

The Euro Area and World Interest Rates

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November 29, 2004

Abstract: We analyze the behavior of world interest rates, focusing on the ramifications of European Monetary Union. Our analysis indicates that nominal US interest rates tend to drive European rates at both the short and long horizons. There is some evidence that US rates are becoming increasingly influenced by European rates, but the relationship is still far from symmetric, despite EMU. We also investigate the empirical determinants of real interest rates over the past decade and a half. Real US interest rates also have an influence upon European rates, although German rates do not appear to have a similar effect upon US rates. Conditioning on foreign interest rates, we find that real interest rates on government debt depend significantly upon current and expected levels of debt, in Europe as in the US. It follows that if US and European budget deficits continue to grow more rapidly than official forecasts, interest rates will rise. What had previously been a strong effect on US interest rates has been diluted by the addition of 2003 to the sample, perhaps reflecting the effect of massive purchases of US securities by foreign central banks.

Keywords: interest rates, inflation, debt, financial integration

JEL Classification Nos.: E43, E58, F41

Acknowledgements: We thank Pierre Siklos, Robert Rasche, Ignazio Angeloni, Jakob de Haan, Petra Geraats, and the other participants at the CEPR/ESI conference on “The Euro Area as an Economic Entity,” (September 2003) for useful comments. Gabriele Galati and Frank Westermann provided useful suggestions, and Thomas Laubach provided data on CBO forecasts. Chinn acknowledges the hospitality of the Chicago Fed, where he was a guest scholar during part of the writing of this paper. The views contained herein are solely those of the authors, and do not necessarily represent those of the institutions with which the authors are associated.

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1. Introduction

How has European monetary integration affected the determination of world interest rates? This question comprises a number of empirical and policy debates. The first question is: Is there a “world interest rate”? In other words, has the dismantling of the legal and regulatory impediments to capital controls, accompanied by decreases in transactions costs, resulted in an essentially integrated pool of financial capital? With the rapid evolution of financial markets in the Euro area, a re-examination is warranted. The opportunity to revisit the theme of world interest rates is particularly welcome because it has been over a decade since the last extensive discussion of the “world interest rate” and its determinants (Blanchard and Summers, 1984; Barro and Sala-i-Martin, 1990). Another decade of data is always useful, and another chance to see if the 30-year trend of increasing integration across markets has continued. But there are two more topical issues to be addressed as well.

The first has to do precisely with the achievement of European Economic and Monetary Union in 1999. In the past, US interest rates have had a greater influence on rates in Europe than the influence of European interest rates on the United States, even though the European economies in the aggregate are roughly as large as the United States – larger, if one includes the non-euro members of the European Union.¹ One explanation is that the asymmetry arose from strategic interaction between one central bank in the United States versus 15 central banks in Europe. The US has had a first-mover advantage (which game theory could model as a Stackleberg equilibrium), and the European monetary authorities have been left with “take it or leave it.” A second, not inconsistent, explanation for the asymmetry is that it arose from the fact that the European countries have been more sensitive to their exchange rates, because they have been more open to international trade as a share of their GDPs (which in turn is primarily because they are smaller, and secondarily because they are close together, while the US has fewer natural trading partners). Each of these two explanations should have disappeared now. That the ECB now speaks for all 12 euro countries should have obviated the first explanation. That the euro area as a whole is no longer substantially more open to trade than the United States should have obviated the second explanation. Thus the year 2004, when we have the benefit of

¹ Furthermore, US interest rates have had a greater influence on third countries – especially those in the Western Hemisphere and East Asia – than have European interest rates. E.g., Chinn and Frankel (1994) and Frankel and Wei (1995).

four years of experience with EMU, is a good time to see if the asymmetry of US dominance remains, or if Europe taking on a more central role in world financial markets.²

The other topical issue concerns the role of fiscal policy. One might have thought that the debate over whether fiscal policy affects interest rates would have been settled by now. [The authors might have thought that the debate had been settled in the direction of rejecting Ricardian equivalence as a practical description of the real world, with all sorts of available theoretical explanations.] But the issue has taken on renewed controversy in the light of a current domestic debate in the United States regarding the 2001 and 2003 tax cuts and the associated budget deficits. Gale and Orszag (2003) review the literature regarding effects of current and expected future budget deficits on interest rates,³ and conclude:

“...studies that (properly) incorporate deficit expectations in addition to current deficits tend to find economically and statistically significant connections between anticipated deficits and current long-term interest rates.” (p. 20)

But others strongly disagree with many of these studies, and with the Gale and Orszag’s overall characterization of the state of empirical evidence. Looking at additional European data may shed additional light on this unsettled debate. Perhaps the major incremental contribution of this paper is to make a first attempt at measuring the effect of expected future euro-area budget deficits on European interest rates, in the manner that others have done for the United States. Furthermore, it is not just the long-run fiscal outlook in the United States that is deteriorating; many European countries face even larger future fiscal demands from the next generation of retirees. Meanwhile, the Stability and Growth Pact that was supposed to limit European fiscal deficits appears to be coming unravelled. Thus the up-to-date international evidence on interest rate determination should be equally useful on both sides of the Atlantic.

These two issues – trans-Atlantic monetary transmission and the effects of deficits on interest rates – are conveniently addressed in the same study. That is because interest rates are determined by multiple factors. Indeed it will turn out in our results that conditioning on foreign interest rates is essential for uncovering the effects of domestic debt.

² That the United States has gone deeply into net international debtor position is another reason to ask if its dominance over international financial markets may have diminished over time, even while its geopolitical dominance has increased.

