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Abstract

As the Spanish economy gets more integrated in international markets, competitiveness becomes a key determinant of the monetary transmission. In this paper we trace out the dynamic response of prices, output and the exchange rate following a monetary policy shock. We estimate a structural VAR model whose identification scheme is based on the long run properties common to a large class of models. The results suggest that a small model with efficient asset markets plus nominal inertia and long run monetary neutrality, captures the essential features of the monetary transmission mechanism in Spain. The interest rate shock is well identified and the exchange rate overshoots its long run value. There are no signs of *liquidity puzzle* nor of *price puzzle* or *exchange rate puzzle* either.

1. INTRODUCTION.

In a world of highly integrated international financial markets, domestic monetary authorities are losing grounds on their ability to influence the real rate of return of financial assets. Thus, the importance of expectations and competitiveness in the transmission mechanism of monetary impulses to the real activity and inflation is enhanced. In a small open economy with nominal rigidities the initial response of the exchange rate is of particular importance, since it determines to a great extent the path of disinflation following an increase in the interest rate. Most asset-markets models of exchange rate determination predict that an increase in the domestic interest rate induced by a monetary policy action, leads to an immediate appreciation of the nominal exchange rate, probably overshooting its long run level. If domestic prices are rigid the economy suffers a sharp fall in competitiveness which reduces demand and inflation latter on. This appreciation also reduces imported inflation and moderates inflation expectations. Unfortunately, the empirical evidence on exchange rate determination has encountered that the response to monetary shocks does not always fit with the prediction of the theory[1]. Furthermore, when the central bank sets the interest rate according to an inflation rule (i.e. disregarding the level of nominal variables) neither the magnitude, nor even the sign, of the initial exchange rate response can be uniquely determined[2].

In this paper we try to characterize the main features of the monetary transmission mechanism in the Spanish economy, with special attention to the response of nominal and real exchange rates to monetary shocks. A by-product of our analysis is an estimate of the initial response of the exchange rate following a normalized interest rate shock which might help to fix, at least on empirical grounds, the most likely path of nominal and real variables during a disinflation process as the one observed in Spain during the last fifteen years. We approach this by

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[1] Some examples are Sims (1992) for the G-7 countries and more recently Eichenbaum and Evans (1995) for the dollar area.

[2] Andrés, Mestre and Vallés (1997) discuss this point in the context of monetary strategies based on inflation targets.

means of a vector autoregressive model in output, inflation, the interest rate and the exchange rate. The structural VAR methodology (SVAR) is particularly appropriate for our purpose since it helps to isolate the response of each variable to structural shocks. For this to be successful it is of crucial importance that monetary policy shocks are adequately identified. There are different identification strategies some of which have already been used to identify policy shocks in an open economy setting. Some authors, based on informational lags, impose restrictions upon the contemporaneous innovations of the VAR. Recent examples of such identification for the Spanish economy can be found in Kim (1997), Shioji (1997) and Jareño, Sebastián and Vallés (1997). We build upon the work of Galí (1992) and our identification scheme exploits mainly some long run restrictions suggested by a standard monetary open economy model.

The structure of the paper is as follows. Section II briefly introduces the VAR identification based on the open macro model. Section III presents the main results from the analysis of the impulse-responses and variance decomposition using alternative identifications for the 1982-1996 period in the spanish economy. The main results are the followings: first, contrary to what happens with models based on contemporaneous restrictions, a satisfactory identification of monetary shocks can be achieved within the framework of a small parsimonious macro model. The exchange rate responds to interest rate shocks in a way which is consistent with a monetary model with some price rigidity. Furthermore, although both nominal and real exchange rates overshoot their long run levels, we find that there is less price inertia than what is found in VAR models imposing short run restrictions. Secondly, the hypothesis of full capital mobility is rejected for the sample period. Thirdly, productivity or supply shocks might not be the only source of long run fluctuations of output. Finally, the identified external shock may be interpreted as a risk premium or relative financial shock. Section IV concludes with some additional remarks. The overall picture that emerges from our results is that a small macro model, with long run monetary neutrality and limited short-run price inertia, may adequately capture the essentials of the monetary transmission mechanism in Spain. Furthermore, the degree of nominal inertia is found to be small, which means that the ability of domestic monetary policy to induce changes in the degree of competitiveness may be very limited, and so are the disadvantages of handing out monetary sovereignty to the institutions of the European Monetary Union.

2. A STRUCTURAL MODEL TO IDENTIFY MONETARY SHOCKS.

In the standard sticky price model, monetary policy may affect aggregate demand in the short run. Its supply side effects are reduced to the incidence on expectations and the possible long term effect of monetary policies operating through the level of investment or the efficiency in the use of productive factors. In the case of an open economy, the demand story goes as follows: a change in the domestic interest rate (brought about by a positive action undertaken by the monetary authority) shifts the level of demand both intertemporally, if it succeeds in affecting the real interest rate, and internationally, if the change in the nominal interest rate leads to a change in competitiveness. The more open the economy the harder is for the central bank to influence the time structure of demand, since the real interest rate is to a large extent determined by the return to foreign assets in international financial markets. Thus, the ability of monetary authorities to influence economic activity and inflation in the short run relies very much on the response of the exchange rate. The fact that net exports are very sensitive to the real exchange rate enhances the importance of foreign relative prices.

But, how do nominal and real exchange rates respond to changes in the stance of monetary policy?. These models predict a long-run nominal appreciation following an increase in domestic nominal interest rates such that real magnitudes remain constant. However it is the short run response of exchange rates and the dynamic adjustment path of an economy after a monetary shock what we are mainly interested in. This short run response is less predictable since it varies across different models of exchange rate determination. Some models would predict that the exchange rate overshoots its long run level (i.e. Dornbusch (1976), Buiter and Miller (1981)) under asset markets that clear at any moment, whereas others would predict a slow reaction of the exchange rates, or delayed overshooting, because of sluggishness in the financial markets, informational asymmetries and so on (e.g. Gourinchas and Tornell (1996)). Unfortunately, the overshooting hypothesis is difficult to test since exchange and interest rates can either move in the opposite direction (e.g. following a tightening in the monetary policy) or move together (after a positive shock to the foreign exchange rate premium, for instance). Thus, we need to identify, unobservable, components in the fluctuations of interest rates and this is what the VAR methodology is aimed at. The VAR methodology allows us to estimate unobservable monetary shocks that are orthogonal to the other shocks in the economy.

