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Abstract: This paper examines the importance of monetary disturbances for cyclical fluctuations in real activity and inflation. It employs a novel identification approach which uses the sign of the cross correlation function in response to shocks to assign a structural interpretation to orthogonal innovations. We find that monetary shocks significantly drive output and inflation cycles in all G-7 countries; that they are the dominant source of fluctuations in three of the seven countries; that they contain an important policy component, and that their impact is time varying.

Keywords: Structural Shocks, Business Cycles, Monetary Disturbances, Dynamic Correlations.

JEL Classifications: C68, E32, F11.

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1 Introduction

The high correlation between monetary and real aggregates over the business cycle has attracted the attention of macroeconomists for at least forty years. Friedman and Schwartz (1960) were among the first to provide a causal interpretation of this relationship: they showed that the comovements of money with output were not due to the passive response of money to the developments in the economy, and argued that rates of change in money were good approximations to monetary policy disturbances. Since their seminal work, macroeconomists have tried to empirically refute Friedman and Schwartz's causal interpretation. In particular, the literature has documented that unforecastable movements in money produce responses in interest rates that are difficult to interpret - i.e. they generate the so-called liquidity puzzle (see Leeper and Gordon (1991)). To remedy these problems Sims (1980) and Bernanke and Blinder (1992) suggested the use of short term interest rate innovations as indicators of monetary policy disturbances. In this case it is the response of the price level to policy disturbances that is hard to justify (see Sims (1992)). As a consequence of these difficulties, the last ten years have witnessed a considerable effort to try to identify monetary policy disturbances using parsimoniously restricted multivariate time series models (see Gordon and Leeper (1994), Christiano, Eichenbaum and Evans (1996), Leeper, Sims and Zha (1996), Bernanke and Mihov (1998)).

The methodology used in these exercises involves three steps: run unrestricted VAR models; identify monetary policy shocks by imposing exclusion restrictions on the matrix of contemporaneous impacts, justified by economic theory or informational delays; and measure the contribution of identified monetary shocks to output fluctuations at different horizons. On this last issue, the consensus view is that the contribution of monetary policy to output fluctuations in the post World War II era is modest, at least in the G-7 (see e.g Uhlig (1999) and Kim (1999)).

In this paper we assess the importance of monetary disturbances as sources of cyclical movements in economic activity using a novel two-step procedure. First, we extract orthogonal innovations from a reduced form model using a statistical-based approach. These innovations have, in principle, no economic interpretation, but they have the property of being contemporaneously and serially uncorrelated. In the second step, we study their informational content. In this second step we are guided by standard aggregate macroeconomic theory, typically exemplified in an undergraduate textbook by a downward sloping aggregate demand curve, an upward sloping short run aggregate supply curve and a vertical long run aggregate supply curve in the output-inflation space. If, for example, a positive temporary orthogonal innovation represents nominal demand disturbances, e.g. an unexpected increase in the money supply, then it should generate positive responses of output, inflation and real balances. On the other hand, if a positive temporary orthogonal innovation is driven by real demand disturbances, e.g. due to increases in government purchases, then it should generate positive transitory responses in output and inflation and negative transitory responses in real balances. Finally, if a positive temporary orthogonal innovation in one variable represents a supply disturbance, then it should generate positive transitory output responses, negative transitory responses in inflation and an upward movement in real balances. Hence, the comovements of a selected group of variables in response to an orthogonal innovation can be used to assign a structural interpretation to such a disturbance.

Our identification approach has a number of advantages over competing ones. First, our procedure clearly separates the statistical problem of orthogonalizing the covariance matrix of reduced form shocks from issues concerning the identification of structural disturbances. Hence, unlike structural VAR approaches, we refrain from imposing zero constraints on impact responses, potentially inconsistent with the implications of a large class of general equilibrium monetary models (see Canova and Piña (1998)), or zero restrictions on the long run response of certain variables to shocks, for which distortions due to measurement errors and small sample biases may be substantial (see e.g. Faust and Leeper (1997)). Second, we explore the space of possible identifications systematically, and collect information about orthogonal shocks generating sign and shape responses which are interpretable according to theory. Hence, our procedure complements the method recently proposed by Faust (1998), by allowing us to gauge the robustness of the conclusion to different identification schemes, and improves on the one proposed by Uhlig (1999), by avoiding the definition of arbitrary penalty functions on certain orthogonal decompositions.

One important aspect of our exercise, which distinguishes it from the existing literature, is the international focus of the comparison (one exception is Kim (1999)). We are interested in knowing not only whether monetary disturbances are important in driving domestic cycles, but also whether

G-7 countries display important similarities or heterogeneities.

Three major conclusions can be drawn from our analysis. First, our approach identifies monetary disturbances, i.e. shocks that produce positive joint comovements in output and inflation, output and real balances and inflation and real balances, in all seven countries. Second, these disturbances explain large portions of output and inflation fluctuations. They turn out to be the dominant source of output variability in Germany, Japan, UK (explaining between 22 and 99% of output variance) and of inflation variability in the US, UK and Italy (explaining between 54 and 98% of the inflation variance). Third, monetary disturbances are quickly incorporated into the slope of the term structure, thereby supporting the conjecture that the monetary disturbances we have identified have an important policy component.

Our qualitative results are broadly robust to sample splitting with one qualification. The number of monetary innovations that we are able to uncover and their predictive power for the variability of output and inflation changes somewhat across subsamples. Results are also robust to the use of alternative estimation techniques.

The findings that monetary disturbances are clearly identifiable in every G-7 country for the sample under consideration, display a strong policy component, and explain a large percentage of output variations in almost all countries are somewhat surprising, and appear at odds with some recently held views about sources of output fluctuations (exceptions are Roberts (1993) and Faust (1999)). For the case of the US, which has been the focus of the majority of the analyses, our evidence diverges substantially from the assessments of Leeper, Sims and Zha (1996) or Ulhig (1999), who claim that monetary (policy) shocks account for a modest percentage of output variability. For the full sample, we find that monetary disturbances explain between 16 and 60% of output variability, but this percentage is dramatically increased in the post 1982 sample. For the other G-7 countries the monetary shocks we have identified account for a percentage of output variance which is significantly higher than that reported by Kim (1999).

The reminder of the paper is organized as follows. The next section presents the reduced form model and the issues connected with its specification. Section 3 discusses the basic intuition behind our identification procedure and presents a version of a dynamic general equilibrium monetary model which provides a way to interpret the conditional cross-correlations for the variables of interest. Section 4 presents the results of our investigation. Section 5 analyzes the responses of the slope of the term structure to identified monetary shocks. Section 6 concludes.

2 The specification of the statistical model

Our reduced form model is an unrestricted VAR. We use an unrestricted VAR since it is a good approximation to the DGP of any vector of time series, as long as enough lags are included (see e.g. Canova (1995)). We use two alternative setups: single country VAR models including a measure of real activity (IP), of inflation (INF), of the slope of the term structure of the nominal interest rates (TERM) and of real balances (M/P); and a pooled VAR with country specific fixed-effect containing the same four variables for all countries. The sample we use covers monthly data from 1973:1 to 1995:7; industrial production, CPI and nominal interest rates are from the OECD database while monetary (M1) data are from IFS statistics. All series are seasonally adjusted.

Reduced form VAR models, which include real activity, inflation and measures of interest rates and money have been examined by many authors (e.g. Sims (1980); Farmer (1997)). Here we maintain the same structure except that we employ a measure of the slope of the term structure in place of a short term interest rate. We do this because recent results by Stock and Watson (1989), Estrella and Hardouvelis (1991), Bernanke and Blinder (1992), Plosser and Rowenshort (1994) demonstrated the superior predictive power of the slope of term structure for real activity and inflation relative to a single measure of short-term interest rates in many countries. Also, the slope of the term structure has information about nominal impulses that other variables, such as unemployment or real wages, may not have. Unlike part of the literature, we use real balances, as opposed to nominal ones, for two important reasons. First, the model we present in the next section has important implication for real balances. Second, the responses of real balances allow us to distinguish monetary from other types of real demand disturbances. We have experimented with specifications including either stock returns or both a short and a long-term nominal rate separately. The results we present are insensitive to the addition of these variables to the VAR.

In order to interpret responses to shocks as short term dynamics around a stationary (steady) state, the VAR must be stationary, possibly around a deterministic trend. Given the relative small size of our data set, tests for integration and cointegration are likely to have low power and this may affect economic inference at a second stage. We therefore prefer to be guided by economic theory in selecting relevant variables and use that subset of them which is likely to be stationary under standard assumptions. The model we present in section 3 generates stationary paths for linearly detrended output, inflation, term structure and real balances. Visual inspection of the linearly detrended time series for the four variables in the seven countries shows that there is no compelling evidence of non-stationarities. For VAR models with these variables, the Schwarz criterion indicates that the dynamics for all countries are well described by a VAR(1), except for Japan, where a VAR(2) is used.

Because the VAR is a reduced form model, the contribution of different sources of structural disturbances to output and inflation cycles cannot be directly computed. To obtain structural shocks we proceed as follows. First, we construct innovations from the reduced form residual having the property of being serially and contemporaneously uncorrelated. Second, we use theory to tell us whether any of the components of the orthogonal innovation vector has a meaningful economic interpretation. If the orthogonal shocks we have built do not have a structural interpretation, we construct alternative shocks and repeat the exercise.