³ To some observers, the tax cuts enacted by the Bush Administration seem unusually designed to lose tax revenue in the long run, relative to the fiscal stimulus delivered in the short run. Thus the distinction between current deficits and expected future deficits may be more relevant now than in the past.

The importance of taking into account multiple factors seems obvious. But perhaps it needs to be stated explicitly, in that the official response of the Bush White House to critiques of its fiscal policy was that “interest rates do not move in lockstep with budget deficits.”⁴ This proposition is of course true: because interest rates are influenced by a number of factors, including most plausibly the cyclical position of the economy, monetary policy, and international influences, interest rates can often be observed to change at times when fiscal policy has not changed, even under the hypothesis that government borrowing causes interest rates to be higher than they otherwise would. Our regression analysis of long-term interest rates will include a variety of factors, including expected future deficits, cyclical position, and cross-Atlantic influences.

In each case -- the nature and extent of international macroeconomic spillovers and the transmission mechanism for monetary and fiscal policy -- the ultimate motivation concerns effects on real economic activity. Long term interest rates are thought to matter for economic activity more than short rates. Indeed, expected future budget deficits should in theory matter for long-term interest rates, not short. But most statistical studies that emphasize international linkages deal only with short-term interest rates. This paper concentrates primarily on long-term rates. Of course it is long-term *real* rates that should matter, more than nominal rates. Accordingly [and notwithstanding that inflation has been more stable in recent years than in the 1970s and 1980s], our analysis will account for the role of inflation.

The paper proceeds in the following fashion. The empirical evidence for short term interest rates comes first. That for the longer term interest rates follows. Finally we examine the determinants of bond rates. Our first pass at examining the questions posed above using various econometric techniques, produces the following tentative conclusions:

- At the short horizon, financial capital is extremely highly integrated. This conclusion is driven by the examination of standard money market rates at low frequencies (monthly),

⁴ This was the sentence crafted by Glenn Hubbard, as Chairman of the Council of Economic Advisers, to be used for media consumption, presumably because to the public it would appear to be consistent with the Reaganite claim that deficits would have no effect on interest rates and thus would not lead to crowding out of investment. At the same time, he designed a response for a professional readership to the effect that the quantitative effect of budget deficits on interest rates, though positive, is small, because that is all it takes to crowd out the capital stock in a standard economic framework: “the \$1.3 trillion in tax relief included in EGTRRA [the Economic Growth and Tax Relief and Reconciliation Act of 2001] would raise interest rates by only about 19 basis points.” Hubbard (2002) and Council of Economic Advisers (2003).

as well as event studies on high frequency data. Interestingly, the direction of effects seems still to run predominantly from the United States to the Euro area; EMU has not defeated the asymmetry.

- For yields on government debt instruments of longer maturity, the evidence is more mixed. There is evidence that long term instruments are linked, but the linkage is not perfect.
- Real and nominal rates on government bonds appear to have idiosyncratic effects. In particular, rather than being solely affected by global factors, country-specific factors appear to have some effect. Interestingly, while U.S. interest rates appear important for determining European rates, the reverse is not true, suggesting that the United States, up to this point, still dominates world capital markets.
- For the US, current and expected debt to GDP ratios appear to influence real long term interest rates over the 1988-2002 period. However, expected changes in the debt to GDP ratio are not statistically significant when the sample is extended to include 2003. The significance of expected debt changes rises when one econometrically accounts for the large purchases of US Treasury bills, primarily undertaken by East Asian central banks, in 2003.
- A measure of expected future European deficits does have an effect on European long-term interest rates. This is one more piece of evidence that government borrowing does have an effect on interest rates, and presumably crowds out components of private demand.

2. Interest Rates at the Short Horizon

We begin with short-term interest rates.

2.1 A look at the data

At first glance, the proposition that there is, increasingly, a single world interest rate seems questionable. Figure 1 displays the nominal money market interest rates for the US, UK, Germany and Japan. Convergence does not appear evident. Of course, there are good reasons to expect rates to diverge, even with perfectly mobile and substitutable capital. Expected inflation rates and exchange rate changes can introduce wedges between observed interest rates. Hence, Figure 2 displays the corresponding real interest rates (nominal rates adjusted by previous year's inflation). Real rates *have* converged across these four, especially since the 1970's, when large variations in inflation occurred. However, it is not apparent from visual inspection that these rates have converged further since, say, the 1980's when many of the developed country restrictions were dismantled, as reflected in the earlier tests already cited.

These graphs do not include enough European countries to observe the change in interest rate dynamics that occurred with European Economic and Monetary Union. There the change is remarkable. Figure 3 reacquaints the reader with the magnitude of the shift. It exhibits the series for the four large Euro area economies: Germany, France, Italy and Spain.

So we have disparate trends – increasing convergence within the Euro area, but persistent divergence outside. Indeed, the Euro area short term interest rate has diverged substantially from that in the U.S., in both directions at different times, as demonstrated in Figure 4. This outcome has been the inspiration for any number of critiques and defenses of the conduct of Euro area monetary policy. We make no comment here on this interesting subject, except to note that convergence of the levels of nominal variables denominated in different currencies need not carry implications for differences in the real ease of monetary policy.

While a visual examination of the data is illuminating, it is hard to discern whether the rates are converging in a fashion dictated by some economic theory. Moreover, it is hard to impute the direction of causality. Hence further analysis is warranted.