Let us assume that the exchange rate can be included in a covariance stationary vector X which admits a moving average representation on current and past serially uncorrelated structural shocks ϵ's, one of these being a monetary policy shock. In matrix form (Gali´s (1992) notation),

$$x = C(L)\epsilon \qquad [1]$$

where $C(0)=I$. Once ϵ and $C(L)$ are known, the dynamic response of each variable in X to a structural shock is easily computed. The autoregressive representation of the reduced form is:

$$B(L)x = \nu \qquad [2]$$

where $B(0)=I$. From that AR representation, X can be written in the following reduced form moving average format:

$$x = E(L)\nu \qquad [3]$$

where $E(L)=B(L)^{-1}$ and the ν's are the innovations in the elements of X, that are correlated with variance-covariance matrix, $\Sigma=E\nu\nu'$.

Comparing both representations for X (equations [1] and [3]), the innovations in ν can be written as linear combinations of the structural disturbances in ϵ:

$$\nu = S\epsilon \qquad [4]$$

which means that,

$$C(L) = E(L)S \qquad [5]$$

A consistent estimate of $B(L)$ $(E(L))$, ν and Σ can be obtained by OLS from the reduced-form autoregressive representation. We need an estimate of S in order to obtain $C(L)$, from [5], and ϵ, from [4]. Notice that S has n^2 elements (n being the dimension of X). Under the normalisation, $E\epsilon\epsilon'=I$, from [4] we get $SS'=\Sigma$ that gives $(n^2+n)/2$ restrictions. We still need $n(n-1)/2$ equations to estimate all the elements on S that might be obtained from restrictions defined either on the contemporaneous system or on its long run solution.

We shall rely mainly on the matrix of long-run structural multipliers $C(1)$. Faust and Leeper (1994) argue that long-run restrictions are not reliable except under some, rather demanding, conditions[3]. There are some reasons why those criticisms might be less compelling in our empirical setup. On the one hand, although it is true that neutrality restrictions belong to the infinite horizon, money neutrality must hold even for finite horizons unless we are prepared to accept the existence of high nominal inertia and price sluggishness. On the other hand, our 4 and 5 variables systems are less likely to suffer from the problems of compounded shocks that might arise in more standard 2 variables VAR systems. Faust and Leeper call for a careful checking of the robustness of the results to changes in the identification scheme. We follow this advice in the paper and found that the identification of the monetary shock withstands many changes in the identification scheme[4].

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[3] Nevertheless, as these authors argue, some of their criticism to this sort of identification scheme hold also for other econometric approaches.

[4] An additional reason to adopt an identifying scheme based on long-run restrictions is to avoid the problem of structural change in the policy reaction function of the monetary authority. Shioji (1997) finds evidence of such change in Spain.

Let us consider the following Mundell-Fleming-Dornbusch model of a small open economy:

$$y = \delta(e+p^{*}-p) - \gamma(i - E\Delta p_{+1}) + u^{d} \qquad [6]$$

$$m-p = \beta y - \lambda i + u^{l} \qquad [7]$$

$$i = i[m, \Delta p, e, y] - u^{m} \qquad [8]$$

$$\Delta p = \pi + \varphi(y - u^{s}) \qquad [9]$$

$$\pi = \theta \Delta p + (1-\theta)\pi_{-1} \qquad [10]$$

$$E\Delta e_{+1} = i - i^{*} - u^{*} \qquad [11]$$

where the log of demand (y) is a function increasing on the log of real exchange rate (e-p+p^{*}=q, hereafter) and decreasing on the real interest rate plus an IS or real demand shock (u^{d}). Nominal inertia is introduced assuming an accelerationist Phillips curve: price inflation depends on expected inflation (π) and the output gap, measured as the deviation of current output from its supply side value (u^{s}). Inflation expectations in the labour and product markets are adaptative, responding to past forecast errors. The log of the demand of real money balances is a function of income and the nominal interest rate plus a velocity shock (u^{l}), and we assume a very simple money supply rule in which the central bank reacts to the level of money balances, to the inflation rate, to the exchange rate and to output; u^{m} represents the unanticipated component of the interest rate. We also assume that the uncovered parity condition holds and that expectations are rational in the foreign exchange market. The expected rate of depreciation depends on the interest rate differential minus a positive risk-premium shock (u^{*}). This term is included mainly to control for persistent deviations from uncovered interest parity (Taylor, 1995).

There are several reasons to chose this particular representation of the monetary transmission mechanism for the Spanish economy. First, although equations [6]-[11] incorporate the most prominent features of market economies, such as the combination of efficient asset markets and nominal inertia in prices and wages, the dynamics implied by these equations are representative of a wider class of models[5]. Liquidity models (Grilli and Roubini (1992)), characterized by flexible prices and cash-in-advance constraints in asset markets, predict a similar correlation among the interest rate and the exchange rate following a monetary shock. Also, most of the properties of this model can be derived from a dynamic general equilibrium framework with optimizing agents (Kollmann (1997)). When there is price inertia, the exchange rate is expected to overshoot its long run level after a monetary shock. But a slow adjustment process or delayed overshooting can also be rationalized within this class of models assuming that agents have access to imperfect information as regards the nature and persistence of the shocks to the interest rate (Gourinchas and Tornell (1996)). Second, it captures the main consequence of full capital mobility, namely that real interest rates are exogenous to the system in the long run. Finally, and most important, the long run solution of this model reflects, among others, the nominal neutralities common to all macroeconomic models.

Actually, if we characterize the steady-state of the model by a constant inflation (real interest rate) and real exchange rate,

$$\Delta p=\Delta p_{-1}=E\Delta p_{+1} \ , \ \pi=\pi_{-1} \ , \ \Delta e=E\Delta e_{+1}=\Delta p-\Delta p^{*}$$

the restrictions implied by the long run solution can be represented by the following expressions:

$$y=u^{s} \qquad [12]$$

$$i-\Delta p = i^{*}-\Delta p^{*}+u^{*} \qquad [13]$$

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[5] These dynamic relationships are independent on the instrument chosen by the monetary authority, whether the interest rate (as in (8)) or money.

$$q = e+p^{*}-p = \frac{1}{\delta}\left(\gamma\,(i^{*}-\Delta p^{*}+u^{*}) - u^{d}+u^{s}\right) \qquad [14]$$

The first of these simply states that output is supply driven in the long run. The second captures the essential result of the full capital mobility assumption: domestic real interest rates equal the foreign level plus the risk premium. The third shows that the long run solution of the model does not allow to disentangle among a foreign real interest and a risk premium shock. However, this is true only because of the assumption of a single country. In a multicountry model or if the foreign real interest rate were endogenous, an across the board increase in the interest rate must leave the real exchange rate unchanged. This gives us a way to ascertain the nature of the foreign shock: if it is an innovation to the foreign real interest rate $(i^{*}-\Delta p^{*})$ no long run change in competitiveness is expected, whereas a shock to the risk premium (u^{*}) should produce a depreciation.