Formally, let the VAR representation of the system be:

$$Y_t = \mu + A(\ell)Y_{t-1} + e_t \qquad e_t \sim (0, \Sigma) \tag{1}$$

where Y_t is a 4×1 vector and $A(\ell)$ a matrix polynomial in the lag operator. Then, for any nonsingular orthogonal matrix V satisfying $\Sigma = VV'$, (1) can be transformed to have contemporaneously uncorrelated innovations. A general orthogonalization which achieves the purpose is an eigenvalue-eigenvector decomposition of the form $\Sigma = PDP' = VV'$ where P is a matrix of eigenvectors, D is a diagonal matrix with eigenvalues on the main diagonal and $V = PD^{\frac{1}{2}}$. Given this decomposition, (1) can be transformed into:

$$\tilde{Y}_t \equiv V^{-1}Y_t = \tilde{\mu} + A(\ell)\tilde{Y}_{t-1} + \tilde{e}_t \tag{2}$$

where $\tilde{e}_t = V^{-1}e_t \sim (0, I)$, $\tilde{\mu} = V^{-1}\mu$. Let the moving average representation be:

$$\tilde{Y}_t = \phi + C(\ell)\tilde{e}_t \tag{3}$$

where $\phi = (I - A(\ell))^{-1}\tilde{\mu}$ and $C(\ell) \equiv \{c^{ij}(\ell)\} = (I - A(\ell))^{-1}$.

As shown in the next section, economic theory provides important information on the pairwise dynamic cross correlations in response to structural shocks. Using (3) the pairwise dynamic cross correlations conditional on a shock is

$$\rho_{ij|k}(r) \equiv Corr(\tilde{Y}_{it}, \tilde{Y}_{j,t+r}|\tilde{e}_{kt} = 1) = \frac{(\sum_{s=0}^{\infty} c_s^{ik} \sum_{s=0}^{\infty} c_{r+s}^{jk})}{\sqrt{(\sum_{s=0}^{\infty} c_s^{ik})^2 (\sum_{s=0}^{\infty} c_{r+s}^{jk})^2}} \quad (4)$$

where k indicates the shock, i, j the variables under consideration, r the horizon of the responses. Our task will be to examine whether for some k, for certain variables i, j, and for different values of r, $\rho_{ij|k}(r)$ conforms with the predictions of economic theory. If $\rho_{ij|k}(r)$ is not interpretable for some or all k, notice that for any orthogonal Q such that $QQ' = I$, $\Sigma = \hat{V}\hat{V}' = VQQ'V$ is an admissible orthogonal decomposition of the covariance matrix of the VAR residuals. Hence, we can repeat the exercise and examine if orthogonal shocks have a theoretical interpretation under the $\hat{V}$ decomposition.

A class of orthogonal matrices like Q useful for our purposes are rotation matrices. These matrices have a simple representation in terms of sine, cosine functions and ones of the form:

$$Q_{m,n} = \begin{pmatrix} 1 & 0 & 0 & \dots & 0 & 0 \\ 0 & 1 & 0 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & \cos(\theta) & \dots & -\sin(\theta) & 0 \\ \vdots & \vdots & \vdots & 1 & \vdots & \vdots \\ 0 & 0 & \sin(\theta) & \dots & \cos(\theta) & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

where the subscript (m, n) indicates that only rows m and n are rotated by the angle θ. Press at al. (1980) show $P = \prod_{m,n} Q_{m,n}$ so that the original eigenvector matrix is the product of successive rotation matrices.

Since in a system of N variables there are (N(N-1)/2) bivariate rotations and (N(N-1)/4) combinations of bivariate rotations of different elements of the VAR, there are 9 possible rotations one can undertake for every angle θ in our system. Although θ is periodic $mod(2\pi)$, there is an infinite number of possible values of $\theta \in [0, 2\pi]$ that could be used. This multiplicity poses two important problems. First, how to conduct the search systematically over the space of θ for each rotation.

Second, how to proceed when alternative orthogonal representations of VAR residuals recover the same number of interpretable disturbances.

Our algorithm works in three steps. First, we divide the space $[0, 2\pi]$ with a relatively fine grid - depending on the country, we use between 30 and 500 points for each rotation - therefore reducing an infinite dimensional problem to a finite dimensional one. Second, for each grid point we use the sign of $\rho_{ij|k}(r = 0)$ to identify shocks. Among all the decompositions we calculate, we restrict attention to those that maximize the number of shocks exhibiting conditional correlations consistent with theory. If there is no decomposition for which all four shocks are identifiable, we concentrate on those for which only three shocks are identifiable, and so on. Third, if there is more than one decomposition that produces the same number of identifiable shocks, we sequentially eliminate "wrong" ones using the sign of the conditional cross correlation function for $r \neq 0$. This amounts to eliminating orthogonal decompositions which produce unreasonable shapes in the impulse response function.

In our case these three steps were sufficient to uniquely select an orthogonalization for each country. If this were not the case, one could eliminate remaining ties using the *magnitude* of the elements of $\rho_{ij|k}(r)$ for different r (if theory provides this information), or making the identification requirements more stringent, e.g. adding the pairwise correlation between the variables of the system and an additional one, and requiring that the signs at $r = 0$ and/or $r \neq 0$ match those implied by theory.

Once we have determined the informational content of the orthogonal innovations, we measure their contribution to output and inflation cycles using the variance decomposition. The variance of Y_{it} allocated to sources $\tilde{e}_{kt}$ at horizon τ is

$$z^{\tau}(i,k) = \frac{\sum_{s=0}^{\tau-1}(c_s^{ik})^2}{\sum_{k=1}^{4}\sum_{s=0}^{\tau-1}(c_s^{ik})^2} \tag{5}$$

where $\sum_{k=1}^{4} z^{\tau}(i,k) = 1$. We compute confidence bands for the $z^{\tau}(i,k)$ numerically drawing Monte Carlo 1000 replications, ordering them and extracting the 68% band (from the 16th to the 84th percentile) as suggested by Sims and Zha (1999).

There is a basic difference between our identification approach and the one commonly used in structural VARs (SVAR). In SVAR one imposes "economic" or "sluggish" restrictions on the matrix of impact coefficients or on the long run multipliers of shocks and interprets the resulting long run (short run) dynamics. The imposition of economically or informationally motivated restrictions achieves two goals at once: disentangle the reduced form shocks and make them structurally interpretable. The two step approach we propose separates the statistical problem of producing uncorrelated VAR shocks from the economic one of interpreting them. Such separation avoids the imposition of zero restrictions on the contemporaneous impact of shocks, restrictions which may be inconsistent with a large class of general equilibrium models (see Canova and Piña (1998)), or on their long run effects, for which small sample biases may be substantial (see Faust and Leeper (1997)). We instead use the sign and the shape of the responses of a vector of variables to shocks to assign a structural interpretation to orthogonal disturbances.

Our approach shares some similarities with the one recently proposed by Faust (1998), and improves on the one proposed by Uhlig (1999). Faust provides a way to examine the veridicity of a statement for all identification schemes which produce "reasonable" impulse responses, and constructs counterexamples if they exist. We share with Faust the desire of systematically examining a variety of identification schemes, but we differ in the fact that our approach allows to check how results change with different identification schemes, an analysis which Faust's method is not designed to carry out. Uhlig evaluates the correctness of a statement by computing either the variance share of a particular shock for all identifications which minimize a penalty function, or the set of responses which satisfy some a-priori sign restrictions. With both methods, decompositions which produce impulse responses having signs different from those assumed to be "reasonable" are penalized explicitly with arbitrary weights, or implicitly by being completely discarded. Contrary to Uhlig, our identification procedure does not rely on any implicit or explicit penalty function. Moreover, our more informal approach allows to sequentially impose more stringent restrictions to eliminate uninteresting decompositions.

3 The theoretical restrictions

The idea behind our approach to identify the informational content of orthogonal innovations is very simple. Consider a standard undergraduate textbook picture (see e.g. Bernanke and Abel (1995), p. 382) depicting a downward sloping aggregate demand curve (AD), an upward sloping short-run aggregate supply curve (SRAS) and a vertical long-run aggregate supply curve (LRAS) in the inflation-output plane.

Suppose we observe a temporary negative inflation innovation. If it is driven by a temporary (positive) supply disturbance it should generate a positive response of output in the short run, increase money demand and produce a positive response in real balances. These changes in the equilibrium values of the variables are caused by an outward movement of the SRAS curve, keeping AD and LRAS fixed. Suppose, on the other hand, that a positive inflation innovation is driven by a temporary (positive) real demand disturbance, for example, an increase in government expenditure financed by bond creation. In that case we should observe a positive short-run response in output and a decline in real balances. These changes are the result of an outward movement in AD curve, keeping SRAS and LRAS fixed. Finally, suppose a positive inflation innovation is driven by a temporary shock in money growth. Then, we should also observe a positive response of output, if money has real effects and a positive response of real balances if prices do not fully adjust instantaneously. This combined set of circumstances is obtained by moving the AD curve along the SRAS curve, keeping the LRAS curve fixed.

A similar pattern must hold when we observe a temporary innovation in output or real balances. If it is driven by a (positive) supply disturbance, it should be associated with temporary decrease inflation and an increase in real balances. On the other hand, if it is generated by a positive temporary real (monetary) demand disturbance, it should be associated with a positive transitory increase in inflation while real balances should decline (increase).

Therefore, these three types of disturbances produce joint comovements of output, inflation and real balances of different signs. The undergraduate textbook approach has not much to say about the exact timing of these comovements. If prices are flexible, the majority of the adjustments should occur almost contemporaneously. Hence the pairwise contemporaneous cross-correlation of these three variables in response to innovations can be used to identify the informational content of shocks. If prices are sticky or there is sluggishness in output adjustments, propagation may take time. Hence, output and inflation responses may be lagged in response to monetary shocks. In all these cases leads and lags of the pairwise cross correlation function contain the information needed to identify structural disturbances.

