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Abstract

This paper studies the joint behaviour of inflation and unemployment in Spain over the period 1964-1995. We analyze the implications both of *full hysteresis* in unemployment and high *inflation persistence* for inference regarding dynamic Phillips trade-offs and sacrifice ratios in the Spanish economy in response to a demand shock. We organize our empirical approach as a structural but eclectic one. In doing so, we use a bivariate Structural VAR to identify demand and supply shocks. Our eclecticism comes from using three alternative just-identifying outlines, giving rise to alternative interpretations of the unemployment-inflation dynamics. Our results indicate that for a wide range of plausible identifying assumptions it is possible to identify a stable long-run Phillips trade-off. Nonetheless, augmenting the bivariate VAR with a third variable (public expenditure) to disentangling monetary from "non-monetary" shocks indicate that the trade-off may be transitory rather than permanent.

1. INTRODUCTION

The Spanish annual rate of (CPI) inflation has come down from 24.6% in 1997 to 2.5% nowadays. However, the big blot is still unemployment, now slightly down at just under 22% (the largest among OECD countries). From 1977 to 1989, the unemployment rate jumped from 5.1% to 17.2%. Throughout the 1990s it has averaged 20.1% with a maximum of 24.6% in the first quarter of 1994. The fact that the unemployment rate is currently close to what the inflation rate was in 1977 and, conversely, that the inflation rate is only slightly below the unemployment rate in the mid-1970s may look at first sight as if the unemployment-inflation trade-off is close to 1:1. In this paper we tackle this issue in greater depth.

Disentangling the sacrifice ratios implied by those figures is a key issue for judging the performance of the Spanish economy over the last two decades. A possible interpretation of the above mentioned episodes could be a keynesian one under which, contractionary aggregate demand policies are a major cause of the high unemployment rate which, in turn, leads to a fall in inflation. Moreover, in the presence of important hysteretic mechanisms, the trade-off between unemployment and inflation could be a permanent one[1]. Alternative interpretations are related, on the one hand, to the important role played by expectations and credibility-related phenomena (neoclassical-monetarist-rational expectations models) and, on the other hand, to the predominant role played by structural supply-side shocks (real business cycle models); allowing for the latter may even imply the absence of long-run and even short-run trade-offs (see Sargent, 1982).

Naturally, these alternative views imply: (i) different roles for the economic shocks leading the sources of business cycle fluctuations and stochastic growth; (ii) different roles for the propagation mechanisms of those shocks; and, (iii) drastic differences for economic policy design. These simple and well-known ideas pose difficulties for the researcher in

[1] Hysteresis in Spain is related to the existence of high firing costs and long unemployment benefit duration. See, e.g., Bentolila and Dolado (1994), Dolado and López-Salido (1996) and Dolado and Jimeno (1997).

answering the following relevant questions: How convincing is the identification of demand/supply shocks within this unemployment-inflation framework?; How can we measure the costs of disinflation?; How does this depend upon high persistence in both unemployment and inflation?; and finally, How does the sacrifice ratio change across the identification schemes and over time?.

The goal of this paper is to deal with those issues through the analysis of the joint dynamic behaviour of inflation and unemployment in Spain over the period 1964-1995. Our approach will consist of modelling a Vector Autoregression (VAR) in both variables, conditioning on other exogenous variables, and imposing several identifying restrictions on the VAR innovations in order to recover demand and supply shocks. After all, the idea behind the unemployment-inflation trade-off and the sacrifice ratio is to analyse the dynamic responses of both variables to a demand shock, hence the importance of distinguishing between them.

Specifically, our approach will be based upon the Structural Vector Autoregression (SVAR) methodology, following an earlier paper by King and Watson (1994). We do this for two reasons. First, because until the beginning of the 1990s, most of the research on the unemployment-inflation trade-off was based upon the estimation of quasi-structural equations relating wage/price-inflation and the unemployment rate, i.e., the so-called Phillips curve approach (see, e.g., Gordon, 1970) where many of the relevant variables were treated as exogenous and where dubious identification restrictions and measurement problems abounded (see Manning, 1993). And, secondly, because it allows us to gauge how robust some of the results obtained with the previous approach are, under the competing SVAR methodology. Furthermore, as above mentioned, by using the SVAR methodology to map reduced form innovations onto shocks, we will be able to pose a well defined question, namely, What effects will demand shocks have on the levels of inflation and unemployment? and, therefore, What trade-offs and sacrifice ratios are implied?

Following King and Watson (1994) we will be eclectic in the choice of identification schemes which permit to uncover the shocks. In particular, we will choose three identification outlines which give rise to the same reduced form and, in this sense, they fit the data equally well. Yet, they have substantially different implications for the trade-off between unemployment and inflation, and for the interpretation of particular historical episodes. Specifically, we use three strategies: i) a real business-cycle, ii) a monetarist, and iii) a keynesian outline, respectively. By presenting a menu of results based on the different schemes we can examine the robustness of the results according to the different interpretations, and check which one seems more plausible according to prior beliefs.

At this stage, it is important to remark that we introduce several modifications to the King and Watson (1994)' methodology. First, we add some exogenous variables supposedly capturing some further supply shocks. Second, we modify their "keynesian" and "monetarist" identification strategies by choosing outlines in which the short-run impact of demand shocks on unemployment is maximized, under the first case, and where inflation is completely dominated by demand shocks in the long-run, under the second case. We believe that both modifications lead to neater interpretations of the underlying conceptual outlines. And, finally, we check the robustness of the results in the bivariate SVAR by adding a third variable to the VAR which enables to separate monetary from fiscal shocks within the demand class of shocks.

The rest of the paper is structured as follows. We begin in Section 2 by discussing the identification issues related to a bivariate VAR of inflation and unemployment and the possible identification outlines considered in the paper. In Section 3, we discuss the properties of the data and report the empirical results. In Section 4, we consider the issues related to the subsample stability of our estimates and the plausibility of the outlines to explain significant disinflationary periods in the recent history of Spain. In Section 5, we address the robustness of some key parameter estimates to changes in the identifying restrictions. Finally, in Section 6, some conclusions are drawn.

2. ECONOMIC AND ECONOMETRIC ISSUES

2.1. Structural VAR Representation and the Identification Problem

Let us assume that the Phillips curve takes the following structural representation:

$$\Delta u_t = \lambda \Delta \pi_t + \sum_{j=1}^{p} \alpha_{u\pi,j} \Delta \pi_{t-j} + \sum_{j=1}^{p} \alpha_{uu,j} \Delta u_{t-j} + \varepsilon_t^s \qquad [1]$$

where λ indicates the contemporaneous effect of changes in the inflation rate ($\Delta\pi$) on the unemployment rate changes (Δu), and ε_t^s is a structural shock, which will be defined below.

This expression is not the usual one found in the empirical analysis of the Phillips curve. The differences can be stated as follows. First, unemployment appears in the LHS on [1] rather than in the RHS and, conversely happens with inflation; the reason is that, following King and Watson (1994), we define the Phillips trade-off as the ratio of the change in unemployment rate to the change in inflation rate, i.e. $(\partial u/\partial \pi)$. This is the inverse of the traditional measure (see, e.g. Gordon, 1990, and the references therein), and it will be useful because the hypothesis of absence of trade-off corresponds to a zero value for this expression, instead of $-\infty$. Second, we represent the relationship in first differences, rather than in levels, accounting for the importance of both hysteresis mechanisms in the unemployment rate and high persistence in the inflation rate. Both stochastic properties are well documented elsewhere and can be taken as "stylized facts" of the Spanish economy over the sample period used in this paper[2].