The neutrality of money is the basis of this identification scheme, but this is helpless to discriminate among money demand and money supply shocks. We shall deal later with this issue, but first let us remove real money balances from the system and focus in a smaller one in output, prices, interest rate and exchange rate. The shocks u^{l} and u^{m} are collected in a composite one, u^{n}, defined as the structural innovation in the nominal interest rate. In the reduced system we could exploit the following long run identifying restrictions:

Full capital mobility identification

u^{d}, u^{*}, u^{n} do not affect output.

u^{s}, u^{d}, u^{n} do not affect the real interest rate.

u^{n} does not affect the real exchange rate.

This approach has, nonetheless, some shortcomings. The invariance of the real interest rate to all shocks but u^{*} is heavily dependent on the assumption of full capital mobility. Otherwise, even full neutrality is consistent with real shocks (i.e. u^d and u^s) affecting the real interest rate. Thus, a less restricted version of the model could be characterized by a different set of restrictions:

Benchmark identification

u^d, u^*, u^n do not affect output.

u^n does not affect the real interest rate.

u^n does not affect the real exchange rate.

3. EMPIRICAL EVIDENCE: IMPULSE RESPONSES AND VARIANCE DECOMPOSITION.

In this section we asses to what extent the monetary transmission mechanism in the recent Spanish experience is well represented by a model like the one presented in the previous section. Since the distinctive feature of the model in the short run is the overshooting of both the nominal and the real exchange rate we shall focus on the behaviour of this variable. More precisely we use some of the above long run model restrictions to identify the shocks in a VAR whose implied impulse responses and variance decomposition patterns will give us the answer to the following questions: what are the short run effects of monetary shocks?; how different are those shocks from a less model dependent identification?; does the exchange rate behave as a forward looking variable?; What is the nature of the external shocks and how do they affect domestic variables?.

Appendix 1 presents some unit root tests of the variables of interest. These univariate tests indicate that output (y), nominal interest rate (i), prices (p) and nominal exchange rate (e) are $I(1)$ processes. Thus the covariance stationary vector X is represented by $[\Delta y, \Delta p, \Delta i, \Delta e]'$. This long run representation has the unpleasant feature of that the ex-post real interest rate is $I(1)$ which is not a good representation for the very long run[6]; nevertheless, the attempts to impose a stationary real rate is not well accepted by the data, leading to unappealing identified structural shocks. Actually, it is not clear that the inflation rate is stationary within the sample period, but since this representation around a deterministic trend performs better than the unit root, we have chosen to enter Δp in the VAR including a trend as well as seasonal dummies[7].

Three alternative identifications have been used to recover the four structural shocks: ϵ^s, ϵ^d, ϵ^n and ϵ^*. The first one is taken as a benchmark and considers some of the long run restrictions implied by the model. The second one is a more extreme version of the model, implying full capital mobility. The third one allows real demand shocks to have long run real effects. The benchmark identification scheme shall be applied also to disentangle money demand and money supply shocks within a larger model containing real money balances; in this case we shall incorporate some additional structural short run restrictions.

The benchmark case is characterized by the long run neutrality of money plus the absence of output effects of real demand and foreign shocks. This is the set *Rb*, discussed previously, which can be represented as a series of zeros and across rows restrictions in the matrix of long run multipliers *C(1)*:

$$\begin{vmatrix} \Delta y \\ \Delta p \\ \Delta i \\ \Delta e \end{vmatrix} = \begin{vmatrix} c_{11}(1) & 0 & 0 & 0 \\ c_{21}(1) & c_{22}(1) & \alpha & c_{24}(1) \\ c_{31}(1) & c_{32}(1) & 0 & c_{34}(1) \\ c_{41}(1) & c_{42}(1) & \alpha & c_{44}(1) \end{vmatrix} \begin{vmatrix} \epsilon^s \\ \epsilon^d \\ \epsilon^n \\ \epsilon^* \end{vmatrix} \qquad [15]$$

The remaining restriction for an exact identified model will be contemporaneous upon the matrix S, assuming that the external shock has

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(6) Nikolakaki (1997) reports a similar stochastic representation for interest rates in most European countries, including Spain.

(7) Alternatively, the inflation rate has been detrended and the time trend has been excluded from the VAR model. The results do not change in a significant manner and will not be reported here.

no current effect on output[8].

The identification of supply shocks (ϵ^s) based on the long run behaviour of output has been used following the seminal work of Blanchard and Quah (1989) and Galí (1992). The identification of monetary shocks (ϵ^p) that do not affect in the long run to the real exchange rate has also been used among others by Clarida and Galí (1994). Since we allow to all type of real shocks to affect permanently the real interest rate, our identification is consistent with a partial capital mobility setting. External shocks (ϵ^*) are different from domestic demand shocks (ϵ^d) because only the second type of shocks may have an impact effect on output.

The VAR uses as estimation period 1982:1-1996:4 since we try to reflect the main features of the current monetary transmission. Nevertheless the qualitative results are the same under the 1978:2-1996:4 sample period, the wider one in Spain with a homogenous short term interest rate. A likelihood ratio test for the whole sample period shown that a VAR specification with four lags performs better than other with a shorter or larger number of lags. The estimated residuals did not show an autocorrelation structure and were normally distributed at the 95 per cent probability except the estimated output residual that it is only normally distributed at the 99 per cent probability.

Figure 1 shows the responses of the variables to the shocks in the VAR and its corresponding asymptotic bands (e.g., Giannini (1992)). With some exceptions, both the short and the long run responses match the predictions of the theoretical model.

