DEPARTMENT OF ECONOMICS
UNIVERSITY OF CYPRUS

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Sarantis Kalyvitis and Alexander Michaelides

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P.O. Box 20537, 1678 Nicosia, CYPRUS Tel.: ++357-2-892101, Fax: ++357-2-750310
Web site: http://www.econ.ucy.ac.cy

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

Sarantis Kalyvitis
Athens University of Economics and Business,
University of Cyprus, and IMOP

Alexander Michaelides[*]
University of Cyprus

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Abstract

This paper examines the impact of U.S. monetary policy shocks on cross exchange rates. Eichenbaum and Evans (1995) have shown that a U.S. monetary contraction generates a persistent appreciation of the USDollar ("delayed overshooting"), a persistent widening of the U.S.-foreign interest rate differential and therefore a conditional forward premium puzzle. We use the monetary policy indicator proposed by Bernanke and Mihov (1998) that takes into account changes in the operating procedures of the Federal Reserve to investigate whether U.S. monetary policy affects cross exchange rates. We find substantial evidence that after a U.S. contractionary monetary shock, uncovered interest rate parity is also violated in favor of the U.K. relative to Japan, giving rise to another conditional forward premium puzzle.

Keywords: monetary policy, exchange rate, overshooting, excess returns, conditional forward premium puzzle.
JEL classification number: E52, F31.

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[*] **Corresponding author:** Department of Economics, University of Cyprus, PO Box 20537, 1678, Nicosia, Cyprus; e-mail: *alexm@ucy.ac.cy*.

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1. Introduction

In a seminal paper on the empirical effects of U.S. monetary policy on USDollar exchange rates, Eichenbaum and Evans (1995) have shown that in response to a tighter U.S. monetary policy the USDollar exhibits a “delayed overshooting” pattern of 2 to 3 years vis-à-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-à-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 monetary shock.

Eichenbaum and Evans (1995) also offer empirical evidence that after a contractionary U.S. monetary shock, domestic interest rates rise and the USDollar appreciates. This creates a *conditional forward premium puzzle* with opportunities for excess returns by borrowing, for instance, in Germany and investing in the U.S.. Despite the fact that the “forward premium puzzle” is well documented in empirical studies of the foreign exchange market (see, for instance, Hodrick (1987) and Froot and Thaler (1990)), the puzzle now arises conditional on an exogenous change in U.S. monetary policy.

Even though the Federal Open Market Committee is guided primarily by domestic economic considerations, the globalization of international financial markets and the increased trade in real goods raises important considerations on the impact U.S. monetary policy might have on the real economy and asset prices of other countries. In particular, the adoption of floating exchange rates and the gradual removal of capital controls might have intensified the transmission mechanism from U.S. monetary developments to the rest of the world. In the particular context of exchange rate determination, “delayed overshooting” is one specific example of how one economic variable (the exchange rate) might be influenced by economic events in the U.S.. An interesting empirical issue in the particular example is the *magnitude* of the USDollar appreciation against the other major currencies in response to a U.S. contractionary monetary shock; for instance, does the USDollar appreciate more against the DMark or against Sterling? In particular, how are *cross* exchange rates of major currencies (Sterling/DMark, Sterling/Yen, DMark/Yen) affected from monetary policy shocks in the U.S.? How do interest rate differentials between these countries (U.K.-Germany, U.K.-Japan, Germany-Japan) respond to tighter monetary conditions in the U.S.? And finally, are there excess returns in the face of tighter monetary conditions in the U.S. from borrowing, for instance, in Germany and investing in the U.K.?

We attempt to answer the questions on the effects of U.S. monetary policy shocks on third country interest rates and cross exchange rates utilizing a Vector Autoregression (VAR) methodology. In particular, we examine the effects of U.S. monetary policy shocks on the cross exchange rates using an alternative measure of U.S. monetary policy recently constructed by Bernanke and Mihov (1998). Previous empirical studies quantifying the effects of monetary policy changes are based on Vector Autoregressions (VARs) with U.S. monetary policy typically being identified by exogenous shocks in the Federal Funds rate[1] or in non-borrowed reserves[2] or in the federal funds rate target.[3] The Bernanke-Mihov (*B-M*) indicator has several advantages over these approaches. First, its 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 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.

The evidence points towards "delayed overshooting" in some cross exchange rates when the Federal Reserve tightens. Specifically, Sterling is found to appreciate against the DMark after a monetary contraction in the U.S., whilst the Sterling/Yen and the DMark/Yen responses are statistically insignificant. At the same time, the short-term interest rate differential between U.K.-Japan also reacts with a delay in favor of the U.K.. As a result, uncovered interest parity between U.K.-Japan is violated for certain horizons after a monetary shock in the U.S., pointing towards

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[1] The overnight rate in the market for commercial bank reserves.

[2] See Christiano et al. (1998) for an extensive survey on the identification of U.S. monetary policy in the context of VAR models. We discuss the other main category of U.S. monetary policy measures that is known as the "narrative approach" (Romer and Romer, 1989) in Section 2; Eichenbaum and Evans (1995) find that the "delayed overshooting" pattern also arises when the dates identified by Romer and Romer are used to identify U.S. monetary policy contractions.

[3] 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 Dornbusch (1976) "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 Bonser-Neal et al. (1998) also criticize the use of VARs for inaccurate measurement of monetary policy effects due to problems related to the limitation of the information set. They claim that monetary policy may be inadequately represented when measured by shocks in the federal funds rate within a VAR context; see also Rudebusch (1998).

the existence of another *conditional forward premium puzzle*. Specifically, conditional on tighter U.S. monetary policy the Yen weakens against Sterling, the corresponding interest rate differential (U.K.-Japan) widens, and thus excess returns seem to be generated over some horizons by borrowing in Japan, and investing in the U.K.