2.2 Theoretical Linkages

It is useful to recount a decomposition of the international interest rate differential. Consider the difference in interest rates between two economies on assets of equal maturity and default risk, when expressed in common currency terms:

$$(i_t^k - i_t^{k*}) \equiv [i_t^k - i_t^{k*} - (f_{t,t+k} - s_t)] + (f_{t,t+k} - s_{t+k}^e) + \Delta s_{t+k}^e \quad (1)$$

where s is the (log) exchange rate in terms of domestic currency units per foreign currency unit, and $\Delta s_{t+k}^e \equiv s_{t+k}^e - s_t$.

Equation (1) makes clear that nominal interest rates should be equalized only under a number of assumptions. Each of the three terms on the right hand side of (1) are of interest in their own right. The term in square brackets is called the covered interest differential and the term $(f_{t,t+k} - s_{t+k}^e)$ is sometimes labeled the exchange risk premium. The covered interest differential, or country premium, is oftentimes identified as the political risk associated with capital controls or the threat of their imposition (Aliber, 1973; Dooley and Isard, 1980). When both of these terms are zero, then the interest differential equals expected depreciation. One useful terminology goes as follows: Total linkages among countries' interest rates depend on the strength of financial links (measured by the narrowness of the covered interest differential) and currency links (measured by the narrowness of the risk premium and expected depreciation, combined). Or: the interest differential is equal to the country premium (determined by such factors as capital controls, transaction costs, imperfect information, default risk, tax differentials, and risk of future capital controls) plus the currency premium (determined by expected depreciation plus the exchange risk premium).⁵

In this context, it is of some interest to consider how the evolution of short term nominal interest rates has proceeded. As illustrated in Figure 3, all short term interest rates within the Euro area have converged with the advent of monetary union, so that it is no longer meaningful to talk about disparate money market rates (Galati and Tsatsaronis, 2001; Hartmann, et al., 2003). That is, both financial and currency barriers are essentially gone within the Euro area.⁶ However, considerable differences remain between interest rates in continental Europe versus other countries. Since covered interest differentials for the industrialized economies have been nearly zero since the 1980s⁷, this dispersion must be attributable to currency differences.

⁵ The analogous decomposition can be applied to either the nominal interest differential or the real interest differential. See Chinn and Frankel (1994), Frankel (1991, 1992), and Frankel and MacArthur (1988).

⁶ This refers to short horizons. There are still some non-zero differentials in the rates at which different European governments can borrow long-term, attributable to country risk, as predicted by Goldstein and Woglom (1992) on the basis of experience among US states.

⁷ E.g., Frankel (1991, 1992).

2.3 What Affects Currency Links?

Much of the convergence in nominal interest rates is associated with the convergence in inflation rates. So, beyond the global phenomenon of reduced inflation over the past few decades, it is difficult to assert on the basis of this evidence that short term rates are more “linked” than they used to be. In the language of econometrics, it may be that an observed covariance of interest rates is due to common shocks affecting national economies. Monetary authorities who exert substantial control over short rates may be reacting to common shocks. Disentangling these different explanations is a difficult task.

There are (at least) two ways of approaching this task. In both cases, it proves useful to relegate the interest rate decomposition to the background, allowing for the risk premia and expected depreciation to become the residual terms, while bringing forward the individual interest rate series.⁸ Making the problem concrete, we focus on the US-Euro interest rate relationship, taking advantage of a new four years of data in which continental Europe can be represented by a single interest rate.

The first approach is to ask what observable factors drive short term interest rates in both countries at high frequency. Ehrmann and Fratzscher (2002) examine the effect of news on both US and Euro rates (as well as German rates from 1993 to 1999). They collect data on monetary policy announcements as well as macro announcements and, using expectations survey data from MMS International, create a series of “news” variables. The announcements pertain to GDP, price, money, consumer confidence, and other announcements. They find that US announcements affect the means of both US and German or Euro area rates, while Euro area announcements do not generally affect the mean of US rates.⁹ In other words, asymmetric causality continues to flow in one direction – Eastward – across the Atlantic.

The second approach is to consider the money market rates as being driven at a slightly lower frequency by changes of policy, bringing to the fore the roles of the ECB and the Federal Reserve. By now, there is a vast amount of research that examines the intermediate targets of the Federal Reserve. It is fair to say that most accounts do not ascribe a central role to foreign interest rates or the exchange rate.

⁸ There is an enormous literature on the subject of what determines the exchange risk premium, and how expectations of depreciation behave. Engel (1996) reviews the (not entirely successful) literature on bias in the forward discount. Chinn and Frankel (2002) study exchange rate expectations.

⁹ There is slightly more evidence of two way effects for the variances of the rates. Furthermore, German or Euro area announcements do appear to affect mean US rates at the one month maturity.

In contrast, there is a widespread view that the European bank has followed the Fed's actions. This was especially true in the first two years of the ECB's existence. The ECB was somewhat slow to follow the Fed's lead in reducing interest rates after the start of the 2001 recession; but as recently as March 2003, when the ECB has eased, the US interest rate reductions have been cited as an impetus (perhaps mediated by the decline in the dollar against the euro, which lagged behind the US switch to monetary ease by about a year). Casual inspection of Figure 4 would lend credence to this perspective. One statistical study extending to late 2002, however, found little evidence that Fed decisions on the target Fed Funds rate systematically preceded ECB changes in the refinance rate.¹⁰ So the question is open.