The behavior of the term structure of nominal interest rates in response to the three structural shocks depends on the exact features of the underlying economy. For example, when capital is fixed over the adjustment path, supply and (real) demand disturbances may increase or decrease short-term interest rates relative to long-term ones, depending on the elasticities of money demand function and on how impatient are agents in their consumption needs. This lack of robustness is further complicated in the case of monetary disturbances by the presence of liquidity and the expected inflation effects. When the former dominates (due to a temporary decrease in the real rate combined with a temporary increase in inflation of smaller size), the slope of the nominal term structure will temporarily increase in response to expansionary monetary policy shocks. If the latter prevails, the slope of the nominal term structure will decline. Since the response of the slope of the term structure to structural shocks depends on the exact features of the economy, we will not use it to provide additional (overidentifying) information to identify shocks. Instead, we will use its reaction to the monetary shocks to study whether these disturbances have significant policy components.

Since this simple identification scheme is based on static economic theory, it is legitimate to wonder whether shocks in models with micro-foundations generate similar dynamic responses. The class of models whose reduced form innovations move aggregate demand and supply curves in the way we have described is relatively broad. For example, in Lucas (1972) misperception model, where agents cannot distinguish shocks to relative prices from shocks to the aggregate price level, demand and supply disturbances produce comovements in output, inflation and real balances with the required characteristics. New-keynesian models with menu costs or sticky prices monopolistic competition of the type examined by Mankiw (1985) or Gali (1999), are able to generate the pattern of comovements in response to demand and supply disturbances we have outlined, even though the quantitative features of inflation and output responses in the short run will be different from those produced by Lucas' model. Similarly, models of indeterminacy of the type described in Farmer (1999) produce outcomes which are qualitatively similar to new-keynesian ones. Finally, market clearing general equilibrium models are also able to generate a reduced form that fits the prototype model of AS-AD curves and generate the joint dynamics in response to innovations in output and inflation we have described.

To outline one such a model consider a version of the limited participation model used by Christiano, Eichenbaum and Evans (1997). The economy is populated by a continuum of homogeneous infinitely lived households maximizing the expected discounted sum of instantaneous utilities (with discount factor $\beta \in (0,1)$) derived from consuming an homogenous good, C_t and from enjoying leisure. The timing of the decision is the following: agents choose deposits, I_t, at the beginning of the period out of money held, M_{t-1} before observing the shocks ; then all the shocks are realized, and the monetary injection, X_t^A, is fed into the bank. At this point households choose the number of hours to work. The time endowment is normalized to one; capital is in fixed supply and normalized to one. At the end of production time, households collect the wage payment, W_tN_t, and uses it with the money left, $M_{t-1} - I_t$, to buy goods. After goods are purchased agents receive income from holding one-period government bonds, $R_t^bB_{t-1}$, from owning shares in the firms and in the bank, and from deposits, $R_t^MI_t$ and pay taxes, where R_t^M is gross return on money deposits (and credit) and R_t^b is gross nominal return on bonds. Out of disposable income the household decides the composition of its portfolio to be carried over next period. The program solved is

$$Max_{\{C_t,I_t,N_t,M_t,B_t\}} E_0 \sum_0^\infty \beta^t[(\ln(C_t)) + \gamma \ln(1-N_t)] \tag{6}$$

subject to

$$P_tC_t \leq M_{t-1} - I_t + W_tN_t \tag{7}$$

$$M_t + B_t \leq W_tN_t + P_tR_t^M(I_t + X_t) + R_t^bB_{t-1} + M_{t-1} - I_t - P_t(C_t + T_t) \tag{8}$$

where M_{-1}, B_{-1} are given and E_0 is the expectation conditional on information at time 0.

There exists a continuum of identical firms, facing a constant returns to scale technology perturbed by an exogenous technology shock v_t. Each firm maximizes profits subject to the given technology and to a cash-in-advance constraint, since wages are paid before the firm collects revenues from the sales of the product. Profits at each t are measured by the difference between the receipts from selling the good, Y_t, at price P_t, and the costs associated with paying wages, $(1 + R_t^M)W_tN_t$. The problem solved by the firm is

$$Max_{\{N_t\}} P_tY_t - (1 + R_t^M)W_tN_t \tag{9}$$

subject to

$$W_t N_t \leq I_t + X_t \tag{10}$$

$$Y_t \leq v_t N_t^{\alpha} K_t^{1-\alpha} \tag{11}$$

We assume $\ln(v_t) = a\ln(t) + (1-\rho)\ln(v) + \rho\ln(v_{t-1}) + \vartheta_t$, with $\vartheta_t \sim iid(0, \sigma_\vartheta^2)$, $|\rho| < 1$, $\alpha \in [0, 1]$.

The financial intermediary collects money from the households in the form of deposits, I_t and pays R_t^M of gross interest. It also receives X_t from the monetary authority, issued at zero cost and supplied at zero price. It then rents these funds to firms at the price R_t^M. The profits from financial intermediation, $R_t^M X_t$, are paid-out to the household in the form of dividends.

The government in this economy plays a simple role. Government consumption G_t, is financed by issuing one-period bonds, B_t, after repaying outstanding debt, $R_t^b B_{t-1}$, and lump sum taxes. That is, $P_t(G_t - T_t) = B_t - R_t^b B_{t-1}$. We assume $\ln(G_t) = (1-\theta)\ln(G) + \theta\ln(G_{t-1}) + \varphi_t$, with $\varphi_t \sim iid(0, \sigma_\varphi^2)$, $|\theta| < 1$.

The monetary authority issues cash at no cost every period and transfers to the bank are in the form of an "helicopter drop" of money. For the purpose of this paper we assume a simple monetary rule with monetary injections defined as $X_t^A = M_t^A - M_{t-1}^A$ where $X_t = \varepsilon_t M_{t-1}^A$ where $\ln(\varepsilon_t) = (1-\phi)\ln(\varepsilon) + \phi\ln(\varepsilon_{t-1}) + \omega_t$, with $\omega_t \sim iid(0, \sigma_\omega^2)$, $|\phi| < 1$.

In equilibrium all markets clear and the following condition must be satisfied for $k = 0, 1, 2, \ldots$.

$$\frac{1}{C_t} = E_t\left[\frac{\beta R_{t+k}}{(P_{t+k+1}/P_{t+k})}\frac{1}{C_{t+k+1}}\right] \tag{12}$$

where $R = R^M = R^b$. Since an analytic solution to the model can not be computed, an approximate solution is obtained by log-linearizing the equilibrium conditions around the steady state. We construct the slope of the term structure by taking the difference between a long term rate and a short one ($SL_t = \lim_{k\to\infty} \hat{R}_{t+k} - \hat{R}_{t+1}$) where a "hat" indicates percentage deviations from the steady state. To generate time series out of the model, we choose the time unit of the model to be a quarter. We let $\bar{N} = 0.30$, $\alpha = 0.65$, $\overline{\Pi} = 1.0$, $\beta = 0.99$, $\overline{c}/\overline{y} = 0.8$ where $\overline{c}/\overline{y}$ is the share of consumption in output, $\bar{N}$ is hours worked and $\overline{\Pi}$ is gross inflation in the steady states, α is exponent of labor in the production function, β is the discount factor. These parameters imply that in steady-state the gross real interest rate is 1.01, output is 0.46, deposits are 0.29, real balances

0.37, the real wage 0.88, the share of leisure in utility is 0.65, and $\gamma = 1.86$, which are in line with those used in the literature. Finally, we parametrize the stochastic processes for the three shocks to all have the same persistence (0.95) and the same coefficient of variation (1/0.71).

Figure 1 reports the conditional cross correlation of the three variables in response to the three structural shocks. A technology disturbance generates S-shaped correlations between output and inflation and inflation and real balances but in both cases the contemporaneous cross correlation is negative. On the other hand, the cross correlation between real balances and output is positive. Government expenditure shocks produce an inverted S-shape correlation between inflation and output and the contemporaneous cross correlation is positive. The cross correlation between inflation and real balances has an S-shape with a negative contemporaneous cross correlation while the correlation between real balances and output is negative everywhere in the range. Finally, monetary disturbances produce positive contemporaneous cross correlations for all pairs of variables.

The interpretation of the dynamics generated by the shocks is very simple. Given a process for M_t, a surprise increase in $\hat{v}_t$ increases output and consumption on impact since g_t is constant at its steady state level. This increase in consumption requires an increase in the money needed to finance expenditure. With a fixed money supply, short term nominal rates increase (the slope of the term structure declines) to make agents hold exactly the right amount of money. Since agents are richer, the wealth effect of the shock makes hours decline and leisure increases temporarily. Note that because labor demand by firms has increased, the real wage is higher after the shocks, making the wealth effect even stronger. In other words as agents become more productive, they devote more time to leisure and less to production. Also, because the nominal rate increases and the inflation rate declines, real balances and the ex-post real rate increase substantially after the shock.

A unitary surprise increase in $\hat{G}_t$ makes c_t decline and, because of a wealth effect, labor supply and output increase. Given the money supply, aggregate demand increases and this raises prices on impact. Since consumption declines, money demand also declines and the short term rate decreases (the slope of term structure increases) to induce agents to hold exactly the amount of money in circulation. As a consequence, leisure decline to maintain the time constraint satisfied. Real balances and ex-post real returns also decline, as the nominal rate decreases while inflation has increased on impact.

