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AN EMPIRICAL STUDY OF THE CYCLICAL EFFECTS OF MONETARY POLICY IN SPAIN (1977-1997)

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In this paper, we provide empirical evidence for the Spanish economy, over the period 1977-97, on whether monetary policy shocks have had different effects on real output growth depending on the state of the business cycle. To do so, we adopt an extension of Hamilton's(1989) Markov Switching Model, as recently proposed by Garcia and Schaller(1995), where shocks to an interest rate policy rule followed by the Bank of Spain are allowed to affect both the growth rate of output and the transition probabilities of moving from one phase to another. The analysis is carried out both at the aggregate level and the sectorial level, with the aim of addressing the following questions:(i) Does monetary policy have the same effect regardless of the current phase of economic fluctuations?, (ii) Does monetary policy only have an incremental effect on output growth rate within a given state or does it also affect the probability of a state switch, and, (iii) How do the aggregate and sectorial results compare?

Keywords: State asymmetries, monetary policy, interest rate shocks, switching regime models

(*JEL* C32, D92, E52, E58)

1. Introduction

Traditionally, the empirical analysis of the potentially asymmetric effects of unanticipated monetary policy changes on real aggregate activity has focused on testing for two particular versions of asymmetry:

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(i) *the traditional Keynesian asymmetry*, associated to the "sign" of the shocks, and (ii) *the standard menu costs asymmetry* related to the "size" of those shocks. The underlying intuition behind the first type of asymmetry hinges upon the familiar Keynesian assumption that nominal wages are flexible upwards and rigid downwards. That implies that "positive" shocks in nominal demand are bound to be neutral while "negative" shocks might be associated with lower output and employment. As for the second type, the underlying motivation stems usually from models with menu-costs in price-setting, according to which "big" monetary policy shocks will be neutral whereas "small" shocks are deemed to have real effects. This is so since a fixed price strategy is subject to first-order costs when shocks are large (relative to the size of the menu-cost) but only to second-order costs when shocks are of moderate size.

There is a large literature establishing the theoretical microfoundations of both types of asymmetry. For example, Caballero and Engel (1992) and Tsiddon (1991), *inter alia*, have analyzed S-s type price adjustment rules which lead to a convex aggregate supply curve, as in the Keynesian framework; likewise, Akerlof and Yellen (1985) and Blanchard and Kiyotaki (1987), *inter alia*, have examined the issue of whether menu costs can lead to significant nominal stickiness in response to monetary shocks. More recently, the possibility of having a "hybrid" asymmetry, according to which only "small negative" shocks affect real output, has been considered as well in models which combine dynamic menu-costs with a positive steady-state inflation rate. As pointed out by Ball and Mankiw (1994), the underlying explanation for that type of asymmetry is that, in the face of a positive steady-state inflation rate, "small negative" shocks should bring the actual price closer to the optimal price and conversely so for positive shocks. Thus, in the face of a positive shock, firms will adjust their prices more frequently and, therefore, real effects will be absent.

As regards the empirical evidence on the above-mentioned types of asymmetry, a large number of papers have found support for some of them. These include, to name a few, Cover (1992), DeLong and Summers (1988), Karras (1996), and María-Dolores (1997), whose results support the existence of the "Keynesian asymmetry" in the US, a number of European countries, and Spain, respectively. Ravn and Sola (1996), in turn, using an empirical approach similar to the one adopted in this paper, conclude that there is stronger evidence for the "hybrid" asymmetry in the US.

Besides the previous cases, there is, however, a further type of asymmetric effect which, despite its potential relevance, has seemingly received far less attention in the empirical literature. It is the so-called "state" asymmetry which relates to the issue of whether monetary policy affects real activity differently in different phases or states of the business cycle. There are at least two strong theoretical arguments which justify that type of asymmetry. First, the above-mentioned price adjustment models leading to a convex aggregate supply curve could be re-interpreted as implying that monetary policy will have stronger real effects during recessions, when output is below its long-run level, than in expansions, when the aggregate supply curve is almost vertical. Secondly, and most important, there is a broad class of models which provide support to the "state" asymmetry by modelling explicitly the credit or lending channel of the monetary transmission mechanism. According to this well-known interpretation, if financial markets face information asymmetries, credit and liquidity may be readily available in booms whilst agents may find it harder to obtain funds in recessions. Therefore, it is likely that monetary policy will have stronger effects on their consumption and investment decisions during recessions than during expansions. This is the mechanism derived in the extensive research on financial market imperfections including agency costs and debt overhang models, developed, *inter alia*, by Bernanke and Gertler (1989), Gertler (1988), Kiyotaki and Moore (1998), Lamont (1995) and Repullo and Suarez (1996).

In spite of the relevance of the previous arguments, so far there is hardly any evidence on that type of asymmetry in the literature[1]. Indeed, to our knowledge, the only available empirical study on the existence of "state" asymmetries is Garcia and Schaller (1995), who find strong evidence that monetary policy has had larger effects during recessions than during expansions in the US, over the period 1955-93.

In view of the scarcity of empirical studies on this topic, our goal in this paper is to provide further evidence on how monetary policy affects real activity depending on the state of the economy, using this time Spanish quarterly data over the period 1977-97 both at the aggregate and at the sectorial level. The contribution of this study may be interesting for two reasons. First, Spanish financial markets have been

[1]There is, however, a large literature on asymmetries in business cycles considered from a univariate perspective. See, e.g., Neftci (1984), Beaudry and Koop (1993), Huh (1993) and McQueen and Thorley (1993).

less developed over the sample period than in the US and, in this sense, Spain may provide a good illustration of an economy where the factors highlighted by the credit channel in explaining "state" asymmetries might be operative. Second, the analysis of "state" asymmetries at the sectorial level may be also useful insofar as it helps to ascertain which sectors are most important in explaining the aggregate results and which behave in a different way.

For that purpose, we follow Ravn and Sola(1996) and García and Schaller (1995) in applying the Hamilton's (1989) Markov Switching methodology (MS henceforth) to endogenously determine from the data the dating and the transition probabilities from one cyclical phase to another in multivariate models with regime shifts, where output growth is allowed to depend on shocks to the monetary policy rule. The use of the MS methodology is particularly appropriate to analyze the cyclical effects of monetary policy in a country like Spain since, unlike happens with the NBER dating for the US cycle, an "officially approved" dating of the Spanish cycle is not yet available. Hence, in this way, the MS approach will allow us to examine a number of interesting questions ranging from whether monetary policy shocks have different effects on output depending on the current phase of the business cycle, or on the phase where the change in monetary policy took place, to whether changes in the monetary policy stance are also able to alter the transition probabilities from a recession to an expansion and conversely.

To measure the stance of monetary policy in Spain, we emphasize changes in the marginal interest rate of intervention of the Bank of Spain in the daily interbank market. This choice is bound to be a controversial one since, until the mid-1980s, the Bank of Spain was controlling a broad monetary aggregate(ALP) and therefore it was not officially targeting a short-term interest rate[2]. Notwithstanding, several studies (see Ayuso and Escriva,1997 and Maria-Dolores,1997) have provided both narrative and econometric evidence that changes in the intervention rate over most of 1977-97 period have been usually the result of deliberate policy actions, therefore suggesting that, to a reasonable extent, changes in such an interest rate may be considered as a relevant indicator of monetary policy stance in Spain. Further,

[2]For a detailed description of the evolution of monetary policy in Spain during the sample period considered in this paper, see Servicio de Estudios del Banco de España(1997).

to control for the potential endogeneity of the intervention rate, we consider a measure based on innovations from a small VAR which includes the interest rate as one of the variables in the system and where identification proceeds in a recursive way. As it will be discussed later, the shocks identified in this way turn out to have acceptable properties in describing the standard features of the monetary transmission mechanism in Spain.

