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# SHORT- AND LONG-RUN PHILLIPS TRADE-OFFS AND THE COST OF DISINFLATIONARY POLICIES

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# ABSTRACT

## Short- and Long-run Phillips Trade-offs and the Cost of Disinflationary Policies*

This paper studies the joint behaviour of inflation and unemployment in Spain over the period 1964–95 in order to estimate dynamic Phillips trade-offs and sacrifice ratios in response to a demand shock. We organize our empirical approach as a structural (albeit eclectic) one. In so doing, we use a Structural VAR to identify demand shocks in a framework where the high persistence in both series allows us to differentiate between permanent and transitory components. Our eclecticism comes from using three alternative identifying schemes which fit the data equally well, but place different emphasis on the effects of demand shocks on the unemployment rate. Our estimates suggest, according to the reader's prior belief (Keynesian or monetarist), that a one percentage point reduction in inflation following an aggregate demand contraction is associated with cumulated output losses of between 2.6% and 5% over five years.

JEL Classification: E12, E13, E24, C32
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# NON-TECHNICAL SUMMARY

The Spanish rate of (Consumer Price Index) inflation in 1977 was 24.6%, while the unemployment rate stood at 5.1%. By 1994 unemployment had risen to 24.2% and inflation had fallen to 4.3%. The fact that unemployment is nowadays close to what inflation was in 1977, and *vice versa*, may look at first sight as if the unemployment-inflation trade-off is one-to-one. Nonetheless, the Phillips trade-offs are usually interpreted as being induced by demand shocks, whereas the observed evolution of the unemployment-inflation relationship is governed by both demand and supply shocks. In this paper we tackle this issue in greater depth.

To disentangle demand from supply shocks, we use a structural, if eclectic, approach. On the one hand, we make use of a Structural VAR (Vector Autoregression) approach which, under the assumption that both types of shock are independent, since they are from different sources, which allows us to identify them by adding an extra restriction in a just-identified system. On the other hand, given the latter property, we adopt an eclectic approach since the extra restriction comes from three different outlines about the issue at hand. First, we use a Keynesian outline which maximizes the short-run effects of demand shocks on unemployment. Second, we take a monetarist outline whereby it is assumed that inflation is a demand (monetary) phenomenon in the long run, namely, there is no long-run effect of unemployment on inflation. Lastly, there is a real business cycle interpretation which is equivalent to assuming that unemployment is unaffected by demand shocks at all frequencies. All these outlines fit the data equally well and none of them precludes the existence of Phillips trade-offs, given the possible dynamic interaction between unemployment and inflation.

We model our VAR in terms of the first-differences of the inflation and unemployment rates, given that there is clear evidence of a unit root in both time series. This will allow us to get permanent components in both variables, and thereby, to compute trade-offs and sacrifice ratios at different frequencies. The latter are defined as the accumulated number of annual unemployment percentage points corresponding to an impulse in the demand shock that eventually lowers inflation by one percentage point.

Our main findings can be summarized as follows. Conditional on European inflation and unemployment rates, we find that inflation does not help to predict unemployment but that unemployment helps to predict inflation. This implies that the real business cycle outline predicts absence of trade-offs and zero

sacrifice ratio. The Keynesian and monetarist outlines, in turn, imply sacrifice ratios of 1.4 and 2.5 and cumulated output losses of 2.6% and 5% over a horizon of five years, respectively. This means that, given *ceteris paribus* supply shocks, a permanent reduction in the current rate of inflation of 3.5% to, say, 1.5% (the average rate in the three least inflationary countries in the EU), could leave unemployment unchanged, according to the first extreme view, or would increase the unemployment rate from the current 23% to between 23.6% and 24.2%.

Other results relate to subsample stability. In this respect, we find evidence that before 1980 there was hardly any trade-off, inflation and unemployment movements being almost completely dominated by supply shocks. Thereafter the trade-offs are very much the same as with the full sample, however. Similarly, we find evidence that the trade-offs and sacrifice ratios worsened during two disinflationary periods in the second half of the 1980s where monetary policy became significantly tighter. A possible interpretation of this result is that the credit restrictions in place during February 1989 to April 1990 affected investment more than consumption and, hence, unemployment more than inflation.

## 1. INTRODUCTION

The Spanish annual rate of (CPI) inflation in 1977 was 24.6%. By 1989, inflation dropped to 6.8%, and from 1990 through the end of 1995, it has fluctuated narrowly around an average of 5.4%. In turn, from 1977 to 1989, the unemployment rate jumped from 5.1% to 17.2%, averaging 15.4% and peaking at 21.6% in the first quarter of 1985. 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 nowadays close to what the inflation rate was in 1977 and, conversely, that the inflation rate is down to roughly the unemployment rate in the mid-70s may look at first sight as if the unemployment-inflation trade-off is 1:1. In this paper we will try to tackle this subject in greater depth.

Disentangling the sacrifice ratios implied by those figures is a key issue for judging the economic performance of the Spanish economy over the last two decades. Disinflation is in principle a desirable outcome, but there is disagreement on the size of the implied costs in terms of unemployment and, furthermore, on how to measure them. Thus, the concept of the sacrifice ratio is one of the subjects in macroeconomics that is the heart of many policy discussions, but at the same time tends to lack academic consensus.

A possible interpretation of the above mentioned episodes could be as follows: (i) Contractionary aggregate demand policies are a major cause of the high unemployment level which, in turn, leads to a fall in inflation. Accordingly, under this (keynesian) view, the Phillips trade-off is still alive, providing room for successful exploitation, at least in the short run. (ii) Additionally, unemployment and inflation seem to behave dynamically as incorporating important hysteresis-nominal rigidities persistence mechanisms, so that the trade-off between them could even be interpreted as a permanent one. Yet, in the presence of such mechanisms, estimation of the costs of disinflationary policies becomes an even more difficult task.

Alternative interpretations are related, on the one hand, to the important role played by the modelling of expectations and of credibility-related phenomena (neoclassical-monetarist-rational expectation models); and, on the other hand, to the predominant role played by structural supply-side shocks (real business cycle models). Allowing for such features in any analysis of the relationship between inflation and unemployment may lead to the absence of both short-run and long-run trade-offs. That is, under this view, the evolution of inflation and unemployment reflect independent phenomena, the former related to price-setting and informational-credibility problems and the latter to wage-setting institutions and other labour market frictions.

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 order to answer 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 the high persistence in both unemployment and inflation?; and finally, How does the sacrifice ratio change across the identification outlines and over time?.

The goal of this paper is to deal with some of those queries 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 and imposing several identifying restrictions on the innovations of the VAR, in line with the different views expressed above. Hence, in this sense, our approach will be both **structural** and **eclectic**.

On the one hand, it will be **structural** because we use a Structural Vector Autoregression (SVAR) approach. 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 unemployment, i.e. the so called Phillips curve approach (see, e.g. Gordon, 1970). The usefulness of such an exercise in answering some of the earlier questions depends upon the credibility on the underlying economic model and the estimation procedure (i.e. the exogeneity assumptions). Both are open to dispute. In a series of important papers, Robert Lucas and Thomas Sargent criticised the previous approach by pointing out that unless inflation expectations were treated properly, researchers would tend to find apparent long-run trade-offs when none was implied by the true model. Nonetheless, if inflation is an integrated process of order one, I(1), as it seems to be in many countries, the criticism does not apply, as noted, inter alia, by King and Watson (1994). Furthermore, if unemployment is also I(1), as again seems to be the case in Spain over the sample period, variations in the stochastic trends of inflation and unemployment will allow to determine the long-run Phillips trade-off. The intuition is clear: if we identify demand and supply shocks from the innovations in a VAR consisting of first differences of both inflation and the unemployment rate, a well posed question is to ask ourselves what permanent effects will demand shocks have on the levels of both inflation and unemployment and, therefore, what trade-offs and sacrifice ratios are implied.

On the other hand, it will be **eclectic** because we use several alternative identification outlines which will 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. In particular, we use three strategies: i) a **keynesian**, ii) a **monetarist-rational expectations**, and iii) a **real business cycle** outline, respectively. All of them will be carefully explained in the next section. By presenting a menu of results based on the different outlines we can check the robustness of the results to the different interpretations and, hence, leave readers the option to choose their favourite.

To preview our results, Table 1 reports the Phillips trade-offs and sacrifice ratios obtained under the three previous identification strategies. These outlines place a decreasing emphasis on the role of demand shocks in governing the joint behaviour of unemployment and inflation, ranging from the keynesian to the real business cycle interpretation. Thus, our estimates suggest, according to the readers' priors, that a permanent one percentage point reduction in inflation, induced by a contraction in aggregate demand, is associated with a permanent increase in unemployment of around 0, 0.3 or 0.6 percentage points in the long-run. The resulting sacrifice ratios over a five-year horizon are, respectively, 0, 1.3 or 2.5. As we will see later, these sacrifice ratios could be interpreted as cumulated output losses of 0%, 2.6% or 5% over the five years.

Technically, as it will become clear later in the paper, these sharply different results depend crucially on the near causality ordering of inflation and unemployment. This is so since in our reduced form vector autoregression, lagged unemployment helps predict inflation, but lagged inflation does not contain information on current unemployment. This leads to controversial policy implications for the previous sacrifice ratios.

The rest of the paper is structured as follows. We begin in Section 2 by discussing the identification issues related to a bivariate dynamic model of inflation and unemployment and the possible identification outlines considered in the paper. In this respect, we follow the approach recently advocated by King and Watson (1994), albeit with slight variations. 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. In Section 5, we address the robustness of some key parameter estimates to changes in the identifying restrictions. Finally, Section 6 offers some concluding remarks.