There is no direct evidence that the ECB takes into account exchange rate fluctuations directly into its decision-making process. However, there is suggestive evidence from the Clarida-Gali-Gertler papers examining the behavior of European central banks indicating that exchange rates have mattered in the past. It is not even necessary to argue that the exchange rate enters *directly* into the objective function of the ECB; it may be that the Euro area is sufficiently sensitive to imports, for example, that the exchange rate is an important determinant of output and inflation, which *are* in the ECB's Taylor Rule.¹¹ This point is implicit in the *Economist's* assessment of the ECB's March 6th decrease in the policy rate. As it turns out, Clarida et al. (1998) do find that exchange rate considerations matter for Bundesbank and Bank of Japan behavior. However, they also find the effects are quantitatively small.

We undertake an analysis of whether, statistically speaking, US nominal money market rates drive German, vice versa, or whether both drive each other. The data we analyze are presented in Figure 5. We specify a vector error correction specifications incorporating nominal US money market rates (i^{US}) and German (and subsequently Euro area) rates (i^*).

$$\Delta i_t^{US} = \eta_{10} + \phi_1(i_{t-1}^{US} - i_{t-1}^*) + \sum_{k=1}^j \nu_{1k} \Delta i_{t-k-1}^{US} + \sum_{k=1}^j \theta_{1k} \Delta i_{t-k-1}^* + e_{1t} \quad (2)$$

$$\Delta i_t^* = \eta_{20} + \phi_2(i_{t-1}^{US} - i_{t-1}^*) + \sum_{k=1}^j \nu_{2k} \Delta i_{t-k-1}^{US} + \sum_{k=1}^j \theta_{2k} \Delta i_{t-k-1}^* + e_{2t} \quad (3)$$

¹⁰ See Garcia-Cervero (2002). Formally, she uses a Granger causality test using daily data, with varying windows. Only when two months of lags are allowed is there some evidence of Fed decisions Granger causing ECB decisions. Interestingly, the link from the Fed to the Bank of England is much stronger.

¹¹ An example of this approach can be seen in Chinn and Meredith (2004). The monetary authorities are assumed to react to output and inflation gaps, but aggregate demand and supply depend upon the real exchange rate. Hence the exchange rate indirectly affects the central bank's decisions.

Notice that we have imposed long run cointegration between the nominal rates of interest, where the long run elasticity between US or European rates are unity.

Using monthly data, the lag length is selected so that the residuals are approximately white, according to a Q-statistic test for sixth and twelfth order serial correlation. We also check to see that higher order lags are not statistically significant.

Of central interest is the coefficient on the error correction term. If ϕ_1 is statistically significant, then the US rate moves to close any gaps between the US and German rate. That is, the German rate would be weakly exogenous for the US rate. Analogously, if ϕ_2 is statistically significant, then the German rate responds.

The results are reported in Table 1. According to the top panel, for the earlier period of 1973m03-1995m12, the US rate does not respond to the disequilibrium, while the German rate does. In the later period of 1996m01-2004m09, displayed in the bottom left hand side panel, this same pattern persists. That is, once again the US rate does not respond, while the German rate does. In a sense, this is not the most interesting comparison; the behavior of the euro rate is the variable of attention. At the cost of reducing the sample size, we find that the euro area's money market rate also seems to respond more than does the US rate (bottom right hand side panel).

While none of these empirical results is conclusive, the weight of evidence seems to suggest that US rates tend to have greater influence on Euro rates than the reverse.

3. The Longer Horizon: Time Series Evidence

If our motivation for considering international interest rate linkages is transmission of monetary policy, then we should ultimately be more interested in long-term real interest rates than short-term nominal rates.

3.1 The Extant Literature

Tests of the integration of markets for bonds of longer maturity using the covered interest parity and uncovered interest parity conditions are much less common than those at the short horizon. The key reason is obvious – there is a dearth of appropriate data for such instruments. In principle, one requires zero coupon yields for constant maturities. These data are seldom available. Moreover, when it comes to statistical analysis of expected returns (for tests of

uncovered interest parity, real interest parity, or the exchange risk premium) very few non-overlapping observations on the realized change in the exchange rate or price level are available when the maturity or horizon is long-term.

That being said, several studies have recently examined how well markets for government bonds are integrated using the covered and uncovered parity conditions, at 5 year horizons (Popper, 1993) and at 10 year horizons (Meredith and Chinn, 1998). They have not necessarily supported the conventional wisdom that financial markets are less highly integrated at these longer horizons than at short horizons. Popper found that covered interest parity held approximately, while Meredith and Chinn found that for the G-7 currencies uncovered interest parity was more difficult to reject at the 5 and 10 year horizons as compared to the short horizons. Fujii and Chinn (2001) also found that real interest parity was more likely to hold at longer horizons than short, although the interpretation of the results was complicated by the difficulties in proxying expected inflation.

It would appear that these failures to reject uncovered interest parity combined with rational expectations (sometimes termed the unbiasedness hypothesis¹²), or real interest parity, would indicate a fully integrated world capital market. The failure to reject a null is of course not the same as rejecting the alternative; in this case this observation is critical. Chinn and Meredith obtained point estimates that often deviated from the posited value of unity, and with very large standard errors, so that the power of the tests could be construed as low. A similar point can be applied to the real interest parity tests of Fujii and Chinn.

Perhaps more important is the fact that certain countries consistently fail the ex post RIP test – including Italy. Once one leaves the set of G-7 countries, one finds even less evidence in favor of either uncovered interest parity or real interest parity. In Madarassy and Chinn (2002), for instance, the Spanish peseta fails real parity tests (using forecasted inflation). Hence, how nominal and real rates of different countries covary remains an open research question.

