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AN EMPIRICAL INVESTIGATION ON THE LIQUIDITY EFFECTS OF MONETARY POLICY SHOCKS ON EXCHANGE RATES

By

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Abstract

This paper examines recent work on the identification of monetary policy disturbances and the effect on the interest rates and exchange rate. A method of identifying monetary policy using non borrowed reserves is proposed. Under this specification, policy has strong persistent liquidity effects in interest and exchange rates. The fluctuation of the liquidity level impacts the level of the interest rates and spills over to the asset prices and to the foreign exchange market (JEL Classification: E51, F41, G1).

1. Introduction

An important issue in discussion of the monetary policy is that market interest rates follow a particular time path in response to changes in the rate of monetary growth. The traditional analysis of the effects of changes in money growth in nominal interest rates runs in terms of liquidity, income, and expectation effects.

The theoretical argument of the transmission mechanism runs as follows: an unanticipated increase in the monetary growth rate results initially in an excess supply in the money markets at the existing income, interest rate and price level. Part of this excess shows up as an increase in the demand for securities where the prices of these securities are bid up, and nominal yields decline until the market clears. If the price level and real income adjust slowly then the nominal interest rate must decrease to equate money demand and money supply. This negative response of the nominal interest rate at least in the short and medium runs is known as the liquidity effect. However, two other effects can counter the liquidity effect.

First, over time, this money stock increase will have an expansionary, effect on both real income and the price level. The rise in income will increase money demand, which will result in higher interest rates. Finally, there is the Fisher effect as nominal interest rates increase because of a rise in inflationary expectations. Higher expected inflation resulting from money stock increases would, through a fisherian relation, increase nominal interest rates. This "price anticipation effect" could thus not only mitigate the decline in interest rates stemming from the liquidity effect, but could also overpower it.

In an open economy environment, the monetary transmission mechanism is one of the central questions. It is fair to say today that there is no canonical description of how the monetary innovations are transmitted internationally. Traditional static IS/LM models like the Mundell-Fleming's asserts that a monetary expansion at home shifts the LM curve outwards reducing the rate of interest and causing an increase in output. As a consequence the home currency will depreciate. But dissatisfaction with this paradigm has lead authors either to extend the Mundell — Fleming model, Dornbousch (1976) or to seek and explore alternative models of international transmission, Helpman and Razin (1985) and Grilli and Roubini (1992) emphasizing the presence of liquidity constraints and the linkage from the financial markets to the money markets. In this environment, certain amount of liquidity is needed in the financial transactions to ensure smoothness in the financial markets. The fluctuation of the liquidity level will impact the level of the interest rates and it will spill over to the asset prices and to the foreign exchange market. The purpose of this study is to identify first, and analyze later, any existing liquidity effects deriving from the monetary transmission mechanism channel.

Section 2 briefly presents a literature survey on liquidity effects, in which an exogenous positive innovation in the supply of money generates persistent declines in short-term interest rates and in nominal and real exchange rate.

In section 3, we concentrate on isolating a measure of shocks to monetary policy and ask how the interest and exchange rates respond to these specific shocks. We use data from the flexible exchange rate era for the G-7 countries and measure shocks to their monetary policy by using the money supply as the policy instrument. In addition, we present evidence of liquidity effects and some key implications of our model.

Section 4, considers the problem of nonstationarity of the data and tests for cointegration relationships among the variables. The implementation of the cointegration relationships, as a last periods equilibrium error gives rise to a vector error correction system. Finally, section 5 contains some concluding remarks.

2. Equilibrium and Liquidity Models

In a general equilibrium framework, a representative agent maximizes her present value utility, in a two-country world, subject to budget constraint and two cash-in-advance constraints. The agent is required to hold cash not only for the purchase of goods but also for the purchase of assets. In these economies, asset markets and goods markets are separated for one period and shocks to the stock of money have one period effect on interest rates, currency prices and relative prices of goods. Thus, the theory generates greater volatility of relative prices than would exist in ana analogous model without the segmented market structure. Although these models have a lot of similarities with the international Real Business Cycle (RBC) models they differ in a fundamental way: they allow for liquidity effects. In both models the money is introduced via cash-in advance constraints but the RBC models suffer from a generic implication. RBC models allow the change in money stock to affect the interest rates through an anticipated inflation effect. As a result, the interest rate and consequently the exchange rate exhibit persistent positive correlation to unanticipated shock to the growth rate of money.

Recent literature [Grilli and Roubini (1992); and Schlagenhauf and Wrase (1992a, b)] tried to explain the liquidity effects on the interest and exchange rates after a change in the monetary policy. These papers were built on earlier contributions by Grossman and Weis (1983); Rotemberg (1984); Lucas (1990); and Christiano (1991) which have stressed the importance of liquidity effects for explaining the co-movements between interest rates and monetary aggregates.

In particular, Grilli and Roubini (1992) show that an unexpected increase in the supply of bonds of the domestic country (through stochastic open market operations) will drive the price of the bond down. Consequently, the domestic real and nominal rate of interest will rise and lead to the appreciation of the domestic currency. In addition, liquidity effects deriving from the open market operations spill over to the foreign exchange market and leads to excess exchange rate volatility.

2.1 Empirical Studies on Liquidity Effects

In the empirical area, Eichenbaum and Evans (1993) investigated only the effects of shocks to monetary policy on nominal interest rates and on nominal and real exchange rates by nonborrowed reserves as the monetary instrument. They found that an expansionary monetary policy leads to an initial and persistent decline in the U.S. short-term interest rates and to a significant depreciation of the U.S. currency. By using nonborrowed reserves as the measure of money they were able to produce sharp and persistent declines in short-term interest rates and consequently identify U.S. currency deprecations . In addition, they found that a temporal pattern of the U.S. dollar following a positive innovation of the U.S. monetary policy is not consistent with the overshooting model considered by Dornbusch (1976) . They observed, that the dollar continued to depreciate arriving at its maximum depreciation rate after a long time. According to the authors, this is puzzling because it leads to the violation of the "uncovered interest parity condition" .

Grilli and Roubini (1993) used short-term interest rate innovations as the indicator of the changes in the monetary policy and found that, positive innovations to the U.S. interest rate leads to an appreciation of the U.S. dollar, while innovations to the other G-7 countries leads to a surprising depreciation of their currencies. These currency depreciation results are completely inconsistent with the economic view that random disturbances in monetary policy cause the domestic currency to appreciate.

3. Evidence on the Exchange Rate of Monetary Policy

This paper examines the effect of U.S. expansion shock to U.S. dollar and also the effects of the other non-U.S. policy shocks to their currencies. In identifying U.S. monetary shocks we use the nonborrowed reserves as the policy instrument basically for two reasons. While, an innovation in the other monetary measures is regarded as a shock to demand (Goodfriend 1993, Strongin 1992) or money demand (Bernanke and Blinder 1990, King and Watson 1992 and Sims 1992) an innovation in the NBR is considered as a shock to the supply of money . Secondly, a positive shock has a transitory positive impact on NBR. Furthermore, NBR is directly controlled by the Federal Open Committee (FOMC) and its innovations represent exogenous shocks to the supply of money and which according to Boschen and Mills (1995) is negatively correlated with the short-term interest rate: Christiano and Eichenbaum (1992a) report that there is a strong statistically significant, negative contemporaneous correlation between the federal fund rate and the nonborrowed reserves and that the federal funds rate is negatively correlated with leads and lags of nonborrowed reserves up to one year. However, these correlations can not be taken as evidence that unanticipated expansionary monetary policy disturbances drive short term interest rates down.

