BANK OF GREECE

EUROSYSTEM

Working Paper

Some empirical evidence on the effects of U.S. monetary policy shocks on cross exchange rates

Sarantis Kalyvitis

Ifigeneia Skotida

65

JANUARY 2008

BANK OF GREECE
Economic Research Department – Special Studies Division
21, E. Venizelos Avenue
GR-102 50 Athens
Tel: +30210-320 3610
Fax: +30210-320 2432

www.bankofgreece.gr

Printed in Athens, Greece
at the Bank of Greece Printing Works.

ISSN 1109-6691

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

Sarantis Kalyvitis
Athens University of Economics and Business

Ifigeneia Skotida
Bank of Greece and Athens University of Economics and Business

ABSTRACT

This paper examines the impact of U.S. monetary policy shocks on the cross exchange rates of sterling, yen and mark. The main finding of the paper is a 'delayed overshooting' pattern for all currency cross rates examined (sterling/yen, yen/mark and mark/sterling) following an unexpected U.S. monetary policy change, which in turn generates excess returns. We also provide evidence that the 'delayed overshooting' pattern in cross exchange rates is accompanied by asymmetric interventions by central banks in the foreign exchange markets under consideration triggered by U.S. monetary policy shocks.

Keywords: Monetary Policy; Delayed Overshooting; Foreign Exchange Intervention.
JEL classification: E52; F31.

Acknowledgements: Financial support through project 'Pythagoras II' co-financed by the European Social Fund and the Ministry of Education in Greece is gratefully acknowledged. We have benefited from useful discussions with S. Brissimis, H. Gibson, D. Kosma, A. Michaelides and E. Pappa on earlier drafts and from comments and suggestions by seminar participants at the Athens University of Economics and Business and the 5th Annual European Economics and Finance Society conference. The views expressed in this paper are those of the authors and do not necessarily reflect those of their respective institutions.

Correspondence:
Sarantis Kalyvitis
Department of International and European Economic Studies
Athens University of Economics and Business, 76 Patission Street
10434 Athens, Greece
Tel: +302108203273
Fax: +302108221011
Email: skalyvitis@aueb.gr

1. Introduction

Following the classic Dornbusch (1976) 'overshooting' model on the impact of monetary policy on exchange rates and interest rates in the presence of price stickiness, a large empirical literature has focused on the assessment of these effects.[1] The standard theoretical framework predicts that a monetary tightening leads to an immediate exchange rate 'overshooting'. Several empirical papers have focused on the impact of U.S. monetary policy on interest rates and exchange rates vis-à-vis the U.S. dollar, and have established that the peak timing of this response occurs one to three years after rather than immediately ('delayed overshooting'). This accumulated evidence creates in turn a 'conditional forward premium puzzle' with opportunities for excess returns by borrowing abroad and investing in the U.S.. Although the standard 'forward premium puzzle' is well documented in empirical studies of the foreign exchange market (Hodrick, 1987; Froot and Thaler, 1990), the puzzle now arises *conditional* on an exogenous change in U.S. monetary policy.

In particular, Eichenbaum and Evans (1995) have shown that, in response to a tighter U.S. monetary policy, the dollar exhibits a 'delayed overshooting' behavior of 2 to 3 years vis-à-vis the major currencies, a pattern that is confirmed by Clarida and Gali (1994). 'Delayed overshooting' is also assessed by Evans (1994), who uses weekly data and finds that the dollar overshoots with a delay of 2 to 3 years vis-à-vis the mark and the yen, and Lewis (1995), who finds that the dollar appreciates against the mark and the yen for the first 5 months after the monetary policy shock. Eichenbaum and Evans (1995) offer also empirical evidence that after a contractionary U.S. monetary policy shock, domestic interest rates rise relative to foreign interest rates and the dollar appreciates. Kalyvitis and Michaelides (2001) adopt a specification with relative output and prices in order to capture the relative business cycle position of the United States and the domestic country; this approach solves the 'delayed overshooting' effect, but the authors report persistent deviations from the uncovered interest rate parity hypothesis.

The 'delayed overshooting' and the 'conditional forward premium puzzle' are specific examples of how economies might be influenced by monetary policy abroad. However, the size of these impacts is likely to vary between countries due, for instance,

[1] See Christiano et al. (1999) for an extensive survey of the relevant studies.

to discrepancies in the structural characteristics of the economy, differences in nominal rigidities and/or asymmetries in the monetary policy functions of foreign countries driven by differential responses to deviations of inflation or output from the respective targets. A challenging empirical issue is therefore the potential *asymmetry* of 'delayed overshooting' between cross exchange rates, i.e. whether the magnitude of, say, the dollar appreciation against major currencies following a U.S. monetary policy tightening differs. This question was originally posed by Frankel (1986), but has only recently received some attention in the study by Lobo et al. (2006) who examine the impact of changes in the Federal Funds Rate (*FFR*) target on daily dollar exchange rates and find that surprises associated with monetary contraction have a larger effect compared to monetary easing for the sterling, mark and Canadian dollar rates, whereas the opposite holds for the yen.

In this vein and taking 'delayed overshooting' as a stylized fact, we first attempt to investigate how and to what extent cross exchange rates of major currencies (sterling, Japanese yen and German mark) respond to U.S. monetary policy shocks. We also assess the response of interest rate differentials between the three countries (UK, Japan, and Germany) and the existence of excess returns in these economies. To this end, we use the Structural Vector Autoregression (SVAR) approach that has been routinely used in the recent literature, in which we proxy U.S. monetary policy changes by the Romer and Romer (2004) narrative index (*RR*). This measure of U.S. monetary policy is better equipped to overcome the endogeneity and anticipatory biases that are inherent in other standard indices, like the *FFR* or the non-borrowed reserves ratio.

We find a 'delayed overshooting' pattern for all the currency cross rates examined (sterling/yen, yen/mark and mark/sterling) when the Federal Reserve tightens U.S. monetary policy. Specifically, the mark appreciates with a delay relative to the yen with a peak at around ten months following the U.S. monetary policy shock, whereas the mark appreciates against the sterling and the sterling against the yen with a peak at around six months after the shock. We find that the responses of exchange rates and interest rates following the U.S. monetary policy tightening leave room for excess returns in the three foreign exchange markets under consideration.

Next, we take our analysis one step further by attempting to explore whether the driving force of 'delayed overshooting' in the cross exchange rates has been *asymmetric* foreign exchange interventions by central banks (that is, interventions following a specific foreign monetary policy shock, which differ in size and/or direction). Our investigation is motivated by several studies that have investigated the repercussions of foreign exchange intervention on the exchange rate following a monetary policy shock. Lewis (1995) has reported that central banks intervene to support a monetary policy that is consistent with their exchange rate targets, as monetary policy changes driven by domestic targets may trigger counter-movements in the exchange rate. Bonser-Neal et al. (1998) have claimed that interventions may at times react to past monetary policy actions, e.g. if U.S. monetary authorities wished to keep the exchange rate path within a particular zone. They find that various policies were evident at different periods, but also that the exchange rate responses to *FFR* changes are unaffected when one controls for central bank foreign exchange intervention. Kim (2003, 2005) has examined the joint effects of monetary policy and foreign exchange intervention on the U.S.-Canada exchange rate and has found evidence that 'delayed overshooting' can be explained by interventions in the foreign exchange market intended to weaken the exchange rate appreciation following a monetary policy tightening.

Given these points, we use recently published foreign exchange intervention data to assess the potential impact of central bank intervention in the foreign exchange markets under consideration following a U.S. monetary policy shock. Our evidence shows that the 'delayed overshooting' pattern in cross exchange rates is accompanied by significant asymmetric foreign exchange interventions. The evidence points towards a 'leaning-in-the-wind' intervention policy by the Japanese monetary authorities, a finding that is in accordance with an effort to drive the yen to its new equilibrium against the dollar following a U.S. monetary policy shock. In contrast, we find evidence of a 'leaning-against-the-wind' intervention by the German monetary authorities, which is consistent with a strengthening of the mark against the dollar following a U.S. monetary policy shock.

The paper makes two contributions in the relevant literature. First, the 'delayed overshooting' pattern of cross exchange rates has, to our knowledge, been unnoticed in existing empirical studies on the monetary policy transmission mechanism. Given the robustness of our empirical results, this pattern is likely to have comprised a substantial factor of exchange rate variability in the floating rate era. Second, the paper documents a source of exchange rate variability triggered by asymmetric central bank interventions, which offers a route for further explorations of the role of central banks in excess exchange rate movements, a role that is now conditional on an external monetary policy shock.

The rest of the paper is structured as follows. Section 2 outlines the empirical methodology and the data utilised. Section 3 assesses the impact of the monetary policy shocks from two SVAR specifications and Section 4 explores the response of foreign exchange interventions. Finally, Section 5 concludes the paper.