In order to close the model, we next consider the demand side of the economy, represented through the following equation:
where the parameter δ reflects the contemporaneous effect of changes in unemployment on the inflation changes, and ε_t^d is another structural

[2] See, for instance, Dolado and López-Salido (1996) and Andrés (1991) where a battery of unit root tests cannot reject the null hypothesis of a unit root in both series.

$$\Delta \pi_t = \delta \Delta u_t + \sum_{j=1}^{p} \alpha_{\pi\pi,j} \Delta \pi_{t-j} + \sum_{j=1}^{p} \alpha_{\pi u,j} \Delta u_{t-j} + \epsilon_t^d \qquad [2]$$

shock which again is yet to be defined.

Whether the system [1] - [2] is an adequate representation of the supply and demand sides of the economy is a debatable issue. To shed some light on our chosen interpretation, we first summarize the key points somehow heuristically; and, next, we will proceed to formalize those ideas, rearranging [1] and [2] in a more familiar SVAR context.

Let us start by interpreting equation [1]. It can be obtained from standard price-setting and a wage-setting equations given by

$$P = A^{-1}(1+\mu)W \qquad [3]$$

$$W = P^e AF(u,u_{-1},z) \qquad [4]$$

where P = price level, W = nominal wage, P^e = expected price level; μ = price-cost mark-up, z = wage pressure (aggregate supply) variables, A = productivity. Equation [3] corresponds to non-competitive price setting under a constant-return-to-scale production function and [4] is the typical wage-setting relation underlying many theories of wage determination, where the presence of u_{-1} allows for hysteretic mechanisms[1]. Substituting [4] in to [3], and log-linearizing yields.

$$\pi_t = \pi_t^e + \mu + z - \xi_1 u + \xi_2 u_{-1} \qquad [5]$$

Next, we assume that $\pi_t^e = \pi_{t-1}$; that there is full hysteresis, so that $\xi_1 u - \xi_2 u_{-1}$ is proportional to Δu; that the markup μ is constant; and that z is a process governed by the innovation ϵ^s. Then, inverting equation [5] with u as the dependent variable yields an equation similar to [1]. As regards equation [2], the easiest way to interpret it is as an

[1] See, e.g., Layard, Nickell and Jackman (1991) for a good review of hysteresis models.

aggregate demand equation where output growth (Δy) is just a function of the acceleration of real money balances[4]. Using Okun's law to convert Δy into Δu, and assuming that the innovation to $\Delta^2 m$ is ϵ^d yields an equation that, when inverted, is similar to [2].

If, as is a standard practice in the literature on SVAR (see Blanchard and Quah, 1989), it is assumed that ϵ^d and ϵ^s are independent i.i.d. processes, the system formed by [1] and [2] is not identified unless one further restriction is imposed. To deal more formally with the identification problem, we use the stacked SVAR form[5]:

$$\alpha(L)X_t = \mu + \varepsilon_t \qquad [6]$$

$$\alpha(L) = \sum_{j=0}^{p} \alpha_j L^j \quad ; \quad X_t = (\Delta u_t \ , \ \Delta\pi_t)' \quad ;$$

$$\varepsilon_t = (\varepsilon_t^s , \varepsilon_t^d)' \quad ; \quad E(\varepsilon_t \varepsilon_t') = \Omega = [\sigma_{ij}] \quad i,j=1,2 \quad ;$$

where μ is a vector of deterministic terms, and:

$$\alpha_0 = \begin{pmatrix} 1 & -\lambda \\ -\delta & 1 \end{pmatrix} ; \quad \alpha_j = \begin{pmatrix} \alpha_{uu_j} & \alpha_{u\pi_j} \\ \alpha_{\pi u_j} & \alpha_{\pi\pi_j} \end{pmatrix} , \quad j=1,\ldots,p$$

As noted earlier, we interpret equation (1) as the Phillips curve. Correspondingly, the structural disturbance ε_t^s in expression [1] corresponds to a *supply shock*. Conversely, the structural error term ε_t^d in [2] is interpreted as a *demand shock*. We will assume that shocks are mutually uncorrelated, $\sigma_{12}=0$, so that any contemporaneous correlation between π_t and u_t arises from nonzero values of the parameters λ and δ. This framework will allow us to address a number of relevant issues:

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[4] The possibility of extending this set of arguments is discussed in Section 5.

[5] Notice that we write down the model in first differences, so that both u_t and π_t are assumed to I(1) and not cointegrated. See Section 3 for further details.

(i) the estimation of the short- and long-run effects of both demand and supply shocks on unemployment and inflation, since the specification in first differences implies that shocks potentially have long-lasting effects.

(ii) the estimation of the Phillips curve trade-off (PTO, henceforth), namely, the inverse of the slope of the Phillips Curve-. This concept traces out the relative dynamic effects of demand shocks on unemployment and inflation. Formally, it can be computed as:

$$PTO = \frac{\partial u_{t+k} / \partial \varepsilon_t^d}{\partial \pi_{t+k} / \partial \varepsilon_t^d} \;;\; k = 0,1,\ldots,\infty \qquad [7]$$

(iii) tests for both long and short-run neutrality; i.e, the verticality of the short and long-run Phillips curve. These hypotheses hold when expression [7] is zero for k=0 and $k \rightarrow \infty$, respectively.

From the previous discussion, it is clear that the structural model given by the SVAR system in [6] is not identified. To see this consider the equivalent reduced form VAR derived from the model[6]:

$$\Delta u_t = a(L)\ \Delta u_{t-1} + b(L)\ \Delta \pi_{t-1} + e_{ut} \qquad [8a]$$

$$\Delta \pi_t = c(L) \Delta u_{t-1} + d(L)\ \Delta \pi_{t-1} + e_{\pi t} \qquad [8b]$$

or in stacked form:

$$\Gamma(L) X_t = e_t \qquad [9]$$

where $e_t = (e_{ut}\ e_{\pi t})'$ is a vector of zero-mean identically distributed innovations; $\Gamma(L) = I - \Gamma_1 L - \Gamma_2 L^2 - \ldots - \Gamma_p L^p$ is an autorregressive polynomial lag matrix with all its roots outside the unit circle; and, $E(e_t e_t') = \Sigma = [\omega_{ij}]$ is the variance-covariance matrix of the reduced form residuals.

Comparing [6] and [9], the following relationships hold: $\Gamma_i = -\alpha_0^{-1}\ \alpha_i$, and

[6] Notice that, for simplicity, deterministic terms have been omitted from the formulae.

$e_t = -\alpha_0^{-1} \varepsilon_t$. Thus, the matrices α_i and the variance covariance matrix of the structural shocks, Ω, are determined by the following set of equations:

$$-\alpha_0^{-1} \alpha_i = \Gamma_i \quad , \; i = 1, \ldots, p \qquad [10]$$

$$\alpha_0^{-1} \Omega (\alpha_0^{-1})' = \Sigma \qquad [11]$$

The identification problem can be stated as follows. The first set of equations linking the variance of e_t and ε_t imposes no restrictions on α_0. That is, there are no restrictions on the coefficients on lags entering equation [6]. Thus, equation [11] determines the unknowns in both α_0 and Ω as a function of the variance-covariance matrix of the reduced form innovations. Yet, since Σ is a 2 x 2 symmetric matrix, only three unknown parameters can be identified in α_0 and Ω. Hence, even after assuming that $\sigma_{12}=0$, the four parameters σ_{11}, σ_{22}, λ and δ cannot be identified, and one additional restriction is required.

Nevertheless, by adding whatever single restriction one should wish, all the resulting models are just-identified and, hence, their unrestricted reduced forms fit the data equally well. Notwithstanding, each one will have different implications for disentangling: i) the sources of business cycle fluctuations and stochastic trends; ii) the trade-off between unemployment and inflation; and, iii) the policy interpretations of particular historical episodes. In this respect, the following section explores three alternative identifying restrictions which seem to us especially meaningful from an economic point of view. The three schemes share the orthogonality assumption, $\sigma_{12}=0$, and none of them imposes long-run verticality of the Phillips curve, since this is one of the propositions we wish to test.