On the other hand, short-time interest rates are not, at best, a better proxy in identifying monetary changes. Although, Bernanke and Blinder (1992) found that transitory movements in the federal funds rate and the treasury bill rate are closely related to policy changes, Boschen and Mills (1995) found that a substantial amount of monthly variation in interest rates is not associated with policy decisions. In addition, the short-term interest rates can be regarded as a polluted measure of policy disturbances knowing that a portion of the innovation to interest rates represents an endogenous response of the policy makers to non-policy disturbances . We have no way of knowing what percentage of interest rate innovations represent exogenous policy disturbances and what percentage represent endogenous reaction. Therefore, there is certainly no *a priori* reason for working with the innovations to the interest rate attributable entirely to exogenous shocks in monetary policy. Simply, if we use interest rate innovations, we will systematically overstate the importance of policy disturbances.

The variables employed in our analysis differ from the ones that Eichenbaum and Evans (1993) and Grilli and Roubini (1993) incorporate. According to Eichenbaum and Evans (1993), the exclusion of a measure of high order foreign monetary aggregate from their analysis have a minimal impact on identifying shocks to the U.S. monetary policy. Nevertheless, the inclusion of a measure of a U.S. monetary aggregate on identifying shocks to the other non-U.S. G-7 countries would have a significant impact on the foreign monetary policy. In other words, U.S. monetary variables are included since it is clear that U.S. events are a major factor in generating foreign business cycles. Omitting U.S. monetary aggregate variables could cause important biases when analyzing the effects of foreign innovations in non-U.S. VAR systems. Therefore in our analysis we include a measure of a foreign monetary aggregate instead of a measure of foreign output. In addition, we address a new element which is the issue of the liquidity effects on the exchange rates of monetary shocks in the other G-7 countries .

3.1 Identifying Shocks to Monetary Policy

In order to identify Monetary Policy shocks we incorporate the standard VAR methodology and measure orthogonalised components of the innovation to one of the monetary aggregates, namely, the money supply. The innovations to monetary policy are identified with the disturbance term in a regression function of the form:

$$\Lambda_t=\delta(\Gamma) + \varepsilon_{\Lambda t} \qquad (1)$$

where At is the monetary authority's policy instrument at time t - in our case a monetary aggregate (NBR), δ is the linear function, Γ_t is the information set available to the monetary authorities at time t when At is set and $\varepsilon_{\Lambda t}$ is a serially uncorrelated policy innovation which is orthogonal to the elements of the information set and represents the exogenous shock to the monetary authority's policy instrument. The monetary authorities set the level of the money supply by taking into account the values of the variables (past and some current) that are included in the information set.

The dynamic response of a variable to a monetary policy shock can be derived by computing the impulse response function in an appropriately identified Vector Autoregression (VAR). In other words, equations were estimated for the system:

$$Z_t=A(L)Z_{t-1}+v_t \qquad (2)$$

where Vt is iid, $Ev_t\ v'_t$ and Z_t = vector of variables and

$$A(L) = A_0+A_1L+\ldots+A_nL_n$$

where L is the lag operator and η is the number of lags. To proceed one must specify the variables involved in the VAR system the optimum number of distributed lags and the Wold ordering of the variables. Variables appearing before the policy instrument can have a contemporaneous effect on the policy instrument. In other words, the monetary authorities before setting Z, observe all the lagged variables in the system as well as the current values of the variables appearing prior to the policy instrument. The shock to monetary policy is the component of the innovation to the instrument variable and is orthogonal to the variables that are causally prior to the monetary instrument.

3.2 Empirical Results: Identifying U.S. Monetary Policy Shocks

In this section we present the dynamic responses of nominal exchange rate (along with foreign money supply, foreign interest rates U.S. money supply and U.S. interest rates) to a shock in the U.S. monetary policy in the post Bretton Woods era. We consider six nominal exchange rates for the following G-7 countries (Germany, France, Italy, Japan, U.K. and Canada) for the sample period of 1974 to 1994:3 and 1974:1 to 1992:12 for the case of France. The monthly data are taken from the International Financial Statistics tape and its detailed form can be found in the appendix. In identifying appropriately the shocks to monetary policy we are forced to examine the flexible exchange rate regime by itself -which begins on 1973- since the fixed exchange rate regime imposed constraints on the monetary policy[7].

We consider a seven variable VAR system including, U.S. industrial production (Y), (where industrial production is a proxy for output) U.S. consumer price index (P), (as a proxy for prices) foreign monetary aggregate (M*), (an asterisk in this section denotes a foreign variable) foreign short term interest rate (R*), U. S nonborrowed reserves (M) , U.S. short term interest rate (R) and a nominal exchange rate (E) (defined as the number of foreign currency units needed to buy one U.S. dollar), where E={DM, FF, Lira, Yen, PD, Can$} respectively. The above specification and order meets Sim's and Eichenbaum's criteria for a good measure of monetary policy. We initially examine the unrestricted version of VAR system in levels and not in differences or pre — testing for cointegrating relations for the following reason . In our multivariate VAR system (i.e. in our case seven variable system) is difficult to give the exact economic interpretation to any existing true cointegrating relationships. Imposing inappropriate co-integration relationships can lead to biased estimates and biased impulse responses derived from this particular specification. Nevertheless, is still interesting to test the robustness of our results by imposing the cointegrating vectors. Therefore, we test for cointegrated relations at the end of the paper.

The Wold ordering of the variables {Y, P, M*, R*, M, R, E} assumes that the monetary authorities observe all lagged values of the variables as well as the current values of the variables that appear prior to the policy instrument (M), before setting the policy. In other words, the contemporaneous portion of the feedback rule for setting the level of M involves only the variable that appears causal-prior to M . A shock to monetary policy is measured by the innovation on M that is orthogonal to innovations in Y, P, M*, and R*(in a Standard Choleski decomposition). Although, one may argue that the above ordering is not the one that reflects at least the state of the U.S. economy, nevertheless we adopt the one used in Christiano and Eichenbaum (1993) and Grilli and Roubini (1995) for comparison purposes. The particular Wold ordering seems more appropriate for the case of the other six countries, which are impacted by U.S. monetary events and act as the followers in setting their monetary policy. Therefore, any contemporaneous information coming from U.S. variables are certainly used appropriately.

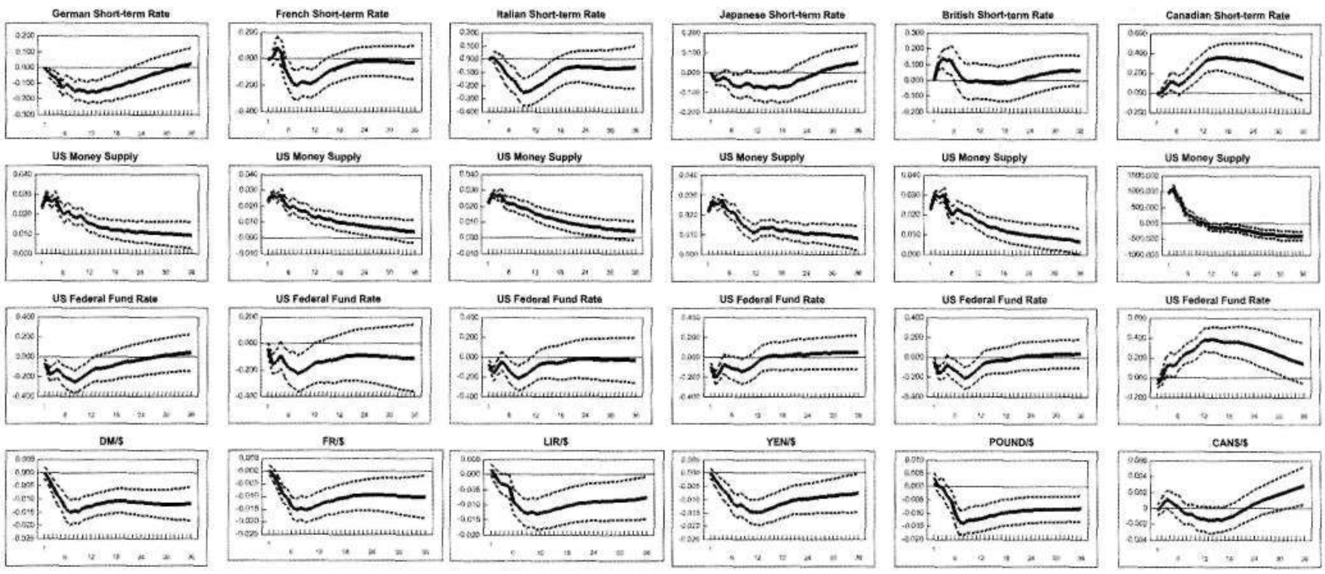
In discussing the impulse responses we use the following convention. Suppose the system is at equilibrium and that equilibrium is placed at the origin of our coordinate system that is, all variables are zero in equilibrium. Then an effect of a one-time impulse on a variable is traced through time. In addition, if the variable returns to its initial equilibrium the effect is called transitory.

