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Regional asymmetric shocks in Spain: an State Space approach*

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Abstract

Given the constraints imposed by EMU membership, the nature of potential shocks impinging on a set of countries or regions may have important implications for relevant aspects of economic policy. This paper addresses the shocks issue empirically by applying the State Space methodology and the Kalman Filter to the case of the Spanish regions. The main conclusions are as follows: it seems that the shocks affecting the Spanish regions have been mostly symmetric; their effects have been persistent rather than transitory; supply shocks have been slightly more frequent that demand shocks.

Keywords: shocks, State Space models, Kalman filter.

JEL codes: R11, E5

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1. INTRODUCTION

One of the main issues covered by the recent literature on EMU is the nature of potential shocks and how these impinge on member states. As Bayoumi and Eichengreen (1997) indicate "*The most important of the characteristics which make stable exchange rates and monetary unification more or less desirable are asymmetric disturbances*......". In effect, if the probability of asymmetric shocks hitting the various areas is high, the loss of monetary policy as an adjustment instrument at the country level could be very serious. This may also have important implications for the integration process.

In the context of a currency union, an asymmetric shock can be defined as a shock affecting a particular country in a different way than to other member states of the union[1]. Then, asymmetric shocks may pose a significant problem when an autonomous monetary policy is unavailable to offset the negative effects of these shocks. However**,** there are other aspects that are also relevant when assessing the potential impact of a shock: mainly its degree of persistence (permanent or transitory) and its origin (demand or supply driven).

An abundant number of studies have analyzed empirically the symmetric or asymmetric nature of shocks[2]. The bulk of this literature has been developed

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[1] There are other alternative definitions but the basic notion is the same. See, for example, Patterson and Amati (1998).

[2] It is important to keep in mind, however, that there is not a direct form to know whether a shock is symmetric or asymmetric. Therefore, research on this area has to use indirect indicators that, in

within the framework of EMU, making use of different methodologies**.** Some authors (Fatás, 1997) have tried to ascertain whether a particular shock is symmetric or asymmetric by means of looking at the fluctuations of relevant economic variables. A different approach, pioneered by Cohen and Wyplosz (1989), is based upon the adjustment of a trend to some relevant economic series to ascertain the nature of the shock. Finally, VAR analysis also offers a potential avenue of research for this issue (see, e.g. Blanchard and Quah (1989)).

The aim of this paper is to make a contribution to this literature by examining the probability that Spanish regions be affected by asymmetric shocks. The paper also examines the issue of the persistence and origin of both symmetric and asymmetric shocks. The methodology pursued is none of the aforementioned but a new, more promising one: the State Space representation and the application of the Kalman filter. This methodology not only overcomes the drawbacks present in the previous methodologies but allows to identify the origin (demand or supply) of the shock as well as to examine whether a common shock has similar or dissimilar effects on various regions. In fact the State Space approach, which can be used in very different contexts, is an exceptionally powerful tool that opens the way to handling a wide range of time series models.

The structure of the paper is the following. Section 2 describes and estimates the empirical model that we use to disentangle common and asymmetric shocks to production and prices. Section 3 explores the potential asymmetric effects of

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turn, capture at the same time the effect of the shock and the response to the shock (De Grauwe and Vanhaverbeke, 1993; Bayoumi and Eichengreen, 1993).

common disturbances and Section 4 analyses the possible symmetric impact of specific shocks. Section 5 concludes.

2. – THE NATURE OF SHOCKS: AN EMPIRICAL ANALYSIS OF THE SPANISH REGIONS

In this section we apply the State Space methodology to the Spanish regions[3] (Figure 1) using homogeneous data on output (GAV in million of 1986 pesetas) and prices (implicit GAV price deflator). These data, as derived from the Fundación BBVA, cover the period 1955-1997.

2.1.- The State Space model[4]

Following Jansson (1997), we design a State Space model that analyses the output and prices fluctuations in the Spanish regions. These series have been detrended by means of differentiating their log values[5] to make them stationary.

We denote by X_{it} the vector of output (y) and prices (p) series for the region *i* in period *t* once the trend has been removed. Next, these series are disentangled in two non-observable components: the first one (X_t^C) is common for all regions and the second (X_{it}^E) is specific for each region. Analytically, the measure equation is

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[3] This methodology can also be applied to the EU or EMU regions. However, we apply it to the Spanish case because this methodology requires the use of long time series.

[4] Model diagnosis is showed in the appendix.

$$X_{it} = \gamma_i X_t^C + X_{it}^E \tag{1}$$

where γ_i reflects the impact of a common shock in region *i*. Under certain assumptions (in particular, that they are independent and that their behaviour is known) X_t^C and X_{it}^E can be estimated. Moreover, we subject equation (1) to stochastic shocks. Thus, it is assumed that the non-observable components follow a first order autoregressive process described by the following transition equations:

$$\begin{aligned} X_t^C &= \alpha X_{t-1}^C + \varepsilon_t^C \\ X_{it}^E &= \beta_i X_{it-1}^E + \varepsilon_{it}^E \end{aligned} \tag{2}$$

where ε_t^C and ε_{it}^E represent the common and specific shocks respectively. It seems reasonable to assume that the common component captures the symmetric shocks, whereas the region specific component reflects the asymmetric shocks. Nevertheless, this assumption will be relaxed in the next sections.