## 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 $\lambda$ indicates the contemporaneous effect of changes in the inflation rate ($\Delta \pi$) on the unemployment rate changes ($\Delta u$), and $\varepsilon_t^s$ is a structural shock which, for the time being, we will not define.

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 being 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 which covers the last three decades.[3]

In order to close the model, we next consider the demand side of the economy, represented through the following equation:

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

where now the parameter $\delta$ reflects the contemporaneous effect of changes in unemployment on the inflation changes, and $\varepsilon_t^d$ is another structural shock which again is yet to be defined.

Whether or not 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 the debate, we first summarise the key points heuristically; and, next, we will proceed to formalise those ideas, rearranging expressions (1) and (2) in a more familiar SVAR context.

Intuitively, the simplicity of these representations implies that the system could account for different economic models in explaining the dynamics of these two variables. Through this statement, we simply note an issue that has been stressed in the recent empirical analysis, namely, how the identification implied by any economic model affects the interpretation of the shocks generating the business cycle and stochastic trends of the variables.

To highlight the effects of this identification problem upon the analysis of the unemployment-inflation trade-off, let us only consider, without loss of generality, the existing contemporaneous interactions between both variables in expressions (1) and (2). Under a keynesian interpretation, the second equation can be understood as a price equation. Thus, this expression describes how

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[3] See, for instance, Andrés (1991) and Dolado and López-Salido (1996).

inflation responds to the unemployment rate.[2] In such a representation the unemployment rate is an indicator of the demand conditions. This kind of specification also corresponds to new-keynesian models with microfoundations of sticky prices.[3] In turn, the first equation describes the unemployment determination as a function of the inflation rate and a demand shock, capturing the familiar IS-LM determination of real variables as a function of prices (and implicitly wages). By contrast, monetarist modellers use a completely different argument to interpret the same set of equations. So, in their view, equation (1) can be interpreted as an aggregate supply curve, and equation (2) as a quantity equation together with an Okun's law. Finally, advocators of the real business cycle interpretation place the emphasis on the importance of real-supply side shocks. That is, the first equation (simply understood as an unemployment equation) does not reveal any information about nominal shocks.

Summing up, the existence of several economic approaches using the same empirical representation implies that those models are observationally equivalent in terms of expressions (1) and (2). That is, there is at least one mapping from the shocks and parameters in one model to the shocks and parameters in the others and viceversa (see, for details, King and Watson (1994)).

Let us now develop this argument in more detail. To deal more formally with the identification problem we use a more familiar representation of the simultaneous equation model in (1)-(2) as the following SVAR:

$$\alpha_{uu}(L)\ \Delta u_t = \alpha_{u\pi}(L)\ \Delta \pi_t + \varepsilon_t^s \qquad (3a)$$

$$\alpha_{\pi\pi}(L)\ \Delta \pi_t = \alpha_{\pi u}(L)\ \Delta u_t + \varepsilon_t^d \qquad (3b)$$

where L is the lag operator and:

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[2] In general, this price equation is a simplified version of the supply side of a keynesian model. This is so since this equation is only part of the wage-price mechanism (see, for instance, Blanchard and Fischer (1989)). This simplification does not seem very important because many researchers view price-setting as a fixed mark-up over wages.

[3] See, for instance, Fischer (1977), Taylor (1979), Calvo (1983) and Rotemberg (1982).

$$\alpha_{uu}(L) = 1 - \sum_{j=1}^{p} \alpha_{uu,j} L^j \quad ; \quad \alpha_{u\pi}(L) = \lambda + \sum_{j=1}^{p} \alpha_{u\pi,j} L^j$$

$$\alpha_{\pi\pi}(L) = 1 - \sum_{j=1}^{p} \alpha_{\pi\pi,j} L^j \quad ; \quad \alpha_{\pi u}(L) = \delta + \sum_{j=1}^{p} \alpha_{\pi u,j} L^j$$

In stacked form, the model becomes:[4]

$$\alpha(L)X_t = \varepsilon_t \tag{4}$$

with:

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

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

and:

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

As noted earlier, we interpret equation (3a) as the Phillips curve. Correspondingly, the structural disturbance $\varepsilon_t^s$ in expression (3a) corresponds to a supply shock. Conversely, the structural error term $\varepsilon_t^d$ in (3b) is interpreted as a demand shock. We will assume that shocks are mutually uncorrelated, $\sigma_{12}=0$, so that any contemporaneous correlation between $\pi_t$ and $u_t$ arises from nonzero values of the parameters $\lambda$ and $\delta$. This framework will allow us to address a number of relevant issues:

(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 have long-lasting effects.

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[4] Notice that we write down the model in first differences, so that both $u_t$ and $\pi_t$ are assumed to be I(1) and not cointegrated. See section 3 for further details.

(ii) the estimation of the Phillips curve trade-off -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:

$$\frac{\partial u_{t+k}/\partial \varepsilon_t^d}{\partial \pi_{t+k}/\partial \varepsilon_t^d} \; ; \; k = 0,1,\ldots,\infty \tag{5}$$

(iii) tests for both long and short-run neutrality; i.e, the verticality of the long and short-run Phillips curve. These hypotheses hold when expression (5) is zero for $k = 0$ and $k \to \infty$, respectively.

From the previous discussion, it is clear that the structural model given by equations (3a)-(3b) is not identified. To see this, consider the equivalent reduced form VAR derived from the model:[5]

$$\Delta u_t = a(L)\ \Delta u_{t-1} + b(L)\ \Delta \pi_{t-1} + e_{ut} \tag{6a}$$

$$\Delta \pi_t = c(L)\Delta u_{t-1} + d(L)\ \Delta \pi_{t-1} + e_{\pi t} \tag{6b}$$

or in stacked form:

$$\Gamma(L)X_t = e_t \tag{7}$$

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 autoregressive 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 (4) and (7), the following relationships hold: $\Gamma_i = -\alpha_0^{-1}\ \alpha_i$, and $e_t=-\alpha_0^{-1}\ \varepsilon_t$. Thus, the matrices $\alpha_i$ and the variance covariance matrix of the structural shocks, $\Omega$, are determined by the following set of equations:

$$-\alpha_0^{-1}\ \alpha_i = \Gamma_i \; , \; i= 1,\ldots,p \tag{8}$$

The identification problem can be stated as follows. The first set of equations (8)

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[5] Notice that, for simplicity, both deterministic and constant terms have been omitted from the formulae.

$$\alpha_0^{-1}\Omega(\alpha_0^{-1})' = \Sigma \tag{9}$$

imposes no restrictions on $\alpha_0$. That is, there are no restrictions on the coefficients on lags entering equation (4). Thus, equation (9) determines the unknowns in both $\alpha_0$ and $\Omega$ as a function of the variance-covariance matrix of the reduced form innovations. But, since $\Sigma$ is a 2 x 2 symmetric matrix, only three unknown parameters can be identified in $\alpha_0$ and $\Omega$. Hence, even after assuming that $\sigma_{12}=0$, the four parameters $\sigma_{11}$, $\sigma_{22}$, $\lambda$ and $\delta$ cannot be identified, and one additional restriction is required.

Nevertheless, by adding whatever single restriction one wishes to add, all the resulting models are just-identified and, hence, they fit the data equally well. Notwithstanding, each one have different implications for disentangling the sources of business cycle fluctuations and stochastic trends, the trade-off between unemployment and inflation, and 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 outlines share the orthogonality assumption, $\sigma_{12}=0$, and none of them imposes long-run verticality of the Phillips curve, as this is one of the propositions we wish to test.

## 2.2. Three Alternative Identification Outlines

A simple comparison of expressions (4) and (7) 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 (6a) and (6b)) a closed-form solution for the long-run Phillips curve trade-off (expression (5)) can be calculated:[6]

$$\lim_{k\to\infty} \frac{\partial u_{t+k}/\partial \varepsilon^d_t}{\partial \pi_{t+k}/\partial \varepsilon^d_t} = \frac{(1-d(1))\lambda + b(1)}{(1-a(1))+\lambda c(1)} = \frac{\alpha_{u\pi}(1)}{\alpha_{uu}(1)} \qquad (10)$$

Thus, the long-run Phillips curve trade-off is a function of the short-run Phillips curve trade-off ($\lambda$) 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 Phillips long-run trade-off does not have any discontinuity for $\lambda<0$, since the denominator in expression (10) will always be positive.

As noted earlier, to just-identify the model we can use both the short-run and long-run restrictions implied by alternative economic models[7] In particular, in this section we discuss **three** different sets of identifying restrictions base 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 imply that the long-run Phillips trade-off is zero since, as can be seen from expression (10), the latter will also be the case if $b(1)=0$. Hence, the long-run Granger-causality from inflation to unemployment in the VAR reduced is crucial for the existence of Phillips long-run trade-off.

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[6] To obtain this we solve (6a) and (6b) for the long-run trends in unemployment and inflation.

[7] Notice that the use of long-run restrictions is possible because we are considering non-stationary variables.