Figure 1 reports results for the German, French, Italian, Japanese, U.K. and Canadian case respectively. The solid lines in figure 1 represent the dynamic responses of foreign money (M*), foreign short-term interest rate (R*), U.S. money, U.S. short-term interest rate (R)and the exchange rate to one standard deviation shock to U.S. monetary policy. The dotted lines represent one standard deviation confidence intervals of the point estimates of the coefficients in the impulse response functions .

But also of interest are the correlations between the innovations presented in table 1. Table 1 depicts the covariance matrix of the innovations in the VAR system underlying the response functions in figure 1. Note that the correlations among the innovations in each VAR system are low suggesting that orthogonalisation have little impact on the ordering of the variables. This can be easily seen from table 1 where most of the off diagonal elements are very close to zero. Also, note the strong negative correlations of the interest rate and exchange rate to an innovation in U.S. money supply - row four and six in column five for each system. The strong negative correlations of the U.S. interest rate to an innovation in U.S. money supply (NBR) ranging from {-.029 to -.093} supports the finding by Christiano and Eichenbaum (1991) that the unconditional correlation between NBR and Federal Funds rate is negative. In addition, the innovations of the U.S.

FIGURE 1

Impulse Response Functions: Orthogonalised Shocks in U.S. Money (Nonborrowed Reserves) 7 Variable System*



* Column 1 depicts the dynamic effect of an orthogonalised innovation in U.S. money on the German interest rate, the U.S. money supply, the U.S. interest rate and the nominal exchange rate DM/$.
Columns 2 through 6 do the same for France, Italy, Japan, U.K. and Canada.

money supply (NBR) output (Y) and prices (P) are negative-row four in column one and two in each system-suggesting that the policy makers move quickly to forestall the inflationary pressures by contracting the money supply (NBR) thereby inducing an increase in the short term interest rate.

TABLE 1

Correlation matrix of innovation in VAR:Seven variable systems

Y	P	M*	R*	M	R	E
U.S. vs Germany						
1.000						
0.068	1.000					
-0.095	0.056	1.000				
0.056	0.002	-0.007	1.000			
-0.076	-0.018	-0.282	0.036	1.000		
0.287	0.113	-0.101	-0.010	-0.029	1.000	
0.181	0.115	0.032	0.065	-0.020	0.217	1.000
U.S. vs France						
1.000						
0.057	1.000					
0.003	-0.145	1.000				
-0.077	-0.078	0.305	1.000			
-0.074	-0.061	0.170	0.006	1.000		
0.282	0.105	0.049	0.050	-0.076	1.000	
0.170	0.066	-0.257	-0.041	-0.024	0.176	1.000
U.S. vs Italy						
1.000						
0.057	1.000					
0.003	-0.145	1.000				
-0.077	-0.078	0.305	1.000			
-0.074	-0.061	0.170	0.006	1.000		
0.282	0.105	0.049	0.050	-0.076	1.000	
0.170	0.066	-0.257	-0.041	-0.024	0.176	1.000
U.S. vs Japan						
1.000						
0.121	1.000					
-0.089	-0.193	1.000				
0.011	0.156	-0.092	1.000			
-0.127	-0.043	0.255	0.020	1.000		
0.291	0.118	0.002	0.039	-0.047	1.000	
0.159	0.077	-0.088	-0.110	-0.017	0.199	1.000

(cont'd)

U.S. vs Britain						
1.000						
0.071	1.000					
0.040	-0.206	1.000				
0.049	0.114	-0.129	1.000			
-0.064	-0.078	0.156	0.076	1.000		
0.279	0.095	0.062	0.070	-0.081	1.000	
0.140	-0.006	-0.038	-0.046	0.046	0.097	1.000
U.S. vs Canada						
1.000						
0.110	1.000					
-0.029	-0.030	1.000				
-0.211	0.048	0.241	1.000			
-0.047	-0.051	0.245	0.084	1.000		
0.293	0.193	0.016	0.056	-0.093	1.000	
0.083	0.057	0.050	0.010	-0.022	0.148	1.000

The negative correlation of the U.S. money supply (M) and U.S. interest rate (R) can be manifested in the response of the interest rate (R) to an innovation of the U.S. money supply (M) which is depicted in figure 1 row three across. The U.S. short-term interest rate declines on impact to an innovation of the U.S. money supply, and it stays -for over eight months — under its initial equilibrium point. Onl in U.S. money is associated with an impact decline of the interest rate followed by sharp successive increases. Nevertheless in all cases, the impact decline is statistically significant and the liquidity effects in the short-run are evident. But interestingly enough to see is that the decline of the interest rates is followed by subsequent increases. These increases are attributed to the "Fisherian effect" where a decline in the short-term interest rate is followed by increases in nominal income and revisions of the agents' inflationary expectations. The latter is causing the nominal rates to increase.

Second, consistent with Grilli and Roubini (1992) "spill over effect" hypothesis, a positive shock to U.S. monetary policy leads to a persistent depreciation in the exchange rate (row five across) and the confidence intervals suggest that the dynamic coefficients are statistically significant (except in the case of Canada). But the maximal depreciation of the exchange rate which is defined as For/$: For={DM, FR, Lira, Yen, PD, Can$) does not occur contemporaneously but after six to 9 months[12] .The delayed maximal depreciation of the dollar can be explained with the hypothesis that the agents might be learning about the change in monetary policy after awhile and gradually revise their expectation [Lewis (1989)] .

Finally, in this VAR setting, the strong evidence of the persistence of liquidity effects is directly related to the persistence of NBR response to an innovation in policy. This suggests that even anticipated accommodative policy actions have substantial negative impact on interest and exchange rates. The results of the exchange rate send mixed signals on simple overshooting models Dornbusch (1976) in which a positive shock to monetary policy generates sharp initial drop on the exchange rate. But surprisingly, the exchange rate after reaching the maximal depreciation point begins to appreciate in all cases until it reaches the long-run equilibrium point. The maximal depreciation of the exchange rate Et:E={DM, FF, Lira, Yen, PD, Can$}/U.S. $ occurs {6, 8, 9, 8, 7, 13} months after the shock to monetary policy. These results are in favor of Dornbusch's overshooting model in which the initial depreciation of the exchange rate is followed by subsequent appreciations.

The intuition of the overshooting model is simple. At the time of the shock to monetary policy, output and prices are fixed (or adjusting slowly), so that the domestic nominal interest rate must decrease. As a result, the interest differential (between the two countries) generates capital outflow and depreciation until it is expected to appreciate to the point where the domestic and foreign bonds are equally attractive.