2. Methodology and data

2.1. Empirical specifications

The empirical studies on 'delayed overshooting' are largely based on VAR models with U.S. monetary policy typically being identified by exogenous shocks in the *FFR*, the ratio of non-borrowed to total reserves or the target *FFR*. In their extensive study on the empirical effects of U.S. monetary policy on dollar exchange rates, Eichenbaum and Evans (1995) estimated VAR models for the U.S. and the other G-7 economies, including U.S. and foreign output, prices, interest rates, U.S. non-borrowed reserves, the *FFR* and the nominal U.S. dollar exchange rate vis-à-vis the foreign currencies, and assuming a recursive VAR structure in which the monetary policy shock is identified as an orthogonal innovation to the *FFR* or non-borrowed reserves.[2]

Subsequent empirical studies on the impact of monetary policy on asset prices have mostly involved VARs with identification imposed as restrictions mapping the reduced-form shocks to structural shocks. Cushman and Zha (1997) constructed a two-country

[2] Bonser-Neal et al. (1998) use the *FFR* target as a monetary policy indicator and find that the dollar overshoots immediately after the shock, thus exhibiting the classic Dornbusch (1976) 'overshooting' pattern. These authors claim that due to large deviations of the actual *FFR* (used in previous studies) from the *FFR* target, the latter should be considered as a better proxy for the true monetary policy measure. Bonser-Neal et al. (1998) also criticise the use of VARs for inaccurately measuring 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 *FFR* within a VAR context; see also Rudebusch (1998). Another main category of U.S. monetary policy measures is known as the 'narrative approach' (Romer and Romer, 1989). Eichenbaum and Evans (1995) find that the 'delayed overshooting' pattern also arises when the dates identified by Romer and Romer (1989) are used to identify U.S. monetary policy contractions.

SVAR model assuming block exogeneity for the domestic variables of a small open economy (Canada) relative to the external (U.S.) variables. Their specification resolves some standard empirical puzzles, like the domestic currency depreciation following a domestic contractionary monetary policy and the 'price puzzle', but the authors find short-run deviations from uncovered interest rate parity. Kim and Roubini (2000) have used a non-recursive VAR that allows monetary policy to respond contemporaneously to exchange rate shocks and resolved partially the 'delayed overshooting' effect and the 'conditional forward premium puzzle'. Furthermore, the authors provide evidence that, in response to an unexpected increase in the U.S. monetary policy rate, the short-term interest rates of non-U.S. G7 countries increase and their currencies relative to the dollar depreciate on impact. Faust and Rogers (2003) have assessed the robustness of conclusions drawn from SVAR models relative to changes in the identifying assumptions and find that the 'delayed overshooting' result is sensitive to the assumptions adopted. In contrast, they provide evidence that deviations from uncovered interest rate parity are robust to various assumptions and, moreover, that the estimates of the share of exchange rate variance due to monetary policy shocks can take quite large values.

Given these considerations, our identification of U.S. monetary policy is based on a number of standard structural assumptions. Our general empirical strategy is to develop a two-economy setup and include an external economy (U.S.) that is assumed to be large and relatively closed. Thus we assume that a U.S. monetary policy shock reflects an exogenous shock for other economies, which in turn respond to domestic and external developments. The country pairs considered are UK-Japan, Japan-Germany and Germany-UK, a choice that is mainly dictated by the high economic integration among these economies and the almost perfect substitutability of their assets in international financial markets.

Our first SVAR specification reports the effects of a shock in the monetary policy of a large foreign economy on the interest rates of country pairs and their corresponding cross exchange rates (Model I). This specification is broadly based on the identification scheme proposed by Kim and Roubini (2000) and is modified to account for the responses of two countries' variables to an exogenous shock in the monetary policy of the foreign economy. In particular, we assume that the structural shocks, $e(t)$, are related to the reduced form residuals, $u(t)$, by $e(t)=G_0\ u(t)$ with the contemporaneous coefficient matrix, G_0, given by:

$$\begin{bmatrix} eIP_1 \\ eIP_2 \\ eP_1 \\ eP_2 \\ eM_1 \\ eM_2 \\ eIR_1 \\ eIR_2 \\ eXR_{1/2} \\ ePW \\ eRR \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a2 & 0 \\ a3 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & a4 & 0 \\ 0 & a5 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & a6 & 0 \\ a7 & 0 & a8 & 0 & 1 & 0 & a9 & 0 & 0 & 0 & 0 \\ 0 & a10 & 0 & a11 & 0 & 1 & 0 & a12 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a13 & 0 & 1 & 0 & a14 & a15 & 0 \\ 0 & 0 & 0 & 0 & 0 & a16 & 0 & 1 & a17 & a18 & 0 \\ a19 & a20 & a21 & a22 & a23 & a24 & a25 & a26 & 1 & a27 & a28 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a29 & 1 \end{bmatrix} \begin{bmatrix} uIP_1 \\ uIP_2 \\ uP_1 \\ uP_2 \\ uM_1 \\ uM_2 \\ uIR_1 \\ uIR_2 \\ uXR_{1/2} \\ uPW \\ uRR \end{bmatrix}$$

The vector of variables for countries 1 and 2 consists of the log of output (IP_1 and IP_2), the log of the price index (P_1 and P_2), the log of a narrow monetary aggregate (M_1 and M_2), the central bank interest rate (IR_1 and IR_2), the log of the nominal cross exchange rate expressed in units of the currency of country 1 in terms of the currency of country 2 ($XR_{1/2}$), the log of the world commodity price index (*PW*). Finally, the U.S. monetary policy indicator (*RR*) is given by Romer and Romer (2004); see the next subsection for more details on the *RR* indicator.

The equations of the model are divided into three blocks that broadly follow Gordon and Leeper (1994), Kim (1999), and Kim and Roubini (2000). The first block with four equations represents the goods markets in countries 1 and 2 under the plausible assumptions that real activity does not respond contemporaneously to the price level, the monetary aggregate, the interest rate and the exchange rate of the domestic economy. Thus, firms cannot adjust their output contemporaneously due to inertia and other adjustment costs, although unexpected changes in prices or financial variables affect real activity in the long run. We also assume that there are no contemporaneous mutual effects between the real sectors of the two countries and that both output and prices do not respond contemporaneously to innovations in the *RR* indicator, which are sensible assumptions given our monthly data frequency.

The second block describes the demand and supply of money. Specifically, the 5th and 6th equations represent the money demand equations for the two countries where the standard approach with the demand for real money balances depending on real income and the opportunity cost of holding money is adopted. Next, the 7th and 8th equations describe the monetary policy rule with the discount rate set by the central bank after observing the current domestic monetary aggregate and the exchange rate vis-à-vis the other foreign country (cross exchange rate). Jang and Ogaki (2004) have shown that results from VARs on the effects of U.S. monetary policy on exchange rates are sensitive to this assumption, which is consistent with central bank policy.[3] Notice that the central bank does not react to shifts in the current values of the monetary aggregate of the foreign economy and to the domestic and foreign output and price levels, due to information delays in data availability. Also, as in Kim and Roubini (2000) the domestic interest rate is restricted from responding contemporaneously to unexpected shifts in the external (U.S.) monetary policy shocks.

Finally, in the third block of the system the 9th equation is an arbitrage condition where we assume that the cross exchange rate is contemporaneously affected by all previous variables. The world commodity price index is exogenous to any domestic variable. Last, we treat the *RR* index as not responding to the foreign countries' variables, although we allow for contemporaneous response to the world commodity price index. This reflects the widespread view that the Federal Reserve has conducted monetary policy acting as the leader in international interest rate movements and has been less concerned with external factors than other central banks.[4]

---

[3] Although central banks typically do not admit targets for the exchange rate, they definitely pay attention to exchange rate developments. For example, the Bank of England's Inflation Report reviews explicitly how the current level of the sterling and its forecasted path will impact the inflation forecast and, in turn, monetary policy. Also, both the Bank of Japan and the Bundesbank were concerned with the exchange rate. See McKinnon (1995) for a relevant point on the Bank of Japan's monetary policy reaction. The Bundesbank's Monthly Reports mentioned frequently how fluctuations in the mark exchange rate would be mirrored into monetary policy, as a weak (strong) mark indicated possible inflationary pressures (demand contraction); see also Clarida (2001). Evidence from VARs reported by Clarida and Gertler (1997) showed that the day-to-day money rate, the instrument of Bundesbank monetary policy, indeed responded to the mark in the way described above.

[4] Notice that the Federal Reserve's policy decisions are usually based on permanent changes rather than short-term developments in foreign capital markets. This may explain, to some extent, the neglect of contemporaneous shocks in foreign interest rates in their monetary policy stance. The Federal Reserve has traditionally been concerned with U.S. developments (as prescribed in the 1977 amendment to the Federal Reserve Act) and has rarely made policy decisions based on international considerations, perhaps with the exception of some contractions during steep dollar changes (see also Cooper and Little, 2001). Along this reasoning, the output, prices and monetary aggregates of the large, external economy (U.S.) are not

The previous specification entails a detailed framework for investigating the impact of external monetary policy shocks on individual country's variables, but we are also interested in examining the impact on the relative position of the two countries. In general, two-country open economy models suggest that the *relative* position of a country is crucial for exchange rate determination; see, for instance, Obstfeld and Rogoff (1996). For this reason, we follow the approach by Kalyvitis and Michaelides (2001) and use a model specified in relative terms (Model II), which has been shown to eliminate 'delayed overshooting' in the assessment of the effects of U.S. monetary policy shocks when a recursive error structure is adopted. Relative output captures the relative business cycle position of the two 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. Relative price differentials are then used to capture the long-run exchange rate adjustment based on purchasing power parity. In turn, the relative money supply and the interest rate differential between the two countries are included in the money market block. Furthermore, this approach requires the estimation of fewer parameters, increasing hence the degrees of freedom, and allows us to assess the robustness of our results based on the previous specification.

