Unemployment forecasts, time varying coefficient models and the Okun's law in Spanish regions

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Resumen:

During the Great Recession, output and unemployment responses have differed markedly across Spanish regions. Our objective is to evaluate the relative accuracy of forecasting models based on the Okun's law compared to alternative approaches. In particular, we want to analyse if a time varying coefficient specification of the Okun's law provide better forecasts than alternative models in two different periods: a first period from 2002 to 2007 characterized by sustained economic growth in all provinces, and a second period from 2008 to 2013 characterized by the impact of the Great Recession. The obtained results allow us to conclude that, in general, the use of these models improve the forecasting capacity in most regions, but do not provide reliable forecast.

Palabras Clave: Unemployment forecasts, Okun's Law, Time-varying coefficient models, Regional Labor Markets

Clasificación JEL: C53, R23, J64

1. Introduction

During the last decades, the Spanish labour market has been characterised by high unemployment rates, particularly when compared to other European Union countries. Moreover, the low interregional geographical mobility together with the peculiarities of the collective bargaining systems until the last reforms have amplified the differences in unemployment rates from a regional perspective (López Bazo, et al. 2005).

More recently, the financial crisis, the burst of the housing bubble and the dramatic fall of employment in the construction sector during the Great Recession has magnified the problem. Given its social and political significance, forecasting unemployment rates is particularly important to help policy makers in their decision-making. As a result, the literature dealing with unemployment rate forecasting is consequently large: see, for instance, Funke (1992), Rothman (1998), Elliot and Timmerman (2008) or, more recently, Franses et al. (2014). The literature has also recently rediscovered (see Knoteck, 2007; Ball et al. 2014 or Guisinger and Sinclair, 2014) the possibility of using the Okun's law as a simple but potentially powerful forecasting model. Using 1950's data for the US economy, Okun (1962) found an empirical negative relationship between changes in the unemployment rate and output growth. This relationship has been estimated and tested for several countries (see for instance Huang and Yen, 2013), but also for regions: Freeman (2000) and Pereira (2014) for the United States, Adanu (2005) for Canadian regions; Durech et al. (2014) for regions in the Czech Republic and Slovakia; Kangarsharju et al. (2012) for the Finnish regions; Christopoulos (2004), Karfakis et al (2014), and Apergis and Rezitis (2014) for Greek regions; Marie-Estelle and Facchini (2013) for French regions and, for the Spanish regions, it is worth mentioning the research by Villaverde and Maza (2007 and 2009), Ballesteros et al. (2012), Martín-Román and Sylvina-Porras (2012). However, none of these studies are focused on regional forecasting but structural analysis.

The objective of this paper is to evaluate the relative accuracy of forecasting models based on the Okun's law compared to alternative approaches in the particular context of Spanish regions. We want to analyse if the use of time varying coefficient models improves the forecasting accuracy of the Okun's law when compared to fixed coefficient models in two different periods: a first period from 2002 to 2007 characterized by sustained economic growth in all provinces, and a second period from 2008 to 2013 characterized by the impact of the Great Recession.

2. Methods

The Okun's law is given by the following expression:

$$\Delta UR_t = \alpha + \beta \cdot \Delta GDP_t + \varepsilon_t, \qquad (1)$$

where ΔUR_t and ΔGDP_t denote, respectively, changes in the unemployment rate from *t-1* to *t* (or differences in logs) and output growth (usually measured by changes from *t-1* to *t* in the logarithm of Gross Domestic Product - GDP); α is an intercept; β, usually known as Okun's coefficient, explains how changes in the logarithm of output affect variations in the unemployment rate; and, ε_t denotes a random term. The ratio $-\frac{\alpha}{\beta}$ provides an estimate of the required output growth to stabilize the unemployment rate.

An alternative version of the Okun's law relates changes in the unemployment rate to the output gap (i.e, the difference between actual output and potential output - GDP_t^*). This alternative version of the law is given as follows:

$$\Delta UR_t = \alpha + \beta \cdot \left(GDP_t - GDP_t^*\right) + \varepsilon_t, \qquad (2)$$

where the intercept α can be interpreted as the unemployment rate in the case of full employment. Eq. 2 can be reformulated as:

$$UR_t - UR_t^* = \beta \cdot \left(GDP_t - GDP_t^*\right) + \varepsilon_t, \qquad (3)$$

where UR_t^* is the natural unemployment rate, and, so $UR_t - UR_t^*$ is the unemployment gap. Although probably the relationship captured by Eq. 3 is more meaningful than Eq. 1 from an economic point of view, the main problem is that potential output and the natural unemployment rate are not observable, so it is necessary to estimate them using filtering methods such as the Hodrick-Prescott or pass-band filters[1] before Eq. 3 can be empirically analysed. For this reason, and taking into account that the objective of this paper is to analyse Okun's law forecasting accuracy, we will use Eq. 1 instead of Eq. 3.

The strategy to test if the Okun's law can provide useful information to improve forecasts of regional unemployment rate in Spain has been the following. Four different sets of models have been considered (naïve, auto-regressive, fixed coefficient models and time varying coefficient models) to obtain forecasts for the unemployment rate of the different Spanish provinces and the Mean Absolute Percentual Error (MAPE) has been computed for different forecast horizons. The comparison of the MAPE values for the models not based in the Okun's law with those derived from it would permit to assess whether it is useful or not to improve unemployment forecasts.

Naïve method

As usual in the literature, the naïve method considers that the value of the variable of interest in a particular period does not change from the last valid observation:

$$UR_t = UR_{t-1}. \tag{4}$$

Autoregressive models

The widely known autoregressive model (also known as distributed-lags model) explains the behaviour of the endogenous variable as a linear combination of its own past values:

$$UR_t = \phi_1 UR_{t-1} + \phi_2 UR_{t-2} + ... + \phi_p UR_{t-p} + \varepsilon_t. \tag{5}$$

The key question is how to determine the number of lags that should be included in the model. We have considered different models with a minimum number of 1 lag up to a maximum of 3 (including all the intermediate lags), selecting that model with the lowest value of the Akaike Information Criteria (AIC). In order to check the robustness of the results to different selection criteria, we have also considered the Schwartz criteria yielding exactly the same results.

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[1] Moreover, there is no consensus in the literature on which of the different procedures is more appropriate to estimate the unobservable variables.

