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Inflation and Nominal Rigidities in Spanish Regions: The Ball and Mankiw Approach¹

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1. Introduction

Nominal price rigidity assumption has generated a vast literature in recent macroeconomics. There are several theories trying to explain it. This paper is focused on New Keynesian menu cost models, and more precisely on the empirical testing strand proposed by Ball and Mankiw (1994, 1995), who explain why a relative-price shock, which serves as a measure of a supply shock, can affect the average inflation rate, whereas in a flexible price framework changes in relative prices don't affect average inflation.

Basically, those papers assume a monopolistic competition model characterized by firms that face menu costs when they adjust prices. In this setting, a distribution of the desired relative price changes for the firms can be defined². When firms experience a shock to their desired relative price, they change their prices only if the profit from the adjustment is larger than the menu cost. We will analyze the implications of this behavior under two alternative scenarios with respect to inflation: no trend inflation - Ball and Mankiw (1995)- and trend inflation -Ball and Mankiw (1994)-:

a) No trend inflation or stable inflation, near zero. In this case, if the distribution of the desired relative price changes of the firms of a sector or geographical area is symmetrical, around zero, as the price adjustment costs differ among firms, there will be an inaction range of the firms around zero; but the firms that are in the right tail of the distribution will rise their price, whereas those in the left tail will lower it. As the distribution is symmetrical, a shock that affects that sector or geographical area won't affect the general price level, because the price increases will be balanced by the reductions. However, if the distribution of price changes is skewed to the right (left), the

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left tail will be smaller (bigger) than the right one, so the net effect of a shock will be a price increase (decrease). Therefore, a testable implication of the menu cost model is the positive association between the average inflation and the skewness of the distribution of the desired prices changes. We can also point out that a larger variability³ will magnify the effects of skewness, increasing the relative weight of the tails; however, if the distribution of desired prices is symmetrical, an increase in variability strengthens both tails equivalently, so the change in variability doesn't affect inflation.

b) Trend inflation. In this context, for a negative shock, firms have two options: to pay the menu cost or let inflation erode their relative prices until the desired level. The higher the inflation, the faster the erosion process and the smaller the probability of firms paying menu costs. Therefore, positive inflation reduces the range of the zone in which firms pay menu costs, and reduces their price. On the contrary, for a positive shock, as inflation is also positive, if the firm doesn't pay the menu cost the gap between current and optimal price will increase, so the firms are more likely to pay menu costs and increase their price, strengthening the right tail of the distribution. To sum up, in a trend inflation framework downward price rigidity appears. Finally, an increase in the variability of the distribution of the shocks increases in absolute values the right tail in relation to the left one, so inflation increases independently of the skewness of the distribution of the shocks.

To sum up, under this theoretical framework the conclusion is that if average inflation is stable and near zero the inflation-skewness relation is stronger than the inflation-variability relation, whereas in a trend-inflation framework the inflation-variability relation is stronger.

The empirical evidence in this area is mixed. In general, a positive association inflation-skewness and inflation-variability is supported by the data, but the results are not conclusive about which relation is stronger. The following table summarizes the most relevant contributions:

² A problem arises when we try to test these models because the desired price changes for the firms can't be observed, so a proxy like the observed price changes must be used.

³ Relative price variability is referred to variance or standard deviation of the distribution.

EMPIRICAL EVIDENCE			
AUTHORS	DATA	RESULTS	OTHER APPLICATIONS
Ball and Mankiw (1995)	US, 1949-1989, annual data, producer price	* Positive inflation/skewness association stronger than inflation/variability	Short run Phillips curve. Inflation-skewness causality
Debelle and Lamont (1997)	US cities, 1954-1986, annual data, producer price	* Positive inflation/skewness association not significant * Significant positive inflation/variability association	
Lourenco and Gruen (1995)	Australia, 1970-1992, quarterly data, consumer price, producer price	* Annual inflation lower than 4-5%: inflation/skewness relation stronger than inflation/variability * Annual inflation higher than 4-5%: inflation/variability relation stronger	Inflation-variability causality. Instrumental variables
Amano and Macklem (1997)	Canada, 1962-1994, annual data, quarterly data, producer price	* Positive inflation/skewness association * Weak inflation/variability association	Inflation-variability and inflation-skewness causality. Granger causality test
Hall and Yates (1998)	UK, 1975-1996, monthly data, consumer price	* Inflation/skewness association weaker than inflation/variability	Inflation-variability and inflation-skewness causality. Granger causality test
Aucremanne <i>et al.</i> (2002)	Belgium, 1976-2000, monthly data, consumer price	* Positive inflation/skewness association independently of mean inflation * Positive inflation/variability association	Robust estimators of core inflation
Döpke and Pierdzioch (2003)	Germany, 1969-2000, annual data, consumer price and producer price	* Positive inflation/skewness association	Short run Phillips curve
Other related works	<ul style="list-style-type: none"> • Loungani and Swagel (1995): 13 OECD countries, annual data. Positive inflation/skewness association. • Bryan and Cecchetti (2001): Latin America, high inflation countries. Positive inflation/variability and inflation/skewness associations, negative inflation/kurtosis relation. • Sobczak (1998): Spain, 1975-1997, monthly data of producer price index. Analysis of the influence of relative price adjustment (taking skewness and standard deviation of price distribution as proxies) on 1996-1997 disinflation: a very weak influence is observed. • Álvarez and Matea (1999): Spain, 1987:1-1998:9, monthly data, year-on-year consumer price index inflation rate. Core inflation indicators. 		

The analysis presented in this paper has different applications. Firstly, a deeper knowledge of the inflation behavior (moments) will ease a more effective control of this variable. So, in the case of a relative price shock, if inflation is affected by these variables -variability and skewness-, or some of their transformations, then our economy will be vulnerable, making the control of inflation especially difficult. According to this perspective, we will try to determine if there are some regions especially vulnerable to inflation, or if, on the contrary, the behavior of the regions is very homogeneous at this respect. A second application refers to core inflation: if higher moments of the distribution of relative prices only have transitory effects on inflation, a feasible way to measure core inflation consists in removing the transitory effects introduced by skewness -see Aucremanne *et al.* (2002)- from inflation. Finally, this type of analysis can contribute to test if downward price rigidity is an exogenous phenomenon -Tobin (1972)-, or the response of optimizing agents that face menu costs in an inflationary context -see Hall and Yates (1998) and Aucremanne *et al.* (2002)-. Despite these utilities, the Ball and Mankiw (1995) approach has been rarely applied to Spanish economy.

Basically, this paper analyzes the plausibility of the menu costs model for Spanish economy, following the Ball and Mankiw (1995) methodology, and the degree of homogeneity among Spanish regions at this respect. The rest of the paper is organized as follows: Section 2 presents the data and variables used in our analysis, the methodology applied and the results of our first approximation to Ball and Mankiw (1995). In section 3 alternative measures of variability and skewness are considered. Section 4 analyzes the role of kurtosis and introduces two real variables (unemployment and production) as control variables. In section 5 we attend to the causality problem. After the analysis at a regional level, section 6 studies whether the regions present an homogeneous behavior in the field studied. Section 7 concludes summarizing the main results and pointing out feasible extensions.

2. Data, basic variables, methodology and baseline specification⁴

Our period of analysis is 1994.01-2001.12; period characterized by a mean monthly inflation rate around 0.25%, and lower than 5% in annual terms. We have

⁴ Along this work we refer to some results that are not presented explicitly in it in order to avoid a too long exposition. Those results, as well as the data used, before and after their seasonal adjustment, are disposable.

chosen this low inflation period because around an annual 4-5% is placed the upper limit for which the model predicts a strong inflation-skewness relation –see Lourenco and Gruen (1995)-.

Our study is based on consumer prices. The data come from the series of monthly change rates of price indexes, disaggregated by goods and services (33 subgroups), elaborated by the Instituto Nacional de Estadística (INE). The weight of each subgroup offered by the INE is defined as the proportion of expenditure made on that article in relation to total expenditure made by households. The weight is kept constant by the INE along the period analyzed. When price rigidity models are trying to be tested this constancy is an advantage, because if this is not the case the price indexes could change simply due to changes in the weights and not because of flexibility.

