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Change of regime and Phillips curve stability: The case of Spain, 1964-2002*

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RESUMEN

Las curvas de Phillips tradicionales que relacionan la inflación con alguna medida del nivel de actividad, y ampliadas para incluir la inflación pasada (suponiendo que aproxima la inflación esperada), han resultado altamente inestables a lo largo del tiempo. En este trabajo intentamos investigar, utilizando recientes desarrollos econométricos, si tal afirmación puede ser corroborada durante un período largo de tiempo. En la aplicación empírica, analizamos el caso de España durante el periodo 1964 a 2002.

Palabras clave: Cambios estructurales, Inflación, Curva de Phillips.

ABSTRACT

Traditional Phillips curves relating inflation to a measure of the level of activity, and augmented to include past inflation (assumed to proxy expected inflation), have been thought to be highly unstable over time. In this paper we try to investigate, using recent econometric developments, whether such a statement can be supported over a long time period. In the empirical application, we analyze the case of Spain along the period 1964 to 2002.

Keywords: Structural changes, Inflation, Phillips curve.

JEL classification: E31, C22.

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1 Introduction

The Phillips curve, i.e., the negative relationship between inflation and unemployment (or, more generally, a measure of the level of activity), is one of the most important stylized facts in macroeconomics. Started as the result of an empirical investigation of UK wage behaviour by Phillips (1958), it was extended and given a theoretical interpretation by Lipsey (1960), and was applied to the US and set in a policy context by Samuelson and Solow (1960), offering policymakers a menu of choice between inflation and unemployment. Later on, the original version of the Phillips curve was criticized by Friedman (1968) and Phelps (1968) for not considering the role of inflation expectations. Once these expectations were allowed for, Friedman and Phelps argued, there was no permanent trade-off between inflation and unemployment, with a unique ("natural") unemployment rate compatible with any rate of inflation; the trade-off, however, survived in the short run due to lags in the adjustment of expectations.

The above criticism was eventually assumed, so that the original Phillips curve was "augmented" to include expected inflation as an additional variable. In this way, a consensus emerged in the early 1970s on the main empirical characteristics of the wage-price mechanism embodied in most macroeconometric models of the time (Tobin, 1972). Prices were set as markups over unit costs, and wages were explained by the expectations-augmented Phillips curve, i.e., in terms of unemployment and past inflation (assumed to proxy expected inflation). The question of whether the coefficient on past inflation was equal to (in line with Friedman and Phelps' insights) or lower than one, was left as an empirical issue (Blanchard, 1990).

However, the estimated Phillips curves proved to be quite unstable along time, coinciding with a period of ever-increasing inflation in Western economies during the 1970s. Part of the explanation might be related to the occurrence of exogenous shocks to aggregate supply over that period, which shifted upwards the Phillips curve. But, indeed, the instability of the Phillips curve was probably the most famous application of the influential "Lucas critique". According to Lucas (1976), changes in the behaviour of policymakers, through their effect on the agents' expectations, might cause the estimated parameters from macroeconometric models also to change, so that inferences based on those parameters would be invalid. Therefore, while the existence of a trade-off between inflation and unemployment, due to price stickiness in the short run, is something generally accepted by most macroeconomists (Mankiw, 2000), the instability of the estimated Phillips curves in the presence of a structural break (following either exogenous shocks or changes in policy regimes) would mean an important obstacle for their use as a policy tool.

On the other hand, the Lucas critique would not be "a pure theoretical result, but rather a warning that highlights the importance of applying stability tests to macroeconomic models" (Estrella and Fuhrer, 2003, p. 102). Hence, the availability of adequate econometric techniques to test for parameter stability, would be crucial in order to properly assess the applicability of the Lucas critique. In this sense, recent econometric developments by Bai and Perron (1998, 2003a, 2003b) allow to test endogenously for the presence of multiple structural changes in an estimated relationship, as well as to estimate the different values of the parameters before and after any of the structural changes previously detected.