An inspection of ten year benchmark bond yields for US, Japan, Germany and UK provides a telling picture of interest rate convergence, with the notable exception of Japan (Figure 6). An inspection of real rates leads to a slightly different conclusion. Now Germany

¹² Chinn and Frankel (2002) and Froot and Frankel (1989) argue that a test whether the interest differential is an unbiased predictor of future exchange rate changes should not be referred to as a test of uncovered interest parity alone. Findings from survey data bolster the claim that the other half of the joint hypothesis might fail -- that expectations might be biased within a given sample, whether due to peso problems, gradual learning in a changing world, or a failure of most investors to process optimally all available information.

appears to be the outlier as of mid-2003, while Japan's recent real interest rate appears not dissimilar to those of the US and the UK (although there is a wide variation in 1997). But of course, this finding hinges crucially upon the measure used for proxying expected inflation over the relevant horizon. Here we have used the simple expedient of the current trailing one year inflation rate as a proxy for the expected inflation rate over the subsequent ten years. We will discuss this assumption at further length below, and additionally will present some sensitivity tests to demonstrate how the results change with alternative measures. We will not examine the behavior of the Japanese interest rate, in part because expectations of inflation in Japan have been subject to such uncertainty in recent years.

3.2 An Econometric Analysis

In this investigation, we will use quarterly data on ten-year benchmark bonds, adjusted by lagged one-year inflation. The data appendix describes the data series and sources in greater detail. We adopt the methodology from Chinn and Frankel (1995), treating the real interest rates over the sample period of 1973q1 to 2003q1 as nonstationary.¹³ We then examine the vector error correction specifications to determine whether US rates (r^{US}) respond to European rates (r^*), and vice versa.

$$\Delta r_t^{US} = \mu_{10} + \varphi_1 (r_{t-1}^{US} - r_{t-1}^*) + \sum_{k=1}^j \lambda_{1k} \Delta r_{t-k-1}^{US} + \sum_{k=1}^j \kappa_{1k} \Delta r_{t-k-1}^* + \varepsilon_{1t} \quad (4)$$

$$\Delta r_t^* = \mu_{20} + \varphi_2 (r_{t-1}^{US} - r_{t-1}^*) + \sum_{k=1}^j \lambda_{2k} \Delta r_{t-k-1}^{US} + \sum_{k=1}^j \kappa_{2k} \Delta r_{t-k-1}^* + \varepsilon_{2t} \quad (5)$$

Notice that we have imposed long run cointegration between the real rates of interest, where the long run elasticity between US or European rates are unity.

The approach is quite similar to that laid out in the previous section. However, a statistical analysis of real interest rates encounters an additional level of complexity, as it requires a measure of expected inflation. As already noted this problem is particularly difficult when the relevant horizon is quite long. That is, in order to calculate the ex ante real interest rate, we require the expected inflation rate over the subsequent period conforming to the maturity of

¹³ The assumption that the real interest rate is nonstationary is a contentious one. Theory suggests that the real rate should be stationary, but for purposes of statistical inference one wants the best time series characterization in the sample period under investigation. There is the additional complication that real rates over a later sample (1988 onward) appear more stationary than in the earlier period, or the entire sample.

the debt instruments. In general, we are using benchmark bond yields that have an original maturity of ten years, so the relevant horizon is approximately a decade. Modeling inflation expectations at this horizon is a difficult endeavor. Oftentimes in the case of the United States, resort is made to survey-based measures of inflation expectations, such as the Livingstone survey. Unfortunately, no such measures exist on a consistent basis across the sample of countries we examine.

Sack (2001) observes that the implied long term inflation rate derived from the spread between inflation-indexed instruments and nominal counterparts covaries strongly with the one year inflation rate.¹⁴ Consequently, in these regressions, we assume that the lagged inflation rate is an adequate measure of expected inflation. Our empirical measures of the real rates are illustrated in Figures 7-9.

3.3 The Empirical Results

One central question is whether EMU means that European interest rates in recent years have had a greater influence on US real interest rates than vice versa. Hence, we estimate the equations estimated over two subsamples: 1973q1-1995q4, and 1996q1-2004q2/3. The breakpoint is somewhat arbitrary. It is mainly dictated by data considerations – enough data points are required so as to be able to model adequately the short run dynamics in the error correction specifications. Consequently, we are not able to investigate a purely post-EMU sample from 1999q1 onward. But 1996 is also roughly the date when various measures indicate that European monetary integration became credible.

The results are reported in Table 2; panel A reports the results for the early sample, while Panel B reports that for later. Both the US and European reversion coefficients are reported, for each pairing. For the early sample, the US rate in all cases fails to respond to European long term real rates. In contrast, European rates respond fairly strongly. French and Italian rates respond most rapidly, closing a real interest rate gap (up to a constant) by over ten percent per quarter. Ignoring the short run dynamics, this means that the half life of a deviation was a little over one and a half years.

¹⁴ Complementary evidence is provided by Atkeson and Ohanian (2001). They report that at the one year horizon, the lagged one year inflation rate outperforms forecasts from structural macroeconomic models, and is as good as the Fed's Green Book forecasts, over the 1984-99 period, which corresponds approximately to our sample.

The results for the more recent period since the end of 1995 are more ambiguous. In some cases, the US long term real rate appears to move to close the gap between rates for all cases, but German and Spanish rates also exhibit this characteristic. Clearly, US rates close the gap at a more rapid pace than they did in the earlier period. Strong conclusions, however, must be tempered by an acknowledgement of the imprecision of estimates.¹⁵

For the later period, we can examine the aggregate behavior of the Euro area bond rates. In this later subsample, US rates adjust at a rapid rate of 0.39; Euro area rates – as measured by a weighted average of ten year bond rates – adjust at a rate of 0.12.