For this specification, the contemporaneous coefficient matrix, G_0, is given by:

$$\begin{bmatrix} eIP_{1/2} \\ eP_{1/2} \\ eM_{1/2} \\ e(IR_1 - IR_2) \\ eXR_{1/2} \\ ePW \\ eRR \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & a1 & 0 \\ a2 & 1 & 0 & 0 & 0 & a3 & 0 \\ a4 & a5 & 1 & a6 & 0 & 0 & 0 \\ 0 & 0 & a7 & 1 & a8 & a9 & 0 \\ a10 & a11 & a12 & a13 & 1 & a14 & a15 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & a16 & 1 \end{bmatrix} \begin{bmatrix} uIP_{1/2} \\ uP_{1/2} \\ uM_{1/2} \\ u(IR_1 - IR_2) \\ uXR_{1/2} \\ uPW \\ uRR \end{bmatrix}$$

Here $IP_{1/2}$, $P_{1/2}$, and $M_{1/2}$, denote the log of the ratio of industrial production, price level and monetary aggregate in country 1 relative to country 2, (IR_1-IR_2) denotes the central bank interest rate differential, whereas the interpretation of the previous

included here for two reasons. First, these effects are already incorporated in the *RR* index and, second, we focus on the effects on cross exchange rates and not on the exchange rates vis-à-vis the dollar.

specification is carried over in a straightforward manner.

2.2. Data and estimation

To identify U.S. monetary policy shocks we use the (cumulated) indicator proposed by Romer and Romer (2004), who have further developed the narrative approach introduced by Friedman and Schwartz (1963) and formalised by Romer and Romer (1989). In Romer and Romer (2004) a series of intended *FFR* around the meetings of the Federal Open Market Committee is first derived. To account for endogenous interest rate changes linked to economic conditions, the series is regressed upon the Federal Reserve's internal forecasts of inflation and real activity with the residuals representing changes in intended funds rate that are orthogonal to information on future economic conditions. Romer and Romer (2004) find that the policy effects are substantially stronger and quicker using this indicator relative to other conventional U.S. monetary policy measures, like innovations in the *FFR* or the non-borrowed reserves. However, to assess the robustness of our results to the adoption of the *RR* index we shall also use alternatively the *FFR* and the indicator proposed by Bernanke and Mihov (1998); see subsection 3.2 for more details.

To estimate the SVAR models outlined above the following variables were used. Output (*IP*) is measured by the industrial production index, the price level (*P*) by the consumer price index, and money (*M*) by the monetary aggregate M1, with the exception of the UK for which M0 is used (all series are seasonally adjusted). We also used the key central bank interest rate (*IR*), the nominal cross exchange rate ($XR_{1/2}$) expressed in units of the currency of country 1 for a unit of the currency of country 2, the World All Commodities Prices index (*PW*), and the *RR* index. All data are taken from the IMF's International Financial Statistics with the exception of the Romer and Romer (2004) U.S. monetary policy index, which is provided by the authors. The dataset used to estimate the model consists of monthly observations covering the period 1980:01-1996:12 and the reduced-form specifications are estimated with 6 lags and a constant unless otherwise noted.[5]

[5] The choice of the starting period was based on the point raised by Clarida et al. (1998) that during 1979 there were large regime shifts in the conduct of monetary policy by the major central banks, as the control

3. The effects of monetary policy shocks on cross exchange rates

In this Section we first assess the effects of a U.S. monetary policy shock on the cross exchange rates and the interest rates for the three economies considered (UK, Japan and Germany) in the context of Model I and Model II developed in the previous Section. We then assess the robustness of our results to the utilization of alternative U.S. monetary policy measures.

3.1. Impulse responses to a shock in the RR index

Figure 1 displays the impulse responses of the exchange rate and interest rates for the UK-Japan, Japan-Germany and Germany-UK pairs following a contractionary U.S. monetary policy shock (illustrated as a positive one standard deviation of the *RR* index) for both Models I and II. Solid lines are the point estimates, and dotted lines represent one-standard-error bands for a 48-month period derived from 8000 draws by Monte Carlo integration following Sims and Zha (1999). The results for output, prices and monetary aggregates (not reported here) show that tightening U.S. monetary policy affects foreign output for a period lasting up to one year; however, this effect evaporates when relative industrial production is considered. The response of the price level is insignificant for all the pairs of countries indicating the absence of any 'price puzzle' effects, with the sole exception of the relative price level for Japan-Germany under Model II that becomes negative in the short run. The monetary aggregates increase significantly for Japan and Germany, but are found to diminish in the case of the UK following the U.S. monetary policy tightening.

Turning to the variables of interest, we observe that after a *RR* contractionary shock the central bank interest rates in the UK and Germany remain virtually unaffected (see first rows in Figure 1). However, the Japanese interest rate rises immediately and persistently. The findings from the impulse responses of the central bank interest rates are also confirmed by Model II, in which the Japan-Germany interest rate spread widens (see first row of lower part of Figure 1). In addition, all cross exchange rates under both

---

of inflation became their primary objective. The availability of the *RR* monetary policy measure as provided by Romer and Romer (2004) determined the ending period of our sample.

models exhibit a 'delayed overshooting' pattern. Specifically, the mark appreciates with a delay relative to the yen with a peak at around ten months following the U.S. monetary policy shock, whereas the 'delayed overshooting' pattern for the sterling/yen and the mark/sterling is somewhat shorter. The mark appreciates against sterling and sterling against the yen with a peak at around six months after the shock; this behavior is in line with the appreciation of the mark against the yen.

The overall picture suggests that there may be room for excess returns in the pairs of countries considered; to investigate this hypothesis we estimate the effects of a monetary policy shock on ex-post excess returns on the basis of our estimated SVAR.[6] The results are presented in Figure 2, which shows the point estimates and the one-standard-error bands of the impulse responses for a 48-month period following a tightening monetary policy shock in the *RR* indicator. We find that the hypothesis of no excess returns can be rejected in all cases at around four-to-six months following the U.S. monetary policy shock, pointing towards a short-lived violation of uncovered interest rate parity.

We next assess the extent to which U.S. monetary policy shocks have been a prominent source of exchange rate fluctuations during the period under consideration. By examining this issue, it may be possible to shed some light on the causes of exchange rate volatility, which often occurs despite the apparent stability in the domestic macroeconomic environment. In the same vein, external monetary policy shocks might provide -at least partially- an explanation for the periodic turbulence that had been observed e.g. in the Exchange Rate Mechanism of the European Monetary System (EMS).

The upper part of Table 1 summarises the percentage of the *n*-step ahead forecast errors in the central bank interest rates and the cross exchange rates that is attributable to innovations in U.S. monetary policy based on Model I. The lower part of Table 1 displays the corresponding picture for the interest rate spreads and the cross exchange rates based on Model II. As can be readily seen, a non-negligible part of the cross exchange rates variation for all pairs of countries can be attributed to the U.S. monetary policy shock. This effect exceeds 10% of total variation for the cross exchange rates under

[6] The impulse responses of excess returns are related to the impulse responses of the interest rates and the cross exchange rate as follows: $ER^{1/2} = IR_2 - IR_1 + XR_{t+1}^{1/2} - XR_t^{1/2}$.

consideration at a one-to-three-year horizon, reaching 22% for the yen/mark rate in the second year after the shock. To convey a sense of the uncertainty associated with these point estimates, the standard errors are also reported. Although the confidence intervals are wide, we find that U.S. monetary policy shocks are significant for the variation of cross exchange rates, particularly for the yen/mark. A smaller but non-negligible part of the variation in interest rates and interest rate spreads is also attributable to the *RR* shock under both models, especially at a longer horizon.

To sum up, our evidence points towards a strong response of the interest rate in Japan following a contractionary U.S. monetary policy shock. At the same time, we observe a 'delayed overshooting' pattern in the cross exchange rates between the currencies of UK, Japan and Germany, indicating the substantial impact of the U.S. monetary policy shocks on the foreign currencies.

3.2. Sensitivity tests

In this subsection we present some additional sensitivity tests on the empirical impact of U.S. monetary policy on foreign interest rates and cross exchange rates. We use two alternative measures of U.S. monetary policy in our SVAR specifications to assess the robustness of our findings. The first measure is the *FFR* that has been proposed by Bernanke and Blinder (1992) and has been routinely utilised by the majority of studies attempting to assess empirically the impact of U.S. monetary policy. The second measure, also used by Kalyvitis and Michaelides (2001), is the Bernanke and Mihov (1998) indicator (*BM*) that is based on a model of commercial bank reserves and Federal Reserve operating procedures and has the ability of reflecting both interest rate and reserves targeting. According to Bernanke and Mihov (1998) the Federal Reserve has exercised both types of monetary policy: non-borrowed reserves targeting in the period from late 1979 to late 1982, and *FFR* targeting from 1983 onwards. Therefore, the *BM* indicator provides an overall measure of monetary policy stance. We thus estimate the impulse responses of our models by using alternatively these two measures of U.S. monetary policy in the place of the *RR* indicator. The results are presented in Figure 3 and 4, which correspond to the *FFR* and the *BM* indicator respectively. In order to facilitate comparisons we present the results by country pairs.