In this paper, we apply these procedures to the Phillips curve, using Spain as a case study. The Spanish case can be of a particular interest, since she has traditionally experienced high inflation rates, even increased in the mid-1970s, and gradually decreasing since then, which has allowed her to be able to participate in the European Economic and Monetary Union (EMU) since the outset.

The paper is structured as follows. The specification of the Phillips curve to be estimated and tested is presented in section 2, the methodology and empirical results are discussed in section 3, and section 4 concludes.

2 A model of the Phillips curve

In his original contribution, Phillips (1958) assumed that the rate of change of nominal wages depended on (i) the unemployment rate, which would be a proxy of excess demand in the labour market; (ii) the change in unemployment, which would reflect cyclical factors; and (iii) the rate of change of retail prices, operating through exogenous shocks, i.e., changes in import prices that are large enough to disturb the equilibrium wage/price relationship [see the discussion in Desai (1984, pp. 254-255)]. If, in addition, a link between prices and wages is assumed (e.g., prices are set as a markup on wages), the standard Phillips curve equation relating inflation and a measure of the level of activity would appear.

Formally, the above hypotheses can be stated in the following way (Layard, Nickell and Jackman, 1991). Nominal wages would change according to:

$$\Delta w_t = \Delta p_{C,t}^E + \varphi x_t + \varphi' \Delta x_t + z_t^w \tag{1}$$

where w is the log of nominal wages, p_C^E is the log of the expected consumer price index, x is a measure of the level of activity, and z^w collects any other variables influencing the wage setting process (the so called wage pressure factors). In turn, prices would evolve as:

$$\Delta p_t = \Delta w_t + z_t^p \tag{2}$$

where p is the log of domestic prices, and z^p collects any variables influencing the markup[1]. Finally, the consumer price index would be defined as a weighted average of domestic and import prices:

$$p_{C,t} = \sigma p_t + (1 - \sigma) p_{M,t} \tag{3}$$

where p_M is the log of the imported goods' prices measured in domestic currency. Hence, replacing (1) in (2), and taking into account (3), we would obtain:

$$\Delta p_t = \sigma \Delta p_t^E + \varphi x_t + \varphi' \Delta x_t + (1 - \sigma) \Delta p_{M,t}^E + (z_t^w + z_t^p) \tag{4}$$

As for expectations on domestic and imported inflation, we assume they are formed as an AR(1) process, i.e., in a backward-looking manner[2], so that the equation to be estimated would be:

$$\Delta p_t = \gamma_1 + \gamma_2 \Delta p_{t-1} + \gamma_3 x_t + \gamma_4 \Delta x_t + \gamma_5 \Delta p_{M,t-1} + \varepsilon_t \tag{5}$$

being ε_t an error term.

In the empirical application, we use Spanish annual data for the period 1964-2002, with the variables defined as follows:

- Δp is the domestic inflation rate, computed as the annual percentage change of the GDP deflator. Source: Banco de España (2004a, Table 2.1).
- x is an indicator of the level of economic activity, measured using three alternative variables:
  - (i) the output gap, computed as the difference between real GDP at market prices and its potential level, the latter obtained by applying the Hodrick-Prescott filter using a smoothing parameter $\lambda = 10$ (as proposed by Baxter and King, 1999). Source: Banco de España (2004a, Table 2.1).

[1] Notice that both the wage and the price equations could include a productivity term. However, since their coefficients are usually assumed to be equal in both equations, in order to avoid that productivity would affect unemployment in the long run (Layard, Nickell and Jackman, 1991), they have not been included in equations (1) and (2).

[2] Recently, some attention has been given in academic circles to the so called New Keynesian Phillips curve, where expected inflation is proxied by expected future inflation, rather than lagged inflation, i.e., in a forward-looking manner. This specification, however, has been subject to increasing criticism on several grounds. So, expectations of future prices have been shown to be unempirically important in explaining inflation behaviour (Fuhrer, 1997), at the same time that the New Keynesian Phillips curve does not appear at all consistent with the standard stylized facts about the dynamic effects of monetary policy, unlike the traditional Phillips curve based on backward-looking expectations (Mankiw, 2000). More recently, the econometric procedures used to estimate the New Keynesian Phillips curve have been also criticized; see, e.g., Ma (2002) or Rudd and Whelan (2001).