2.2. Three Alternative Identification Schemes

A simple comparison of expressions [6] and [9] implies that the innovations of the reduced form, e_{ut} and $e_{\pi t}$, can be expressed as linear combinations of the structural shocks. In particular, simple derivations lead to the following relationships: $e_{ut} = D(\lambda\varepsilon_t^d + \varepsilon_t^s)$ and $e_{\pi t} = D(\varepsilon_t^d + \delta\varepsilon_t^s)$, with $D=(1-\lambda\delta)^{-1}$.

Using these relationships and the VAR reduced form (expressions [8a] and [8b]) a closed-form solution for the long-run PTO (expression [7]) can be calculated:[7]

$$\lim_{k\to\infty} \frac{\partial u_{t+k}/\partial\varepsilon_t^d}{\partial\pi_{t+k}/\partial\varepsilon_t^d} = \frac{(1-d(1))\lambda+b(1)}{(1-a(1))+\lambda c(1)} = \frac{\alpha_{u\pi}(1)}{\alpha_{uu}(1)} \qquad [12]$$

Thus, the long-run PTO is a function of the short-run PTO (λ) and the long-run relationships between unemployment and inflation (the lag-polynomials of the reduced form VAR evaluated at L=1). Notice also that if $c(1)<0$, the long-run PTO does not have any discontinuity for $\lambda<0$, since the denominator in expression [12] will always be positive, assuming $0<a(1)<1$.

As noted earlier, to just-identify the model we can use both the short-run and long-run restrictions implied by alternative economic models. In particular, in this section we discuss three different sets of identifying restrictions based upon: (i) a *real business cycle* approach, (ii) a *rational expectations-monetarist* approach, and (iii) a *keynesian* approach, respectively.

2.2.1. A Real Business Cycle Approach (RBC)

From this standpoint, real variables, such as the unemployment rate, are not affected by nominal shocks. That is $e_{ut}=\epsilon^s_t$ and, hence, identification is achieved by setting $\lambda=0$, i.e. the short-run trade-off is zero. This restriction has been recently used by King and Watson (1994) as an interpretation of the RBC characteristics. Notice that it does not

[7] To obtain this we solve [8a] and [8b] for the long-run trends in unemployment and inflation.

imply that the long-run Phillips trade-off is zero since, as can be seen from expression [12], the latter will only be the case if b(1)=0. Hence, the existence of long-run Granger-causality from inflation to unemployment in the VAR is crucial for the existence of a long-run PTO in this case.

2.2.2. A Monetarist Approach (M)

From this viewpoint, there is no long-run impact of supply shocks on the level of inflation, i.e., inflation is a demand (monetary) phenomenon in the long-run, i.e. $\alpha_{\pi u}(L)=0$ in [6]. It is easy to check that this restriction implies $\delta = -c(1)/1-\alpha(1)$, which, together with $\lambda = (\omega_{12}-\delta\omega_{11}) / (\omega_{22}-\delta\omega_{12})$ obtained from [11], defines a corresponding value for λ.

This identification assumption is similar in spirit to that used in Roberts (1993) in identifying "core inflation". King and Watson (1994), in turn, use a so-called Rational Expectations-Monetarist identification whereby an implicit value of λ is estimated as $cov(u,\tilde{m})/cov(p,\tilde{m})$ where $\tilde{m}$ stands for unanticipated money (see Barro and Rush, 1980). Since the validity of the hypothesis that only unanticipated money matters in dubious for the Spanish economy (see Dolado, 1984) we rather prefer the one chosen here. Notice that, in this case, the PTO will only be zero if $\lambda=b(1)/1-d(1)$.

2.2.3. A Keynesian Approach (K)

The keynesian view implies that short-run (one-quarter) unemployment fluctuations are completely dominated by demand shocks, whereas in the long-run both types of shock are allowed to affect unemployment in a possibly permanent way. This implies a choice of λ such that it maximises the ratio $\lambda/1-\lambda\delta$ (see the relation between e_u and ϵ^d) subject to $\delta = (\omega_{12} - \lambda\omega_{22}) / (\omega_{11}-\lambda\omega_{12})$. This procedure differs from the one chosen by King and Watson (1994) who implicitly define λ by using the contemporaneous value of u_t as an instrument to estimate [1] or equivalently, estimating [1] by OLS using the reverse regression of π_t onto u_t and relevant lags, as performed by Gordon (1970) and other researchers in the Keynesian tradition. Again, we believe that our identification outline is neater.

2.3. The Lucas-Sargent Critique

In this section we just want to point out briefly that the fact that we cannot reject a unit root in the inflation process over the sample period saves the analysis from the traditional Lucas-Sargent criticism. The critique runs as follows. Suppose that unemployment is simply a function of unexpected inflation as in Lucas (1972a,b) and that this hypothesis is tested in the following expectations-augmented version of [8a]

$$u_t = \lambda\pi_t - \lambda^*\pi_t^e + \eta_t \qquad [13]$$

where $\pi^e_t = E_{t-1}(\pi_t)$, and the natural rate hypothesis implies that $\lambda=\lambda^*$.

Assume that π_t is governed by the process $\pi_t = \rho_1(L)\pi_{t-1} + \rho_2(L)u_{t-1} + \epsilon_t$, where, without affecting the basic result, the contemporaneous value of u_t has been excluded. Then, under rational expectations, $\pi_t^e = \rho_1(L)\pi_{t-1} + \rho_2(L)u_{t-1}$. Thus, the reduced for unemployment and inflation relation is given by

$$u_t = \lambda\pi_t - \lambda^*[\rho_1(L)\pi_{t-1} + \rho_2(L)u_{t-1}] + \eta_t \qquad [14]$$

so that the long-run trade-off is $\partial u/\partial\pi = (\lambda - \lambda^*\rho_1(1))/(1+\lambda^*\rho_2(1))$. Hence, even if there is long-run neutrality ($\lambda=\lambda^*$), estimation of [14] would lead to an apparent long-run trade-off unless $\rho_1(1)=1$. Naturally, the existence of a unit root in π_t implies precisely that the condition $\rho_1(1)=1$ holds and, therefore, the criticism does not apply in our case.

3. EMPIRICAL RESULTS

3.1. The data set and reduced-form estimates

The data set spans the period 1964:1-1995:4 and consists of: the Spanish CPI annual inflation rate ($\pi_t = \Delta_4 \ln p_t$), the Spanish unemployment rate (u_t), the EU(15) CPI annual inflation rate ($\pi_t^* = \Delta_4 \ln p_t^*$) and the EU(15) unemployment rate (u_t^*). All data are quarterly, seasonally unadjusted and are drawn from the Statistical Bulletin of the *Banco de España* and OECD Economic Outlook (various issues).

Figure 1 depicts the evolution of the Spanish unemployment and inflation rates over the sample period. Both series move together up to the late 1970s, reflecting the stagflationary period that followed the oil price crises. Later, their correlation becomes negative, with the exception of the 1986-91 subperiod where seemingly no correlation is present. Nevertheless, as these simple movements are dominated by both domestic and foreign demand and supply shocks, they are not informative about their driving forces. To disentangle the source of those correlations and analyze the PTOs following a demand shock is the task of the rest of the paper.