3.3 Identifying Non-U.S. Monetary Policy Shocks

In this section we identify shocks to the other non U.S. G-7 countries monetary policy namely to Germany, France, Italy, Japan, U.K. and Canada by employing the same procedure as before. We consider six 7-variable VAR systems. Each VAR system includes domestic industrial production (Y), domestic consumer price index (P), U.S. monetary aggregate (M*), U.S. short-term interest rate (R*), domestic monetary aggregate (M), a domestic short-term interest rate (R) and a nominal exchange rate (E), defined as the number of domestic units required to buy one U.S. dollar.

The impulse response functions are calculated again based on the Wold ordering of {Y, P, M*, R*, M, R, E}. This corresponds to the assumption that the domestic monetary authorities -before setting their monetary aggregate- observe the current values of the domestic industrial production, domestic short-term interest rate, U.S. monetary aggregate and U.S. short-term interest rate and the lagged values of all the variables within the VAR system. Therefore, in this environment, domestic monetary shock is measured as the component of the innovation in domestic money supply (M) that is orthogonal to innovations in Yt, Pt, M*t, and R*t. The response functions of the six 7-variable VAR systems are presented in figure 2. Also, table 2 presents the correlations between the innovations in the various VAR systems.

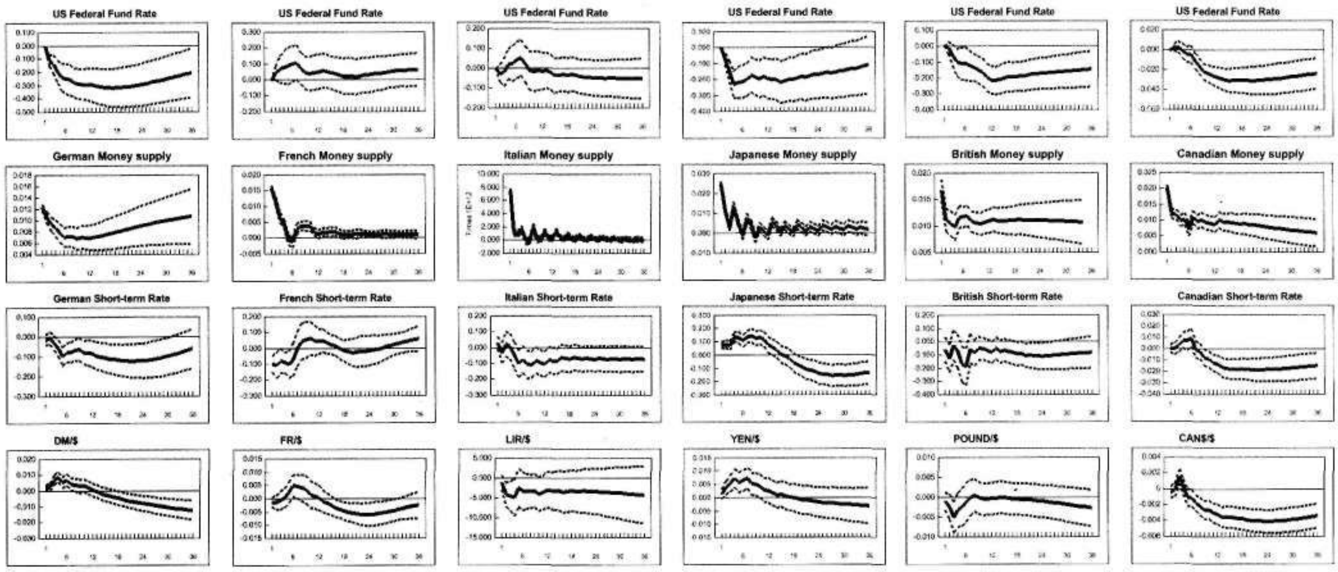
The results derived from these systems are very surprising. Other than the case of Germany[14] and Japan - where a German (or Japanese) expansionary monetary policy is followed by an impact depreciation of the German mark (or Japanese yen), there is no clear evidence of a domestic currency depreciation. In the contrary, the U.K. Pound and the Italian Lira, persistently appreciate on impact after an expansionary monetary policy of their own. The other currencies, the Canadian Dollar and the French Franc appreciate on impact before any depreciation prevails. Only in the cases of Germany and Japan an expansionary monetary policy of their own leads to a sharp persistent depreciation of their currencies against the U.S. dollar . Moreover, the maximal depreciation of these currencies occurs not on impact but after four months. This delayed maximal depreciation response as previously pointed out can be attributed to the hypothesis that the agents might be reacting slowly to the change in monetary policy and gradually revise their expectations. Another possible explanation of the puzzling behavior of the exchange rate is that some of the countries like France and Italy have pegged their currencies to the German mark while U.K. and Canada have managed their currency to varying degrees at different times. Only US, Germany and Japan have had truly independent floating rate .

3.4 Results Emerging from a Modifying Non-U.S. VAR System

In this section of the paper we will try to address and resolve the "liquidity puzzling" of the exchange rate, which appears in the analysis of some non-U.S. G-7 countries. While, in identifying U.S. shocks to monetary policy we used nonborrowed reserves as the monetary tool, in identifying non-U.S. G-7 countries shocks to their monetary policy we used a broader measure of monetary aggregate (usually a MO or Ml). In a modified VAR system we now employ the reserves of the foreign Central Banks as a proxy for the foreign monetary instrument which consists of deposits from the member banks plus currency outside the Central Bank. Changes in reserves in Central Bank can be considered as exogenous shocks to the money supply, which can have a noticeable impact on the nominal interest rates including the exchange rate. Therefore, we concentrate on the rela-

FIGURE 2

Impulse Response Functions: Orthogonalised Shocks in Money in G-7 Countries other than U.S. 7 Variable System*



* Column 1 depicts the dynamic effect of an orthogonalised innovation in German money on the U.S. interest rate, the German money supply, the German interest rate and the nominal exchange rate DM/$.
Columns 2 through 6 do the same for France, Italy, Japan, U.K. and Canada.

tionship between the monthly series for the reserves, the interest rate and the exchange rate. The reserves are more closely associated with any foreign open market operations, and they are Central Bank's control variable.

TABLE 2

Correlation matrix innovations in VAR:Seven variable systems

Y	P	M*	R*	M	R	E
Germany						
1.000						
0.024	1.000					
-0.205	0.017	1.000				
0.010	0.025	-0.061	1.000			
0.074	0.084	-0.288	-0.120	1.000		
0.046	-0.039	0.066	0.056	-0.053	1.000	
0.003	0.110	0.029	0.230	0.049	0.095	1.000
France						
1.000						
0.093	1.000					
-0.188	-0.092	1.000				
0.037	0.165	-0.072	1.000			
-0.072	-0.173	0.239	0.006	1.000		
0.113	0.040	0.009	0.024	-0.088	1.000	
-0.058	0.060	-0.055	0.216	-0.131	-0.086	1.000
Italy						
1.000						
0.133	1.000					
-0.017	0.072	1.000				
0.156	0.039	-0.138	1.000			
0.075	-0.097	0.319	0.020	1.000		
-0.044	0.162	-0.045	0.068	-0.012	1.000	
0.008	0.068	-0.022	0.187	-0.153	0.073	1.000
Japan						
1.000						
-0.147	1.000					
-0.052	-0.229	1.000				
-0.062	0.091	-0.115	1.000			
0.046	-0.086	-0.120	-0.085	1.000		
-0.093	-0.269	0.014	0.026	-0.005	1.000	
-0.091	0.036	-0.135	0.061	-0.055	-0.383	1.000