It is also assumed that the shocks follow a normal distribution, with zero mean and constant variance. Asymmetric shocks are uncorrelated among themselves ($\mathrm{Cov}(\varepsilon_{it}^E, \varepsilon_{jt}^E)$ = 0 for all $i \neq j$) and with symmetric shocks ($\mathrm{Cov}(\varepsilon_{it}^E, \varepsilon_t^C)$ = 0 for all i).

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[5] More specifically, the series employed are $X_{it} = \left[\Delta \log(GAV_{it}) - \mathrm{E}\left(\Delta \log(GAV_{it})\right)\right]$ and $X_{it} = \left[\Delta^2 \log(P_{it}) - \mathrm{E}\left(\Delta^2 \log(P_{it})\right)\right]$ for the GAV and price index P, respectively, where Δ is the lag operator and E is the expected value operator.

Once the State Space model has been specified, the next step is to apply the Kalman filter in order to estimate its parameters[6]. This is a recursive procedure for computing the optimal estimator of the non-observable components in period *t*, based upon information available in that same period.

Thus, the estimation of this model allows to identify the type of shock impinging upon the economy. First, as regards persistence, it is known that the values of the parameters associated to the lags of the dependent variable in equation (2) provide information on the degree of persistence of a disturbance. Since the process is AR(1), the closer to unity the parameter associated to the first lag, the more persistent the shocks.

Moreover, in order to ascertain the importance of common (or symmetric) and specific (or asymmetric) shocks, the variance of the original series has been decomposed as follows:

$$\mathrm{Var}(\mathrm{X}_{\mathrm{it}}) = \gamma_{\mathrm{i}}^{2}\mathrm{Var}(\mathrm{X}_{\mathrm{t}}^{\mathrm{C}}) + \mathrm{Var}(\mathrm{X}_{\mathrm{it}}^{\mathrm{E}}) \tag{3}$$

where

$$\begin{aligned}\mathrm{Var}(\mathrm{X}_{\mathrm{t}}^{\mathrm{C}}) &= \mathrm{Var}(\varepsilon_{\mathrm{t}}^{\mathrm{C}}) + \alpha\,\mathrm{Cov}(\mathrm{X}_{\mathrm{t}}^{\mathrm{C}}, \mathrm{X}_{\mathrm{t-1}}^{\mathrm{C}})\\ \mathrm{Var}(\mathrm{X}_{\mathrm{it}}^{\mathrm{E}}) &= \mathrm{Var}(\varepsilon_{\mathrm{it}}^{\mathrm{E}}) + \beta_{\mathrm{i}}\,\mathrm{Cov}(\mathrm{X}_{\mathrm{it}}^{\mathrm{E}}, \mathrm{X}_{\mathrm{it-1}}^{\mathrm{E}})\end{aligned} \tag{4}$$

By applying this decomposition, the percentage of the changes in X_{it} that is explained by symmetric and asymmetric shocks can be computed.

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[6] For a thorough reference of this type of analysis, see Harvey (1989) or Hamilton (1994).

We still have to identify demand shocks and supply shocks. The model itself does not provide an answer to this question, but some information can be ascertained by examining the error terms. In particular, it is possible to disentangle the disturbances into demand and supply shocks as follows. For the level of output the expressions are:

$$\begin{aligned} \varepsilon_t^C(y) &= \alpha^y D_t^C + \beta^y S_t^C \\ \varepsilon_{it}^E(y) &= \delta_i^y D_{it}^E + \gamma_i^y S_{it}^E \end{aligned} \qquad (5)$$

and for the price level:

$$\begin{aligned} \varepsilon_t^C(p) &= \alpha^p D_t^C + \beta^p S_t^C \\ \varepsilon_{it}^E(p) &= \delta_i^p D_{it}^E + \gamma_i^p S_{it}^E \end{aligned} \qquad (5')$$

where $D_t^C\,(D_{it}^E)$ represent the symmetric (asymmetric) demand shocks and $S_t^C\,(S_{it}^E)$ represent the symmetric (asymmetric) supply disturbances. Since these shocks are structural, the $\mathrm{Cov}\,(Z_t, Y_t)$ is equal to zero for all $Z_t \neq Y_t$, where $Z_t, Y_t = D_t^C,\, D_{it}^E,\, S_t^C,\, S_{it}^E$.

