
$\beta^-$	-0.413 (0.059)	-1.135 (0.257)
$\beta^+ = \beta^-$	7.261 0.007	3.106 0.077
$\bar{R}^2$	0.406	
Sargan		1.447 0.835
Orthog.		0.907 0.988

**Notes:** Standard errors in parentheses. The column (WG) presents within-group estimates, the column (GMM) presents GMM estimates in first differences. In this case, the instruments are first and second lags of  $\Delta(y_{it} - y_{it}^*)^+$ , fifth lag of  $(y_{it} - y_{it}^*)^-$ , second lag of  $\Delta^2 a_{it}$ , lag of  $\Delta y_{it}$  and a constant.

**Source:** Author's calculations.

Table 6 presents a similar exercise for each autonomous community. As can be seen, the results are not conclusive. First of all, while  $R^2$  values for OLS estimates are similar to those obtained in Table 3, the results of the Sargan and orthogonality of the residuals tests for the GMM estimates are worse. On the one hand, the values of the two  $\beta$ s for Spain are very similar; on the other, the significance level of the test of the equality of coefficients is around 30%. Second, most autonomous communities register a higher absolute value of  $\beta^+$  than that reported in Table 3, but the opposite is true for  $\beta^-$ ; the only cases where this does not happen is with the OLS estimates for the Balearics, the Canary Islands and Navarre, and the GMM estimates for Navarre and Rioja. Furthermore, Extremadura and Rioja remain problematic, with the former being the only case in which we obtain a positive value for one  $\beta$ , albeit not statistically significant. Third, the test of equality again reveals a high degree of regional heterogeneity: while some autonomous communities are above the 50% level of significance, there are some rejections at the 10% significance level (Castile-La Mancha and Galicia, with OLS estimates; and Castile-La Mancha, Castile-Leon and the Basque Country, with GMM ones).

**Table 6** Okun's Law in Spain: Testing Asymmetry with Regional Data

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

**Notes:** Standard errors in parentheses. The instruments for GMM estimates are different lags of  $\Delta U_t, y_t, \Delta y_t, \Delta(y_t - y_t^*), (y_t - y_t^*)^+, (y_t - y_t^*)^-, \Delta(y_t - y_t^*)^+, \Delta(y_t - y_t^*)^-$ , and, sometimes, a constant.

**Source:** Author's calculations.

Testing the asymmetry hypothesis with the model in differences is problematic, given that it is not obvious what output growth rate should be taken as a benchmark. Applying the previous procedure to Equation (5) would imply that this benchmark should be the potential output growth rate. In principle, however, this does not seem as appropriate as a zero output gap is for the model in levels. Even if we try to find a more realistic alternative benchmark for the model in differences, such as an output growth rate below the potential rate, it is not obvious to us what value to take for it, or how we could identify it. In this context, Crespo (2003) analyzes asymmetry for a non-zero output gap, finding that the confidence interval of the estimated benchmark contains the zero, thus concluding in favor of exogenously imposing a zero bound. Alternatively, Holmes and Silverstone (2006) provide a good example of the difficulties faced when the zero bound is not imposed.

Therefore, most of the tests of asymmetry based on the model in differences regress the increase in unemployment on both the series of the increases and decreases

in output, as Lee (2000), Harris and Silverstone (2001) and Virén (2001) do; it is not unusual to find unrealistic estimated parameters (below -1, for example). In any case, we have tested asymmetry with panel data techniques, and the results are displayed in Table 7. We have decomposed  $\Delta y_{it} - \Delta y_{it}^*$  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, from Equation (3) we obtain:

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

The results obtained are shown in Table 7 confirm the asymmetry of Okun's Law for Spain. However, if we take this evidence jointly with previous results reported in Tables 5 and 6, it is clear that this issue deserves more research. In particular, Spain has also experienced a jobless recovery in recent years.

**Table 7** Okun's Law in Spain: Testing Asymmetry with Panel Data

	$\Delta U_{it} - \Delta U_{it}^* = \beta^+(\Delta y_{it} - \Delta y_{it}^*)^+ + \beta^-(\Delta y_{it} - \Delta y_{it}^*)^- + \theta_i^{\Delta y} + \omega_{it}$	
	(WG)	(GMM)
$\beta^+$	-0.073 (0.054)	0.893 (0.848)
$\beta^-$	-0.541 (0.049)	-1.958 (0.568)
$\beta^+ = \beta^-$	6.461 0.011	4.681 0.030
$\bar{R}^2$	0.189	
Sargan	1.077 0.982	
Orthog.	1.296 0.995	

**Notes:** Standard errors in parentheses. The column (WG) presents the within-group estimates and the column (GMM) presents GMM estimates in first differences. In this case, the instruments are second to fifth lags of  $\Delta^2 a_{it}$ , lag of  $u_{it}$ , fifth lag of  $y_{it}$ , second lag of  $\Delta u_{it} - \Delta u_{it}^*$  and a constant.