Finally, a unitary surprise increase in X_t decreases the cost of production for firms which increase their labor demand. Hence both wages and hours increase, leading to an increase in output and consumption. Furthermore, as money increases are larger than output increases there will be inflation. However, since the increase in inflation is smaller than the increase in X_t, real balances increase. Since the liquidity effect dominates the expected inflation effect, a positive monetary shock decreases nominal short term rates at impact and rises the slope of the term structure.

In conclusion, the model generates the same sign restrictions on the cross correlation function in response to structural disturbances as the standard textbook approach. Since the joint dynamic behavior of output, inflation and real balances in response to shocks is shared by a large class of models with different micro-foundations, we feel confident to use the sign restrictions of the cross correlation function to disentangle structural disturbances without reference to any specific model.

4 The results

4.1 Identifying the disturbances: The US

To illustrate how the identification procedure works we first examine sources of fluctuations in US output and inflation in detail. Figures 2-4 present, respectively, the estimated cross correlation function for inflation and industrial production, inflation and real balances and real balances and industrial production, conditional on the four orthogonalized VAR innovations for $r = -4, \ldots, 0, 1, \ldots, 4$; the impulse response of the variables of the system to each orthogonal innovations; and the time path of the four disturbances. All figures are constructed orthogonalizing the covariance matrix of the shocks with an eigenvalue-eigenvector decomposition and rows 1 and 3 and rows 2 and 4 of the standardized eigenvector matrix simultaneously rotated by the angle $\theta = 0.94$. We have selected this decomposition because it allows us to identify four shocks using the contemporaneous cross correlation function, and because, among the two orthogonalizations which produce this outcome, the impulse responses it produces are interpretable.

Figure 2 shows that the first and fourth orthogonal shocks generate positive pairwise contemporaneous cross correlations functions in the relevant range, and therefore qualify as "monetary" disturbances. The second orthogonal shock produces cross correlation functions for inflation and output and inflation and real balances with negative contemporaneous values, and a positive contemporaneous cross correlation function for real balances and output. Hence, this shock qualifies as a "supply" disturbance. The third orthogonal shock produces a positive cross correlation function between industrial production and inflation and negative cross correlation functions for the other two pairs of variables. Thus, it qualifies as a "real demand" disturbance.

Figure 3 shows that the two monetary disturbances we have identified produce very different dynamics in the system. The first monetary shock has sizable effects on industrial production but it does not produce any visible liquidity effect: increases in real balances are in fact associated with temporary increases in inflation and in short term rates relative to the long ones. Note also that the response of real balances is almost synchronized with that of industrial production, suggesting that a cash-in-advance mechanism with constant velocity may be at work. The other monetary disturbance, on the other hand, does not have significant short run real effects, but the impact response of inflation is strong. Furthermore, this monetary disturbance makes the slope of the term structure decline considerably for about two years after the shock. Since also output declines over this period, it may be reasonable to suspect that long term rates have increased relative to short term ones, suggesting the presence of strong expected inflations effects. Hence, the two monetary disturbances have distinct effects on real activity and on the slope of the term structure, probably because of the different inflation expectations they generate.

The dynamics generated by the two other disturbances are also easily interpretable. The second orthogonal shock looks like a Lucas' (1972) supply disturbance: it produces a small increase in industrial production accompanied by a decline in inflation on impact, but this tendency is quickly reversed with inflation increasing and output declining for about four years. Real balances increase in response to the disturbance and long term rates increase relative to short term ones. Over the adjustment path there is some overshooting and eventually inflation falls relative to its trend and industrial production increases. The third orthogonal shock induces adjustments typically associated with a real demand shock: contractionary shocks of this type make both industrial production and inflation decline on impact, real balances increase and the long term rate falls relative to the short term one.

Figure 4 shows that the volatility of the first monetary shock (shock 1) is constant over the sample. However, there are large spikes around 1987-1989 and significant negative movements in 1974, 1979 and around the so-called Romer and Romer dates. The second monetary shock (shock 4) displays periods of high volatility in 1973-75 and 1979-82. Also, after 1982 its volatility seems to decline, and there appear to be only two episodes of significant negative disturbances: in correspondence with the Plaza Agreement (end of 1985) and at the end of 1988.

The second shock has most of its variability concentrated between 1979 and 1982, at a time when the real rate of interest was very volatile. Hence, although one maybe tempted to attribute this volatility to the choice of monetary targets by the Federal Reserve, our procedure selects such a shock as a supply disturbance. This is because it increases long term real rates (relative to short ones) and this contracts economic activity and inflation. The third orthogonal shock has two large spikes, one around 1975 (positive) and one at the end of 1988 (negative), both of which seemed to be associated with substantial changes in consumer and government spending. Note also that this shock displays an increase in volatility between 1979 and 1982 and presents a stronger pattern of persistence in the 1990's.

In conclusion, when applied to US data, our identification approach recovers four disturbances whose historical path is reasonable and produce dynamics which are structurally interpretable. For reason of space, we confine figures of the cross correlation functions, of the impulse responses and of the time path of the shocks for the other six countries in an appendix available on request. Next, we comment on the identification results obtained in the other G-7 nations.

4.2 Identifying monetary disturbances in the other G-7 countries

We summarize the informational content of structural shocks in the remaining countries in table 1, where we also report the rotation employed and the angle used to achieve identification.

Table 1 contains two important facts. First, for four of the remaining six countries (UK, France, Italy and Canada) our approach is able to identify all four orthogonal shocks. For Germany and Japan we are able to interpret the informational content of only three of the four shocks. Second, we identify at least one monetary disturbance in all six countries, and in Japan, Italy and UK three orthogonal shocks appear to be of monetary type.

Identified monetary disturbances seems to fit three broad patterns across countries. First, in five countries (Germany, France, Italy, Japan and Canada) at least one of the identified shocks fits our a-priori idea of what a monetary *policy* disturbance does, i.e. if it is contractionary, such a shock should reduce nominal balances, decrease output, either on impact or with a short lag, contract inflation instantaneously, make real balances decline and the short nominal interest rate increase relative to the long one. Notice that the joint behavior of the four variables of the system in these instances is consistent with the presence of a liquidity effect and the absence of the so-called "price puzzle" (see Sims (1992)).

Second, there is a group monetary shocks which has perverse output effects. In fact, expansionary monetary disturbances of this type have the characteristic of increasing nominal balances, of decreasing output on impact or with a short lag, of producing a strong positive response of inflation, followed by a decline, and of generating a positive and humped shaped response in the slope term structure. As shown in figure 5, there are monetary disturbances in Germany, UK and Japan with these features.

One possible interpretation of these dynamic responses is the following: a surprise increase in nominal balances creates an instantaneous inflation effect - probably because these shocks occur close to full employment - making real balances decline on impact. Output then declines either because demand has declined or because high inflation has increased costs of production. These effects appear to be very persistent therefore generating expected inflation effects which translate into an increase in the long term interest rates relative to short term ones over the medium run.

The final typical pattern characterizing identified monetary shocks across countries appear to be linked to international factors. That is, some of the monetary disturbances tend to have spikes at time of turbulence in international money and financial markets and, for European countries, at time of realignment of their exchange rates within the EMU. In figure 6 we report the time path of two such shocks, one for Germany and one for Italy. There are significant spikes for Italy in 1979 and 1992 and for Germany in 1983-86 and in 1992. In general, we observe an increase in the volatility of these shocks at times of significant speculative pressure in international currency markets. Notice also that positive realizations of this type of monetary disturbances tend to generate strong expected inflation effects and produce positive humped shaped responses in the term structure.

In sum, our procedure identifies monetary disturbances in all countries. The finding that at least one source of structural disturbances in each of the seven countries can be classified as monetary is remarkable, because domestic money markets in the G-7 have very different characteristics, and they were subject to substantial changes over the period. The monetary disturbances we have identified across countries have three typical patterns: one which is interpretable if the shock represents policy innovations (there is a liquidity effect in the economy); another which points to the existence of strong and persistent inflation (and expected inflation) effects; and a final one, primarily evident in European countries, which appears to be connected with common speculative shocks in international currency markets.

4.3 The Explanatory Power of Monetary Disturbances

Having identified the informational content of orthogonal VAR innovations across countries, we next calculate the contribution of monetary shocks to output and inflation cycles for every country. Notice that what we compute for Germany and Japan are lower bounds, because there are orthogonal innovations without a clear informational content. These innovations may also contain components which may be monetary in nature, distinct from and uncorrelated from the ones we are able to disentangle, so that the percentages we present here could be augmented if, by means of other variables or additional information, we could uncover what drives the remaining unnamed innovations. Table 2 presents 68% bands for the forecast error variance decomposition of output and inflation at 24 steps. Varying the forecasting horizon between 12 and 48 steps has no effects on the results, since shocks are typically completely absorbed after 12 periods.

Table 2 displays four important features. First, monetary disturbances are a significant source of real fluctuations in every country except France. Second, in three countries they are the dominant source of variability in industrial production. In particular, monetary disturbances account for 37-77% of the variance of industrial production in the UK, for 95-99% of the variance of industrial production in Germany, for 22-45% of the variance of industrial production in Japan. In the other three countries, monetary disturbances explain between 16 and 60% of the variability of industrial production. Third, monetary shocks are also the dominant source of inflation fluctuations in the US, Japan, UK and Italy, where they explain between 54 and 98% of inflation variance. Fourth, although monetary disturbances appear to be important, there is a substantial portion of industrial production variability in Japan which is left unexplained.