Each of the individual time series seems to have only limited information regarding the dynamics of real interest rates. In order to obtain more precision, we impose some homogeneity, and estimate panel fixed effects regressions for equations (4) and (5). Of course, this approach is not costless. We impose a common reversion rate for the European interest rates, while allowing their short run dynamics to differ.

These results are reported in Table 3. The entries in Panel A confirm the impression that US rates in the early period were unresponsive to disequilibria, while Euro area rates were. It is likely that the errors to each equation are correlated (since the differentials are all expressed relative to the US interest rate), so we also estimated seemingly unrelated regressions. These estimates are similar to those reported for the fixed effects regressions.

In Panel B, the panel fixed effects regressions indicate that both rates revert to parity with statistical significance. Interestingly, the US reversion rate is now more rapid than the European rate. This result is reversed when we re-estimate using SUR; then the European rates revert at a pace more rapid than that of the US (and the US rate of reversion is quite slow; the statistical significance arises from the small standard errors, rather than the magnitude of the coefficient).

In the panel context, we now have enough observations to estimate the model for the post-EMU period. These results, reported in Panel C, still exhibit great imprecision. While the US reversion rate shows up as rapid and statistically significant, the result appears very sensitive to the treatment of the errors across country-pairs. The SUR estimates indicate slow and insignificant reversion for the US real rate, and rapid reversion for the Euro area real rates.

¹⁵ In general, formal tests fail to reject the null of no structural break at 1996q1; most identified structural breaks occur in the mid-1980s around the time of the rapid decline in inflation rates. CUSUM squares tests do indicate structural breaks that encompass the 1996q1 date.

These results indicate that up to 1995, US real interest rates appeared to be driven by own-dynamics, while the real interest rates of Germany, France, Italy and Spain seemed to move to close gaps with the US. In the post 1995 period, the evidence is more ambiguous, with the US rate responding in some country pairs, and not in others. If we treat the aggregated European country rates as a single rate, then both US and Euro area interest rates respond to gaps between the two rates.

The fact both interest rates revert to a statistical concept of disequilibrium is interesting, but not definitive. We would like to know how the economic links between the two markets drive the evolution of real interest rates in the two economies. One complementary piece of evidence is provided in an analysis by Goldberg and Leonard (2003). They show, using hourly data on US and German two year and ten year note yields, that US announcements affect German yields at both horizons, but that German and Euro area announcements display little effect on US yields. These results extend those of Ehrmann and Fratzscher (2002) to instruments of longer maturity.

4. Government Bond Markets: Integrated or Not?

4.1 Review of the Literature

Thus far in the examination of interest rates on government bonds, the analysis has relied primarily upon the pure time series evidence. However, examination of interest rates alone tells us little about the determinants of those rates. Here, we take tackle the issue of the medium-run determinants of real interest rates. The central issue will be the relative importance of *identifiable* global versus national factors.

The question of whether interest rates are determined in national or global markets has been a source of debate over the past few years. On one side are those who view the capital market as a single pool of funds for the OECD countries (Ford and Laxton, 1999). Sometimes, in fact, the complete integration of the capital markets is taken as given, as in Barro and Sala-i-Martin (1990). On the other side are those who aver that, while global factors are important, national factors retain a key importance (Christiansen and Pigott, 1997; Breedon et al., 1999).

The methodology underlying the tests for national versus global factors is quite straightforward. The government bond rate is related to own-country variables, after controlling

for either the inflation rate or the short rate. This relation is augmented by either a proxy for global variables, foreign interest rates, or both. Hence, the regressions take the form of:

$$r_t = \beta_0 + \beta_1 X_t + \beta_2 Z_t + u_t \quad (6)$$

where r is the national real interest rate, X includes domestic factors and Z includes global factors.

Ford and Laxton (1999) examine one year off-shore real (ex post) interest rates for eight OECD countries over the period December 1977 to December 1997. Essentially, they place own country debt to GDP ratio in X , OECD-wide debt to GDP ratio, and OECD-wide government consumption to GDP ratio (and change therein) in Z . They find that the OECD-wide variables explain a large proportion of variance in national real rates, with adjusted R-squared ranging from 25 to 60 percent (Denmark and Germany respectively). OECD-wide debt is always statistically significant, as are the changes in aggregate consumption (the levels are significant about half the time). The statistically significant coefficient estimates on OECD debt range from 0.23 to 0.45 (Germany and the UK, respectively). Their panel estimate of the effect is 0.23 for all eight countries in the sample, and 0.18 for the European countries of Belgium, Denmark, Germany, Netherlands and Switzerland.

The inclusion of own country debt should yield statistically significant positive coefficients under the “national factors matter” view. In fact they do occasionally (Belgium); but more often the significant coefficients have a negative sign, which is surely counterintuitive. Their finding that aggregate debt and consumption matter is robust to the addition of other OECD-wide variables including the *growth rates* of the labor force, employment, GDP, labor productivity, net public debt and GDP inflation.

Breedon et al. (1999) find, in contrast, a substantial role for domestic factors. Examining the G-3 economies over the 1975q2-1988q4 period,¹⁶ they estimate the regression:

$$r_t^\ell = \gamma_0 + \gamma_1 d_t + \gamma_2 d_t^w + \gamma_3 r_t^s + \gamma_4 r_t^{\ell,w} + u_t \quad (7)$$

where r^ℓ ($r^{\ell,w}$) is the national (global) real interest rate, d (d^w) is the national (global) debt to GDP ratio, and r^s is the short term national real interest rate.