### 2.2.2. A Monetarist-Rational Expectations Approach (M)

From this view, 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. Formally, $a_{\pi u}(1)=0$ in expression (3b). Furthermore, it implies a fixed value for the short-run Phillips trade-offs. To see this, let us consider the moving average (MA) representations of the structural and reduced forms in (4) and (7). The structural MA representation is:

$$\begin{pmatrix} \Delta u \\ \Delta \pi \end{pmatrix} = \begin{pmatrix} d_{11}(L) & d_{12}(L) \\ d_{21}(L) & d_{22}(L) \end{pmatrix} \begin{pmatrix} \varepsilon^s \\ \varepsilon^d \end{pmatrix} \tag{11}$$

and the reduced-form MA representation is:

$$\begin{pmatrix} \Delta u \\ \Delta \pi \end{pmatrix} = \begin{pmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{pmatrix} \begin{pmatrix} e_u \\ e_\pi \end{pmatrix} \tag{12}$$

where:

$$\begin{pmatrix} e_u \\ e_\pi \end{pmatrix} = \frac{1}{(1 - \lambda\delta)} \begin{pmatrix} 1 & \lambda \\ \delta & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_u \\ \varepsilon_\pi \end{pmatrix} \tag{13}$$

Thus, by setting $d_{21}(1)=0$ under our M outline, we are implicitly choosing $\delta=\phi_{21}(1)/\phi_{22}(1)$ , which together with:

$$\Sigma = \frac{1}{(1 - \lambda\delta)^2} \begin{pmatrix} 1 & \lambda \\ \delta & 1 \end{pmatrix} \begin{pmatrix} \sigma^2_{\varepsilon^s} & 0 \\ 0 & \sigma^2_{\varepsilon^d} \end{pmatrix} \begin{pmatrix} 1 & \delta \\ \lambda & 1 \end{pmatrix}$$

defines a corresponding value for λ.

### 2.2.3 A Keynesian Approach (K)

Models based on simple forms of nominal stickiness imply short-run and even long-run trade-offs between inflation and unemployment (see, e.g. Romer

(1996)). The latter could be reinforced through unemployment hysteresis mechanisms. This Keynesian view implies that short-run unemployment fluctuations can be dominated by demand shocks, whereas in the long-run, both types of shock are allowed to affect unemployment in a permanent way.

Using these arguments, we consider short-run identifying restrictions to define Keynesian models. For comparability, this implies the choice of a λ value (i.e. a contemporaneous Phillips trade-off) such that it maximises the short-run demand effects on unemployment given our theoretical representation. More formally, the chosen value is such that:[8]

$$\lambda = \operatorname{argmax}_{\lambda} \frac{\lambda}{1-\lambda\delta} \tag{14}$$

subject to the following restriction stemming from the orthogonality assumption[9]:

$$\delta = \frac{\omega_{12} - \lambda\,\omega_{22}}{\omega_{11} - \lambda\,\omega_{12}}$$

## 2.3. The Lucas-Sargent Critique

In this section we just 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 (1972) and that this hypothesis is tested in the following expectations-augmented version of (3a)

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[8] Notice that, our procedure is different to the one proposed by King and Watson (1994). That is, our identification scheme for Keynesian models involves the joint effects of both δ and λ parameters instead of only the latter, as considered by those authors.

[9] Alternatively, for given λ, δ can be estimated by IV from equation (2) using the estimated $\epsilon_t^a$ as additional instrument.

$$u_t = \lambda \pi_t - \lambda^* \pi_t^e + \eta_t \tag{18}$$

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

Assume that $\pi_t$ is governed by the process $\pi_t = \rho(L)\pi_{t-1} + \epsilon_t$, such that, under rational expectations, $\pi_t^e = \rho(L)\pi_{t-1}$. Then, the reduced for unemployment and inflation relation is

$$u_t = \lambda \pi_t - \lambda^* \rho(L)\pi_{t-1} + \eta_t \tag{19}$$

so that the long-run trade-off is $\partial u/\partial \pi = \lambda - \lambda^* \rho(1)$ . Thus, even if there is long-run neutrality ($\lambda = \lambda^*$), estimation of (19) would lead to an apparent long-run trade-off unless $\rho(1)=1$. Naturally, the existence of a unit root in $\pi_t$ implies precisely that $\rho(1)=1$ and, therefore, the criticism does not apply.

## 3. EMPIRICAL RESULTS

### 3.1. The data set and the reduced-form estimates

The data set spans the period 1964:I-1995:IV and consists of: the Spanish CPI annual inflation rate ($\pi_t = \Delta_4 \log p_t$), the Spanish unemployment rate ($u_t$), the EU(12) CPI annual inflation rate ($\pi x_t = \Delta_4 \log px_t$) and the EU(12) unemployment rate ($ux_t$). All the data are quarterly, seasonally unadjusted and are drawn from the Statistical Bulletin of the Banco de España and OECD Economic Outlook.

Figure 1 depicts the course of the Spanish unemployment and inflation rates over the sample period. Some summary features of both time series are shown in Table 2, which reports means, standard deviations and correlations for various subintervals of the sample period. These correlations are positive up to the late 70's, reflecting the stagflation that followed the oil crises. Since then, they turned out to be negative, large and fairly stable, with the exception of the 1986-1991 subperiod where no correlation is present. Nevertheless, as these simple correlations are dominated by both domestic and foreign demand and supply shocks, they are not informative about the nature of the driving forces behind. To disentangle the source of these correlations and analyse the Phillips trade-offs following a shock in aggregate demand is the task of the remainder of the paper.

Table 3 shows a summary of results from the estimation of the reduced-form with lag length ranging from 4 to 8 lags. The VAR in $(\Delta u_t, \Delta \pi_t)'$ given by equations (6a) and (6b) in section 2 was augmented with a constant, three seasonal dummies and current and lag values of the first differences of the EU(12) unemployment and inflation rates accounting for external shocks leading to shifts in the aggregate demand equation and the Phillips curve. In this latter respect, two comments are in order. The first is that both foreign variables enter the VAR unrestrictedly. However, the VAR can be interpreted as explaining the Spanish inflation and unemployment differentials vis-a-vis EU(12) countries. In fact, re-parameterization of the VAR in terms of inflation and unemployment differentials cannot be rejected at standard confidence levels. The second is that, under the small country assumption, both foreign variables are strongly exogenous, and hence, conditioning do not alter either the economics or the econometrics in section 2. Nevertheless, the structural disturbances $\epsilon_t^s$ and $\epsilon_t^d$ in equations (3a) and (3b) must be reinterpreted as idiosyncratic national supply and demand shocks though, for the sake of brevity, we will stick to the labels in section 2.

There are no signs of cointegration among any of the series and the specification of the VAR in first-differences seems appropriate, according to various portmanteau tests on the residuals[10]. As for the choice of lag length, both the AIC and SBIC criteria point out to five and four lags, respectively, though results for lag length ranging for 4 to 8 are reported in Table 3 in order to highlight their robustness for such a choice.

Various implications follow from the table. Firstly, although the correlation between the VAR innovations ($e_u$ and $e_\pi$) is negligible, the correlation between the stochastic trends of unemployment and inflation is sizeable, between -0.2 and -0.3 (s.e.=0.088). 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 unemployment). Thirdly, estimates of a(1) and c(1) are more sizeable and significant, albeit the second is marginally so; that c(1) is significant and

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[10] All the econometric programs and empirical results not reported in the paper are available upon request.

negative implies that there is Granger-causality from unemployment to inflation. And finally, since $a(1)\approx0$ and $c(1)<0$, it follows from expression (10) in section 2 that the long-run Phillips trade-off is a monotonic function for negatives values of $\lambda$. Figure 2 depicts the estimated long-run trade-offs as a function of $\lambda$ for the various lag lengths in Table 3. It can be observed that for small values of $\lambda$ the trade-off is almost absent, whilst for high values, the trade-off is around -2.0. The choice of lag length does not seem to have any noticeably effect on these estimates.

### 3.2. Impulse Response Functions and Variance Decompositions

Let us now turn to the results under the different identification outlines. We begin the discussion with the Keynesian (K) identifying restriction. Using the procedure described in section 2.2.3, $\lambda=-0.25$ proved to maximise the short-run demand effects on unemployment given by (14). Figure 3 depicts in the top panel 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, $\lambda=-0.12$ turned out to be the value obtained from the procedure described in section 2.2.2. Figure 4 shows the same information as above. Since inflation is a monetary phenomenon in the long-run under this outline, its IR function converges quickly towards unity, whereas unemployment falls by 0.3 percentage points in the long-run. The Phillips trade-off 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 outline, but statistically different from zero.

Next we turn to the RBC outline. Since $b(1)=d(1)\approx0$, , the RBC implies a vertical long-run Phillips curve. Figure 5 shows a similar IR function for inflation to the one obtained under the M outline. 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 4 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 outline, 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 outline, $\epsilon^d_t$ explains 15% of the unemployment variability and almost 90% of inflation variability. Finally, under the RBC outline, unemployment variability is completely explained by $\epsilon^s_t$ ; 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 costs of disinflation. Table 5 shows the estimated dynamic responses of the levels of unemployment and inflation to an $\epsilon^d_t$ 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 rises 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. 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 in a similar full-hysteresis framework by Dolado and Lopez-Salido (1995), we can compute the corresponding cumulated output losses over any period. According to these authors' 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

In this section we investigate the stability of the bivariate relation analyzed above. We started this paper by pinpointing that the mid-70s represented key years in the recent history of Spanish inflation. Thus, it seems natural to test whether those years are the natural breaking dates in the sample. A first eyeball impression on this issue is given by Figure 6, where recursive estimates of the gains in the VAR are presented since 1973. It is clear that b(1) is fairly stable and around zero, but that there is lack of parameter constancy in a(1), c(1) and d(1) around 1979. Figure 7, in turn, plots recursive estimates of the long-run Phillips trade-offs for $\lambda=-.12$ and $\lambda=-.25$ and shows the same message, namely, that before 1980 there was no trade-off, being unemployment completely dominated by supply shocks. More formal evidence on split-sample Chow tests indicate that there was a break point in 1979:1. Therefore, in what follows, we concentrate on results for the sample 1979:2-1995:4, letting aside the initial period in view that there were no trade-offs present in that subsample.

Although the details of the estimation of the VAR in the second subsample are skipped for the sake of brevity, Figure 8, which compares the Phillips trade-offs (across different values of $\lambda$) for the complete sample and the chosen subsample, shows that the results are very much the same and, therefore, that the discussion above applies as well. Indeed, the $\lambda$'s implied by the M and the K outlines are similar. As regards the VD analysis, Table 6 shows again similar contributions of demand shocks to unemployment variability to those in Table 4. In turn, it shows a much higher contribution to inflation variability under both the K and M identification outlines and a lower contribution under the RBC outline.