(cont'd)

Britain						
1.000						
0.033	1.000					
0.033	0.097	1.000				
0.002	-0.010	-0.031	1.000			
-0.089	-0.245	0.006	-0.012	1.000		
0.086	-0.002	-0.057	0.128	0.004	1.000	
0.030	-0.067	0.001	0.128	-0.006	0.132	1.000
Canada						
1.000						
-0.080	1.000					
0.092	-0.259	1.000				
0.255	0.044	-0.017	1.000			
0.082	-0.084	0.289	0.050	1.000		
0.183	-0.011	0.003	0.376	0.025	1.000	
0.096	0.116	-0.004	0.278	-0.027	0.433	1.000

Figure 3 exhibits the impulse responses emerged from the non U.S. G-7 countries VAR — systems. Consider first the results for the exchange rate. Notice that, regardless of which country is viewed, innovations to monetary policy are always followed by sharp, persistent statistically significant increases in the exchange rate. In all but one case, Japan, the dynamic response of the exchange rate is the same:the immediate impact of the shock to monetary policy to non-U.S. G-7 countries is to raise the value of the exchange rate above of its preshock level[18] . Even in the case of Japan, the immediate depreciation of the exchange rate is followed by subsequent statistically significant appreciation of the exchange rate.

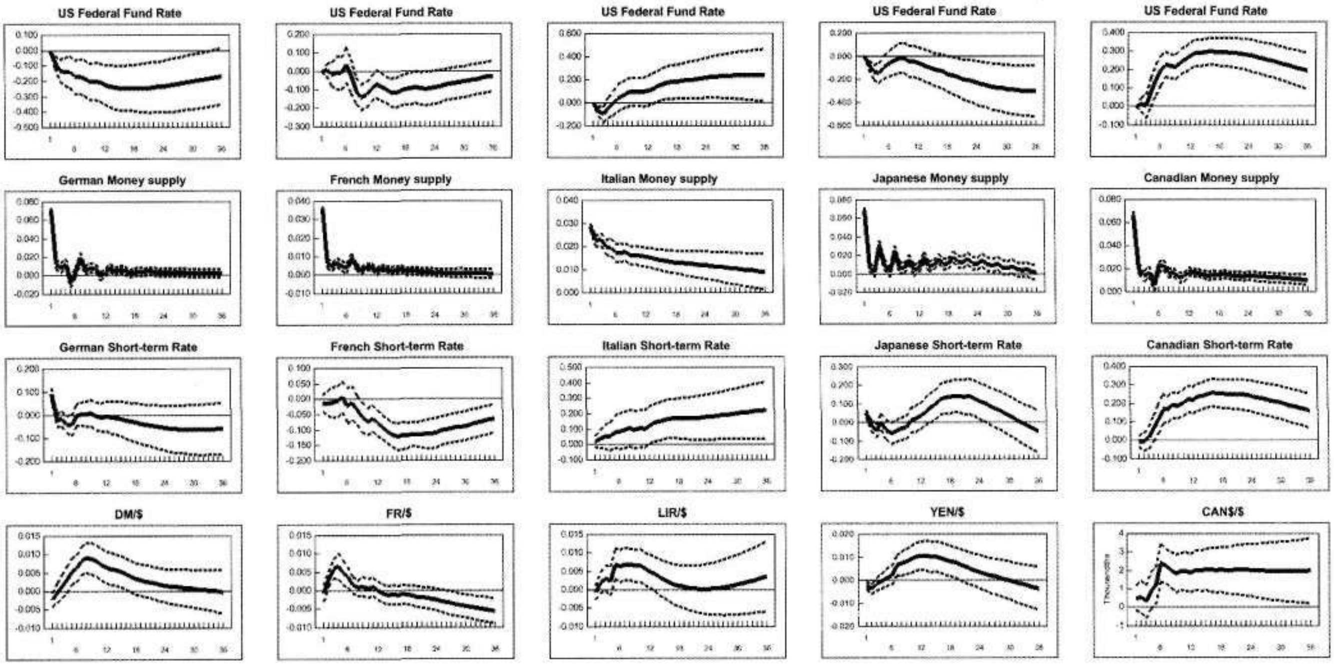
Even in this modified scheme, the maximal appreciation of the exchange rate is not achieved on impact but after a few periods: and this hump-shape dynamic responses of the exchange rate appears in almost all countries which are under consideration. But the behavior of the domestic interest rate, in general, is not consistent with the hypothesis of the liquidity effects derived from the monetary transmission mechanism. The interest rate does not decline on impact -to an innovation of the domestic supply- but rather stays unchanged or even increases on impact.

4. Nonstationarity

In this section, as previously pointed out, we examine the nonstationarity issue where there may exist some linear combination of these variables that converge to long-run relationship overtime .

FIGURE 3

Impulse Response Functions: Orthogonalised shocks in Reserves in G-7 Countries other than U.S. 7 Variable System*



* Column 1 depicts the dynamic effect of an orthogonalised innovation in German Reserves on the U.S. interest rate, the German money supply, the German interest rate and the nominal exchange rate DM/$.
Columns 2 through 6 do the same for France, Italy, Japan, U.K. and Canada.

Therefore, it is useful to test explicitly for manifestations of nonstationarity since most of the macroeconomic time series demonstrate signs of nonstationarity and because the presence of such nonstationarity often has important econometric implications.

A variable y is said to have a unit-root in its autoregressive process if its autoregressive representation is of the form:

$$(1\text{-}L)y_t=\Phi_1(1\text{-}L)y_{t-1}+\ldots+\Phi_p(1\text{-}L)y_{t-p}+e_t \quad (3)$$

where e_t is white noise and $\Sigma\Phi_i$ 1.

Classic statistical methods such as augmented Dickey-Fuller tests are used most often to detect the possible existence of unit roots in data series.

The Dickey-Fuller test can be computed by running the regression

$$(1\text{-}L)y_t=\beta_{t-1}+\alpha+\sum_{i=1}^{p}\Phi_i(1\text{-}L)Y_{t-1}+e_t$$

The above equation represents a regression of a I(0) variable on a I(1) variable and therefore, test statistics are not distributed with traditional distribution (e.g. "t" test). Its distribution is negatively skewed with most of the mass below zero. Hence, critical values in the left-hand tail should be smaller than those of the conventional Student — t statistics. Fuller (1976) derived appropriate limit distributions for the statistics, Dickey (1976) computed empirical approximations for selected sample sizes and McKinnon (1991) among others, have tabulated critical values for any sample size and for any choice of independent variables in the Dickey-Fuller regression.

4.1 Unit Root Test: Empirical Results

Tests are conducted against two alternatives, one consistent with fluctuations around a constant mean and the other with fluctuations around a deterministic linear trend. The latter is more relevant to our analysis due to the tendency of most of the variables to trend up over time.

Table 3 contains the results of the augmented Dickey-Fuller alternative tests. The first row of each sub-table reports the results of the first test (i.e. containing a mean) and the second row the results of the second alternative (i.e. including a deterministic linear trend). In both cases four lags are included to account for serial correlation in the error term. The results are found to be insensitive to other lengths.