The evidence is in accordance with empirical estimates of policy reaction functions for the Bundesbank and the Bank of Japan reported by Clarida, Gali and Gertler (1998) for the post-1979 era. These authors have shown that the estimated responses of the Bundesbank and the Bank of Japan to a change in U.S. monetary policy are quite similar and quantitatively small; as pointed out by the authors: "*...the Bank of Japan looks a lot like the Bundesbank over this period*." Our estimated German-Japanese interest rate differential responses and the response of the DMark/Yen exchange rate to tighter U.S. monetary policy conditions are statistically insignificant and are therefore consistent with the Clarida et. al. (1998) estimated reaction functions for the Bundesbank and the Bank of Japan to Federal Reserve policy changes.

The empirical findings are consistent with the interpretation that there is a positive correlation between U.K. and U.S. monetary policy shocks and that this correlation is higher than the corresponding correlation between the U.S.-German and U.S.-Japanese monetary innovations. Investigating the validity of this conjecture requires an estimated Bank of England policy reaction function in response to changes in U.S. monetary policy. Unfortunately, this is a difficult task due to England's evolving commitment to the ERM (and the concomitant dependence of U.K. monetary policy on German monetary policy; see the evidence in Clarida et al. (1998)), the September 1992 EMS crisis, and the limited autonomy the Bank of England enjoyed for most of the period under consideration. We therefore delegate the testing of this hypothesis to future research.

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 and outlines the methodology used in the paper. Section 3 discusses the empirical results from two VAR specifications for the cross exchange rates. Section 4 examines the effects of the U.S. monetary policy shock on cross exchange rates and third country interest rate differentials. Finally, section 5 concludes the paper.

2. Measuring the effects of U.S. monetary policy

To assess the effects of U.S. monetary policy, a stand on the empirical 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". Following Friedman and Schwartz (1963), Romer and Romer (1989) use the "narrative approach"; based on the minutes of the FOMC, Romer and Romer (1989) identify when policy-makers appeared to shift to a more anti-inflationary stance. The second general strategy for measuring monetary policy, which is also followed in the current paper, uses information about central bank operating procedures to develop data-based indexes of policy.[4] 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.[5]

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

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

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 used here 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.[6]

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[4] Bernanke and Blinder (1992) is an early application of this method utilizing VAR innovations to the federal funds rate as an index of monetary policy.

[5] A large strand of the literature on monetary policy has investigated empirically the effects of various measures of monetary policy (M1, interest rates, reserves) on real and nominal variables, with special emphasis placed on its impact on output and prices. For a recent survey on the measurement and the effects of monetary policy in the U.S. in the context of alternative empirical methodologies, see Walsh (1998).

[6] Less favourable for this type of approach is the potential for model misspecification since there is no a priori argument for the use of a linear model. In fact, the Federal Reserve raises interest rates by 25 basis point multiples, avoids sizeable modifications, and once it embarks on a tightening mode, it continues to be on one for some time. Non-linearity, compounded by serial dependence in setting the monetary policy instrument, could induce errors in the linear approximation used here resulting in a loss of efficiency. Of course, it is hard to assess this error without prior knowledge or assumption(-s) on the precise form of non-linearity arising from the Fed's decision rule. Conditional on these caveats, we follow the procedure implied by the linear specification, also employed by Eichenbaum and Evans (1995).

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 nonborrowed 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.[7] Eichenbaum and Evans (1995) have used both *FYFF* and *NBRX* to assess the effects of a U.S. monetary shock on the USDollar exchange rate.

However, using solely either the federal funds rate or non-borrowed reserves as an indicator of the Fed's monetary policy raises an identification issue with respect to the true monetary stance in the U.S.. As is well known, for the period up to late 1979 the FOMC was choosing initial targets for the federal funds rate which were then indirectly signalled to the market. The situation changed in October 1979 when the FOMC began targeting the non-borrowed reserves (the 'Volcker regime') with the federal funds rate moving freely. In 1983 and up to the stock market crash in October 1987 borrowed reserves became the prime –though more informal- monetary objective. From 1988 onwards the FOMC started again to control closely the federal funds rate, allowing the quantity of reserves to vary. This implies that for the period under investigation the FOMC has exercised at least two types of monetary control; thus, any attempt to uniquely identify U.S. monetary policy either by the federal funds rate or non-borrowed reserves is likely to result in a misspecified measure of U.S. monetary policy stance.

Therefore, in this paper we use the *B-M* indicator of monetary policy that can take into account changes in FOMC operating procedures. The *B-M* indicator is derived from an estimated model of central bank operating procedures and provides an optimal measure of monetary policy stance, which may reflect both interest rate and reserves targeting. Moreover, the indicator captures well the change in weights placed on policy targets in the post Bretton Woods period covered by our data sample.[8] Therefore, as shown in Figures 1A and 1B, the *B-M* indicator is

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[7] Christiano and Eichenbaum (1992) and Christiano et al. (1996) do not normalize non-borrowed reserves by total reserves, but the results do not change when this measure is used.

[8] Strongin (1995) and Meulendyke (1998) give historical presentations of the Fed's operating procedures and the associated policy targets.

better equipped to identify both the federal funds rate target (up to October 1979 and from 1988 onwards) and the non-borrowed reserves targeting (from October 1989 to 1983) of the FOMC.