With regard to the sacrifice ratios, Table 7 shows the same ordering as before. It is noteworthy that the ratios corresponding to the RBC and M outlines are almost identical to the ones obtained with the whole sample, whereas the one implied by the K identification is half of a percentage point lower[11].

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[11] A detailed analysis of two recent disinflationary episodes, which are seemingly dominated by tighter monetary policy, can be found in the Appendix.

## 5. THE ROBUSTNESS OF THE IDENTIFYING RESTRICTIONS

As discussed earlier, the model given by equations (3a) and (3b), plus condition $\sigma_{12}=0$ lacks econometric identification. Thus, an extra identifying restriction is needed. In this section, the structural model is estimated in the first place for a range of $\lambda$'s, so that the previous K, M and RBC outlines can be seen as particular cases within this framework. Once $\lambda$ is assumed to be known, the other three structural parameters of interest can be estimated: (i) $\delta$, the slope of the short-run aggregate demand function (the short-run effect of supply shocks on inflation and unemployment); (ii) the slope of the long-run aggregate demand function (the short-run effect of supply shocks on inflation and unemployment); and (iii) the slope of the long-run Phillips curve (the long-run Phillips trade-off). From this starting point, following King and Watson (1992), a set of graphs is used to present point estimates and confidence intervals for the parameters of interest of the observationally equivalent models. This will allow us to analyse the robustness of some conclusions derived from the chosen identifying assumption.

The results are shown in the three panels of Figure 9. This figure shows, for a wide range of $\lambda$'s, the resulting point estimates and confidence intervals for the slope of the long-run Phillips curve and the slopes of the short and the long-run aggregate demand functions.

The top panel of the figure depicts the monotonic relationship between the short- and long-run Phillips trade-offs, showing what values of $\lambda$ are compatible with the hypothesis of a vertical long-run Phillips curve[12]. For $\lambda<-1.27$ the estimated long-run Phillips trade-offs are large, though not statistically significant. However, for $\lambda>-1.27$, a range which includes the three previous identification outlines in section 3, the hypothesis is rejected unless prior beliefs close to the RBC identification are assumed (i.e $\lambda>-.09$). For $\lambda>-.09$, two extreme and implausible implications follow: shocks to aggregate demand have no short-run effects on unemployment (the short-run Phillips curve is also vertical) and shocks to aggregate supply have no significative short-run effects on inflation (the short-run aggregate demand is flat).

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[12] It should be noted that results on the slope of the long-run Phillips curve do not depend on the assumption $\sigma_{12}=0$ since, once $\lambda$ is assumed to be known, equation (3a) is identified.

The middle and bottom panels of the Figure 9 plot, again for a range of $\lambda$ values, point estimates and confidence intervals for the slopes of the short- and long-run aggregate demand functions ($\delta$ and $\gamma_{\pi u}$, respectively). Two interesting results are worth commenting. First, the slope of the short-run aggregate demand function is positive and significant for $\lambda$ values lower than -0.09. And second, whatever the value of $\lambda$ is chosen, the slope of the long-run aggregate demand function is not statistically different from zero. That is, supply shocks have no long-run effect on inflation or, following our M-outline, inflation is a demand phenomenon in the long-run.

To end up with this section, we represent our results in a compact and familiar textbook diagram. Demand and supply are brought together in Figure 10. The demand side comes in two parts: the upward sloping short-run aggregate demand ($AD_{SR}$), and the horizontal long-run demand ($AD_{LR}$). The latter schedule can reflect either the horizontal PPP line or the money growth rate of the economy. As for the supply side, it is represented by a Phillips curve which is downward sloping both in the short and in the long-run, reflecting that full hysteresis mechanisms play an important role in the inflation-unemployment dynamics. This simple representation can help understand policy implications from our empirical results: disinflationary demand policies in economies suffering from high persistence may become costly in terms of unemployment unless supply-side reforms are implemented.

## 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 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 outlines which fit the data equally well, but that have different implications for the magnitude of Phillips trade-offs and for sacrifice ratios, defined as the unemployment cost of moving to a permanently lower inflation rate induced by demand changes. 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.

A traditional keynesian identification yields: (i) large estimated long-run trade-offs between inflation and unemployment of around -0.6 ; (ii) 1-year demand shocks explain essentially all of unemployment and only 12% of inflation; (iii) long-run variability in inflation with a source that is approximately 12% demand shocks, whereas long-run variability in unemployment is basically explained by demand shocks. Finally, sacrifice ratios over five years are around 2.5. By contrast, a monetarist identification yields long-run trade-offs of around -0.3, 90% of inflation variability explained by demand shocks and only 15% of unemployment variability explained by those shocks, and sacrifice ratios of 1.0 over five years. Finally, an alternative real business-cycle identification yields negligible trade-offs and sacrifice ratios, with unemployment variability being completely explained by supply shocks and 40% of inflation variability accounted by demand shocks.

As regards the analysis of different subsamples, we find that the shifts in Phillips curve before the end of the 70's were very much explained by supply shocks (oil prices, reallocation of labour supply, etc.), whereas the behaviour during 1979-1995 followed the same pattern as in the total sample.

Finally, in section 5, we addressed the robustness of some key structural parameters estimates -namely, the slopes of the long-run Phillips curve, the short aggregate demand function and the long-run aggregate demand function- to changes in the identifying restrictions. We found some interesting results. On the one hand, we cannot reject that supply shocks have no long-run effect on inflation whatever the value of $\lambda$ is chosen; that is, following the M-outline, inflation is a demand phenomenon in the long-run. On the other hand, for a wide range of plausible $\lambda$'s ($\lambda > -1.27$), we do reject at standard confidence levels the verticality of the long-run Phillips curve unless prior beliefs close to the RBC identification were assumed. However, under RBC interpretations, one should accept as well that shocks to aggregate demand have no short-run effect on unemployment (the short-run Phillips curve is vertical) and that shocks to aggregate supply have no significative short-run effect on inflation (the short-run aggregate demand is flat), which seems to be at odds with alternative studies on the importance of supply and demand shocks in larger overidentified systems[13]. On the contrary, if we are left with interpretations close to our K and M outlines, the results may differ in magnitude but not in content: disinflationary demand policies in an economy suffering from high persistence may become costly in terms of unemployment unless supply-side reforms are implemented.

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[13] See Dolado and López-Salido (1996) and Dolado and Jimeno (1996)

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## APPENDIX: INTERPRETING TWO DISINFLATIONARY EPISODES

According to Figure A.1, which plots the inflation rate and the Central Bank intervention interest rate[14] during the period 1987:1-1995:4, there are two recent episodes of disinflation which seem to be clearly driven by tighter monetary policy. The first one goes from 1987:1 to 1987:3 and the second one from 1989:3 to 1990:4. In the first period, the interest rates rose by 5 percentage points, and during the second one they were held stable around 15% and were accompanied by credit restrictions. The disinflation after 1993, at first sight, was more due to deregulation in both labour and goods markets. Since both episodes are too short for any econometric estimation on their own, we examine the cost of disinflation by reporting results derived from estimating the VAR across the different subsamples: 1964-1986 (before the episodes), 1964-1990 (during the episodes) and 1964-1995 (after the episodes). Again, for the sake of saving space, the details of the VARs are not reported.

The top panel of Figure A.2 shows the IR functions of unemployment and inflation to a unit variance positive demand shock under the M outline and the bottom panel depicts the corresponding Phillips trade-offs. It is noteworthy that, as we move across longer samples, inflation tends to increase by less whilst unemployment also decreases by less. Nonetheless, the bottom panel proves that the trade-offs worsened during the two episodes and, then, improved after 1990. So, the trade-off shifted from being zero in 1964-1986 to -0.6 in 1964-1990 with a value in between of -0.3 in 1964-1995. Figure A.3, which corresponds to the K outline, shows a similar picture, with the trade-offs worsening from -0.6 to -0.7 during the intermediate sample and, then, going back to -0.6 after 1990. As regards the sacrifice ratios, reported in Table A.1, the messages are slightly different. So, whereas the M outline indicates a progressive decline, the K outline points towards a progressive rise.

All in all, however, we tend to find evidence that the two episodes earlier discussed were characterised by both a worsening of the Phillips trade-offs and of the sacrifice ratios.

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[14] See Escrivá and Santos (1991) for details on the construction of the interest rate.

# TABLE 1

## ESTIMATED SACRIFICE RATIOS

| Sample Period | Keynesian | Monetarist | RBC |
|---|---|---|---|
| 1964-86 | 2.1 | 1.9 | 0 |
| 1964-90 | 2.4 | 1.9 | 0 |
| 1964-95 | 2.5 | 1.4 | 0 |

**Note:**

The sacrifice ratio is defined as the cumulative annual percentage-point changes in unemployment required to produce a permanent one percentage point reduction in inflation following a negative demand shock.