For the UK-Japan pair, the response of the sterling/yen cross rate to *FFR* innovation is a statistically significant appreciation of the sterling against the yen, which is similar to the response following the shock in the *RR* index. However, the sterling/yen cross rate remains virtually unaffected following a shock in the *BM* indicator. Under Model I, both central bank interest rates exhibit an immediate and significant rise after a U.S. monetary policy shock when the *FFR* and *BM* indicators are used (see the first column in upper part of Figures 3 and 4); moreover, the response of the central bank interest rate spread shows an increase under Model II (see the first column in lower part of Figure 3 and 4). Regarding the presence of excess returns, under both U.S. monetary policy measures (*FFR* and *BM*) the hypothesis of no excess returns can be rejected for the fourth period under Model I and for a larger period lasting up to one year under Model II (see the first column in Figures 3 and 4).

Turning to the Japan-Germany pair, under both models the impulse responses to innovations in the *FFR* are close to the responses to the *RR* indicator with similar short-term excess returns generated immediately after the *FFR* shock (see the second column of Figure 3). Notice that the impulse responses following the shock to the *BM* index differ from those generated when the *RR* index is used. In particular, the yen rate shows a significant appreciation relative to the mark on impact, while there is no evidence of excess returns (see the second column of Figure 4).

As regards the Germany-UK pair, the impulse responses of all variables following the *FFR* and *BM* innovations are similar to those obtained by the *RR* indicator, with the exception of the mark/sterling rate whose response is found to be statistically insignificant under Model II. Again, there is evidence of excess returns for the second quarter under Model I and for the fourth period under Model II following a monetary policy shock to either the *FFR* or the *BM* indicator (see the third column of Figures 3 and 4).

Finally, another robustness test involves the use of the real exchange rate instead of the nominal rate. Given short-run price rigidities, we are interested in testing whether monetary policy shocks translate into real exchange movements as well. Hence, this modification allows us to investigate the impact of U.S. monetary policy shocks on the relative competitiveness of other countries and, moreover, facilitates comparisons with earlier studies (like, for instance, Eichenbaum and Evans, 1995). The results, which are not reported here for reasons of space, verify our earlier findings that sterling appreciates significantly against the yen, and the mark against both the yen and sterling. The rise in the interest rate in Japan remains statistically significant and we find again short-lived excess returns in all cases under both models that are close to those reported earlier on.[7]

4. Interpreting the evidence: A foreign exchange intervention approach

Given our empirical findings so far, which have established the 'delayed overshooting' effect for the pairs of countries under consideration, in this Section we attempt to interpret the reaction of cross exchange rates after the U.S. monetary policy shock by investigating the role of foreign exchange intervention. The two major theories on the impact of interventions on the exchange rate are the portfolio balance channel and the signalling channel. The portfolio balance theory recognizes that sterilized intervention changes the relative supplies of bonds denominated in different currencies, which in turn affects the expected returns due to the change in either the price of the bonds or the exchange rate. The signalling channel, in constrast, suggests that official intervention conveys information about future monetary policy or the long-run equilibrium value of the exchange rate.

In turn, foreign exchange interventions can be broadly classified into two types according to their targets: i) as 'leaning-against-the-wind' policies, under which the authorities aim at mitigating the dominant trend in the exchange rate (for example selling a currency when it is appreciating) and ii) as 'leaning-in-the-wind', when the authorities seek to hasten the exchange rate trend in the expected direction (like accelerating the depreciation of a currency to the desired level).[8]

We emphasize that our investigation does not aim at discriminating between

[7] Given the data availability for the *FFR*, we have also investigated the impulse responses for the period 1980:01–2004:12 for all country pairs, but the findings were similar under the two sample periods.

[8] Following the Plaza Agreement (September 1985) and the Louvre Accord (February 1987) according to which central banks conducted concerted foreign exchange transactions aiming at mitigating the overvaluation of the U.S. dollar, and, generally, stabilising exchange rates by means of interventions, several authors have investigated the conduct of foreign exchange market intervention and its impact on the exchange rate. See, among others, Schwartz (2000), Sarno and Taylor (2001), Dominguez (2003) and Neely (2005) for detailed surveys on interventions in the foreign exchange market and the related theoretical and empirical literature.

alternative intervention theories, but rather at identifying the potential impact and direction of foreign exchange intervention following a foreign monetary policy shock in conjunction with our previous finding of 'delayed overshooting' in cross exchange rates. Given this purpose, we follow Kim (2003, 2005) in our empirical setup in order to investigate the extent to which foreign exchange intervention can be a source of asymmetric exchange rate responses to a U.S. monetary policy shock.

To this end, we extend our empirical specifications to account for the impact of foreign exchange intervention. Notice that some studies have attempted to identify foreign exchange intervention by changes in central bank reserves. This approach, however, has been criticized because reserves may fluctuate excessively due to changes in valuation or interest receipts. In addition, they do not include intervention operations like hidden reserves, which involve changes in official deposits of foreign currency with domestic currency and are regularly used by many central banks.[9] Taking these considerations into account, the dataset we use in our study covers reported interventions (in millions of domestic currency) in dollars and marks by the Bank of Japan during the period 1991-1996, in dollars by the Bundesbank during the period 1979-1995 when interventions ceased, and interventions in dollars and marks by the Bank of England during the period 1988-1993 when interventions ceased.[10] We then define foreign exchange interventions by each central bank as the ratio of net transactions (purchases or sales) of the three foreign currencies under consideration during the corresponding month over the domestic monetary base defined as money in circulation and credit institutions' current accounts for Japan and Germany, and money in circulation (M0) for the UK.

After including the foreign exchange interventions in the specification with the country-specific economic variables (Model III) the contemporaneous coefficient matrix (G_0) becomes:

[9] See Sarno and Taylor (2001) for a more extensive discussion.

[10] With the exception of intervention by the Federal Reserve, intervention data for the large economies have only recently been disclosed publicly. The Japanese Ministry of Finance in August 2000 started to publish daily intervention data, and in July 2001 it released historical data starting from April 1991. The Bank of England also started to publish intervention data in 2000, while the Bundesbank has not released publicly any data on intervention, but both central banks have provided some historical series for academic research.

$$
\begin{bmatrix} eIP_1 \\ eIP_2 \\ eP_1 \\ eP_2 \\ eM_1 \\ eM_2 \\ eIR_1 \\ eIR_2 \\ eFEI_1 \\ eFEI_2 \\ eXR_{1/2} \\ ePW \\ eRR \end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a1 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a2 & 0 \\
a3 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a4 & 0 \\
0 & a5 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a6 & 0 \\
a7 & 0 & a8 & 0 & 1 & 0 & a9 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & a10 & 0 & a11 & 0 & 1 & 0 & a12 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & a13 & 0 & 1 & 0 & a14 & 0 & a15 & a16 & 0 \\
0 & 0 & 0 & 0 & 0 & a17 & 0 & 1 & 0 & a18 & a19 & a20 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & a21 & 0 & 1 & 0 & a22 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a23 & 0 & 1 & a24 & 0 & 0 \\
a25 & a26 & a27 & a28 & a29 & a30 & a31 & a32 & a33 & a34 & 1 & a35 & a36 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a37 & 1
\end{bmatrix} \begin{bmatrix} uIP_1 \\ uIP_2 \\ uP_1 \\ uP_2 \\ uM_1 \\ uM_2 \\ uIR_1 \\ uIR_2 \\ uFEI_1 \\ uFEI_2 \\ uXR_{1/2} \\ uPW \\ uRR \end{bmatrix}
$$

We assume that the foreign exchange intervention variables, termed FEI_1 and FEI_2 respectively, react contemporaneously to the exchange rate, while the central bank interest rate is set contemporaneously in reaction to domestic monetary aggregate and exchange rate changes as in the original specification. Furthermore, we allow contemporaneous interactions between the two policies. The rest of the variables are structured as before, whereas analogous adjustments are made in the specification with the relative variables (Model IV).[11] Figure 5 depicts the impulse responses of the foreign exchange interventions and the cross exchange rates for an 18-month period following a *RR* monetary policy shock.

For the UK-Japan pair of countries (see the first column in Figure 5), intervention rises only for the Bank of Japan, whereas the intervention by the Bank of England remains unaffected. Interestingly, the 'delayed overshooting' pattern for the sterling/yen exchange rate is now insignificant. The second column in Figure 5, which plots the corresponding figures for the Japan-Germany pair, confirms this pattern. Again, the rise in intervention by the Bank of Japan triggers dollar purchases in both models. These interventions are now accompanied by dollar purchases by the Bundesbank, which are however only marginally significant in Model IV. Again, the 'delayed overshooting'

[11] We also include a dummy to capture the large interventions that preceded the September 1992 crisis. The results are not sensitive to the inclusion of this dummy. Given the data availability, our sample spans over the period 1991:01-1996:12, except for the Germany-UK pair where it covers 1988:01-1996:12, and the models are estimated with two lags.

pattern in the yen-mark cross rate is virtually eliminated. These findings are in accordance with a 'leaning-in-the-wind' intervention by the Japanese monetary authorities that expect the yen to depreciate against the dollar following the U.S. monetary policy contraction, and decide to buy dollars in an attempt to stabilise the domestic currency at a higher level. The evidence presented here seems therefore to support the view that, conditional on a U.S. monetary policy shock, the Japanese monetary authorities have attempted to drive the yen to its new equilibrium against the dollar.[12]

The picture is somewhat different when we turn to the Germany-UK pair (see the third column in Figure 5). The response of the Bundesbank is to sell dollars following the U.S. monetary contraction. This can be interpreted as a 'leaning-against-the-wind' intervention by the German monetary authorities, which aim at strengthening the mark against the dollar.[13] Following the 'leaning-against-the-wind' intervention in support of the mark and the lack of intervention by the Bank of England, the mark appreciates with a delay against sterling after the U.S. monetary policy tightening. The evidence is consistent with the low inflation target implemented by the Bundesbank and its leading role in the EMS with monetary authorities in Germany intervening in the foreign exchange market after an unexpected U.S. monetary tightening to prevent the depreciation of the mark vis-à-vis the dollar that would have affected the stability of the EMS, which in turn generated a strong response in the mark/sterling exchange rate.