Proceeding in this way, we obtain several interesting results. First, we find evidence in favour of "state" asymmetries at the aggregate level, whereby interest rate shocks have larger effects in recessions than in expansions. Second, we find that those shocks not only have a different state-dependent linear effect on output growth, yet they also seem to affect directly the transition probabilities. Finally, we find that the previous asymmetries seem to be particularly relevant for Construction and Services, two sectors which are especially sensitive to the financial constraints highlighted by the credit channel approach.

The rest of the paper will be structured in the following way. Section 2 offers a brief explanation of the empirical methodology which is used throughout the paper and presents results for aggregate GDP in a MS model with constant transition probabilities. Section 3 repeats the analysis, this time disaggregating GDP into its main four sectors. Section 4, in turn, relaxes the previous assumption by allowing the transition probabilities to be affected by monetary policy shocks in a direct way. Finally, Section 5 concludes.

2. The aggregate approach: a Markov switching model for GDP growth

In this section we start by presenting the different econometric models which underlie the results discussed in the remaining sections of the paper. First, we introduce a brief discussion of basic aspects of the MS methodology in a univariate framework (see Hamilton,1989,1990,1991). Next, we explain how the "state" asymmetric effects of monetary policy can be tested by allowing policy shocks to affect the growth rate of output in multivariate extensions of the previous model.

2.1 A Markov switching model for aggregate growth rate of real output

As is well-known, Hamilton's(1989) MS approach is based on the assumption that the actual state of the economy, i.e., recession (r) or expansion (e), is determined by an unobserved latent random variable with a Markovian structure. The version presented below is a mean-shift one where the average growth rate of GDP(μ) is allowed to vary depending on whether the economy is in an expansion (μ_e) or in a recession (μ_r). In what follows, we will denote that univariate model as HMS model, according to which GDP growth is assumed to be determined by the following AR(p) process:

$$\begin{aligned} \Delta y_t \ = \ & \phi_1 \Delta y_{t-1} + \ldots + \phi_p \Delta y_{t-p} + \mu_r (1 - \phi_1 - \ldots - \phi_p) + \\ & \Delta\mu (S_t - \phi_1 S_{t-1} - \ldots - \phi_p S_{t-p}) + \sigma \eta_t \end{aligned} \qquad [1]$$

where Δy is the quarterly growth rate seasonally adjusted GDP, $\Delta\mu = \mu_e - \mu_r$, S_t is the state variable and η_t is distributed N(0,1).

The state variable in the model, S_t, is assumed to follow a discrete-time Markov process which is characterized by the following transition probability matrix:

$$\begin{bmatrix} p_{rr} \ p_{er} \\ p_{re} \ p_{ee} \end{bmatrix} = \begin{bmatrix} p_{rr} & 1 - p_{ee} \\ 1 - p_{rr} & p_{ee} \end{bmatrix} \qquad [2]$$

where:

$$p_{ij} = \Pr(S_t = j / S_{t-1} = i), \text{ with } \sum_{j=r}^{e} p_{ij} = 1 \text{ for all i} \qquad [3]$$

and p_{ij} is the probability of going from state i to state j (e.g. , p_{re} is the probability of going from a recession to an expansion, etc.). Initially, we assume that the transition probabilities are constant over time and are determined by the following logistic distribution functions:

$$p_{rr} = \Pr(S_t = r / S_{t-1} = r) = \frac{\exp(\theta_r)}{1 + \exp(\theta_r)} \qquad [4]$$

$$p_{ee} = \Pr(S_t = e / S_{t-1} = e) = \frac{\exp(\theta_e)}{1 + \exp(\theta_e)} \qquad [5]$$

where θ_r and θ_e are the parameters that determine the probabilities of being in a recession and in an expansion, respectively.

As Hamilton(1989) has shown, the above assumptions allow us to obtain a sequence of joint conditional probabilities $\Pr(S_t = i, \ldots, S_{t-s} = j / \Phi_t)$, which are the probabilities that the GDP growth series is in state i or $j(i, j = r, e)$ at times t, $t-1$, until $t-s$ respectively, conditional upon the information available at time t. By adding those joint probabilities we can obtain the so-called smoothed filter probabilities, namely, the probabilities of being in states r or e at time t, given information available at time t:

$$\Pr(S_t = j/\Phi_t) = \sum_{i=r}^{e} \ldots \sum_{j=r}^{e} \Pr(S_t = i, ..., S_{t-s} = j/\Phi_t) \text{ i,j = e,r} \quad [6]$$

where Φ_t is a set information in period t. The smoothed filter probabilities provide information about the regime in which the series is most likely to have been in time t at every point in the sample. Therefore, they turn out to be a very useful tool for dating phase switches and will be reported for each of the models estimated throughout the paper.

Table 1 shows the results obtained from the estimation of the MS model in [1] with p = 4 for the sample 1977:3-1997:4. The choice of four lags turns out to be appropriate to obtain serially uncorrelated residuals[3]. The first regime corresponds to a low growth phase with a quarterly growth rate of 0.20% (0.80% annually). This result implies that it is more appropriate to interpret that phase as one of mild growth rather than a proper recession. The second regime, in turn, corresponds more clearly to an expansion phase with an average quarterly growth rate of 0.96% (3.8% annually).

As regards the probabilities of remaining in each regime, they are estimated to be 0.90 for a recession and 0.70 for an expansion, implying mean durations of 10 quarters and 3.3 quarters in recessions and expansions, respectively[4]. Hence, the probability of switching from a recession to an expansion is 0.10 while the probability of the converse switch is 0.30. Figures 1 and 2 plots quarterly GDP growth rates and the smoothed filter probability of being in an expansion. As can be observed, the largest probabilities are those in the second half of the 1980s, whilst the lowest probabilities correspond to the recession in the

[3]Moreover, when extending the maximum lag length to p_{max}=8,the BIC lag length criterion chooses p=4

[4]Mean duration in state i is defined as $1/(1\text{-}p_{ii})$, i=e,r.

FIGURE 1
GDP growth

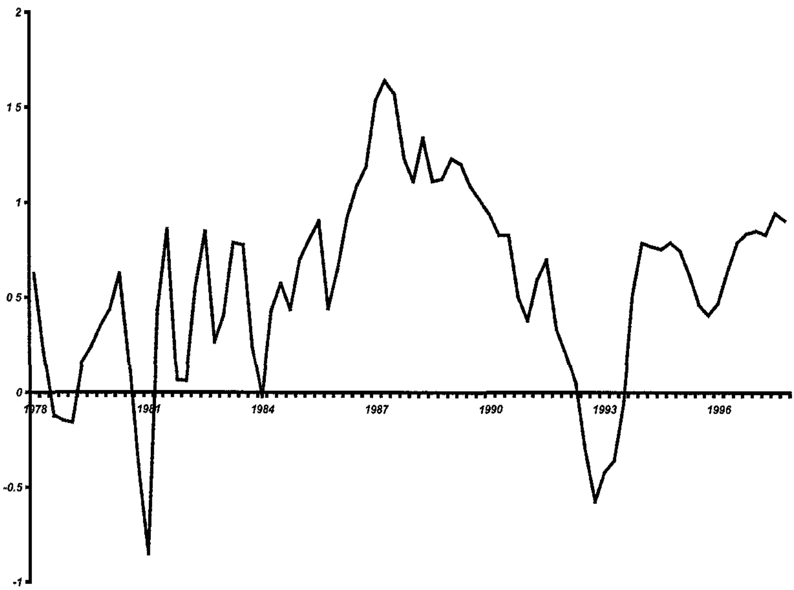
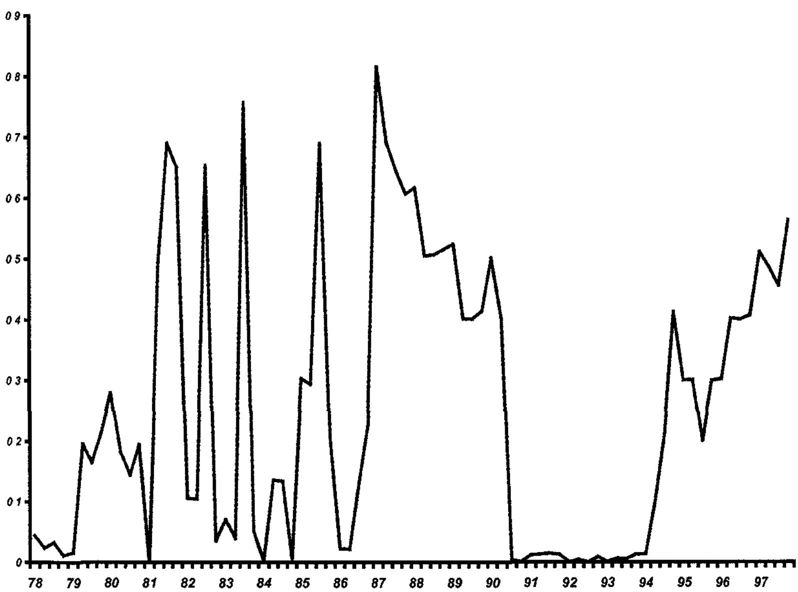