We are aware of the limitations of our data, because the indexes hide information when we aggregate; however, at this moment those problems don't have an easy solution because we haven't got other kind of data. Other problems are related to the weights: if a economy presents rigidity in some sectors but not in others, with the weighted data the presence of rigidity can be captured only in the sectors with a large weight under the criterion used. In our work we will focus on the results obtained for the weighted variables, because our main objective is the detection of global difficulties for the control of average inflation, and not to determine whether price rigidity is relevant in a specific sector. Notwithstanding a parallel analysis for the non-weighted variables has been developed as well, and in some points of the work we compare both types of results.

We now define some of the essential variables in our analysis⁵. As a proxy of the moments of the distribution of the shocks we use the second and third cross-sectional moment of the distribution of price changes. The expressions of the standard deviation for each region (S_{jt}) and the skewness for each region (A_{jt}) are as follows:

$$S_{jt} = \left[\sum_{i=1}^n w_{ij} (\pi_{ijt} - \pi_{jt})^2 \right]^{0.5}; \quad A_{jt} = \frac{\sum_{i=1}^n w_{ij} [\pi_{ijt} - \pi_{jt}]^3}{(S_{jt})^3}$$

⁵ We have to introduce a precision about notation. It is usual in this literature to distinguish between relative price variability (RPV) and relative price dispersion (RPD): RPV is defined as the variance or the standard deviation of the distribution of the price change rate, whereas RPD refers to the distribution of the price levels. In general, attending to the availability of data, it is common to use RPV, which is the variable that we use in our work.

where π refers to inflation rate, i to goods, j to regions and t to time periods. Consequently: π_t : domestic inflation in period t ; π_{jt} : inflation of region j in period t ; π_{it} : domestic inflation of subgroup i in period t ; π_{ijt} : inflation of subgroup i in region j in period t ; and w_{ij} is the weight of each subgroup i and region j used by the INE to build the consumer price index of each region along this period.

As an interaction measure between S_{jt} and A_{jt} we define: $M_{jt} = S_{jt} \cdot A_{jt}$. If the distribution is symmetrical M_{jt} takes a null value independently of the standard deviation, but for other value of skewness the value of this variable -in absolute terms- is positively correlated with standard deviation; in other words, the standard deviation magnifies the value of skewness.

Some empirical problems with the estimations arise. Firstly, as data are monthly, they present an important seasonal component, that has been removed by means of an X-12 ARIMA method. All the results presented in our work refer to seasonally adjusted variables.

Secondly, as we use basically the higher-order moments of the distribution of inflation, multicollinearity problems could appear. In order to tackle this aspect we calculate the correlation coefficients between standard deviation and skewness for all the regions, observing that it goes from 0.04 for Ceuta y Melilla to 0.24 for Castilla-La Mancha. Given these small coefficients we have considered that it is plausible to introduce jointly both variables in the estimations.

Thirdly, the stationarity of inflation and its moments has been tested by means of the ADF test⁶.

Following Ball and Mankiw (1995) we have estimated 5 regressions for each region, and we compare the adjusted R^2 in order to study the contribution of skewness to the estimations. Initially we include just one lag for inflation and the Breusch-Godfrey test on autocorrelation in the residuals is carried out until order 12. For regions with autocorrelation problems we include an additional lag and we repeat the Breusch-

⁶ In order to analyze the stationarity of the series we have estimated the following equation using ordinary least squares:

$$\Delta Y_t = \delta + \beta \cdot t + \rho \cdot Y_{t-1} + \sum_{i=1}^p \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

where p is the number of lags required to remove the autocorrelation in the residuals. From now on we follow the usual steps. The unique region that presents stationarity problems in the series is Canarias. For example, for inflation series we include initially 4 lags, and the Wald statistic presents a value of 4.017, so we continue applying the steps of the test until we conclude that

Godfrey test until order 12, and so on; in other words, we include the lags of the dependent variable required to avoid autocorrelation problems in the residuals. In this sense, the regions with a lag of order 2 are Cataluña, Cantabria, Galicia, Ceuta y Melilla and Navarra, and in La Rioja we include until the lag number 7. We want to point out that, although in general we follow this method in our work, in the analysis presented in Table 1 we have opted for the inclusion of two lags for all regions, in order to ease the comparison with the analysis offered in section 6⁷. In any case, the inclusion of one or two lags doesn't generate important differences in the results that we consider relevant: the sign and significance of the variables and their contribution to adjusted R². The second lag of inflation is not significant in none of the 5 estimations for the regions, so it doesn't appear in the table. The regressions are estimated using ordinary least squares (OLS)⁸ and, as usual, the value of the t statistic (in brackets in the tables) is corrected by means of the White method.

The regressions of Table 1, following the order of the columns, are as follows:

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \varepsilon_{jt} \quad [1]$$

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \beta_3^j S_{jt} + \varepsilon_{jt} \quad [2]$$

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \beta_4^j A_{jt} + \varepsilon_{jt} \quad [3]$$

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \beta_3^j S_{jt} + \beta_4^j A_{jt} + \varepsilon_{jt} \quad [4]$$

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \beta_5^j M_{jt} + \varepsilon_{jt} \quad [5]$$

where $j=1 \dots 18$ for all the equations.

for this region the inflation series has a unit root without constant nor drift. It is also the only region with evidence of unit root for the rest of the moments of the distribution.

⁷ The results of Table 1, for the case in which we introduce just the lags required to remove the autocorrelation in the residuals, appear in Caraballo *et al.* (2003a).

⁸ As it is well known, if the lagged endogenous variable isn't correlated with the error term, the properties of the OLS estimators remain. In order to verify that this correlation doesn't exist we

TABLE 1. VARIABILITY AND SKEWNESS

ANDALUCÍA						ARAGÓN					
α_j	0.113	-0.009	0.104	-0.008	0.098	α_j	0.128	0.035	0.090	0.026	0.092
	(3.666)	(-0.185)	(3.346)	(-0.163)	(3.232)		(3.867)	(0.707)	(2.777)	(0.551)	(2.912)
$\pi_{j,t-1}$	0.480	0.429	0.469	0.424	0.467	$\pi_{j,t-1}$	0.369	0.360	0.316	0.315	0.332
	(4.692)	(4.301)	(4.612)	(4.260)	(4.700)		(3.544)	(3.554)	(3.220)	(3.252)	(3.451)
S_{jt}		0.199		0.186		S_{jt}		0.106		0.077	
		(2.948)		(2.734)				(0.043)		(1.839)	
A_{jt}			0.006	0.005		A_{jt}			0.026	0.024	
			(1.587)	(1.202)					(3.741)	(3.348)	
M_{jt}					0.014	M_{jt}					0.026
					(2.574)						(4.131)
$A.R^2$	0.234	0.293	0.246	0.297	0.278	$A.R^2$	0.160	0.203	0.265	0.284	0.286
$D-W$	2.001	1.923	2.000	1.930	1.967	$D-W$	1.955	1.933	2.065	2.034	2.048
ASTURIAS						BALEARES					
α_j	0.125	0.026	0.112	0.031	0.113	α_j	0.224	0.090	0.195	0.091	0.191
	(3.868)	(0.488)	(3.540)	(0.599)	(3.619)		(5.687)	(1.308)	(4.852)	(1.342)	(4.800)
$\pi_{j,t-1}$	0.450	0.418	0.408	0.387	0.391	$\pi_{j,t-1}$	0.287	0.254	0.291	0.263	0.270
	(4.400)	(4.139)	(4.108)	(3.914)	(3.907)		(2.746)	(2.465)	(2.850)	2.588	(2.666)
S_{jt}		0.131		0.108		S_{jt}		0.153		0.125	
		(2.213)		(1.856)				(2.323)		(1.880)	
A_{jt}			0.015	0.014		A_{jt}			0.014	0.012	
			(2.865)	(2.583)					(2.358)	(1.921)	
M_{jt}					0.017	M_{jt}					0.016
					(2.960)						(2.747)
$A.R^2$	0.211	0.243	0.269	0.288	0.273	$A.R^2$	0.057	0.100	0.102	0.126	0.120
$D-W$	1.991	1.941	2.029	1.981	2.037	$D-W$	1.904	1.976	1.924	1.973	1.938
CANARIAS						CANTABRIA					
α_j	0.224	0.162	0.220	0.162	0.223	α_j	0.217	0.088	0.196	0.083	0.193
	(5.132)	(2.185)	(4.889)	(2.181)	(4.978)		(5.708)	(1.441)	(5.163)	(1.388)	(5.098)
$\pi_{j,t-1}$	0.097	0.091	0.093	0.089	0.094	$\pi_{j,t-1}$	0.273	0.267	0.252	0.249	0.254
	(0.929)	(0.873)	(0.882)	(0.850)	(0.895)		(2.629)	(2.655)	(2.477)	(2.516)	(2.521)
S_{jt}		0.074		0.071		S_{jt}		0.168		0.151	
		(1.050)		(0.970)				(2.646)		(2.403)	
A_{jt}			0.003	0.001		A_{jt}			0.015	0.013	
			(0.432)	(0.187)					(2.336)	(2.065)	
M_{jt}					0.001	M_{jt}					0.019
					(0.196)						(2.674)
$A.R^2$	0.001	0.009	0.001	0.002	0.001	$A.R^2$	0.054	0.113	0.098	0.144	0.114
$D-W$	2.011	1.966	1.992	1.960	2.001	$D-W$	1.963	1.924	1.974	1.934	1.943
CASTILLA-LA MANCHA						CASTILLA-LEÓN					
α_j	0.121	-0.025	0.107	-0.020	0.104	α_j	0.137	0.059	0.115	0.055	0.115
	(3.709)	(-0.45)	(3.230)	(-0.363)	(3.179)		(4.105)	(1.146)	(3.443)	(1.089)	(3.453)
$\pi_{j,t-1}$	0.482	0.460	0.456	0.447	0.456	$\pi_{j,t-1}$	0.356	0.336	0.355	0.339	0.348
	(4.611)	(4.602)	(4.377)	(4.437)	(4.417)		(3.461)	(3.302)	(3.542)	(3.395)	(3.488)
S_{jt}		0.208		0.189		S_{jt}		0.100		0.081	
		(3.108)		(2.725)				(1.937)		(1.575)	
A_{jt}			0.010	0.006		A_{jt}			0.013	0.012	
			(1.790)	(1.087)					(2.433)	(2.144)	
M_{jt}					0.014	M_{jt}					0.016
					(2.107)						(2.612)
$A.R^2$	0.218	0.286	0.237	0.288	0.247	$A.R^2$	0.134	0.159	0.178	0.191	0.186
$D-W$	1.999	1.941	2.011	1.956	2.010	$D-W$	2.019	1.997	2.031	2.019	2.030