Fixed and time varying coefficient models

Ordinary Least Squares (OLS) estimation of Eq. (1) allows to obtain forecasts for the unemployment rate. However, as previously mentioned in the presence of structural instability, estimates of α and β will not be appropriate and lead to misleadings forecasts. For this reason, a part of considering forecasts from the OLS robust estimation of Eq. 1, we also consider a time varying coefficient specification. In particular, time varying coefficient models try to consider in the specification and estimation of the model the instability in the relationship between the endogenous and the exogenous variables. This instability can be caused by structural changes but also by specification errors ((Dzciechciarz, 1989; Engle and Watson, 1987; Min and Zellner, 1993). Time varying coefficient models are usually formed by two equations: a first equation that captures the time evolution of the considered coefficients denoted by β_t :

$$\beta_t = \phi_t \cdot \beta_{t-1} + W_t \cdot \theta_t + \eta_t , \tag{6}$$

and where ϕ_t represents the magnitude of the change in the coefficient in each time period, W_t denotes potential explanatory variables of the value of β_t, θ_t are the coefficients associated to these variables and η_t is a random error term that is assumed to follow a normal distribution with zero mean and variance σ_η^2. The second equation is related to the equation of interest, in our case, the Okun's law, with Y_t denoting the endogenous variable, X_t the explanatory variables with time varying coefficients and Z_t other explanatory variables with non-time varying coefficients, denoted by γ:

$$Y_t = X_t \cdot \beta_t + Z_t \cdot \gamma + \varepsilon_t , \tag{7}$$

ε_t is a random error term following a normal distribution with zero mean and variance σ_ε^2.

Taking into account the previous literature and the arguments provided by Engle and Watson (1987) this general specification model is usually simplified for empirical work assuming that ϕ_t=1 and θ_t =0. This restricted specification is known as systematically varying coefficient models and, in this case, coefficients are assumed to behave as a random walk (Shively and Kohn, 1997). The system formed by the restricted specification of Eq. 6 and Eq. 7 can be transformed into a state-space model where the first is the state equation and the second is the measurement equation. In the particular case of the Okun's law the model to estimate would be the following one:

$$UR_t - UR_{t-1} = \alpha_t + \Delta GDP_t \cdot \beta_t + \varepsilon_t \,, \tag{8}$$

$$\alpha_t = \alpha_{t-1} + \eta_t \,, \tag{9}$$

$$\beta_t = \beta_{t-1} + \zeta_t \,. \tag{10}$$

The estimation of this model can be done using the Kalman filter, once the values of the hyperparameters of the model (variance of the random terms of the three equations) are estimated by maximum likelihood and the OLS estimates of the Okun's law are used as initial values.

3. Data

In order to carry out our analysis, we have used information for the 17 Spanish Autonomous Communities (NUTS-II level regions). Data for unemployment rates comes from the Spanish Labour Force Survey (LFS) provided by the National Institute of Statistics (INE) while data for real output growth comes from the Spanish Regional Accounts (SRA). Although unemployment rates data are available at the quarterly frequency, regional output is only available at the annual frequency. In both cases, data is available since 1980 up to 2013.

4. Results

Before moving to the analysis of the forecast competition, figure 1 shows the evolution of changes in unemployment and GDP growth for the Spanish economy for the considered period.

As we can see from figure 1 and figure 2, where the time evolution of changes in unemployment and GDP growth is shown, it is not straightforward to conclude that the first difference of both series behave as stationary time series. This is a relevant point as this is a requirement of the Okun's law specification used to derive the different time series models used for the forecasting competition. Detailed results of the analysis of the time series properties of unemployment and GDP for Spain and the 17 Spanish Autonomous Communities using the Augmented Dickey Fuller test, Phillips and Perron test, Elliot-Rothenberg-Stock test, Schmidt-Phillips test, Kwiatkowski-Phillips-Schmidt-Shin test, Zivot-Andrews test and the Clemente-Montañes and Reyes test are available from the authors on request. Due to space limitations, we only show the results of the Augmented Dickey-Fuller test in table 1 and summary results of the Clemente-Montañes and Reyes test in Annex 1.

Results from table 1 permit us to conclude that, with the only exception of unemployment in the Basque country (País Vasco), in all Autonomous Communities at the usual significance levels we reject the null hypothesis that there is a unit root in the two variables after differentiating. Results from other unit roots or stationary tests are very similar and validate our empirical specification of the Okun's law. However, it is worth mentioning that, as it can be seen in the first panel of table 1, in a few regions like Asturias, Extremadura and La Rioja a different specification could perhaps be more appropriate. However, we prefer to keep a homogenous specification across the considered regions.

Another relevant issue that could also affect the validity of the specification is the potential existence of structural breaks in the considered relationship. Just to illustrate the relevance of the problem, annex 1 shows some summary results of the Clemente-Montañes and Reyes test for the Spanish GDP and the Spanish unemployment arte. As we can see from the figures in the annex, two breaks are detected in both series at mid-nineties and mid two-thousands, probably related to the impact of the two recent economic crisis experienced by the Spanish economy. This result suggests that the sampling period used to estimate the model would affect the forecasting accuracy of the models considered. However, regional results are quite heterogeneous in relation to the moment of the structural break, so as before, and in order to keep an homogenous specification across regions, we do not control for it.