We close this Section by stressing that even though asymmetric short-lived foreign exchange interventions appear to be a potential mechanism generating prolonged 'delayed overshooting' in currency crosses following an external monetary policy shock, an in-depth treatment of this causal channel is beyond the scope of the present paper. Given the short data span, we view our results on the response of foreign exchange interventions as a first step towards understanding the repercussions for excess exchange rate fluctuations triggered by foreign monetary policy innovations. A more extensive

[12] Recently published data show that the Bank of Japan intervened in the 1990s to affect the yen/dollar rate in a stabilising manner by selling (buying) dollars and buying (selling) yen when the parity was above (below) a target level of 125 yen/dollar (Ito, 2003, 2007; Frenkel et al., 2005).

[13] Weber (1996) claims that after 1985 the Bundesbank conducted interventions jointly with the Federal Reserve aiming at countering the trend of the dollar. See Fatum and Hutchison (2003) for a detailed description of the concerted intervention by the Bundesbank and the Federal Reserve between 1985 and 1995 that targeted at the dollar/mark rate.

investigation regarding the relationship of the response of foreign exchange interventions in conjunction with cross exchange rate responses, possibly by using intervention data covering larger periods as well as higher frequency exchange rate data, seems therefore warranted.

5. Concluding remarks

This paper has investigated the effects of U.S. monetary policy shocks on foreign interest rates and cross exchange rates. Building upon the spirit of Eichenbaum and Evans (1995) and using a SVAR approach, we first attempted to assess the impact of unanticipated U.S. monetary policy on foreign interest rates and cross exchange rates in the UK, Japan and Germany. We provided evidence in support of 'delayed overshooting' in all the currency crosses examined (sterling/yen, yen/mark and mark/sterling) accompanied by excess returns in the foreign exchange markets considered, whereas a non-negligible portion of exchange rate variability between the currency crosses can be attributed to the U.S. monetary policy shock. We then investigated the possibility that 'delayed overshooting' in cross exchange rates is triggered by central bank interventions in the corresponding foreign exchange market following the U.S. monetary policy shock. Our evidence indicated the presence of asymmetric foreign exchange interventions, which are likely to have generated 'delayed overshooting' effects in the cross exchange rates examined. Thus, our paper stresses another aspect of asymmetry in central bank behaviour during the floating exchange rate era, namely the possibility that exchange rate fluctuations were generated by foreign exchange interventions following external monetary policy disturbances.

We close the paper by noting that here we focused on the international effects of monetary policy that mainly arise through the exchange rate channel and work through the uncovered interest rate parity condition. These effects may be exacerbated by the presence of asymmetries in the monetary policy functions of foreign countries, like differential responses to deviations of inflation or output from the respective targets. To sharpen our understanding of the implications generated by the conduct of foreign monetary policy we delegate a more in-depth analysis of the structural characteristics of domestic monetary policy responses following external shocks to future research.

References

Bernanke B. and A. Blinder, 1992, 'The Federal Funds Rate and the channels of monetary transmission', *American Economic Review*, 82, 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, 147-77.

Christiano L., M. Eichenbaum, and C. Evans, 1999, 'Monetary policy shocks: What have we learned and to what end?', in J. Taylor and M. Woodford (eds.), *Handbook of Macroeconomics*, Volume 1A, Elsevier Science: Amsterdam.

Clarida R., 2001, 'The empirics of monetary policy rules in open economies', *International Journal of Finance and Economics*, 6, 315-323.

Clarida R. and J. Gali, 1994, 'Sources of real exchange rate fluctuations: How important are nominal shocks?', *Carnegie-Rochester Conferences Series on Public Policy*, 41, 1-56.

Clarida R. and M. Gertler, 1997, 'How the Bundesbank conducts monetary policy', in C. Romer and D. Romer (eds.), *Reducing Inflation*, University of Chicago Press: Chicago.

Clarida R., J. Gali and M. Gertler, 1998, 'Monetary policy rules in practice: Some international evidence', *European Economic Review*, 42, 6, 1033-67.

Cushman D.O. and T. Zha, 1997, 'Identifying monetary policy in a small open economy under flexible exchange rates', *Journal of Monetary Economics*, 39, 3, 433-48.

Cooper R.N. and J.S. Little, 2001, 'U.S. monetary policy in an integrating world: 1960 to 2000', *New England Economic Review*, 3, 33-56.

Dominguez K.M., 2003, 'Foreign exchange intervention: Did it work in the 90s ?', in J. Williamson and F. Bergsten (eds.), *Dollar Overvaluation and World Economy*, Institute for International Economics: Washington.

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.

Fatum R. and M. Hutchison, 2003, 'Is sterilised foreign exchange intervention effective after all? An event study approach', *Economic Journal*, 113, 390-411.

Faust J. and J.H. Rogers, 2003, 'Monetary policy's role in exchange rate behavior', *Journal of Monetary Economics*, 50, 1403-24.

Frankel J.A., 1986, 'The implications of mean-variance optimization for four questions in international macroeconomics', *Journal of International Money and Finance*, 5, S53-75.

Frenkel M., C. Pierdzioch, and G. Stadtmann, 2005, 'Japanese and US interventions in the Yen/US dollar market: Estimating the monetary authorities' reaction functions', *Quarterly Review of Economics and Finance*, 45, 680-98.

Froot K. and R. Thaler, 1990, 'Anomalies: Foreign exchange', *Journal of Economic Perspectives*, 4, 179-92.

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

Gordon D. and E. Leeper, 1994, 'The dynamic impacts of monetary policy: An exercise in tentative identification', *Journal of Political Economy*, 102, 228-47.

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

Ito T., 2003, 'Is foreign exchange intervention effective? The Japanese experiences in the 1990s', in P. Mizen (ed.), *Monetary History, Exchange Rates and Financial Markets*, Edward Elgar: Cheltenham.

Ito T., 2007, 'Myths and reality of foreign exchange interventions: An application to Japan', *International Journal of Finance and Economics*, 12, 133-54.

Jang K. and M. Ogaki, 2004, 'The effects of monetary policy shocks on exchange rates: A structural vector error correction approach', *Journal of the Japanese and International Economics*, 18, 99-114.

Kalyvitis S. and A. Michaelides, 2001, 'New evidence on the effects of US monetary policy on dollar exchange rates', *Economics Letters*, 71, 2, 255-63.

Kim S., 1999, 'Do monetary policy shocks matter in the G-7 countries? Using common identifying assumptions about monetary policy across countries', *Journal of International Economics*, 48, 387-412.

Kim S., 2003, 'Monetary policy, foreign exchange intervention and the exchange rate in a unifying framework', *Journal of International Economics*, 60, 355-86.

Kim S., 2005, 'Monetary policy, foreign exchange policy, and delayed overshooting', *Journal of Money, Credit and Banking*, 37, 4, 775-82.

Kim S. and N. Roubini, 2000, 'Exchange rate anomalies in the industrial countries: A solution with the structural VAR approach', *Journal of Monetary Economics*, 45, 561-86.

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

Lobo, B.J., A. Darrat and S. Ramchander, 2006, 'The asymmetric impact of monetary policy on currency markets', *The Financial Review*, 41, 289-303.

McKinnon R., 1995, *The Rules of the Game*, MIT Press: Cambridge.

Neely C.J., 2005, ‘An analysis of recent studies of the effect of foreign exchange intervention?’, *Federal Reserve Bank of St. Louis Review*, 87, 6, 685-717.

Obstfeld M. and K. Rogoff, 1996, *Foundations of International Macroeconomics*, MIT Press: Cambridge.

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

Romer C. and D. Romer, 2004, ‘A new measure of monetary shocks: Derivation and implications’, *American Economic Review,* 94, 1055-84.

Rudebusch G., 1998, ‘Do measures of monetary policy in a VAR make sense?’, *International Economic Review*, 39, 907-31.

Sarno L. and M.P. Taylor, 2001, ‘Official intervention in the foreign exchange market: Is it effective and, if so, how does it work?’, *Journal of Economic Literature*, 39, 839-68.

Schwartz A., 2000, ‘The rise and fall of foreign exchange market intervention as a policy tool’, *Journal of Financial Services Research*, 18, 2/3, 319-39.

Sims C. and T. Zha, 1999, ‘Error bands for impulse responses’, *Econometrica*, 67, 5, 1113-55.

Weber A., 1996, ‘Foreign exchange intervention and international policy coordination: Comparing the G3 and EMS experience’, in: M.B. Canzoneri, W.J. Ethier and V. Grilli (eds.), *The New Transatlantic Economy*, Cambridge University Press: Cambridge.