## TABLE 2

## SUMMARY STATISTICS

| SAMPLE PERIOD | UNEMPLOYMENT | | INFLATION | | SAMPLE CORRELATION |
|---|---|---|---|---|---|
| | $\overline{u}$ | $s_u$ | $\overline{\pi}$ | $s_\pi$ | |
| 1964:1 - 1970:1 | 1,23 | 0,25 | 6,20 | 3,65 | 0,71 |
| 1970:2 - 1973:3 | 1,77 | 0,53 | 7,95 | 1,88 | 0,71 |
| 1973:4 - 1979:2 | 4,70 | 1,79 | 16,90 | 3,13 | 0,32 |
| 1979:3 - 1986:1 | 16,25 | 4,10 | 12,07 | 2,27 | -0,90 |
| 1986:2 - 1991:4 | 18,33 | 1,94 | 6,08 | 9,15 | -0,04 |
| 1992:1 - 1994:1 | 21,01 | 2,70 | 5,08 | 0,76 | -0,80 |
| 1992:1 - 1995:4 | 22,05 | 2,36 | 4,85 | 0,65 | -0,79 |

**Note:**
$\overline{x}$ denotes the sample mean and $s_x$ the sample standard deviation $(x = u, \pi)$ .

# TABLE 3

## 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 | | | Trends'Covariance Matrix | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AIC | SBIC | a(1) | b(1) | c(1) | d(1) | sd($e_u$) | sd($e_\pi$) | corr( ) | sd($\tau_u$) | sd($\tau_\pi$) | corr ( ) |
| 4 | 3,623 | -1,348 | 0,65<br>(0,10) | 0,01<br>(0,04) | -0,41<br>(0,24) | -0,09<br>(0,14) | 0,29 | 0,98 | -0,041 | 0,87 | 1,03 | -0,341 |
| 5 | 3,619 | -1,254 | 0,62<br>(0,11) | 0,01<br>(0,05) | -0,24<br>(0,15) | 0,136<br>(0,16) | 0,30 | 1,03 | -0,049 | 0,80 | 1,22 | -0,223 |
| 6 | 3,653 | -1,119 | 0,57<br>(0,11) | -0,001<br>(0,05) | -0,29<br>(0,17) | 0,126<br>(0,19) | 0,30 | 1,05 | -0,055 | 0,71 | 1,24 | -0,266 |
| 7 | 3,710 | -0,963 | 0,57<br>(0,11) | 0,002<br>(0,06) | -0,34<br>(0,19) | 0,012<br>(0,20) | 0,30 | 1,05 | -0,055 | 0,71 | 1,11 | 0,270 |
| 8 | 3,761 | -0,810 | 0,543<br>(0,12) | 0,003<br>(0,07) | -0,42<br>(0,21) | -0,15<br>(0,23) | 0,31 | 1,05 | -0,058 | 0,68 | 0,97 | -0,290 |

**Note:**
Standard errors in parenthesis. AIC = Akaike Information Criterion and SBIC = Schwarz Bayesian Information Criterion. The estimates are obtained from a VAR including a constant, seasonal dummies and the first differences of the EU(12) unemployment rate and the first differences and lagged first differences of the EU(12) inflation rate.

# TABLE 4

# 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 5

## 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 |
| 20 | 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 |
| 20 | 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 |
| 20 | -0,03 | -1,00 | **-0,15** |

## TABLE 6

## DEMAND VARIANCE DECOMPOSITIONS

(1979-1995)

| Horizon | RBC MODEL | | ($\lambda$ = -0,12) MONETARIST MODEL | | ($\lambda$ = -0,25) KEYNESIAN MODEL | |
|---|---|---|---|---|---|---|
| | u | $\pi$ | u | $\pi$ | u | $\pi$ |
| 1 | 0,00 | 71,37 | 23,51 | 94,96 | 0,00 | 87,73 |
| 4 | 0,008 | 47,40 | 23,98 | 91,43 | 1,37 | 67,46 |
| 8 | 0,021 | 45,33 | 24,07 | 91,13 | 3,97 | 65,51 |
| 12 | 0,022 | 44,95 | 24,08 | 90,92 | 4,20 | 65,08 |
| 16 | 0,023 | 44,87 | 24,08 | 90,88 | 4,22 | 64,90 |
| $\infty$ | 0,023 | 44,85 | 24,08 | 90,88 | 4,23 | 64,88 |

## TABLE 7

## SACRIFICE RATIOS (SR) FOR A 1 PERCENTAGE POINT PERMANENT REDUCTION IN THE INFLATION RATE

(Sample period: 1979-1995)

| Horizon | KEYNESIAN MODEL | | |
|---|---|---|---|
| | u | $\pi$ | SR |
| 1 | 0,23 | 0,93 | 0,23 |
| 4 | 0,28 | 1,32 | 0,28 |
| 8 | 0,46 | 0,91 | 0,74 |
| 12 | 0,42 | 1,03 | 1,16 |
| 16 | 0,42 | 0,99 | 1,58 |
| 20 | 0,42 | 1,00 | **2,00** |

| Horizon | MONETARIST MODEL | | |
|---|---|---|---|
| | u | $\pi$ | SR |
| 1 | 0,14 | 0,66 | 0,14 |
| 4 | 0,24 | 1,32 | 0,24 |
| 8 | 0,26 | 0,99 | 0,50 |
| 12 | 0,27 | 0,99 | 0,77 |
| 16 | 0,26 | 1,01 | 1,03 |
| 20 | 0,26 | 1,00 | **1,29** |

| Horizon | RBC MODEL | | |
|---|---|---|---|
| | u | $\pi$ | SR |
| 1 | 0,00 | 1,01 | 0,00 |
| 4 | -0,06 | 0,98 | -0,06 |
| 8 | 0,08 | 1,02 | 0,02 |
| 12 | 0,04 | 0,99 | 0,06 |
| 16 | 0,05 | 1,00 | 0,11 |
| 20 | 0,05 | 1,00 | **0,16** |

FIGURE 1

# INFLATION AND UNEMPLOYMENT IN SPAIN

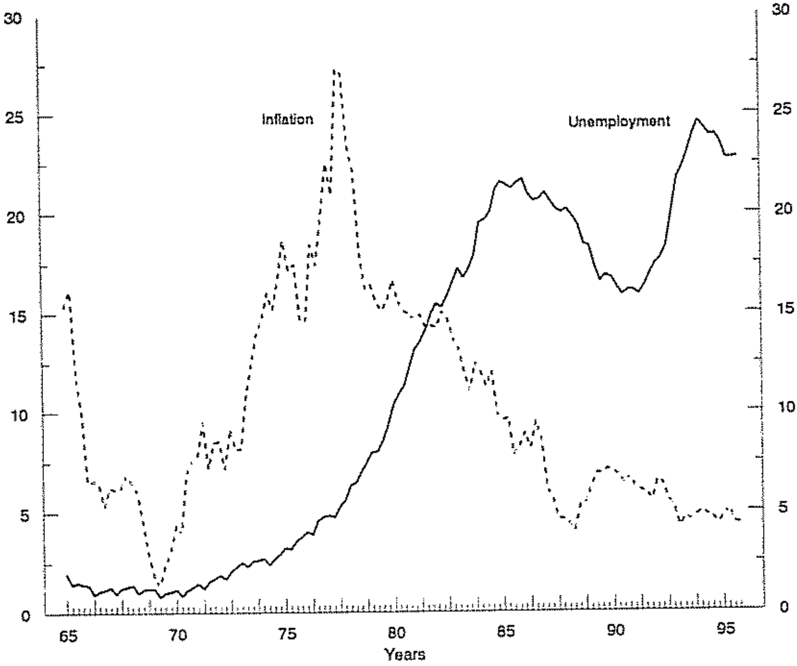


FIGURE 2

## IMPLIED LONG-RUN PHILLIPS TRADE-OFFS

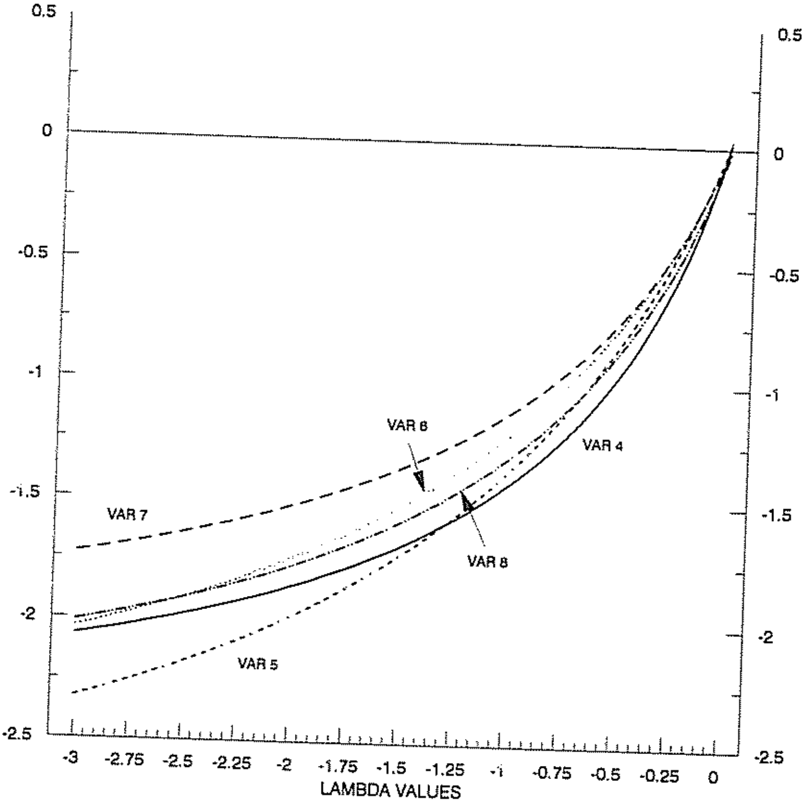
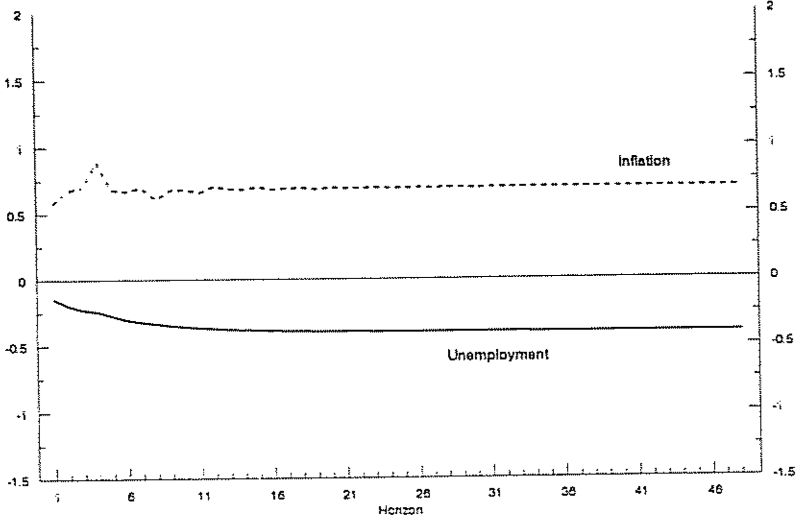