Figure 1. Changes in unemployment– Spain 1980-2013

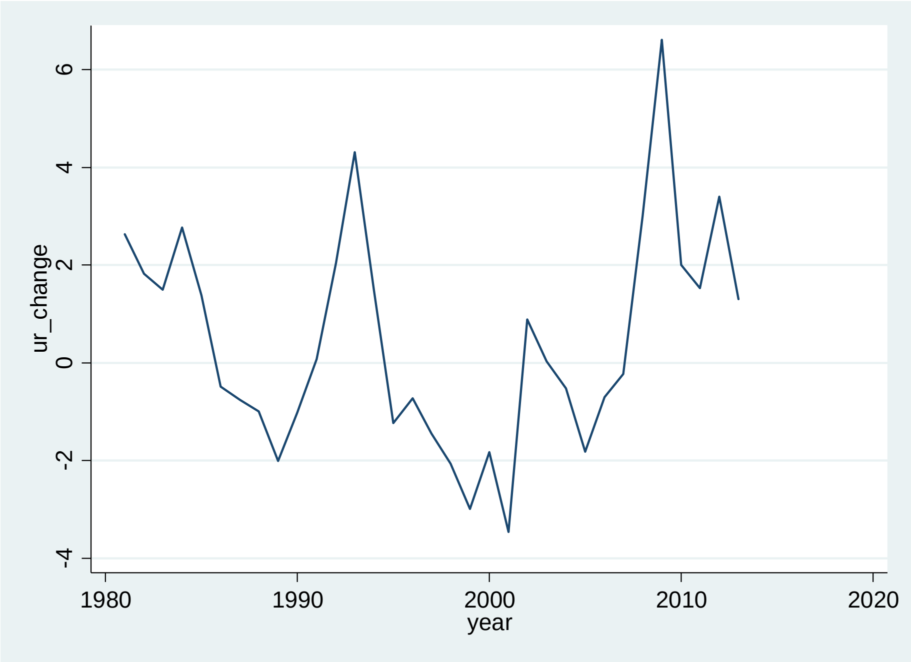

Figure 2. GDP growth – Spain 1980-2013

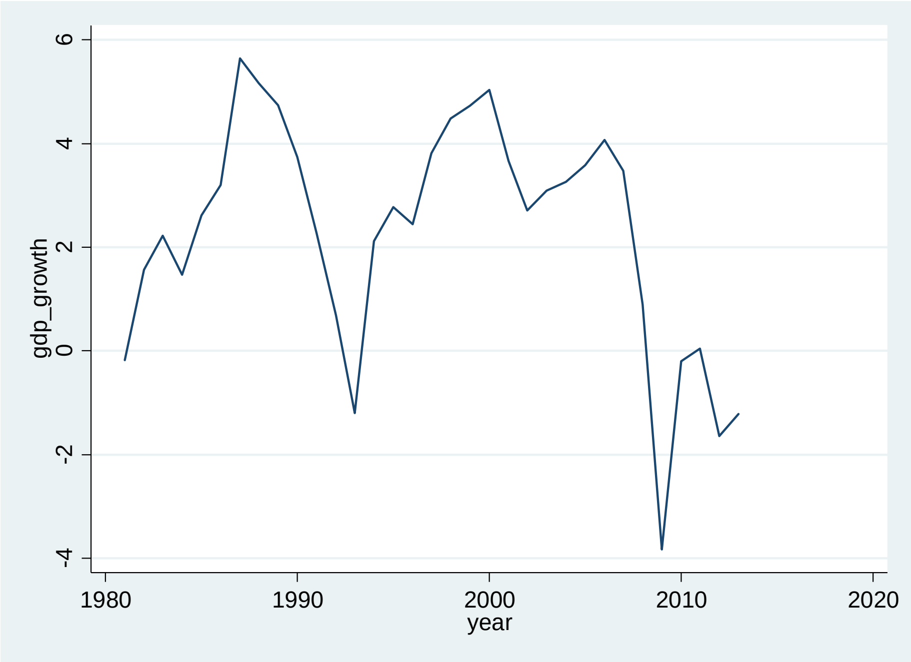

Table 1. Results of the Augmented Dickey-Fuller test (1/2)

Level of the series is I(1)	Unemployment rate							Gross Domestic Product						
		Trend and intercept			Intercept		None		Trend and intercept			Intercept		None
Region	lag	test	trend	int	test	int	test	lag	test	trend	int	test	int	test
Spain	0	-2.762	2.646	3.961	-2.745	3.777	-2.761	0	-2.535	2.652	3.970	-2.068	2.145	-1.450
Andalucía	0	-2.825	2.715	4.072	-2.849	4.058	-2.844	0	-3.266	4.074	6.111	-2.662	3.544	-1.838
Aragón	0	-3.163	3.615	5.420	-3.053	4.664	-3.078	0	-4.154	6.353	9.525	-3.372	5.692	-2.129
Asturias, Principado de	0	-4.389	6.538	9.805	-4.451	9.910	-4.440	0	-4.255	6.180	9.237	-3.782	7.184	-2.964
Balears, Illes	0	-3.481	4.057	6.059	-3.467	6.039	-3.491	0	-4.282	6.213	9.251	-2.793	3.954	-1.942
Canarias	0	-3.530	4.310	6.465	-3.636	6.609	-3.647	0	-3.354	3.841	5.739	-3.225	5.223	-2.742
Cantabria	0	-3.312	3.747	5.601	-3.252	5.308	-3.247	0	-3.591	4.381	6.567	-3.360	5.649	-2.476
Castilla - La Mancha	3	-3.639	4.456	6.683	-3.434	5.898	-3.504	0	-2.757	3.025	4.537	-2.337	2.732	-1.606
Castilla y León	0	-2.946	3.004	4.477	-2.929	4.319	-2.962	0	-2.779	2.643	3.925	-2.572	3.347	-2.078
Cataluña	0	-3.097	3.226	4.838	-3.000	4.501	-2.893	0	-6.263	14.656	21.914	-5.039	12.749	-3.110
Comunitat Valenciana	0	-3.251	3.849	5.755	-3.233	5.243	-3.284	0	-3.597	4.754	7.114	-3.353	5.639	-2.441
Extremadura	0	-5.049	8.500	12.749	-5.121	13.112	-5.087	0	-4.741	7.832	11.743	-3.904	7.623	-2.841
Galicia	0	-3.204	3.451	5.175	-3.263	5.325	-3.157	0	-3.465	4.098	6.128	-3.506	6.165	-2.599
Madrid, Comunidad de	0	-3.076	3.217	4.823	-3.065	4.698	-3.108	0	-2.814	2.976	4.449	-2.358	2.795	-1.609
Murcia, Región de	0	-3.090	3.242	4.858	-3.077	4.740	-3.067	0	-2.879	2.930	4.376	-2.810	3.967	-2.150
Navarra, Comunidad Foral de	0	-3.048	3.209	4.812	-2.881	4.152	-2.914	0	-3.713	4.662	6.947	-3.692	6.862	-2.813
País Vasco	0	-3.315	3.869	5.775	-3.421	5.882	-3.486	0	-2.895	2.916	4.338	-2.938	4.354	-2.470
Rioja, La	4	-4.403	6.794	10.132	-4.236	9.030	-4.339	0	-4.986	8.340	12.471	-4.666	10.924	-3.466

Highlighted cells indicate a rejection of the null hypothesis at the 0.05 significance level.