TABLE 1. Variance decomposition of interest rates and cross exchange rates (*RR* indicator)

Model I

	UK - Japan			*Japan - Germany*			*Germany - UK*		
Period	UK rate	Japan rate	sterling/yen	Japan rate	German rate	yen/mark	German rate	UK rate	mark/sterling
1-3	0.4323	2.5387	1.7183	2.2895	0.7470	0.8913	0.4943	0.2796	1.1470
	(0.618)	(1.757)	(1.769)	(1.618)	(0.858)	(1.155)	(0.651)	(0.345)	(1.329)
4-6	2.3010	7.1177	5.1830	9.3083	1.5673	3.8293	1.7530	1.2457	4.9290
	(2.375)	(4.508)	(4.340)	(4.550)	(1.484)	(2.766)	(1.768)	(1.270)	(3.832)
7-12	3.5102	8.3110	13.2217	8.7368	2.6002	16.8010	2.6677	2.6232	14.4407
	(3.047)	(6.168)	(7.370)	(5.448)	(2.396)	(7.233)	(2.618)	(2.174)	(7.176)
13-24	4.6573	8.6967	14.0337	10.1157	4.4128	22.7528	3.7588	5.6413	13.4908
	(3.487)	(7.488)	(8.414)	(7.517)	(4.594)	(8.875)	(3.741)	(4.077)	(6.823)
25-36	8.2971	7.7270	12.0755	11.0953	5.7665	19.6210	4.9108	8.8376	12.3107
	(6.096)	(6.629)	(8.127)	(8.111)	(5.916)	(7.711)	(4.866)	(6.610)	(6.273)
37-48	10.3114	8.4070	11.2006	11.3577	6.8393	17.4558	5.5130	8.0281	11.8683
	(7.250)	(6.920)	(7.332)	(8.498)	(6.730)	(7.212)	(5.183)	(5.724)	(6.174)

Model II

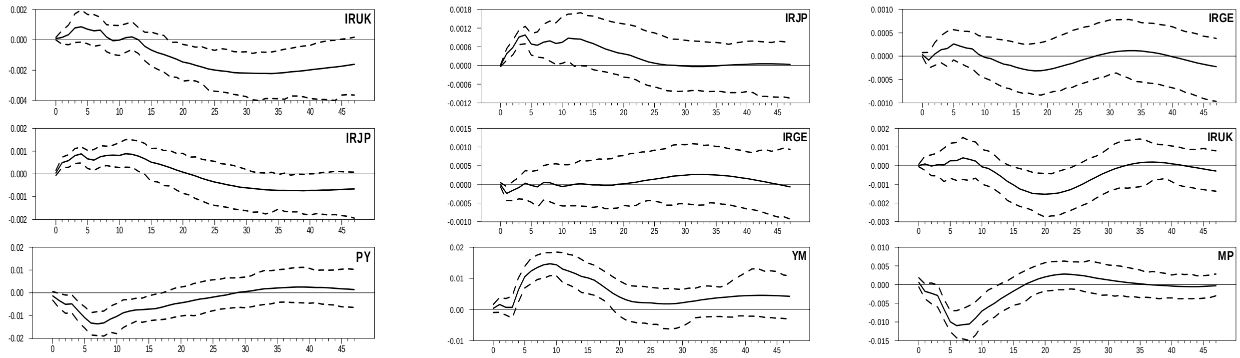
	UK - Japan		*Japan - Germany*		*Germany - UK*	
Period	Interest rate spread	sterling/yen	Interest rate spread	yen/ mark	Interest rate spread	mark /sterling
1-3	0.4272	0.7247	1.6767	0.8147	0.4490	0.7490
	(0.548)	(0.940)	(1.390)	(1.003)	(0.548)	(0.984)
4-6	1.4407	1.6917	4.7163	2.1937	1.7047	2.2043
	(1.523)	(1.799)	(3.603)	(1.858)	(2.008)	(2.091)
7-12	3.1470	5.8505	5.3642	6.9045	3.0583	9.0855
	(3.104)	(4.440)	(4.835)	(4.770)	(3.306)	(6.0655)
13-24	5.8043	10.9274	8.5613	12.2148	5.0140	13.8310
	(5.218)	(8.276)	(7.416)	(8.714)	(4.702)	(9.022)
25-36	10.3633	13.2352	9.7298	12.5364	6.7160	14.8378
	(8.212)	(10.108)	(7.940)	(8.808)	(6.128)	(10.0591)
37-48	12.7359	14.1970	9.9587	12.3477	7.6191	14.5407
	(9.636)	(10.411)	(7.268)	(8.410)	(6.660)	(9.798)

Note: Standard errors are in parentheses.

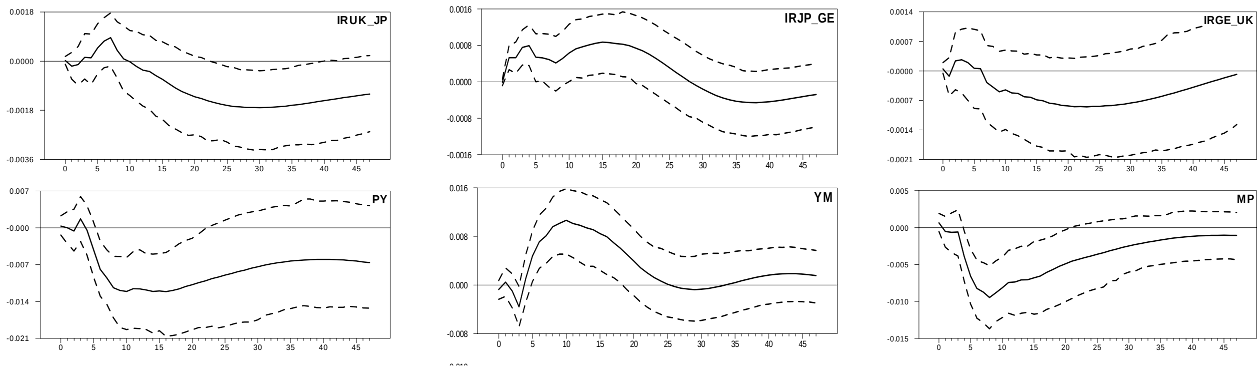
FIGURE 1. Impulse responses of interest rates and cross exchange rates to a U.S. monetary policy shock (*RR* indicator)

UK – Japan *Japan - Germany* *Germany – UK*

Model I



Model II

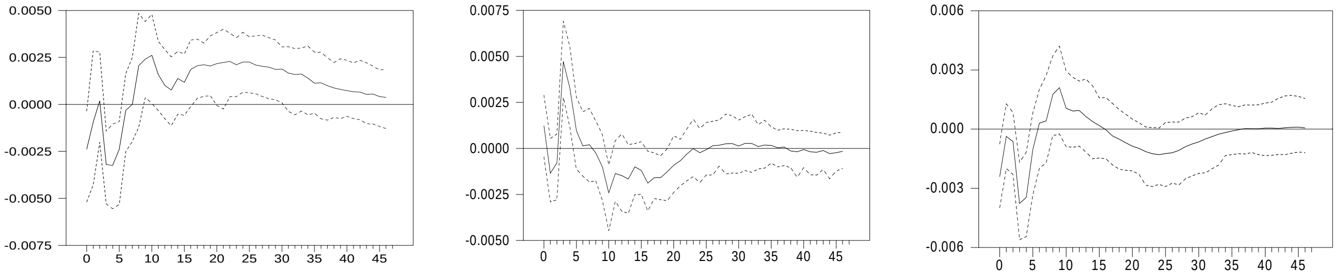


Notes: The labels next to the variables refer to the countries presented above the graphs. The exchange rates considered (PY, YM and MP) are sterling/yen, yen/mark and mark/sterling respectively.

FIGURE 2. Impulse responses of excess returns to a U.S. monetary policy shock (RR indicator)