FIGURE 3

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



## PHILLIPS CURVE TRADE-OFFS

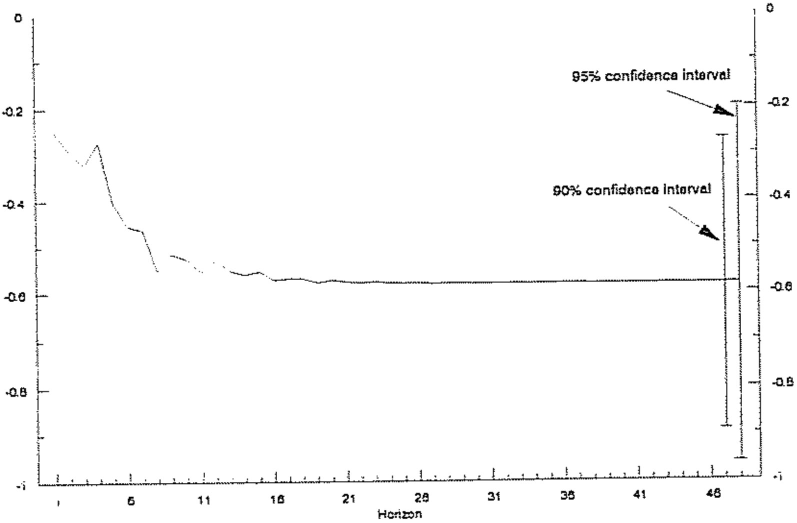
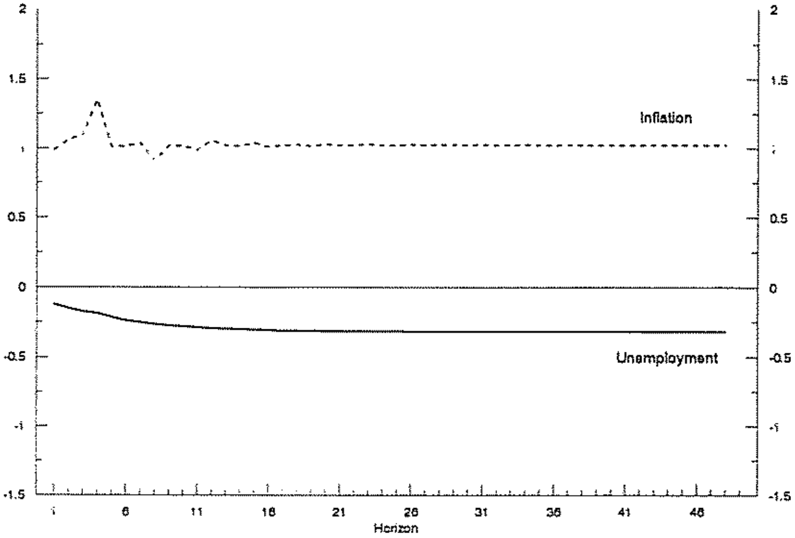


FIGURE 4

MONETARIST MODEL
(RESPONSES TO A UNIT DEMAND SHOCK)



PHILLIPS CURVE TRADE-OFFS

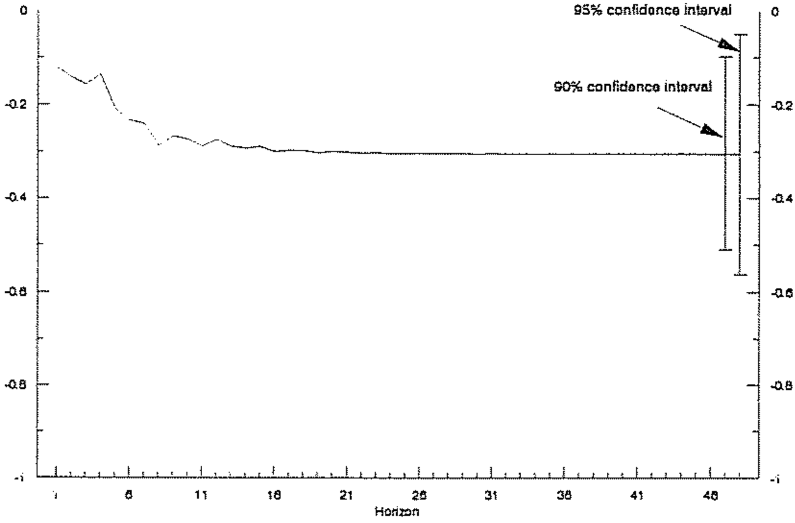
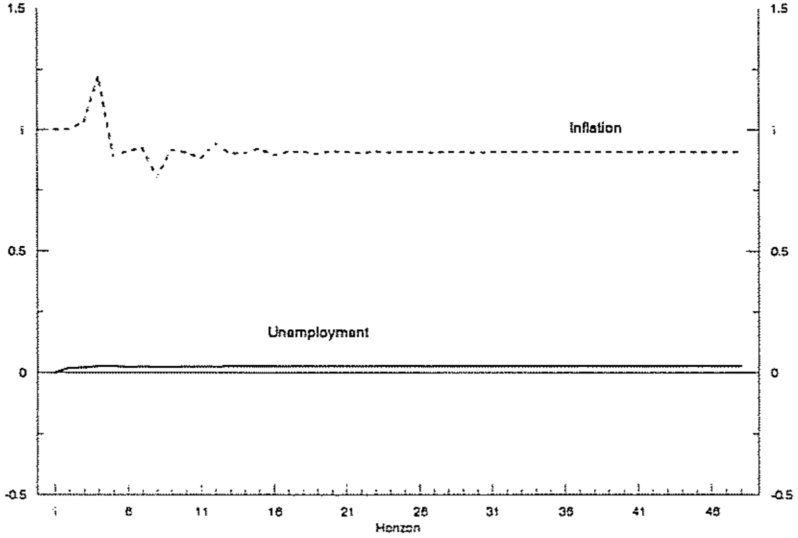


FIGURE 5

RBC MODEL
(RESPONSES TO A UNIT DEMAND SHOCK)



PHILLIPS CURVE TRADE-OFFS

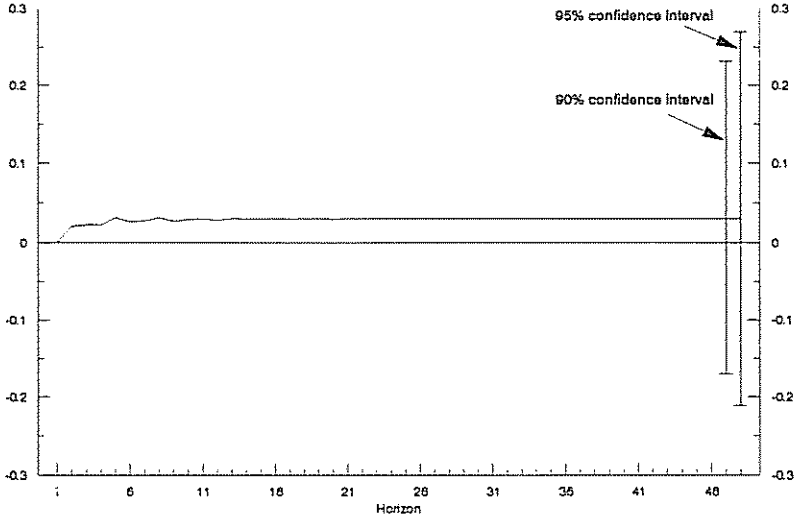
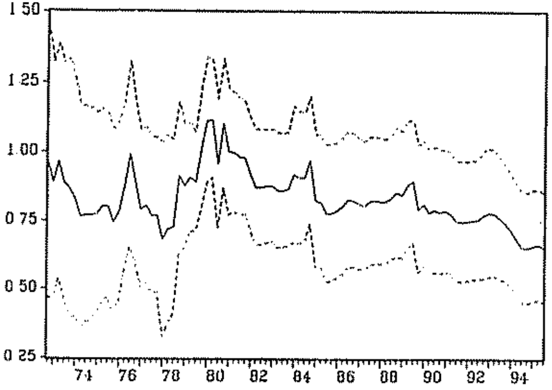


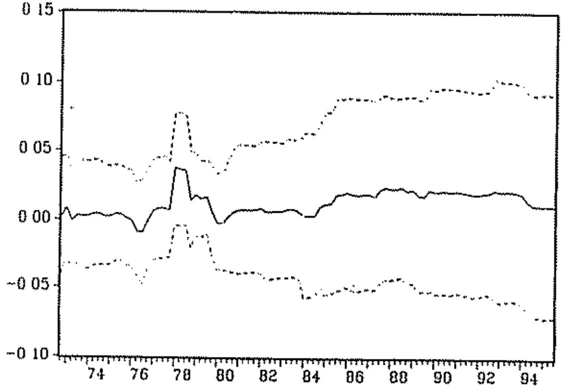
FIGURE 6

RECURSIVE ESTIMATES OF LONG-RUN PARAMETERS(*)