FIGURE 2
Estimated probabilities of an expansion for GDP growth



first half of the 1990s. It is particularly interesting to notice the steady rise of the filtered probability since 1994, reflecting the consolidation of the current expansionary phase in Spain. Before 1987, the filtered probability oscilate a lot reflecting the lack of clear business cycle fluctuations in GDP growth.

Finally, in order to check whether the chosen HMS model in [1] is appropriate, it seems convenient to test whether the above specification is not rejected against other alternative non-linear or linear specifications. For that purpose, first we nest the previous mean-shift specification within a more general HMS model where both the mean and variance are allowed to shift with the state variable. The restriction that the variance of the residuals is invariant to the phase is not rejected using a LR test, which yields a p-value of 0.28. Next, we test the constant variance/mean-shift specification against a linear AR(4) specification using Hansen's (1992) approach, where linearity constitutes the null hypothesis. We find a p-value of 0.02 rejecting linearity at the 5% level. Therefore, the HMS model reported in Table 1 seems to capture reasonably well the stochastic time series properties of the data at hand and will remain the baseline specification for the further analysis in the rest of the paper.

2.2 An extended Markov switching model including monetary policy shocks

To analyze the asymmetric effects of monetary policy on output growth we will follow Garcia and Schaller(1995) in considering multivariate extensions of the HMS model in [1]. In these models, output growth is allowed to be affected by interest rate shocks which, as noted in the Introduction, is the measure we choose in this paper to gauge the stance of monetary policy. We consider two alternative versions of the extended model. The first version is one where the different effects of monetary policy on output growth may exist depending on the state of the economy at the time where policy action was taken. In the second version we modify slightly the previous dating to allow this time for different effects depending on the current state of the economy, rather than on the state at the time when the shock took place.

Before discussing those models, however, a brief explanation of the method used to measure the monetary shocks is in order. As noticed in the Introduction, there are good reasons to believe that changes in the intervention interest rate provide a good indicator of the stance of monetary policy in Spain over the sample period analyzed in this paper. Nonetheless, interest rates are not exogenous since they may be affected by the set of explanatory variables which determine the monetary policy reaction function. One possibility is to use directly the residuals from an estimated reaction function. However, those residuals may not necessarily represent pure monetary policy shocks, since they may be correlated with the residuals from the other equations determining the explanatory variables. Thus, a standard way to deal with this problem is to orthogonalize the residuals though a structural VAR identification approach, possibly using a short-run lower triangular Choleski decomposition. This is the route chosen here, where we estimate a VAR for a six variable system(X_t) with the intervention rate placed as the penultimate equation, such that

$$A(L)X_t = U_t \quad ; X_t = (e, y, p, p^c, m, i, s)' \qquad [7]$$

where e is the (log of) DM/$ exchange rate, y is the (log of) GDP, p is the (log of) CPI, p^c is the (log of) Commodity Price Index (in US dollars), m is the (log of) ALP monetary aggregate, i is the marginal intervention rate interest rate of the Bank of Spain, s is the (log of) Pta/DM exchange rate and U_t is a vector of innovations distributed as N(0, $\sum$). The VAR is estimated in levels with two lags of each variable and includes a linear time trend. Similar ordering appear in Cochrane (1998) and Gordon and Leeper (1991) in VARs where they try to identify monetary policy shocks in the US. However, Shioji (1997) claims that a non-recursive identification scheme yields better results when modelling Spanish monetary policy though he considers a slightly different set of variables in the system[5]. Notwithstanding, our simple identification scheme yields satisfactory results in terms of the signs of impulse response function of the variables to a one standard deviation interest rate shock[6]. In particular, money and prices respond negatively to a positive(contractionary) shock in interest rates. Likewise, both output and the Pta/DM exchange rate fall, the latter effect reflecting an appreciation of the exchange rate following the rise in interest rate. So, for example, the "liquidity", "price" and

[5] The order in the system is (e, p, y, i, m, s) where the variables are defined as before. Notice that p^c is omitted. He assumes a short-run block recursive identification structure distinguishing between (e,p,y) and the (i,m,s) blocks.

[6] The results are not reported to save space. However, they are available upon request. The quarterly standard deviation of the interest rate shock is 128 basis points

"exchange rate" puzzles, which often appear in small VARs with recursive identification schemes, seem to be absent once we condition on the commodity price index and on the DM/$ exchange rate. The former variable captures potentially inflationary pressure that the central bank may take into account when setting interest rates while the latter variable captures external nominal shocks in a small open economy framework. Thus, under the chosen short-run identification scheme, the orthogonalized residuals of i_t have a reasonably good interpretation as monetary policy shocks. In what follows we will denote those shocks as u_t.

Next, once the interest rate shocks have been obtained, we address the issue raised in the first extended model, namely, whether there are asymmetric effects of monetary policy on output growth depending on the business cycle phase that the economy was undergoing at the time the shock took place. For that purpose, we estimate the following extended MS specification, which in short is labelled as (u_t, $S_{t-\imath}$).

$$\begin{aligned}\Delta y_t &= \phi_1 \Delta y_{t-1} + ... + \phi_p \Delta y_{t-p} + \mu_r(1-\phi_1 - ... - \phi_p) + \\ &\quad \Delta\mu(S_t - \phi_1 S_{t-1} - ... - \phi_p S_{t-p}) + \beta_{or} u_t + \\ &\quad \Delta\beta_o S_t u_t + \beta_{1r} u_{t-1} + \Delta\beta_1 S_{t-1} u_{t-1} + ... + \beta_{rs} u_{t-p} + \\ &\quad \Delta\beta_p S_{t-p} u_{t-p} + \sigma\eta_t \end{aligned} \quad [8]$$

where $\Delta\beta_\imath = \beta_{\imath e} - \beta_{\imath r}$, and $\beta_{\imath r}$ and $\beta_{\imath e}$ are the coefficients on the shocks in recessions and expansions, respectively. The remaining variables are the same as in the HMS specification given in (1).

The second column of Table 1 presents detailed estimates of the differential effects of the shocks in expansions and recessions[7]. Figure 3, in turn, depicts the impulse response function of the GDP growth rate to a one-standard deviation increase in u_t. It becomes clear that the effects are much larger in mild growth phases than expansions. Indeed, the null hypothesis that the expansion coefficients are zero ($H_0 : \beta_{\imath e} = 0$) is not rejected with a p-value of 0.18, whereas the corresponding null for recessions ($H_0 : \beta_{\imath r} = 0$) is clearly rejected

[7]Note that the standard errors of the estimated coefficients in this model and in the remaining ones might not be consistent due to the "generated regressors" nature of the monetary shocks, as Pagan (1984) has shown. However, the joint estimation of the VAR and the MS model proved to be too cumbersome. Nonetheless Pagan (1984) shows that the inconsistency is less important when the generated regressor is a residual, as in this case, than when it is a fitted value.

with a p-value of 0.02. Accordingly, the null hypothesis of symmetry ($H_0 : \beta_{ir} = \beta_{ie}$) is also rejected, this time with a p-value of 0.002.