(ii) the "harmonized" unemployment rate as a percentage of the labour force, according to the Eurostat definition. Source: Banco de España (2004b, Table 2.2, column 5), and European Commission (2003, Table 3, column 6).

(iii) the capacity utilisation rate of total industry (excluding construction). Source: Banco de España (2004a, Table 23.6, column 2).

- Δp_M is the imported inflation rate, computed as the annual percentage change of the index of import prices in domestic currency. Source: Ministerio de Economía y Hacienda (2004).

3 Methodology and empirical results

Earlier work by, e.g., Chow (1960) or Brown, Durbin and Evans (1975), focused on testing for structural change at a single known break date. More recently, however, the econometric literature has developed methods that allow estimating and testing for structural change at unknown break dates; see Andrews (1993) and Andrews and Ploberger (1994) for the case of a single structural change, and Andrews, Lee and Ploberger (1996), Liu, Wu and Zidek (1997), and Bai and Perron (1998, 2003a, 2003b) for the case of multiple structural changes.

A key feature of the Bai and Perron procedure is that it allows testing for multiple breaks at "unknown" dates, so that each break point is successively estimated by using a specific-to-general strategy in order to determine consistently the number of breaks. As an additional advantage, the Bai and Perron procedure allows investigating whether some or all the parameters of the estimated relationship have changed.

More specifically, Bai and Perron (1998, 2003a) consider a linear model with m multiple structural changes (i.e., $m+1$ regimes) such as:

$$\begin{aligned}
y_t &= z_t'\delta_1 + u_t, \qquad t = 1, ..., T_1, \\
y_t &= z_t'\delta_2 + u_t, \qquad t = T_1 + 1, ..., T_2, \\
&\dots \\
y_t &= z_t'\delta_{m+1} + u_t, \qquad t = T_m + 1, ..., T.
\end{aligned}$$

where y_t is the observed dependent variable at time t, $z_t(q \times 1)$ is a vector of covariates, $\delta_j (j = 1, ..., m+1)$ is the corresponding vector of coefficients, and u_t is the error term at time t. The indices $T_1, ..., T_m$, i.e., the break points, are explicitly treated as unknown. The procedure consists of estimating the unknown regression coefficients together with the break points, when T observations on (y_t, z_t) are available.

The issue of testing for structural changes is also considered under very general conditions on the data and the errors. The Bai and Perron tests are based upon an information criterion in the context of a sequential procedure, and allows one to find the numbers of breaks implied by the data, as well as estimating the timing and the confidence intervals of the breaks, and the parameters of the processes between breaks. This procedure, on the other hand, is not computationally excessive, allowing for the computation of the estimates using at most least-squares operations of order $O(T^2)$ for any number of structural changes m, unlike a standard grid search procedure which would require least squares operations of order $O(T^m)$.

Bai and Perron (1998, 2003a) propose three methods to determine the number of breaks: a sequential procedure, SP (Bai and Perron, 1998); the Schwarz modified criterion, LWZ (Liu, Wu and Zidek, 1997); and the Bayesian information criterion, BIC (Yao, 1988). Finally, the authors suggest several statistics in order to identify the break points:

- The $\sup F_T(k)$ test, i.e., a $\sup F$-type test of the null hypothesis of no structural break ($m = 0$) *versus* the alternative of a fixed (arbitrary) number of breaks ($m = k$).

- Two maximum tests of the null hypothesis of no structural break ($m = 0$) *versus* the alternative of an unknown number of breaks given some upper bound M ($1 \leq m \leq M$), i.e., $UD\max$ test, an equal weighted version, and $WD\max$ test, with weights that depend on the number of regressors and the significance level of the test.

- The $\sup F_T(l+1|l)$ test, i.e., a sequential test of the null hypothesis of l breaks *versus* the alternative of $l+1$ breaks.