UK - Japan *Japan - Germany* *Germany - UK*

Model I



Model II

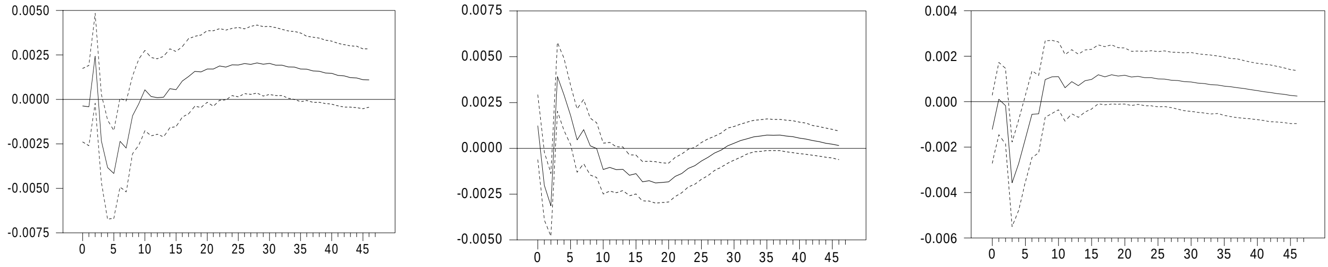
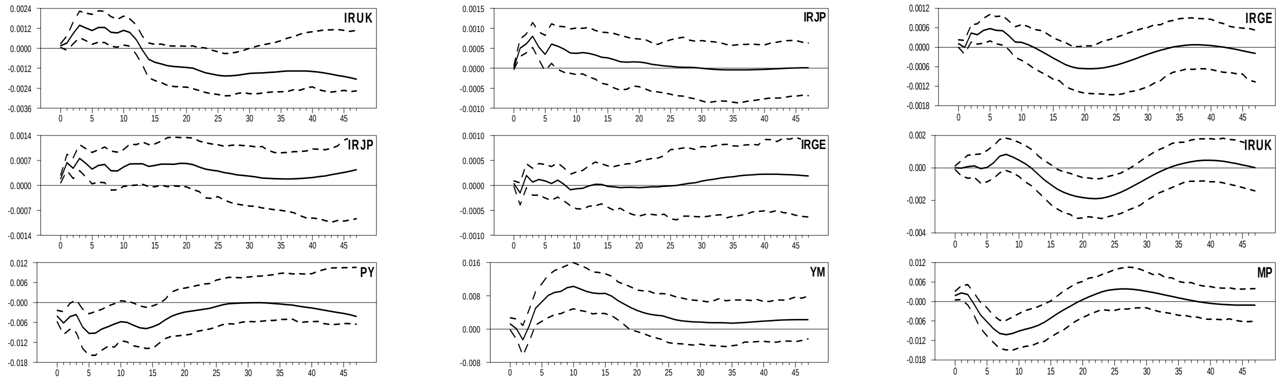


FIGURE 3. Impulse responses to a U.S. monetary policy shock (*FFR* indicator)

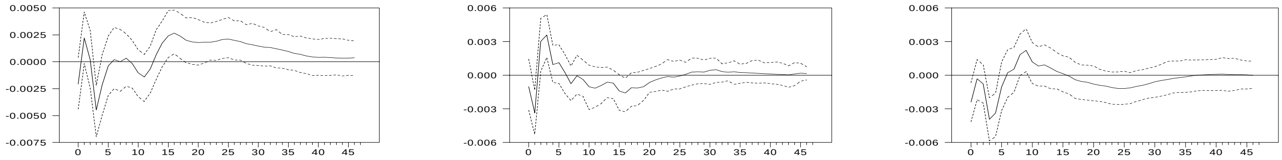
UK - Japan *Japan - Germany* *Germany - UK*

Model I

Exchange rates and interest rates

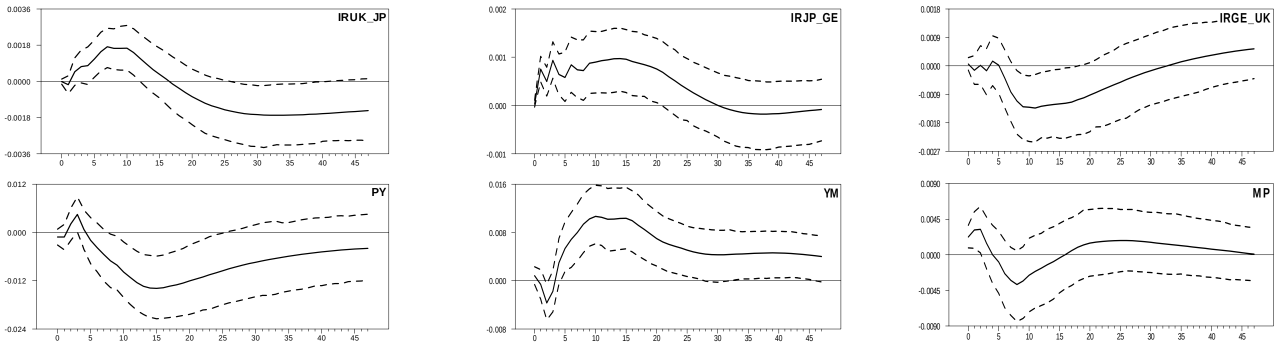


Excess returns



Model II

Exchange rates and interest rates



Excess returns

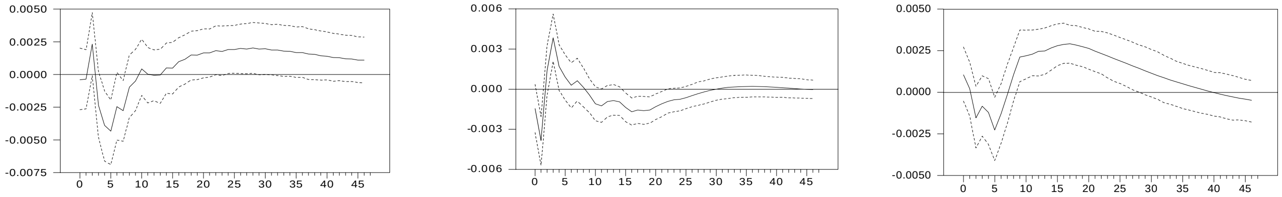
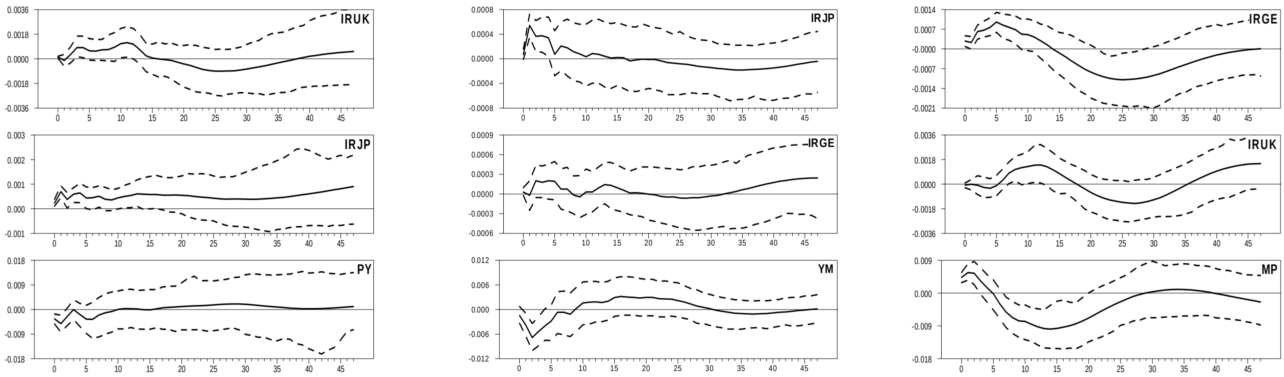


FIGURE 4. Impulse responses to a U.S. monetary policy shock (*BM* indicator)

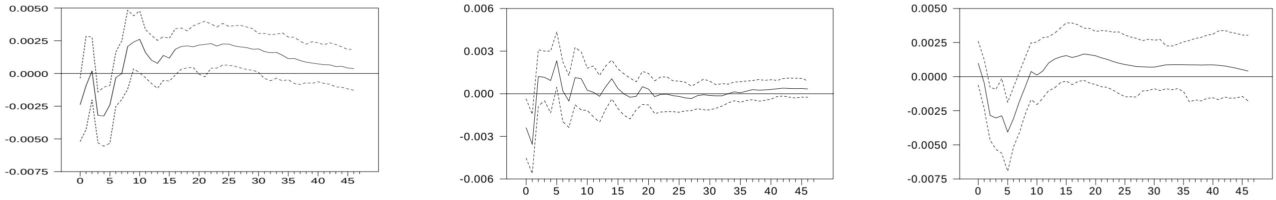
UK - Japan | *Japan - Germany* | *Germany - UK*

