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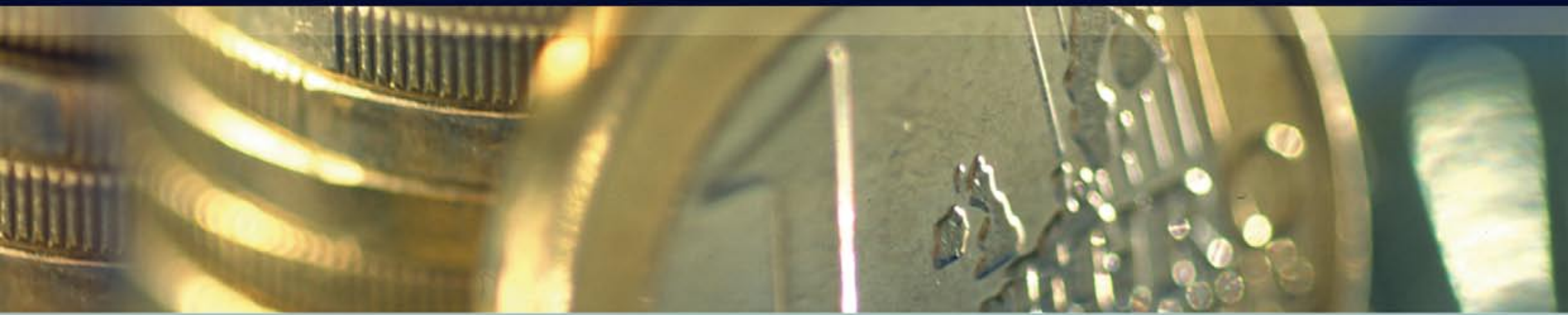

The ECB and the bond market

Carlo Favero and Francesco Giavazzi

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In May 2008, it will be ten years since the final decision to move to the third and final stage of Economic and Monetary Union (EMU), and the decision on which countries would be the first to introduce the euro. To mark this anniversary, the Commission is undertaking a strategic review of EMU. This paper constitutes part of the research that was either conducted or financed by the Commission as source material for the review.

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The ECB and the bond market*

Carlo Favero and Francesco Giavazzi†

March 2008

Abstract

Despite the fact that the correlation between policy rates in the U.S. and in the euro area has been low–at least over the past three decades–long term interest rates in the two regions have been highly correlated. More recently (since the early 1990s) their levels have also converged. Decomposing long-rates in their underlying factors—real rates (plus an inflation risk premium), term premia, expected monetary policy and expected inflation–we find that this convergence reflects more similar economic structures in the U.S. and in the euro area, rather than a change in the distribution of shocks that hit the two regions. As far as the response to shocks is concerned, since the start of EMU Euro area long rates have become more responsive to local non-monetary shocks: in the long run, however, they converge to the same level of U.S. long rates because expected inflation and expected monetary policy also converge to similar levels. Policy rates in the euro area have also become more responsive to local non-monetary shocks. Finally, since the start of EMU, a monetary tightening by the ECB raises long rates, contrary to what used to happen in the 1990s when the Bundesbank was running monetary policy. Interestingly long rates in the Euro area fall following a monetary tightening in the U.S.

Keywords: US and German Term Structure, Term Premia, Inflation Expectations, Monetary Policy

JEL Classification: E27, E37, E43.

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1 The convergence of U.S. and euro area long rates

This paper is an investigation into the factors that determine long-term interest rates in the euro area. We measure long rates in the euro area with the yield on 10-year German benchmark government bonds: we thus abstract from credit and liquidity spreads that vary both among euro bonds issued by different governments and between corporate and sovereign bonds. We are interested in understanding to what extent—if at all—and through which channels the transition to a monetary union has affected European long rates. In particular we are interested in understanding whether it has affected the comovement of U.S. and European yields. Why is this relevant? Because long rates incorporate long-term inflation expectations and expectations on future monetary policy: they thus provide a direct assessment of the credibility of a central bank's inflation target.

Our data on long rates (the frequency is monthly and the source is Datastream) are shown in Figure . The sample extends over three decades: we divide it into three sub-samples (the 1980s, the 1990s and the years following the start of EMU), which correspond to distinct periods in the euro area: the EMS, its crisis in the early nineties, followed by the transition to EMU, and the years since the creation of EMU. Along with European rates Figure 1 also shows the evolution of U.S. long rates: the 10-year benchmark U.S. Treasury. We note two facts: *(i)* the correlation between European and U.S. yields has always been high (*rho* in Figure 1 indicates the coefficient of correlation between the two series), but the levels of the two yields, which were different in the 1980s, have converged to the same unconditional mean since the early 1990s; *(ii)* the high positive correlation between U.S. and European long-term rates is not a feature shared by monetary policy rates (shown in Figure 2) in any of the periods we have considered. This suggests that there are factors beyond monetary policy that explain the correlation between euro area and U.S. long rates.

To understand which factors these might be it is useful to start by decomposing 10-year yields in two different ways:

- first, we split the nominal yield on a T-year bond, $i_{t,T}$, in the weighted sequence of expected future policy rates—which we denoted with $i^*_{t,T}$—and a term premium, $TP_{t,T}$, as shown in equation (1);
- alternatively, in equation (2), we split the nominal yield in the expected inflation over the remaining life of the bond, $\pi^*_{t,T}$, and the sum of the inflation risk premium, $IP_{t,T}$ and the real rate, $rr_{t,T}$ both also measured over the remaining life of the bond:

$$
\begin{aligned}
i_{t,T} &= i^*_{t,T} + TP_{t,T} \\
&= \frac{1-\gamma}{1-\gamma^{T-t}} \sum_{j=1}^{T} \gamma^{j-1} E_t i_{t+j-1,t+j} + TP_{t,T}
\end{aligned} \tag{1}
$$

$$
\begin{aligned}
i_{t,T} &= \pi^*_{t,T} + (rr_{t,T} + IP_{t,T}) \\
&= \frac{1-\gamma}{1-\gamma^{T-t}} \sum_{j=1}^{T} \gamma^{j-1} E_t \pi_{t+j-1,t+j} + (rr_{t,T} + IP_{t,T})
\end{aligned} \tag{2}
$$

Equation (1) applies the linearized expectations model of Shiller (1979). It is derived from a no-arbitrage condition: expected one-period returns from holding a long-term bond must be equal to the one-period risk-free interest rate, plus a one-period term premium. For long term bonds bearing a coupon C, the one-period holding-return is a non-linear function of the yield to maturity $i_{t,T}$. Shiller (1979) proposes a linearization in the neighborhood of $i_{t,T} = i_{t+1,T} = \bar{R} = C$, in which case we have:

$$
E[h_{t,T} \mid I_t] = E\left[\frac{i_{t,T} - \gamma_T i_{t+1,T}}{1-\gamma_T} \mid I_t\right] = i_{t,t+1} + \phi_{t,T} \tag{3}
$$

where $h_{t,T}$ is the one-period holding return of a bond with maturity date T, I_t is the information set available to agents at time t, $i_{t,t+1}$ is the short-term (one-period) risk free interest rate, γ_T is a constant of linearization which depends on the maturity of the bond. (For a long-term bond such a constant can be approximated by $1/(1+\bar{R})$, since $\lim_{T\longrightarrow\infty} \gamma_T = \gamma = 1/(1+\bar{R})$). $\phi_{t,T}$ is a term premium—defined over a one-period horizon—for holding for one period a bond with residual maturity $T-t$. Solving equation (3) forward we obtain (1) , where $TP_{t,T}$ is the term premium over the entire residual life of the bond.

Equation (2) decomposes the nominal long-term yield to maturity into an expected inflation component, a real long-term interest rate and an inflation risk premium (see for instance Blanchard and Summers, 1984 and Ang, Bekaert and Wei, 2007).