Consequently, to identify the impact of a monetary policy shock we estimated VARs of the following form:

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

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 VARs were estimated using Ordinary Least Squares and the effects of U.S. monetary policy on exchange rates are measured by dynamic responses calculated via a Wold ordering of the set of variables comprising *Z* according to *Z*={*output, prices, B-M, interest rates, exchange rate*}.[9] This ordering implies that shocks in the monetary policy indicator are orthogonal to output and prices or, otherwise stated, that the Federal Reserve observes contemporaneously output and prices, but not interest rates and the exchange rate.

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.

3. Empirical results for cross exchange rates

The analysis of Eichenbaum and Evans (1995) indicated a “delayed overshooting” pattern of the USDollar after a U.S. monetary contraction vis-à-vis the major currencies, which generates positive excess returns stemming from rising U.S. interest rate differentials and the appreciating USDollar. An interesting extension deals with the behaviour of cross exchange rates and third

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[9] Zha (1997) criticizes the Eichenbaum and Evans (1995) empirical framework on the basis of its implications for the conduct of U.S. monetary policy. This assumption is not restrictive for the present analysis, where foreign interest rates are included in the information set.

country interest rates. In particular, we investigate these effects using two VAR specifications. Policy shocks are contractionary and the results were generated with monthly data covering the period 1975 to 1996 (the *B-M* indicator is available until 1996:12; see the Data Appendix for details on the other variables). A 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.

3.1. Model I: the Eichenbaum and Evans (1995) specification

We start the analysis with a VAR specification that reports the effects of U.S. monetary policy on interest rates for three pair of countries and the corresponding cross nominal exchange rate. The country pairs are U.K.-Germany, U.K.-Japan, and Germany-Japan. The benchmark specification is chosen to be as close as possible to the expanded specification used by Eichenbaum and Evans (1995), but with the inclusion of the cross exchange rate rather than the USDollar exchange rate.

The VARs are estimated with different lag lengths depending on the currency cross.[10] We consider the three nominal spot exchange rates, $s_t^{1/2}$, where 1/2 = (Sterling/DMark), (Sterling/Yen), (DMark/Yen); thus, $s_t^{1/2}$ denotes the log of the left hand side currency (1) needed to buy one unit of the right hand side currency (2) at time t.[11]

Regarding potential VAR specifications, Kim (1999) has shown that U.S. monetary policy affects significantly output in major economies as, for instance, an expansionary shock triggers a fall in world interest rates and boosts consumption and growth. Output responses in foreign countries are found to be about one fourth to a half of U.S. output change. The author has also

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[10] Lag length was chosen using a likelihood ratio test statistic following a top to bottom strategy: the U.K.-Germany system has 5 lags, the U.K.-Japan system has 4 lags, and the Germany-Japan system has 5 lags.

[11] We have also considered the effects on DMark/French Franc and DMark/Italian Lira, and the results point towards a weakening of the DMark against these currencies when the Fed tightens. We are not reporting these results because it is likely that due to the evolution of the Exchange Rate Mechanism, the exchange rate regime in this period was gradually changing for the participating currencies. For example, after 1983 the French-German short-term interest rate differential was declining considerably. Moreover, the interest rate differential of France and Italy versus Germany spikes temporarily during the European Monetary System crisis of September 1992, and again in the beginning of 1995 due to the Mexican-induced (December 1994) crisis in world financial markets. Over the period, however, there is a discernible downward trend in the interest rate differential indicating that the assumption of a constant-parameter VAR holding over the whole sample period for these variables is questionable.

analyzed the case of transmission through import prices and wage adjustment in the foreign country, but the quantitative effects of this link are found to be weak. Higher foreign growth might also affect the exchange rate either through a productivity channel or through an expectation of tighter monetary policy abroad to limit aggregate demand and rising inflationary pressures. Therefore, ignoring foreign industrial production and prices for the pair of countries included in each specification might affect the results.

Thus, our seven-variable benchmark VAR (Model I) includes the log of industrial production index *IP* in countries (1) and (2), the log price level *P* in countries (1) and (2), the *B-M* indicator of monetary policy, one month Euro interest rates R_1 and R_2 in countries (1) and (2), and the log of the nominal exchange rate $s_t^{1/2}$ with the following ordering: $\{IP_1, IP_2, P_1, P_2, B\text{-}M, R_1, R_2, s_t^{1/2}\}$.[12] This ordering implies that the Federal Reserve observes contemporaneously output and prices in third countries, but not interest rates and the exchange rate. Notice here that we relax the assumption that only the interest rate differential is relevant for exchange rate determination. Using the differential interest rate can be motivated naturally from the perspective of various theoretical models but it is desirable to assess the impact of relaxing it; this is also done in the expanded specification used by Eichenbaum and Evans (1995). An additional advantage from allowing interest rates to enter separately is that we can then explicitly assess the impact of monetary policy shocks on the level of interest rates.[13]

Figures 2A, 2B, and 2C display the dynamic response functions to a contractionary U.S. monetary shock, as illustrated by a one standard deviation of the *B-M* indicator, for the first 48 months after the shock occurs for UK-Germany, UK-Japan and Germany-Japan respectively. Dotted lines denote standard errors of impulse responses at the 95% confidence level derived over 500 Monte Carlo draws from the estimated asymptotic distribution of the VAR coefficients and covariance matrix of the innovations.[14] The first two rows show the impact on industrial production and the price level. Contractionary U.S. monetary policy does not seem to statistically

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[12] All specifications reported include the nominal exchange rate. The results are identical when the real exchange rate is used.