**Source:** Author's calculations.

## 5. Conclusions

In this paper we have estimated Okun's Law for Spain using regional data for the period 1980-2011. We have estimated it separately for each autonomous community and for Spain, as well as for the regional sample with panel data techniques. We highlight the consistency and homogeneity of the labor series used, given the problems with these variables in previous empirical research for Spain (see Belmonte and Polo 2004).

On the one hand, our results confirm a negative Okun coefficient in Spain, but higher than -1, both for the model in levels and for the model in differences. On the other hand, our estimates show that, by international standards, the coefficient is very high in absolute value. As is well known, this has been attributed in the past to the higher share of temporary contracts in the Spanish labor market.

Second, the results also confirm a remarkable degree of regional heterogeneity in the Okun coefficient, making it possible to identify a group of autonomous

communities where unemployment is more sensitive to changes in output; in principle, this makes them especially suitable for aggregate demand policies. At the same time, this result suggests it would be appropriate to design a regionally-oriented economic policy with the aim of reducing Spanish unemployment, an idea already emphasized by previous studies (see Bande and Martín-Román 2018).

In third place, we have verified the stability of Okun's Law through rolling regression techniques. We have confirmed that panel data estimates, both WG and GMM, are much more stable than time series estimates obtained using the same Spanish regional database. These results support Freeman's (2001) claim that panel data are more suitable than time series data for analyzing this issue. In any case, we have found more instability in Spanish estimates with aggregate data than BLL found in US time series estimates.

We have also found evidence of a fall in the absolute value of the Spanish Okun coefficient estimated with aggregate data from the onset of the last crisis, at the same time as the share of fixed-term contracts in total contracts was undergoing an appreciable decline in the Spanish labor market. This is noteworthy given that many authors have recently emphasized a possible relationship between these parameters. In any case, everything points to this being a very complex issue requiring further research.

Finally, panel data techniques have allowed us to find evidence of asymmetry in Okun's Law for Spain, confirming previous evidence from aggregate data. However, the asymmetry tests for each autonomous community overshadow this result, due to the high degree of regional heterogeneity found in this field; we identify a group of regions for which cyclical asymmetry is firmly rejected. Given that the Spanish aggregate unemployment rate has shown clear asymmetric behavior in past cyclical expansions and contractions, further research on this issue is necessary, paying special attention to regional differences in this respect. Despite the difficulties involved in using the model in differences to test this hypothesis, we have made a first attempt in this regard, and the results seem to confirm the existence of asymmetry. Moreover, our results indicate that Okun's Law in Spain is very weak in times of crisis, meaning the term "jobless recoveries" could be applicable in the Spanish case. In any case, taken jointly, these results suggest the need for more research.

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## Appendix

**Table A1** Time Series Unit Root Tests

	ADF				KPSS			
	$U_{it} - U_{it}^*$	$y_{it} - y_{it}^*$	$\Delta U_{it} - \Delta U_{it}^*$	$\Delta y_{it} - \Delta y_{it}^*$	$U_{it} - U_{it}^*$	$y_{it} - y_{it}^*$	$\Delta U_{it} - \Delta U_{it}^*$	$\Delta y_{it} - \Delta y_{it}^*$
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
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

**Notes:** ADF: Augmented Dickey-Fuller test; KPSS: Kwiatkowski, Phillips, Schmidt, and Shin test. The null hypothesis in ADF is the existence of a unit root, while in KPSS it is stationarity. In all cases, we report the test statistics. \*\* indicates that the null hypothesis is rejected at 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.

**Source:** Author's calculations.

**Table A2** 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)		
	$\beta$	$\bar{R}^2$	$\beta$	Sargan	Orthog.
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
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

**Notes:** Standard errors in parentheses. The instruments for the GMM estimates are different lags of  $\Delta a_t$ ,  $\Delta U_t - \Delta U_t^*$ ,  $\Delta y_t$ ,  $\Delta y_t - \Delta y_t^*$ ,  $\Delta^2 y_t$ ,  $a_t$  and a constant.

**Source:** Author's calculations.

**Table A3** Okun's Law in Spain: System of Seemingly Unrelated Regressors (SUR) with Regional Data
$$e_t - e_t^* = \gamma(y_t - y_t^*) + \eta_t$$

$$U_t - U_t^* = \delta(e_t - e_t^*) + \mu_t$$

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

	(SUR)		
	$\gamma$	$\delta$	$\beta$
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)
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)

**Notes:** Standard errors in parentheses.**Source:** Author's calculations.