To carry out these decompositions we need forecasts of future policy rates and future inflation. We construct them by estimating the following VAR:

$$
\mathbf{y}_t = \mathbf{A}_t(L)\mathbf{y}_{t-1} + \mathbf{u}_t
$$

where

$$\mathbf{y}_t = \begin{bmatrix} \mathbf{y}_t^{US} & \boldsymbol{\pi}_t^{US} & i_{t,t+1}^{US} & i_{t,t+120}^{US} & \mathbf{y}_t^{EU-GER} & \boldsymbol{\pi}_t^{EU-GER} & i_{t,t+1}^{GER} & i_{t,t+120}^{GER} \end{bmatrix}'$$

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{0} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{bmatrix}$$

- $\mathbf{y}_t^{US}$ and $\mathbf{y}_t^{EU-GER}$ are measures of the output gap computed by applying the Hodrick-Prescott filter to the log of industrial production. The filter is one-sided and it is computed recursively in real time, that is the output gap at time t uses only information available at time t. $\mathbf{y}_t^{EU-GER}$ is obtained using German industrial production up to 1998:12 and euro area industrial production from 1999:1 onward;

- $\boldsymbol{\pi}_t^{US}$ and $\boldsymbol{\pi}_t^{EU-GER}$ are annual inflation rates (based on consumers prices). $\boldsymbol{\pi}_t^{EU-GER}$ is obtained by considering German data up to 1998:12 and the euro area HCPI index from 1999:1 onward;

- the short term rates $i_{t,t+1}^{US}, i_{t,t+1}^{GER}$ are the policy rates: the Federal Funds rate for the U.S., the German policy rate up to 1999:1, and the euro area overnight rates thereafter;

- the long-term rates $i_{t,t+120}^{US}, i_{t,t+120}^{GER}$ are the yields to maturity on 10-year benchmark government bonds.

To construct forecasts of future policy rates and future inflatio, we estimate a sequence of VARs by rolling least squares using a window of ten years of observations. The lag length of each estimated VAR is decided on the basis of standard optimal lag-length selection criteria. The restriction $\mathbf{A}_{12} = 0$ saves degrees of freedom by applying the standard assumption that U.S. variables do not respond to euro area variables.

Denoting with $\mathbf{Z}_t = \mathbf{A}_t \mathbf{Z}_{t-1} + \mathbf{u}_t$ the stacked representation of the sequence of estimated VARs, we construct $i_{t,T}^{*,US}$, $i_{t,T}^{*,GER}$, $\pi_{t,T}^{*,US}$ and $\pi_{t,T}^{*,EU-GER}$ as follows:

$$
\begin{aligned}
i_{t,T}^{*,US} &= \frac{1-\gamma_{US}}{1-\gamma_{US}^{T-t}}\sum_{j=1}^{T}\gamma_{US}^{j-1}e_3'\mathbf{A}_t^{j-1}\mathbf{Z}_t \\
i_{t,T}^{*,GER} &= \frac{1-\gamma_{GER}}{1-\gamma_{GER}^{T-t}}\sum_{j=1}^{T}\gamma_{GER}^{j-1}e_7'\mathbf{A}_t^{j-1}\mathbf{Z}_t \\
\pi_{t,T}^{*,US} &= \frac{1-\gamma_{US}}{1-\gamma_{US}^{T-t}}\sum_{j=1}^{T}\gamma_{US}^{j-1}e_2'\mathbf{A}_t^{j-1}\mathbf{Z}_t \\
\pi_{t,T}^{*,EU-GER} &= \frac{1-\gamma_{GER}}{1-\gamma_{GER}^{T-t}}\sum_{j=1}^{T}\gamma_{GER}^{j-1}e_6'\mathbf{A}_t^{j-1}\mathbf{Z}_t \\
T &= t+120
\end{aligned}
$$

where γ_{US} and γ_{GER} are computed using average long-term rates over the previous 120 observations and the e_k' $(k = 2, 3, 6, 7)$ are column selection vectors with elements equal to 1 in the kth position, and equal to 0 anywhere else.

Figures 3&4, and 5&6 show the results of our two decompositions. We are unable to identify separately the long real rate $rr_{t,T}$ from the inflation premium $IP_{t,T}$ in equation (2), since we can only project future values of observed variables: thus, in Figure 4, we report the sum of the two.

Before analyzing the various components we check the reliability of our VAR-based decompositions comparing $\pi_{t,T}^{*,US}$ and $\pi_{t,T}^{*,EU-GER}$ with the break-even inflation rates implicit in the yield on inflation-indexed bonds: 10-year U.S. TIPs and the French 10-year OATi (indexed to the French CPI) for the euro area. The comparison—over the available sample—is reported in Figures 7&8. In both series expected inflation is the average expected inflation over a ten-year period computed using the same weights used to build long rates from a sequence of expected short rates. Break-even inflation rates built from indexed bonds include, however, an inflation risk premium that is not present in the series we construct. As Figure 7&8 show the measures of expected inflation constructed using our VAR are close to breakeven inflation.

We now return to Figures 3 through 6. The main message from these figures is that the convergence in the levels of euro area and U.S. long rates, documented in Figure 1 is mainly due to the convergence in expected inflation and in expected monetary policy. Moire specifically:

- convergence in the levels of nominal yields is mainly due to the convergence in the levels of expected monetary policy in the two areas (Figure 5): the convergence in levels is paired with a clear increase in the correlation between the two series that rises from a value of 0.17 in the first decade to values of .71 and .51 in the second and third decades;

- parallel to the convergence in expected monetary policy there has been a sharp (though not complete) convergence in long-term expected inflation—though expected inflation remains slightly higher in the U.S. relative to the euro area. (Figure 3);
- term premia fall, from the first to third decade, in both the U.S. and in the euro area (Figure 6). Their correlation across the two regions also becomes smaller (from 0.74 in the first decade to 0.16 in the most recent one). A lower level of term premia and a lower correlation of term premia across regions—while the correlation between long rates remains high—suggests that the importance of term premia in explaining fluctuations in U.S. and German yields has declined over time;
- finally, convergence of nominal yields, but higher expected inflation in the U.S. than in the euro area means that the sum of real long term yields plus the inflation risk premium has become higher in the euro area compared with the U.S.

An alternative way to investigate what determines the convergence of long rates in the two regions is to analyze the steady state solutions of the VARs we have estimated. These are reported in Figure 9 and show the long run equilibrium values of long rates and their components. (For each of the samples we dynamically simulate the three estimated VARs starting from the initial conditions for all observable variables at the beginning of the sample). The results suggest that the convergence in the levels of long-term rates is explained by the fact that the equilibrium values of all components have become more similar: real rates (plus the inflation risk premium), term premia, expected monetary policy and expected inflation all appear to converge.

An interesting fact emerges from the lower panel of Figure 9: the convergence between euro area and U.S. expected monetary policy and expected inflation was already achieved in the early nineties: there is no difference between the second and third decades of our sample. This is not the case for term premia and real rates (plus the inflation risk premium) for which convergence happens only in the EMU decade. Thus, to the extent that one can detect a difference between the last decade of the

1990s and the most recent one, this seems to depend on factors that are not directly related to monetary policy.

2 Shocks, or structure?

Long rates have converged because expected monetary policy (and thus expected inflation) has converged. But why did expected monetary policy converge? One possibility is that the shocks that hit the two regions are increasingly correlated: if this were the case it would not be surprising that expected monetary policies also converge. An alternative is that the shocks keep being different (as the low correlation of policy rates suggests) but long rates have converged because the structures of the two economies, including importantly the objectives of the two central banks, have become more similar.

To provide evidence on the relative importance of shocks and changes in economic structure—the systematic components of the VARs—in determining the convergence in the levels of long-term rates we run the following simple experiment.

- we first construct counterfactual long-rates post-1990. We do this simulating (dynamically) a model constructed by augmenting the systematic part—the VAR estimated over the post 1990 sample—with residuals drawn from their empirical distribution estimated on the pre-1990 sample;
- we then run the reverse exercise. We construct counterfactual pre-1990 rates (dynamically) simulating a model constructed by augmenting the systematic part—the VAR estimated over the pre-1990 sample—with residuals drawn from their empirical distribution estimated on the post-1990 sample. (Note that this exercise uses the reduced form residuals: it is thus independent of any assumption needed to identify structural shocks, except for the restriction $\mathbf{A}_{12} = 0$.)