TABLE 1
Models for GDP growth
Sample period. 1977: 3-1997.4 (Dependent variable Δy_t)

Estimated coeficients	HMS	u_t, S_{t-j}	u_t,S_t
μ_r	0.20	0.52	0.59
	(1.85)	(2.36)	(2.81)
μ_e	0.96	1.14	1.22
	(4.31)	(4.96)	(5.54)
ϕ_1	1 47	1.52	1.47
	(9 80)	(14.48)	(14.84)
ϕ_2	-1.20	-1.20	-1 14
	(5.06)	(7.50)	(7 26)
ϕ_3	0.9	1.02	1.01
	(4.95)	(6.30)	(6 69)
ϕ_4	-0 42	-0.43	-0.45
	(3 50)	(4.31)	(4 87)
β_{0r}	-	-0.01	-0.02
	-	(0.60)	(0.55)
β_{0e}	-	-0.01	-0 05
	-	(0.36)	(0 29)
β_{1r}	-	-0.03	-0.05
	-	(2 85)	(2 79)
β_{1e}	-	-0 01	-0.03
	-	(0.55)	(1 26)
β_{2r}	-	-0 02	-0.006
	-	(1.38)	(1.27)
β_{2e}	-	0.008	-0.004
	-	(0.40)	(1.06)
β_{3r}	-	-0.04	-0.001
	-	(2.05)	(1.15)
β_{3e}	-	-0.01	-0.02
	-	(0.77)	(1.64)
β_{4r}	-	-0.003	0.007
	-	(2.00)	(0.35)
β_{4e}	-	0.0073	0.001
	-	(1.17)	(0 07)
σ	0 04	0.03	0 03
	(5.18)	(5 89)	(5.86)
p_{rr}	0.90	0 95	0.95
	(31.11)	(33.33)	(47 5)
p_{ee}	0.70	0.87	0.87
	(3 35)	(11 78)	(11 01)
Log-Likelihood	66.27	81 76	75.70

Note. t- values in parenthesis

Next, we estimate the second version of the model, assuming now that the effects of monetary policy actions on output growth depend on

FIGURE 3
GDP growth Impulse-Response function to an unanticipated increase in interest rates (Conditioning on the state at the time of the increase)

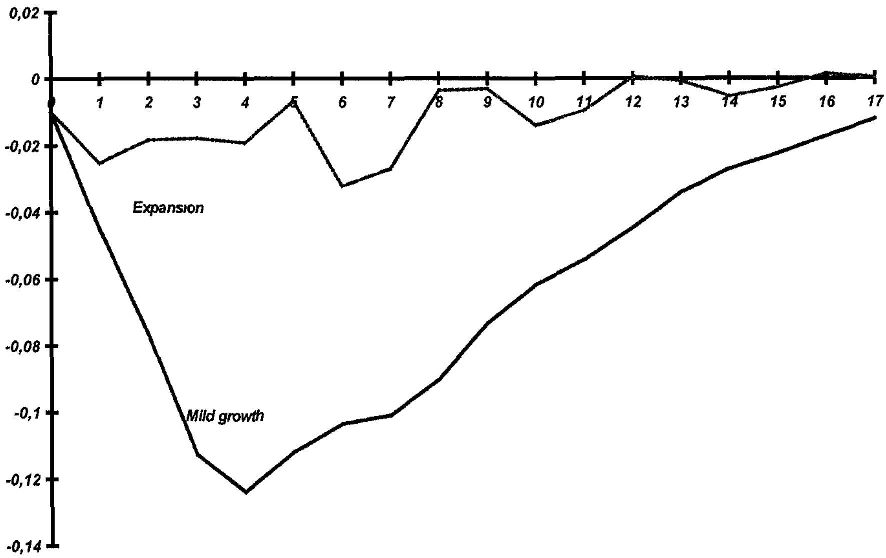
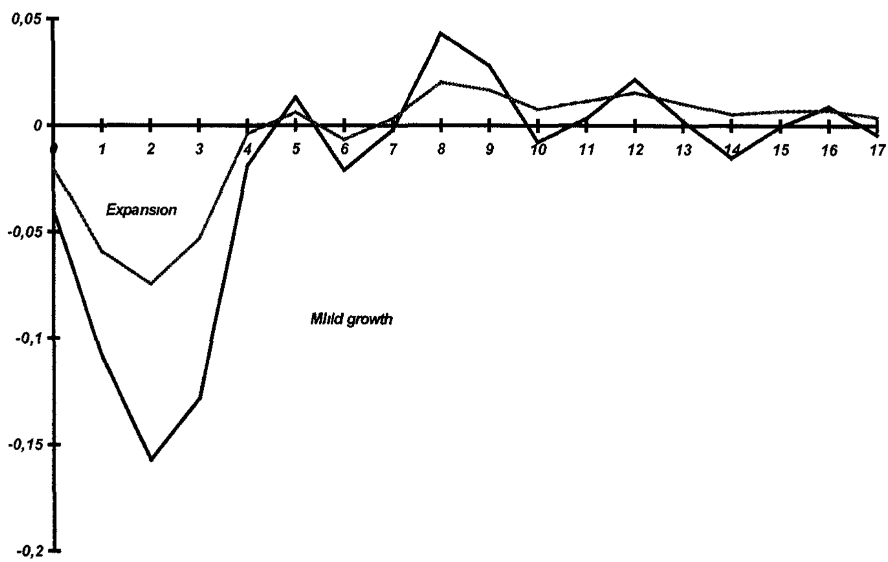


FIGURE 4
GDP growth Impulse-Response function to an unanticipated increase in interest rates (Conditioning on the current state)



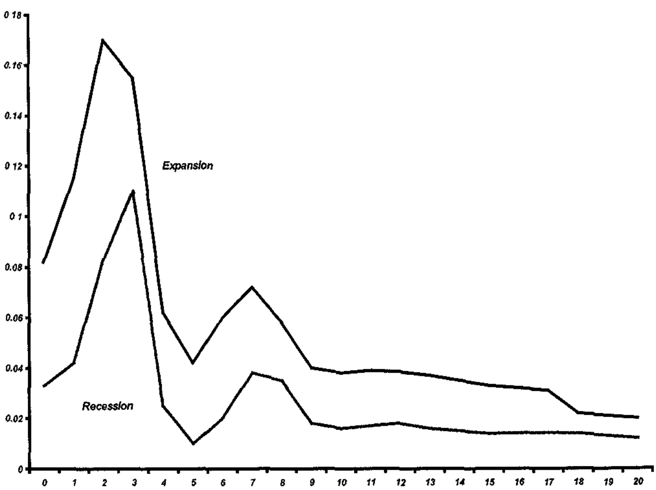
the current state of the economy. It seems important to investigate this second possibility since an unanticipated change in interest rate in period t-s may have different effects in period t, depending on whether the economy is currently in an expansion or in a recession. To do that, we estimate the following extended MS specification, denoted in short as (u_t, S_t).

$$\begin{aligned}\Delta y_t &= \phi_1 \Delta y_{t-1} + \ldots + \phi_p \Delta y_{t-p} + \mu_r(1-\phi_1 - \ldots - \phi_p) + \\ &\quad \Delta\mu(S_t - \phi_1 S_{t-1} - \ldots - \phi_p S_{t-p}) + \beta_{or} u_t + \Delta\beta_o S_t u_t + \\ &\quad \beta_{1r} u_{t-1} + \Delta\beta_1 S_t u_{t-1} + \ldots + \beta_{rs} u_{t-p} + \Delta\beta_p S_t u_{t-p} + \sigma\eta_t\end{aligned} \quad [9]$$

The results are reported in the third column of Table 1. The main difference with the estimates obtained for model [8] is that the coefficients on shocks during expansions turn out to be more significant, with a p-value of 0.04 for the null hypotheses $\mathrm{H}_0 : \beta_{ie} = 0$. However, both null hypotheses $\mathrm{H}_0 : \beta_{ir} = 0$ and $\mathrm{H}_0 : \beta_{ir} = \beta_{ie}$ turn out to be rejected with p-values of 0.002 and 0.04 respectively. The impulse-response function in Figure 4 shows that the asymmetry remains, though for a shorter period than in the previous case.