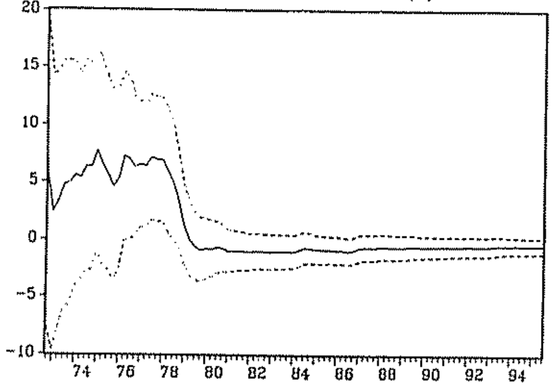
(Results from a VAR 4)



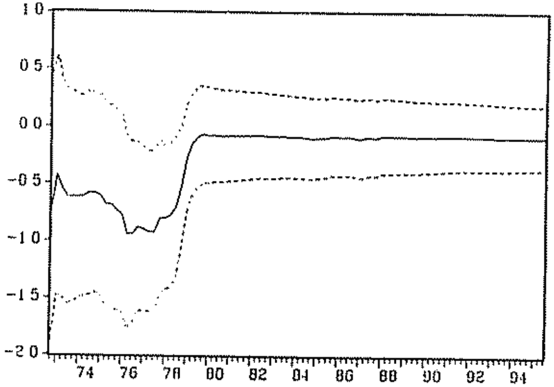
RECURSIVE ESTIMATES OF a(1)



RECURSIVE ESTIMATES OF b(1)



RECURSIVE ESTIMATES OF c(1)



RECURSIVE ESTIMATES OF d(1)

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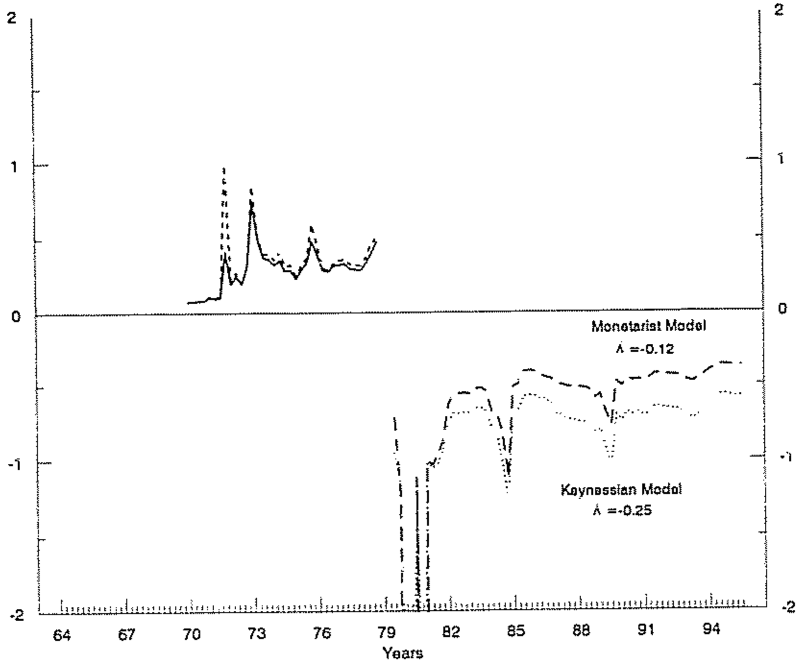
(*) Note: Dotted lines +/- 2 standard errors

FIGURE 7

## RECURSIVE LONG-RUN PHILLIPS TRADE-OFF ESTIMATES
## (VAR 4)



NB: The results are robust to lambda values

FIGURE 8

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

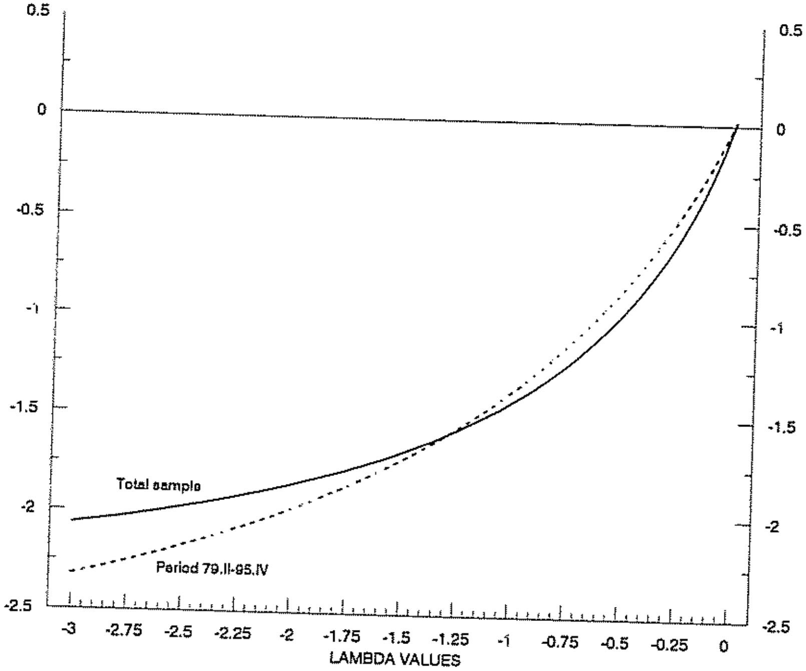
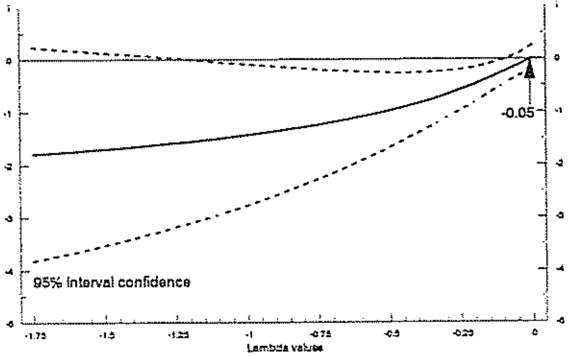
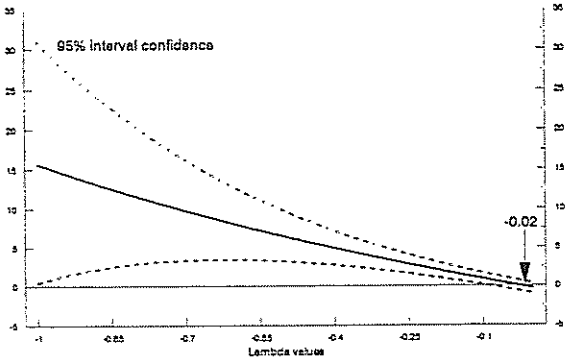


FIGURE 9

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



## SHORT RUN DEMAND SLOPE AS A FUNCTION OF LAMBDA (SHORT RUN PHILLIPS TRADE-OFF)



## LONG RUN DEMAND SLOPE AS A FUNCTION OF LAMBDA (SHORT RUN PHILLIPS TRADE-OFF)

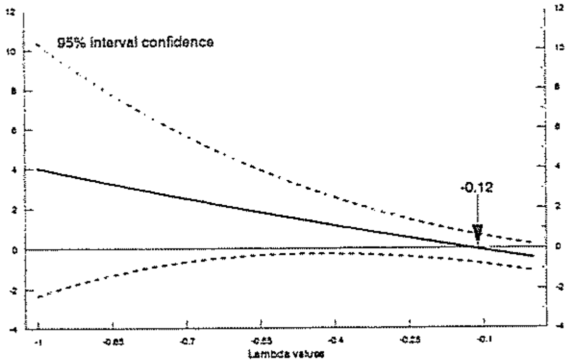
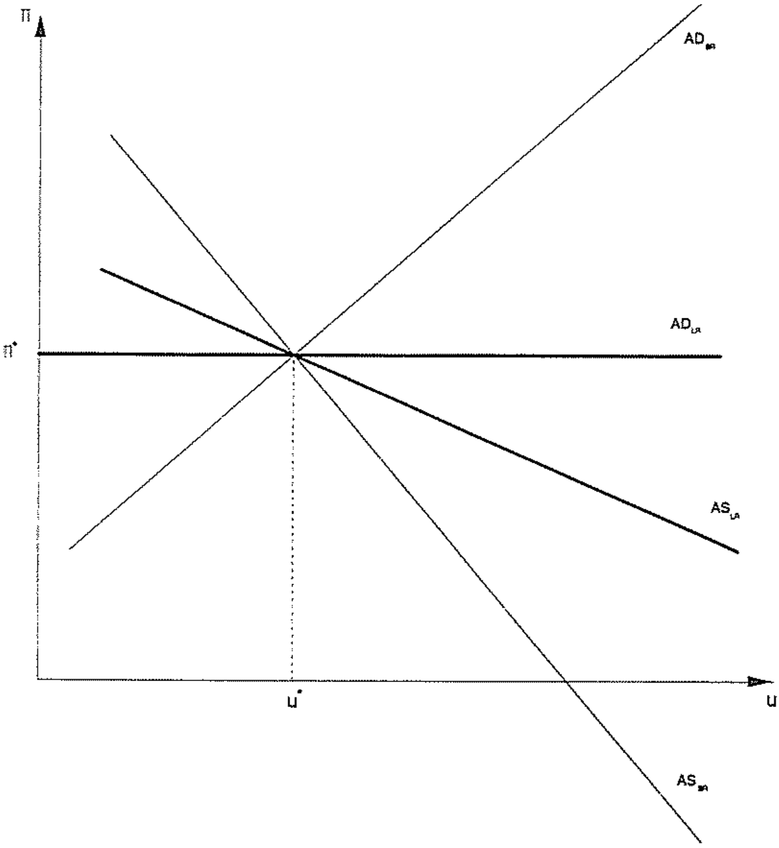