These counterfactual simulations are shown in Figure 10. The results strengthen the evidence in favour of the hypothesis that the level of yields converged because the structure of the U.S. and euro area economies converged, rather than the shocks which hit them[1]. In the pre-1990 counterfactual, the levels of European and U.S. yields—generated using the pre-1990 structure and the post-1990 shocks—remain

[1] Our exercise is similar to what Stock and Watson (2002) and Ahmed, Levin and Wilson (2004) have done to evaluate the "good policy" against "good luck" explanations of the Great Moderation. Benati and Surico (2007) argue that the evidence that switching shocks across subperiods inverts the

different. On the contrary, in post-1990 sample, the counterfactual the level of yields—constructed using post-1990 structure and pre-1990 shocks—remain close to each other.

2.1 Which elements of the "economic structure" have converged?

To address this question (remembering that "economic structure" includes the objectives of central banks) we study how the two long-rates respond to monetary, to macroeconomic and to term premia shocks and whether these responses have changed over time.

To do this we need first to identify such shocks: this requires additional identifying assumptions beyond $\mathbf{A}_{21} = 0$. We identify four financial shocks: two monetary policy and two non-monetary policy shocks, respectively in the U.S. and in the euro area. Monetary policy shocks are deviations from the systematic response of the two central banks to macroeconomic variables. Non-monetary shocks—as we shall learn from impulse responses—are shocks to term premia: thus from now on we shall refer to them as "term premia shocks". We do not identify the shocks to the two macro variables, inflation and the output gap: we just consider them as macro shocks.

We make the following identifying assumption on the contemporaneous relations among the variables in the VAR: all macro variables react with at least a one-month lag to financial variables. Financial variables react simultaneously to macroeconomic developments. Monetary policy does not react to financial shocks in the month they happen. The recursive structure between the U.S. and the euro area ($\mathbf{A}_{21} = 0$) is assumed to hold also for the simultaneous relation among shocks.

Imposing these identification assumptions on the relation $C\,\boldsymbol{\epsilon} = B\mathbf{u}$ between the the eight VAR residuals $\mathbf{u}$ and the structural shocks

$$\boldsymbol{\epsilon} = \begin{bmatrix} \epsilon_t^{US,MP} & \epsilon_t^{US,TP} & \epsilon_t^{US,macro} & \epsilon_t^{US,macro} & \epsilon_t^{EU,MP} & \epsilon_t^{EU,TP} & \epsilon_t^{EU,macro} & \epsilon_t^{EU,macro} \end{bmatrix}'$$

means restricting B to be a diagonal matrix (*i.e.* standardizing the shocks) and imposing upon C the following restrictions [2]

final outcome is not decisive: the volatility of estimated shocks could be affected by the structure of the economy. However, our result–namely that switching shocks does not invert the final outcome–cannot be explained by the Benati and Surico (2007) argument.

[2] These assumptions are often used to identify U.S. monetary policy shocks (see, for example, Christiano et al. 1999) and shocks to U.S. long-term rates (see Evans and Marshall, 1998 and Edelberg and Marshall, 1996). The restrictions they imply satisfy the rank and order conditions for identification discussed in Amisano and Giannini (1997).

$$C = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_{31} & c_{32} & 1 & 0 & 0 & 0 & 0 & 0 \\ c_{41} & c_{42} & c_{43} & 1 & 0 & 0 & 0 & 0 \\ c_{51} & c_{52} & 0 & 0 & 1 & 0 & 0 & 0 \\ c_{61} & c_{62} & 0 & 0 & c_{65} & 1 & 0 & 0 \\ c_{71} & c_{72} & c_{73} & c_{74} & c_{75} & c_{76} & 1 & 0 \\ c_{81} & c_{82} & c_{83} & c_{84} & c_{85} & c_{86} & c_{87} & 0 \end{bmatrix}.$$

Table 1 summarizes the effects of the structural shocks on euro area long rates The entries in the table are the forecasting errors when we use our VAR to predict long rates in the future. Our identification assumptions allow U.S. to decompose the variance of these forecasting errors in six orthogonal components: monetary policy, term premia and macro shocks (a combination of shocks to inflation and output gaps) in the U.S. and in the euro area. We compute the variance of the forecasting errors at two different horizons: one-month ahead and 120-months (ten years) ahead. The exercise is repeated for three subsamples.

Table 1: Variance decomposition of European 10-year rates

		U.S. shocks			euro **area shocks**		
sample		**macro**	**MP**	**TP**	**macro**	**MP**	**TP**
79-89	1-step	*0.09*	*0.06*	*0.21*	*0.02*	*0.01*	*0.62*
	120-step	*0.35*	*0.11*	*0.24*	*0.11*	*0.05*	*0.14*
90-98	1-step	*0.03*	*0.01*	*0.11*	*0.04*	*0.01*	*0.80*
	120-step	*0.27*	*0.01*	*0.25*	*0.33*	*0.01*	*0.12*
99-07	1-step	*0.01*	*0.01*	*0.38*	*0.05*	*0.01*	*0.57*
	120-step	*0.12*	*0.06*	*0.18*	*0.30*	*0.04*	*0.30*

Two findings emerge from Table 1:

- the 1-month ahead forecasting error is always almost totally explained by a combination of U.S. and euro area term premia shocks; the forecasting variance of long rates attributable to monetary policy shocks is small, both at the short and long (10 year) horizon. This is true in EMU as it was in the two previous decades;

- since the start of EMU the share of the forecasting variance (at the 10-year horizon) attributable to euro area idiosyncratic macro and term premia shocks has increased. In the 1999-2007 sample 60% $(0.30+0.30)$ of the variance of the forecasting error at a 10-year horizon is attributable to local non-monetary policy shocks; this share was 45% in the previous decade $(0.33+0.12)$. Thus, when euro area long rates deviate from their systematic component ($\mathbf{A}_t(L)\mathbf{y}_{t-1}$ in (**??**)) this is mainly because of shocks to the local and U.S. term premia and to local macro variables.

To better understand the effects of financial shocks on long rates in Figures 11-14 we analyze impulse responses. We report the responses of long-term rates and of their components as generated by the two decompositions proposed in the first section of the paper.

- The impact of U.S. monetary policy shocks is shown in Figures 11.1-11.2. The response of euro area long-term rates changed significantly since the start of EMU. Now a U.S. monetary tightening induces a fall in long rates in the euro area: this was not the case in the two preceding decades. As far as U.S. variables are concerned our evidence confirms recent results by Roush (2007) who finds that the expectations theory works well to explain the behavior of the U.S. term structure, conditionally upon monetary policy shocks.

- The effect of U.S. non-monetary policy financial shocks is analyzed in Figure 12.1-12.2. The impulse responses show that these are shocks to U.S. term premia and real 10Y rates (plus an inflation term premium). These shocks have a much stronger impact than U.S. monetary policy shocks on European long-rates. They generate a significant response in all sub-samples, but the response is consistently much stronger in the post 1990 period than in the pre-1990 period. The response of European monetary policy to these shocks was much stronger in the 1990-1998 period than it is the post 1999 period. As a consequence, in the 1990-1998 period, the non monetary policy related components of long rates react less to U.S. term premia shocks. This is consistent with decoupling of term premia in the period 1990-98 reported in the dynamic simulation shown in Figure 9.

- The effect of euro area (German prior to 1999) monetary policy shocks is shown in Figure 13. Here we note immediately that in the period 1990-98, when the Bundesbank was conducting monetary policy, what we found in the U.S. case—

namely the evidence in favour of the expectations theory conditional upon monetary policy shocks—is not replicated in Europe (Germany): monetary policy shocks have a significant negative effect on term premia. Interestingly, a contractionary monetary policy shock over the 1990-98 period induces a negative response in nominal long-term rates, as the reduction in risk premia more than compensates the increase in expected monetary policy rates. Real and nominal long-term rates move in different directions. Such a response is completely overturned in the 1999-2007 period where a surprise monetary tightening moves the long-rate upwards, as term premia, expected monetary policy and the real long-term rates all move in the same direction.