TABLE 3

Augmented Dickey-Fuller Unit Root Tests 1974: 1-1994: 3a

a: Exchange Rates							
USA	**CAN**	**FRA**	**GER**	**ITA**	**JAP**	**UK**	**5%**
—	-1.845	-1.473	-1.405	-1.464	-0.553	-2.111	-2.874
—	-1.671	-1.467	-1.795	-1.606	-2.437	-2.211	-3.43
b: interest rates							
-0.906	-1.265	-2.97**	-1.815	-2.807	-1.753	-1.831	-2.874
-1.209	-1.45	-2.941	-2.054	-2.989	-2.275	-1.934	-3.43
c: industrial production							
-0.434	-0.735	-0.981	-0.847	-1.11	-1.273	-0.613	-2.874
-3.267*	-2.301	-2.89	-2.443	-2.217	-1.915	-2.752	-3.43
d: cpi							
-0.686	-3.28**	-3.35**	-1.921	-3.91**	-7.22**	-4.86**	-2.874
-1.33	-0.148	0.681	-1.623	-0.385	-5.61**	-2.57	-3.43
e: money supply							
-0.973	-1.437	-3.28**	0.159	-2.79	-1.541	-5.1**	-2.874
-1.893	-0.152	-0.304	-1.382	-0.438	-3.1	-3.09	-3.43

*(**) denotes significance at the 10% and 5% level respectively.

The values of the first row of each table are t — statistics on β_0 in the regression $\Delta y_t=\alpha+\beta_0 y_{t-1}+\Sigma^4_{t=1}\beta_t\Delta y_{t-1}$ and the values of the second row are t — statistics on β_0 in the regression $\Delta y_t=\alpha_0+\alpha 1_t+\beta_0 y_{t-1}+\Sigma^4_{i=1}\beta i\Delta y_{t-1}$. McKinnon critical values for rejection of the hypothesis of a unit root at 5% level are -2.87 for the first equation and -3.43 for the second one. At 10% level the critical values are -2.5734 and -3.1709 respectively.
a The data sample for France is from 1974:1 to 1992:12.

The test statistics are quite consistent with the hypothesis that unit-root nonstationarity characterizes each of the variables. The null hypothesis of a unit root in the representation can not be rejected for any of the variables at reasonable significance level (i.e. 5% level) except for Japan's CPI variable. The Japanese price level appears to be stationary.

Further analysis of the data signifies that the degree of integration is of order one. In all cases, first-difference data, test statistics imply rejection at 5 percent significance of the null hypothesis of nonstationarity for all variables, which suggest that the variables be integrated of, order one. Therefore, the levels of all variables (except in the case of Japan) must be first differenced to achieve stationarity. In the next section, tests for cointegration will determine whether a linear combination of the series results in stationary disturbances around zero.

4.2 Cointegration Analysis

The cointegration analysis -in our case- has two purposes. First, if we wish to specify an easily interpreted form for exchange rate equation or money supply equation, like an error correction model, we must first determine the existence and number of the cointegrating relationship in the data. Secondly, this acts as a check on the adequacy of our model. If the long-run exchange rate is determined by factors other than these associated with the variables in the system, then their omission should prevent us from finding evidence of cointegration. In addition, evidence of cointegration implies that the variable in the system can adequately capture all the permanent innovations in the money supply and exchange rate over our sample period.

The methodology used in this study is based on the work of Johansen (1990) who derived the statistical properties of cointegrating vectors by relating these vectors to the canonical correlations between the levels and first -differences of the process (corrected for any short-run dynamics). By specifying an explicit AR/Gaussian process for the data, Johansen was able to develop likelihood ratio tests for the number of cointegrating vectors. The maximum likelihood framework has the additional virtues of facilitating inferences concerning the structure and relative importance of the cointegrating vectors as well as providing relatively powerful tests when the model is correctly specified.

The choice of the maximum lag length used in the specification of the VAR system can affect the determination of the dimension of the cointegration space i.e. the rank of as pointed out in Park and Ogaki (1991) and Reimers (1991). In particular, Reimers (1991) finds that overfitting implies a loss of power while underfitting leads to potential spurious cointegration.

Although, the lag order selection criteria such as AIC or Schwarz perform relatively well in determining the size and power of cointegration tests, they lead to selecting small low order VAR models usually of order two or three. But our problem is however here different for we are trying to develop a first stage model that has to be general enough to capture the long run relations, but also the short run dynamics. Consequently, we use VAR's of relatively high order (4 lags) to be certain that the short run dynamic is well captured.

Table 4 summarizes the cointegration properties of the data. It reports the results derived from the German vs U.S. VAR system, as well as the other VAR systems, by listing the estimated likelihood ratio (LR) test for the number of cointegration vectors and the estimated cointegration rank, along with critical values at 5 and 1 percent level when a linear deterministic trend is present and its coefficients are not restricted.

TABLE 4

Cointegration analysis of seven dimensional VAR system

Likelihood ratio	5% critical value	1% critical value	Cointegrating equations
Germany vs. U.S.			
172.4	124.2	133.6	p=0**
114.2	94.2	103.2	p=1**
73.5	68.5	76.1	p=2*
France vs. U.S.			
187.2	124.2	133.6	p=0**
115.6	94.2	103.2	p=1**
73.1	68.5	76.1	p=2*
Italy vs. U.S.			
173.6	124.2	133.6	p=0**
100.6	94.2	103.2	p=1*
64.1	68.5	76.1	p=2
U.K. vs. U.S.			
170	124.2	133.6	p=0**
124.3	94.2	103.2	p=1**
86.2	68.5	76.1	p=2**
49.5	47.2	54.5	p=3*
Canada vs. U.S.			
202.5	124.2	133.6	p=0**
124.3	94.2	103.2	p=1**
86.2	68.5	76.1	p=2**
49.5	47.2	54.5	p=3*

*(**) denotes rejection of the hypothesis at 5% (1%) significance level

For example, the likelihood ratio test indicates two cointeg. equations for Germany at 1% significance level and three cointeg. equations at 5% level.

For the German vs. US VAR system, the sequential testing procedure provides 3 cointegrating vectors at 5 percent value and 2 cointegration vectors at 1 percent critical value. In other words, the cointegration tests strongly reject the null of no cointegration but not the null of at most three cointegrating vectors. For the other systems the cointegrating vectors at the 5 percent critical level are {3, 2, 3, 4, 4} for {France, Italy, Japan, U.K., Canada} and at the 1 percent critical level {2, 1, 1, 3, 4} respectively . Therefore, a VEC (vector error correction)model should be deployed to correct for any spurious results in the regressions.

4.3 Vector Error Correction Estimates

The long-run equilibrium VAR model (cointegration regression) was first fit to the variables and the calculated cointegration vectors from that model could be used in a vector error-correction model to specify the system's short-run dynamics. The vector error correction (VEC)is a restricted VAR designed for use with non-stationary series that are known to be cointegrated.

The VEC specification restricts the long run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short run dynamics. According to Engle and Grnager (1987) the main purpose of the error-correction model is to determine if a part of the disequilibrium from one estimation period is corrected in the following period. This can be written as:

$$A(L)\Delta Y_t=\alpha\beta'Y_{t-1}+d(L)e_t$$

where Y is the n-vector of variables in the model, Δ is the first difference operator, β is the nxr martix of co-integrating vectors, α is a n x r matrix of coefficients, A(L) and d(L) are matrix polynomials in the lag operator L with A(L) = e, and I is a zero-mean n-vector of white noise disturbances. The error correction representation is not the only possible parameterization of a dynamic model with cointegrated variables, but it has the advantage that all of the variables in the representation are I(0). This means that the standard asymptotic theory can be used to conduct statistical inference.

Another issue that has to be addressed is the technique employed in estimating the EC terms. An estimation of a fully specified EC system is more desirable than single estimation of an EC. Single equation estimation of an ECM is generally not sufficient unless the variables in the regressor set are strongly exogenous for the cointegrating coefficients[21].