[13] Our results are not affected if the U.S. monetary policy indicator precedes foreign output and prices in the VAR ordering. Note here that U.S. output and prices are not included in this specification because this information is already captured by the *B-M* indicator; moreover we focus here on the effects on cross exchange rates and not on the exchange rate vis-à-vis the USDollar.

[14] Eichenbaum and Evans (1995) use a one standard deviation error band while the 95% confidence interval used here corresponds roughly to plus- and minus-two-standard-deviation bands.

affect foreign output (with the exception of the U.K. case in the U.K.-Germany pair). On the other hand, surprisingly the U.K. price level exhibits a rising pattern indicating a ‘price puzzle’ for a period lasting one to two years after the shock and returns to baseline afterwards.

Turning to short-term interest rates, the U.K. interest rate rises and peaks after 15 months in the VAR with Germany, and somewhat faster (after around 10 months) in the second VAR with Japan. In turn, the evidence with regards to the German interest rate response is ambiguous since there is a significant response for a period lasting from 5 to 20 months after the shock in the UK-Germany specification but the response is statistically insignificant for the same period in the Germany-Japan sepcification. The Japanese interest rate response is statistically insignificant.

The final graph for each pair of countries reports the exchange rate response to the monetary policy shock. The figures show that there is statistically significant “delayed overshooting” for Sterling/DMark after the monetary shock, with the response being maximized at 6 months after the original monetary policy shock occurs. The response for Sterling/Yen and DMark/Yen, on the other hand, is not statistically significant (except of a slight depreciation of the DMark against the Yen in the beginning period).[15]

This picture is confirmed when we calculate the effects of a monetary policy shock on *ex post* excess returns.[16] The results are now tabulated for the three pairs of countries, so that direct model comparisons can be made across models. The first, third, and fifth columns in Table 1 show the average responses for U.K.-Germany, U.K.-Japan, and Germany-Japan, respectively, along with their significance levels. In the U.K.-Japan case we can reject the hypothesis of no excess returns for the period covering 6 to 18 months, confirming the existence of the *conditional forward premium puzzle.* On the other hand, in the U.K.-Germany and Germany-Japan cases there is no evidence in favour of the existence of excess returns between these pairs of countries for the periods following the monetary contraction in the U.S..

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[15] The effects on the rest of the variables in the VAR are consistent with standard results from theoretical models. Industrial production falls temporarily due to the rise in interest rates. The decline is larger in the U.K. relative to Germany due to Sterling’s appreciation against the DMark. Interestingly, some evidence in favor of a ‘price puzzle’ is given by a marginally significant rise of the U.K. price level. This effect, however, is eliminated when relative prices are used in the estimated specification of section 3.2.

[16] Responses are generated by the model after replacing the interest rates and the cross exchange rate with excess returns, defined as $xr^{1/2} = R_2 - R_1 + s_{t+1}^{1/2} - s_t^{1/2}$. The use of one-month interest rates from Euro markets ensures that uncovered interest parity is not violated due to non-matching maturity horizons of interest rates and exchange rates. This circumvents the potential criticism that overnight interest rates should not be compared with monthly exchange rate changes.

We conclude this subsection by noting that there is evidence in favour of a *conditional forward premium puzzle* between U.K.-Japan; *conditional on U.S. monetary shock, the short term interest rate differential with Japan rises in favour of the U.K., while Sterling also appreciates against the Yen*. Thus, when the Federal Reserve tightens borrowing in Japan and investing in the U.K can generate excess returns. This *conditional* forward premium puzzle does not, however, extend to the Sterling/DMark and DMark/Yen crosses.

3.2. Model II: relative output and prices

In the previous specification, output and prices entered in an unrestricted form in the VARs. Alternatively, we can use relative output and relative prices as endogenous variables (Model II). The use of relative output captures the relative business cycle position of the two foreign countries; 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.[17] Moreover, relative price differentials can be used to capture the long-run exchange rate adjustment based on Purchasing Power Parity. Therefore, we repeat the analysis using a VAR consisting of $\{IP_{1/2}, P_{1/2}, B\text{-}M, R_1, R_2, s_t^{1/2}\}$, where $IP_{1/2}$ is the log of industrial production in country (1) relative to country (2) and $P_{1/2}$ is the log of the price level in country (1) relative to country (2).[18]

Results are depicted in Figures 3A, 3B, and 3C, and overall corroborate the findings from Model I. The response of relative industrial production remains virtually insignificant, indicating that the relative business cycle between these countries is not affected by U.S. monetary developments. The rise in the U.K. price level detected in Model I is eliminated in the UK-Germany pair, but for the UK-Japan price level the response shows that prices rise more in the U.K. relative to Japan.

Turning to the response of interest rates and exchange rates, Sterling appreciates against the Yen and the DMark, but the effect is now in both cases insignificant. The DMark/Yen rate is

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[17] Koray and McMillin (1999) utilize an alternative specification, which focuses on the trade balance effects of U.S. monetary policy. They find that the pattern of the trade balance after the contractionary monetary shock exhibits the traditional J-curve effect. Interestingly, in their specification the overshooting effect in the exchange rate lasts for around half a year, which according to these authors does not confirm the “delayed overshooting” result reported by Eichenbaum and Evans (1995).

[18] In a related paper (Kalyvitis and Michaelides, 2000) we show that the inclusion of relative output and prices in the original Eichenbaum and Evans specification practically eliminates the “delayed overshooting” effect, providing us with a strong empirical rationale for using these variables.

again not affected against the Yen, except for a one month interval of Yen strengthening right after the monetary shock takes place. Consistent, in general, with the results from the previous 2 VARs, interest rates rise in favour of the U.K. relative to Germany and Japan, particularly in the latter case, while the Germany-Japan interest rate differential is virtually unaffected.