- Finally, Figure 14 considers responses to euro area financial, non-monetary policy shocks. Once again, these shocks can be interpreted as shocks to term premia and real rates, and are always paired by a vigorous response of monetary policy, with the ECB being more aggressive than the Bundesbank. This evidence, along with the finding commented above on the response to U.S. term premia shocks, suggests that the ECB has responded to local financial shocks more than the Bundesbank used to.

3 Conclusions

We have concentrated on two important facts emerging from the evolution of long rates in the euro area and in the U.S. over the past three decades:

- the correlation between euro area and U.S. yields has always been high, but the levels of the two yields, which were different in the 1980s, have converged to the same unconditional mean since the early 1990s;

- the high positive correlation between U.S. and euro area long-term rates is not a feature shared by monetary policy rates in any of the periods we have considered.

Decomposing long-rates in their underlying factors—real rates (plus an inflation risk premium), term premia, expected monetary policy and expected inflation–we find that the convergence of long rates reflects more similar economic structures in the U.S. and in the euro area, rather than a change in the distribution of shocks that hit the two regions.

As far as the response to shocks is concerned, since the start of EMU euro area long rates have become more responsive to local non-monetary shocks: in the long run, however, they converge to the same level of U.S. long rates because expected inflation and expected monetary policy also converge to similar levels. Policy rates in the euro area have also become more responsive to local non-monetary shocks.

Finally, since the start of EMU, a monetary tightening by the ECB raises long rates, contrary to what used to happen in the 1990s when the Bundesbank was running monetary policy. Interestingly long rates in the euro area fall following a monetary tightening in the U.S.

Our evidence calls for a close study of the relative importance of monetary policy and international asset price fluctuations in determining euro area macroeconomic variables. If macro fluctuations in the euro area depend more on asset price fluctuations than on shifts in the monetary policy rate, than the impact of policy on macro fluctuations is likely to be limited. Our results thus suggest that the models used for the design of euro area monetary policy should consider explicitly the effects asset price fluctuations and of their international comovements. This feature is currently absent from the main DSGE models used at the ECB—for example Smets and Wouters (2004).

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Long rates in the U.S. and in euro area

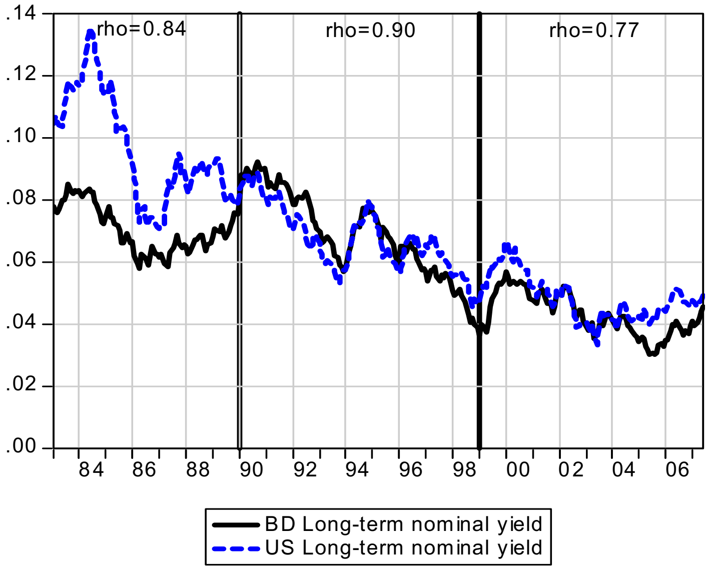

Figure 1: Yields to maturity of U.S. and German 10Y benchmark bonds

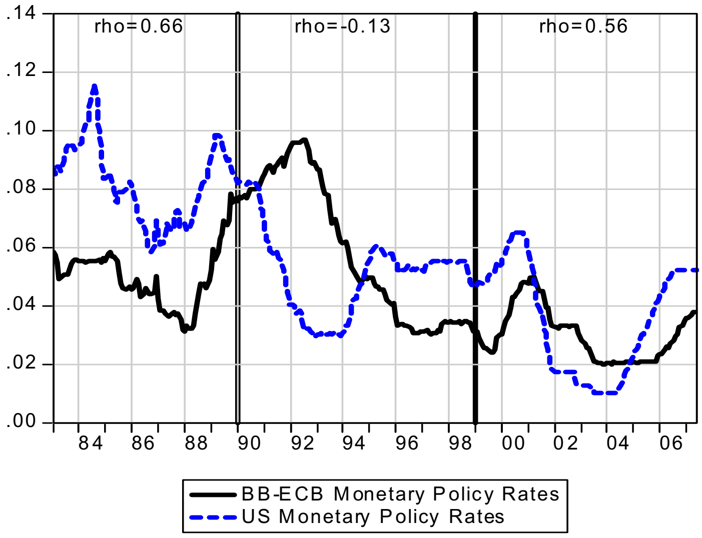

Figure 2: U.S. and Bundesbank-ECB monetary policy rates

Decomposing long rates into expected inflation and the sum of long real rates plus the inflation risk premium