have estimated the model using OLS and we have checked that there isn't autocorrelation in the residuals.

CATALUÑA						CEUTA Y MELILLA					
α_j	0.160	0.106	0.120	0.089	0.122	α_j	0.219	0.004	0.211	0.002	0.207
	(4.709)	(2.346)	(3.618)	(2.077)	(3.784)		(4.886)	(0.066)	(4.838)	(0.030)	(4.892)
$\pi_{j,t-1}$	0.421	0.409	0.423	0.415	0.415	$\pi_{j,t-1}$	0.020	0.005	0.001	-0.012	-0.005
	(4.194)	(4.114)	(4.526)	(4.443)	(4.522)		(0.203)	(0.057)	(0.016)	(-0.133)	(-0.053)
S_{jt}		0.073		0.045		S_{jt}		0.232		0.226	
		(1.737)		(1.129)				(3.804)		(3.833)	
A_{jt}			0.023	0.022		A_{jt}			0.025	0.024	
			(3.885)	(3.605)					(2.615)	(2.668)	
M_{jt}					0.0257	M_{jt}					0.028
					(4.340)						(3.560)
A.R²	0.156	0.174	0.269	0.271	0.294	A.R²	-0.015	0.115	0.046	0.172	0.100
D-W	1.961	1.953	1.882	1.880	1.926	D-W	1.944	1.910	1.906	1.901	1.935
EXTREMADURA						GALICIA					
α_j	0.103	-0.066	0.088	-0.065	0.084	α_j	0.139	0.053	0.127	0.069	0.122
	(3.233)	(-1.234)	(2.714)	(-1.221)	(2.631)		(4.169)	(1.021)	(3.978)	(1.366)	(3.837)
$\pi_{j,t-1}$	0.334	0.263	0.316	0.256	0.304	$\pi_{j,t-1}$	0.342	0.326	0.305	0.298	0.311
	(3.253)	(2.696)	(3.119)	(2.634)	(3.041)		(3.454)	(3.343)	(3.211)	(3.153)	(3.302)
S_{jt}		0.233		0.217		S_{jt}		0.119		0.082	
		(3.808)		(3.510)				(2.094)		(1.458)	
A_{jt}			0.010	0.007		A_{jt}			0.014	0.012	
			(1.928)	(1.365)					(3.178)	(2.765)	
M_{jt}					0.016	M_{jt}					0.017
					(2.607)						(3.397)
A.R²	0.214	0.316	0.237	0.322	0.261	A.R²	0.134	0.165	0.213	0.223	0.224
D-W	2.013	1.931	2.035	1.946	2.015	D-W	1.881	1.877	1.906	1.897	1.901
LA RIOJA						MADRID					
α_j	0.189	0.074	0.167	0.076	0.167	α_j	0.130	0.055	0.119	0.057	0.116
	(4.662)	(1.252)	(4.201)	(1.315)	(4.271)		(4.140)	(1.157)	(3.707)	(1.190)	(3.644)
$\pi_{j,t-1}$	0.339	0.309	0.292	0.275	0.285	$\pi_{j,t-1}$	0.322	0.312	0.318	0.311	0.324
	(3.276)	(3.060)	(2.895)	(2.763)	(2.844)		(3.144)	(3.098)	(3.123)	(3.081)	(3.211)
S_{jt}		0.118		0.097		S_{jt}		0.100		0.088	
		(2.580)		(2.139)				(2.013)		(1.715)	
A_{jt}			0.022	0.018		A_{jt}			0.007	0.004	
			(2.842)	(2.440)					(1.340)	(0.857)	
M_{jt}					0.020	M_{jt}					0.010
					(3.167)						(1.823)
A.R²	0.103	0.156	0.168	0.200	0.184	A.R²	0.118	0.147	0.126	0.145	0.140
D-W	2.016	1.993	1.949	1.915	1.946	D-W	1.952	1.977	1.971	1.985	1.975
MURCIA						NAVARRA					
α_j	0.211	0.000	0.189	0.009	0.188	α_j	0.201	0.185	0.152	0.159	0.169
	(4.838)	(0.010)	(4.432)	(0.147)	(4.523)		(4.876)	(2.870)	(3.806)	(2.665)	(4.214)
$\pi_{j,t-1}$	0.150	0.095	0.107	0.069	0.094	$\pi_{j,t-1}$	0.224	0.220	0.307	0.309	0.275
	(1.454)	(0.982)	(1.062)	(0.728)	(0.950)		(2.166)	(2.100)	(3.139)	(3.114)	(2.776)
S_{jt}		0.254		0.224		S_{jt}		0.017		-0.008	
		(4.041)		(3.548)				(0.323)		(-0.171)	
A_{jt}			0.022	0.016		A_{jt}			0.025	0.025	
			(2.857)	(2.186)					(4.053)	(4.019)	
M_{jt}					0.025	M_{jt}					0.018
					(3.460)						(3.414)
A.R²	0.011	0.153	0.083	0.188	0.117	A.R²	0.041	0.031	0.180	0.171	0.141
D-W	1.987	1.972	1.921	1.906	1.871	D-W	1.999	1.992	2.029	2.033	1.999

PAÍS VASCO						VALENCIA					
α_j	0.163	0.117	0.145	0.116	0.146	α_j	0.146	0.055	0.128	0.055	0.125
	(4.352)	(2.373)	(3.936)	(2.407)	(4.004)		(4.212)	(0.980)	(3.706)	(1.010)	(3.660)
$\pi_{j,t-1}$	0.262	0.232	0.247	0.228	0.234	$\pi_{j,t-1}$	0.306	0.287	0.294	0.279	0.293
	(2.536)	(2.212)	(2.465)	(2.231)	(2.332)		(2.924)	(2.777)	(2.867)	(2.747)	(2.898)
S_{jt}		0.071		0.047		S_{jt}		0.136		0.112	
		(1.415)		(0.956)				(2.046)		(1.690)	
A_{jt}			0.013	0.012		A_{jt}			0.012	0.010	
			(2.570)	(2.327)					(2.298)	(1.981)	
M_{jt}					0.015	M_{jt}					0.017
					(2.757)						(2.790)
A.R²	0.092	0.102	0.145	0.144	0.154	A.R²	0.103	0.133	0.143	0.161	0.165
D-W	2.020	2.009	2.027	2.015	2.005	D-W	1.992	1.952	2.007	1.965	1.976

With respect to the main results of Table 1, it can be observed that S_{jt} is significant for 10 regions (for three of them at a level of significance of 6%); for Andalucía, Castilla-La Mancha and Extremadura only is significant S_{jt} (for Madrid only is significant S_{jt} at 8%). A_{jt} is significant for 13 regions (for Baleares at a level of significance of 6%); for six of them -Cataluña, Galicia, Navarra, Castilla-León, País Vasco and Valencia- only is significant A_{jt} . For Canarias none of the two variables are significant. In all the cases the coefficients are positive.