Table 1 shows a summary of results from the estimation of the VAR with lag length ranging from 4 to 8 quarters. The VAR in $(\Delta u_t, \Delta \pi_t)'$, given by equations [8a] and [8b], was augmented with a constant term, three seasonal dummies, current and lagged values of Δu_t^* and lagged values of $\Delta \pi_t^*$, accounting for external shocks leading to shifts in the aggregate demand relations and the Phillips Curve. Both Δu_t^* and $\Delta \pi_t^*$ are treated as exogenous, given the small-open economy assumption. In this respect, two comments are in order. First, the current value $\Delta \pi_t^*$ has been excluded since including it seems to run directly against the spirit of the RBC identification strategy. Indeed, including the current value or the first lag leaves the results almost unchanged. Secondly, reparameterizing the long-run solution of the VAR in terms of inflation and unemployment differentials cannot be rejected at standard confidence levels. Thus, the structural shocks ϵ_t^d and ϵ_t^s can be interpreted as *idiosyncratic national supply and demand shocks* though, for the sake of brevity, we will stick to the labels in section 2. And third, the foreign variables have also been introduced to help explaining a possible structural break in the late seventies. In this respect, we also introduced some oil-price series and some (foreign) labour-market variables (such as replacement ratios) directly, but they did not prove to be significant.

It should also be noticed that there are no signs of cointegration among any of the series and, thus, that the specification of the VAR in first-differences seems appropriate[8]. Furthermore, according to various portmanteau test on serial correlation and tests on ARCH in the error terms, reported in Table 1, there is no sign of misspecification in the VAR. As for the choice of the VAR lag length, both AIC and SBIC criteria point out to 5 and 4 lags, respectively. Nevertheless, results for lag length ranging from 4 to 8 are also reported in Table 1 to highlight their robustness for such a choice.

Various implications follow from the above results. First, the correlation between the VAR innovations (e_u and e_π) is small, implying that $\lambda \simeq -\delta\omega_{11}/\omega_{12}$. Secondly, the estimates of b(1) and d(1) are found to be small and non significant; that b(1) is non significant implies that there is no Granger-causality from inflation to unemployment (given foreign inflation and foreign unemployment). Thirdly, the estimates of a(1) and c(1) are more sizeable and significant, albeit the second is marginally so; that c(1) is significant and negative implies that there is Granger-causality from unemployment to inflation. And finally, since $0<a(1)<1$ and $c(1)<0$, it follows from expression [12] in section 2 that the long-run PTO is a monotonic function for negative values of λ. Figure 2 depicts the estimated long-run trade-offs as a function of λ for the various lag lengths reported in Table 1. It can be observed that, for small values of λ, the PTO is almost nil whilst, for high values, it is around -2.0. The choice of lag length, in turn, does not seem to have any noticeable effect on these estimates.

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[8] Conditioning on Δu_t^*, and $\Delta \pi_{t-1}^*$, Johansen's maximum eigenvalue test for cointegration between u_t and π_t yields 9.33 (for r=0) and 5.36 (for r=1) where r is the cointegration rank. The critical values are 14.90 and 8.18, respetively.

3.2. Impulse Response Functions and Variance Decompositions

Let us now turn to the results under the different identification schemes. We begin the discussion with the keynesian (K) identifying restriction. Using the procedure described in section 2.2.3, λ=-0.25 proved to maximise the short-run demand effects on unemployment. Figure 3a depicts the impulse-response (IR) functions of unemployment and inflation to a unit demand shock whereas the bottom panel depicts the Phillips trade-off for various horizons; the short-run trade-off is -0.3 whilst the long-run trade-off, which is achieved after four years, is -0.6.

As regards the M identifying restriction, λ=-0.12 turned out to be the value obtained from the procedure described in section 2.2.2. Figure 3b shows the same information as above. Since inflation is a monetary phenomenon in the long-run under this scheme, its IR function converges quickly towards unity, whereas unemployment falls by 0.3 percentage points in the long-run. The PTO is -0.12 in the short run and, after two years, reaches a steady state value of -0.3. Both trade-offs are smaller (in absolute value) than under the K scheme, but they turn out to be statistically different from zero.

Next, we turn to the RBC scheme. Since $b(1)=d(1)\simeq 0$, the RBC implies a vertical long-run Phillips curve. Figure 3c shows a similar IR function for inflation to the one obtained under the M scheme. Naturally, what differs is the shape of the unemployment IR function which, under the RBC assumption, implies an almost zero trade-off at all horizons.

Table 2 summarises the importance of demand shocks in explaining the variability of forecast errors of inflation and unemployment at various horizons, by means of the forecast error-variance decomposition (VD) method. Under the K scheme, demand shocks explain 100% of unemployment variability, reflecting that inflation does not Granger-cause unemployment, and only 12% of inflation variability (the remaining proportions are explained by supply shocks). As expected, under the M scheme, ϵ^d_t explains 15% of the unemployment variability and almost 90% of inflation variability. Finally, under the RBC scheme, unemployment variability is completely explained by ϵ_t^s , whereas 93% of inflation variability is explained in the short-run and almost 60% in the long-run by those shocks.

3.3. Sacrifice Ratios

Once we have examined the different trade-offs implied by the various identification outlines, we turn to an alternative measure of the cost of disinflation. Table 3 shows the estimated dynamic responses of the levels of unemployment and inflation to an ϵ_t^d shock that eventually leads to a 1% *permanent* reduction in inflation. In addition, the table shows the *sacrifice ratio* defined as the sum over a number of years of the incremental annual levels of unemployment following the demand shock; i.e, the sum over the period of the differences in the annual levels of unemployment with and without the demand shock. Under a stable Okun's law, these sacrifice rate would be proportional to the cumulated loss in output over the relevant horizon.

The K identification suggests that the unemployment rate raises by 0.35% after one year, is 0.5% higher after two years, and around 0.6% higher after five years. By contrast, the M identification yields smaller unemployment responses: 0.18% after a year and 0.30% after the five years. Finally, under the RBC identification, unemployment is governed essentially by supply shocks, so that the reduction in inflation has costs in terms of unemployment which are negligible at all horizons.

The resulting sacrifice ratios over five years are, respectively, 2.5%, 1.3% or 0%. Following the results obtained by Dolado and López-Salido (1996) about the dynamic interaction between unemployment and output in a similar full hysteresis framework, we can compute the corresponding cumulated output losses over any period. According to their estimates, the Okun's coefficient for the Spanish economy is around 2 over the sample 1970-1994. Consequently, the cumulated loss in output over the five-year horizon could be estimated around 5%, 2.5% or 0%, depending on the specific identification outline.

4. SUBSAMPLE STABILITY AND TWO DISINFLATIONARY PERIODS

In this section we investigate the stability of the bivariate relation analyzed above. We began this paper by pinpointing that the late 1970s represented key years in the recent history of Spanish inflation. Thus, it seems natural to test whether that period is the natural breaking date in the sample. In particular, using 1979:1 as the breaking point (the most likely date for a break according to recursive estimation), split-sample Chow tests for a VAR(4) yield $F(14,100)=1.58$ for [8a] and $F(14,100)=1.83$ for [8b]. The p-values of both tests are only slightly above 5%, indicating some signs of lack of parameter constancy. Moreover, the long-run PTO was marginally insignificant during the first subsample, a period which was dominated by supply shocks.

However, when the VAR was re-estimated in the sample 1979:2 - 1995:4, the results were very similar to those obtained for the whole sample, as shown in Figure 4 which compares the PTOs (across different values of λ) for the complete sample and the chosen subsample. As regards the VD analysis, not reported for the sake of brevity, the results were again similar to those shown in Table 2. Finally, with regard to the sacrifice ratios, the results were almost identical for the RBC and M outlines, while the one implied by the K identification was only half of a percentage point lower in the subsample.