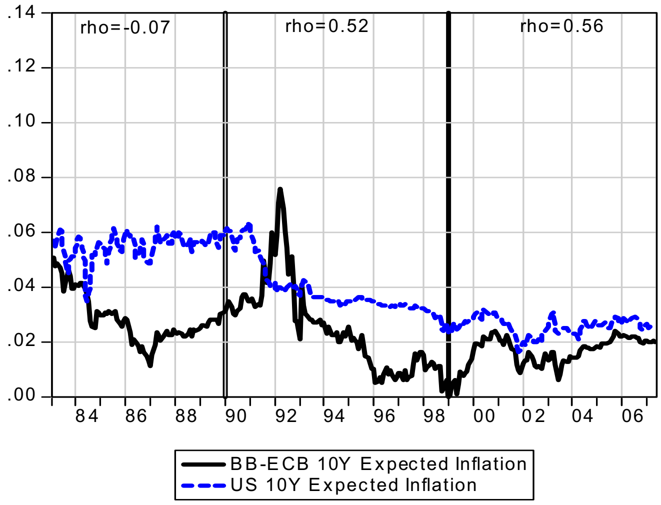

Figure 3: 10-Year expected inflation

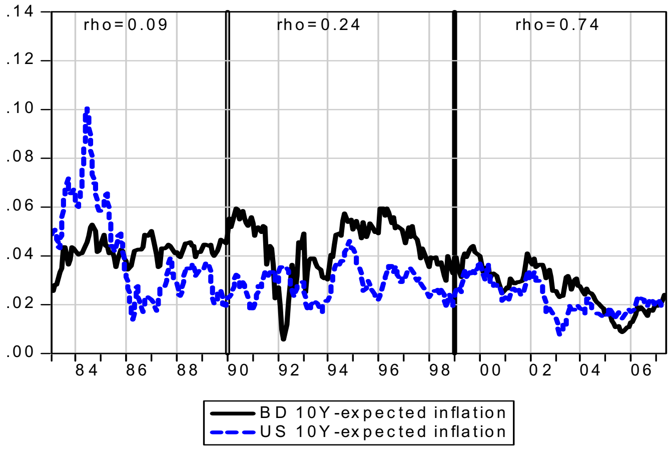

Figure 4: 10Y yields- 10Y expected inflation

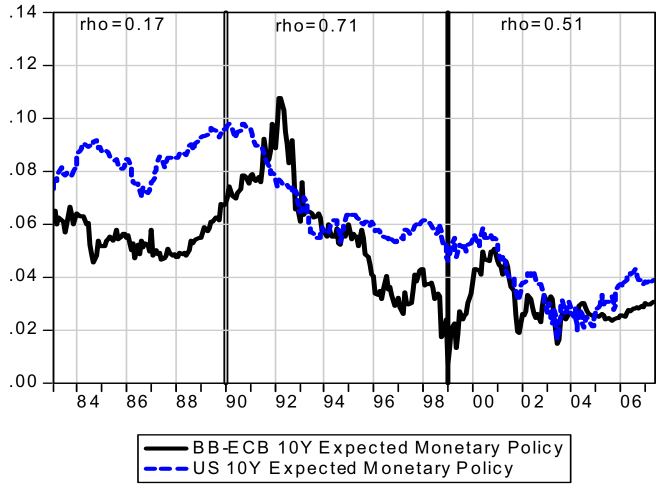

Figure 5: 10Y expected monetary policy

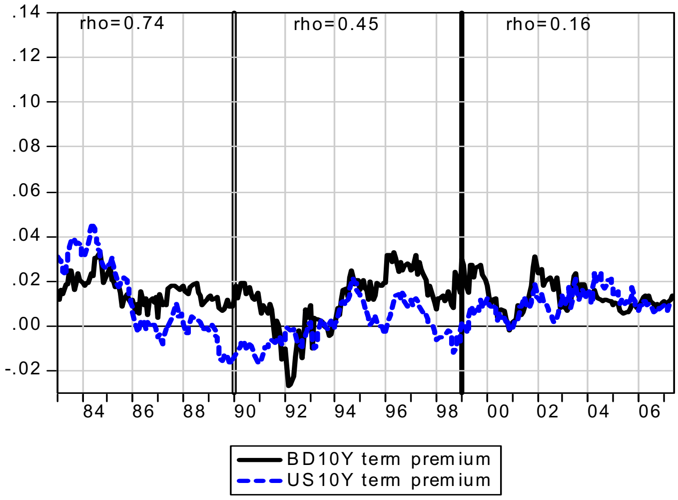

Figure 6: 10Y term premia

Comparing break-even inflation and VAR-based expected inflation

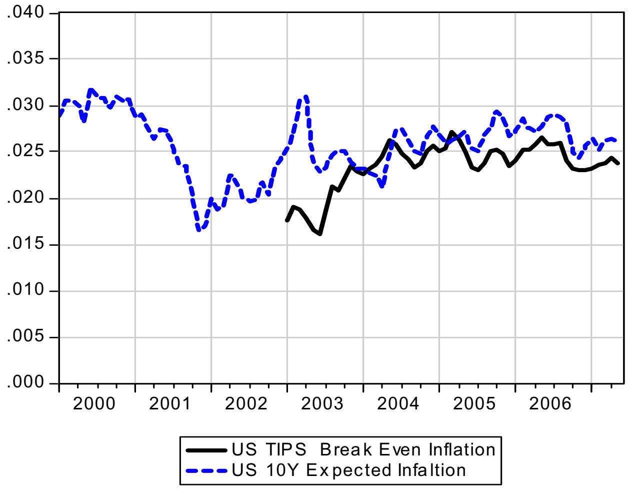

Figure 7: US VAR-based 10Y expected inflation and break-even inflation in US 10Y TIPS

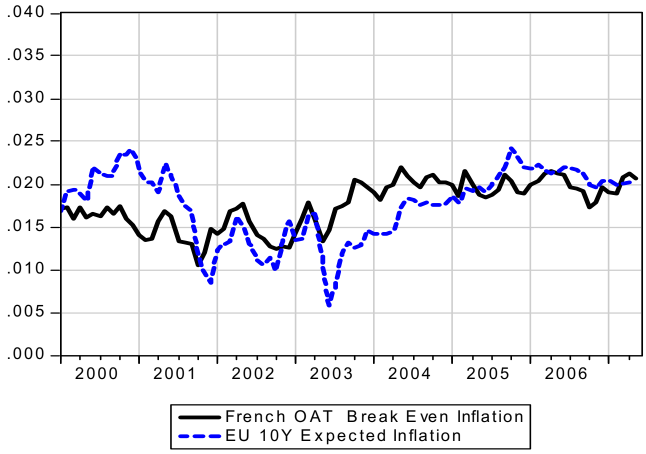

Figure 8: VAR based 10Y Euro area expected inflation and break-even inflation in 10Y French OATi

Dynamic simulations of VARs estimated over three different decades

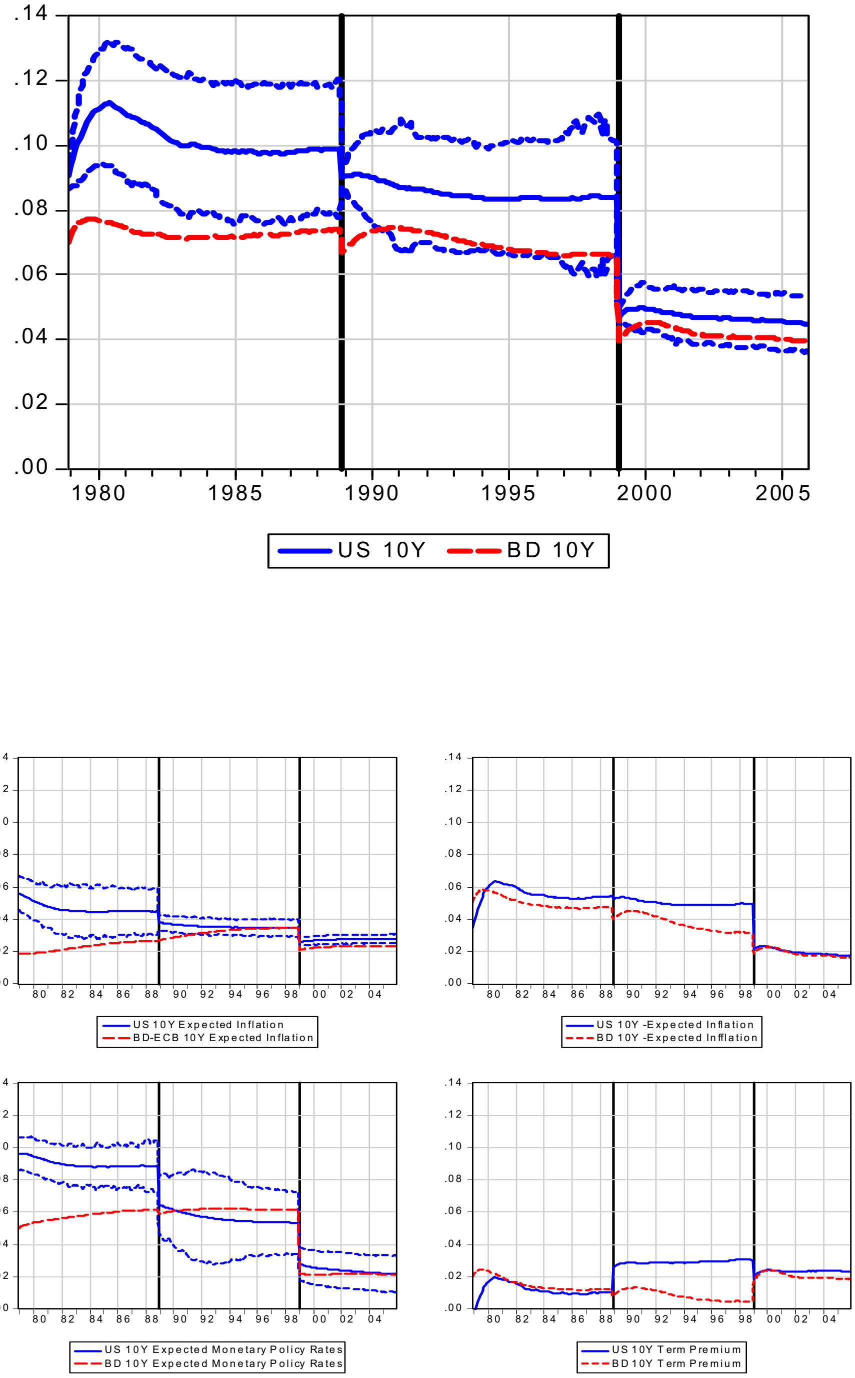

Figure 9

Counter-factual simulations: pre-1990 structure with post 1990 shocks, and post 1990 structure with pre-1990 shocks