Referred to the relative contribution of skewness and standard deviation⁹, in all cases R^2 rises when one of them is included, and the largest R^2 is achieved when both are included, with the exception of Navarra, where the best estimation is obtained when only skewness is included. For Andalucía, Cantabria, Castilla-La Mancha, Ceuta y Melilla, Extremadura, Madrid and Murcia the R^2 is larger when we only consider the standard deviation than when we only consider the skewness, whereas for the rest of the regions the opposite occurs.

It can also be observed in the table that the value of the standard deviation coefficient is larger than the value of the skewness coefficient. With respect to the interaction variable, as it was expected, is significant for all cases, except Canarias (for Madrid is significant at 6%).

We want to point out that the regressions with the non-weighted variables don't yield qualitative differences in the results. In this sense, the standard deviation coefficient is larger than the skewness one, although the standard deviation coefficients are slightly smaller and the skewness coefficients slightly larger than for the weighted

⁹ The results for Canarias aren't commented due to their atypical nature.

variables. And when those variables are introduced in the estimations, a better R^2 is obtained as well.

It can be concluded that the significance, both of standard deviation and skewness, shows the presence of rigidities in the price adjustment of the regions. It is also observed that in most of the regions the weight of skewness is slightly larger than the weight of standard deviation, in line with the results of Ball and Mankiw. Of course, some differences among regions are observed; for example, in those regions where the only significant variable is the standard deviation the coefficient of this variable is around 0.2, larger than the value obtained for the rest of the regions. Further studies are required in order to settle if those differences are significant; this analysis is developed in section 6.

3. Alternative measures of price skewness and variability

In this section we define some alternative measures as proxies for the moments of the distribution of the price shocks. Firstly, we attend to the variability and skewness of the distribution of regional prices in relation to domestic inflation, because economic agents can receive better information about the domestic consumer price index than about the regional one. According to this, the standard deviation of the inflation of the goods and services of each region in relation to the domestic inflation rate (SG_{jt}) and the skewness of the inflation of the goods and services of each region in relation to the domestic inflation (AG_{jt}) are defined as follows:

$$SG_{jt} = \left[\sum_{i=1}^n w_{ij} (\pi_{ijt} - \pi_t)^2 \right]^{0.5} ; AG_{jt} = \frac{\sum_{i=1}^n w_{ij} [\pi_{ijt} - \pi_t]^3}{(SG_{jt})^3}$$

At this point, an analysis similar to that developed in Table 1 has been carried out, and similar results yield. However, we can't forget that the correlation coefficient between S_{jt} and SG_{jt} and between A_{jt} and AG_{jt} is over 0.90 for all regions, so at this stage we can't conclude whether SG_{jt} and AG_{jt} are significant *per se*, or due to their high degree of correlation with S_{jt} and A_{jt} .

To confront that problem, firstly, we have defined two auxiliary variables ($DS_{jt} = SG_{jt} - S_{jt}$ and $DA_{jt} = AG_{jt} - A_{jt}$) in order to test if, once the variability and the skewness of the regions is substracted, the remainder of SG_{jt} and AG_{jt} contributes to the explanation of mean inflation. The results for the introduction of DA_{jt} are reported in Table 2.

We have followed again the steps that led us to Table 1¹⁰. In this analysis DA_{jt} is significant for all regions, whereas DS_{jt} is only significant for Navarra. It can be observed that the coefficient of DA_{jt} in Table 2 is higher than the coefficient of skewness reported in the estimations of the columns 3 and 4 of Table 1 for all regions. Comparatively, it can also be observed in Table 2 an increase in R^2 . Another result to take into account is that the effects of the introduction of DA_{jt} on standard deviation are very heterogeneous. To sum up, this auxiliary variable ensures the relevance of skewness. Despite our positive comments on DA_{jt} , we will keep on using the skewness variable (A_{jt}) in our analysis, because it allows us to compare our results with those of other authors.

Secondly, we define the regional component of standard deviation and skewness. These measures seem us very interesting because they can show whether the weight of domestic elements is bigger than the corresponding to regional components in the explanation of regional inflation; the reason could be that the nexus between inflation and its moments is based rather on domestic shocks than on regional factors. Following Debelle and Lamont (1997) we define those regional components subtracting from the standard deviation and the skewness of each region the corresponding values at a domestic level. Therefore, we need to define the standard deviation (SIS_t) and the skewness (AIS_t) for the Spanish economy:

$$SIS_t = \left[\sum_{i=1}^n w_i (\pi_{it} - \pi_t)^2 \right]^{0.5}; AIS_t = \frac{\sum_{i=1}^n w_i [\pi_{it} - \pi_t]^3}{(SIS_t)^3}$$

where w_i is the weight of each subgroup used by the INE to build the domestic consumer price index.

Working with these new variables the regional component of standard deviation ($DSN_{jt} = S_{jt} - SIS_t$) and skewness ($DAN_{jt} = A_{jt} - AIS_t$) can be defined. If these components affect inflation in a region, then specific measures would be required in order to control

¹⁰ The regressions implemented take inflation as the dependent variable, and as explanatory variables the lags required to remove the autocorrelation in the residuals and the following variables depending of each case: DS_{jt} , DA_{jt} , S_{jt} and DA_{jt} , DS_{jt} and A_{jt} . We only present the regression that corresponds to S_{jt} and DA_{jt} because it offers the best R^2 . The lags included in the estimations of Table 2 in order to avoid autocorrelation are: 2 for Galicia, 3 for Ceuta y Melilla, 7 for Aragón, Asturias, Cantabria, Cataluña, Castilla-León, Castilla-La Mancha, La Rioja and Madrid, and 12 for Navarra –it is 1 for the rest of regions–.

the inflation of that region. Applying the same methodology used for Table 1¹¹ we obtain that DAN_{jt} is not significant, with the exception of Navarra, and that DSN_{jt} is not significant, with the exception of País Vasco. Paradoxically, the regional components of standard deviation and skewness don't affect regional inflation.