Supply shocks. ϵ^s is well identified as a positive supply shock which increases output and reduces inflation. The effect on output is fast and

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[8] Under some alternative contemporaneous restrictions upon the elements of S, specially with restrictions in S^{-1}, the algorithm did not converge. When it did the results were largely similar to the ones reported here.

strong with an average initial increase of 0.2 percentage points. The increase in the rate of growth of the economy remains significantly above its long run level during 6 quarters, leading to a 1.4% increase in output. The impact fall in inflation is also of 0.2 percentage points and remains significant during 3 quarters, with an overall fall of prices of about 0.8%. Neither the interest rate nor the exchange rate respond significantly to the supply shock on impact. The behaviour of the exchange rate following this shock is rather puzzling though, since both the nominal and the real rates suffer a long run appreciation. This result appears also under alternative open economy identifications both for the dollar area (Clarida and Gali (1994)) or the Deusche mark area (Canzoneri, Vallés and Viñals (1996))[9]. Table 1 shows the variance decomposition for each variable at different forecast horizons. ϵ^s accounts for most of output variability (around 90%) at long run forecast horizons. Surprisingly it accounts for a similar proportion at shorter run frequencies (4th quarter forecast) which is at odds with keynesian interpretations of the business cycle[10]. The supply shock explains very little of the interest rate variation and a small but significant proportion of inflation and exchange rate variations in the long run.

Real demand or IS shocks. Unlike the supply shock, the response of all four variables to ϵ^d are consistent with it being a demand shock in all accounts. The short run effects go in the expected direction. Both output and inflation increase significantly on impact; on the other hand, the nominal interest rate goes up inducing a significant currency appreciation. The pattern differs with respect to the supply shock also as regards the order of magnitude. Prices react more intensively (0.4 percentage points) despite the moderate increase in demand (less than 0.1 points). The inflation rate returns very quickly to its steady state level and the increase in output dies away very rapidly too. The long run response is also one of higher prices, interest rate and an appreciated currency both in real and in nominal terms. These results are compatible

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[9] Nikolakaki (1997) also obtains this result in a SVAR model identified under a very similar set of long run restrictions.

[10] Galí (1992) finds a similar result for the US.

with what could be expected in an economy with high but not full capital mobility. On the one hand, the response of the exchange rate seems dominated by the inflow of capital following a temporary positive interest rate differential, rather than by the fall in net exports associated with a domestic demand driven expansion[11]. But on the other hand, the level of the domestic interest rate is not uniquely determined by foreign factors; the long run increase in the real interest rate following IS and supply shocks is positive. ϵ^d contributes very little to the forecast error of output, whereas it plays a key role in the fluctuation of prices, specially in the short term (55%) but also over the long run. On the other hand, its contribution to the short run fluctuations of interest and exchange rates is between 11 and 15%.

Monetary shocks. According to the impulse response functions, ϵ^r is very precisely identified as a positive structural shock to the interest rate process that may come either from an unanticipated contractionary monetary policy or from a positive money demand shock. As can be seen in Figure 1, a positive interest shock increases short interest rates, reduces real growth and inflation and appreciates the currency on impact; all these impact effects are unambiguously signed and significant. Figure 2 presents the responses on the level of output, prices, exchange rates, real interest rates and real exchange rates. This shock has a small, barely significant, real impact effect on output that becomes maximum at the fourth quarter, along with a quick and significant fall of the inflation rate of 0.2 percentage points[12]. This disinflation is brought about by increased real interest rates and a temporary loss of competitiveness together with an accumulated fall in output of 0.1 percentage points at the fourth quarter. The price level and the nominal exchange rate adjust to its new equilibrium level six quarters after an initial jump on both variables. The significant impact reaction of prices is in accordance with the results reported by Kim (1997) whereas Jareño, Sebastián and Vallés

[11] This would have led to an increase in the demand for foreign currency and, hence, to a depreciation of the domestic currency.

[12] Alternative identifications find that the recession takes time to show up and it is of a small magnitude.

(1997) obtain a more sluggish response[13]. The change in prices is consistent with what could be expected after a contractionary shock, so that no *price puzzle* is found. The magnitude of this impact response is, in any case, much smaller than that of the nominal exchange rate[14].

Turning now to the main effect we are interested in, the response of the exchange rate to monetary shocks is unequivocal: it appreciates on impact, both in nominal and real terms, with an overreaction with respect to its long run level as it may be observed in Figure 2. The estimated initial jump in the nominal exchange rate of 0.8 percentage points to an increase of 15 basis points in the nominal interest rate represents around a 5% appreciation in response to one point unexpected increase on short run interest rates and induces a significant change in the real exchange rate. These results are summarized in Table 2, which also provides a comparison with some related studies. There is not evidence of an *exchange rate puzzle* nor of delayed overshooting (see Eichenbaum and Evans (1995)), which is consistent with other Spanish evidence on this issue. Jareño, Sebastián and Vallés (1997) also find a higher exchange rate response on impact, similarly Kim (1997), who rejects some of his identification schemes on the basis of the odd response of the exchange rate to interest rate shocks, obtains overshooting and finds no evidence of forward discount bias. Conversely, full sample estimates reported by Shioji (1997) do show signs of exchange rate puzzle, that can only be eliminated once the model is estimated for 1984 onwards; similarly, Nikolakaki (1997) obtains an impact appreciation after a positive monetary shock. In our model the exchange rate appreciates significantly on impact after a rise in domestic interest rates, and depreciates thereafter until it returns to its preshock value. Thus, although no formal test of the forward discount bias is proposed, our results do seem fully compatible with the assumptions behind the uncovered interest parity (UIP)

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(13) Although the initial response is imposed to be nil in both identifications.

(14) A similar result is also obtained by Alberola, Ayuso and López-Salido (1997) when the nominal exchange rate faces a nominal shock and the information set is the real exchange rate and relative prices.

condition. The exchange rate response is greater than the one observed for prices (around 1%), so that the impact effect and the dynamics are consistent with the basic feature of the overshooting model, namely the combination of efficient financial markets and inefficient goods markets.

The contribution of ϵ^n to the unexplained variance of the rate of growth of output is very small, around 4%[15], although nominal shocks have a significant influence in the fluctuations of prices, interest rates and exchange rates. This is again at odds with a keynesian interpretation of the business cycle, but consistent with the predominant role of supply shocks as discussed earlier. It should be noticed that the structure of the forecast error variance decomposition is very similar at different horizons for output and prices. This suggests that nominal inertias do not play a major role in the fluctuations of the Spanish economy, thus reducing the scope for monetary policies[16].

Foreign interest rate or risk premium shocks. Our model leaves the origin of the external shock ϵ^* indeterminate. It may have a real origin, moving the level of real interest rates worldwide or it may correspond to a pure risk premium or financial disturbance associated with a country specific shock. In the model both types of shocks affect in the same manner to all the variables, except perhaps the real exchange rate that should not be affected by an across the board increase in the interest rate. According to the estimated impulse-response functions, the foreign shock looks more like a relative one (i.e. an innovation to the risk premium), since it leads to a permanent and significant currency depreciation. Notice that this is the only shock that is expected to move both domestic interest and exchange rates in the same direction as indeed we observe in Figure 1. An increase in the premium, required for domestic bonds to be sold abroad, leads to a substantial increase in the

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[15] Most of the alternative identifications of monetary shocks for the spanish economy also obtain a low forecast variance decomposition for output. Only Shioji (1997) finds that this contribution has increased (18 to 30%) from 1984 onwards.