So far we have discussed the three alternative identification schemes on equal grounds. After all, their reduced forms are identical. Are there any grounds to choosing a particular one on the basis of extraneous information to the model? In this respect, we use information on three recent disinflationary periods to evaluate the identification schemes. The first one goes from 1987:1 to 1988:1 and was dominated by tighter monetary policy with interest rates raising by 5 p.p. in a single year. The second one runs from 1989:3 to 1991:3 and, while interest rates remained high and stable around 15%, it was accompanied by tight credit restrictions. So, both disinflationary periods seem to follow a monetary contraction. Conversely, the available evidence about the third disinflationary period, which covers 1992:1 to 1993:1, points out to the effects of deregulation in labour and goods markets as the major causes behind the fall in inflation (see Dolado and Jimeno, 1997). Accordingly, we expect the first two periods to be dominated by demand shocks, whilst the last one should be explained by supply shocks.

Using the VD results for the above mentioned episodes we found that according to the M scheme the contribution of demand shocks to the variance of $\Delta\pi$ during the first two subperiods was above 90%. while in the third episode it was only 20%. The K outline, in turn, explains that more than 70% of the variability is due to demand shocks in all three episodes, whereas according to the **RBC** scheme, it is always below 5%. Thus, according to our prior beliefs on the distribution of shocks in each period, our hunch is that of the three cases considered above, the monetarist one is closest to the real workings of the Spanish economy.

Finally, in order to check the robustness of our results, we report in Figure 5, for a wide range of values for λ, the resulting point estimates and confidence intervals for the long-run PTO, showing what values of λ are compatible with the hypothesis of a vertical long-run Phillips curve. For $\lambda<-1.27$, the estimated long-run PTO are large, though non significant. However, for $-1.27<\lambda<-0.09$, a range which includes two of the three previous outlines, the hypothesis is rejected, unless prior beliefs close to the RBC outline are assumed. Thus, the evidence points out that even under the M scheme (λ=-0.12) the rise in unemployment/output loss, due to a disinflation led by negative demand shocks, seems to be permanent, a result which is line with the strong available evidence pointing out that the staggering rise in Spanish unemployment has a strong hysteresis component (see, e.g., Blanchard and Jimeno, 1995).

5. ROBUSTNESS OF THE RESULTS TO A TRIVARIATE VAR

So far, we have relied upon the assumption that there are only two important shocks which can be identified from the bivariate **VAR** in equation [1]-[2]. A controversial implication of our results is that there seems to be a permanent PTO even under the sensible monetarist assumption that inflation is a purely monetary phenomenon in the long-run. Therefore, it is important to explore whether this result is robust or not to changes in the specification of the model.

As pointed out by Evans (1994), suppose there is a third shock; then the identified supply and demand shocks from the bivariate VAR will be a linear combination of the three shocks. In particular, what this model identifies as a demand shock is not necessarily a (nominal) monetary shock but a mixture of the latter and possibly a fiscal shock. After all, the underlying theory behind equation [2] is that of an aggregate demand equation where output depends on real money balances, government expenditure and taxes. For simplicity the last two variables where ignored in our earlier discussion. Yet, they could be important. Hence, in our bivariate framework we are just able to identify pooled demand shocks. Thus, to disentangle a pure "monetary" shock, one possibility is to add a third variable (x_t) to the VAR which contains information about "non-monetary" shocks so that ϵ_t^d can be interpreted appropriately. Empirically, this is done by adding lagged values of x_t to the VAR in [8a]-[8b], allowing x_t to be influenced by contemporaneous values of Δu_t and $\Delta \pi_t$ in its own equation (i.e., the original demand and supply shocks are treated as Wold causally prior to the third shock). We considered various candidates for x_t and found logged government current expenditure (in second differences) as a suitable one[9]. In Table 4 we report the corresponding sacrifice ratio, that is a cumulative transitory increase of the unemployment rate of between 2.5 to 3.25 p.p. per 1 p.p. of inflation reduction, which in terms of lost output is equivalent to 5 to 6.5 percent of GDP.

While the new results arising from attempting to distinguish between monetary and non-monetary shocks yield different implications regarding whether a long-run PTO exists, it is interesting to note that they turn out to be not that different when comparing the costs and benefits of achieving lower inflation. In particular, as claimed by Feldstein (1996), if the benefits of lower inflation measured in terms of GDP gains are permanent, via lower distortions stemming from the interaction of inflation and taxes,

[9] Using alternative variables of fiscal impulse, like the cyclical adjusted deficit, yielded similar results.

then, discounting an annual benefit of x percent of GDP at a discount rate of ρ in an economy that has a normal growth rate of 2.5% a year (the Spanish normal rate over the sample period), yields a present value of $x/(\rho-0.025)$. If the costs in terms of output are permanent as in the bivariate system, then disinflation of 1 p.p. will be a worthy enterprise if $x>c$, where c is the annual loss of GDP; on the other hand, if they are transitory, as in the trivariate system, then the required condition is $x>\bar{c}(\rho-0.025)$, where $\bar{c}$ is the cumulated output loss. According to the monetarist model, using an Okun's coefficient of 2.0 and a discount rate of 9,5% (see Dolado et al., 1997)[10], the threshold value in the first case of GDP is 0.52% of GDP per year (obtained, following Table 2, as 2 times 1.3, divided by 5, since the sacrifice ratio is computed every 5 years) whereas in the second case is between 0.35% to 0.46% (0.07 times 5 or 6.5%, respectively), not such a different figure.

Finally, we would like to comment briefly on how our results, based upon the SVAR methodology, compare to the more traditional ones obtained under the estimation of a simultaneous equations model. In this respect, Andrés et al. (1996) make use of a small quarterly macroeconometric model to compute the sacrifice ratio of permanently reducing inflation in Spain by 1 p.p. They conclude that these costs are about 0.45% of GDP per year on a permanent basis, which is very similar to what we find in the monetarist case. Equally, Ball (1996) suggests that a permanent reduction in inflation of 1 p.p. comes with a permanent annual output loss of about 0.55% of GDP, a figure again remarkably close to the 0.52% estimated for the monetarist case.

6. CONCLUSIONS

In this paper, we study the joint dynamic behaviour of inflation and unemployment in the Spanish economy over the period 1964-1995, with the aim of documenting the existing trade-offs between both variables at high and low frequencies, and over several subperiods. We proceed in the style

[10] The discount rate corresponds to the average real net return on the Madrid Stock Exchange Index during 1985-1995.

of King and Watson (1994), who used structural VAR techniques to undertake an identification of the Phillips curve system. We have used, in particular, three identification schemes which fit the data equally well, but that have different implications for the magnitude of Phillips trade-offs and for sacrifice ratios. A key assumption in our analysis is that both unemployment and inflation can be described as first-order integrated processes -I(1)- for the sample period, therefore avoiding the Lucas-Sargent critique about the econometric estimation of "spurious" trade-offs (Lucas and Sargent (1979).

As regards the different identification outlines, the following results stand out. A traditional keynesian scheme yields: (i) a large estimated long-run trade-off between inflation and unemployment of around -0.6; (ii) the short-run (one year) and long-run variability of unemployment is almost completely explained by demand shocks which, in turn, only explain 12% of the variability of inflation at all frequencies; and (iii) the sacrifice ratio over five years is estimated to be a cumulative rise of 2.5 p.p. in unemployment for a permanent disinflation of 1 p.p. By contrast, a monetarist interpretation yields: (i) a long-run trade-off of -0.3, half of that estimated under the keynesian scheme; (ii) demand shocks explain almost 90% of inflation variability and 15% of unemployment variability; and (iii) a sacrifice ratio of 1.3 over five years. Finally, an alternative real business-cycle outline yields: (i) negligible trade-off; (ii) unemployment variability is almost fully explained by supply shocks whereas 90% of inflation variability in the short-run, and 60% in the long-run, is due to demand shocks.

With regard to the analysis of different subsamples, we find that the results for the total sample are seemingly dominated by the behaviour during the 1979-1996 subsample, whereas the shifts in the Phillips curve before the end of the 1970s were dominated by supply shocks.