TABLE 2. ALTERNATIVE MEASURES OF VARIABILITY AND SKEWNESS									
ANDALUCÍA		ARAGÓN		ASTURIAS		BALEARES		CANARIAS	
α_i	0,037 (0,669)	α_i	0,043 (0,686)	α_i	0,024 (0,346)	α_i	0,063 (0,789)	α_i	0,150 (2,670)
$\pi_{j,t-1}$	0,380 (4,731)	$\pi_{j,t-1}$	0,359 (3,552)	$\pi_{j,t-1}$	0,475 (4,934)	$\pi_{j,t-1}$	0,270 (2,520)	$\pi_{j,t-1}$	0,223 (2,562)
S_{jt}	0,173 (2,037)	S_{jt}	0,107 (2,153)	S_{jt}	0,105 (1,730)	S_{jt}	0,148 (2,027)	S_{jt}	0,061 (1,122)
DA_{jt}	0,123 (3,536)	DA_{jt}	0,216 (4,880)	DA_{jt}	0,133 (2,929)	DA_{jt}	0,181 (2,618)	DA_{jt}	0,257 (6,355)
Adjust. R ²	0,362	Adjust. R ²	0,358	Adjust. R ²	0,371	Adjust. R ²	0,251	Adjust. R ²	0,303
D-W	1,747	D-W	1,791	D-W	1,829	D-W	1,922	D-W	1,830
CANTABRIA		CAST-LA MANCHA		CASTILLA-LEÓN		CATALUÑA		CEUTA-MELILLA	
α_i	0,067 (0,776)	α_i	0,023 (0,306)	α_i	0,059 (0,736)	α_i	0,039 (0,533)	α_i	0,069 (1,228)
$\pi_{j,t-1}$	0,248 (2,416)	$\pi_{j,t-1}$	0,351 (4,321)	$\pi_{j,t-1}$	0,359 (3,152)	$\pi_{j,t-1}$	0,416 (4,176)	$\pi_{j,t-1}$	0,206 (2,588)
S_{jt}	0,122 (1,834)	S_{jt}	0,133 (1,689)	S_{jt}	0,095 (1,504)	S_{jt}	0,094 (1,957)	S_{jt}	0,124 (2,494)
DA_{jt}	0,161 (3,599)	DA_{jt}	0,255 (4,853)	DA_{jt}	0,134 (3,564)	DA_{jt}	0,162 (3,735)	DA_{jt}	0,226 (7,803)
Adjust. R ²	0,177	Adjust. R ²	0,495	Adjust. R ²	0,205	Adjust. R ²	0,291	Adjust. R ²	0,466
D-W	1,718	D-W	1,774	D-W	1,895	D-W	1,897	D-W	1,717
EXTREMADURA		GALICIA		LA RIOJA		MADRID		MURCIA	
α_i	0,017 (0,360)	α_i	0,043 (0,774)	α_i	0,036 (0,529)	α_i	0,045 (0,687)	α_i	-0,003 (-0,067)
$\pi_{j,t-1}$	0,364 (4,910)	$\pi_{j,t-1}$	0,334 (3,366)	$\pi_{j,t-1}$	0,338 (4,179)	$\pi_{j,t-1}$	0,407 (4,135)	$\pi_{j,t-1}$	0,228 (2,457)
S_{jt}	0,190 (3,134)	S_{jt}	0,137 (2,273)	S_{jt}	0,130 (2,958)	S_{jt}	0,081 (1,324)	S_{jt}	0,227 (3,915)
DA_{jt}	0,101 (3,984)	DA_{jt}	0,115 (2,390)	DA_{jt}	0,257 (6,442)	DA_{jt}	0,149 (2,728)	DA_{jt}	0,227 (4,430)
Adjust. R ²	0,369	Adjust. R ²	0,199	Adjust. R ²	0,353	Adjust. R ²	0,208	Adjust. R ²	0,326
D-W	2,053	D-W	1,805	D-W	1,798	D-W	1,871	D-W	1,771
		NAVARRA		PAÍS VASCO		VALENCIA			
		α_i	0,014 (0,149)	α_i	0,092 (1,898)	α_i	0,037 (0,643)		
		$\pi_{j,t-1}$	0,232 (2,039)	$\pi_{j,t-1}$	0,310 (3,217)	$\pi_{j,t-1}$	0,376 (4,641)		
		S_{jt}	0,061 (0,873)	S_{jt}	0,101 (2,178)	S_{jt}	0,158 (2,066)		
		DA_{jt}	0,161 (2,465)	DA_{jt}	0,105 (2,490)	DA_{jt}	0,186 (4,177)		
		Adjust. R ²	0,172	Adjust. R ²	0,130	Adjust. R ²	0,268		
		D-W	1,784	D-W	1,848	D-W	1,872		

¹¹ These estimations take as explanatory variables the lags in inflation required in order to remove autocorrelation and, depending on each case, DSN_{jt} , DAN_{jt} , S_{jt} and DAN_{jt} , A_{jt} and DSN_{jt} .

We can also point out that the analysis for the non-weighted variables shows similar results: DA_{jt} is significant for all the regions, the coefficient of DA_{jt} is greater than the skewness coefficient, and R^2 rises with DA_{jt} in relation to skewness. The differences in the results for the rest of aforementioned variables don't deserve comments.

4. Introduction of kurtosis and control variables

In order to complete the analysis of the moments of the distribution, we introduce in our analysis the kurtosis (K_{jt}). The corresponding expression is the following:

$$K_{jt} = \frac{\sum_{i=1}^n w_{ij} [\pi_{ijt} - \pi_{jt}]^4}{S_{jt}^4}$$

The correlation coefficient between K_{jt} and S_{jt} goes from the 0.66 for Cataluña to the 0.22 for Cantabria, whereas the coefficient between K_{jt} and A_{jt} goes from the 0.35 for Castilla-La Mancha to the -0.007 for Ceuta y Melilla. Due to those results we think that standard deviation and kurtosis can generate multicollinearity problems, so they are not included jointly in the regressions. The results of the introduction of kurtosis appear in Table 3 (column 1).

From that table it can be observed that kurtosis is significant only for Aragón, so it doesn't seem to be important for our analysis. With respect to the negative sign of the coefficient for 7 regions, we have to point out that it is the expected according to Bryan and Cecchetti (2001). Hall and Yates (1998) find a negative correlation between kurtosis and inflation as well, but very weak, so they don't deepen in this aspect.

In this section we also want to capture the influence of real variables on inflation. For this analysis we have selected unemployment and industrial output. For unemployment we use the change of the monthly unemployment rate of the regions, denoted by U_{jt} . The unemployment rates have been obtained dividing the monthly number of unemployees (Instituto Nacional de Empleo) by the labor force of the corresponding quarter (*Encuesta de Población Activa*, INE). With respect to industrial

production we use the monthly change of the industrial output index that appears in the *Boletín de Coyuntura Regional*¹²; this variable is denoted as IPI_{jt} .

TABLE 3. KURTOSIS AND CONTROL VARIABLES								
ANDALUCÍA			ARAGÓN			ASTURIAS		
α_j	0,113	-0,019	α_j	0,082	0,021	α_j	0,026	0,026
	(3,375)	(-0,322)		(2,178)	(0,385)		(0,523)	(0,523)
$\pi_{j,t-1}$	0,428	0,386	$\pi_{j,t-1}$	0,352	0,414	$\pi_{j,t-1}$	0,379	0,379
	(4,569)	(4,266)		(4,136)	(4,857)		(4,082)	(4,082)
S_{jt}		0,212	S_{jt}		0,078	S_{jt}	0,127	0,127
		(2,350)			(1,825)		(2,306)	(2,306)
A_{jt}	0,006	0,003	A_{jt}	0,020	0,021	A_{jt}	0,009	0,009
	(1,366)	(0,918)		(3,561)	(3,613)		(1,921)	(1,921)
K_{jt}	0,0001		K_{jt}	0,001		K_{jt}	0,00006	
	(0,583)			(2,280)			(0,080)	
IPI_{jt}		-0,0007	IPI_{jt}		0,003	IPI_{jt}	-0,010	-0,010
		(-0,241)			(0,908)		(-2,464)	(-2,464)
U_{jt}		-0,019	U_{jt}		-0,017	U_{jt}	-0,032	-0,032
		(-0,847)			(-1,755)		(-2,470)	(-2,470)
Adjust. R ²	0,206	0,269	Adjust. R ²	0,253	0,280	Adjust. R ²	0,340	0,340
D-W	1,859	1,830	D-W	2,094	2,130	D-W	1,821	1,821
BALEARES			CANARIAS			CANTABRIA		
α_j	0,186	0,079	α_j	0,278	0,151	α_j	0,228	0,159
	(5,011)	(1,265)		(5,740)	(1,921)		(6,057)	(2,597)
$\pi_{j,t-1}$	0,287	0,252	$\pi_{j,t-1}$	0,064	0,074	$\pi_{j,t-1}$	0,121	0,126
	(3,500)	(3,095)		(0,563)	(0,688)		(1,488)	(1,503)
S_{jt}		0,128	S_{jt}		0,088	S_{jt}		0,048
		(1,715)			(1,213)			(0,761)
A_{jt}	0,015	0,013	A_{jt}	0,007	-	A_{jt}	0,017	0,016
	(2,562)	(1,906)		(0,738)	-		(2,955)	(2,855)
K_{jt}	-0,0002		K_{jt}	-0,001		K_{jt}	-0,0008	
	(-0,371)			(-1,363)			(-1,183)	
IPI_{jt}		-0,0008	IPI_{jt}		-0,002	IPI_{jt}		0,002
		(-0,240)			(-0,375)			(0,577)
U_{jt}		-0,001	U_{jt}		-0,011	U_{jt}		0,015
		(-0,615)			(-0,539)			(1,187)
Adjust. R ²	0,112	0,131	Adjust. R ²	0,002	0,001	Adjust. R ²	0,075	0,060
D-W	1,959	2,026	D-W	1,961	1,919	D-W	1,835	1,722
CASTILLA-LA MANCHA			CASTILLA-LEÓN			CATALUÑA		
α_j	0,109	-0,024	α_j	0,139	0,080	α_j	0,137	0,111
	(3,230)	(-0,466)		(3,677)	(1,665)		(3,536)	(2,100)
$\pi_{j,t-1}$	0,451	0,433	$\pi_{j,t-1}$	0,332	0,323	$\pi_{j,t-1}$	0,347	0,322
	(4,958)	(4,729)		(3,339)	(3,319)		(3,214)	(2,836)
S_{jt}		0,192	S_{jt}		0,086	S_{jt}		0,042
		(2,750)			(1,768)			(1,024)
A_{jt}	0,008	0,004	A_{jt}	0,012	0,010	A_{jt}	0,024	0,023
	(1,386)	(1,004)		(2,359)	(2,060)		(4,358)	(4,239)
K_{jt}	0,0001		K_{jt}	0,0001		K_{jt}	-0,000001	
	(0,376)			(0,214)			(-0,002)	
IPI_{jt}		-0,0008	IPI_{jt}		-0,003	IPI_{jt}		0,0006
		(-0,189)			(-1,041)			(0,177)
U_{jt}		-0,008	U_{jt}		-0,010	U_{jt}		0,008
		(-0,653)			(-0,588)			(0,743)
Adjust. R ²	0,226	0,275	Adjust. R ²	0,139	0,163	Adjust. R ²	0,218	0,219
D-W	1,968	1,911	D-W	1,904	1,884	D-W	1,643	1,620

