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

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Abstract

Following the emergence of the Lucas critique, 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 deemed 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 1964–2002.
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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

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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 macro-econometric 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 rather 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 would have shifted the Phillips curve upwards. 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, as Estrella and Fuhrer (2003, p. 102) stress, 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". 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) would be particularly adequate for this task. More specifically, the Bai and Perron procedure allows 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 particular interest, since she has traditionally experienced high inflation rates, even increased in the mid-1970s but gradually decreasing since then, so she has been able to participate in the European Economic and Monetary Union (EMU) from the outset. Also, these developments occurred simultaneously with major changes in the instrumentation of monetary policy (Ayuso & Escrivá, 1998). So, our sample period features the adoption of up-to-date monetary policy instruments in 1973; a greater concern about controlling inflation by adjusting interest rates in 1989; the granting of operational independence to the Bank of Spain in 1994, following the approval of an independence statute; and the new monetary policy conducted by the European Central Bank after 1999, in the EMU scenario. In particular, a significant monetary policy shift can be detected before and after June

1989 (i.e., when Spain joined the European Monetary System), as shown in Díaz-Roldán and Montero-Soler (2004). All this could be characterised as a change in the policy regime which, according to Lucas (1976), might have led to some instability in the parameters of the Phillips curve.

The paper is structured as follows. The specification of the Phillips curve to be estimated and tested is examined in Section 2, the methodology and empirical results are presented in Section 3, and Section 4 concludes and discusses some policy implications.

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 unemployment (or, more generally, a measure of the level of activity) would appear.

Formally, the above hypotheses can be stated in the following way (Layard, Nickell, & 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 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:

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

Regarding expectations on domestic and imported inflation, they were alternatively modelled by means of (i) their past values (i.e., in a backward-looking manner), as in the traditional Phillips curve; (ii) expected future inflation (i.e., in a forward-looking manner), as in the so called New Keynesian Phillips curve; and (iii) an average of past and future inflation, as suggested by Fuhrer

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[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, & Jackman, 1991), they have not been included in Eqs. (1) and (2).

and Moore (1995). The best results by far, and those presented below, were obtained using a simple AR(1) process. Hence, the equation to be estimated would be:

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

where ε_t is an error term. Notice, on the other hand, that this specification closely resembles the sticky-information Phillips curve of Mankiw and Reis (2002).

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 & King 1999). Source: Banco de España (2004a, Table 2.1).
    (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., Brown, Durbin, and Evans (1975) or Chow (1960), 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), Bai and Perron (1998, 2003a,2003b), and Liu, Wu, and Zidek (1997)for the case of multiple structural changes.

A key feature of the Bai and Perron procedure is that 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:

$$y_t = z_t'\delta_1 + u_t, \qquad t = 1, \ldots, T_1,$$
$$y_t = z_t'\delta_2 + u_t, \qquad t = T_1 + 1, \ldots, T_2,$$
$$\cdots$$
$$y_t = z_t'\delta_{m+1} + u_t, \qquad t = T_m + 1, \ldots, T.$$

where y_t is the observed dependent variable at time t, $z_t (q \times 1)$ is a vector of covariates, δ_j ($j = 1, \ldots, m + 1$) is the corresponding vector of coefficients, and u_t is the error term at time t. The indices

$T_1, \ldots, T_m$, 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 number 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 & Perron, 1998); the Schwarz modified criterion, LWZ (Liu et al., 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 Eq. (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]–[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

Table 1
Estimated Phillips curves for Spain, 1964–2002

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

Notes: a, b, and c denote significance at the 1%, 5%, and 10% levels, respectively. 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.

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, followed the next year by the Bank of Spain's announcement of its monetary control target.[2] 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, which points to a significant decrease in the persistence of domestic inflation after 1977.

Now we turn to investigate whether the estimated Phillips curves appearing in Table 1 are subjected to a similar structural change as their dependent variable. In this regard, recall the major transformations experienced by monetary policy during our sample period, which could be characterised as a change in the policy regime. We apply Bai and Perron's procedure as before, and the results are shown in Table 3, where columns [1]–[3] correspond to the three specifications of the empirical model in Table 1.

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[2] 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, which led to a social pact between the government, political parties, and labour unions. The pact was complemented with the withdrawal of the previously accommodating monetary policy by the Bank of Spain.

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

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

Note: See 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 conventional 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 and policy implications

Last 30 years have contemplated an ongoing debate on the usefulness of the Phillips curve. Following the emergence of the Lucas critique, the Phillips curve was put heavily into question as regards its ability to characterise inflation dynamics, and as a policy tool, because of its alleged instability in the face of changes in the economic environment.