In Table 1 we report the ordinary least squares (OLS) estimates of equation (5), making use of the correction proposed by Newey and West (1987), which provides consistent estimates of the covariance matrix in the presence of heteroscedasticity and autocorrelation of the residuals to the estimated equations. The sample runs from 1964 to 2002, and, as noticed before, three alternative variables are used to proxy for the level of activity: namely, the output gap, the unemployment rate, and the capacity utilisation rate. The results for the three alternative indicators are shown in columns [1], [2], and [3], respectively, and, as can be seen, all the coefficients have the expected signs, and are statistically significant at the usual levels. The only exception would be the change in the capacity utilisation rate, whose coefficient did not prove to be significantly different from zero, so this variable has been dropped in column [3].

Next, we consider first the structural stability of the dependent variable in the equations shown in Table 1, namely, the domestic inflation rate. When implementing Bai and Perron's procedure, we use one lag of the domestic inflation rate as regressor, and take into account any potential serial correlation via parametric adjustments; in particular, the covariance matrix is constructed, following Andrews (1991) and Andrews and Monahan (1992), using a quadratic kernel with automatic bandwidth selection based on an AR(1) approximation. We allowed up to 3 breaks, with a trimming equal to 0.20, so that each segment has at least 7 observations. The results are reported in Table 2, where the critical values are taken from Bai and Perron (1998, 2003b).

Both the $UD\max$ and $WD\max$ tests are highly significant, which implies that at least one break is present. The $\sup F_T(1)$ test is significant at the 5% level, unlike $\sup F_T(2)$, suggesting that the data do not support a two-break model. In turn, the $\sup F_T(l+1|l)$ test is not significant for any $l \geq 2$. All the three methods SP, LWZ, and BIC, select one as the number of breaks. Overall, the results suggest a model with one break, estimated at 1977. This breakpoint can be related to the anti-inflation program implemented at the end of that year, following the so called "Moncloa Agreements" signed in October 1977, together with the introduction of money targeting by the Bank of Spain[3]. On the other hand, the estimate of the autoregressive coefficient on the domestic inflation rate changes from 1.13 to 0.87, before and after the breakpoint, pointing to a significant decrease in the persistence of domestic inflation after 1977.

Now we turn to investigate whether the estimated Phillips curves show a similar structural change as their dependent variable, by applying Bai and Perron's procedure as before. The results are shown in Table 3, where columns [1], [2], and [3] correspond to the three specifications of the empirical model appearing in Table 1.

As can be seen, when either the output gap or the unemployment rate are used as a proxy of the level of activity, both the $UD\max$ and $WD\max$ tests, which would indicate the existence or absence of a break, are not significant. Next, the $\sup F_T(1)$ test, under the null hypothesis of no change and the alternative of one change, is not significant at any conventional level, so that the data would not support a one-break model. Finally, all the three methods proposed by Bai and Perron to determine the number of breaks select zero breaks. Therefore, the evidence points strongly to reject the presence of any breakpoint in the estimated equations.

In turn, when the level of activity is measured using the capacity utilisation rate, the $UD\max$ and $WD\max$ tests are significant at the 10% and 1% levels, respectively, so at least one break could be present. However, both the $\sup F_T(1)$ and the $\sup F_T(2|1)$ tests are not significant at any conven-

[3] The "Moncloa Agreements" were the result of a compromise among all the political forces represented in the first democratic Parliament, issued after the general election of June 1977, and leading to a social pact between the government, political parties, and the labour unions. It was complemented with the withdrawal of the previously accomodating monetary policy by the Bank of Spain.

tional level, indicating that the data would not support a one-break model. As before, all the SP, LWZ, and BIC methods select zero as the number of breaks, so that the evidence would point again in this case to the absence of any breakpoint in the estimated equation.

4 Conclusions

Traditional Phillips curves relating inflation to a measure of the level of activity, and augmented to include past inflation (assumed to proxy expected inflation), were thought to be highly unstable along time, following the increase in inflation experienced by Western economies during the 1970s. And this was usually explained in terms of the Lucas critique, which states that the estimated parameters from macroeconometric models would change in response to policy actions, through their effect on the agents' expectations, so rendering invalid any inferences based on those parameters.