¹² This statistics doesn't offer production data for Ceuta y Melilla.

CEUTA Y MELILLA			EXTREMADURA			GALICIA		
α_j	0,221 (4,484)	0,019 (0,285)	α_j	0,110 (2,845)	-0,029 (-0,552)	α_j	0,147 (3,874)	0,110 (2,181)
$\pi_{j,t-1}$	-0,081 (-0,855)	-0,091 (-1,025)	$\pi_{j,t-1}$	0,441 (5,535)	0,394 (5,442)	$\pi_{j,t-1}$	0,227 (1,879)	0,231 (1,851)
S_{jt}		0,227 (3,750)	S_{jt}		0,198 (3,126)	S_{jt}		0,091 (1,643)
A_{jt}	0,027 (2,774)	0,025 (2,750)	A_{jt}	0,007 (1,244)	0,006 (1,245)	A_{jt}	0,013 (2,827)	0,012 (2,671)
K_{jt}	0,0003 (0,366)		K_{jt}	0,0003 (0,621)		K_{jt}	0,0006 (1,216)	
IPI_{jt}		-	IPI_{jt}		0,005 (1,235)	IPI_{jt}		-0,005 (-1,645)
U_{jt}		-0,0003 (-0,037)	U_{jt}		-0,022 (-2,058)	U_{jt}		-0,006 (-0,442)
Adjust. R²	0,053	0,171	Adjust. R²	0,196	0,294	Adjust. R²	0,148	0,156
D-W	1,717	1,708	D-W	2,192	2,238	D-W	1,706	1,655
LA RIOJA			MADRID			MURCIA		
α_j	0,225 (5,261)	0,087 (1,571)	α_j	0,130 (3,724)	0,054 (0,972)	α_j	0,203 (4,593)	0,018 (0,323)
$\pi_{j,t-1}$	0,284 (2,851)	0,255 (2,715)	$\pi_{j,t-1}$	0,278 (2,831)	0,273 (2,657)	$\pi_{j,t-1}$	0,146 (1,450)	0,099 (1,044)
S_{jt}		0,104 (2,207)	S_{jt}		0,099 (1,880)	S_{jt}		0,235 (3,951)
A_{jt}	0,024 (3,127)	0,018 (2,559)	A_{jt}	0,006 (1,236)	0,005 (1,144)	A_{jt}	0,021 (2,956)	0,016 (2,526)
K_{jt}	-0,001 (-1,491)		K_{jt}	0,0005 (1,191)		K_{jt}	0,0003 (0,387)	
IPI_{jt}		-0,001 (-0,590)	IPI_{jt}		0,002 (0,526)	IPI_{jt}		-0,005 (-1,217)
U_{jt}		-0,009 (-1,356)	U_{jt}		-0,015 (-1,182)	U_{jt}		0,001 (0,115)
Adjust. R²	0,163	0,186	Adjust. R²	0,090	0,116	Adjust. R²	0,082	0,201
D-W	1,874	1,848	D-W	1,891	1,910	D-W	2,012	1,964
NAVARRA			PAÍS VASCO			VALENCIA		
α_j	0,211 (4,719)	0,151 (2,449)	α_j	0,193 (5,352)	0,135 (2,710)	α_j	0,137 (3,879)	0,046 (0,709)
$\pi_{j,t-1}$	0,267 (2,513)	0,272 (2,486)	$\pi_{j,t-1}$	0,284 (3,171)	0,252 (2,823)	$\pi_{j,t-1}$	0,315 (3,622)	0,321 (3,472)
S_{jt}		0,011 (0,246)	S_{jt}		0,059 (1,273)	S_{jt}		0,094 (1,278)
A_{jt}	0,025 (4,416)	0,026 (4,710)	A_{jt}	0,013 (2,704)	0,012 (2,523)	A_{jt}	0,011 (2,021)	0,012 (2,302)
K_{jt}	-0,001 (-1,509)		K_{jt}	-0,0003 (-0,726)		K_{jt}	0,0002 (0,645)	
IPI_{jt}		0,004 (1,610)	IPI_{jt}		0,0009 (0,481)	IPI_{jt}		0,0009 (0,333)
U_{jt}		0,004 (0,458)	U_{jt}		-0,002 (-0,190)	U_{jt}		-0,027 (-1,674)
Adjust. R²	0,168	0,160	Adjust. R²	0,118	0,110	Adjust. R²	0,131	0,172
D-W	1,875	1,897	D-W	2,016	2,018	D-W	2,018	2,046

As the correlation coefficient between U_{jt} and IPI_{jt} goes (in absolute values) from the 0.217 for Andalucía to the 0.015 for Murcia we think that both variables can

be included jointly in the estimation. So, for this analysis we introduce U_{jt} and IPI_{jt} in the regression of equation [4] but considering the inflation lags required to avoid autocorrelation in the residuals for each region specified in section 2. The results of that estimation appear in Table 3 (column 2). It can be observed that only for Asturias both variables are significant (U_{jt} is significant for Extremadura at 5% but not at 1%). These results lead us to eliminate these variables in the rest of the work.

5. Causality analysis

One of the novelties of the Ball and Mankiw (1995) approach is that they reverse the causality relation between inflation and relative price variability generally accepted. So, these authors depart from an important branch of literature inspired in Lucas (1972), that studies the effects of a higher inflation on price variability¹³. Ball and Mankiw (1995) also establish that, at least theoretically, it is possible to think in a direction of causality from inflation to skewness. In order to evaluate this possibility these authors attend to the historical evolution of US inflation, and observe anomalies in the data: in 1975 inflation decreased while skewness was positive, and in 1982 inflation also decreased while the distribution of price changes was symmetrical. Ball and Mankiw argue that in both cases the reduction of inflation was due to a restrictive monetary policy, in other words to an exogenous demand factor, and the fact that skewness wasn't affected shows that inflation changes don't affect that variable.

Different works, in line with Ball and Mankiw (1995), as those of Amano and Macklem (1997) and Hall and Yates (1998), also analyze the causality relation between inflation and skewness, in both cases by means of the Granger causality test, concluding that in general there is empirical evidence supporting the causality from skewness to inflation.

In our empirical work we have tackled this question firstly carrying out instrumental variable estimation, because if causality goes from inflation to variability and skewness there will be an endogeneity bias in our previous specifications, in the sense that error terms will be correlated at least with one of the explanatory variables. The main problem in this kind of approximation relies on how to find the appropriate instruments; in our analysis we have to look for instruments correlated with standard

¹³ The question of causality in this area was also studied by Fischer (1981), for US quarterly data of the period 1948-1972. The results offered by this author don't show a clear causality pattern between the variables. In this same line, some recent works aren't conclusive.

deviation and skewness but not correlated with the error term. Due to previous results we think that kurtosis and the regional component of skewness (DAN_{jt}) can be appropriate instruments for standard deviation and skewness respectively. So, we make instrumental variable estimation of the regression that corresponds to the fourth column of Table 1¹⁴. The following stage is the implementation of the Hausman test for the null hypothesis that standard deviation and skewness are not correlated with the error term; the statistic of this test is distributed under the null hypothesis as a χ_k^2 , where k is the number of parameters estimated. The results of this analysis appear in Table 4.