On the other hand, the Spanish economy can represent an interesting case of study, since she has been able to decrease to a great extent her traditionally high inflation rates. And this occurred simultaneously with major shifts in the instrumentation of monetary policy, which could be characterised as a change in the policy regime that might have led to some instability in the parameters of the Phillips curve, according to Lucas (1976).

In this paper we have tried to investigate, by means of recent econometric developments, whether the traditional Phillips curve has been stable over a long time period, using Spanish data for the years 1964–2002. Specifically, we have made use of 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.

A structural break was detected in the series for domestic inflation rate at 1977, which can be related to the anti-inflation program following the "Moncloa Agreements", signed in October of that year. On the contrary, we were 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.

Overall, our results would support the existence of a trade-off between inflation and the level of activity, with inflation rising in booms and decreasing in slumps, which would reflect the business cycle and the effects of monetary policy, and would be basically stable over a long-term horizon. In fact, the traditional Phillips curve is still an important piece in many macroeconometric models, used for policy analysis; a recent example is Fagan, Henry, and Mestre (2005). Starting from here, some significant policy implications can be drawn.

Firstly, recall that our estimated Phillips curves make use of traditional backward-looking inflation expectations, since they proved to be clearly significant, unlike their forward-looking counterpart. Notice also that our specification was similar to the sticky-information Phillips curve of Mankiw and Reis (2002). According to Ball (2000), backward-looking expectations can be interpreted as a "near-rational rule of thumb" in the sense of Akerlof and Yellen (1985), given that it is costly to gather and process the information needed for fully rational inflation forecasts.

However, the use of backward-looking expectations has been recently dismissed by the advocates of the New Keynesian Phillips curve, where inflation expectations are modelled in a forward-looking way. Yet, although based on rigorous microeconomic foundations, such a specification has been the subject of increasing criticism on several grounds. So, for instance, expectations of future prices have been shown to be empirically unimportant 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 generally, some recent studies find that backward-looking, autoregressive, representations of an economy usually prove to be more stable than micro-founded models with forward-looking expectations (Estrella & Fuhrer, 2003; Rudebusch, 2005); and even the econometric procedures used to estimate the New Keynesian Phillips curve have been also recently criticized (Ma, 2002; Rudd & Whelan, 2005).

On the other hand, we have found a trade-off between inflation and the level of activity in the short run, but also in the long run, since our estimates of the coefficient on lagged domestic inflation were always below one (see Table 1).[3] This is a logical consequence of assuming explicitly an open economy framework in the theoretical model of Section 2, since the coefficient on lagged domestic inflation in Eq. (5) should be equal to σ, i.e., the weight of domestic goods in the consumer price index, which is always lower than one. In other words, even though workers were able to respond fully to expected inflation in order to keep their desired real wage, and as far as domestic prices are not the only component of the consumer price index, the long-run aggregate supply curve (and hence its dynamic equivalent, the Phillips curve) would have a positive slope. Such a result, which roots back to the classical contribution of Sachs (1980), is usually neglected in the literature, typically concerned with the closed economy assumption, more adequate for the US than for the European economies.

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[3] A Wald test on the null hypothesis that the coefficient on lagged domestic inflation was equal to one, distributed as a $\chi^2(1)$, gives the values 37.0, 37.0 and 38.0, respectively, for the equations in columns [1]–[3] of Table 1. Accordingly, the null hypothesis would be rejected in all cases.

Another reason that could yield a non-vertical Phillips curve in the long run has been suggested by Akerlof, Dickens, and Perry (2000). According to these authors, the near-rational behaviour of agents when inflation rates are low enough, would lead to wage and price setters to respond less than proportionally to expected inflation. The empirical relevance of money illusion in macroeconomics has been recently illustrated in Fehr and Tyran (2001).

Finally, recall the main conclusion of the paper: in spite of having detected a structural break in the domestic inflation series, which we related to a particular policy change, we found no evidence that the Spanish Phillips curve was unstable in the long run. But this result should be taken with caution. We have found a relationship between inflation and the level of activity that we were unable to characterise as unstable, but if policymakers try to exploit it, in the sense of using it as a "policy menu" (i.e., getting higher inflation in exchange for a higher level of activity, or *vice versa*), the relationship might become unstable.

In this regard, as argued by Fuhrer (1995), maybe the reason for not detecting instability in our estimated Phillips curve is that the policy changes occurring along our sample period have not been large enough. That is, despite the important modifications in the management of monetary policy in Spain during those years, described in the introduction to the paper, it is still possible that the changes in policy regime needed to trigger instability into the Phillips curve should be even stronger.

To conclude (and with all these caveats in mind), it would seem that, in Fuhrer (1995) words, the Phillips curve is "alive and well".

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