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NEW EVIDENCE ON THE EFFECTS OF U.S. MONETARY POLICY ON EXCHANGE RATES

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Abstract
We examine the impact of U.S. monetary policy shocks on exchange rates using the monetary policy indicator proposed by Bernanke and Mihov (1998). We find evidence for instantaneous, rather than delayed, U.S. dollar overshooting after a monetary shock when relative output and relative prices are included in the VAR specification. The forward premium puzzle persists due to the interest rate differential response.
Keywords: monetary policy, overshooting, excess returns, forward premium puzzle.
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1. Introduction

In a seminal paper Eichenbaum and Evans (1995) have shown that in response to tighter U.S. monetary policy, the USDollar exhibits a "delayed overshooting" pattern of 2 to 3 years vis-a-vis the major currencies (Japanese Yen, DMark, Italian lira, French Franc, and Pound Sterling). "Delayed overshooting" is confirmed by Evans (1994), who uses weekly data and finds that the USDollar overshoots with a delay of 2 to 3 years vis-a-vis the DMark and the Yen, and Lewis (1995), who finds that the USDollar response relative to the DMark and the Yen increases for the first 5 months after the shock.

Eichenbaum and Evans (1995) also offer empirical evidence that after a contractionary U.S. monetary shock, domestic interest rates rise as the USDollar appreciates. This creates a *conditional forward premium puzzle;* by borrowing in Germany and investing in the U.S., for instance, positive excess returns can be generated, conditional on tighter U.S. monetary policy. Despite the fact that the "forward premium puzzle" is well documented in empirical studies of the foreign exchange market, the puzzle now arises conditional on an exogenous change in U.S. monetary policy.

These empirical findings are based on Vector Autoregressions (VARs) with U.S. monetary policy typically being identified by exogenous shocks in the Federal Funds rate or in non-borrowed reserves.[1] In this paper, we re-examine the effects of U.S. monetary shocks on the USDollar using an alternative measure of U.S. monetary policy recently constructed by Bernanke and Mihov (1998). The Bernanke-Mihov (*B-M*) indicator has several advantages over previous approaches. First, the specification is based on a model for commercial bank reserves and Federal Reserve operating procedures that nests most of the VAR-based indicators mentioned earlier. Second, the estimator is consistent with the estimated parameters describing the Fed's operating procedure and the market for bank reserves. Third, the indicator takes into

[1] See Christiano et. al. (1999) for an extensive survey on the identification of U.S. monetary policy in the context of VAR models. Alternatively, Bonser-Neal et al. (1998) use the federal funds rate *target* as a monetary policy indicator and find that the USDollar overshoots immediately after the shock, thus exhibiting the classic "overshooting" pattern. These authors claim that due to large deviations of the *actual* federal funds rate (used in previous studies) from the federal funds rate *target*, the latter should be considered as a better proxy for the true monetary policy measure.

account changes in the Federal Open Market Committee (FOMC) operating procedures and provides an optimal measure of monetary policy stance which may reflect both interest rate and reserves targeting.

In addition, we modify the original specifications by Eichenbaum and Evans (1995) to include relative output and relative prices as endogenous variables; this aims at capturing the relative business cycle position of the U.S. and the foreign country, as well as long-run exchange rate adjustment based on Purchasing Power Parity. The recent strand of two-country open economy models suggests that the *relative* position of the country is crucial for exchange rate determination (see, for instance, Obstfeld and Rogoff (1996) for a textbook exposition). Interestingly, when relative output and prices are included in the VAR specification, the "delayed overshooting" pattern disappears in most cases. On the other hand, excess returns continue to exist indicating that uncovered interest parity is still violated.

The rest of the paper is structured as follows. Section 2 gives a brief account of the measurement and identification of U.S. monetary policy shocks proposed by Bernanke and Mihov (1998) and outlines the methodology used in this paper. Section 3 discusses the empirical results from the VAR specifications and section 4 concludes the paper.