However, the Lucas critique is not a pure theoretical result, but rather an empirical issue, so that models should be tested carefully for stability before being used for policy analysis (Estrella and Fuhrer, 2003). Therefore, in this paper we try to investigate, using recent econometric developments, whether the traditional Phillips curve has been stable over a long time period. In particular, we use the techniques recently developed by Bai and Perron (1998, 2003a, 2003b), which allow to test endogenously for the presence of multiple structural changes in an estimated relationship, as well as to estimate the different values of the parameters before and after any of the structural changes previously detected. In the empirical application, we analyze the case of Spain, a country that has traditionally experienced high inflation rates, though greatly reduced in more recent years, which has allowed her to be able to participate in EMU since the outset. The period of analysis cover the years 1964 to 2002.

We first applied the Bai and Perron tests to the autoregressive representation of the domestic inflation rate, finding one break at 1977, which can be related to the anti-inflation program following the "Moncloa Agreements" signed in October 1977; and such a breakpoint led to a significant decrease in the persistence of domestic inflation. However, when analyzing the stability of the previously estimated Phillips curves, we found no evidence of structural change in any of the estimated relationships, which use three alternative proxies for the level of economic activity, namely, the output gap, the unemployment rate, and the capacity utilisation rate.

To conclude, despite the structural break detected in the series for domestic inflation rate, we have been unable to find any evidence on structural change in the Spanish Phillips curve over the period 1964-2002; and this result was robust to the indicator of the level of economic activity used in the empirical application. All this points to confirm the crucial role played by the inflation-unemployment trade-off in macroeconomic theory and policy (see, e.g., Mankiw, 2000).

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Table 1
Estimated Phillips curves for Spain, 1964-2002

	[1]	[2]	[3]
constant	1.20^b	2.42^b	-24.5^a
	(0.53)	(0.98)	(6.90)
Δp_{t-1}	0.80^a	0.81^a	0.78^a
	(0.07)	(0.09)	(0.07)
x_t	0.61^b	-0.12^b	0.32^a
	(0.31)	(0.05)	(0.08)
Δx_t	0.66^c	-0.47^b	—
	(0.35)	(0.21)	
$\Delta p_{M,t-1}$	0.08^b	0.07^b	0.06^b
	(0.03)	(0.02)	(0.03)
R^2	0.80	0.81	0.82
σ^2	2.40	2.30	2.25

Notes:
[1] a, b, and c denote significance at the 1%, 5%, and 10% levels, respectively.
[2] Heteroscedasticity and autocorrelation-consistent standard errors in parentheses.

Table 2
Stability of the Spanish inflation rate, 1964-2002

Tests	
$UD\max$	9.52^b
$WD\max$	9.52^b
$\sup F_T(1)$	9.52^b
$\sup F_T(2)$	4.21
$\sup F_T(3)$	2.79
$\sup F_T(2\|1)$	1.75
$\sup F_T(3\|2)$	0.16

Number of breaks selected	
SP	1
LWZ	1
BIC	1

Note:
See Table 1.

Table 3
Stability of the estimated Phillips curves for Spain, 1964-2002

Tests

	[1]	[2]	[3]
$UD\max$	15.07	13.74	15.71^{c}
$WD\max$	19.04	17.37	22.66^{a}
$\sup F_T(1)$	10.11	9.82	7.77
$\sup F_T(2)$	15.07^{b}	13.74^{b}	15.71^{b}
$\sup F_T(3)$	12.35^{c}	9.67	14.85^{a}
$\sup F_T(2\|1)$	10.43	9.70	3.54
$\sup F_T(3\|2)$	40.00^{a}	96.32^{a}	10.87

Number of breaks selected

	[1]	[2]	[3]
SP	0	0	0
LWZ	0	0	0
BIC	0	0	0

Note:
See Table 1.