To identify these shocks it is assumed that the sign of the impact of the demand shocks is the same for output and prices, whereas supply shocks have opposite effects on these variables. Thus, the sign of the parameters can be determined. As for an output shock, either demand or supply driven, has the same effect, it can be said that $\alpha^y, \delta_i^y > 0; \beta^y, \gamma_i^y > 0$. However, as for the price level, supply and demand shocks have opposite effects, it happens that if $\alpha^p, \delta_i^p > 0$, then $\beta^p, \gamma_i^p < 0$. Subsequently, it is easily seen that, since

$$\begin{aligned} &\mathrm{Cov}(\varepsilon_t^C(y), \varepsilon_t^C(p)) = \alpha^y \alpha^p \mathrm{Var}(D_t^C) + \beta^y \beta^p \mathrm{Var}(S_t^C) \\ &\mathrm{Cov}(\varepsilon_{it}^E(y), \varepsilon_{it}^E(p)) = \delta_i^y \delta_i^p \mathrm{Var}(D_{it}^E) + \gamma_i^y \gamma_i^p \mathrm{Var}(S_{it}^E) \end{aligned} \quad (6)$$

the sign of the correlation coefficient between the estimated error terms gives information on the importance of supply and demand shocks. A positive (negative) sign indicates that demand (supply) shocks are predominant.

2.2. - Main results

The results obtained in equations (1) and (2) are displayed in Table 1. The first two columns show how the common component affects fluctuations in output and prices in all regions –equation (1). The results have been normalized and the sensitivity of output and prices fluctuations relative to the common component of Madrid has been set to one. This means that if the coefficient for a particular region is larger (lower) than one, that region is more (less) vulnerable to common shocks than Madrid. Values in parenthesis are the p-values, computed by means of the likelihood ratio test (Harvey, 1990). They can be interpreted, under the null hypothesis, as the probability of a region not being influenced by the common component.

The main results provide evidence that changes in the common coefficient affect all regions. The point estimates of the coefficients are by and large close to one, and they are significant in all cases. However, it seems that some regions react in quite a different way to this kind of shock. This aspect will be further discussed in the next section.

The rest of the columns of Table 1 show the degree of persistence of a shock – equation (2). Recall that, the closer the coefficient is to one in absolute terms, the more persistent is the shock. If the coefficient is zero, then the shock may be regarded as purely transitory. The results show that the impact of symmetric shocks[7] are quite persistent on output and less on prices. On the other hand, the findings are less homogeneous as far as asymmetric shocks are considered. It can also be seen that these asymmetric shocks are more persistent on output than on prices. For output, the probability of these shocks been fully transitory is especially small for País Vasco, Canarias and Asturias, whereas Castilla-León and Cantabria are in the opposite case. In terms of prices, Madrid shows the highest level of persistence, followed by Cantabria and Castilla-La Mancha. Again, the converse is true for Aragón and the País Vasco, where the probability of these shocks been fully transitory is higher that 90%. Generally speaking, it can be concluded that there is no apparent spatial pattern on the persistence of asymmetric shocks.

Table 2 summarizes changes in output and prices by employing the variance decomposition technique described above –equations (3) and (4). The table also presents a ranking of the regions, being Comunidad Valenciana (for output) and Cataluña (for prices) with the label 1 the regions with the smallest probability of being hit by an asymmetric disturbance. It can be seen that symmetric shocks are more important in the majority of regions than asymmetric shocks (Figures 2 and 3). This is especially the case for prices -which is clearly important in relation to competitiveness and the cost structure of firms. Regions where asymmetric shocks

[7] Shocks in the common component.

are less relevant are Comunidad Valenciana, Cataluña and Aragón (for output) and Cataluña, Comunidad Valenciana, Madrid, Murcia and Aragón (for prices). However, in some specific regions asymmetric shocks play a prominent role: in particular, Asturias (both for output and prices) and Extremadura (for output). On the whole, two conclusions can be obtained. First, asymmetric shocks are less important in the eastern, more advanced regions of Spain than in the rest of the country. On the contrary, asymmetric shocks are more relevant in some regions in which the industrial mix is very different to the national average.

Finally, we consider whether the disturbances are demand or supply driven by examining the correlations among the shocks in output and prices –equation (6). The main outcomes are presented in Table 3. The first one is that in most cases the coefficient is not statistically significant, meaning that there is no clear pattern as to the origin of the shock. However, in that cases where the coefficients are statistically different from zero, supply shocks seem to have been relatively more important than demand shocks. Andalucía exhibits the highest negative correlation (-0,67), followed by the País Vasco, Castilla-León and Madrid. Regions that have been hit by demand shocks are Extremadura and Comunidad Valenciana.

3. - COMMON SHOCKS AND ASYMMETRIC EFFECTS

Up to now, we have assumed that common shocks produce symmetric effects, thus they have been considered tantamount to symmetric shocks. It could be possible, however, that a common shock had similar (symmetric) effects in some regions and a different (asymmetric) impact in others (see, e.g. Blanchard and

Wolfers, 1999). This would be the case if, for example, the industry mix is dissimilar among regions**.** We address this issue in this section.