2. Measures of U.S. monetary policy and identification

To assess the effects of U.S. monetary policy, a measure of such shocks is needed. There are two general categories of monetary policy measures. The first category is broadly known as the "narrative approach" (Romer and Romer, (1989)). Based on the minutes of the FOMC, these authors identify when policy-makers appeared to shift to a more anti-inflationary stance. The second general strategy for measuring monetary policy uses information about central bank operating procedures to develop data-based indexes of policy. In particular, data-based measures of monetary policy utilize restrictions imposed by central bank operating procedures to identify and estimate a VAR comprised of a set of macroeconomic and monetary policy variables.

Monetary policy shocks are identified as a disturbance term in the equation

$$V_t = \zeta(\Omega_t) + \varepsilon_t \quad (1)$$

where V_t is the time t setting of monetary policy, ζ is a (linear) function, Ω_t is the information available to the monetary authority when policy is set at time t, and ε_t is a serially uncorrelated shock, orthogonal to the elements of Ω_t. The measures arise from different specifications of Ω_t and V_t . The shock ε_t can reflect a number of random factors that affect policy decisions; these include the personalities and views of the FOMC members, revisions of original data that cause members to change their opinion about the state of the economy, political and external factors, or other technical problems.

As is well known, for the period up to late 1979, and from 1983 onwards, the FOMC controlled closely the federal funds rate, allowing the quantity of reserves to vary. Instead, for the period starting from late 1979 to late 1982 the FOMC targeted directly non-borrowed reserves, with the federal funds rate moving freely (the Volcker disinflation period). This implies that for the period under investigation, the FOMC has exercised (at least) two types of monetary control. Any attempt to identify U.S. monetary policy either by the federal funds rate or by changes in non-borrowed reserves might result in a misspecified measure of the U.S. monetary policy stance.[2]

The *B-M* indicator explicitly addresses this potential misspecification by providing a measure of monetary policy which may reflect both interest rate and reserves targeting. Indeed, Bernanke and Mihov (1998) summarize their findings by arguing that "the Fed's procedures appear to have changed over time,

[2] Early studies on the effects of U.S. monetary policy used the federal funds rate (*FYFF*) as a policy measure. Bernanke and Blinder (1992) and Sims (1992) have argued that the orthogonalized component of the innovation to *FYFF* is a better measure of shocks to monetary policy than orthogonalized shocks to the stock of money (M1 or M2). An alternative measure of monetary policy involves the orthogonalized component of the innovation to the ratio of non-borrowed to total reserves (*NBRX*). According to Strongin (1995), innovations to this ratio are a better measure of exogenous shocks to monetary policy than innovations to broader monetary aggregates, which tend to reflect shocks to money demand. Eichenbaum and Evans (1995) have used both the *FYFF* and *NBRX* to assess the effects of a U.S. monetary shock on the USDollar exchange rate.

and hence no single model is optimal for the 1965-1996 time period. The FFR [federal funds rate] model is found to do well for the pre-1979 period, as argued by Bernanke and Blinder [1992], and it does exceptionally well for the Greenspan era, post-1988, which most Fed watchers would not find surprising. The FFR model also appears to be (marginally) the best choice for the sample period as a whole, based on both the monthly and biweekly results. As noted above, the NBR [non-borrowed reserves] model does well for the brief period of the Volcker experiment, 1979-1982, but is otherwise strongly rejected." These results are graphically illustrated in Figures 1A and 1B; the *B-M* indicator is very highly correlated with the federal funds rate except in the 1979-1982 period (figure 1A), when the indicator covaries positively with the ratio of non-borrowed to total reserves (figure 1B).

3. Empirical results for the USDollar with relative output and prices

To assess the impact of a monetary policy shock we estimate VARs of the following form:

$$Z_t = A_0 + \sum_{i=1}^{k} A_1 Z_{t-i} + u_t \tag{2}$$

where A_0 is a *nX1* vector of constants, A_1 are *nXn* matrices of coefficients and u_t is a *nX1* vector of residuals with $E(u_t) = 0, E(u_t u_s') = 0 \forall t \neq s, E(u_t u_s') = \Sigma \forall t = s$ and Σ defined as a symmetric positive semidefinite matrix. The results were generated with monthly data covering the period 1975:01 to 1996:12 (the *B-M* indicator is available until 1996:12; see the data appendix for a more detailed description of data sources). All VARs in this section were estimated, after testing the robustness of the results to higher order specifications, with a 6-month lag length.