Thus, the conditional forward premium puzzle arises once more from the contraction in U.S. monetary policy between U.K.-Japan. This is confirmed by the calculation of the responses of excess returns that strongly suggest that excess returns occur in the U.K.-Japan case for a substantial period of time (2 years following the shock); see the fourth and sixth column in Table 1 (Model II). Finally, there is no evidence in favour of excess returns either for the U.K.-Germany case or the Germany-Japan case.

4. Variance decompositions

A related question is to what extent have U.S. monetary shocks been a prominent factor of exchange rate fluctuations observed in the post Bretton Woods period? In particular, does U.S. monetary policy play a crucial role in fluctuations of third country exchange rates? By examining these issues, we may be able, first, to shed some light in the causes of exchange rate volatility, despite the apparent stability in the macroeconomic environment in these countries. Second, external shocks (in the form of U.S. monetary shocks) might provide -at least partially- a rationale for the periodic turbulence that was observed in the Exchange Rate Mechanism of the European Monetary System.

Table 2 summarizes the percentage of the *n*-step ahead forecast errors in cross exchange rates that is attributable to innovations in the *B-M* indicator of U.S. monetary policy. According to the evidence, the variation of the Sterling/DMark rate brought about by changes in U.S. monetary policy is considerably larger than the corresponding one for the Sterling/Yen and DMark/Yen rates. In addition, the pattern of these variations differs significantly for the three rates. More specifically, in the one year horizon the results on the variability of the Sterling/DMark and DMark/Yen rates are not conclusive, since variations in Model I (amounting from 2 to 9%) are found to be significant, whilst they are insignificant for Model II. On the other hand, it is to be noted that U.S. monetary shocks play only a very minor (and statistically insignificant) role in accounting for the variability of the Sterling/Yen rate during the twelve-month period.

Results change considerably when a longer horizon is considered. Viewed at horizons from 2 to 4 years, around 15% of total Sterling/DMark variability can be attributed to U.S. monetary shocks, whilst the corresponding fraction for the Sterling/Yen rate now becomes statistically significant and rises to more than 10% of total volatility for Model II, while it is lower (around 4% and statistically significant at the 10% level) for Model I. On the other hand, inference on the DMark/Yen rate still depends on which variant of the model is used, but nevertheless plays a role for both models that does not exceed 10% of total variance.

In a recent paper Rogers (1999) examines the impact of monetary policy on the USDollar/Sterling real exchange rate; his findings show that the contribution of monetary shocks to the volatility of the real exchange rate ranges from 19% to 60%. Despite the different identification scheme, the evidence presented here shows that, in general, U.S. monetary policy also affects the variability of cross exchange rates. In fact, our empirical estimates suggest that the repercussion of U.S. monetary policy changes on some cross exchange rates is, first, significant and, second, holds in the longer run as well. Particularly, U.K. monetary authorities should pay close attention to the development in U.S. monetary policy, as the latter seems to play a fundamental role in the evolution of Sterling variability, especially vis-à-vis the DMark.

5. Conclusions and implications

This paper has investigated the effects of U.S. monetary policy shocks on currency crosses (third country exchange rates). We used a new indicator of monetary policy developed by Bernanke and Mihov (1998) to explore these effects. Building on the work of Eichenbaum-Evans (1995), we provide some further evidence in support of the existence of a *conditional forward premium puzzle*. The interest rate differential moves in favour of the U.K. emanating from a delayed rise of the U.K. short-term interest rate, rather than from a fall in the interest rates in Germany and Japan. The increase in the U.K.-Germany and U.K.-Japan differentials occurs simultaneously with the strengthening of Sterling against the Yen. This leads to another *conditional forward premium puzzle*: following a U.S. monetary contraction, borrowing overnight in Japan and investing in the U.K. leads to excess returns over some horizons. On the other hand, there is no evidence of excess returns after a U.S. monetary shock, either between U.K. and Germany, or between Germany and Japan.

The interpretation of these results requires some assumptions about the behaviour of central banks during the period under investigation, which is beyond the scope of the present paper. Central bank reaction functions estimated by Clarida et al. (1998) suggest that the response of the Bundesbank and the Bank of Japan to a change in U.S. monetary policy is of similar and very small magnitude. This is consistent with the finding in this paper that the DMark/Yen exchange rate does not react significantly to a change in U.S. monetary policy, since monetary authorities in these countries react similarly to the change. In contrast, our results indicate that the Bank of England responds differently from the Bundesbank and the Bank of Japan to U.S. monetary policy shocks. Unfortunately, isolating the response of U.K. monetary policy to Federal Reserve policy changes for the post-1979 period is complicated by the limited autonomy the Bank of England enjoyed at the time, by the influence of Bundesbank policy on the Bank of England (see e.g. Clarida et. al. (1998)), and the September 1992 EMS crisis. An interesting hypothesis to be examined in future research is whether U.K. monetary policy reacts more aggressively to changes in U.S. monetary policy than either the Bundesbank or the Bank of Japan do. Verifying this hypothesis would provide a potential explanation for the violation of uncovered interest parity in favour of the U.K. vis-à-vis Japan once the Fed tightens.

An interesting extension of this work could be to estimate the above effects under a global policy interdependence scheme. In the current paper we have limited the potential information set within the two-country framework. However, in line with other empirical studies we have shown that the conduct of monetary policy vis-à-vis the Fed is likely to differ between countries. Therefore, extending the analysis to an *n*-country setup along with an asymmetric treatment of non-US monetary policies could yield some interesting insights in the understanding of U.S. monetary policy effects in other countries, and help towards clarifying the puzzle of excess returns in international financial markets.