4.4 Sub-sample analysis

The presence of subsample instabilities may distort our conclusions concerning the informational content of orthogonal VAR innovations and the importance of various structural disturbances as sources of output and inflation cycles. The domestic and international portions of monetary markets of all the G-7 countries have undertaken substantial changes over the sample. For example, capital controls and restrictions on domestic holdings of foreign currencies have been gradually eliminated during the 1980's. Domestic banking constraints, e.g. regulation Q in the US or quotas on the portfolio of banks in European countries, have also been scrapped over the sample period in favor of more market oriented policies. These changes may have affected the way monetary disturbances are transmitted to the real economy, as well as the adjustment lag needed for prices and quantities to fully adjust to these disturbances.

In this subsection we report evidence obtained from two subsamples (73:1-82:10 and 82:11-95:7) in order to check whether subsample instabilities change the essence of the results we have presented. It should be kept in mind that by breaking the sample we avoid to mix periods with different structural characteristics, but estimates of the cross-correlation functions are more likely to be imprecise, and the informational content of orthogonal VAR innovations more difficult to detect in the subsamples. We chose 1982:10 as common break point following the existing literature (see e.g. Kim (1999)): the first subsample includes the oil shocks, the inflationary period of the 1970's and the Volker experiment of targeting monetary aggregates, while the second sample covers the most recent years with declining inflation, increased economic integration and vigorous US expansion. While there are arguments in favor of choosing a unique sample break for all countries, it is also the case that, at least for European countries, there are episodes which may require further subdivisions (the German unification in 1990, the breakdown of the monetary snake in 1979 and of the EMS in 1992, and so on). We do not investigate these additional potential breaks as the sample size becomes too short to make sense of the estimates of the cross correlation function. The time path of the identified disturbances in the two subsamples suggests that these episodes are better characterized as outliers than as structural breaks with changing dynamics.

The qualitative results we obtain for the first subsample are similar to the ones obtained for the full sample, but quantitatively some differences emerge. For example, the number of identified shocks is smaller than that found in the full sample. As shown in table 1, we are able to identify all four shocks in the US, Italy and Japan, while we identify three shocks in the UK, France and Canada and only two shocks in Germany. Furthermore, the informational content of identified disturbances changes. While in the US, Japan and Italy we able to recover three monetary disturbances; in UK, France and Canada we recover two monetary shocks while in Germany only one of the two interpretable shocks represent monetary disturbances.

Despite these differences, the general conclusions we have drawn hold true also for this subsample. Monetary disturbances significantly contribute the variability of industrial production in six of the seven countries (the exception in this case is Germany) and they are the dominant source of industrial production variations in five countries. These shocks are also the dominant source of variability in inflation in five of the seven countries. Notice that as a results of the small sample problems, there are some countries (UK and Canada, in particular) where there is still a large component of inflation variability that is not explained by identified shocks.

In the second subsample, we recover at least one source of monetary disturbances in all seven countries. However, the relative importance of these shocks for industrial production fluctuations has changed. For example, in Japan, the UK and France, the contribution of monetary disturbances to real fluctuations is insignificant or modest. On the other hand, monetary disturbances become preponderant in the US and Italy where they explain, respectively, between 94 and 99% and 50 and 83% of the variance of industrial production. A similar pattern holds for inflation variance: the importance of monetary disturbances declines in US, Canada, Japan and Italy while it increases in Germany and the UK. Despite these difference, we find also in this subsample that monetary disturbances significantly contribute the variability of industrial production in five of the seven countries and dominate the variability of inflation in three of the seven countries.

For this subsample monetary disturbances explain a larger portion of the variability of inflation than industrial production in three of the four European countries (the exception is Italy). Inspection of the time path of the estimated disturbances indicates that most of their variability occurs at times associated with realignments and/or disruptions of the European Monetary System and with the German unification of 1990. Hence, these disturbances are somewhat common to European countries, and appear to be due to turbulence present in international money markets rather than to domestic (policy) changes.

In conclusion, the analysis of this subsection has highlighted four important facts. First, structural sources of disturbances driving output and inflation cycles appear to be changing over time. Despite of these variations, monetary disturbances are an important sources of industrial production variability in several countries in both subsamples. Second, it appears that the events occurring in the first part of the sample tend to dominate the dynamics present in the full sample. Third, the explanatory power of the monetary disturbances for industrial production cycles is significantly reduced in the second subsample in Japan, UK and France and significantly increased in Italy and the US. Fourth, monetary disturbances in several European countries in the second subsample appear to occur at times when international financial and monetary markets were in turmoil.

4.5 Results from the Pooled Specification

Instead of asking how important are monetary disturbances in explaining output and inflation cycles in each of the G-7 countries, one may be interested in knowing what is the "typical" information content of a monetary innovations in an average country of the panel. To investigate this question we examine a pooled VAR model with a country specific intercept where the dynamics in response to various structural disturbances are estimated using data from all countries. Such a model provides us with a cross country mean estimate of the pairwise cross correlation functions of the three variables of interest.

A pooled model correctly recovers the average informational content of orthogonal innovations if the DGP of the actual data were the same for all countries, apart from a level effect. When this is the case and the time series dimension of each sample is short, we can obtain more precise estimates of the cross correlation function by pooling together the seven data sets. In practice, this means that inference may be more accurate since the mechanism driving output and inflation fluctuations may have been operating in a larger number of instances. For example, one should a-priori expect monetary shocks which drive fluctuations in the European countries to have a common component with the differences previously noted due to small sample sizes. By pooling data together one hopes that this commonality will translate in repeated observations on either the same source or the same propagation mechanism, therefore providing a more accurate representation of the forces at work.

The drawbacks of pooling are well understood. Neglecting heterogeneity in the dynamics produces inconsistent estimates of the parameters and biases structural inference, i.e. we get more precise estimates of the possibly wrong source of disturbance. Note that under the assumption that short term dynamics are the same across countries and the samples are large enough, single countries VARs and the pooled VAR will both give identical information on the structural sources of output and inflation cycles.

Table 1 show that for a pooled VAR we identify a real demand, two monetary and one supply disturbance in the full sample, which are the same types of shocks present in the US. The qualitative similarities between the pooled model and the US are remarkable: not only identified shocks are the same but also their relative importance is similar. In fact, the explanatory power of monetary shocks for both industrial production and inflation variability is very close to those obtained for the US (see table 2). These similarities emerge because the pairwise conditional cross correlations (and the impulse responses) are very much alike in the two cases.

For the first subsample, we are able to identify only three disturbances: two monetary and one real demand shocks. Here monetary disturbances dominate the variability of industrial production, explaining between 74 and 91% of its variance. They also explain between one-third and two-thirds of the variability of inflation. For the second subsample, we identify only two orthogonal shocks, one supply and one monetary disturbance, but they both account for negligible portions of the variability of both industrial production and inflation. Hence, the pooled VAR model is somewhat misspecified for the period 1982-1995 since there are large portions of the variability of pooled industrial production and inflation which are left unexplained. In other words, the heterogeneities across countries in the transmission of shocks are important in this subsample and averaging across countries produces misleading results.

To summarize, it appears that the cross country dynamics following orthogonal VAR innovations are sufficiently homogeneous for the full sample to make estimates of the average dynamics of the three variables in a typical country meaningful. The results once again emphasize the important role that monetary disturbances play in explaining real fluctuations in two of the three samples considered [1].

5 The variability of the slope of the term structure

The previous section has shown that monetary shocks do represent a significant source of variability in real variables for several countries in all subsamples we analyzed. Implicit in our identification scheme is the idea that monetary disturbances are policy driven, i.e. they are expected to represent disturbances that move the supply of funds, and we have heavily relied on this presumption in discussing both the responses they generate and the features of their time path. However, it may be the case that under certain policy design (for example, an interest rate targeting) identified monetary shocks could represent money demand disturbances. One way to disentangle these two possible interpretations is to examine how the slope of the term structure responds to these shocks, and measure the time needed for these disturbances to be fully incorporated in the bond markets.

Liquidity theories of monetary policy (see e.g. Christiano, Eichenbaum and Evans (1997)) stress that the magnitude of the real effects crucially depends on how quickly financial markets adjust to monetary disturbances. For example, Evans and Marshall (1998) have shown that, at least for the US, contractionary monetary policy shocks produce a contemporaneous positive response of the slope of the term structure, and this response changes sign in the medium run when expected inflation effects become important. Moreover, since for some of the period under consideration several Central Banks followed monetary rules that implicitly or explicitly gave heavy weights to interest rates, we should expect a speedy reaction of the slope of the term structure in many of the G-7 countries, if the disturbances we have identified are truly policy shocks. In this situation, disturbances that move money demand should leave the term structure of interest rate unaffected - exactly if the central bank follows a fully accommodative rule, and approximately if interest rate smoothing policies are implemented.

Our discussion in section 4 has already pointed out to the fact that the slope of the term structure in the US quickly responds to all monetary disturbances, and that the shape of the response depends on the relative importance of liquidity and expected inflation effects. The remaining G-7 countries

[1] We have also examined the typical dynamics obtained by averaging the relevant statistics over the seven countries as suggested by Pesaran and Smith (1995). The results obtained are mixed and the procedure is unable to provide any sharp conclusion about sources of output and inflation cycles.

appear to display very similar features.

Out of the 13 monetary disturbances we identified in the remaining six countries for the full sample, eight disturbances, if contractionary, produce an instantaneous increase in the slope of the term structure and, in five cases, hump shaped responses in the medium run. In the remaining five cases a shock, if contractionary, produces first a decline and then an increase in the slope, but in all cases we observe humped shaped responses in the medium run. One reason for these differences may be related to the credibility of that different central banks may have gained over the period. Another may have to do with the fact that some monetary shocks are related to disturbances in international financial markets, thereby producing strong expected inflation effects.