In previous specifications in the relevant literature, output and prices entered in an unrestricted form in the VARs. Here, we use relative output and relative prices. Relative output captures the relative business cycle position of the U.S. and the foreign country; the variable can be an important determinant of short-run exchange rate movements either through a relative productivity channel or by generating expectations of tighter monetary policy (and thus a stronger currency) in the faster growing economy. Relative price differentials are used to capture long-run exchange rate adjustment based on Purchasing Power Parity.

After dropping time subscripts for simplicity, our five-variable VAR consists of {$IP_{US/For}$, $P_{US/For}$, $B\text{-}M$, $(R_{For}\text{-}R_{US})$, $s_t^{US/For}$}, where $IP_{US/For}$ is the log of industrial production in the U.S. to the foreign country, $P_{US/For}$ is the log of the price level in the U.S. to the foreign price level, $B\text{-}M$ is the indicator of monetary policy, $(R_{For}\text{-}R_{US})$ denotes the difference between short term interest rates, where R_{For} and R_{US} denote the foreign and U.S. short term interest rates respectively, and $s_t^{US/For}$ denotes the log of the nominal exchange rate with respect to {Yen, DMark, Lira, Franc and Sterling}, at time *t*.[3] The quantitative characterization of the exchange rate response to a monetary policy shock is provided by impulse response functions. Consider, in particular, the effect of a monetary shock at time *t* on the exchange rate between months $t+i$ and $t+j$ with $j>i$. In population, these responses are equal to the average value of the coefficients *i* through *j* of the corresponding impulse response functions.[4]

Figure 2 displays the dynamic response functions of the interest rate differential and the USDollar exchange rate to a contractionary U.S. monetary policy shock as illustrated by a standard deviation shock to the *B-M* indicator. Dotted lines denote standard errors of impulse responses at the 95% confidence level

[3] Using the real, rather than the nominal, exchange rate leads to nearly identical conclusions about the response of the exchange rate to the monetary policy shock. This result arises because nominal and real exchange rates are highly correlated at the monthly frequency for the countries under consideration.

[4] Note that previous studies that have used data based indices of monetary policy have been criticized on the grounds of the "price puzzle"; U.S. prices are predicted to rise in estimated VARs in response to tighter U.S. monetary policy. Sims (1992) argues that the result can be attributed to the fact that the Fed takes into account commodity price inflation in its reaction function, while this variable was omitted from previous VARs. We did not include the commodity price index in our set of variables, because the B-M indicator controls explicitly for the effect of commodity prices on U.S. monetary policy.

derived over 500 Monte Carlo draws from the estimated asymptotic distribution of the VAR coefficients and covariance matrix of the innovations.

Interest rate differentials are diminished after the shock and remain lower and statistically different from zero for approximately 6 months in Japan and the U.K., 11 months in Germany and Italy and 17 months in France. On the other hand, there is a statistically significant appreciation of the USDollar for around 3 months after the shock for all the currencies involved; note, however, that the appreciation is instantaneous rather than displaying "delayed overshooting". The only difference occurs in the case of Sterling, which depreciates against the USDollar approximately one year after the shock and remains statistically different from zero for around two and a half years after the initial shock.

How do relative prices and relative output respond to a tighter U.S. monetary stance?[5] The rise of the U.S interest rate differential vis-à-vis the rest of the countries triggers a decline in relative output. The fall is significant in the cases of Japan, Germany and France, lasting up to approximately three years. The effect on relative prices is not statistically significant, however.

Even though "delayed overshooting" does not arise in the current setup, uncovered interest parity is still violated. Responses are generated by the model after replacing the interest rates and the real exchange rate with excess returns, defined as

$$xr^{US/For} = R_{For} - R_{US} + s_{t+1}^{US/For} - s_t^{US/For} \tag{3}$$

Ex post excess returns[6] exist for all countries (see Table 1), but in the cases of U.K. and Germany these are significant at the 10% level only for the 6-month period following the shock. On the other hand, returns are significant in the case of Japan for a year after the shock, Italy (for 18 months following the shock), and

[5] The results are not reported here; these are available from the authors upon request.