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, and 112..AF.. is British Sterling.

Short term interest rates:

The interest rates are one-month middle rates from Datastream: Germany Euro-DMark (LDN:FT), Japan: Euro-$ (LDN:FT), U.K. Euro-£ (LDN:FT), US Euro-$ (LDN:FT). All series are available from February 1975, except of the Japanese 1-month interest rate which is available from August 1978.

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.

References

Bernanke, B. and A. Blinder, 1992, "The Federal Funds rate and the channels of monetary policy transmission", *American Economic Review*, 82, 4, 901-21.

Bernanke, B. and I. Mihov, 1998, "Measuring monetary policy", *Quarterly Journal of Economics*, 113, 3, 869-902.

Bonser-Neal, C., V. Roley and G. Sellon Jr., 1998, "Monetary policy actions, intervention and exchange rates: A reexamination of the empirical relationships using federal funds rate target data", *Journal of Business*, 71, 147-177.

Christiano, L. and M. Eichenbaum, 1992, "Identification and the liquidity effect of a monetary policy shock", in A. Cuckierman, Z. Hercowitz and L. Leiderman (eds.), *Political Economy, Growth, and Business Cycles*, MIT Press.

Christiano, L., M. Eichenbaum, and C. Evans, 1996, "The effects of monetary policy shocks: Evidence from the flow of funds", *Review of Economics and Statistics*, 78, 16-34.

Christiano, L., M. Eichenbaum, and C. Evans, 1998, "Monetary policy shocks: What have we learned and to what end?", *NBER Working Paper No. 6400.*

Clarida, R., J. Gali and M. Gertler, 1998, "Monetary policy rules in practice: Some international evidence", *European Economic Review*, 42, 1033-1067.

Dornbusch, R., 1976, "Expectations and exchange rate dynamics", *Journal of Political Economy*, 84, 6, 1161-76.

Eichenbaum, M. and C. Evans, 1995, "Some empirical evidence on the effects of shocks to monetary policy on exchange rates", *Quarterly Journal of Economics*, 110, 4, 975-1009.

Evans, C., 1994, "Interest rate shocks and the dollar", *Economic Perspectives, Federal Reserve Bank of Chicago*, 18, 11-24.

Friedman, M. and A. Schwartz, 1963*, A Monetary History of the United States, 1867-1960*, Princeton University Press.

Froot, K. and R. Thaler, 1990, "Anomalies: Foreign exchange", *Journal of Economic Perspectives*, 4, 179-192.

Hodrick, R., 1987, *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets*, Harwood Academic Publishers.

Kalyvitis, S. and A. Michaelides, 2000, "New evidence on the effects of U.S. monetary policy on dollar exchange rates", *mimeo.*

Kim, S., 1999, "International transmission of the U.S. monetary policy shocks: Evidence from VARs", *mimeo.*

Koray, F. and W. D. McMillin, 1999, "Monetary shocks, the exchange rate, and the trade balance", *Journal of International Money and Finance*, 18, 925-940.

Lewis, K., 1995, "Are foreign exchange intervention and monetary policy related, and does it really matter?", *Journal of Business*, 68, 185-214.

Meulendyke, A., 1998, *U.S. Monetary Policy and Financial Markets*, Federal Reserve Bank of New York.

Rogers, J., 1999, "Monetary shocks and real exchange rates", *Journal of International Economics*, 49, 269-288.

Romer, C. and D. Romer, 1989, "Does monetary policy matter? A new test in the spirit of Friedman and Schwartz" in Olivier Blanchard and Stanley Fischer (eds.), *NBER Macroeconomics Annual*, MIT Press, Cambridge.

Rudebusch, G., 1998, "Do measures of monetary policy in a VAR make sense?", *International Economic Review*, 39, 907-931.

Sims, C., 1992, "Interpreting the macroeconomic time series facts: The effects of monetary policy", *European Economic Review*, 36, 5, 975-1000.

Strongin, S., 1995, "The identification of monetary policy disturbances: Explaining the liquidity puzzle", *Journal of Monetary Economics*, 35, 3, 463-97.

Walsh, C., 1998, *Monetary Theory and Policy*, MIT Press.

Zha, T., 1997, "Identifying monetary policy disturbances: A primer", *Economic Review, Federal Reserve Bank of Atlanta*, second quarter, 26-43.

TABLE 1. Dynamic responses of excess returns: U.K.-Germany, U.K.-Japan, Germany-Japan

	U.K.-Germany		*U.K.-Japan*		*Germany-Japan*	
Period	Model I	Model II	Model I	Model II	Model I	Model II
1-6: average	-0.043	-0.033	0.160	0.248	0.177	0.050
(standard error)	(0.204)	(0.203)	(0.223)	(0.224)	(0.216)	(0.214)
significance level	0.416	0.435	0.236	0.133	0.206	0.407
7-12: average	0.068	0.111	0.219	0.361	0.192	0.117
(standard error)	(0.117)	(0.112)	(0.130)	(0.134)	(0.152)	(0.139)
significance level	0.280	0.162	0.046**	0.004**	0.104	0.200
13-18: average	0.073	0.124	0.137	0.276	0.140	0.086
(standard error)	(0.096)	(0.103)	(0.101)	(0.126)	(0.139)	(0.139)
significance level	0.225	0.115	0.098*	0.014**	0.156	0.268
19-24: average	0.038	0.081	0.055	0.181	0.091	0.049
(standard error)	(0.095)	(0.096)	(0.104)	(0.123)	(0.127)	(0.136)
significance level	0.344	0.200	0.300	0.071*	0.238	0.358
25-36: average	-0.021	-0.017	-0.015	0.051	0.051	-0.001
(standard error)	(0.092)	(0.086)	(0.097)	(0.117)	(0.105)	(0.125)
significance level	0.412	0.423	0.437	0.331	0.315	0.495
37-48: average	-0.036	-0.061	-0.020	-0.012	0.041	0.034
(standard error)	(0.086)	(0.083)	(0.086)	(0.010)	(0.101)	(0.126)
significance level	0.339	0.232	0.407	0.458	0.343	0.395

Notes:

1) Results in column 'Model I' are from the specification with log levels of industrial production and prices and in column 'Model II' from the specification with relative log levels of industrial production and prices. See the text (section 3) for further details.