Table 1. Results of the Augmented Dickey-Fuller test (2/2)

Series' first difference is I(1)	Unemployment rate							Gross Domestic Product						
		Trend and intercept			Intercept		None		Trend and intercept			Intercept		None
	lag	test	trend	int	test	int	test	lag	test	trend	int	test	int	test
Spain	2	-3.519	4.138	6.194	-2.080	2.219	0.117	0	-5.500	10.150	15.215	-1.661	19.200	-5.776
Andalucía	0	-6.364	13.573	20.359	-1.182	1.176	-6.584	0	-7.044	16.790	25.125	-1.742	15.574	-6.183
Aragón	0	-6.001	12.066	18.039	-0.950	0.721	-6.180	0	-7.180	17.790	26.519	-1.844	17.263	-6.753
Asturias, Principado de	1	-7.346	18.041	27.053	-1.739	1.685	0.376	1	-7.732	19.941	29.905	-1.887	4.260	2.109
Balears, Illes	0	-5.973	11.924	17.876	-1.196	1.119	-6.183	0	-7.373	18.123	27.182	-4.119	40.778	-6.856
Canarias	4	-4.697	7.356	11.033	-1.781	1.593	-0.081	1	-5.572	10.355	15.525	-1.380	2.267	1.574
Cantabria	0	-6.306	13.321	19.981	-1.032	1.214	-6.519	3	-4.688	7.335	11.002	-1.382	1.927	1.335
Castilla - La Mancha	3	-4.471	6.733	10.097	-1.952	1.907	-0.171	0	-5.731	10.950	16.424	-1.419	15.285	-6.045
Castilla y León	0	-5.686	10.815	16.211	-1.275	1.367	-5.834	4	-3.743	4.754	7.114	-1.595	2.124	1.229
Cataluña	1	-6.619	14.714	22.048	-1.849	1.956	0.459	0	-9.106	28.711	42.655	-1.451	10.835	-7.647
Comunitat Valenciana	1	-5.918	11.689	17.534	-2.065	2.139	-0.100	0	-7.529	19.072	28.597	-1.050	8.688	-6.890
Extremadura	0	-10.443	36.519	54.734	-1.680	1.803	-10.770	1	-7.150	17.117	25.661	-2.632	6.995	2.368
Galicia	0	-7.278	17.688	26.514	-2.416	4.575	-7.487	0	-7.488	18.694	28.039	-0.598	11.119	-7.551
Madrid, Comunidad de	0	-6.926	16.041	24.060	-1.040	0.635	-7.161	1	-5.585	10.416	15.612	-1.917	3.388	1.637
Murcia, Región de	2	-3.631	4.454	6.677	-2.315	2.724	0.025	0	-7.777	20.171	30.248	-0.945	11.685	-7.412
Navarra, Comunidad Foral de	2	-4.253	6.045	9.066	-1.334	0.906	-0.052	0	-9.479	30.048	45.031	-1.049	11.299	-8.506
País Vasco	2	-3.392	3.842	5.753	-1.631	1.336	-0.327	4	-4.151	5.781	8.637	-1.524	3.071	1.874
Rioja, La	4	-3.603	4.688	7.032	-2.502	3.152	-0.089	3	-4.702	7.394	11.063	-1.480	2.672	1.688

Highlighted cells indicate a rejection of the null hypothesis at the 0.05 significance level.

In order to evaluate the relative forecasting accuracy of the models, for each province all models were estimated for two different periods: until 2001 and until 2007. This allows us to consider two different periods to assess the capacity of the model in terms of forecasting: a first period from 2002 to 2007 and a second period from 2008 to 2013. The first corresponds to a period of sustained economic growth in all provinces, while the second one is clearly a recessionary period. For the two periods, models are reestimated in each year and forecasts are computed. Given the availability of actual values, forecast errors for each province and method can be computed in a recursive way (i.e., for the 1 year forecast horizon, 6 forecast errors can be computed for each province and period). In order to summarise this information, the Mean Absolute Percentage Error (MAPE) [2] has been computed. Its values provide useful information in order to analyse the forecast accuracy of each method, so methods can be ranked according to their values. For the 2 year forecast horizon, the strategy has been similar as shown in table 2.

Before moving to the analysis of the results of the forecasting competition, and as preliminary evidence of the explanatory capacity of the Okun's law, Annex 2 provides summary evidence of the OLS HAC-robust estimates of the law for Spain and the 17 considered regions for the period 1980-2013 and for the two sample periods linked to our ex-post forecasting competition: 1980-2001 and 1980-2007. For the whole period, the law fits in 15 out of the 17 considered regions, with the exception of Extremadura and La Rioja. When reducing the sample period, GDP growth is not statistically significant in other four regions: Asturias, Balears, Canarias and Castilla-León. So, it seems that, in at least, six regions we should not expect a high forecasting performance of the Okun's law during the considered periods.

The results of the forecasting competition are shown in tables 3 and 4. In particular, the average values of the MAPE obtained from recursive forecasts for 1 and 2 years ahead for the different models and provinces are shown in these tables.

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[2] $MAPE = \frac{1}{T}\sum_{t=1}^{T}\frac{|UR_t - \hat{U}R_t|}{UR_t}\cdot 100$, where $\hat{U}R_t$ is the forecast of the unemployment rate for period t from the different forecasting techniques. According to the MAPE's value, it is usual in the literature to establish that a value below 3% indicates an excellent performance, a value between 3% and 5% a good performance and a value above 5% a bad forecasting performance.

The obtained results permit to conclude that, as expected, forecasts errors increase in the second period when compared to the first one. Regarding the forecast accuracy of the different methods, in most cases the fixed and the time varying coefficient specifications of the Okun's law are not outperformed by the rest of the methods, being the autoregressive model the one usually displaying the highest MAPE values. However, it is worth mentioning that, for most regions, the accuracy of the models is limited as the MAPE is usually above the 5% threshold. For instance, the values of the MAPE are clearly above the average in the three regions where the ADF test yielded some doubts about the validity of the specification (Asturias, Extremadura and La Rioja), so it is possible that in some regions forecasting accuracy could be improved if we deviate for the common specification assumed in this paper.