FIGURE 10

AGGREGATE DEMAND-AGGREGATE SUPPLY DIAGRAM



# TABLE A.1

## SACRIFICE RATIOS (SR) IN TWO DISINFLATIONARY EPISODES

| MONETARIST IDENTIFICACION ($\lambda$ = -0,12) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample = 1964:1-1986:4 | | | Sample = 1964:1-1990:4 | | | Sample = 1964:1-1995:4 | | |
| Horizon | u | $\pi$ | SR | u | $\pi$ | SR | u | $\pi$ | SR |
| 1 | 0,12 | -0,50 | 0,12 | 0,13 | -0,76 | 0,13 | 0,13 | -0,94 | 0,13 |
| 4 | 0,19 | -0,89 | 0,19 | 0,20 | -1,13 | 0,20 | 0,18 | -1,30 | 0,18 |
| 8 | 0,31 | -0,71 | 0,50 | 0,32 | -0,81 | 0,52 | 0,25 | -0,88 | 0,43 |
| 12 | 0,40 | -0,86 | 0,90 | 0,39 | -0,96 | 0,91 | 0,29 | -1,03 | 0,72 |
| 16 | 0,45 | -0,87 | 1,35 | 0,44 | -0,94 | 1,35 | 0,31 | -0,98 | 1,3 |
| 20 | 0,59 | -1,99 | **1,94** | 0,55 | -1,00 | **1,90** | 0,33 | -1,00 | **1,36** |

| KEYNESIAN IDENTIFICACION ($\lambda$ = -0,25) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample = 1964:1-1986:4 | | | Sample = 1964:1-1990:4 | | | Sample = 1964:1-1995:4 | | |
| Horizon | u | $\pi$ | SR | u | $\pi$ | SR | u | $\pi$ | SR |
| 1 | 0,13 | -0,53 | 0,13 | 0,17 | -0,67 | 0,17 | 0,20 | -0,82 | 0,20 |
| 4 | 0,20 | -0,91 | 0,20 | 0,25 | -1,07 | 0,25 | 0,33 | -1,25 | 0,33 |
| 8 | 0,33 | -0,72 | 0,53 | 0,40 | -0,79 | 0,65 | 0,47 | -0,86 | 0,80 |
| 12 | 0,43 | -0,83 | 0,96 | 0,49 | -0,93 | 1,14 | 0,54 | -,01 | 1,34 |
| 16 | 0,48 | -0,88 | 1,44 | 0,57 | -0,93 | 1,71 | 0,56 | -0,98 | 1,90 |
| 20 | 0,63 | -1,00 | **2,07** | **0,70** | -1,00 | **2,41** | 0,60 | -1,00 | **2,50** |

FIGURE A.1

CENTRAL BANK INTERVENTION
NOMINAL INTEREST RATE AND INFLATION

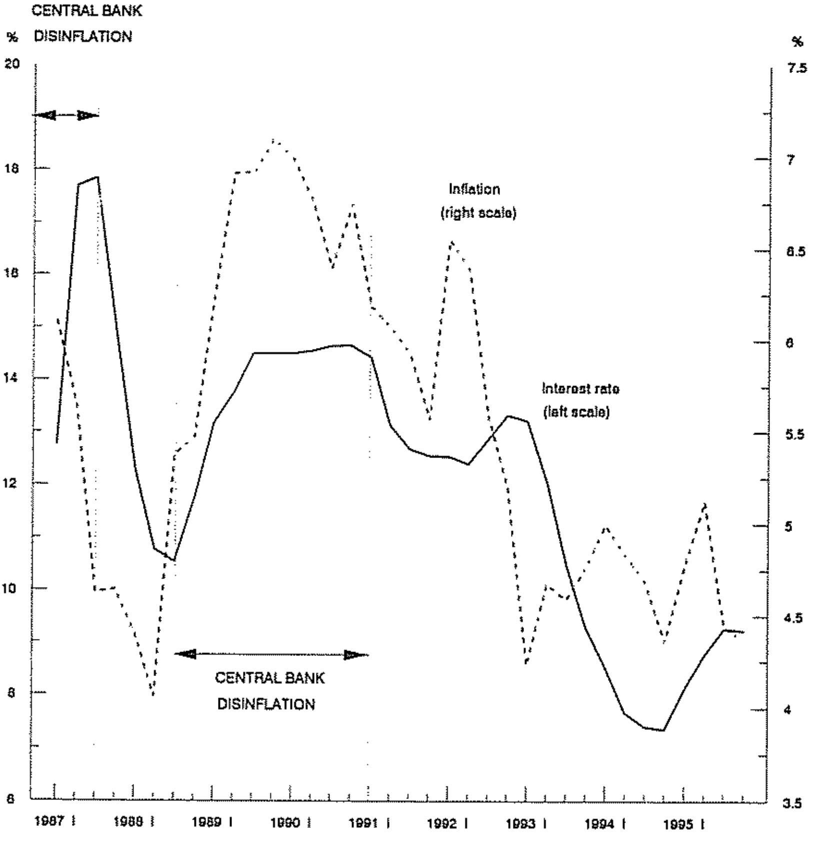
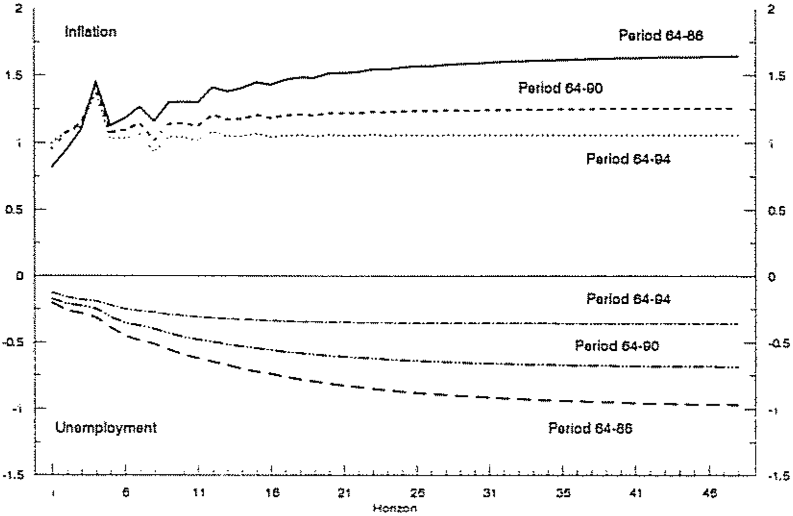


FIGURE A.2

## STABILITY OF THE INFLATION-UNEMPLOYMENT IMPULSES-RESPONSES (MONETARIST IDENTIFICATION OF DEMAND SHOCKS)



## STABILITY OF THE PHILLIPS CURVE TRADE-OFF (MONETARIST IDENTIFICATION)

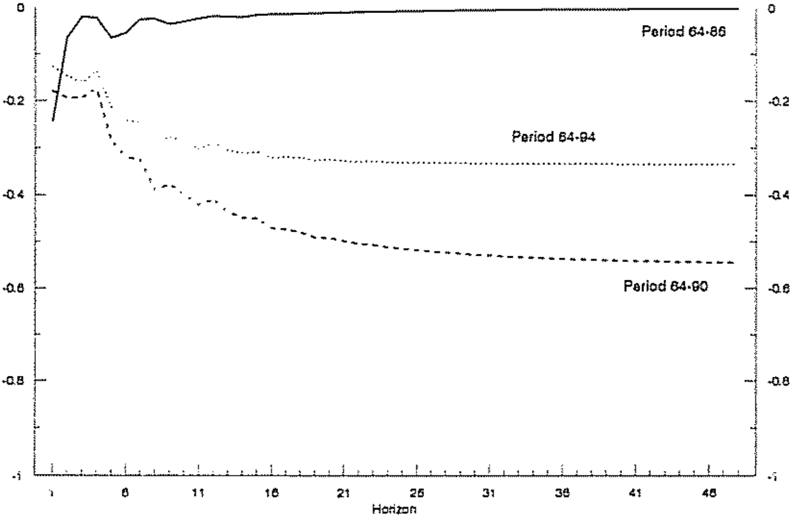
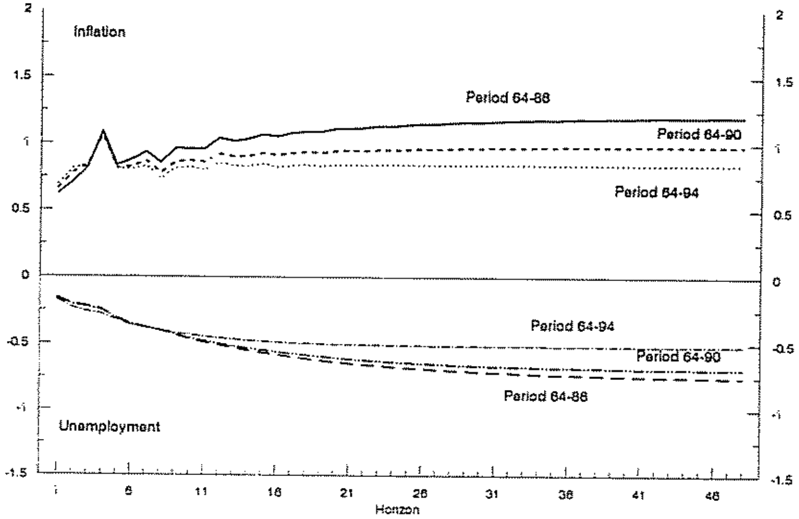


FIGURE A.3

### STABILITY OF THE INFLATION-UNEMPLOYMENT IMPULSES-RESPONSES (KEYNESIAN MODEL: LAMBDA=-0.25)



### STABILITY OF THE PHILLIPS CURVE TRADE-OFF