2) An asterisk denotes significance at the 10% level and two asterisks at the 5% level.

TABLE 2. Variance decomposition of nominal exchange rate (% due to a U.S. monetary shock): Sterling/DMark, Sterling/Yen, DMark/Yen

	Sterling/DMark		Sterling/Yen		DMark/Yen	
Period	Model I	Model II	Model I	Model II	Model I	Model II
1-6: average	2.5	1.3	0.1	0.1	4.6	2.8
(standard error)	(1.6)	(2.2)	(1.4)	(2.2)	(1.9)	(2.4)
significance level	0.059*	0.285	0.470	0.485	0.007**	0.121
7-12: average	7.7	3.1	0.1	0.6	9.0	3.6
(standard error)	(2.3)	(3.0)	(1.9)	(3.4)	(2.6)	(3.2)
significance level	0.000**	0.150	0.486	0.430	0.000**	0.133
13-18: average	10.8	5.5	1.4	3.3	9.1	3.2
(standard error)	(2.7)	(3.4)	(2.3)	(4.1)	(3.0)	(3.7)
significance level	0.000**	0.054*	0.277	0.210	0.001**	0.190
19-24: average	13.4	8.7	3.1	7.8	8.6	4.6
(standard error)	(3.0)	(3.7)	(2.6)	(4.6)	(3.2)	(4.0)
significance level	0.000**	0.009**	0.113	0.045**	0.004**	0.121
25-36: average	17.0	13.2	4.2	12.3	8.6	6.9
(standard error)	(3.5)	(4.0)	(2.8)	(5.1)	(3.5)	(4.3)
significance level	0.000**	0.000**	0.070*	0.008**	0.006**	0.054*
37-48: average	19.3	16.9	4.3	13.1	8.4	7.2
(standard error)	(3.9)	(4.1)	(3.0)	(5.4)	(3.6)	(4.6)
significance level	0.000**	0.000**	0.073*	0.007**	0.010**	0.058*

Notes: See Table 1.

SELECTED RECENT PUBLICATIONS

Anil K. Bera and Yannis Bilias, Rao´s Score, Neyman´s C (α) and Silvey´s LM Tests: An Essay on Historical Developments and Some New Results, *Journal of Statistical Planning and Inference,* forthcoming.

Bertaut C. and M. Haliassos, Precautionary Portfolio Behavior from a Life - Cycle Perspective, *Journal of Economic Dynamics and Control,* 21, 1511-1542, 1997.

Bilias Y., Minggao Gu and Zhiliang Ying, Towards a General Asymptotic Theory for the Cox model with Staggered Entry, *The Annals of Statistics*, 25, 662-682, 1997.

Blundell R., P. Pashardes and G. Weber, What Do We Learn About Consumer Demand Patterns From Micro-Data?, *American Economic Review*, 83, 570-597, 1993.

Bougheas S., P. Demetriades and T. P. Mamouneas, Infrastructure, Specialization and Economic Growth, *Canadian Journal of Economics,* forthcoming.

Caporale W., C. Hassapis and N. Pittis, Unit Roots and Long Run Causality: Investigating the Relationship between Output, Money and Interest Rates, *Economic Modeling*, 15(1), 91-112, January 1998.

Caporale G. and N. Pittis, Efficient estimation of cointegrated vectors and testing for causality in vector autoregressions: A survey of the theoretical literature, *Journal of Economic Surveys*, forthcoming.

Caporale G. and N. Pittis, Unit root testing using covariates: Some theory and evidence, *Oxford Bulletin of Economics and Statistics*, forthcoming.

Caporale G. and N. Pittis, Causality and Forecasting in Incomplete Systems, *Journal of Forecasting,* 16, 6, 425-437, 1997.

Clerides K. S., Lach S. and J.R. Tybout, Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Morocco, and Mexico, *Quarterly Journal of Economics* 113(3), 903- 947, August 1998.

Cukierman A., P. Kalaitzidakis, L. Summers and S. Webb, Central Bank Independence, Growth, Investment, and Real Rates", Reprinted in Sylvester Eijffinger (ed), Independent Central Banks and Economic Performance, Edward Elgar, 416-461, 1997.

Dickens R., V. Fry and P. Pashardes, Non-Linearities and Equivalence Scales, *The Economic Journal*, 103, 359-368, 1993.

Demetriades P. and T. P. Mamuneas, Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economies, *Economic Journal,* July 2000.

Eicher Th. and P. Kalaitzidakis, The Human Capital Dimension to Foreign Direct Investment: Training, Adverse Selection and Firm Location". In Bjarne Jensen and Kar-yiu

Wong (eds), Dynamics,Economic Growth, and International Trade, The University of Michigan Press, 337-364, 1997.