[6] The results do not change when Euromarket rates of one-month maturity are used.

France (for 2 years following the shock). Given the exchange rate response, these excess returns can be accounted for by the persistent widening of the interest rate differential in favor of the U.S..

4. Conclusions

This paper has re-investigated the effects of U.S. monetary policy shocks on the USDollar. Building on the work of Eichenbaum-Evans (1995), we provide further evidence on the effects of U.S. monetary policy on exchange rates. These authors have shown that a U.S. monetary contraction generates a persistent appreciation of the USDollar ("delayed overshooting") combined with a persistent widening of the U.S.-foreign interest rate differential, which generates a conditional forward premium puzzle.

We use a new indicator of monetary policy developed by Bernanke and Mihov (1998) to explore these effects. The new indicator takes into account changes in U.S. monetary policy targets. We find that the picture changes starkly when this indicator of monetary policy is used over the period under consideration. We find that "delayed overshooting" is eliminated and the USDollar appreciates instantaneously (except for the case of sterling which continues to display "delayed overshooting"). This response is much closer to the classic "overshooting" pattern described in the literature (Dornbusch, 1976). Still, we find that the *conditional forward premium puzzle* persists for all countries under consideration due to the widening of the U.S.-foreign interest rate differential stemming from the contractionary shock in U.S. monetary policy.

Data Appendix

The data used in the study were extracted from the following sources.

Nominal exchange rates:

All exchange rates are from the IFS CD ROM and are bilateral monthly exchange rates constructed using the following IFS foreign currency per USDollar exchange rates: 158..AF.. is the Japanese Yen , 134..AF.. is the DMark, 136..AF.. is the Italian Lira, 132..AF.. is the French Franc, and 112..AF.. is British Sterling.

Short term interest rates:

The interest rates are from the IFS CD ROM: 15860B.. for Japan (call money), 13460B.. for Germany (call money), 13660B.. for Italy (money market), 13260B.. for France (call money), 11260B.. for U.K. (overnight interbank). For the U.S. 11160B.. is the federal funds rate FYFF.

Industrial production:

For all countries industrial production (seasonally adjusted) is from the OECD database.

Price level:

The data are collected from the OECD, CITIBASE and IFS databases; for all countries the Consumer Price Index was used, except for the U.K. where the Retail Price Index (all items) was used.

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TABLE 1. Dynamic responses of excess returns:

Model: {U.S. foreign industrial production, U.S. foreign prices, Bernanke-Mihov indicator, excess returns}

Period	Japan	Germany	Italy	France	United Kingdom
1-6: average	-0.508	-0.319	-0.454	-0.401	-0.278
(standard error)	(0.224)	(0.208)	(0.192)	(0.192)	(0.214)
significance level	0.012**	0.063*	0.009**	0.018**	0.097*
7-12: average	-0.360	-0.139	-0.353	-0.333	-0.021
(standard error)	(0.188)	(0.151)	(0.148)	(0.164)	(0.169)
significance level	0.027**	0.179	0.009**	0.021**	0.450
13-18: average	-0.179	-0.062	-0.196	-0.280	-0.120
(standard error)	(0.172)	(0.137)	(0.126)	(0.146)	(0.151)
significance level	0.150	0.325	0.060*	0.085*	0.214
19-24: average	-0.038	0.020	-0.105	-0.205	0.127
(standard error)	(0.166)	(0.145)	(0.117)	(0.139)	(0.152)
significance level	0.409	0.445	0.186	0.070*	0.203

Notes:

1) *Excess returns are monthly earnings from investing in the foreign country relative to an investment in the U.S. See also Eichenbaum and Evans (1995).*
2) *An asterisk denotes significance at the 10% level and two asterisks at the 5% level.*

Figure 1A.