[16] Nikolakaki (1997) obtains a similar result, not only for Spain but also for most European countries.

nominal interest rate along with a sharp depreciation of the currency. The output and price (inflation) effects after this shock are very small even in the short run.

The variance decomposition in Table 1 shows that the contribution of ϵ^* to the variability of output and prices is nil. Nevertheless, as it could be expected in an open economy with high capital mobility, innovations to the foreign interest rate or to the risk premium help to predict the future path of domestic interest and exchange rates. The short run fluctuations of the exchange rate are mostly explained by monetary and risk premia shocks. In the long run, the percentage of exchange rate variance explained by real shocks increases, but still risk premia shocks are the main source of fluctuations. Similar conclusions are obtained by Canzoneri et al. (1996) for many European bilateral exchange rates but with a different sample and identification procedure. Again, the fact that ϵ^* helps to explain the fluctuations of nominal variables (interest and exchange rates), along with its little influence on output and inflation, indicates that this shock is mostly an innovation to the exchange risk premium of the Spanish economy. Also, for these shocks to nominal variables not to have substantial real effect, prices must react very quickly; this is another sign of the minor role played by nominal inertias to account for the main features of the business cycle in the Spanish economy.

Full capital mobility

We have also estimated the model imposing all long run restrictions associated with full capital mobility, namely that the real interest rate is isolated from domestic disturbances, other than those operating through the risk premium. Notice that under this set of restrictions we can have a direct test of this hypothesis since it enlarges the set of long run zero restrictions available to seven (see previous section) and therefore **S** is overidentified. There are two reasons to do so. First, we want to confirm our previous surmise that full capital mobility does not adequately characterize our sample period. Secondly, and most important, we are interested on the robustness of the identified monetary shock, to check whether it withstands a number of variations with respect to the basic model.

The overidentification restriction is unambiguously rejected by the data (with a $X^2(1)$=18). We also observe some differences in the short run dynamics between this and the benchmark identification scheme, which suggests that high but partial capital mobility is a better approximation for the behaviour of our small macroeconomic system during the sample period. On the one hand, although the impact response of the interest rate to supply shocks is more significant here than in the benchmark case, now a positive demand shock causes an interest rate fall and a large currency appreciation. Such unexpected result from a demand shock, is also opposed to the movements expected from the UIP condition and is a consequence of the long run restriction of demand shocks on the real interest rate. On the other hand, ϵ^* has similar effects on output and prices than ϵ^d. This could be rationalized as if the external shock has an international demand component, but this is not fully consistent with the estimated long run depreciation of the exchange rate[17]. Alternatively the innovation in the risk premium might anticipate an increase in inflation, leading to a rise in interest rates and a depreciation of the peseta.

What is more interesting though, is that despite these differences between both identifications, the similarities as regards the two fundamental issues we are concerned with, are outstanding. Even in this more restricted setting, the monetary or interest rate shock is clearly identified by its short run impact upon all variables: inflation and output fall significantly on impact while the interest rate goes up inducing a significant depreciation that eventually dies away over the long run. Also the exchange rate responds quickly to all type of shocks, which confirms the efficiency in the operation of the currency market.

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[17] As we argued earlier, an across the board increase in demand should not have a long run impact on the real exchange rate.

Long run effects of Demand Shocks

There is another way in which our identification scheme could be improved. As we saw in the benchmark case, the response of the interest rate and of the exchange rate to supply shocks was at odds with what open economy models predict in highly integrated capital markets. One possible explanation for this result is that some of the maintained long run restrictions are not accepted by the data. In particular real demand shocks might have a long run effect on output. There are several ways in which this can be rationalized. Although most macroeconomic models are built upon the assumption of long run money neutrality, the absence of output responses to demand shocks depends on further, more demanding, assumptions. On the one hand, as we have seen both ϵ^d and ϵ^s affect the real interest rate over the long run. If this is so, is difficult to maintain the assumption of zero real effect of IS shocks. Also, in models in which public capital accumulation is a source of growth[18] or in those with tradable and nontradable goods in which fiscal policies affect the composition of output and growth[19] we might expect the long run multiplier associated to ϵ^d to be different from zero.

We substitute the restriction $c_{12}=0$ in the benchmark scheme by $c_{31}=0$ and found that the interest rate responds in the expected way to supply shocks, falling significantly on impact. Also, the exchange rate depreciates on impact, following a supply shock, although there is still a long run appreciation. Again, the most important feature of this new scheme is that the impulse responses and variance decomposition associated to the monetary shock display the same short run and long run features as in the basic model. This is also true as regards the impact of the foreign shock as well as the sources of fluctuations for the exchange rate.

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[18] Either in exogenous (Aschauer (1989)) or endogenous (Barro (1990))) growth models.

[19] See, for instance, De Gregorio, Giovannini and Wolf (1994).

The forecast error variance decomposition structure also differs in some respects with that corresponding to the benchmark model. The contribution of supply and IS shocks to account for the fluctuations of output and inflation changes sharply. According to this specification, demand shocks explain even more than supply shocks of the short run variation of output (53% versus 42%). Furthermore, the contribution of demand shocks is still high and significant after 20 quarters (45%). Dolado and López-Salido (1996), with an identification based on an insider-outsider model of the labor market, also find that aggregate demand shocks explain a large part of spanish output variability even in the long run. On the other hand, now supply shocks explain a large share of total inflation variability, with a minor role for demand shocks. Despite this switch on the importance of real shocks for output and prices, the nominal block of the model remains largely unchanged. The amount of variation of interest and exchange rates explained by each shock, as well as the contribution of ϵ^n and ϵ^* to explain output and inflation, display a very similar pattern to the one summarized in Table 1. This model has a more keynesian flavour, although the basic message of little nominal price inertias remains.

Identifying money supply and money demand.