Next, on the basis of extraneous information, we analyze the contribution of demand and supply shocks to the variability of inflation and unemployment over significant episodes in the recent disinflationary period in Spain, finding that the monetarist scheme fits better with prior beliefs.

Finally, several robustness exercises have been undertaken. In particular, augmenting the bivariate VAR with a third variable (public expenditure) in order to disentangle monetary from "non-monetary" shocks indicate that the unemployment-inflation trade-off may be *transitory* rather than *permanent*, in spite of the high degree of hysteresis in the Spanish labour market. Nonetheless, the benefits stemming from lower inflation, needed to overcome the estimated costs, are similar in both cases.

TABLE 1
SUMMARY OF REDUCED FORM VARS

(1964-1995)

$$\Delta u_t = a(L)\ \Delta u_{t-1} + b(L)\ \Delta \pi_{t-1} + e_{ut}$$

$$\Delta \pi_t = c(L)\ \Delta u_{t-1} + d(L)\ \Delta \pi_{t-1} + e_{\pi t}$$

VAR lag lenght	Choice of lag lenght Criteria		Sum of the Coefficients				Residual Covariance Matrix			Tests on Residuals			
	AIC	SBIC	a(1)	b(1)	c(1)	d(1)	sd(e_u)	sd(e_π)	corr(.)	BL(8)		ARCH(4)	
4	3.623	-1.348	0.66 (0.10)	0.01 (0.04)	-0.41 (0.24)	-0.09 (0.14)	0.29	0.98	-0.041	0.40 (0.49)	13.3 (0.11)	1.33 (0.86)	3.55 (0.47)
5	3.619	-1.254	0.62 (0.11)	0.01 (0.05)	-0.24 (0.15)	0.136 (0.16)	0.30	1.03	-0.049	1.03 (0.85)	12.4 (0.15)	1.32 (0.87)	3.46 (0.43)
6	3.653	-1.119	0.57 (0.11)	-0.001 (0.05)	-0.29 (0.17)	0.126 (0.19)	0.30	1.05	-0.055	1.01 (0.84)	12.6 (0.14)	1.03 (0.80)	3.35 (0.40)
7	3.710	-0.963	0.57 (0.11)	0.002 (0.06)	-0.34 (0.19)	0.012 (0.20)	0.30	1.05	-0.055	2.06 (0.75)	12.4 (0.15)	1.16 (0.82)	3.33 (0.39)
8	3.761	-0.810	0.543 (0.12)	0.003 (0.07)	-0.42 (0.21)	-0.15 (0.23)	0.31	1.05	-0.058	2.04 (0.75)	11.4 (0.18)	1.36 (0.87)	3.35 (0.40)

Note: For the sum of the coefficients estimates, standard errors are in parenthesis. AIC = Akaike Information Criterion and SBIC = Schwarz Bayesian Information Criterion. BL(8) = Box and Ljung test for correlation up to 8th order. ARCH(4) = Engle test for ARCH effects up to 4th-order (p-values for those tests are in parentheses). The estimates are obtained from a VAR including a constant, seasonal dummies, the first differences of the EU(15) unemployment rate and lagged first differences of the EU(15) inflation rate.

TABLE 2
THE ROLE OF DEMAND SHOCKS IN VARIANCE DECOMPOSITIONS
(1964-1995)

Horizon	(λ = -0.25) KEYNESIAN MODEL		(λ = -0.12) MONETARIST MODEL		(λ = 0) RBC MODEL	
	u	π	u	π	u	π
1	100.00	11.00	15.32	89.98	0.000	93.03
4	99.7	11.78	13.69	87.93	0.004	57.59
8	98.9	12.13	13.93	88.36	0.003	57.75
12	98.8	12.17	13.94	88.50	0.003	57.66
16	98.8	12.17	13.94	88.53	0.004	57.65
∞	98.8	12.17	13.94	88.53	0.003	57.64

Note: The figures represent percentage points.

TABLE 3
SACRIFICE RATIOS (SR) FOR A 1 PERCENTAGE POINT PERMANENT REDUCTION IN INFLATION RATE
(Full sample: 1964-1995)

Horizon	KEYNESIAN MODEL		
	u	π	SR
1	0.22	-0.85	0.22
4	0.35	-1.35	0.35
8	0.49	-0.90	0.84
12	0.54	-1.03	1.38
16	0.57	-1.01	1.95
∞	0.59	-1.00	2.54

Horizon	MONETARIST MODEL		
	u	π	SR
1	0.11	-0.96	0.11
4	0.18	-1.31	0.18
8	0.25	-0.88	0.43
12	0.28	-1.03	0.71
16	0.29	-0.98	1.00
∞	0.30	-1.00	1.30

Horizon	RBC MODEL		
	u	π	SR
1	-0.02	-1.10	-0.02
4	-0.03	-0.98	-0.03
8	-0.03	-1.01	-0.06
12	-0.03	-0.99	-0.09
16	-0.03	-1.00	-0.12
∞	-0.03	-1.00	-0.15

TABLE 4
SACRIFICE RATIOS FOR A 1 P.P. PERMANENT REDUCTION IN INFLATION RATE (TRIVARIATE MODEL)

Horizon	u	SR
4	1.10	1.10
8	0.80	1.90
12	0.52	2.42
16	0.10	2.52
∞	0.04	2.56 (2.50. 3.25)

Note: Bootstrap 90% confidence interval in parenthesis.