Accordingly, we examine if a common shock may behave as an asymmetric disturbance. To do that, we repeat the exercise as in the previous section, but now imposing the same coefficient associated to the common component of the shock for all regions[8]. In analytical terms, the following measure equation is estimated:

$$X_{it} = \gamma X_t^C + X_{it}^E \qquad (7)$$

where the γ coefficient captures the average response of the country to this type of shock. Once this coefficient is estimated, the potential asymmetric effects of a common shock can be approximated by computing the probability of each region responding in an identical way as the country. In other words, the model is estimated under the null hypothesis that the coefficient for each region (γ_i) is the same as the national coefficient (γ). High p–values mean that the probability of a common shock having an asymmetric impact will be low.

Estimates of equation (7) are displayed in Table 4 (to make results comparable with those obtained previously, the coefficient of Madrid is considered again equal to 1). The estimated output coefficient is 1.20. Thus, the common component has a decisive influence in the output fluctuations, because the probability of this coefficient being zero is null. As far as the price level is concerned, Table 4 shows that the coefficient on the common component is

[8] This generalization increases the proportion of variance attributable to common rather than regional shocks. For reasons of clarity, these results are omitted.

estimated to be 0.79 and highly significant. On the other hand, the results on the persistence of shocks, both for output and prices do not differ to a great extent from those obtained in the previous section.

Now, in order to approximate the probability of a common shock having different effects on the Spanish regions we compare the response of each region to that obtained for the country as a whole. The results are given in Table 5.

The first column of the table shows that the response of output is very different in Asturias compared to the rest of the Spanish regions. Other regions reacting somewhat differently from the national norm are Cataluña, Extremadura, Castilla-León and Comunidad Valenciana. The opposite holds true for the País Vasco, Castilla-La Mancha and Canarias; the probability of the response of these three regions being identical to national is large. The second column of Table 5 shows that, in terms of prices, regions such as Canarias, Cataluña, Cantabria and Andalucía react quite differently to the nation. On the contrary, the sensitivity of Aragón, Extremadura and Castilla-León to the common component is analogous to the national one. Once again, a clear spatial pattern emerges neither on output nor on prices.

Finally, when both variables are considered at the same time, it can not be rejected the null hypothesis –at the 5% significance level- of common shocks having symmetric effects in most Spanish regions (apart from Canarias for prices).

4. - SPECIFIC SHOCKS AND SYMMETRIC EFFECTS

In Section 2 the fluctuations experienced by each one of the Spanish regions was disentangled into common and specific shocks. At that point we identified specific shocks with asymmetric disturbances. However, following Karras (1996) it can be inquired whether specific shocks do, or do not, behave in practice as asymmetric shocks. In effect, it could be the case that specific shocks in certain regions were highly correlated and, in this case, they would behave as symmetric disturbances. Accordingly, we have computed the correlation coefficient among specific shocks of the 17 Spanish regions, taken on a two by two basis. Results are displayed in Tables 6 for output and 7 for prices.

As regards output, there are a remarkable number of coefficients that are significantly different from zero. However, there is not enough evidence to conclude the specific shocks have asymmetric effects. It can be pointed out, though, that some regions seem to suffer disturbances that are not in line with that observed in the rest of the country (e.g. Comunidad Valenciana displays negative signs of the correlation coefficients).

As far as prices are concerned (Table 7) the findings show that a larger number of correlation coefficients than for output are significant. Moreover, negative signs are relatively more abundant. Hence it could be tentatively concluded that specific shocks seem to be asymmetric. In particular, Castilla-La Mancha is the region in which shocks appear to be more asymmetric: for this region, the correlation coefficient is negative and significant in eight cases.

6. - CONCLUDING REMARKS

This paper has tried to ascertain whether the probability of Spanish regions experiencing asymmetric shocks is high. Additionally, it has analysed the persistence and the origin of both symmetric and asymmetric shocks. To do that, we have applied a new methodology, rich enough as to offer interesting insights on this issue. According to our estimates, the basic findings of the paper can be summarized as follows: the shocks that have impinged Spanish regions between 1955 and 1997 have been mostly symmetric (less on output than on prices), persistent (less on prices than on output) and more driven by supply than demand factors.

Two possible extensions of the paper seem to be indicated. On the one hand, the estimation methodology can be applied to other cases, mainly to the European regional one. On the other hand, the paper could be extended to evaluate the ability of the Spanish regions to respond to different types of shocks.

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APPENDIX: MODEL DIAGNOSIS

In this Appendix the statistical properties of the model are covered in more detail as regards normality, serial correlation, homocedasticity and stability of parameters. Table A1 displays the main results. Generally speaking, these results suggest that the model is correctly specified.