The identified monetary shock may be a combination of demand and supply shocks from the monetary sector. It could be important to isolate the money supply shocks since its characterization is the ultimate reason of the theoretical model. To do so we add a monetary aggregate to the VAR system. In particular we include in the VAR a fifth variable, the change in real balances defined as the liquid assets hled by the public divided prices (*ALP/P*) and reestimate for the same sample period. Now to obtain the identification we need ten restrictions. Long run monetary neutrality imposes six restrictions on *C(1)* (neither ϵ^d nor ϵ^m affect output, the real interest rate or the real exchange rate over the long run). Two restrictions come from the assumption of long run vertical supply curve. A crucial restriction, which helps to disentangle ϵ^d and ϵ^m, is imposed on the short run structural model: the monetary authority does not react contemporaneously to the realization of output. The remaining restriction has been also imposed on $C(1)$, in particular we assume that ϵ^d has no long run effect on the real interest rate[20].

The enlarged model reproduces most features of the four variables version, in particular the behaviour of the money supply shock is quite similar to the one found for the nominal shock. Figure 3 shows the responses to the level of nominal and real variables to ϵ^m. There is no sign of price nor of exchange rate puzzle. The exchange rate undergoes a sharp appreciation on impact, both in nominal and real terms, to depreciate then all the way to its steady state value. Although the initial response of money is not very precisely estimated, it is negative. The interest rate shock is, thus, identified as a tightening in the money supply and the model does not suffer from the so called liquidity puzzle either.

The comparison of both impulse responses (Figures 2 and 3) gives two main differences: first, prices show some more sluggishness when facing a money supply shock than a nominal shock, being that initial response non significant. Secondly, the exchanges rate overshooting is slightly bigger. It represents around a 10% change in response to one point change of interest rates. Nevertheless the dynamics of the real variables under both type of shocks are very similar. Even more, the variance decomposition of the five variable system also has similar implications. First, output variability is not explained by money supply or money demand shocks. Secondly, although demand shocks become of some importance for exchange rate, still money and risk premium shocks account for the most important part of its variability.

4. CONCLUSIONS.

The behaviour of competitiveness has become one of the key determinants of the monetary transmission mechanism in open economies

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[20] Given the large number of non linear restrictions, the algorithm does not converge under some alternative restrictions.

with high capital mobility. When long run neutrality holds, the short run dynamics of the aggregate variables, which determines the costs of disinflation, depends on the different speed of reaction of prices and the exchange rate. The aim of this paper has been to trace out the dynamic response of prices and the exchange rate, and hence output, following a shock to the interest rate. In order to adequately characterize this dynamic response we need to isolate structural disturbances to the interest rate, i.e. those unanticipated changes that are orthogonal to innovations in other macroeconomic variables. For that purpose, we have estimated a structural VAR on a reduced set of variables, in which the identification scheme is mainly based in the long run properties of these shocks, according to a large class of open economy macro models. Some additional restrictions were imposed in order to test particular versions of this class of models. This strategy allows us to compare our results with those obtained by other researchers who have studied the impact of the monetary policy in Spain resorting to short run identification.

The main features of the estimated impulse-responses can be quickly summarized as follows. First, the model produces a clear cut identification of the nominal or interest rate shock; this is most remarkable since other identification schemes require wider and less parsimonious specifications to do so. Secondly, the long run and short run response of all four variables to this shock match the prediction of a simple open economy macro model with capital mobility. In particular, the identification scheme does not suffer from the *liquidity puzzle* nor from the *price puzzle* or *exchange rate puzzle* either. Both, nominal and real exchange rates, overshoot their long run value, indicating that the Spanish economy combines an efficient foreign currency market with some nominal inertia in goods and factors markets. Thirdly, our model also identifies a foreign shock which has the distinctive feature of moving the exchange rate and the interest rate in the same direction. Fourthly, the reaction of prices to monetary shocks is quick adjusting fully in a few quarters. Finally, these results hold even when the money supply shock is disentangled from liquidity or money demand shocks.

Some real aspects of the model perform better when a long run effect for IS shocks is allowed, reflecting the huge structural changes the Spanish economy has gone through during the sample period. Thus the role of the fiscal changes that the European Monetary Union will bring about may have non negligible real effects. Although most features of the model are consistent with high capital mobility, the restrictions associated with full capital mobility are overwhelmingly rejected. This is not surprising since our sample covers a period of progressive, but still incomplete, financial integration of the Spanish economy in the foreign markets.

These results suggest that a small macro model with short run rigidities and long run monetary neutrality is a useful tool to represent the monetary transmission mechanism in Spain, although there are some hints that the degree of nominal inertia is very limited. This seems so both because the output effect of monetary shocks is short lived and the contribution of those shocks to explain output fluctuations is very small, even at short horizons, and because the price effect of monetary shocks is very significant in the short-run. If this surmise is correct it means that, despite the powerful reaction of the nominal exchange rate to domestic interest rate shocks, the degree of competitiveness may not play such an important role in the monetary transmission. Moreover giving up the right to an autonomous monetary policy within the European Monetary Union should not be very costly for Spain.

Table 1
Variance Decomposition

Forecast Horizon	Δy: Supply	Δy: Demand	Δy: Monetary	Δy: External	Δp: Supply	Δp: Demand	Δp: Monetary	Δp: External
	fraction of forecast error variance due to				fraction of forecast error variance due to			
1	0.91	0.05	0.02	0.0	0.13	0.65	0.20	0.0
	(0.01)	(0.01)	(0.0)	(0.0)	(0.08)	(0.08)	(0.04)	(0.0)
2	0.89	0.06	0.03	0.0	0.16	0.60	0.21	0.01
	(0.01)	(0.01)	(0.0)	(0.0)	(0.07)	(0.08)	(0.04)	(0.0)
3	0.90	0.05	0.04	0.0	0.18	0.57	0.21	0.01
	(0.02)	(0.01)	(0.01)	(0.0)	(0.07)	(0.08)	(0.05)	(0.0)
4	0.91	0.04	0.03	0.01	0.17	0.55	0.25	0.01
	(0.03)	(0.01)	(0.03)	(0.01)	(0.07)	(0.08)	(0.06)	(0.01)
8	0.89	0.04	0.04	0.01	0.20	0.53	023	0.02
	(0.06)	(0.03)	(0.04)	(0.01)	(0.09)	(0.09)	(0.06)	(0.01)
12	0.89	0.04	(0.04	0.01	0.21	0.52	0.23	0.02
	(0.08)	(0.04)	(0.04)	(0.01)	(0.09)	(0.09)	(0.06)	(0.01)
20	0.89	0.04	0.04	0.01	0.22	0.52	0.23	0.02
	(0.08)	(0.04)	(0.04)	(0.02)	(0.10)	(0.09)	(0.06)	(0.01)