FIGURE 1

INFLATION AND UNEMPLOYMENT IN SPAIN

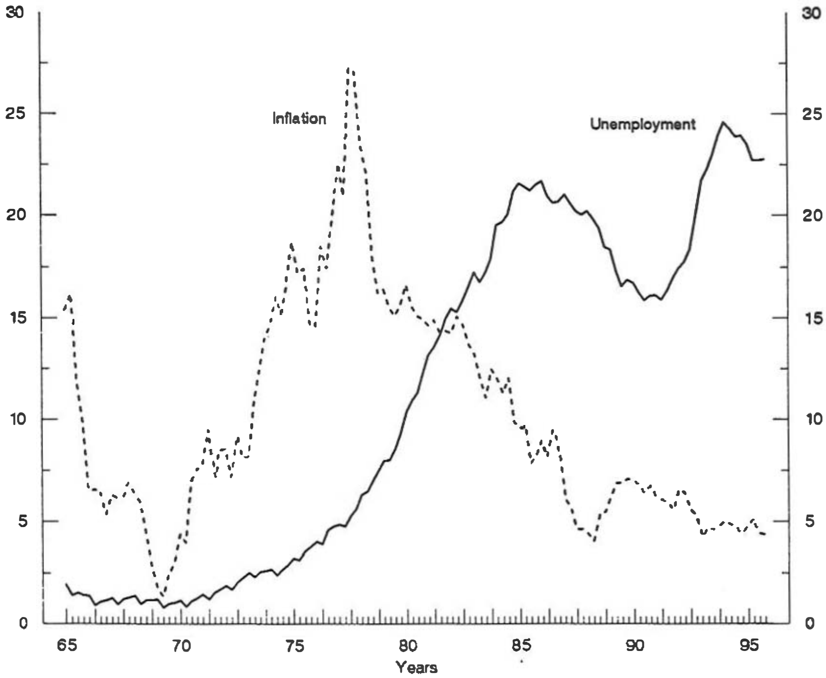


FIGURE 2

IMPLIED LONG-RUN PHILLIPS TRADE-OFFS

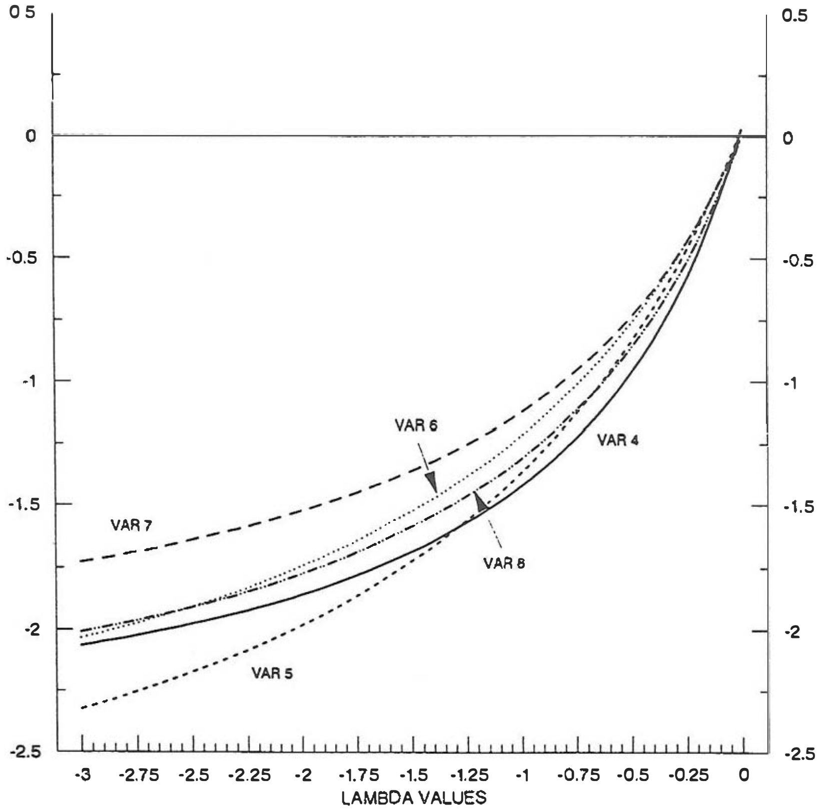
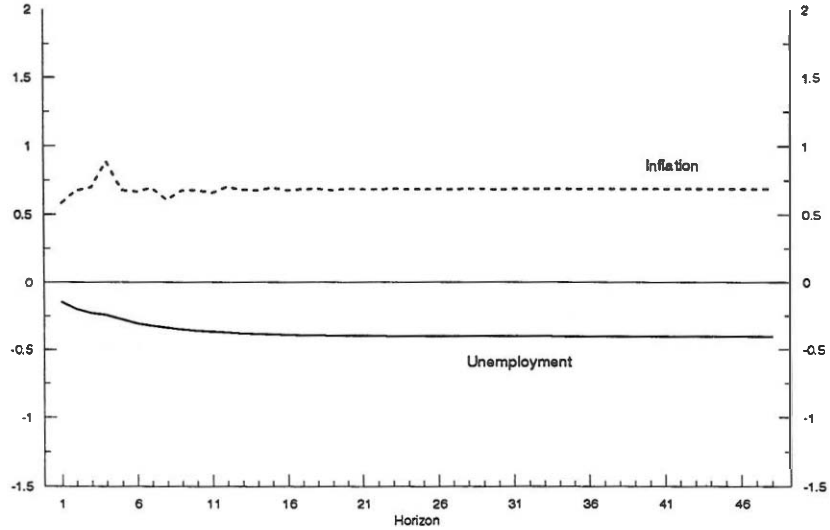


FIGURE 3a

UNEMPLOYMENT AND INFLATION RESPONSES IN
KEYNESIAN MODEL
(RESPONSES TO A UNIT DEMAND SHOCK)



PHILLIPS CURVE TRADE-OFFS

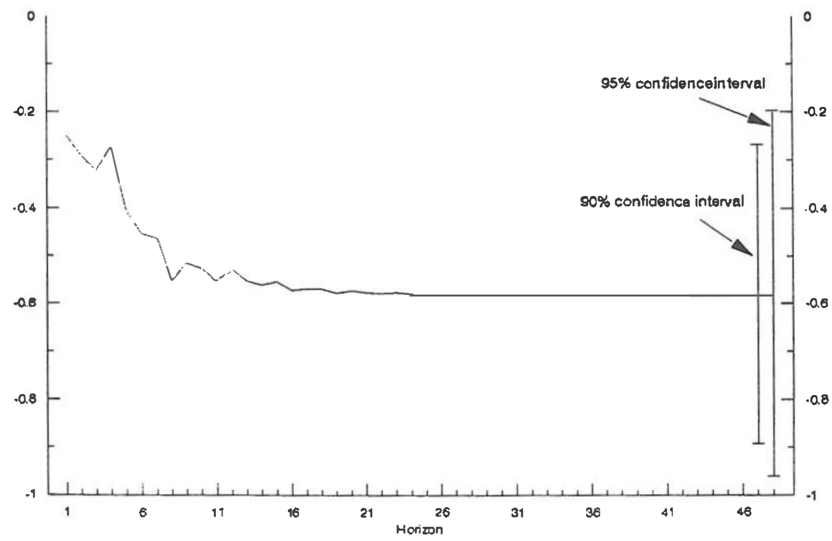
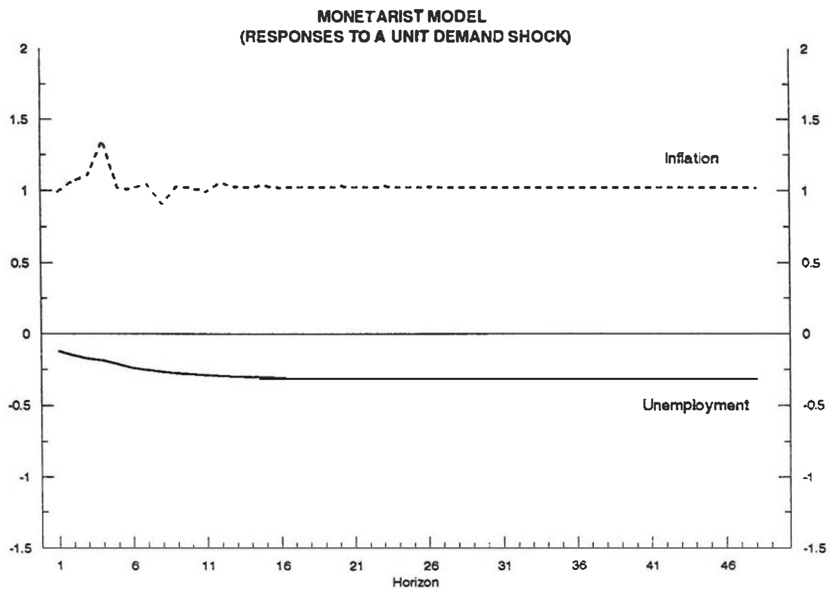


FIGURE 3b


MONETARIST MODEL
(RESPONSES TO A UNIT DEMAND SHOCK)
Inflation
Unemployment
Horizon