FIGURE 5

GDP growth Impulse-Response function to an unanticipated increase in interest rates (Conditioning on the state at the time of the increase)



Finally, in order to check that the results are robust to the use of dependent variable, we estimate the first version of the model using annualised inflation growth rather than GDP as the regressand. Since the previous evidence pointed out that, in the face of an unexpected increase in the interest rate, real effects were much larger in recessions, we should expect that inflation changes are larger in expansion than in recessions. Figure 5 reports the corresponding impulse-response function and confirms the previous conjecture[8].

Thus, the overall evidence in both exercises is that, following a contractionary monetary policy shock, the fall in output growth is much more dramatic when the economy is in a mild growth phase than when it is in an expansion, particularly when we condition on the state at the time of the shocks.

3. The disaggregated approach: Markov switching models for sectorial GDP growth rates

In this section we extend the previous analysis to examine how interest rate shocks affect sectorial GDP growth rates. For that purpose, we split total GDP into its four major components, namely, Agriculture (A), Manufacturing (M), Construction (C) and Services (S). To give an idea of the importance of value added in each sector relative to total GDP, we report the corresponding GDP shares at both extremes of the sample interval(1977 and 1997): 9.8%-4.7% (A), 34.1%-29.5% (M),7.1%-7.6%(C) and 49.4%-58.2% (S). Thus, while the Services sector has increased its share by almost 10 p.p over the sample period, the shares of Agriculture and Manufacturing have experienced a decrease in their shares of about 5 p.p each.

TABLE 2
Models for Sectoral GDP Growth Rates

	HMS(T)	HMS(A)	HMS(M)	HMS(C)	HMS(S)
μ_r	0.8 (2.8)	-1.0 (2.4)	-0.6 (3.5)	-2 4 (2.8)	2.0 (4.5)
μ_e	4.2 (4.3)	4.8 (2.9)	3.0 (5.9)	4.1 (2 1)	3 6 (6.2)
p_{rr}	0 90 (31.1)	0.87 (17.0)	0.79 (7.9)	0.59 (4.8)	0.87 (9.2)
p_{ee}	0.70 (3 3)	0.65 (5.4)	0.90 (22.5)	0.92 (10.2)	0.72 (3.3)
p_r	10	7.7	4.8	2.4	7.7
p_e	3.3	2 9	10	12.5	3.6

There are at least two reasons why the sectorial analysis may be useful. First, it helps to ascertain how robust are the results obtained at the aggregate level in sectors which may have undergone more severe recessions than the mild growth phase found for total GDP. Secondly, it

[8]We are grateful to Harris Dellas for suggesting this test to us.

FIGURE 6
Value Added growth in Agriculture

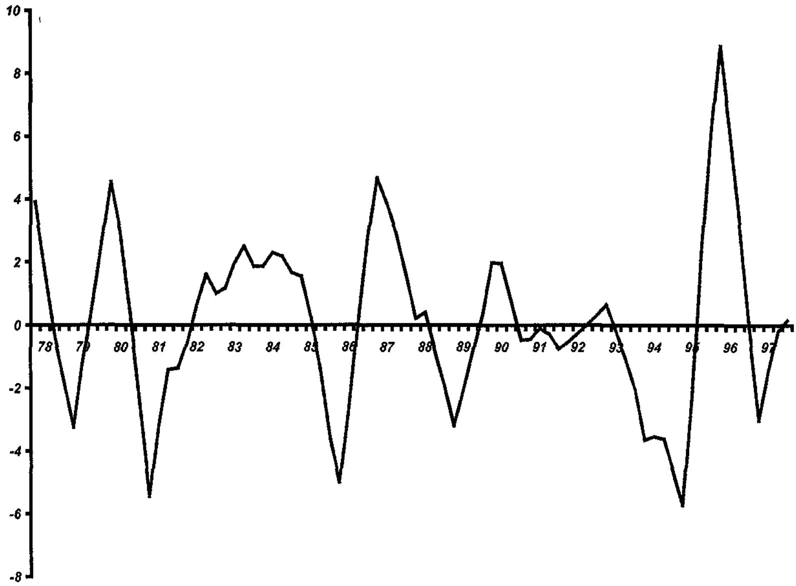
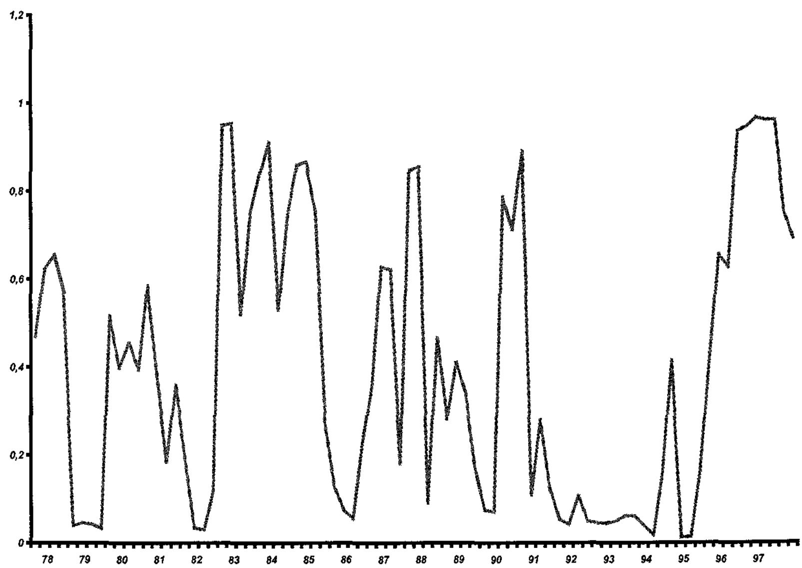


FIGURE 7
Filtered probabilities of an expansion in Agriculture



is an interesting exercise to find which sectors are more likely to suffer from "state" asymmetries on the basis of their financial characteristics.

Figures 6 to 13 show the value added growth rate in each sector together with the filter probabilities of recession estimated for the HMS model in [1]. Table 2 presents a summary of results, comprising the estimates of the different growth rates in expansions and recessions(μ_r and μ_e), the transition probabilities (p_{rr}, p_{ee}) and the mean durations in each phase (d_e and d_r). For comparative purposes, the results obtained for total GDP growth rate in Section 2 are also included in the first column. We can observe how the difference between average growth rates in expansions and recessions is much larger in Agriculture and Construction than in the total economy and the remaining two sectors. In particular, the Construction sector undergoes severe recessions, unlike what happens in Services and total GDP where recessions are better interpreted as mild growth phases. As for Services, given that it has the largest share in GDP, it is not surprising that its regime shifts (probabilities and durations) are found to be similar to those obtained for the aggregate case. As regards the transition probabilities, the probability of moving from a recession to an expansion is lower that the probability of moving in the opposite direction for Agriculture and Services, as it was the case with total GDP, and conversely for Manufacturing and Services. The patterns of transition probabilities and mean durations in each state are mirror images of each other. So, while recessions persist for about twice longer than expansion in Agriculture and Services, expansions turn out to be about two to three times longer than recessions in the remaining two sectors.