Figure 1
THE SPANISH REGIONS

Table 1
SHOCKS PERSISTENCE

Regions	Sensitivity to the common component γ_i		Persistence of symmetric shocks α		Persistence of asymmetric shocks β_i	
	Output	**Prices**	**Output**	**Prices**	**Output**	**Prices**
Andalucía	1.11 (0)	0.93 (0)	0.76 (0)	0.44 (0.0165)	0.54 (0.0157)	0.31 (0.1680)
Aragón	1.34 (0)	0.79 (0)	0.76 (0)	0.44 (0.0165)	0.55 (0.0956)	0.02 (0.9356)
Asturias	0.72 (0.0039)	0.61 (0.0007)	0.76 (0)	0.44 (0.0165)	0.63 (0.0005)	0.25 (0.2402)
Baleares	1.23 (0)	0.99 (0)	0.76 (0)	0.44 (0.0165)	0.60 (0.0015)	-0.07 (0.7440)
Canarias	1.22 (0)	1.01 (0)	0.76 (0)	0.44 (0.0165)	0.66 (0.0003)	0.10 (0.6415)
Cantabria	1.25 (0)	0.70 (0)	0.76 (0)	0.44 (0.0165)	0.33 (0.1074)	0.35 (0.1084)
Castilla-León	0.91 (0)	0.79 (0)	0.76 (0)	0.44 (0.0165)	0.38 (0.1527)	0.16 (0.4076)
Castilla-La Mancha	1.18 (0)	0.70 (0)	0.76 (0)	0.44 (0.0165)	0.56 (0.0053)	0.30 (0.1278)
Cataluña	1.47 (0)	0.86 (0)	0.76 (0)	0.44 (0.0165)	0.46 (0.0367)	0.08 (0.7347)
C. Valenciana	1.43 (0)	0.78 (0)	0.76 (0)	0.44 (0.0165)	0.82 (0.0601)	0.25 (0.2634)
Extremadura	0.83 (0.0026)	0.79 (0)	0.76 (0)	0.44 (0.0165)	0.53 (0.0067)	-0.14 (0.5443)
Galicia	1.10 (0)	0.74 (0)	0.76 (0)	0.44 (0.0165)	0.68 (0.0018)	-0.15 (0.5648)
Madrid	1.00 (-)	1.00 (-)	0.76 (0)	0.44 (0.0165)	0.70 (0.0010)	0.46 (0.0090)
Murcia	1.04 (0)	0.80 (0)	0.76 (0)	0.44 (0.0165)	0.64 (0.0013)	0.10 (0.5006)
Navarra	1.23 (0)	0.75 (0)	0.76 (0)	0.44 (0.0165)	0.52 (0.0061)	0.11 (0.5188)
País Vasco	1.18 (0)	0.68 (0)	0.76 (0)	0.44 (0.0165)	0.74 (0.0001)	0.02 (0.9184)
Rioja (La)	0.98 (0)	0.84 (0)	0.76 (0)	0.44 (0.0165)	0.66 (0.0008)	0.10 (0.6324)

Notes: p-values in parenthesis. The null hypotheses are:

$H_0 : \gamma_i = 0$

$H_0 : \alpha = 0$

$H_0 : \beta_i = 0$

Source: Fundación BBVA and own elaboration

Table 2
DECOMPOSITION INTO SYMMETRIC AND ASYMMETRIC SHOCKS

Regions	Symmetric component		Asymmetric Component		Ranking	
	Output	**Prices**	**Output**	**Prices**	**Output**	**Prices**
Andalucía	84.76	90.23	15.24	9.77	6	8
Aragón	95.38	95.33	4.62	4.67	3	5
Asturias	39.71	49.21	60.29	50.79	17	17
Baleares	79.85	76.20	20.15	23.80	8	16
Canarias	70.07	88.36	29.93	11.64	13	12
Cantabria	75.15	92.62	24.85	7.38	12	6
Castilla-León	77.41	88.90	22.59	11.10	11	9
Castilla-La Mancha	78.39	88.83	21.61	11.17	9	10
Cataluña	95.92	98.19	4.08	1.81	2	1
C. Valenciana	97.13	98.07	2.87	1.93	1	2
Extremadura	47.43	83.53	52.57	16.47	16	14
Galicia	94.28	87.49	5.72	12.51	4	13
Madrid	69.88	97.53	30.12	2.47	14	3
Murcia	77.74	95.47	22.26	4.53	10	4
Navarra	81.99	88.46	18.01	11.54	7	11
País Vasco	59.87	82.03	40.13	17.97	15	15
Rioja (La)	86.84	92.49	13.16	7.51	5	7

Note: figures in percentages.
Sources: Fundación BBVA and own elaboration.

Figure 2
PROPORTION OF ASYMMETRIC SHOCKS (OUTPUT)