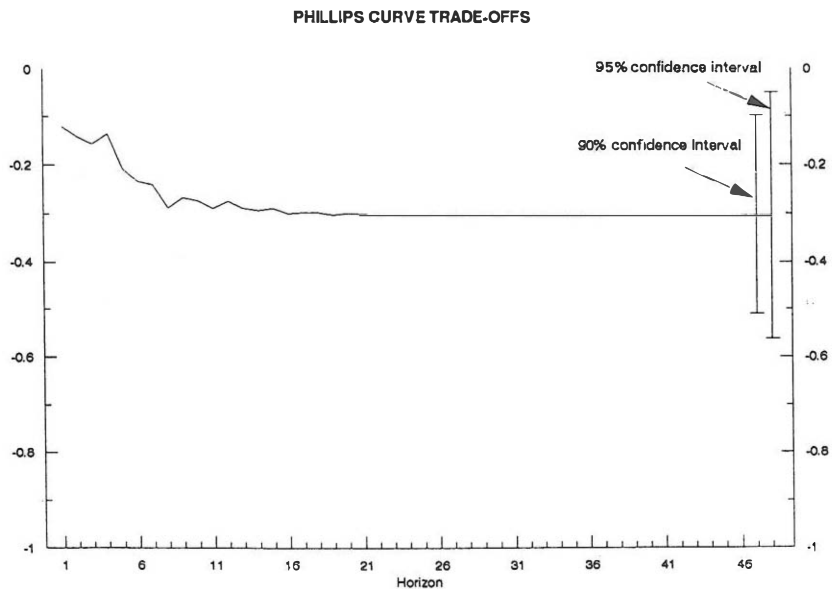
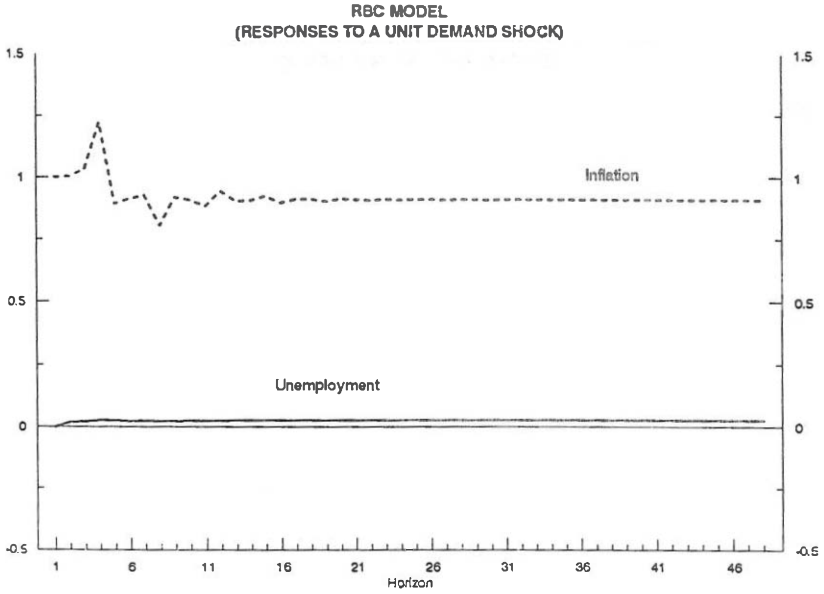
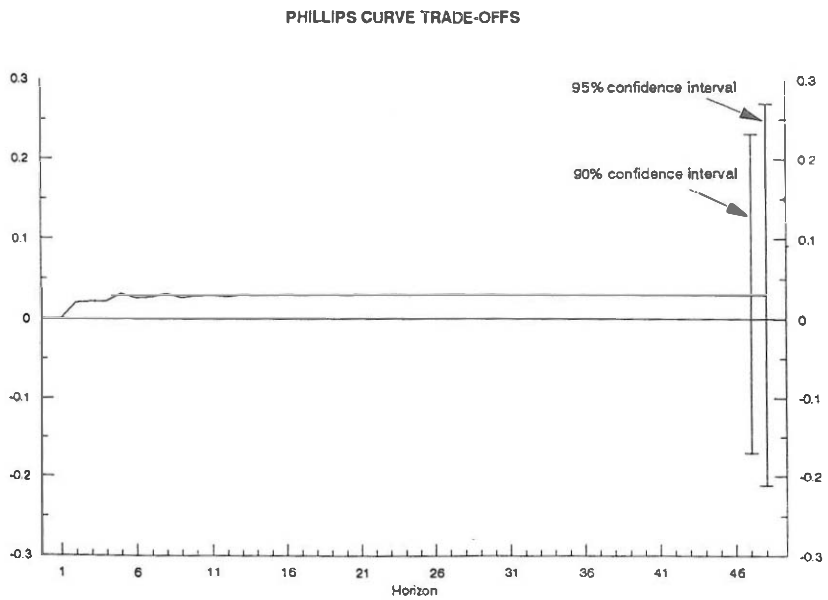

PHILLIPS CURVE TRADE-OFFS
95% confidence interval
90% confidence interval
Horizon

FIGURE 3c



RBC MODEL
(RESPONSES TO A UNIT DEMAND SHOCK)
1.5
1
0.5
0
-0.5
Inflation
Unemployment
1
6
11
16
21
26
31
36
41
46
Horizon



PHILLIPS CURVE TRADE-OFFS
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
95% confidence interval
90% confidence interval
1
6
11
16
21
26
31
36
41
46
Horizon

FIGURE 4

COMPARING LONG-RUN PHILLIPS TRADE-OFFS
(ESTIMATES FROM A VAR 4)

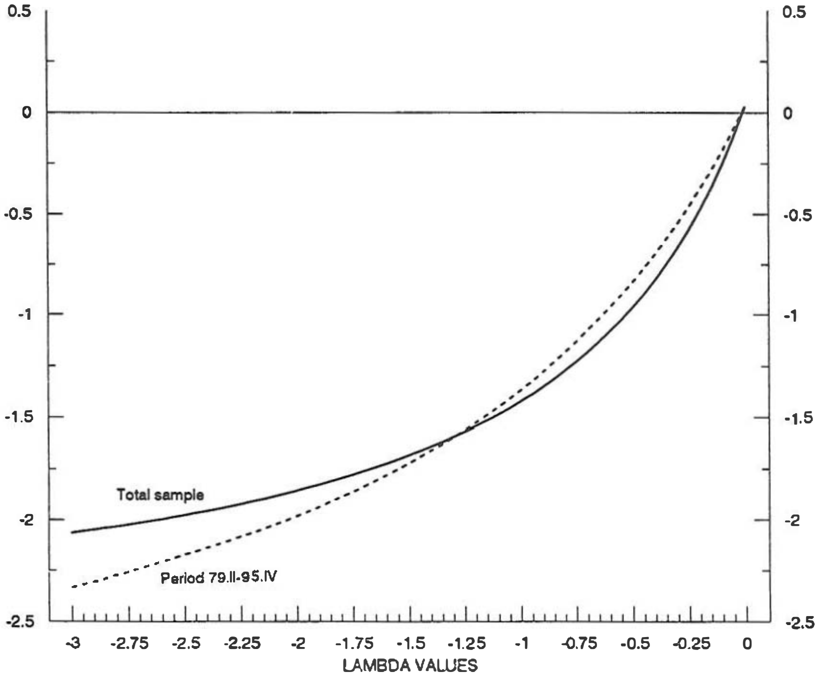
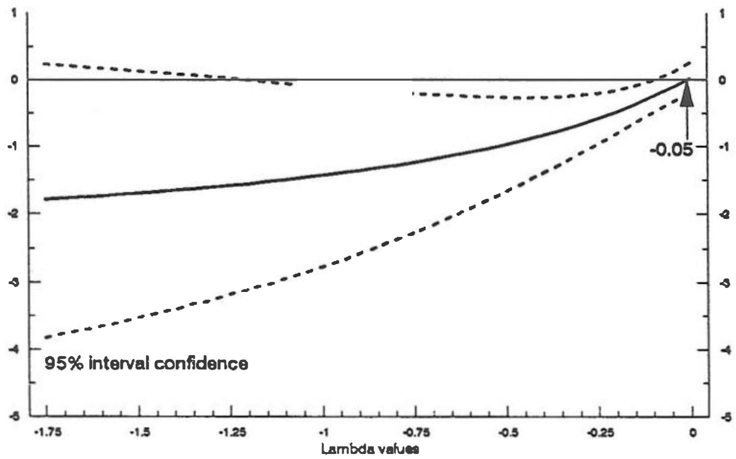


FIGURE 5

LONG-RUN PHILLIPS TRADE-OFFS AS A FUNCTION OF LAMBDA (SHORT RUN PHILLIPS TRADE-OFFS) RESULTS FROM A VAR 4



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