Table 2. 2 year-ahead recursive estimation and forecast

First period		Second period	
Estimation	Forecast	Estimation	Forecast
1980-2001	2002, 2003	1980-2007	2008, 2009
1981-2002	2003, 2004	1981-2008	2009, 2010
1982-2003	2004, 2005	1982-2009	2010, 2011
1983-2004	2005, 2006	1983-2010	2011, 2012
1984-2005	2006, 2007	1984-2011	2012, 2013
1985-2006	2007	1985-2012	2013

The results of our forecasting competition are shown in tables 3 and 4. In particular, the average values of the MAPE obtained from recursive forecasts for 1 and 2 years ahead for the different models and provinces are shown in these tables.

Table 3. 1 year ahead MAPE

	First period Estimation 1980-2001 / *ex-post* forecast 2002-2007				Second period Estimation 1980-2007 / *ex-post* forecast 2008-2013			
	Naive	Autoregressive	Okun (fixed)	Okun (variable)	Naive	Autoregressive	Okun (fixed)	Okun (variable)
Spain	7.25	12.34	5.86	8.25	16.63	17.32	5.81	7.99
Andalucía	8.52	10.67	6.83	8.26	15.37	14.07	6.02	7.95
Aragón	9.39	17.45	18.74	20.68	19.62	20.95	7.18	18.92
Asturias, Principado de	10.79	40.50	7.83	14.50	15.32	18.60	8.03	13.79
Balears, Illes	16.38	17.00	12.59	10.24	16.87	19.64	11.36	10.11
Canarias	4.51	6.64	3.44	5.50	16.34	21.46	9.67	4.85
Cantabria	13.50	14.56	10.11	11.92	17.82	18.63	10.40	10.40
Castilla - La Mancha	6.84	12.75	4.54	13.62	19.25	24.39	14.79	13.35
Castilla y León	9.11	10.86	6.00	9.82	16.44	15.31	8.57	8.46
Cataluña	11.31	14.43	10.15	11.83	17.65	22.27	5.92	12.62
Comunitat Valenciana	8.37	11.85	7.78	8.70	16.35	18.83	6.70	8.21
Extremadura	10.78	14.27	10.32	11.46	14.37	17.81	16.63	9.22
Galicia	14.24	14.52	11.29	15.20	15.94	13.97	7.20	15.61
Madrid, Comunidad de	3.72	12.92	8.39	9.34	16.50	16.99	7.66	10.71
Murcia, Región de	8.65	11.68	10.72	11.90	18.67	21.23	10.86	11.57
Navarra, Comunidad Foral de	7.05	11.58	9.38	11.26	19.11	21.18	11.64	10.11
País Vasco	9.24	14.12	8.65	11.03	15.64	24.82	7.20	12.85
Rioja, La	11.92	27.58	12.21	13.48	18.65	22.01	17.44	11.53
Average	9.53	15.32	9.16	11.50	17.03	19.42	9.62	11.01
Standard deviation	3.14	7.35	3.40	3.25	1.49	3.09	3.51	3.16

Table 4. 2 year ahead MAPE

	First period Estimation 1980-2001 / *ex-post* forecast 2002-2007				Second period Estimation 1980-2007 / *ex-post* forecast 2008-2013			
	Naive	Autoregressive	Okun (fixed)	Okun (variable)	Naive	Autoregressive	Okun (fixed)	Okun (variable)
Spain	12.26	12.84	10.12	5.76	23.49	18.98	9.42	5.17
Andalucía	14.42	10.67	16.35	6.12	21.48	14.66	8.58	5.37
Aragón	11.04	15.80	27.17	6.15	27.23	22.62	12.20	6.49
Asturias, Principado de	12.77	31.26	8.91	5.59	23.84	22.55	14.71	6.18
Balears, Illes	22.22	17.04	22.03	10.21	22.68	20.76	17.37	9.05
Canarias	7.72	5.62	9.30	7.72	21.78	20.69	13.85	6.54
Cantabria	19.93	14.92	22.11	3.33	25.69	22.00	19.82	3.05
Castilla - La Mancha	9.53	12.77	10.69	6.74	26.76	24.64	21.88	5.65
Castilla y León	13.20	10.84	15.34	12.93	23.01	17.05	13.10	12.17
Cataluña	18.26	14.59	17.27	6.02	25.21	23.99	8.77	5.50
Comunitat Valenciana	12.60	12.14	12.04	7.40	23.11	21.12	10.53	7.24
Extremadura	13.77	11.71	15.72	10.22	21.64	19.54	33.02	10.15
Galicia	19.40	15.79	20.68	6.45	23.74	18.05	13.35	6.45
Madrid, Comunidad de	6.81	11.65	15.58	8.17	23.02	19.48	12.43	7.99
Murcia, Región de	14.42	9.64	19.89	10.85	25.15	21.34	14.96	9.06
Navarra, Comunidad Foral de	9.24	9.15	20.40	11.66	26.51	22.73	19.39	11.21
País Vasco	12.65	12.13	7.18	6.60	22.65	26.79	6.60	6.53
Rioja, La	13.06	19.03	18.05	16.55	26.37	23.75	29.28	16.40
Average	13.52	13.76	16.05	8.25	24.08	21.15	15.51	7.79
Standard deviation	4.07	5.23	5.34	3.14	1.81	2.84	6.84	3.06

The obtained results permit to conclude that, as expected, forecasts errors increase in the second period when compared to the first one. Regarding the forecast accuracy of the different methods, in most cases the fixed and the time varying coefficient specifications of the Okun's law are not outperformed by the rest of the methods, being the autoregressive model the one usually displaying the highest MAPE values. However, it is worth mentioning that, for most regions, the accuracy of the models is limited as the MAPE is usually above the 5% threshold. For instance, the values of the MAPE are clearly above the average in the three regions where the ADF test yielded some doubts about the validity of the specification (Asturias, Extremadura and La Rioja), so it is possible that in some regions forecasting accuracy could be improved if we deviate for the common specification assumed in this paper.