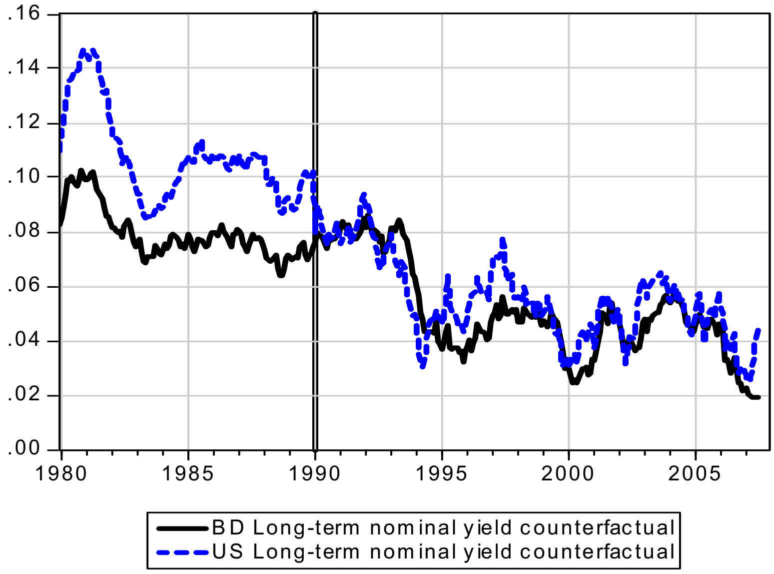

Figure 10

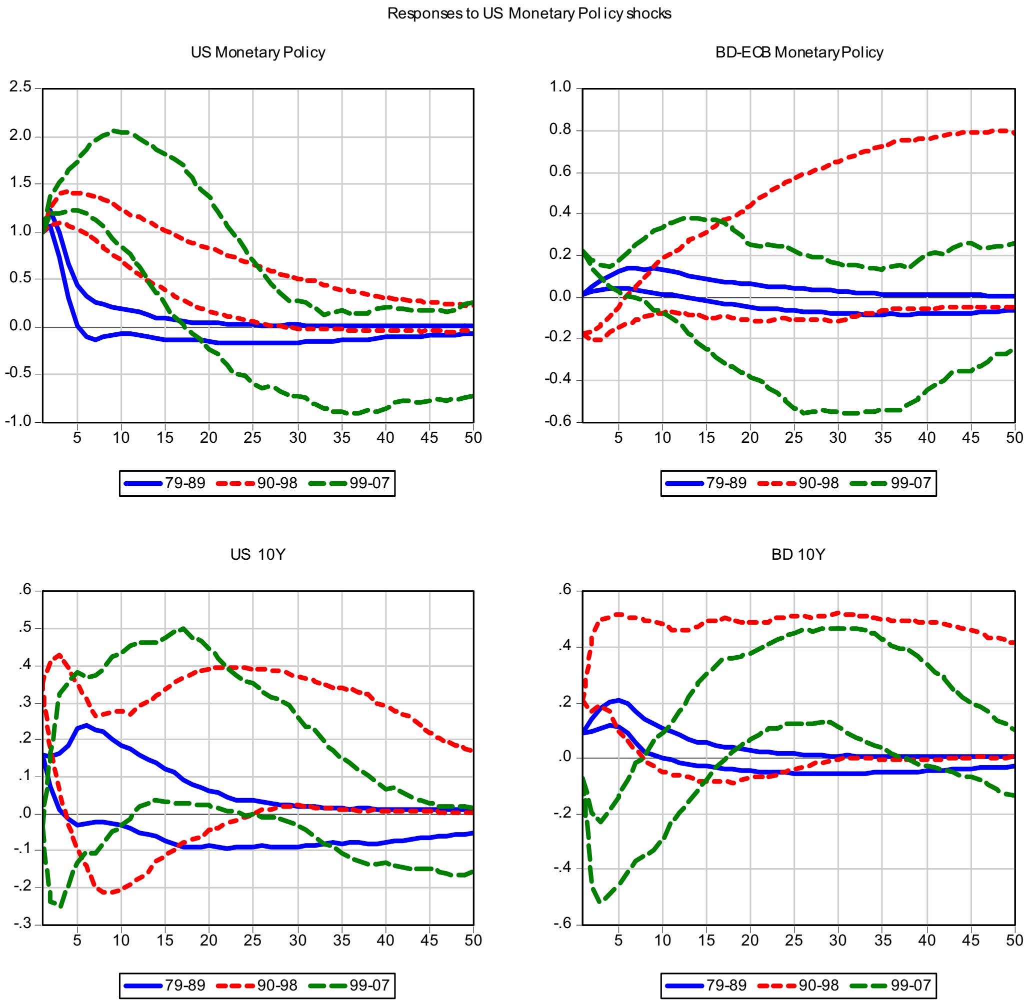

Figure 11.1: Impulse responses to U.S. monetary policy shocks

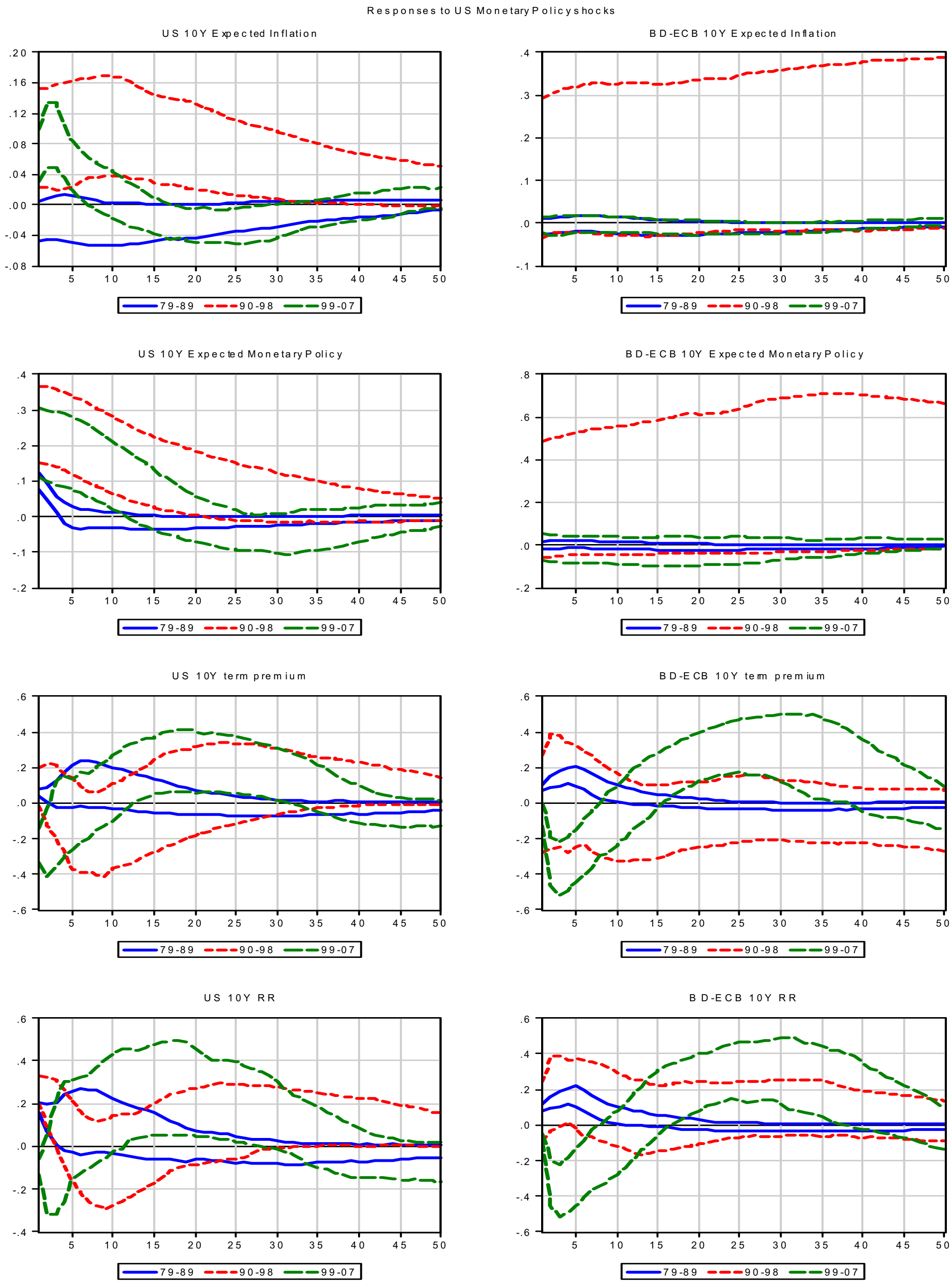