¹⁶ The sample is truncated at 1988 because the authors use ex post 10 year real interest rates.

They find that own-country debt to GDP matters, while OECD-wide debt matters as well, although the effect on Japan's real interest rate is perverse. That is a rise in OECD-wide debt to GDP induces a decline in Japanese real interest rates. In all cases, either one or two of the other country long term real interest rates are also found to be a statistically significant determinant of local interest rates.

To an extent, the results of this study are more relevant for our purposes as the authors examine long term real rates, rather than short term rates. However, there are two caveats to keep in mind here. First, in that Breedon et al. examine the three largest economies in the world, one would expect local factors to be important. Second, because of the limitations imposed by using ex post real rates, the sample encompasses a period (1975-88) of capital account regulation and liberalization, and omits the most recent period when it is believed that capital has become increasingly mobile.

Most recently, Ardagna et al. (2004) have examined a similar question to ours – namely the effects of public debt and deficits on long term interest rates in a panel of 16 OECD countries. They find that a one percentage point increase in the primary deficit leads to a 10 basis point increase in the long term rate, while public debt has a nonlinear effect. At low levels of debt, increasing debt ratios cause a decrease in long term interest rates, while at higher levels, debt causes elevated interest rates.

One factor that is omitted from all previous cross-country studies of the interest rate-debt nexus, including the Ardagna et al. study, is the role of expectations regarding deficits and debt. We cited the Gale-Orszag survey at the outset. Among the many relevant studies, two examples are particularly recent and relevant. Canzoneri, Cumby and Diba (2002) find that changes in the 5 year and 10 year ahead forecasted budget deficits result in a statistically significant increase in the spread between short term and long term interest rates (which they interpret in light of the fiscal theory of the price level). Laubach (2003) finds robust evidence of a relationship between 5 year and 10 year ahead projected deficits and debts and the level of long term real interest rates in the United States.

4.2 Cross-Country Evidence

We compile data on the Euro area economies of the Germany, France, Italy and Spain. Taken together, these countries comprise 80% of Euro area GDP (in 2003q1). We also examine

data for the US, UK, and Japan. The variables of interest are the net debt to GDP ratio, long term interest and inflation rates.

One key constraint is the limited availability on ways of projecting future deficits and debt. Unlike the United States, the various OECD countries do not appear to have produced a consistent series on projected deficits. The EU countries report short horizon budget deficit projections, but these appear to be a relatively new innovation. Hence, we use the two-year ahead OECD projections of budget deficits and net government debt reported in issues of the OECD's semi-annual publication *Economic Outlook*. Various studies have evaluated the time series properties of these forecasts for GDP and inflation, and have generally concluded that they are unbiased predictors.¹⁷ On the specific issue of fiscal forecasts, Artis and Marcellino (1998) find that the OECD projections are relatively accurate.

To be more specific, we use the December forecasts for each calendar year. For instance, the December 1998 forecast for two years ahead pertains to the year-2000 budget deficit and net debt. To retain comparability with some theory, and especially with previous cross-country studies, we focus on net government debt, rather than budget surpluses.¹⁸

The regressions we implement are of the form:

$$i_t^\ell = \gamma_0 + \gamma_1 \pi_t + \gamma_2 d_t + \gamma_3 E_t(d_{t+2} - d_t) + \gamma_4 \hat{y} + \gamma_5 i_t^{\ell, W} + u_t \quad (8)$$

where i_t^ℓ denotes a long term interest rate, π an inflation rate, \hat{y} the output gap, and $E_t(\cdot)$ a subjective expectations operator. In the baseline specification, we use the lagged one year inflation rate as a proxy measure for expected long term inflation.

The logic underlying this specification is straightforward. Expected inflation becomes built into the long term nominal interest rate. The effect is one-for-one under the Fisherian model. But, on the one hand, many models imply incomplete adjustment, at least in the short run (e.g., due to sticky prices or a sticky capital stock), while, on the other hand, some models imply that the effect of expected inflation on the interest rate is more than one-for-one (the Feldstein-

¹⁷ See Koutsogeorgopoulou (2000) for an assessment of forecast biases and precision of the OECD projections for GDP growth, inflation and current account balance. The debate over the relative performance of OECD and private sector projections was sparked by Blix et al. (2001) and Batchelor (2000).

¹⁸ Kitchen (2002), as cited by Gale and Orszag (2002), argues that the current full-employment budget surplus is highly correlated with the projected full-employment budget surplus, so little is gained by including expected variables in addition to the contemporaneous value.

Darby-Tanzi effect, which results from the income tax). This is why we generally do not constrain the inflation coefficient to be one.

With risk aversion, it is possible that there is an additional premium as well. Government debt-to-GDP, in the absence of complete Ricardian equivalence, has an impact to the extent that government financing crowds out private spending. The same argument applies to expected future debt. The output gap enters in as a summary measure of private sector demand for savings. Finally, the “world” interest rate enters to capture international factors. For the non-US economies, the US long term interest rate is used; for the US, the German interest rate is used.

One constraint imposed by the use of expectations data is that we can estimate the regressions only over the 1988 to 2003 period. Prior to 1988, the OECD did not report 2 year ahead debt projections; furthermore only one year-ahead budget surpluses were publicly available.

Another key issue pertains to the appropriate modeling of expected inflation. As discussed in Section 3, the assumption of one year lagged inflation as a proxy measure for future expected inflation appears as plausible as other comparators.