Bernanke and Mihov (1998) U.S. monetary policy indicator and the Federal Funds rate

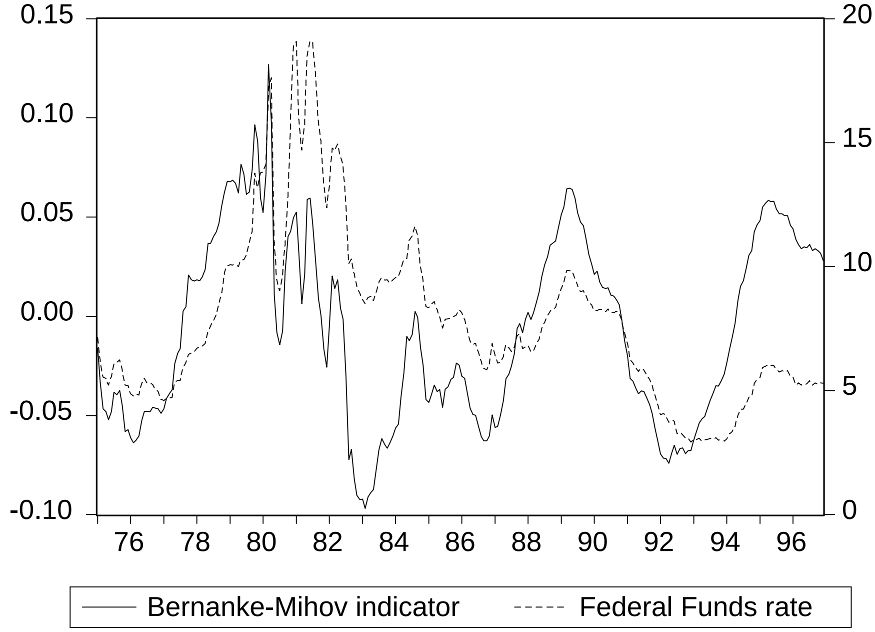

Figure 1B. Bernanke and Mihov (1998) U.S. monetary policy indicator and the non-borrowed to total reserves ratio

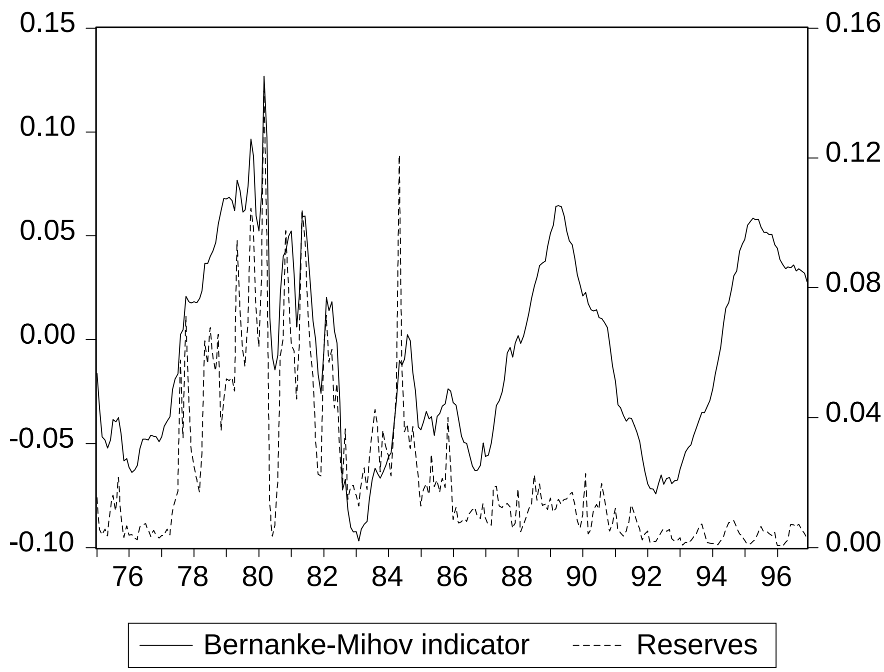

FIGURE 2. Effects of contractionary U.S. monetary policy on interest rates and exchange rates: 5-variable VAR with relative output and prices