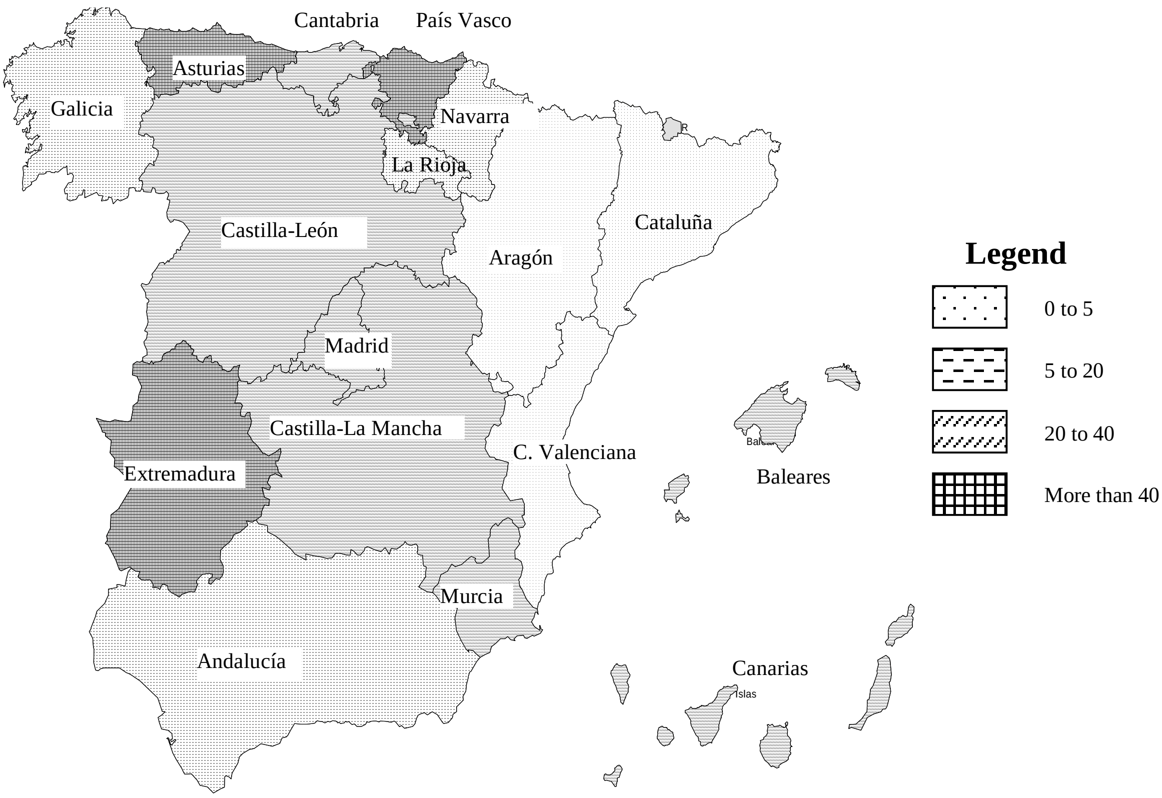

Figure 3
PROPORTION OF ASYMMETRIC SHOCKS (Prices)

Table 3
DEMAND AND SUPPLY SHOCKS

Regions	**Correlation coefficient among shocks**
Common component	0.08
Specific components	
Andalucía	-0.67*
Aragón	-0.19
Asturias	-0.17
Baleares	0.23
Canarias	-0.09
Cantabria	0.08
Castilla-León	-0.32*
Castilla-La Mancha	-0.15
Cataluña	0.25
C. Valenciana	0.31*
Extremadura	0.44*
Galicia	0.20
Madrid	-0.29*
Murcia	-0.21
Navarra	-0.14
País Vasco	-0.38*
Rioja (La)	-0.22

Note: * = significant at 95%.
Source: Fundación BBVA and own elaboration.

Table 4
RESTRICTED MODEL

Regions	Sensitivity to the common component γ		Persistence of symmetric shocks α		Persistence of asymmetric shocks β_i	
	Output	**Prices**	**Output**	**Prices**	**Output**	**Prices**
Andalucía	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.55 (0.0150)	0.23 (0.2968)
Aragón	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.28 (0.2228)	0.01 (0.9501)
Asturias	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.56 (0.0018)	0.18 (0.3932)
Baleares	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.59 (0.0019)	0.07 (0.7280)
Canarias	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.66 (0.0002)	0.18 (0.3259)
Cantabria	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.35 (0.0709)	0.27 (0.1785)
Castilla-León	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.23 (0.2875)	0.17 (0.4016)
Castilla-La Mancha	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.56 (0.0037)	0.36 (0.0766)
Cataluña	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.61 (0.0027)	-0.01 (0.9597)
C. Valenciana	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.59 (0.0047)	0.22 (0.3192)
Extremadura	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.54 (0.0057)	-0.14 (0.5238)
Galicia	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.64 (0.0040)	-0.24 (0.2478)
Madrid	1.00 (-)	1.00 (-)	0.77 (0)	0.45 (0.0139)	0.69 (0.0008)	0.49 (0.0065)
Murcia	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.59 (0.0024)	0.10 (0.5060)
Navarra	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.53 (0.0054)	0.08 (0.6071)
País Vasco	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.73 (0)	-0.06 (0.7049)
Rioja (La)	1.20 (0)	0.79 (0)	0.77 (0)	0.45 (0.0139)	0.77 (0)	0.08 (0.6954)

Notes: p-values in parenthesis. The null hypotheses are:

$H_0 : \gamma = 0$

$H_0 : \alpha = 0$

$H_0 : \beta_i = 0$

Source: Fundación BBVA and own elaboration.