We quantify the importance of identified monetary disturbances in table 3, where we report the percentage of variance in the slope of the term structure accounted for by monetary shocks at 3 and at 24 months horizons. The results we present are strongly supportive of the hypothesis that identified monetary disturbances contain a large policy component. For example, for the full sample in Japan, UK, Germany and Italy, monetary shocks explain between 95 and 99% of the variance of the slope of the term structure at the 3-month horizon and this percentage is large also at the 24 month horizon except for Germany. For France monetary disturbances account between 66 and 84% of the variance of the term structure at the three month horizon, and the percentage at the 24 month horizon is only slightly smaller. For the US the percentage is significantly smaller, but still sizable (25-58%). Finally, for Canada the monetary shocks that we recovered are not responsible for variations in the term structure at the 3 month horizon, and the percentage is only slightly larger at the 24-month horizon.

For the two subsamples the results are similar. For the 1973-1982 period monetary shocks account for 70-99% of the variance of slope of the term structure at the three-month horizon in five countries. In Germany the percentage is smaller and in France there is no evidence that monetary shocks are responsible for variations in the slope of the term structure. For the 1982-1995 period monetary shocks are the overwhelming source of term structure variability in the US, UK and France; they are important in Japan and Germany, and they have no influence in Canada and Italy.

In the US the percentage of the variance of the slope of the term structure explained by monetary disturbances is constant across horizons in all three samples, confirming that monetary shocks are very quickly incorporated in the slope of the term structure and giving credence to the hypothesis that identified disturbances do have an important policy component.

Notice also that, as it was the case for fluctuations in industrial production and inflation, the relative importance of monetary shocks for the variability of the term structure changes over time. For example, in the US and France identified monetary shocks are the sole source of term structure variability in the second subsample, while in Italy and Canada - two countries which heavily relied on exchange rate targeting in the second subperiod - monetary disturbances loose their importance as sources of term structure variability.

6 Conclusions

This paper examined the importance of monetary disturbances for fluctuations in economic activity and inflation using a novel two-step identification approach. The proposed procedure is advantageous for several reasons: it uses the joint conditional dynamics of output, inflation and real balances to identify shocks; it clearly separates the statistical issue of obtaining contemporaneously uncorrelated innovations from the one of identifying their informational content; and it allows us to explore the space of identifications systematically.

The consensus view about the contribution of monetary disturbances to output fluctuations in the literature seemed to be that these shocks have, at most, a modest importance (see Sims (1998) or Uhlig (1999)). This view has been challenged by Roberts (1993) and, more recently, by Faust (1999), who claim that there are identification schemes where monetary disturbances account for a large portion of output variability in the US. Our results reinforce these challenges in several ways.

First, we find that monetary disturbances are at work in all countries and in all samples we analyze. Second, we show that they play a major role in driving output, inflation and term structure variability in most of the G-7 countries. Their importance varies with the country and the sample but when present, they represent a substantive source of cyclical fluctuations. For the US, for example, monetary disturbances explain between 16 and 60% of the variability of industrial production in the full sample, but this percentage dramatically increases when we split the sample in two. For the other countries we report percentages that are even higher, and in some cases significantly so. This should be contrasted with the evidence presented in Kim (1999), where monetary disturbances appear to play a minor role in all the G-7 countries. Third, we demonstrate that identified monetary disturbances are able to generate both liquidity and expected inflation effects in the system. Fourth, for every country and in all subsamples, we show that the slope of the term structure quickly reacts to these disturbances. This last result leads us to conclude that the monetary disturbances we have identified must have important policy components.

The fact that monetary disturbances are important for the post Bretton Wood period provides empirical support to the recent resurgence of interest in theoretical models where monetary shocks are the engine of the business cycle. Furthermore, it suggests that a careful study of the nature of these shocks may shed important light on mechanics of propagation and help us to understand their transmission among various markets within and across countries.

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Table 1: Identification

Country	Rotation	θ	Shock 1	Shock 2	Shock 3	Shock 4
			Sample 1973:1-1995:7			
US	8	0.94	Monetary	Supply	Real Demand	Monetary
GERMANY	5	0.47	Monetary	Real Demand	Monetary	
JAPAN	8	1.53	Monetary	Monetary		Monetary
UK	1	0.31	Real Demand	Monetary	Monetary	Monetary
FRANCE	6	1.09	Real Demand	Monetary	Supply	Real Demand
ITALY	1	0.31	Supply	Monetary	Monetary	Monetary
CANADA	1	0.62	Monetary	Supply	Supply	Supply
POOLED	7	0.47	Real Demand	Monetary	Monetary	Supply
			Sample 1973:1-1982:10			
US	4	0.62	Monetary	Monetary	Monetary	Real Demand
GERMANY	9	0.94			Monetary	Real Demand
JAPAN	1	0.00	Real Demand	Monetary	Monetary	Monetary
UK	3	0.47	Real Demand	Monetary		Monetary
FRANCE	3	0.00	Real Demand	Monetary	Monetary	
ITALY	1	0.47	Supply	Monetary	Monetary	Monetary
CANADA	4	1.09	Real Demand		Monetary	Monetary
POOLED	1	0.62	Monetary	Real Demand	Monetary	
			Sample 1982:11-1995:7			
US	2	0.31	Monetary	Real Demand	Monetary	Monetary
GERMANY	1	1.25	Supply	Monetary		Monetary
JAPAN	5	1.09		Monetary	Real Demand	Real Demand
UK	4	1.25		Real Demand	Monetary	
FRANCE	2	0.62	Real Demand	Supply	Monetary	Monetary
ITALY	7	0.31	Monetary	Supply	Supply	Supply
CANADA	7	1.41	Supply	Monetary	Supply	
POOLED	7	0.94			Supply	Monetary

Notes: In the rotation column, 1 indicates that the first two elements of the covariance matrix are rotated; 2 indicates that elements one and three of the covariance matrix are rotated; 3 indicates that elements one and four of the covariance matrix are rotated; 4 indicates that elements two and three of the covariance matrix are rotated; 5 indicates that elements two and four of the covariance matrix are rotated; 6 indicates that elements three and four of the covariance matrix are rotated; 7 indicates that elements one and two, and three and four of the covariance matrix are contemporaneously rotated; 8 indicates that elements one and three, and two and four of the covariance matrix are contemporaneously rotated; 9 indicates that elements one and four, and two and three of the covariance matrix are contemporaneously rotated. θ measures the angle of rotation.

Table 2
Percentage of the 24 month Forecast Error Variance of
Industrial Production and Inflation Explained by Monetary Disturbances

	Variance of Industrial Production	Variance of Inflation
	Sample 1973:1-1995:7	
USA	16-60	54-64
GERMANY	95-99	25-32
JAPAN	22-45	97-99
UK	37-77	95-98
FRANCE	0-6	16-19
ITALY	25-45	85-95
CANADA	31-59	24-43
POOLED	23-55	51-84
	Sample 1973:1-1982:10	
USA	68-94	76-97
GERMANY	1-19	58-63
JAPAN	55-76	91-98
UK	31-66	3-10
FRANCE	39-60	86-95
ITALY	39-61	76-92
CANADA	34-85	4-15
POOLED	74-91	33-63
	Sample 1982:11-1995:7	
USA	94-99	6-16
GERMANY	61-87	88-97
JAPAN	0-16	19-23
UK	4-15	73-87
FRANCE	7-32	18-83
ITALY	50-83	5-20
CANADA	59-84	3-12
POOLED	4-27	0-5

Notes: The forecast error variance is computed using a 4 variable VAR model. The table shows the 68% error band for the 24-month forecast error variance in the variable explained by sources of structural innovations. Bands are computed using Monte Carlo replications.

Table 3
Percentage of the Forecast Error Variance of the Slope of the Term Structure Explained by Monetary Disturbances

	3 month horizon	24 month horizon
	Sample 1973:1-1995:7	
USA	25-58	25-57
GERMANY	98-99	26-54
JAPAN	98-99	73-91
UK	95-99	77-95
FRANCE	66-84	49-72
ITALY	98-99	95-99
CANADA	0-3	18-34
POOLED	1-67	14-55
	Sample 1973:1-1982:10	
USA	69-96	58-95
GERMANY	19-46	10-26
JAPAN	97-99	78-94
UK	93-98	61-83
FRANCE	3-11	13-39
ITALY	91-99	83-99
CANADA	89-98	55-87
POOLED	86-97	76-87
	Sample 1982:11-1995:7	
USA	97-99	90-99
GERMANY	20-39	34-56
JAPAN	35-63	21-47
UK	91-96	4-14
FRANCE	93-99	77-96
ITALY	0-3	0-7
CANADA	0-2	27-52
POOLED	3-69	18-45

Notes: The forecast error variance is computed using a 4 variable VAR model. The table shows the 68% error band computed using Monte Carlo replications.