Summary statistics from the various VECM systems are reported in table 5. In all equations at least one error correction terms is significant at the 5 percent level[22]. In addition, all of the error correction terms are significant in at least one equation. Furthermore, most of the error correction terms (Johansen's lag cointegrating terms) have significant influence in all of the domestic money supply (M) equations. For example, in the case of Germany (table 5), all of the error correction terms entered in the foreign money equation appear to be statistically significant at the 5 percent level. The t — statistics for the three error terms are 3.4, 2.7 and -3.2 respectively. Similarly, the error correction terms on the exchange equation are statistically significant .

Concluding Remarks

In this study, we tried to identify the international transmission mechanism of monetary disturbances in open economies and generate a number of new results.

First, we investigated the effects of unanticipated shocks to U.S. monetary policy on U.S. interest and exchange rates. When the shock to U.S. monetary policy (i.e. U.S. unanticipated expansionary open market operations) was measured as the orthogonalised component of the innovation to U.S. nonborrowed reserves, the U.S. short-term interest rate and the U.S. dollar displayed sharp persistent decline at least in the short-run- in response to expansionary policy. The intuition is that the Federal Reserve Board lowers the short-term interest rate by withdrawing nonborrowed reserves from the system. In the medium and long-run, the U.S. interest rates exhibit strong subsequent increases across countries - consistent with the "Fisherian effect" hypothesis.

These findings, constitute strong evidence in favor of the view that expansionary U.S. open market operations drive the interest-rate down and depreciate the U.S. currency and can be reconciled with models like Grilli and Roubini (1992) and Schlagenhauf and Wrase (1992) that incorporate liquidity effects. In addition, a major finding of this study is that in response to U.S. expansionary policy the exchange rate overshoots its value (or undershoots), although with some time delay, before it settles to its long-run equilibrium point. This finding (which is evident across the G-7 Countries) consistent with the "delayed response hypothesis" supports the models like Dornbusch (1976) emphasizing exchange rate overshooting.

TABLE V

Vector Error Correction Systems

Equation	Y	P	M*	R*	M	R	E
Germany							
EC(1)	-0.425	-0.003	-0.121	-0.629	0.124	6.22	-0.15
	(-983)	(-449)	(-1.78)	(-0.346)	(-3.41)	(-5.41)	(-1.72)
EC(2)	-0.623	-0.018	-0.124	3.64	0.123	-2.23	0.087
	(-1.16)	(-2.35)	(-3.71)	(-1.614)	(-2.72)	(-1.57)	-0.82
EC(3)	0.004	-0.001	0.003	-0.035	-0.008	-0.36	-0.013
	(-1.3)	(-1.55)	(-0.56)	(-0.29)	(-3.21)	(-4.78)	(-2.32)
France							
EC(1)	-0.135	-0.0004	0.095	0.273	0.0596	6.386	-0.297
	(-3.18)	(-0.064)	(-1.22)	(-0.013)	(-1.104)	(-2.36)	(-3.086)
EC(2)	-0.042	0.002	0.185	2.432	0.184	8.667	-0.118
	(-1.072)	(-0.995)	(-2.563)	(1.224)	(3.69)	(3.46)	(-1.33)
EC(3)	-0.02	-0.003	-0.008	0.012	-0.012	1.005	-0.059
	(2.69)	(2.598)	(0.55)	(0.031)	(1.235)	(2.108)	(-3.514)
Italy							
EC(1)	0.02	0.004	0.065	0.512	0.016	0.525	-0.071
	(1.181)	(1.42)	(3.403)	(.997)	(2.17)	(1.08)	(3.12)
EC(2)	0.048	-0.042	-0.22	-0.482	-0.015	4.57	0.132
	(0.87)	(-5.08)	(-3.48)	(-0.29)	(-604)	(2.917)	(1.79)
U.K.							
EC(1)	-0.1	0.0156	-0.053	5.24	0.016	5.722	-0.16
	(-2.94)	(1.123)	(-0.75)	(3.05)	(0.228)	(3.01)	(-1.9)
EC(2)	-0.023	-0.018	-0.0413	2.18	0.027	2.27	-0.063
	(-1.72)	(3.23)	(-1.47)	(3.21)	(1.26)	(3.02)	(-1.89)
EC(3)	0.024	-0.0004	0.008	0.264	0.055	-0.421	-0.067
	(2.47)	(-0.091)	(-0.385)	(0.533)	(3.45)	(-0.766)	2.778
EC(4)	-0.001	-0.002	0.0002	-0.021	0.017	0.472	0.015
	(-0.21)	(-1.43)	(0.019)	(-0.11)	(2.81)	(2.24)	(1.62)

(cont'd)

Canada							
EC(1)	0.073	0.002	-0.117	5.23	0.151	2.84	0.059
	(2.679)	(0.034)	(-2.25)	(3.85)	(3.24)	(2.16)	(2.39)
EC(2)	0.05	-0.007	-0.16	3.83	0.046	2.24	0.056
	(2.354)	(-1.32)	(-3.78)	(3.544)	(1.25)	(2.15)	(2.85)
EC(3)	-0.007	0.011	-0.13	1.69	-0.025	0.714	-0.03
	(-0.48)	(3.06)	(-4.5)	(2.24)	(-0.96)	(0.98)	(-1.85)
EC(4)	-0.001	0.0004	0.003	-0.131	-0.004	-0.043	0.0003
	(-2.409)	(2.88)	(2.186)	(-3.73)	(-3.51)	(-1.26)	(.49)

This table reports the normalized estimated coefficients of the error correction equations along with the t — statistics in parentheses.

Second, we investigated the effects of unanticipated changes in the other non - U.S. G-7 countries monetary policies. Contrary to the U.S. results (U.S. open market policies), we found that in some G-7 countries an unanticipated change in monetary policy lead to the so-called "liquidity puzzle" as Grilli and Roubini (1993) found, but not for the same countries. In other words, when examining changes in the monetary policy of the other G-7 countries, there is no clear evidence of liquidity effects on interest rates and much less in the exchange rate. In some cases, the exchange rate exhibits strong persistent and opposite behavior that it is hard to reconcile with any existing theoretical model. This finding can be arising from what it perceives to be shocks to the demand for money and not shocks to the supply of money. As suggested by Christiano and Eichenbaum (1992) for the case of U.S. "Shocks that stimulate money demand tend to create a positive association between money and interest rates in an environment K where the Fed seeks to smooth nominal interest rates". Therefore, the interest rates first and then the exchange rate of the other non-U.S. G-7 countries increase in response to an expansionary monetary shock.

In response to this challenge, we substituted the reserves of the Central Banks for the broader measures of money such as Ml or M2. The reserves (a narrow measure of money) were employed as the policy instrument to identify changes in monetary policy. In most countries, expansionary open market operations constituted sharp and persistent depreciation of their currencies supporting the models which exhibit liquidity effects. Furthermore, the values of the currencies arrived at their maximal depreciation not on impact but rather after few periods (but certainly in the short-run) before settling on their long run equilibrium values.

Finally, tests of non — stationarity and evidence of cointegration relationships in all non-U.S. G-7 countries VAR systems compelled us to construct vector error correction systems by imposing restriction on the long-run relationship of the variables. We showed that imposing the model as a long-run equilibrium condition on a dynamic error correction model leads to the determination of the form of the short-run dynamics and to an improved and persistent behavior of the exchange rate.

On the basis of the existing evidence, it is not easy to draw any inference about the relative performance of flexible price models that allow for liquidity effects and slow portfolio adjustment [Grilli and Roubini (1992)], versus overshooting models [Dornbusch (1976)] which allow for slow adjustment of prices and instantaneous portfolio adjustment. Both types of models imply that a monetary shock would have similar empirical implications on the interest rate and on the nominal and real exchange rate until the agents fully adjust their financial based decisions.