As for the asymmetric effects of monetary policy, we use again the (u_t, S_t) and (u_t, $\mathrm{S}_{t-\imath}$) versions of the multivariate extension of the MS model in [8] and [9]. Since the results are qualitatively similar, we will only report evidence from the second version of the model. The state dependent impulse-response functions for each sector are plotted in Figures 14 to 17. We find that in all cases the average growth rate is lower in a recession than in an expansion, supporting the evidence obtained at the aggregate level. In particular, it is interesting to notice that the "state " asymmetries are larger in Construction and Services, respectively. This is confirmed by the statistical tests on the joint null hypothesis of equality of coefficients in both phases, i.e. $\mathrm{H}_0 : \beta_{\imath r} = \beta_{\imath e}$, whose p-values are 0.06, 0.07, 0.009 and 0.006 for Agriculture,

FIGURE 8
Value Added growth ın Manufacturing

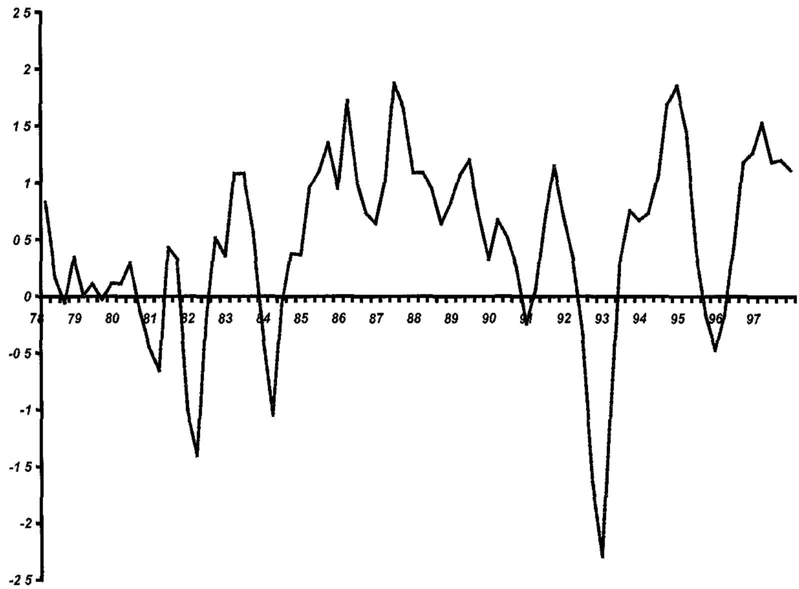


FIGURE 9
Fıltered probabilities of an expansıon in Manufacturing

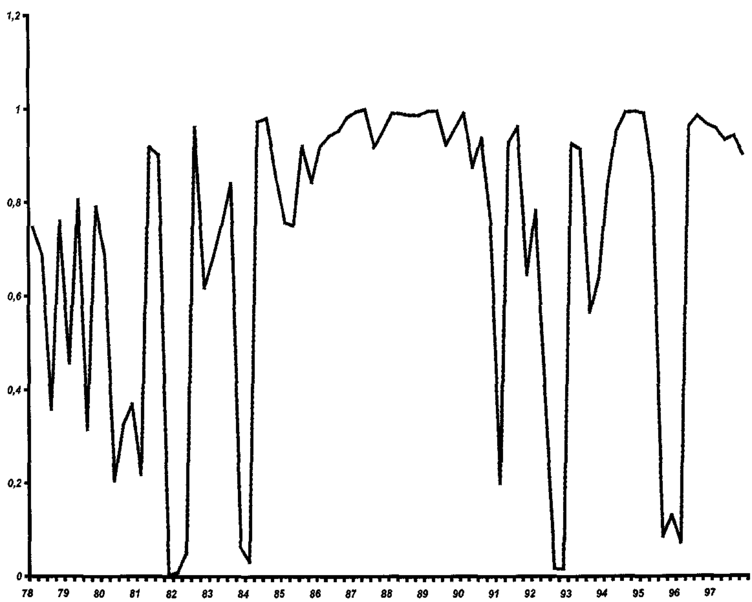


FIGURE 10
Value Added growth in Construction

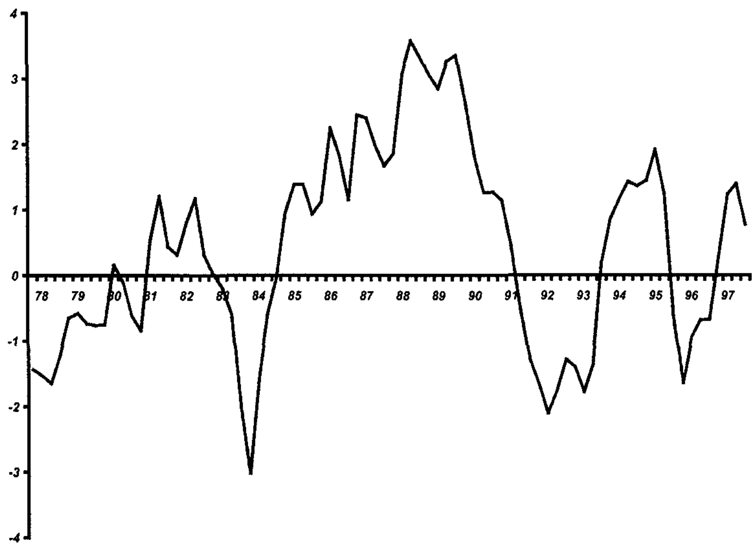


FIGURE 11
Filtered probabilities of an expansion in Construction

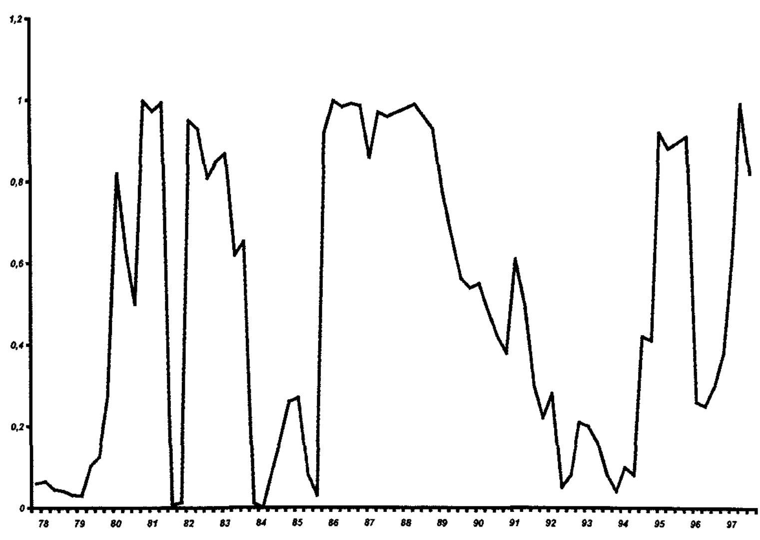


FIGURE 12
Value Added growth in Services

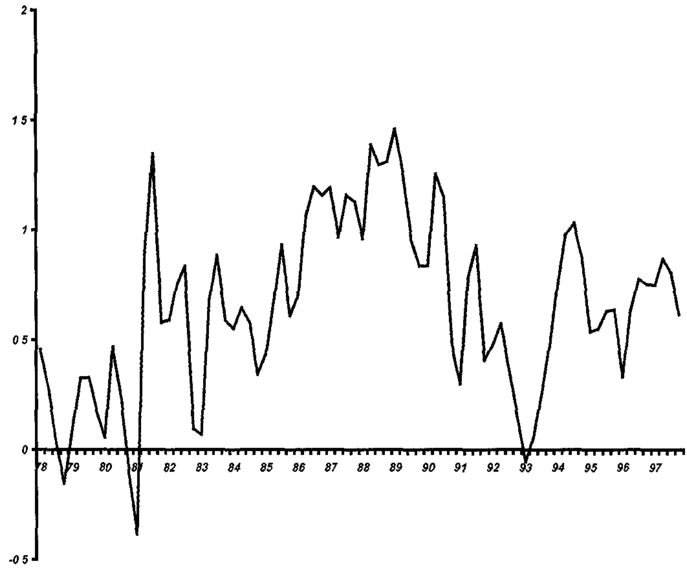


FIGURE 13
Filtered probabilities of an expansion in Services

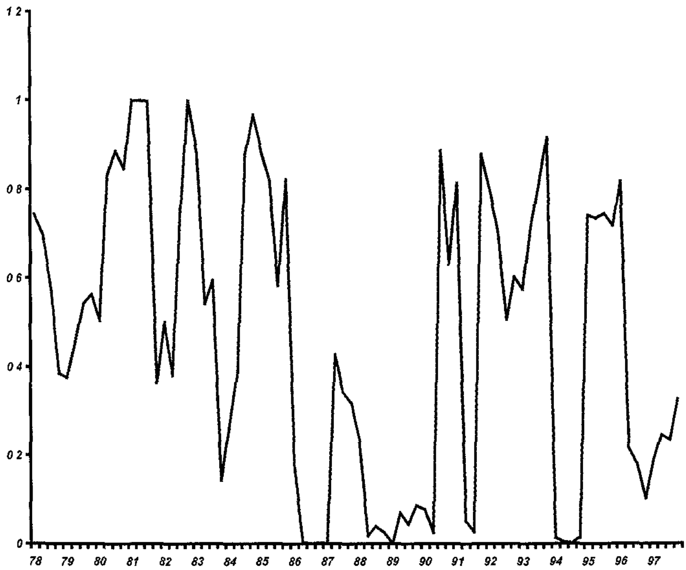


FIGURE 14
Impulse-Reponse function to an unanticipated increase in interest rates in Agriculture (Conditioning on the current state)

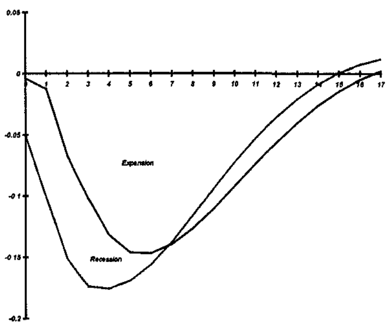


FIGURE 15
Impulse-Reponse function to an unanticipated increase in interest rates in Manufacturing (Conditioning on the current state)

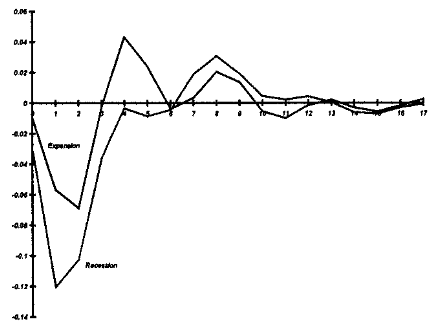


FIGURE 16
Impulse-Reponse function to an unanticipated increase in interest rates in Construction (Conditioning on the current state)

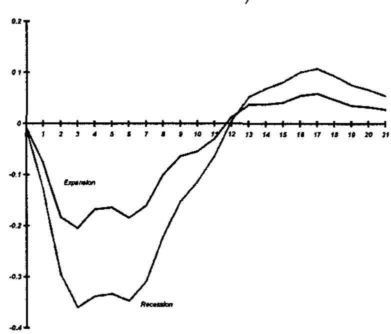
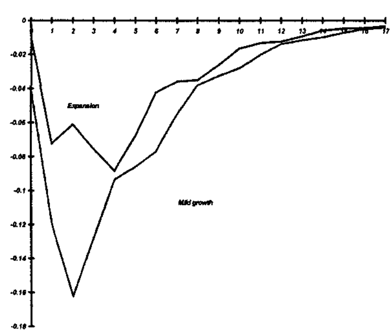


FIGURE 17
Impulse-Reponse function to an unanticipated increase in interest rates in Services (Conditioning on the current state)



Manufacturing, Construction and Services. The fact that we tend to find stronger asymmetries for the last two sectors could be somewhat justified in terms of the strength with which tight credit conditions may impinge on their cyclical behaviour. For example, small firms represent a larger share of total firms in Services than in other sectors and they are likely to face larger barriers to outside finance than larger firms do; for example the fixed costs associated with issuing public traded bonds may be much more important for small firms(see Gertler and Gilchrist, 1994). Likewise, mortgage loans in the Construction sector are generally financed by banks which tend to transmit changes in the intervention rate onto mortgage rates rather quickly and in this way, will exacerbate the effects of debt overhang during recessions[9].

4. The effects of monetary policy on State switches