Figure 1

Conditional Cross-Correlations in a Limited Participation Model

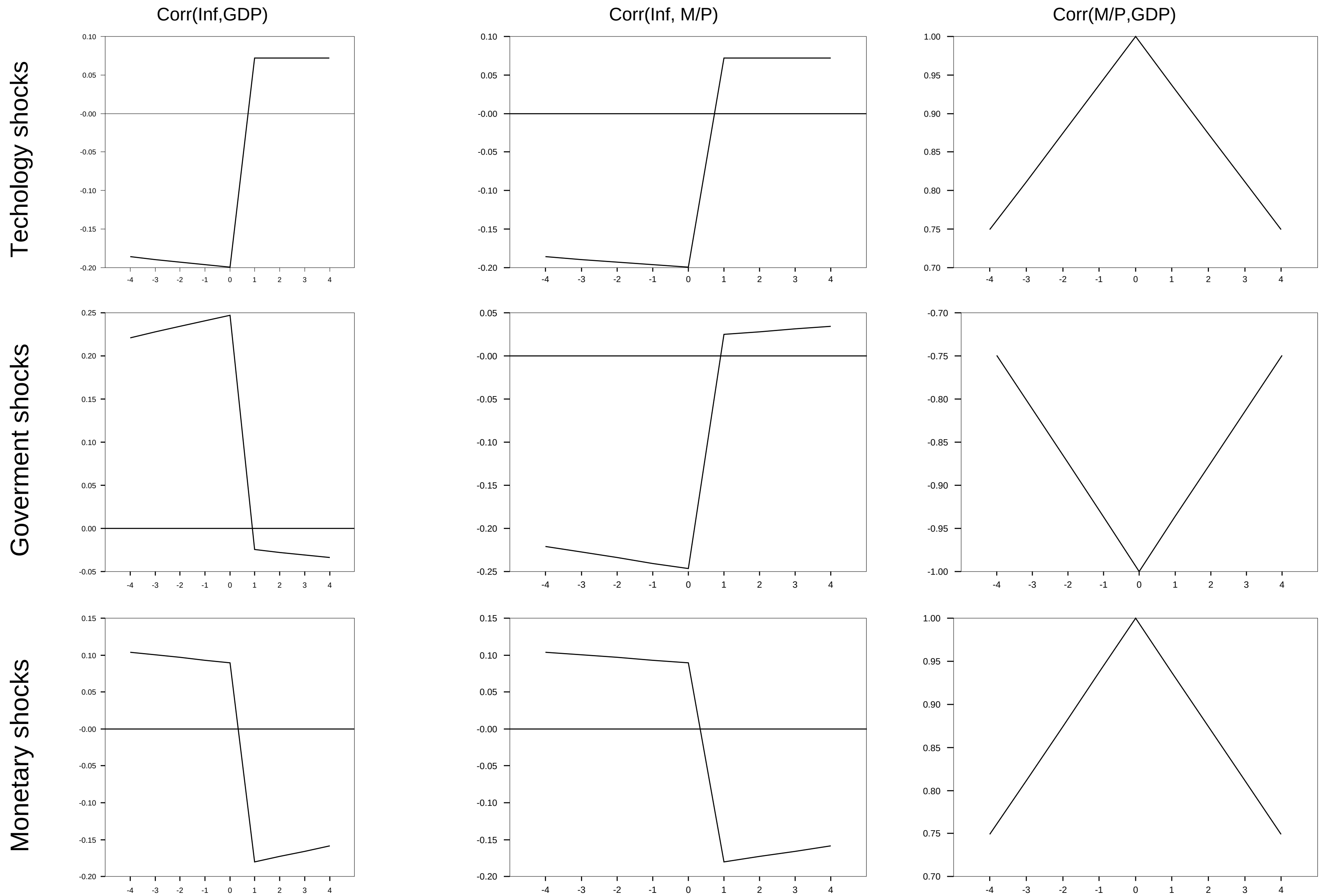

Figure 2: US, Cross Correlations

1973:01-1995:07

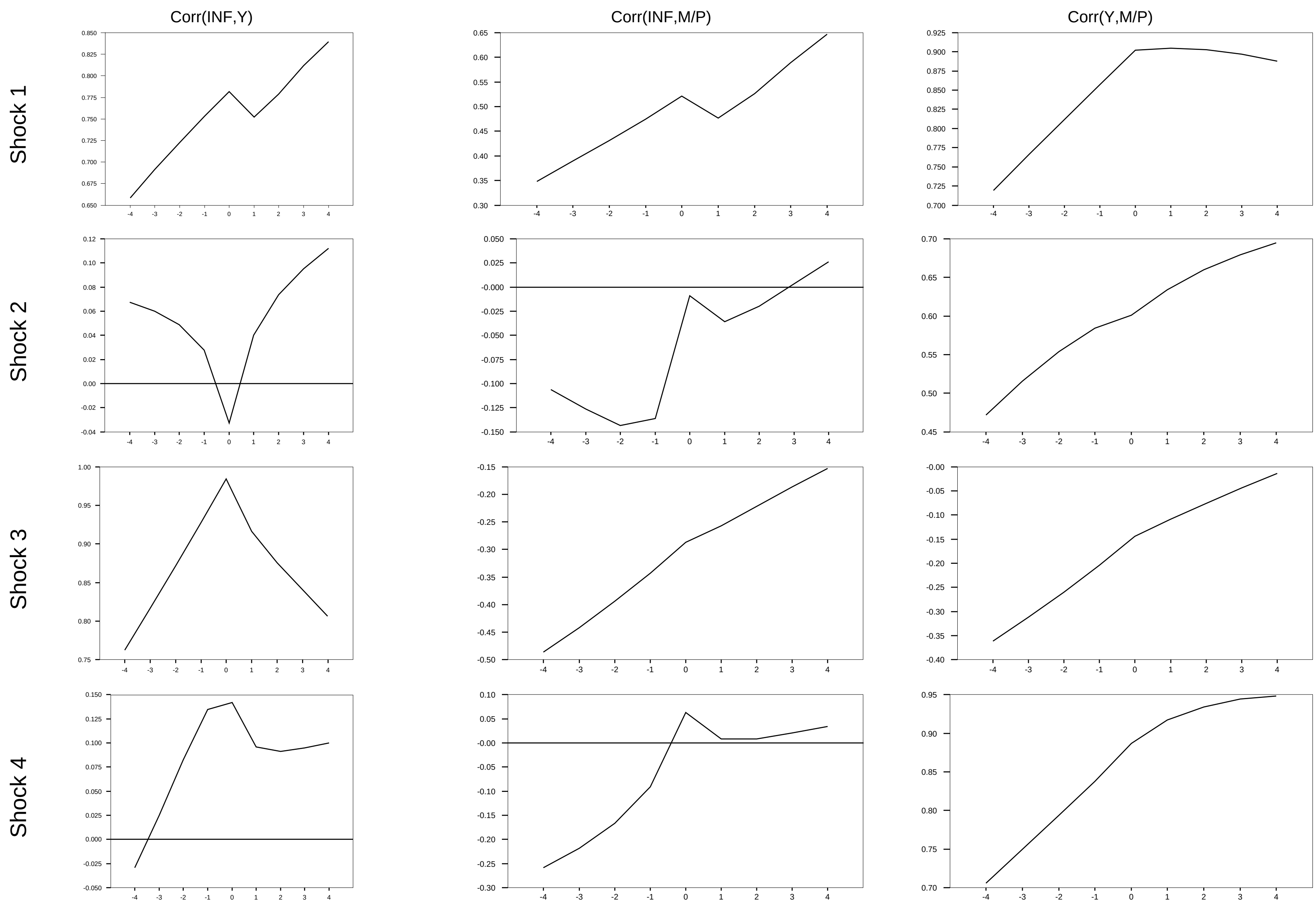

Figure 3: US, Impulse Responses

1973:01-1995:07