Another issue that could be limiting the forecasting capacity of the models is the short time-span considered when working with annual data, particularly for the first period. Working with quarterly data will clearly expand the number of observations, but although regional quarterly unemployment rate are available from the Labour Force Survey, no similar information is available for regional GDP. However, and in order to check if the availability of quarterly data could improve the forecasting accuracy of the models, we have used Spanish quarterly series to re-specify and re-estimate the models and carry out a similar forecasting competition than before. Following a parallel approach to the one used for annual data, we consider two different estimation periods and recursive forecasts that are next used to check the ex-post forecasting accuracy of the model. For each of the two considered periods, now we have 21 4-quarter ahead forecasts and 17 8- quarters ahead forecast. As the specification used to estimate the models based on the Okun's curve imply the transformation of the data, two different possibilities are considered: the change between the current and the previous period and the change between the current and the same period of the previous year. Obtained results are shown in table 5. As we can see, the results from the forecasting competition are not substantially different when comparing the different models, but the MAPE values are now clearly lower and in several cases under 5%, suggesting a potential improvement of regional forecasts if quarterly data were available.

Table 5. 4 and 8 quarters ahead MAPE – Quarterly Spanish unemployment rate

4-quarters ahead forecast – Spain 21 recursive forecasts	First period Estimation 1980-2001 / *ex-post* forecast 2002-2007				Second period Estimation 1980-2007 / *ex-post* forecast 2008-2013			
	Naive	Autoregressive	Okun (fixed)	Okun (variable)	Naive	Autoregressive	Okun (fixed)	Okun (variable)
Change from previous quarter	4.12	3.56	4.09	3.89	5.00	4.14	4.96	4.83
Change from same quarter from previous year	11.36	7.05	8.39	6.58	17.29	9.54	5.50	5.19

8-quarters ahead forecast – Spain 17 recursive forecasts	First period Estimation 1980-2001 / *ex-post* forecast 2002-2007				Second period Estimation 1980-2007 / *ex-post* forecast 2008-2013			
	Naive	Autoregressive	Okun (fixed)	Okun (variable)	Naive	Autoregressive	Okun (fixed)	Okun (variable)
Change from previous quarter	3.84	3.71	3.78	3.96	4.45	3.84	4.41	4.31
Change from same quarter from previous year	9.82	8.49	7.33	7.41	16.23	12.94	4.96	5.28

5. Concluding remarks

The objective of the paper was to analyse the possibility of improving the forecasts for regional unemployment rates in Spain using a time-varying coefficient specification of the Okun's law. With this aim, we have carried out a forecasting competition in two time periods characterized by different macroeconomic conditions. The obtained results allow us to conclude that, in general, the consideration of models based on the Okun's law improve the forecasting performance in nearly all regions, particularly when the time-varying coefficient specification is used. However, the accuracy of the models is not good enough to provide reliable forecasts in real-time forecasting exercises for Spanish regions although our analysis of Spanish quarterly data suggests that, in case, quarterly regional GDP data were available, the forecasting capacity could probably increase.

6. References

Adanu, K. (2005): "A cross-province comparison of Okun's coefficient for Canada", *Applied Economics*, 37 (5), pp. 561-570.

Apergis, N., Rezitis, A. (2003): "An examination of Okun's law: Evidence from regional areas in Greece", *Applied Economics*, 35 (10), pp. 1147-1151.

Ball, L., Jalles, J.T., Loungani, P. (2014): "Do forecasters believe in Okun's Law? An assessment of unemployment and output forecasts", *International Journal of Forecasting*, forthcoming.

Ballesteros Gallardo, J. A., Núñez Hernández, F., Usabiaga Ibáñez, C. (2012): *La Ley Okun para las regiones españolas: Distintas aproximaciones econométricas*, Instituto de Estadística y Cartografía de Andalucía, Documentos de Trabajo 4/2012.

Chinn, M.D., Ferrara, L. and Mignon, V. (2013): *Post-recession us employment through the lens of a non-linear Okun's law*, National Bureau of Economic Research, Working Paper 19047.

Christopoulos, D. K. (2004): “The relationship between output and unemployment: Evidence from Greek regions”, *Papers in Regional Science*, 83 (3), pp. 611-620.

Durech, R., Minea, A., Mustea, L., Slusna, L. (2014): “Regional evidence on Okun's law in Czech Republic and Slovakia”, *Economic Modelling*, 42, pp. 57-65.

Dziechciarz, J. (1989): *Changing and random coefficient models. A survey*. In Hackl, P. (ed.), *Seasonal Analysis and Forecasting of Economic Structural Change*, Springer Verlag, Berlin.

Elliott, G., Timmermann, A. (2008): “Economic forecasting”, *Journal of Economic Literature*, 46 (1), pp. 3-56.

Engle, R.F., Watson, M.W. (1987): “The Kalman filter: applications to forecasting and rational-expectations models” in Bewley, T.F. (ed.), *Advances in Econometrics: Fifth World Congress*, Econometric Society Monograph, vol. 13, Cambridge University Press: Cambridge, pp. 245-283.

Franses, P.H., Mcaleer, M., Legerstee, R. (2014): “Evaluating macroeconomic forecasts: A concise review of some recent developments”, *Journal of Economic Surveys*, 28 (2), pp. 195-208.

Freeman, D.G. (2000): “Regional tests of Okun's law”, *International Advances in Economic Research*, 6 (3), pp. 557-570.

Funke, M. (1992): Time-Series Forecasting of the German Unemployment Rate, *Journal of Forecasting*, 11, pp. 111-125.

Guisinger, A.Y., Sinclair, T.M. (2014): Okun's Law in real time, *International Journal of Forecasting*, forthcoming.

Huang, H.C., Yeh, C.C. (2013): “Okun's law in panels of countries and states”, *Applied Economics*, 45 (2), pp. 191-199.

Kangasharju, A., Tavera C., Nijkamp, P. (2012), “Regional Growth and Unemployment: The Validity of Okun's Law for the Finnish Regions”, *Spatial Economic Analysis*, 7 (3), pp. 381-395.

Karfakis, C., Katrakilidis, C., Tsanana, E. (2014), “Does Output Predict Unemployment? A Look at Okun's Law in Greece”, *International Labour Review*, forthcoming.

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

Lopez-Bazo, E., del Barrio, T.; Artís, M. (2005): “Geographical distribution of unemployment in Spain”, *Regional Studies*, 39(3), pp. 305-318.

Marie-Estelle, B., Facchini, F. (2013): “Okun's law in the French regions: A cross-regional comparison”, *Economics Bulletin*, 33 (1), pp. 420-433.