Table 5
COMMON SHOCKS AND ASYMMETRIC EFFECTS

Regions	Output	Prices
Andalucía	1.11 (0.7371)	0.93 (0.0878)
Aragón	1.34 (0.5127)	0.79 (0.9741)
Asturias	0.72 (0.1221)	0.61 (0.2505)
Baleares	1.23 (0.8549)	0.99 (0.1391)
Canarias	1.22 (0.9110)	1.01 (0.0185)
Cantabria	1.25 (0.7942)	0.70 (0.0858)
Castilla-León	0.91 (0.2636)	0.79 (0.9604)
Castilla-La Mancha	1.18 (0.9385)	0.70 (0.1081)
Cataluña	1.47 (0.2289)	0.86 (0.0762)
C. Valenciana	1.43 (0.2763)	0.78 (0.8413)
Extremadura	0.83 (0.2486)	0.79 (0.9638)
Galicia	1.10 (0.6390)	0.74 (0.5109)
Madrid	1.00 (-)	1.00 (-)
Murcia	1.04 (0.5128)	0.80 (0.8436)
Navarra	1.23 (0.8161)	0.75 (0.6018)
País Vasco	1.18 (0.9466)	0.68 (0.1628)
Rioja (La)	0.98 (0.3392)	0.84 (0.4307)

Notes: p-values in parenthesis. The null hypotheses are:

For output $H_0 : \gamma_i = 1{,}20$

For prices $H_0 : \gamma_i = 0{,}79$

Source: Fundación BBVA and own elaboration.

Table 6
SPECIFIC SHOCKS AND SYMMETRIC EFFECTS (Output)

	And	Ara	ast	bal	can	cant	cl	cm	cat	cv	ext	gal	mad	mur	nav	pv	rio
and	1.00																
ara	-0.31*	1.00															
ast	-0.41*	0.39*	1.00														
bal	0.03	0.11	0.29*	1.00													
can	0.00	0.06	0.02	0.20	1.00												
cant	-0.22	0.03	0.17	0.06	-0.23	1.00											
cl	0.22	-0.04	0.14	-0.34*	0.31*	-0.28*	1.00										
cm	0.49*	-0.12	-0.10	-0.38*	0.22	-0.24	0.60*	1.00									
cat	0.17	-0.05	-0.02	0.39*	-0.51*	0.20	-0.42*	-0.50*	1.00								
cv	0.08	-0.17	-0.32*	0.14	-0.19	0.17	-0.31*	0.02	0.21	1.00							
ext	0.43*	0.07	-0.04	-0.20	0.58*	-0.34*	0.62*	0.55*	-0.30*	-0.25	1.00						
gal	0.23	-0.04	-0.09	-0.48*	0.10	-0.02	0.38*	0.59*	-0.53*	0.21	0.17	1.00					
mad	-0.06	-0.10	0.51*	0.10	0.09	0.00	0.40*	-0.01	0.22	-0.41*	0.25	-0.29*	1.00				
mur	0.24	-0.06	0.14	-0.24	0.18	-0.10	0.37*	0.56*	-0.13	-0.27*	0.31*	0.33*	0.17	1.00			
nav	-0.07	0.22	-0.01	-0.04	-0.46*	0.12	-0.20	-0.34*	0.23	-0.08	-0.38*	-0.03	-0.14	-0.35*	1.00		
pv	-0.24	0.09	0.28*	0.06	-0.69*	0.20	-0.14	-0.40*	0.54*	-0.10	-0.50*	-0.30*	0.38*	-0.21	0.65*	1.00	
rio	0.00	0.36*	-0.07	-0.24	0.02	-0.29*	0.01	0.20	-0.18	-0.29*	0.08	0.30*	-0.14	0.13	0.41*	0.08	1.00

Note: * = significant at 95%. Source: Fundación BBVA and own elaboration.

Table 7
SPECIFIC SHOCKS AND SYMMETRIC EFFECTS (Prices)