Forecast Horizon	Δi: Supply	Δi: Demand	Δi: Monetary	Δi: External	Δe: Supply	Δe: Demand	Δe: Monetary	Δe: External
	fraction of forecast error variance due to				fraction of forecast error variance due to			
1	0.0	0.11	0.38	0.50	0.0	0.05	0.25	0.69
	(0.01)	(0.09)	(0.07)	(0.12)	(0.01)	(0.06)	(0.05)	(0.09)
2	0.01	0.11	0.31	0.55	0.01	0.06	0.23	0.67
	(0.01)	(0.08)	(0.06)	(0.10)	(0.01)	(0.06)	(0.05)	(0.08)
3	0.01	0.10	0.34	0.54	0.01	0.08	0.23	0.66
	(0.01)	(0.07)	(0.06)	(0.10)	(0.01)	(0.07)	(0.05)	(0.09)
4	0.03	0.10	0.33	0.53	0.08	0.15	0.20	056
	(0.03)	(0.07)	(0.07)	(0.10)	(0.05)	(0.07)	(0.04)	(0.09)
8	0.04	0.15	0.27	0.52	0.26	0.11	0.18	0.42
	(0.04)	(0.07)	(0.06)	(0.09)	(0.08)	(0.05)	(0.05)	(0.09)
12	0.04	0.15	(0.27	0.52	0.26	0.11	0.19	0.42
	(0.04)	(0.07)	(0.07)	(0.09)	(0.08)	(0.05)	(0.05)	(0.09)
20	0.04	0.15	0.27	0.52	0.26	0.11	0.19	0.41
	(0.04)	(0.07)	(0.07)	(0.09)	(0.09)	(0.05)	(0.05)	(0.09)

NOTE: Values in parentheses are the asymptotic standard errors.

Table 2

The exchange rate following a monetary contraction

1	G7	Spain	Spain	Spain	Spain
2	Eichenbaum, Evans	Shioji	Kim	Jareño, Sebastián, Vallés	Andrés, Mestre, Vallés
3	Choleski	SVAR Short Run	SVAR Short Run	SVAR Short Run	SVAR Long Run
4	Persistent appreciation	Zero after 2 years	Zero after 2 years	Zero after 2 years	New Long-run value in 2 years
5	Puzzle	Delayed Overshooting	Overshooting	Overshooting	Overshooting
6	Persistent	Significant 2 years	Significant 2 years	Significant 2 years	Transitory

NOTES:
1: Countries.
2: Authors.
3: Identification scheme.
4: Long run response of the nominal exchange rate.
5: Short run response of the nominal exchange rate.
6: Response of the real exchange rate.

FIGURE 1

Impulse Response Function

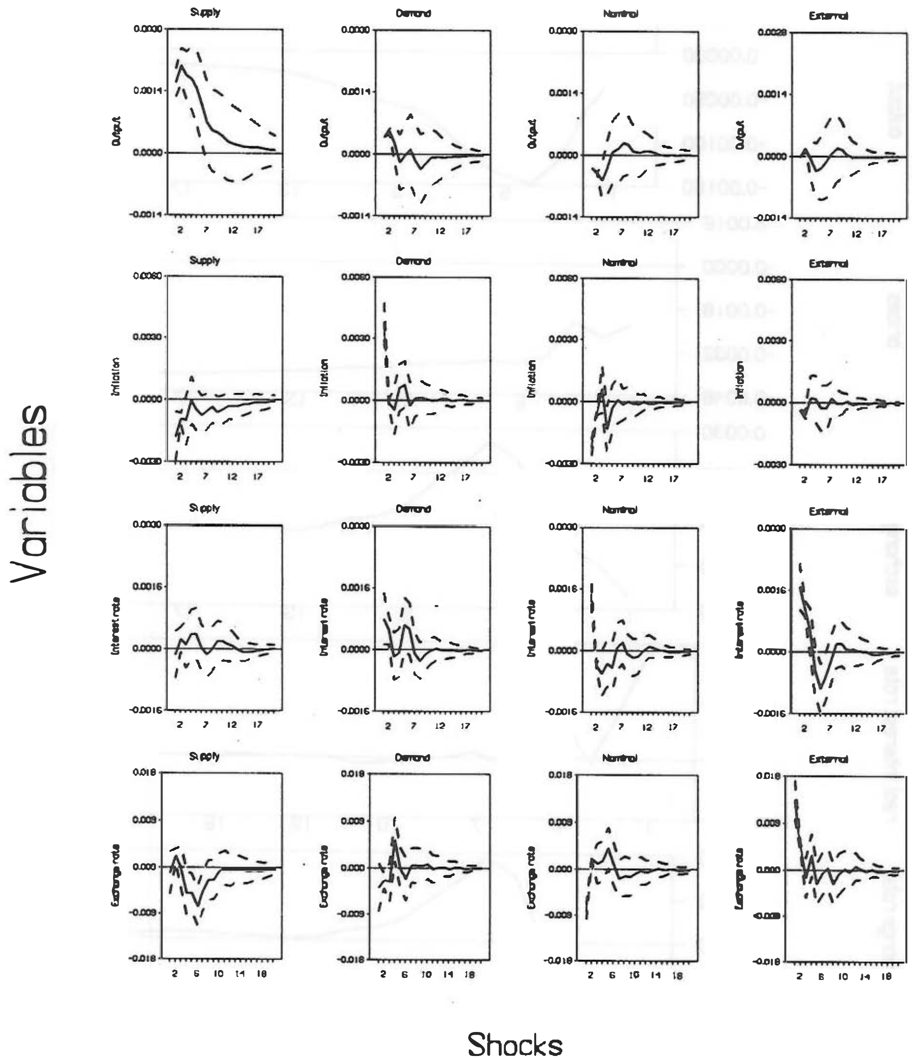
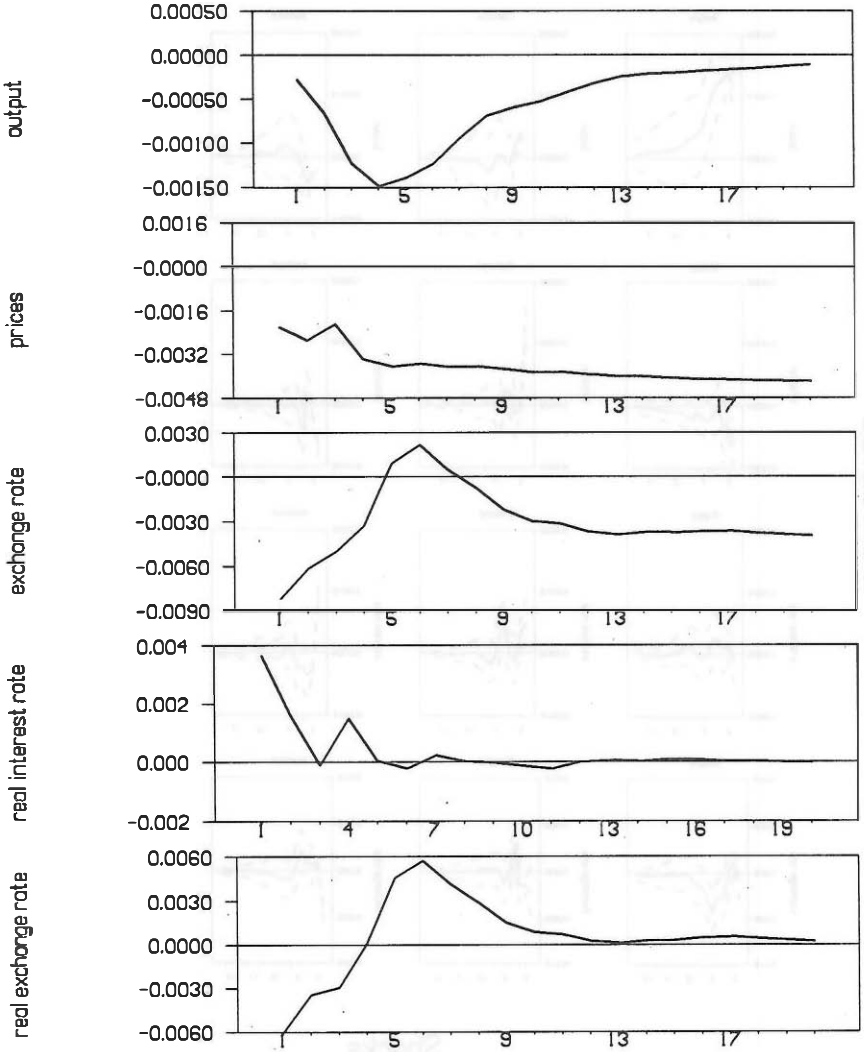