Martín-Román, A., Sylvina-Porras, M. (2012): *La ley de Okun en España ¿por qué existen diferencias regionales?*, Reunion de Estudios Regionales, Bilbao.

Min, C., Zellner; A. (1993): “Bayesian and non-bayesian methods for combining models and forecasts with applications to forecasting international growth rates, *Journal of Econometrics*, 56, pp. 89-118.

Okun, A. M. (1962): “Potential GNP: Its Measurement and Significance”, *Proceedings of the Business and Economic Statistics Section*, American Statistical Association, pp. 98-104.

Pereira, R.M. (2014): “Okun's law, asymmetries and regional spillovers: Evidence from Virginia metropolitan statistical areas and the District of Columbia”, *Annals of Regional Science*, 52 (2), pp. 583-595.

Ramos, R., Clar, M., Suriñach, J. (2000): “Comparación de la capacidad predictiva de los modelos de coeficientes fijos frente a variables en los modelos econométricos regionales: un análisis para Cataluña”, *Estudios de Economía Aplicada*, 15, pp. 125-162.

Rothman, P. (1998): Forecasting Asymmetric Unemployment Rates, *Review of Economics and Statistics* 80, pp. 164-168.

Shively, T., Kohn, R. (1997): “A bayesian approach to model selection in stochastic coefficient regression models and structural time series models”, *Journal of Econometrics*, 76, pp. 39-52.

Villaverde, J., Maza, A. (2007): “Okun's law in the Spanish regions”, *Economics Bulletin*, 18 (5).

Villaverde, J., Maza, A. (2009): “The robustness of Okun's law in Spain, 1980–2004: Regional evidence”, *Journal of Policy Modelling*, 31 (2), pp. 289-297.

ANNEX 1. Summary results of the Clemente-Montañés-Reyes double structural change test for Unit Root. AO and IO Models. Spain.

Figure A.1. Change in the unemployment rate

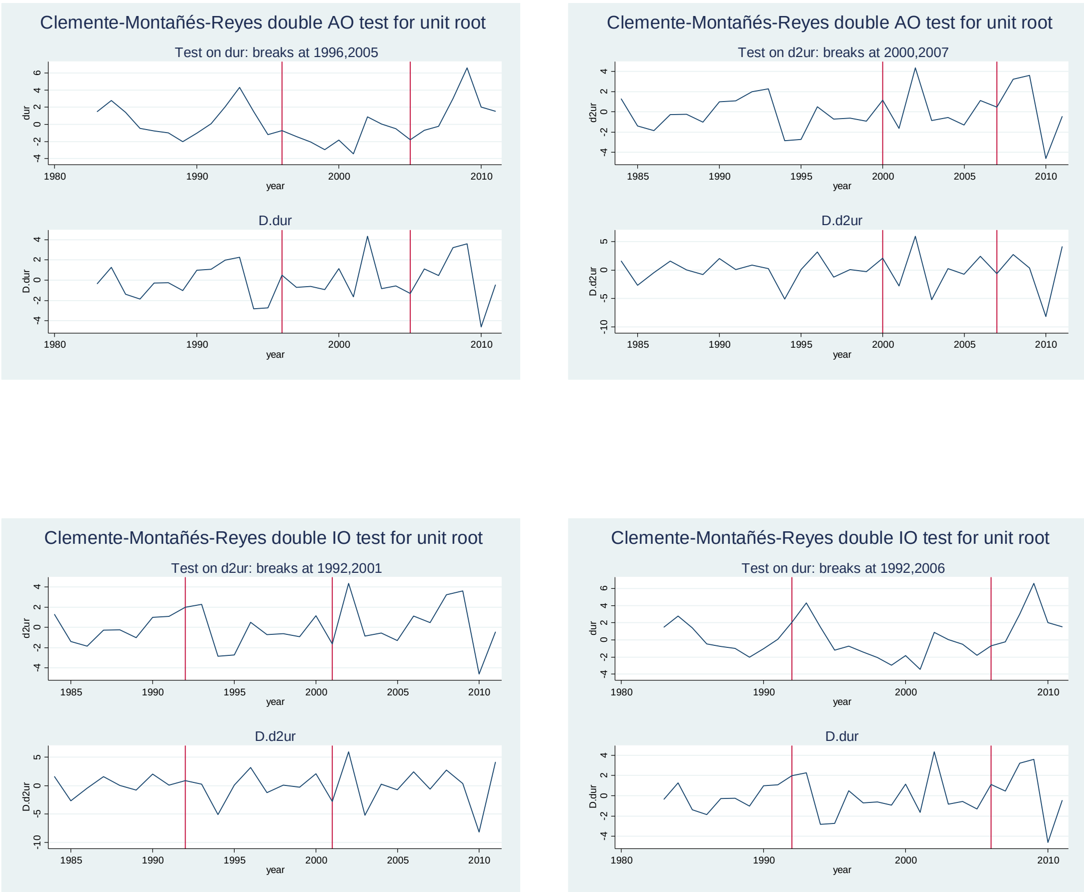
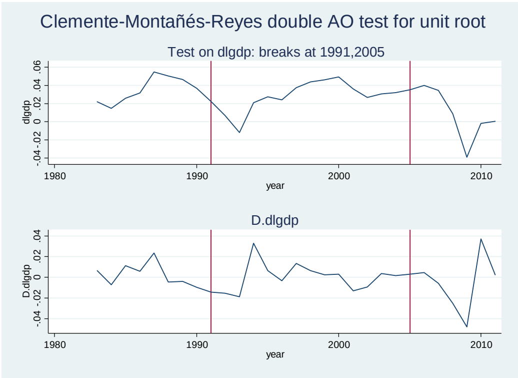
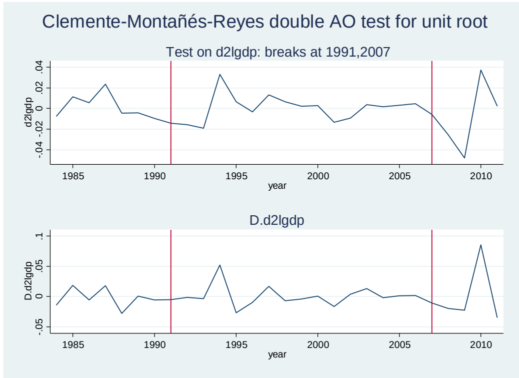
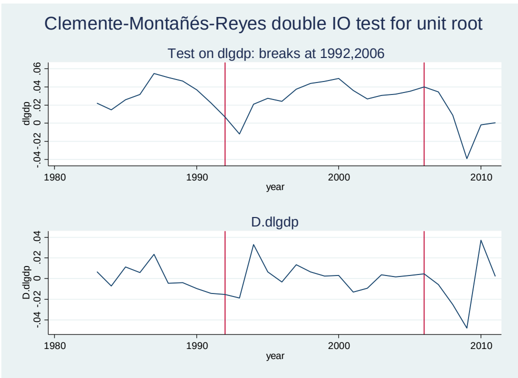
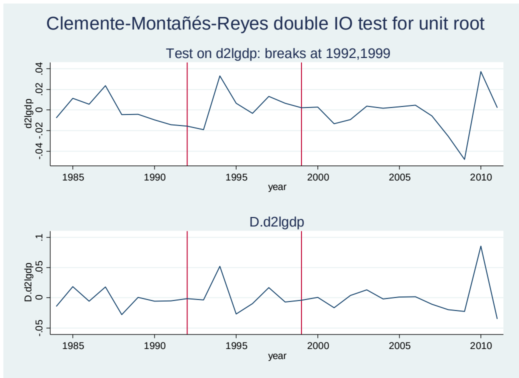