Whereas in the previous sections we allowed for state dependence in the effects of interest rate shocks on output growth, the transition probabilities from one phase to another were not allowed to depend on those shocks. Thus, while we were able to test whether shocks had different incremental effects on output in each state, we were not able to examine the issue of whether those shocks might have a further effect on output growth by directly affecting the probability of a state switch. In this section, we address this issue by allowing those probabilities to depend directly on the shocks[10]. Hence, the logit functions [5] and [6] are replaced by:

$$\begin{aligned} p_{rr} &= \Pr(S_t = r/S_{t-1} = r) \\ &= \frac{\exp(\theta_{or} + \theta_{1r}u_t + \theta_{2r}u_{t-1} + \theta_{3r}u_{t-2})}{1 + \exp(\theta_{or} + \theta_{1r}u_t + \theta_{2r}u_{t-1} + \theta_{3r}u_{t-2})} \end{aligned} \qquad [10]$$

$$\begin{aligned} p_{ee} &= \Pr(S_t = e/S_{t-1} = e) \\ &= \frac{\exp(\theta_{0e} + \theta_{1e}u_t + \theta_{2e}u_{t-1} + \theta_{3e}u_{t-2})}{1 + \exp(\theta_{oe} + \theta_{1e}u_t + \theta_{2e}u_{t-1} + \theta_{3e}u_{t-2})} \end{aligned} \qquad [11]$$

[9]Some evidence in favour of the above tentative conclusions comes from the financial accounts of Spanish firms(see Central de Balances del Banco de España, 1997), broken down by sector. According to that source of information, the external finance premium in Construction and Services was about 1.5p.p and 0.8 p.p higher, repectively, than the average premium for the overall economy during the 1990s. We are grateful to Ignacio Hernando for providing this information to us.

[10]The maximization algorithm with variable transition probabilities is considered in Filardo(1994)

where only two lags of u_t have been chosen in [10] and [11] to keep the number of parameters manageable[11]. Further, as in García and Schaller(1995), to isolate the effect of the shocks from the linear effect examined above, we constrain the latter to be zero. Thus, we estimate the HMS specification [1] rather than the multivariate extensions [8] and [9]. Notice that since the probability of remaining in a recession (expansion) is increasing in the $\theta_{ir}(\theta_{ie})$ parameters, we should expect θ_{ir} to be positive and θ_{ie} to be negative when considering a shock that raises interest rates. In other words, an increase in interest rates reduces the probability of remaining in an expansion and increases the probability of remaining in a recession.

The results of the different models for aggregate and sectorial GDP are offered in Table 3, where it can be observed that the signs of the θ coefficients are broadly in agreement with the above interpretation. Thus, a positive interest rate shock increases p_{rr} and decreases p_{ee} while the converse happens with a negative shock.

To ascertain the effects of interest rate shocks on the transition probabilities we propose a similar experiment to the one undertaken by Garcia and Schaller (1995), who use changes in the Fed Funds rate to illustrate those effects in the US. Suppose that the Bank of Spain were to have produced a sequence of positive (contractionary) interest rate shocks of 50 basis points in each of the three successive quarters (from t to $t-2$) with which u_t appears to affect p_{rr} and p_{ee} in [10] and [11]. Then, the question is: How would those shocks affect the transition probability from an expansion to a recession?. Likewise, if instead we consider a similar sequence of negative (expansionary) shocks of the identical magnitude, how do they affect the probability of a converse switch?.