FIGURE 2

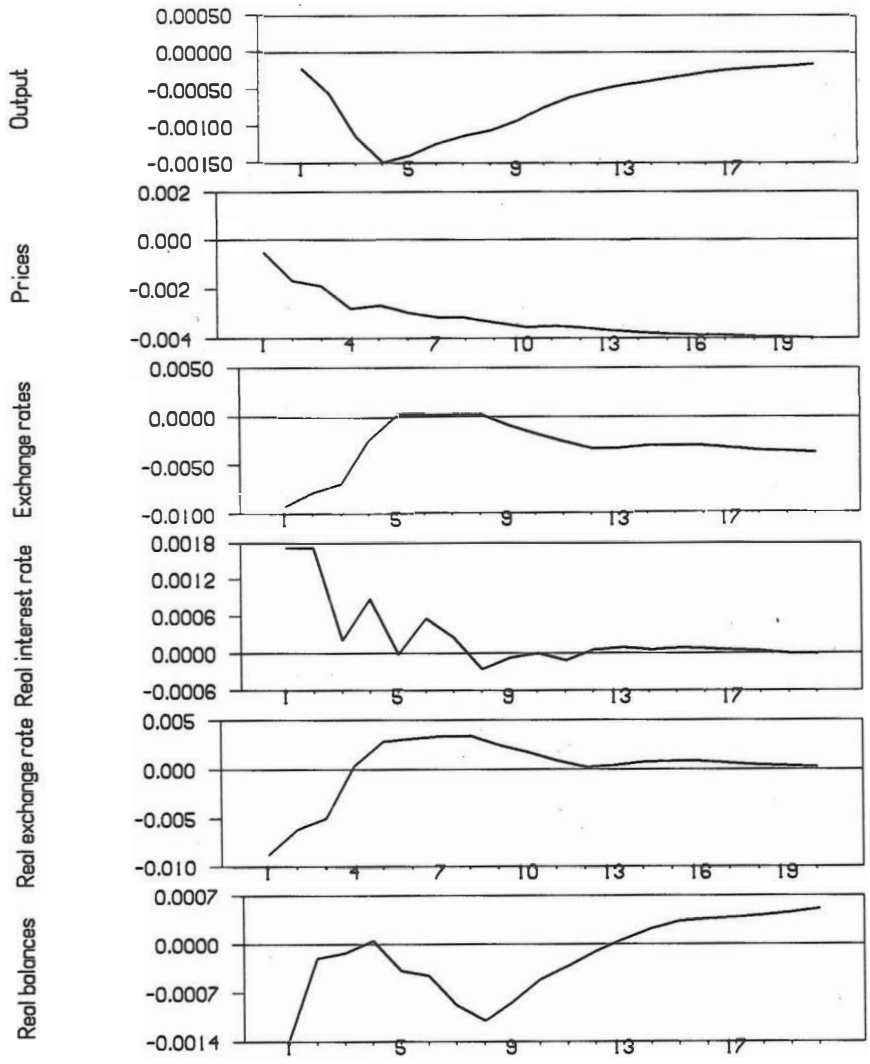
Responses to a nominol shock



Note: **Accumulated responses to an ϵ^a shock in a [Δy, Δp, Δi, Δe] VAR.**

FIGURE 3

Responses to a money supply shock



Note: Accumulated responses to an ϵ^m shock in a [Δy, Δp, Δi, Δe, $\Delta m/p$] VAR.

APPENDIX 1

The definition of the variables (all in logarithms except the interest rate) used in the VAR are:

Δy_t : rate of growth of GDP

Δp_t : CPI inflation

Δi_t : rate of growth of 3 month money market interest rates

Δe_t : rate of growth of multilateral exchange rates

$\Delta(m_t - p_t)$: rate of growth of ALP2 in real terms

Table A.1 reports the Dickey-Fuller test for the null hypothesis of a unit root in Δy, Δp, Δi, Δe, $\Delta(m-p)_t$. At 5 percent critical value (3.69) the tests reject the null hypothesis.

Table A.1

Augmented Dickey-Fuller tests
1970:1 - 1996:4

Variable	t-statistics	number of lags and other deterministic variables[a]
Δy_t	-4.18	two
Δp_t	-4.3	two; truncated trend
Δi_t[b]	-5.8	four
Δe_t	-8.3	zero
$\Delta(m-p)_t$	-5.6	zero

(a) All the regression included constant and seasonal dummies.
(b) The sample period is 1978:1 - 1996:4

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