	And	ara	ast	bal	can	cant	cl	cm	cat	cv	ext	gal	mad	mur	nav	pv	rio
and	1.00																
ara	-0.47*	1.00															
ast	0.26	-0.28*	1.00														
bal	0.05	0.37*	-0.43*	1.00													
can	0.18	-0.54*	0.38*	-0.66*	1.00												
cant	-0.15	0.35*	-0.08	0.43*	-0.68*	1.00											
cl	0.55*	-0.41*	0.58*	-0.54*	0.56*	-0.41*	1.00										
cm	0.38*	-0.44*	-0.07	-0.08	0.28*	-0.25	0.57*	1.00									
cat	-0.08	0.62*	-0.28*	0.71*	-0.58*	0.24	-0.54*	-0.59*	1.00								
cv	-0.40*	0.38*	-0.13	-0.16	-0.06	0.08	-0.32*	-0.47*	0.01	1.00							
ext	-0.48*	0.05	-0.46*	-0.16	0.08	-0.25	-0.36*	-0.15	-0.08	0.64*	1.00						
gal	-0.41*	0.84*	-0.59*	0.65*	-0.64*	0.35*	-0.64*	-0.37*	0.72*	0.27*	0.14	1.00					
mad	-0.31*	-0.16	-0.54*	0.01	-0.18	-0.08	-0.52*	-0.28*	0.14	0.05	0.36*	0.12	1.00				
mur	0.59*	-0.64*	0.36*	-0.21	0.67*	-0.59*	0.58*	0.39*	-0.37*	-0.06	-0.02	-0.61*	-0.26*	1.00			
nav	0.00	-0.24	-0.03	-0.05	-0.42*	0.45*	-0.02	0.27*	-0.34*	-0.29*	-0.19	-0.17	0.16	-0.39*	1.00		
pv	-0.27*	0.25	0.08	0.09	-0.56*	0.47*	-0.28*	-0.23	0.15	-0.27*	-0.32*	0.13	0.07	-0.73*	0.62*	1.00	
rio	-0.68*	0.14	-0.32*	-0.14	0.13	-0.05	-0.32*	0.12	-0.27*	0.10	0.36*	0.21	0.17	-0.37*	0.14	0.07	1.00

Note: * = significant at 95%. Source: Fundación BBVA and own elaboration.

Table A.1
SPECIFICATION TESTS

Region	Normality		Autocorrelation		Heterocedasticity		Stable parameters	
	Output	Prices	Output	Prices	Output	Prices	Output	Prices
Andalucía	0.21 (0.90)	5.78 (0.06)	6.22 (0.19)	2.60 (0.63)	1.01 (0.32)	1.88 (0.17)	Yes	Yes
Aragón	4.34 (0.12)	2.82 (0.25)	4.39 (0.36)	3.75 (0.44)	1.24 (0.26)	4.50 (0.04)	Yes	Yes
Asturias	4.14 (0.13)	0.08 (0.96)	12.11 (0.02)	13.34 (0.01)	0.67 (0.41)	0.26 (0.61)	Yes	Yes
Baleares	5.69 (0.06)	7.93 (0.02)	3.08 (0.55)	14.35 (0.01)	0.05 (0.82)	1.72 (0.19)	Yes	Yes
Canarias	3.87 (0.14)	2.86 (0.24)	6.39 (0.17)	7.70 (0.10)	0.01 (0.95)	2.94 (0.09)	Yes	Yes
Cantabria	3.42 (0.18)	1.31 (0.52)	19.28 (0.00)	3.07 (0.55)	2.22 (0.14)	5.98 (0.02)	Yes	Yes
Castilla-León	9.87 (0.01)	0.47 (0.80)	15.03 (0.01)	5.83 (0.25)	3.69 (0.06)	1.86 (0.17)	Yes	Yes
Castilla-La Mancha	1.20 (0.55)	1.71 (0.43)	9.23 (0.06)	2.48 (0.65)	1.52 (0.22)	2.81 (0.09)	Yes	Yes
Cataluña	3.84 (0.15)	2.43 (0.30)	4.88 (0.30)	4.25 (0.37)	0.79 (0.38)	3.32 (0.07)	Yes	Yes
C. Valenciana	1.63 (0.44)	2.45 (0.29)	5.63 (0.23)	2.49 (0.65)	1.83 (0.18)	2.97 (0.09)	Yes	Yes
Extremadura	7.22 (0.03)	5.51 (0.06)	6.86 (0.14)	3.41 (0.49)	0.11 (0.74)	0.72 (0.40)	Yes	Yes
Galicia	0.16 (0.92)	6.46 (0.04)	10.42 (0.04)	5.36 (0.25)	4.85 (0.03)	0.68 (0.41)	Yes	Yes
Madrid	2.61 (0.27)	0.86 (0.65)	17.26 (0.01)	4.88 (0.30)	2.72 (0.10)	2.59 (0.11)	Yes	Yes
Murcia	0.41 (0.81)	3.59 (0.17)	7.11 (0.13)	3.27 (0.51)	1.52 (0.22)	2.14 (0.14)	Yes	Yes
Navarra	1.08 (0.58)	1.16 (0.56)	4.83 (0.31)	7.26 (0.12)	8.97 (0.01)	1.38 (0.24)	Yes	Yes
País Vasco	0.19 (0.91)	2.15 (0.34)	2.97 (0.56)	8.81 (0.07)	2.71 (0.10)	0.70 (0.40)	Yes	Yes
Rioja (La)	3.88 (0.14)	1.64 (0.44)	4.34 (0.36)	3.63 (0.46)	3.21 (0.07)	2.60 (0.11)	Yes	Yes

Notes: p-values in parenthesis. The null hypotheses are:

H_0 : normality

H_0 : no serial correlation

H_0 : homocedasticity.

Test for normality: Doornik y Hansen. Test for serial correlation: Ljung and Box (autocorrelation up to 5 lags). Test for heterocedasticity: ARCH test of Engle. Test for stability of parameters: Brown, Durbin and Evans. Yes means that the null can not be rejected at the 95% level.