Figure A.2. GDP growth









ANNEX 2. Estimates of the Okun's law (1/2)

Period	Variable	Spain	Andalucía	Aragón	Asturias	Balears, Illes	Canarias	Cantabria	Castilla - La Mancha	Castilla y León	Cataluña
1980-2013	GDP growth	-0.875***	-0.822***	-0.627***	-0.552***	-0.576***	-0.719***	-0.380**	-0.482**	-0.399***	-0.938***
		[0.0872]	[0.116]	[0.104]	[0.151]	[0.172]	[0.151]	[0.181]	[0.193]	[0.0835]	[0.107]
	Constant	2.439***	2.547***	1.859***	1.414***	2.095***	2.371***	1.091***	1.552***	1.231***	2.409***
		[0.270]	[0.423]	[0.334]	[0.295]	[0.648]	[0.473]	[0.356]	[0.556]	[0.299]	[0.322]
	Observations	33	33	33	33	33	33	33	33	33	33
	R-squared	0.778	0.577	0.502	0.273	0.374	0.591	0.247	0.274	0.426	0.761
1980-2001	GDP growth	-0.986***	-0.770***	-0.601***	-0.401	-0.488	-0.547***	-0.253	-0.128	-0.328**	-1.016***
		[0.121]	[0.174]	[0.177]	[0.269]	[0.326]	[0.144]	[0.193]	[0.111]	[0.132]	[0.145]
	Constant	2.820***	2.457***	1.552**	0.858	1.884	1.664***	0.689	0.350	0.822	2.801***
		[0.319]	[0.719]	[0.629]	[0.581]	[1.528]	[0.517]	[0.549]	[0.372]	[0.530]	[0.453]
	Observations	21	21	21	21	21	21	21	21	21	21
	R-squared	0.735	0.424	0.355	0.093	0.169	0.477	0.110	0.033	0.278	0.752
1980-2007	GDP growth	-0.988***	-0.784***	-0.564***	-0.403	-0.481*	-0.546***	-0.264	-0.137	-0.326**	-1.023***
		[0.112]	[0.174]	[0.159]	[0.237]	[0.248]	[0.142]	[0.195]	[0.104]	[0.121]	[0.143]
	Constant	2.851***	2.378***	1.604**	0.955*	1.747	1.645***	0.607	0.333	0.835	2.787***
		[0.310]	[0.700]	[0.605]	[0.545]	[1.048]	[0.465]	[0.506]	[0.337]	[0.511]	[0.438]
	Observations	27	27	27	27	27	27	27	27	27	27
	R-squared	0.724	0.411	0.320	0.094	0.189	0.470	0.112	0.038	0.280	0.717

Estimates of the Okun's law (2/2)

Period	Variable	Comunitat Valenciana	Extremadura	Galicia	Madrid	Murcia, Región de	Navarra	País Vasco	Rioja, La
1980-2013	GDP growth	-0.822***	-0.0303	-0.539***	-0.668***	-0.688***	-0.414***	-0.646***	-0.146
		[0.0957]	[0.340]	[0.122]	[0.112]	[0.107]	[0.0707]	[0.0741]	[0.0963]
	Constant	2.410***	0.649	1.470***	2.088***	2.259***	1.126***	1.195***	0.857
		[0.347]	[0.871]	[0.329]	[0.368]	[0.418]	[0.298]	[0.262]	[0.534]
	Observations	33	33	33	33	33	33	33	33
	R-squared	0.704	0.001	0.384	0.596	0.596	0.485	0.642	0.056
1980-2001	GDP growth	-0.896***	0.270	-0.407**	-0.738***	-0.669***	-0.317***	-0.613***	-0.0129
		[0.130]	[0.318]	[0.172]	[0.176]	[0.144]	[0.0747]	[0.0928]	[0.0949]
	Constant	2.722***	-0.927	1.052**	2.380***	2.010***	0.530	1.103**	0.00735
		[0.494]	[1.132]	[0.480]	[0.638]	[0.570]	[0.413]	[0.397]	[0.663]
	Observations	21	21	21	21	21	21	21	21
	R-squared	0.629	0.092	0.204	0.536	0.542	0.346	0.562	0.000
1980-2007	GDP growth	-0.896***	0.266	-0.437**	-0.718***	-0.651***	-0.314***	-0.611***	-0.0239
		[0.126]	[0.318]	[0.161]	[0.165]	[0.134]	[0.0729]	[0.0925]	[0.0930]
	Constant	2.750***	-0.971	1.097**	2.323***	2.041***	0.629*	1.104***	0.104
		[0.458]	[1.099]	[0.484]	[0.593]	[0.551]	[0.367]	[0.357]	[0.581]
	Observations	27	27	27	27	27	27	27	27
	R-squared	0.617	0.079	0.219	0.521	0.515	0.329	0.547	0.001