Figure 11.2: Impulse responses to U.S. monetary policy shocks

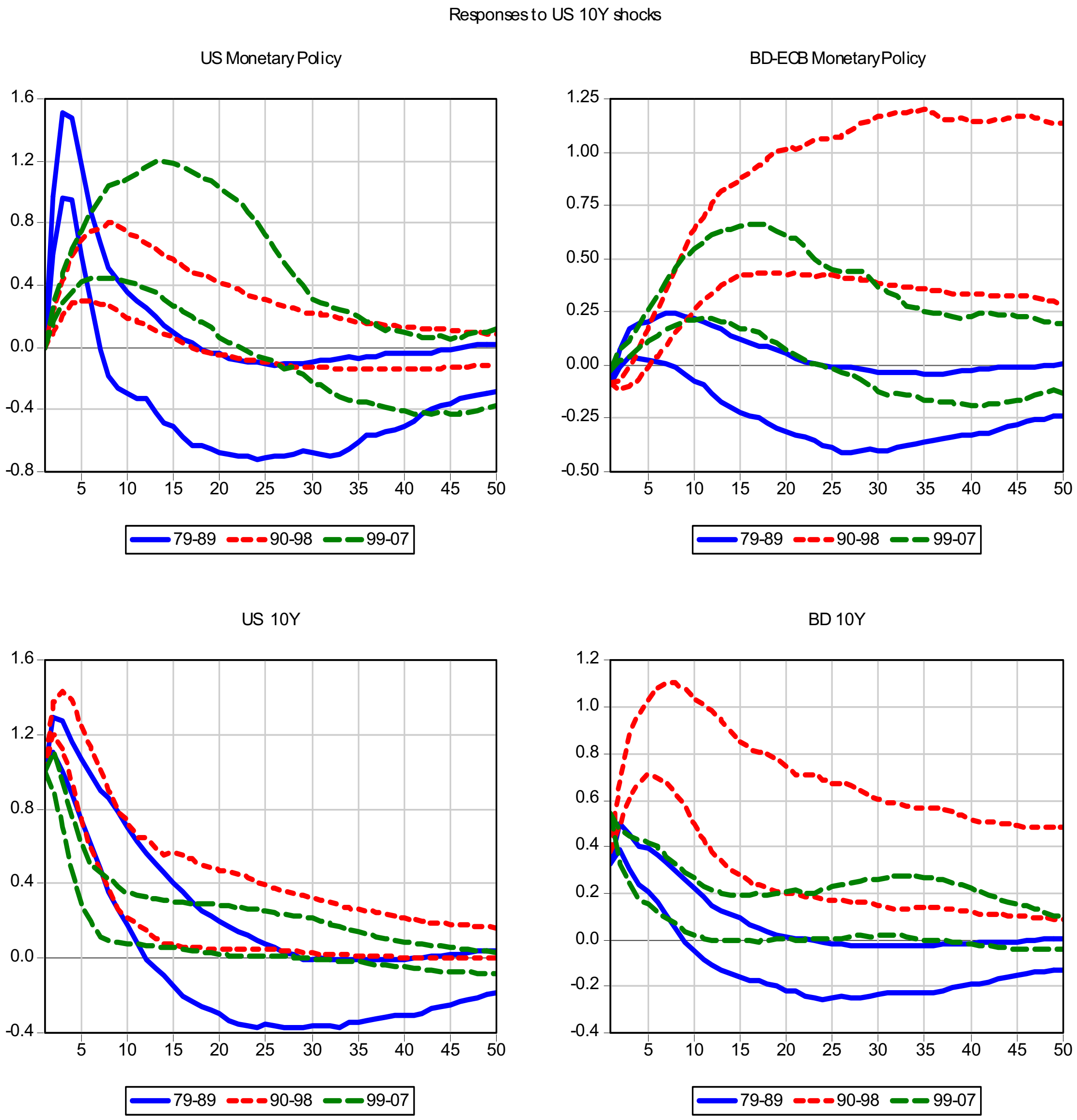

Figure 12.1: Impulse responses to U.S. term premia shocks

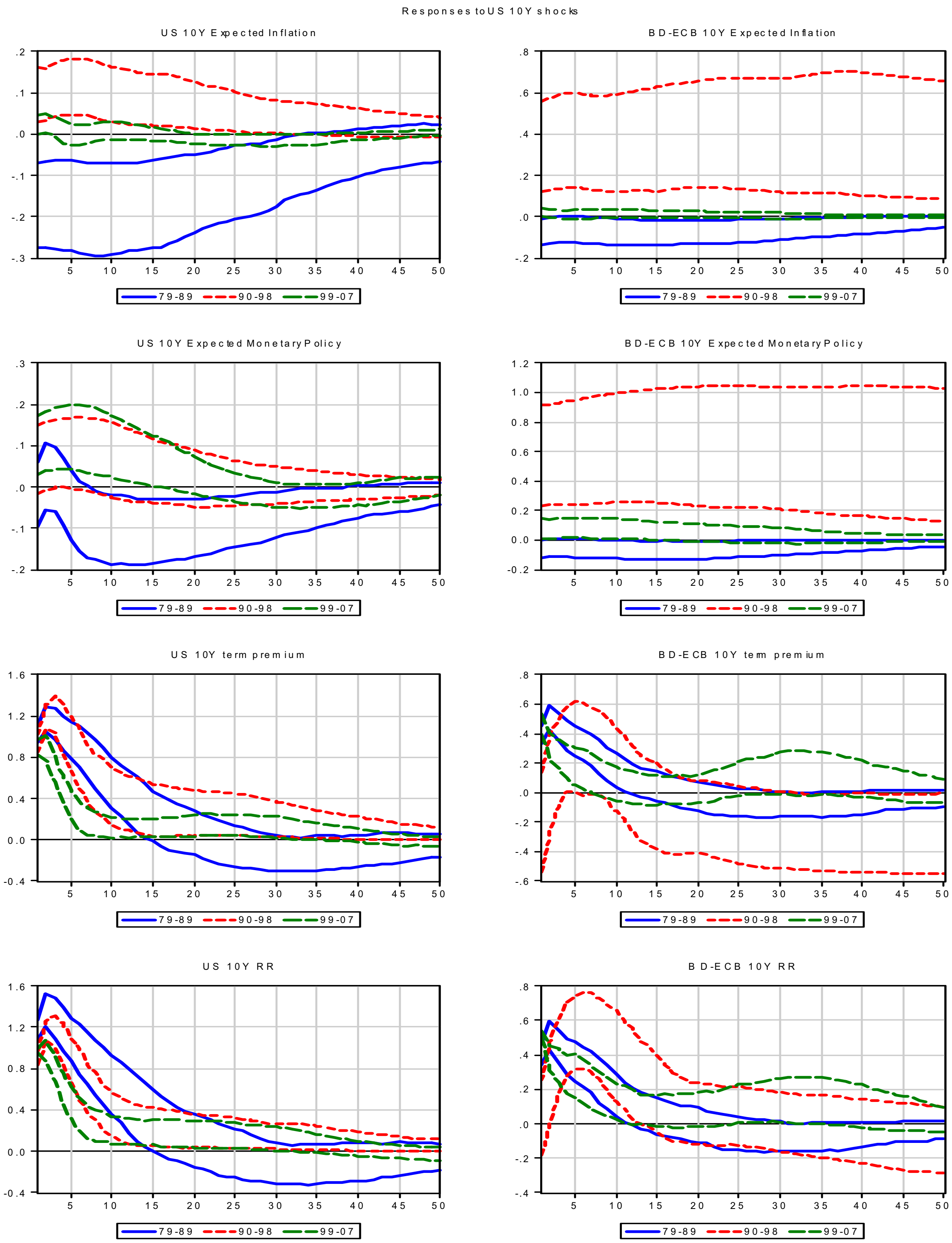

Figure 12.2: Impulse responses to U.S. term premia shocks