7. Appendix

The data (monthly) for tests of the model were extracted from the International Financial Statistics (IFS) tapes. The money stocks are alternative Ml and M2 and for the U.S. is nonborrowed reserves derived from federal Reserve Board. Output is proxied by industrial production and prices by consumer price indices (CPI). Exchange rates are end-of—period units of foreign currency per U.S dollar. Short-term nominal rates are call rates and for the United States is the federal funds rate. Following is a detailed description of the data by country.

Industrial production

U.S. Industrial Production, S.A. IFS 11166...C

U.K. Industrial Production, S.A. IFS 11266...C

Japan Industrial Production, S.A. IFS 15866...C

Germany Industrial Production, S.A. IFS 13466...C

France Industrial Production, S.A. IFS 13266...C

Canada Industrial Production, S.A. IFS 15666...C

Italy Industrial Production, S.A. IFS 13666...C

Price index

U.S. CPI. IFS 11164...ZF

U.K. CPI. IFS 11264...ZF

Japan CPI. IFS 15864...ZF

Germany CPI. IFS 13464...ZF

France CPI. IFS 13264...ZF

Canada CPI. IFS 15664...ZF

Italy CPI. IFS 13664...ZF

Money Supply

U.S. Nonborrowed Reserves. Federal Reserve Board of Governors.

U.K. Ml. IFS 11234...

Japan Ml. IFS 15834...

Germany Ml. IFS 13434...

France Ml. IFS 13234...

Italy Ml. IFS 13634...

Interest rate

U.S. Federal Funds Rate. IFS 11160B...

U.K. Treasury Bill Rate. IFS 11260C...

Japan Call Rate. IFS 15860B...

Germany Call Rate. IFS 13460B...

France Call Rate. IFS 13260B...

Canada Money Market Rate. IFS 15660B...

Italy Call Rate. IFS 13660B...

*Exchange **Rate***

PD/$ U.K. Market Rate. IFS 112…AC

Yen/$ Japanese Market Rate. IFS 158..AC...

DM/$ German Market Rate. IFS 134..AC...

Fr/$ French Market Rate. IFS 132..AC...

Can$/$ Canadian Market Rate. IFS 156..AC...

Lira/$ Italian Market Rate. IFS 136..AC

Reserves

Japan's Reserves. IFS 15814...ZF

Germany's Reserves. IFS 13414...ZF

France's Reserves. IFS 13214...ZF

Italy's Reserves. IFS 13614...ZF

Notes

1. Even that we have a plethora of U.S. monetary aggregates (MO, Ml, M2) at hand, the Open Market Committee directly controls only the nonborrowed Reserves which are governed by different regulations within the Federal Reserve System. [Godfriend (1983) and Stigmum (1990)].

2. Empirically, both types of models (overshooting and flexible price)have similar implications:after a positive innovation, interest rates fall the exchange rate will depreciate and output will increase until the agents adjust their price decisions. The only difference between the two models is that the transmission of monetary policy to output takes place, for the flexible price model, via the aggregate supply channel, while for the overshooting via the aggregate demand channel. As far as the shape of the impulse response functions is concerned, the maximum depreciation of the domestic currency takes place immediately after the shock (and from that point on the currency should start to appreciate), whether in the case of the flexible price models this is not necessary.

3. The exchange rate movement, after the monetary shock, does not seem to be consistent with the interest rate differential. The positive innovation in monetary policy, leads to a

persistent U.S. dollar depreciation in spite of the persistent negative U.S. — foreign interest rate differential.

4. Different authors have shown that innovations to one of the U.S. broad monetary aggregates (MO, M1) are followed with sharp and persistent increases in the short-term nominal interest rates. Leeper and Gordon (1992) provide evidence of this "puzzle" in a closed economy context.

5. Sims (1992) used interest rates as a proxy to identify changes in monetary policy, but he found that a positive innovation to short-term interest rate leads to surprisingly sharp and persistent increases in the price level. According to Sims (1992), this means that the policy makers have information -that is not captured by the variables included in the VAR system -regarding inflationary pressures and they increase the short term interest rates to forestall inflation [Eichenbaum (1992)]. We followed Grilli and Roubini (1993) VAR structure using the interest rate (Federal Funds rate) as the monetary policy instrument and we found that an innovation to interest rate is accompanied consistently with increases in the price level. This is inconsistent with any existing theoretical models including Keynesian, Monetarist and Real Business Cycle whereas monetary contractions lead to periods of inflation.

6. Another difference with Eichenbaum and Evans (1993) model lies on the normalization procedure used for the structure of the nonborrowed reserves. They divide the nonborrowed series with the total reserves while, we use the series in logs.

7. There is a widely accepted notion that the fixed exchange regime imposed constraints on the monetary policy. Evidence can be found (among others) in Eichenbaum and Evans (1993) where the U.S. monetary policy was less volatile under the fixed exchange rate than under the floating exchange regime.

8. The nonborrowed reserve data are adjusted for external credit.

9. VAR in differences is inappropriate since the non inclusion of the error correction term entails a misspecification error and loss of information. In addition we can argue that, when the relationships are not the main focus of the analysis, pre — testing and imposing cointegration may not be the appropriate estimation strategy (R. Ramaswamy, T. Slok).

10. The money supply shock is identified as the 5th element of EVt, where E is lower triangular with ones in the diagonal and EE'=V.

11. We use the method described in Doan (1990) example 10.1 to compute standard errors with 300 draws from the posterior distribution of the VAR coefficients.

12. Eichenbaum and Evans (1993) report that the maximal depreciation of the exchange rate for {Yen, DM, Lira, FF, PD} occurs after {22, 34, 37, 35, 39} months respectively and it is not followed by subsequent appreciations. Their results, are clearly at variance with the overshooting concept. Furthermore, they reject the uncovered interest parity hypothesis on the basis of higher foreign nominal returns (on foreign assets) and expected appreciation of the foreign currency.

13. The behavior of the exchange rate is consistent with the models emphasizing delayed responses of the exchange rate (Delayed response hypothesis).

14. If we consider innovations in the German short-term interest rate we obtain the same puzzling exchange rate effects as in Grilli and Roubini (1993). Also we notice that the German price level responds positive to a positive innovation to the interest rate. This leads us to believe that the monetary authorities increase interest rates to forestall expected inflation. As a result prices and the exchange rate (DM/$) -i.e. DM depreciation- would rise after the monetary contractions but by less than they would have without the contraction [Sims (1992)].

15. Grilli and Roubini (1993) report the same dynamic behavior of the exchange rate to a monetary policy innovation in Japan. Although, they use the interest rate innovations to identify changes in monetary policy, the exchange rate responses are statistically significant and consistent with the theory of liquidity effects. Moreover, the maximal appreciation of Japan's currency does not happen on impact but rather after 4 months.

16. We would like to thank the referee for bringing this explanation to our attention.

17. It is hard or impossible to find data on nonborrowed reserves in the non U.S. G-7 countries. Therefore, at this point we use the total bank reserves as a proxy of money.

18. U.K. is not considered in this environment because of luck of meaningful data.

19. The previous specification mixed stationary with nonstationary series. But following Sims, Stock and Watson (1990) and Lutkepohl and Reimers (1992) this is the most conservative method of estimation for the questions being addressed as there is little damage from failing to impose true cointegration or stationary inducing transforms, but there is significant damage from imposing false relationship.

20. Japan is excluded from further analysis since the Japanese CPI appears to be stationary (table 3).

21. According to Phillips (1991) in cointegrated systems the use of single equation techniques imports bias, nuisance parameter dependencies and loses optimality.

22. Since all variables in the regression are I(0), conventional distribution theory applies.

23. The impulse responses derived from the VECM are almost the same in shape as the ones derived from the alternative VAR models (figure 3) and therefore are not deemed necessary to show. But they are available from the author upon request.

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