TABLE 4. HAUSMAN TEST (EXOGENEITY)									
	Andaluc	Aragón	Asturias	Baleares	Canarias	Cantabr	C.Mancha	C.León	Cataluña
Hausman statistic	-0,035	3,250	1,010	37,218	3,065	5,958	2,331	0,505	-16,749
Value of the χ^2	9,49	9,49	9,49	9,49	9,49	11,1	9,49	9,49	11,1
	Ceuta-M	Extrem	Galicia	La Rioja	Madrid	Murcia	Navarra	P.Vasco	Valencia
Hausman statistic	0,162	3,954	3,012	9,893	1,093	-0,066	41,277	0,230	0,500
Value of the χ^2	11,1	9,49	11,1	18,3	9,49	9,49	11,1	9,49	9,49

As it can be observed, except for Baleares, Cataluña and Navarra, this test doesn't allow us to reject the null hypothesis that the regressors are not correlated with the random shock, and therefore it can't be rejected the possibility that the direction of causality goes from variability and skewness to inflation.

Due to the aforementioned problem of the instruments, secondly we have opted for implementing the Granger causality test, with two lags. As the variables are stationary, we make the causality test running the following regressions for each region:

$$\pi_{jt} = \delta_j + \theta_1 \pi_{j,t-1} + \theta_2 \pi_{j,t-2} + \lambda_1 S_{j,t-1} + \lambda_2 S_{j,t-2} + \varepsilon_{jt} \quad [6]$$

$$S_{jt} = \rho_j + \phi_1 S_{j,t-1} + \phi_2 S_{j,t-2} + \mu_1 \pi_{j,t-1} + \mu_2 \pi_{j,t-2} + v_{jt} \quad [7]$$

Now, in order to test the hypothesis that inflation is not Granger-caused by standard deviation, we use the Wald test for $\lambda_1 = \lambda_2 = 0$. Similarly, to test that inflation doesn't cause standard deviation the Wald test is applied for the null hypothesis $\mu_1 = \mu_2 = 0$. The same procedure is implemented in order to analyze the Granger-causality

¹⁴ Recall that for each region we introduce the number of lags that removes the autocorrelation in the residuals. The results of the instrumental variable estimation are not included because they don't add new information to the analysis previously developed.

relation between inflation and skewness. In Table 5 we show the p-value associated with the F-statistic of those tests.

		TABLE 5. GRANGER CAUSALITY TEST								
$H_0 : S_{jt}$ doesn't cause π_{jt}	Andaluc	Aragón	Asturias	Baleares	Canar	Cantab	C.Mancha	C.León	Catal	
	0,030	0,645	0,458	0,155	0,336	0,155	0,363	0,304	0,650	
$H_0 : \pi_{jt}$ doesn't cause S_{jt}	0,131	0,507	0,097	0,228	0,157	0,160	0,449	0,583	0,173	
	Ceuta-M	Extrem	Galicia	La Rioja	Madrid	Murcia	Navarra	P.Vasco	Valenc	
$H_0 : S_{jt}$ doesn't cause π_{jt}	0,925	0,155	0,180	0,697	0,187	0,198	0,095	0,222	0,250	
	0,819	0,081	0,740	0,439	0,240	0,404	0,331	0,056	0,280	
$H_0 : A_{jt}$ doesn't cause π_{jt}	Andaluc	Aragón	Asturias	Baleares	Canar	Cantab	C.Mancha	C. León	Catal	
	0,707	0,506	0,378	0,983	0,090	0,855	0,478	0,984	0,261	
$H_0 : \pi_{jt}$ doesn't cause A_{jt}	0,812	0,037	0,501	0,363	0,612	0,660	0,264	0,603	0,490	
	Ceuta-M	Extrem	Galicia	La Rioja	Madrid	Murcia	Navarra	P.Vasco	Valenc	
$H_0 : A_{jt}$ doesn't cause π_{jt}	0,631	0,937	0,486	0,494	0,898	0,613	0,629	0,511	0,894	
	0,310	0,406	0,488	0,449	0,731	0,331	0,214	0,784	0,946	

As it can be observed, from Table 5 any conclusion about the direction of causality can arise. At a level of 5% only Andalucía shows evidence in the sense that the direction of causality goes from standard deviation to inflation. To sum up, from our causality analysis we don't obtain a clear conclusion with respect to the direction of causality.

6. Analysis of the homogeneity of inflation behavior for the regions

Up to this point we have analyzed independently the inflation behavior of each region, obtaining results that are not dissimilar with respect to the significance of inflation moments (S_{jt} , A_{jt} , K_{jt}) and their alternative measures (DS_{jt} , DA_{jt} , DSN_{jt} , DAN_{jt}), and with respect to the significance of the change of the unemployment rate and the rate of change of the industrial production index. We also think that inflation figures of the regions will be affected in many cases by common factors, so there will be a strong relation among them. Having this in mind, we attempt to estimate the following system of equations, in which we have included the significant variables of our analysis for each region (S_{jt} , A_{jt}) and two lags in inflation:

$$\pi_{jt} = \alpha_j + \beta_1^j \pi_{j,t-1} + \beta_2^j \pi_{j,t-2} + \beta_3^j S_{jt} + \beta_4^j A_{jt} + \varepsilon_{jt} \quad j = 1, \dots, 18 \quad [8]$$

In order to determine the accurate estimation method for this system we have started checking cross-sectional heteroscedasticity with the Lagrange multiplier¹⁵, that is asymptotically equivalent to a likelihood test and is distributed as a χ^2_{N-1} , where N is the number of regions. As the value of the statistic obtained from the OLS regression is -26.79, the null hypothesis of homoscedasticity can't be rejected. Hence we reject the estimation of the system [8] by means of the seemingly unrelated regression method, because it requires both cross-sectional heteroscedasticity and contemporaneous correlation in the errors. With this result, and taking into account the evidence of homogeneity among regions reported along our work, a plausible method could be the estimation of the 18 equations imposing as a restriction that the parameters to estimate are equal for all regions.

As a previous step to that analysis, we have estimated each one of the 18 equations of the aforementioned system (results that appear in the fourth column of Table 1), and we have performed the Wald test of equal coefficients. The statistic of this test is distributed as a χ^2_{17} . The results of the test are shown in Table 6.

TABLE 6. WALD TEST

NULL HYPOTHESIS (for all $j=1 \dots 18$)	$\alpha_j = \alpha$	$\beta_1^j = \beta_1$	$\beta_2^j = \beta_2$	$\beta_3^j = \beta_3$	$\beta_4^j = \beta_4$
χ^2_{17}	18,116	27,335	14,796	24,234	20,602
p- value	0,381	0,053	0,610	0,113	0,244

As it can be observed, at a level of significance of 5% the null hypothesis of equal coefficients can't be rejected.

To ensure this result, firstly we have considered the case of an individual effect for each region, and secondly we have applied a test for poolability of the data.

In order to test the presence of an individual effect for each region we attend to the following estimation:

$$\pi_{jt} = \alpha_j + \beta_1 \pi_{j,t-1} + \beta_2 \pi_{j,t-2} + \beta_3 S_{jt} + \beta_4 A_{jt} + \varepsilon_{jt} \quad j = 1 \dots 18 \quad [9]$$

¹⁵ See Greene (2003, chapter 14).

Some comments on the estimation of equation [9] are required. Obviously the lagged variables are correlated with the individual effect. Therefore, if the individual effect is considered as a fixed effect and we use a within estimator, this estimator will be biased and inconsistent¹⁶. The problem doesn't disappear if we estimate the model in first differences, because although the individual effect is wiped out, the first-differenced variables are correlated with the random component of the error term. The degrees of inconsistency and bias depend on T ; only if $T \rightarrow \infty$ the within estimator is unbiased and consistent -see Baltagi (1995, p. 126)-. In other words, for a typical panel where N is large in relation to T (T is usually fixed), and where the enlargement of the sample always refers to N and not to T , instrumental variable estimation is required in order to get consistent and unbiased estimators. However, this isn't the case that we attend to, because in it N (regions) is fixed, T is very large in relation to N , and the enlargement of the sample can be referred only to T . Despite the discussion about the number of periods required to get an unbiased and consistent within estimator would deserve a lot of attention, we have just considered that for our sample we can make that estimation without major problems.