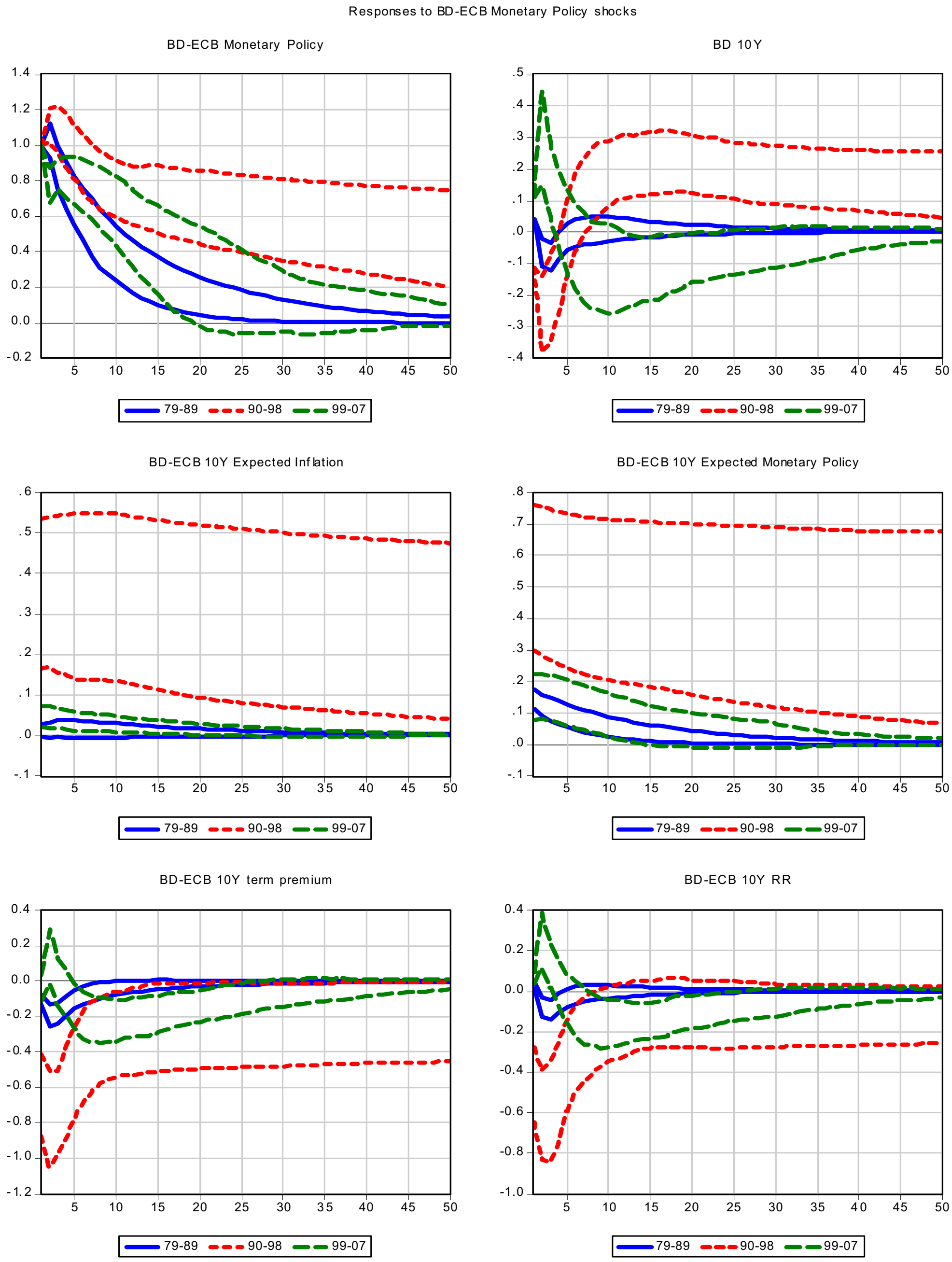

Figure 13: Impulse responses to Bundesbank-ECB monetary policy shocks

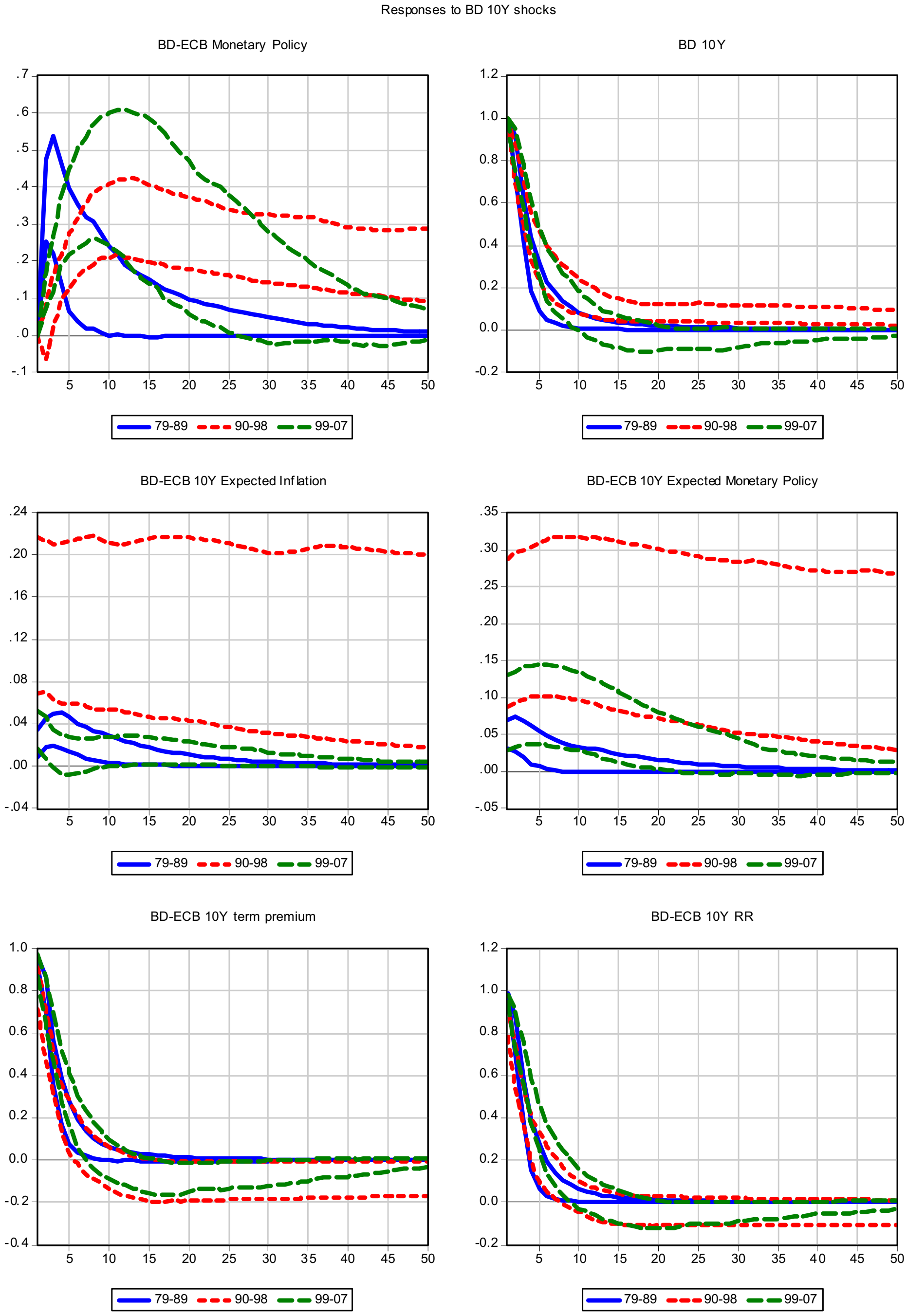

Figure 14: Impulse responses to German-Euro term premia shocks