Table 4 shows the estimated changes for total GDP and its four components, based on the estimates obtained for the θ coefficients in Table 3. For the sake of brevity, we only report the changes in p_{er} (p_{re}) when a positive(negative) interest rate shock is considered. As for the aggregate GDP model, we find that before the string of positive shocks takes place, the probability of going from an expansion to a recession (p_{er}) is 0.32 and that, after the sequence of shocks has taken place, it increases to 0.44. As regards the sectorial evidence, we find that the increase in the previous transition probability is smaller in Manufacturing (from

[11] Moreover, when trying specification with four lags, neither the third nor the fourth lags were significant.

0.12 to 0.18) and larger in Services (from 0.34 to 0.52), with the remaining two sectors showing a similar change to the one obtained for the aggregate GDP. With regard to the effects of the sequence of negative shocks, we find that the probability of moving from a recession to an expansion (p_{re}) increases from 0.12 to 0.23 in the aggregate case. Similar increases take place in Agriculture and Manufacturing, while a much larger rise is found in Construction (from 0.43 to 0.63) and Services (from 0.13 to 0.35).

TABLE 3
Markov Switching Models with variable transition probabilities

Coefficients	GDP Growth	Agricul	Manuf.	Construc.	Services
μ_r	0.50	-0.32	-0.18	-0.79	0.42
	(2.15)	(1.78)	(2.15)	(1.96)	(3.42)
μ_e	0 94	1.01	0 77	1.16	0.91
	(1 93)	(3.13)	(3 65)	(3.47)	(2.41)
ϕ_1	1.26	1.42	1.18	1.49	1.16
	(10.25)	(10.75)	(12.21)	(13.65)	(11.34)
ϕ_2	-0.72	-0.79	-0 65	-1.06	-0.60
	(6 87)	(6.44)	(3.72)	(5.37)	(8.42)
ϕ_3	0.52	0.21	0.29	0.77	0.26
	(3.13)	(2.07)	(2.19)	(1.98)	(2.23)
ϕ_4	-0.12	-0 09	-0 07	-0.33	-0.06
	(2.05)	(1.68)	(1.45)	(1.77)	(1.76)
σ	0.03	0.39	0.08	0.15	0.01
	(5 24)	(6 33)	(5.83)	(7.33)	(5.67)
θ_{0r}	1.98	2.12	1.35	0.28	1.87
	(12.23)	(5.67)	(5 67)	(5.67)	(3.74)
θ_{1r}	0 60	0.56	0.30	0.86	0 56
	(3.12)	(1.12)	(1.93)	(1.34)	(1 27)
θ_{2r}	0.29	0.84	0.59	0.25	0.95
	(1.94)	(1.29)	(1.21)	(1.21)	(0.77)
θ_{3r}	0.45	0.18	0.11	0.51	0.99
	(1.85)	(1 03)	(1.14)	(1.15)	0.63)
θ_{0e}	0.74	0.56	2.05	1.86	0.66
	(7.65)	(3 14)	(3.76)	(4.72)	(6 45)
θ_{1e}	-0.50	-0 87	-0.32	-0.76	-0 44
	(5.73)	(1 17)	(1.46)	(1.17)	(1.24)
θ_{2e}	-0.38	-0 83	-0.56	-0.34	-0.75
	(1.34)	(0 86)	(0.65)	(0.74)	(1.39)
θ_{3e}	-0.12	0 78	-0.18	-0.73	-0.29
	(1 08)	(0.25)	(0.57)	(0 32)	(1 43)
Log-Likelihood	80.05	43.22	21.14	8.97	68.79

Note t- values in parenthesis

Summing up, the overall evidence presented in this section is in line with the results previously obtained, namely, "state" asymmetries of monetary policy, stemming this time from the potential direct effects of policy shocks on the transition probabilities, are present at the aggregate level and they seem to be particularly relevant in Construction and Services.

TABLE 4
Effects of interest rates shocks on transition probabilities

	GDP		A		M		C		S	
	a/u_t=50 b p (t to t+2)									
	before	after	before	after	before	after	before	after	before	after
Pee	0.68	0 56	0.64	0.55	0.88	0.82	0.87	0 72	0 66	0.48
Per	0.32	0.44	0.36	0.45	0.12	0 18	0.13	0.28	0.34	0.52
	b/u_t=-50 b p (t to t+2)									
	before	after	before	after	before	after	before	after	before	after
Prr	0 88	0.77	0 89	0.79	0.79	0 70	0.57	0.47	0.87	0.65
Pre	0.12	0.23	0.11	0.21	0 21	0.31	0.43	0.63	0.13	0.35

5. Conclusions

In this paper we have examined whether monetary policy shocks have an asymmetric effect on output growth in Spain over the period in which the Bank of Spain has kept an active monetary policy. In particular, we have tested for the so-called "state" asymmetries of monetary policy, according to which the effects of policy actions on output may depend on the current phase/state of the business cycle that the economy is undergoing or on the one that prevailed at the time the shock took place. Further, the possibility that policy shocks may directly affect the transition probabilities of one phase to another has also been addressed. Testing for that type of asymmetry in Spain may be relevant since Spanish financial markets have been less developed than those in the US, which is the only country for which evidence of this issue has been so far obtained. Our analysis is undertaken both at the aggregate and sectorial levels with the aim of identifying those sectors in which "state" asymmetries are stronger.

We find strong evidence that monetary policy shocks, measured as orthogonalized shocks to the intervention rate of the Bank of Spain obtained from a simple VAR, have significantly larger effects during a recession than during an expansion, especially when we condition on the state at the time of the shock. For example, following a positive one-standard deviation shock (about 130 basis points), annual output growth can decrease by about 0.5 p.p. at the trough of a recession whereas it only falls by about 0.1 p.p at the peak of an expansion. Likewise, we find evidence in favour of shocks having a direct effect on the probability of a state switch. For example, an unanticipated increase of 50 basis points in the interest rates in each of three successive quarters increases the probability of moving from an expansion to a recession from 0.32 to 0.44 for the aggregate economy. Conversely, an unanticipated reduction of identical magnitude in interest rates, increases the probability of moving from a recession to an expansion from 0.12 to 0.23. The analysis at the sectorial level, comprising the four main components of GDP, reinforces the above-mentioned results. This is particularly so when we consider the evidence obtained for Construction and Services, two sectors which depend heavily on bank lending and where, therefore, the credit channel of the monetary transmission mechanism is likely to be most relevant in explaining their cyclical fluctuations.

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Resumen

En este trabajo se analiza si la política monetaria tiene efectos asimétricos sobre la producción en las distintas fases del ciclo económico en España, tal y como sugieren diferentes modelos en los que se analizan las implicaciones derivadas de las existencia de precios fijos o restricciones de carácter financiero. Para realizar dicho análisis adoptamos una extensión de la metodología de series temporales sujetas a cambio de régimen de Hamilton (1989) propuesta por García y Schaller (1995), donde se permite que los shocks a la regla de política monetaria seguida por el Banco de España afecten a la tasa de crecimiento de la producción y a las probabilidades de cambiar de una fase a otra del ciclo. El análisis se desarrolla a nivel agregado y sectorial con objeto de responder a las siguientes preguntas: i) ¿Produce la política monetaria un efecto distitntos en las fases del ciclo económico?, ii) ¿Es mayor el efecto de la política monetaria en aquellos períodos en los que se produce un cambio de fase del ciclo económico o dentro de una determinada fase del ciclo? y iii) ¿Qué diferencias existen entre los resultados a nivel sectorial y a nivel agregado?

Palabra clave: Política monetaria, asimetrías de estado, shocks a reglas de política monetaria, series temporales sujetas a cambio de régimen .

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