Considering all those arguments, initially we have to choose between a within estimator, for the case of fixed effects, and a feasible generalized least squares (FGLS)¹⁷ estimator, for the case of random effects. At this respect, the Hausman test has been carried out, and the null hypothesis is that the individual effect is not correlated with the explanatory variables; in other words, the acceptance of the null implies random effects. For our data the Hausman test statistic is distributed as a χ^2_4 and takes the value 156.92, so the null hypothesis is rejected and we choose the within estimator. This estimation appears in the second column of Table 7.

Now, in order to corroborate the results previously obtained with respect to the homogeneity of the regions in this field, we perform a fixed effect test¹⁸ for the null hypothesis $\alpha_j = \alpha$, for all $j = 1 \dots 18$. The test statistic is distributed under the null hypothesis as a $F_{17,1670}$ and its value is 0.33, so we can't reject the null hypothesis that α_j are equal.

¹⁶ The problem with respect to the bias and inconsistency of estimators is similar if we consider the individual effect as a random effect.

¹⁷ The FGLS estimation presented in the third column of Table 7 depends on the method followed in order to estimate the variance-covariance matrix of the shocks. In our work we have followed the estimation method incorporated in *Eviews* 4.1 program.

¹⁸ See Baltagi (1995, p. 12).

Secondly, according to Baltagi (1995, pp. 48-54), we have run a test for poolability of the data; in other words, we check that the coefficients of the system of equations [8] are jointly equal. We perform the estimation using OLS¹⁹ under the null hypothesis: $\alpha_j = \alpha$, $\beta_1^j = \beta_1$, $\beta_2^j = \beta_2$, $\beta_3^j = \beta_3$, $\beta_4^j = \beta_4$, for all $j = 1 \dots 18$ (the results of this estimation appear in the first column of Table 7). We use the following expression:

$$\pi_{jt} = \alpha + \beta_1 \pi_{j,t-1} + \beta_2 \pi_{j,t-2} + \beta_3 S_{jt} + \beta_4 A_{jt} + \varepsilon_{jt} \quad [10]$$

Under the assumption that ε is distributed in expression [10] as a $N(0, \Omega)$ ²⁰, the statistic under the null hypothesis is distributed as a $F_{85,1602}$, and for our data yields a value of -1.132, so the null can't be rejected.

To sum up, all these tests invite us to think that we can pool the data.

Despite our previous comments on the consistency of estimators, we have also applied the instrumental variable estimation suggested by Anderson and Hsiao (1981). In this sense, we estimate the model in first differences, in order to get rid of a hypothetical individual effect:

$$\pi_{jt} - \pi_{j,t-1} = \beta_1(\pi_{j,t-1} - \pi_{j,t-2}) + \beta_2(\pi_{j,t-2} - \pi_{j,t-3}) + \beta_3(S_{jt} - S_{j,t-1}) + \beta_4(A_{jt} - A_{j,t-1}) + (\varepsilon_{jt} - \varepsilon_{j,t-1}) \quad [11]$$

As $\pi_{j,t-1} - \pi_{j,t-2}$ is correlated with the error term, we run an instrumental variable estimation using the inflation variable in levels $\pi_{j,t-2}$ as instrument; for the rest of the variables we don't define instruments. We repeat the estimation with 2 instruments ($\pi_{j,t-2}$ and $\pi_{j,t-3}$) obtaining the same results, that are shown in the fourth column of Table 7. As it can be observed, there aren't remarkable changes with respect to skewness and standard deviation for the four methods of estimation reported in that table.

In conclusion, all the estimations developed in our work point out to the homogeneity in the inflation behavior for Spanish regions. The higher-order moments of inflation are significant and positive, and consequently this shows the vulnerability of inflation to relative price shocks. This explains, for example, that an adverse shock in the oil sector notably affects average inflation. We have also observed in a previous section an important homogeneity with respect to the influence of real variables.

¹⁹ The arguments that justify OLS estimation are the same that appear in footnote number 8.

²⁰ $\varepsilon' = (\varepsilon'_{j1} \dots \varepsilon'_{j18})$, where each ε'_j is a vector of dimension t . In order to verify that $\varepsilon \sim N(0, \Omega)$ in expression [10] we have analyzed the distribution of each ε'_j by means of the Jarque-Bera statistic, obtaining that at level of significance of 5% the normality of residuals isn't rejected - this result applies to all regions-.

TABLE 7. ANALYSIS OF THE HOMOGENEITY OF INFLATION BEHAVIOR FOR THE REGIONS

	OLS	FIXED EFFECTS	RANDOM EFFECTS	ANDERSON-HSIAO
$\pi_{j,t-1}$	0,286 (10,829)	0,249 (9,520)	0,361 (16,297)	0,021 (0,448)
S_{jt}	0,101 (7,586)	0,114 (8,241)	0,076 (13,079)	0,102 (8,432)
A_{jt}	0,012 (8,819)	0,012 (8,900)	0,013 (9,562)	0,011 (8,588)
Adjusted R²	0,198	0,180	0,096	0,080

Of course, some minor differences are observed among regions, as it was commented in section 2, but we think that the analysis developed in this section shows that those differences aren't important enough as to require a specific analysis of inflation for each region. Intuitively we think that those differences are based on the different sectoral composition of the regions; a slight differential behavior can be observed in those regions characterized by a higher weight of non-competitive and inflationary sectors (basically the tourist and financial sectors in our period of analysis)²¹. From other point of view, the fact that for some regions the standard deviation is more significant than skewness can respond to different theoretical backgrounds, but we think that our results aren't robust enough as to point out to a specific theoretical model.

7. Conclusions and extensions of the analysis

The type of analysis followed in this work, *à la* Ball and Mankiw, deepens in the analysis of inflation data, and it is necessary for example for evaluating the plausibility of a common monetary policy in order to control inflation. In general, in our work we observe an homogeneous behavior of the "structure" of inflation for the Spanish regions. Our analysis corroborates the results of Ball and Mankiw (1995) about the relevance of the skewness of the distribution of price changes. Their results in the line that the standard deviation coefficient is larger than the skewness coefficient and that the estimations including skewness yield a better R² are also confirmed. However, in Ball and Mankiw (1995) the significance of skewness is clearly higher than the significance of standard deviation, whereas in our work the difference is relatively

²¹ For a preliminary analysis in this area at a sectoral level see Caraballo *et al.* (2003b).

small. We have to emphasize that the significance of skewness and standard deviation at regional level, obtained in our work from different perspectives, shows the vulnerability of our inflation in terms of relative price shocks; factor that can introduce difficulties in the control of inflation.

Among the feasible extensions of our work, a first option consists in the study for the Spanish case of the additional skewness measures proposed by Ball and Mankiw (1995). With respect to the sectoral perspective, preliminary results that point out to an important sectoral heterogeneity and a higher relevance of skewness in relation to standard deviation are offered in Caraballo *et al.* (2003b). In this line it would be interesting to pay more attention to the sectors that are more vulnerable to inflation, and to the sectors that are more affected by relative price shocks. This type of analysis is necessary in order to implement microeconomic policies in this area. Finally, to test how our results (that correspond to the 1994-2001 period) are affected by the inflationary context, we have also made some work with a period characterized by a higher mean inflation (1986-1992) -the monthly inflation rate changes from 0.25% to 0.5%-, and we obtain a preliminary results in line with those offered by other authors - see for example Lourenco and Gruen (1995) for Australian economy-. In this sense, the standard deviation coefficient increases remarkably, until 0.25 or 0.45 depending on the data -weighted or non-weighted respectively-. With respect to skewness, the results point out to that the variable is not significant. As it can be observed, these preliminary results with respect to the change of period, in which we want to deepen²², seem to fit the results offered by Ball and Mankiw (1995).

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²² In this sense, we also want to develop our analysis comparing the Spanish economy with several Latin-American countries characterized by inflationary regimes very different from European standards.

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