Model I

Exchange rates and interest rates

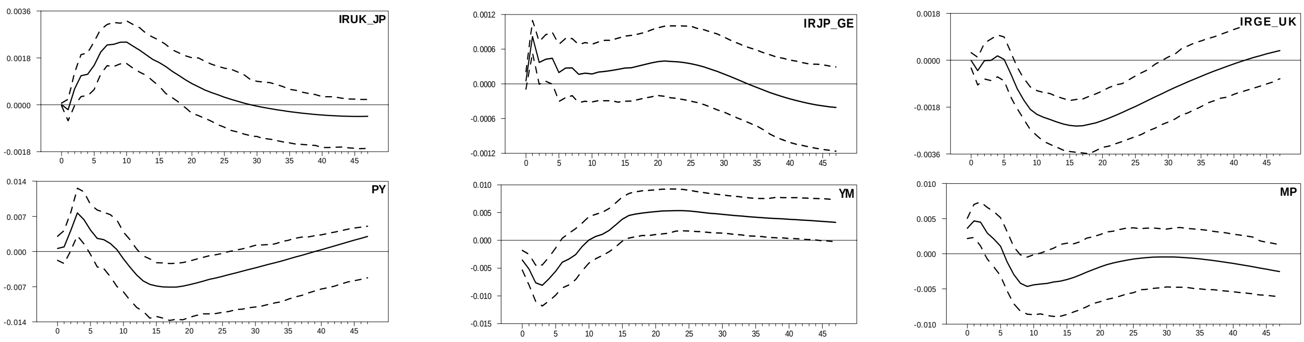


Excess returns



Model II

Exchange rates and interest rates



Excess returns

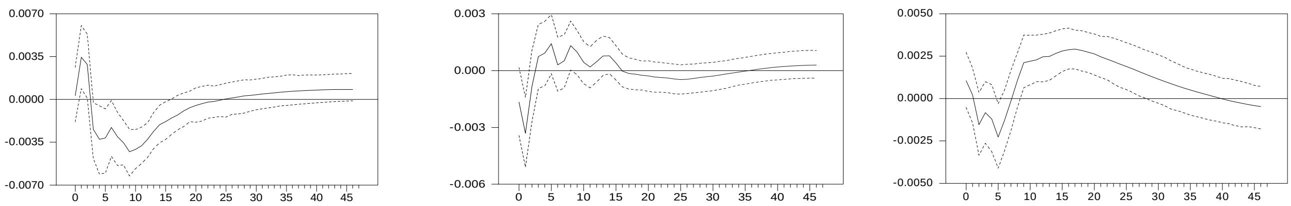
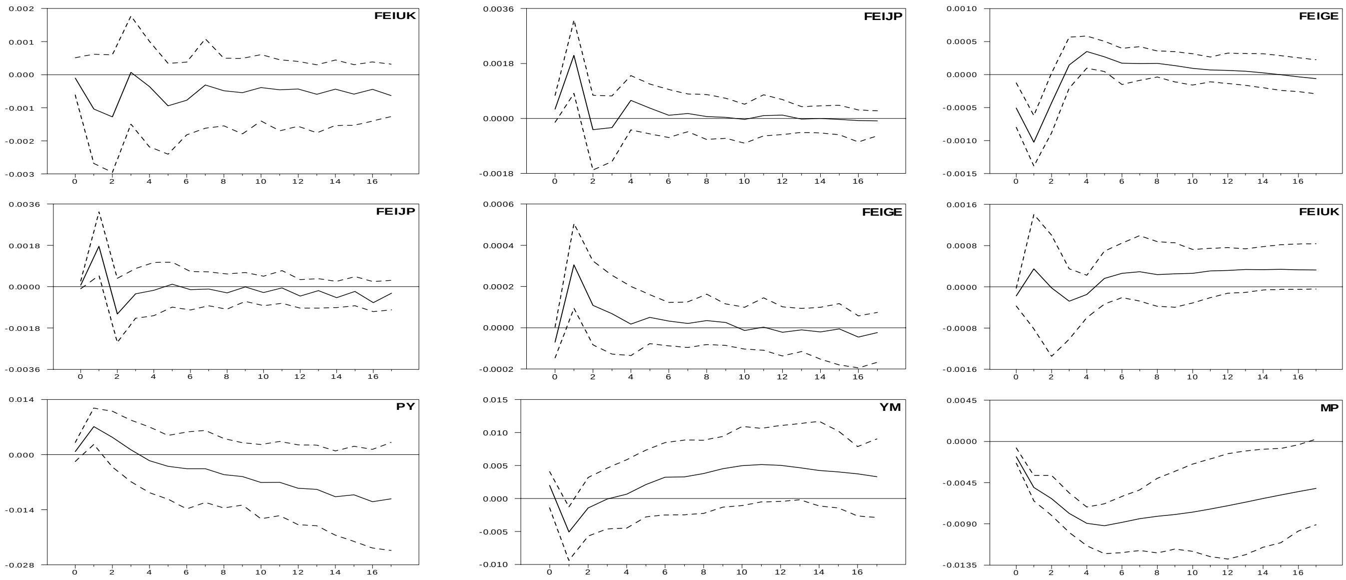


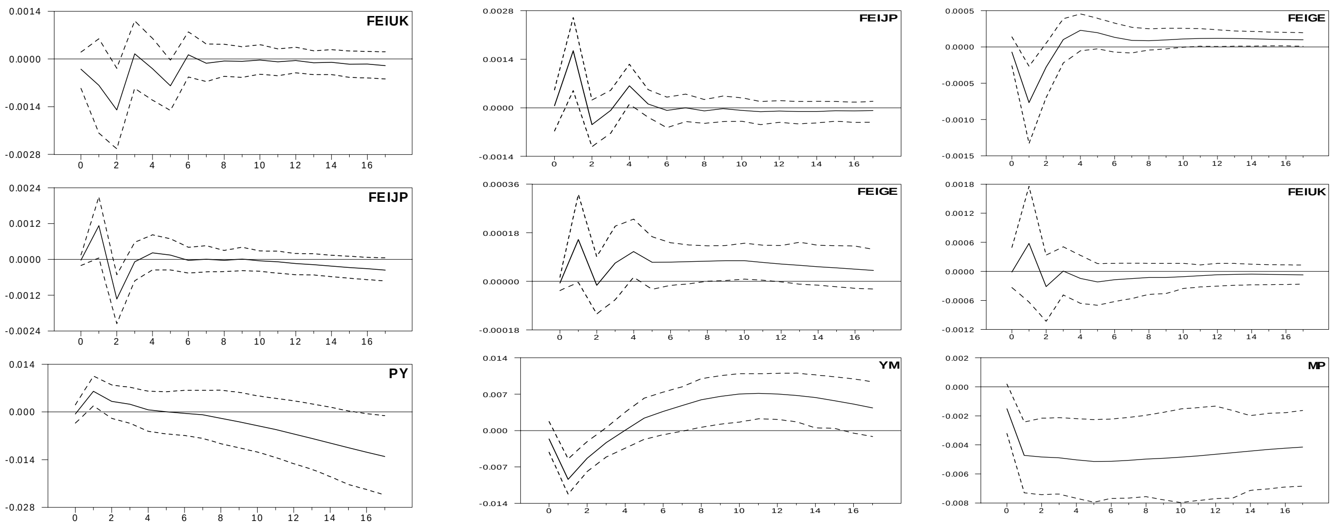
FIGURE 5. Impulse responses of foreign exchange interventions and cross exchange rates to a U.S. monetary policy shock (*RR* indicator)

UK - Japan *Japan - Germany* *Germany - UK*

Model III



Model IV



BANK OF GREECE WORKING PAPERS

41. Genberg, H., "Exchange-Rate Arrangements and Financial Integration in East Asia: On a Collision Course?", including comments by James A. Dorn and Eiji Ogawa, May 2006.

42. Christl, J., "Regional Currency Arrangements: Insights from Europe", including comments by Lars Jonung and the concluding remarks and main findings of the workshop by Eduard Hochreiter and George Tavlas, June 2006.

43. Edwards, S., "Monetary Unions, External Shocks and Economic Performance: A Latin American Perspective", including comments by Enrique Alberola, June 2006.

44. Cooper, R. N., "Proposal for a Common Currency Among Rich Democracies" and Bordo, M. and H. James, "One World Money, Then and Now", including comments by Sergio L. Schmukler, June 2006.

45. Williamson, J., "A Worldwide System of Reference Rates", including comments by Marc Flandreau, August 2006.

46. Brissimis, S. N., M. D. Delis and E. G. Tsionas, "Technical and Allocative Efficiency in European Banking", September 2006.

47. Athanasoglou, P. P., M. D. Delis and C. K. Staikouras, "Determinants of Bank Profitability in the South Eastern European Region", September 2006.

48. Petroulas, P., "The Effect of the Euro on Foreign Direct Investment", October 2006.

49. Andreou, A. S. and G. A. Zombanakis, "Computational Intelligence in Exchange-Rate Forecasting", November 2006.

50. Milionis, A. E., "An Alternative Definition of Market Efficiency and Some Comments on its Empirical Testing", November 2006.

51. Brissimis, S. N. and T. S. Kosma, "Market Conduct, Price Interdependence and Exchange Rate Pass-Through", December 2006.

52. Anastasatos, T. G. and I. R. Davidson, "How Homogenous are Currency Crises? A Panel Study Using Multiple Response Models", December, 2006.

53. Angelopoulou, E. and H. D. Gibson, "The Balance Sheet Channel of Monetary Policy Transmission: Evidence from the UK", January, 2007.

54. Brissimis, S. N. and M. D. Delis, "Identification of a Loan Supply Function: A Cross-Country Test for the Existence of a Bank Lending Channel", January, 2007.

55. Angelopoulou, E., "The Narrative Approach for the Identification of Monetary Policy Shocks in a Small Open Economy", February, 2007.

56.Sideris, D. A., "Foreign Exchange Intervention and Equilibrium Real Exchange Rates", February 2007.

57.Hondroyiannis, G., P.A.V.B. Swamy and G. S. Tavlas, "The New Keynesian Phillips Curve and Lagged Inflation: A Case of Spurious Correlation?", March 2007.

58.Brissimis, S. N. and T. Vlassopoulos, "The Interaction between Mortgage Financing and Housing Prices in Greece", March 2007.

59.Mylonidis, N. and D. Sideris, "Home Bias and Purchasing Power Parity: Evidence from the G-7 Countries", April 2007.

60. Petroulas, P., "Short-Term Capital Flows and Growth in Developed and Emerging Markets", May 2007.

61.Hall, S. G., G. Hondroyiannis, P.A.V.B. Swamy and G. S. Tavlas, "A Portfolio Balance Approach to Euro-area Money Demand in a Time-Varying Environment", October 2007.

62. Brissimis, S. N. and I. Skotida, "Optimal Monetary Policy in the Euro Area in the Presence of Heterogeneity", November 2007.

63.Gibson, H. D. and J. Malley, "The Contribution of Sector Productivity Differentials to Inflation in Greece", November 2007.

64. Sideris, D., "Wagner's Law in 19th Century Greece: A Cointegration and Causality Analysis", November 2007.