Fry V. and P. Pashardes, Abstention and Aggregation in Consumer Demand, *Oxford Economic Paper*s, 46, 502-518, 1994.

Gatsios K., P. Hatzipanayotou and M. S. Michael, International Migration, the Provision of Public Good and Welfare, *Journal of Development Economics*, 60/2, 561-577, 1999.

Haliassos M. and C. Hassapis, Non-expected Utility, saving, and Portfolios, *The Economic Journal*, 110, 1-35, January 2000.

Haliassos M. and J. Tobin, The Macroeconomics of Government Finance, reprinted in J.Tobin, Essays in Economics, vol. 4, Cambridge: MIT Press, 1996.

Haliassos M. and C. Bertaut, Why Do So Few Hold Stocks?, *The Economic Journal*, 105, 1110- 1129, 1995.

Haliassos M., On Perfect Foresight Models of a Stochastic World, *Economic Journal*, 104, 477-491, 1994.

Hassapis C., N. Pittis and K. Prodromidis, Unit Roots and Granger Causality in the EMS Interest Rates: The German Dominance Hypothesis Revisited, *Journal of International Money and Finance*, 18(1), 47-73, 1999.

Hassapis C., S. Kalyvitis and N. Pittis, Cointegration and Joint Efficiency of International Commodity Markets”, *The Quarterly Review of Economics and Finance,* 39, 213-231, 1999.

Hassapis C., N. Pittis and K. Prodromides, EMS Interest Rates: The German Dominance Hypothesis or Else?” in European Union at the Crossroads: A Critical Analysis of Monetary Union and Enlargement, Aldershot, UK., Chapter 3, 32-54, 1998. Edward Elgar Publishing Limited.

Hatzipanayotou P., and M. S. Michael, General Equilibrium Effects of Import Constraints Under Variable Labor Supply, Public Goods and Income Taxes, *Economica*, 66, 389-401, 1999.

Hatzipanayotou, P. and M.S. Michael, Public Good Production, Nontraded Goods and Trade Restriction, *Southern Economic Journal,* 63, 4, 1100-1107, 1997.

Hatzipanayotou, P. and M. S. Michael, Real Exchange Rate Effects of Fiscal Expansion Under Trade Restrictions, *Canadian Journal of Economics,* 30-1, 42-56, 1997.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, A Nonlinear Sensitivity Analysis of Cross-Country Growth Regressions, *Canadian Journal of Economics,* forthcoming.

Kalaitzidakis P., T. P. Mamuneas and Th. Stengos, European Economics: An Analysis Based on Publications in Core Journals, *European Economic Revie*w, 1999.

Kalaitzidakis P., On-the-job Training Under Firm-Specific Innovations and Worker Heterogeneity, *Industrial Relations,* 36, 371-390, July 1997.

Ludvigson S. and A. Michaelides, Does Buffer Stock Saving Explain the Smoothness and Excess Sensitivity of Consumption?, *American Economic Review*, forthcoming.

Lyssiotou Panayiota, Dynamic Analysis of British Demand for Tourism Abroad, *Empirical Economics,* forthcoming, 2000.

Lyssiotou P., P. Pashardes and Th. Stengos, Testing the Rank of Engel Curves with Endogenous Expenditure, *Economics Letters,* 64, 61-65, 1999.

Lyssiotou P., P. Pashardes and Th. Stengos, Preference Heterogeneity and the Rank of Demand Systems, *Journal of Business and Economic Statistics*, 17 (2), 248-252, April 1999.

Lyssiotou Panayiota, Comparison of Alternative Tax and Transfer Treatment of Children using Adult Equivalence Scales, *Review of Income and Wealth*, 43 (1), 105-117, March 1997.

Mamuneas, Theofanis P., Spillovers from Publicly – Financed R&D Capital in High-Tech Industries, *International Journal of Industrial Organization,* 17(2), 215-239, 1999.

Mamuneas, T. P. and Nadiri M. I., R&D Tax Incentives and Manufacturing-Sector R&D Expenditures, in *Borderline Case: International Tax Policy, Corporate Research and Development, and Investmen*t, James Poterba (ed.), National Academy Press, Washington D.C., 1997. Reprinted in *Chemtec*h, 28(9), 1998.

Mamuneas, T. P. and Nadiri M. I., Public R&D Policies and Cost Behavior of the US Manufacturing Industries, *Journal of Public Economics*, 63, 57-81, 1996.

Michaelides A. and Ng, S., Estimating the Rational Expectations Model of Speculative Storage: A Monte Carlo Comparison of three Simulation Estimators, *Journal of Econometrics,* forthcoming.

Pashardes Panos, Equivalence Scales in a Rank-3 Demand System, *Journal of Public Economic*s, 58, 143-158, 1995.

Pashardes Panos, Bias in Estimating Equivalence Scales from Grouped Data, *Journal of Income Distributio*n, Special Issue: Symposium on Equivalence Scales, 4, 253-264,1995.

Pashardes Panos., Bias in Estimation of the Almost Ideal Demand System with the Stone Index Approximation, *Economic Journa*l, 103, 908-916, 1993.

Spanos Aris, Revisiting Date Mining: ´Hunting´ With or Without a License, *Journal of Methodology,* July 2000.

Spanos Aris, On Normality and the Linear Regression Model, *Econometric Reviews,* 14,195-203, 1995.

Spanos Aris, On Theory Testing in Econometrics: Modeling with nonexperimental Data, *Journal of Econometrics,* 67, 189-226, 1995.

Spanos Aris, On Modeling Heteroscedasticity: The Student's *t* and Elliptical Linear Regression Models, *Econometric Theor*y, 10, 286-315, 1994.