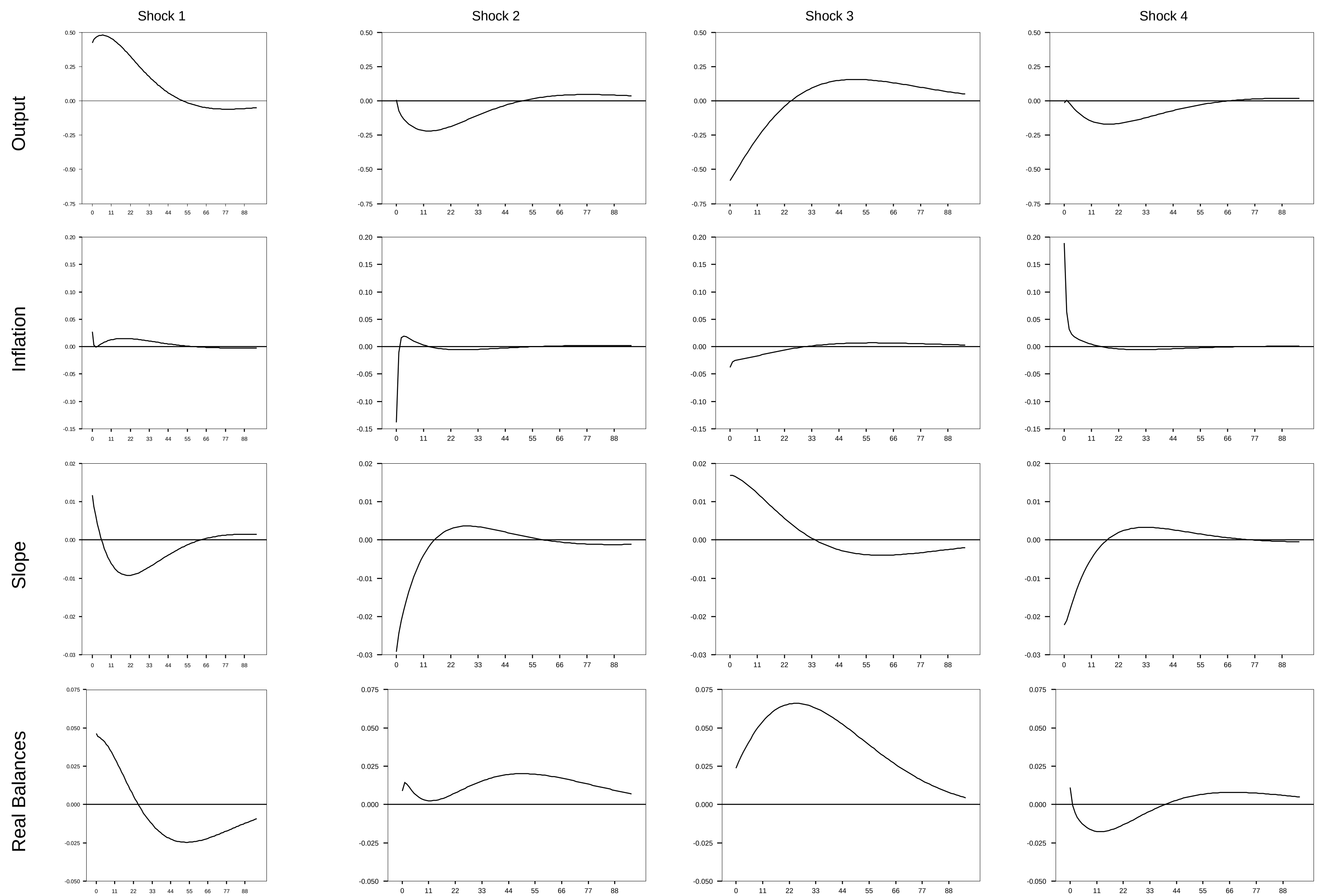

Figure 4: US, Orthogonalized Shocks

1973:01-1995:07

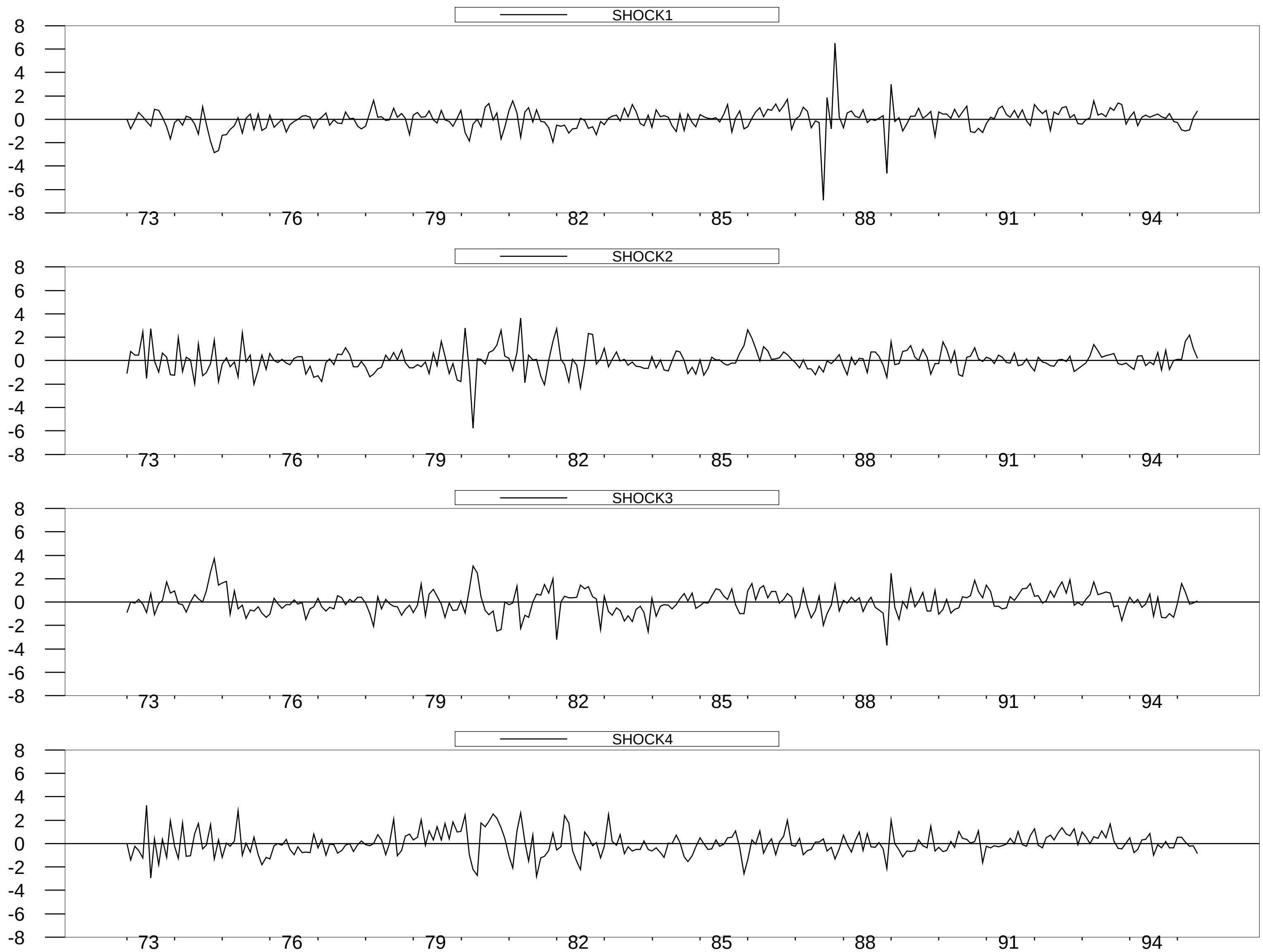

Figure 5: Impulse Responses to Monetary Shocks

1973.1-1995.07

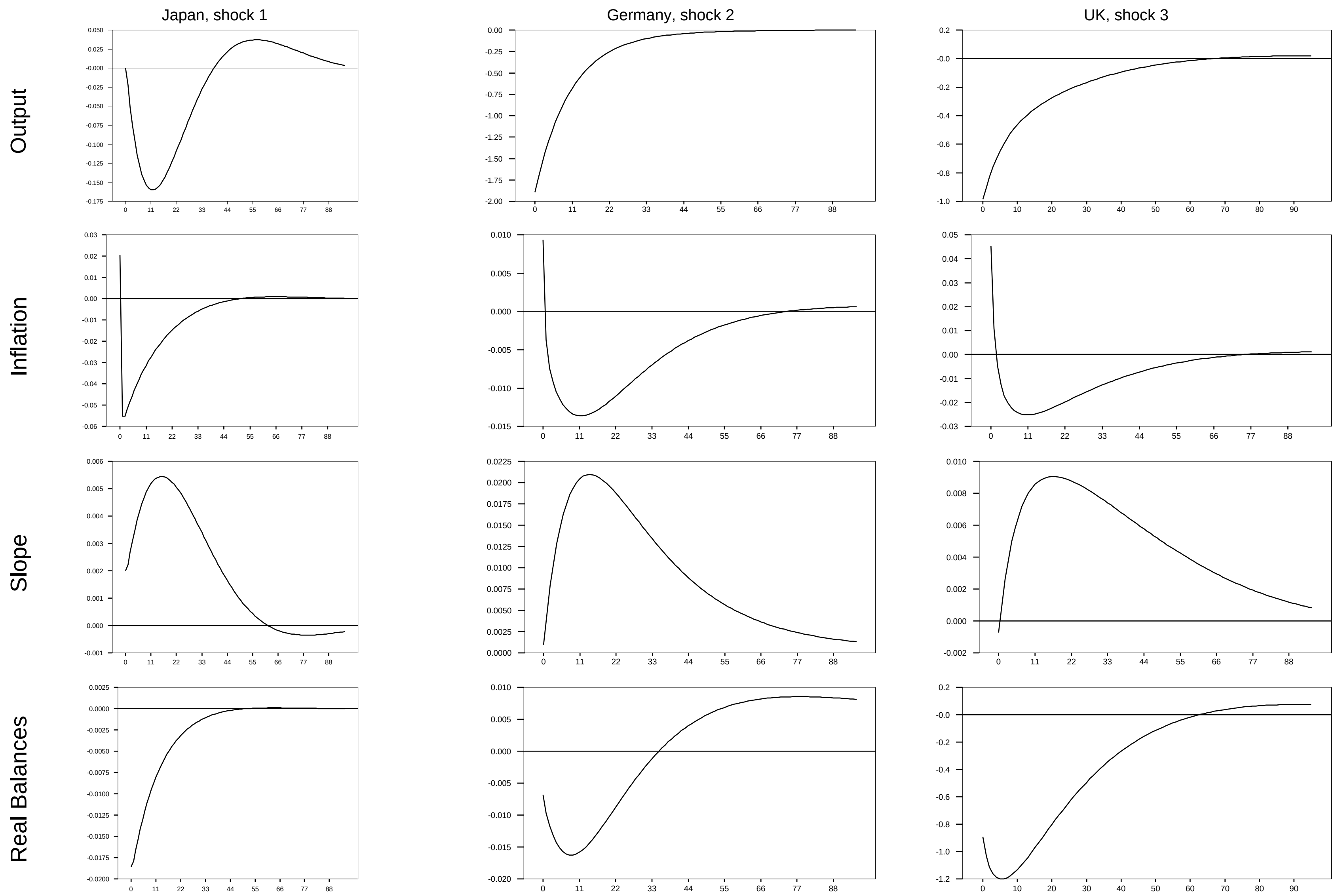

Figure 6, Selected Structural Shocks

1973.1-1995.07