In the basic set of regressions implemented in Table 4, it is clear that a simple regression including only domestic variables – that is omitting US interest rates – yields dismal results, except for the United States, and to a lesser extent, the United Kingdom. In the case of Germany, for instance, the inflation coefficient is near zero, while the current debt-to-GDP ratio coefficient is significantly negative. The expected change in the debt-to-GDP ratio does have the correct sign, as does the output gap. However, the debt variables perform less well for France, (although better for Italy and Spain). Constraining the inflation coefficient to unity – i.e., assuming that the Fisherian relationship holds approximately – results in equally poor results for the German and French economies (these results not reported). For Italy and Spain, the coefficient estimates on the projected change in the two year debt-to-GDP ratio are large and statistically significant. Nonetheless, the equation estimates for these countries cannot be judged a complete success.

For the United States, the results are mixed, regardless of whether the inflation coefficient is freely estimated or constrained to unity. While the output gap and the current debt-to-GDP are statistically significant, expected changes in the debt ratio are not (Column US (1) in Table 4). Interestingly, if one constrains the slope coefficient on current and the expected change in the debt ratio to be the same (Column US (2)), then the debt variable is significant (and indeed more statistically significant than if the current debt variable were entered alone).

It is also noteworthy that the lack of significance is sample-specific. When the sample extends only up to 2002, the expected change in the debt ratio does enter with significance. This finding suggests that special factors prevailing in 2003 are at work. An obvious candidate is the large purchases of US Treasury securities by East Asian central banks over the past couple of years. The correlation between US ten year yields and intervention defined as gross purchases of Treasury securities, divided by US GDP, is depicted in Figure 10. In Column US (3), the regression is augmented by a proxy for this factor. Now the statistical significance of the expected debt ratio rises – although not up to conventional levels – and the proxy enters in negatively.¹⁹

Another way to evaluate this hypothesis is to estimate the equation in Column US (1) over the 1988-2002 period, and then compare the out-of-sample prediction for 2003 against the actual value. The prediction series is depicted in Figure 10 as the “fitted yield”. The estimated equation overpredicts the actual 2003 value of 3.98 percent by 1.83 percentage points²⁰

In Table 5, the constrained regressions are augmented with world factors – in this case the US interest rate for non-US countries. The results are now much more in accord with the maintained hypothesis – that both global factors and domestic factors matter. In all non-US cases but one, the coefficients are correctly signed.²¹ (The results do not differ substantially depending upon whether the inflation coefficient is restricted, so we only report the constrained regression results).

The debt-to-GDP ratio coefficient for Italy is 0.12, while that on the change in the ratio is 0.23. Both of these are quite large effects, and somewhat larger than those for the other Euro area economies. However, there is a large degree of imprecision in all the estimates.

The small size of our data sample argues that we should exploit the information in the cross section as well as that in the time series dimension. Consequently, we present in Table 6

¹⁹ The US balance of payments data do not completely align with IMF reported statistics on the change in the quantity of holdings of US dollars. We conjecture that appealing to IMF data might provide better results, but reserve investigation of this point for future research.

²⁰ Note that the standard error of the regression is 0.006212, or 0.62 percentage points. A two standard error bound implies that the fitted value is significantly different from the actual. In addition, a Chow forecast test rejects the no-break hypothesis for 2003 at the 5% level. The behavior of the long term bond market is also considered aberrant by industry observers; see for instance Dudley et al. (2004). Wilson and Fiotakis (2004) attribute the deviation more to the effect of intervention on the expected depreciation of the dollar as opposed to the direct effect on the stock of debt.

²¹ Inclusion of the German interest rate makes no material change to the results for the US; the German interest rate has a small coefficient estimate, which is not statistically significant. This result confirms the irrelevance of non-US factors over this sample period.

panel estimates of equation (5), using pooled data for France, Germany, Italy and Spain. The regressions include fixed effects, and significance levels are calculated using heteroskedasticity consistent standard errors. Scatterplots of the real interest rate against the debt-to-GDP ratio, the change in the 2 year ahead expected debt-to-GDP ratio, and the output gap are presented in Figures 11-13.

In the column 1, the results from a specification allowing free estimation of the inflation coefficient, and no world effects, is reported.²² The point estimate on the inflation variable is within two standard errors of unity. However, we obtain insignificant coefficients on the debt, expected debt and the output gap variables. Inclusion of the US long term interest rate (column 2) yields more encouraging results. The inflation coefficient is now closer to its posited value, while both the debt-to-GDP ratio and projected change are significant. The US interest rate is strongly related to the national long term rate.

The output gap variable does not appear to be statistically significant (and as we know in the time series regressions has inconstant behavior). Omitting the gap variable (column 3) results in a significant coefficient on debt, but not on expected debt. Constraining the inflation rate coefficient to unity, while including the US rate, does produce plausible coefficient and statistically significant estimates on both debt variables. Current debt has a coefficient of 0.06, while the projected change in the debt ratio obtains a coefficient estimate of 0.11 (column 4). All coefficients are statistically significant.

Even though there is no direct translation of the two-year ahead forecasts to five-year ahead for these countries, one can make a guess at the relationship using the US data. The slope coefficient of the regression of CBO's 5 year ahead change in the debt-to-GDP ratio on the OECD's 2 year ahead change yields a coefficient of approximately 2.27.²³ Now, the point estimate on the quasi-5 year ahead debt-to-GDP ratio is 0.058. For the sake of contrast, Laubach estimates the corresponding relationship for the US (over 1985-2002) of 0.053. Extending this

²² We have sidestepped the issue of nonstationary time series. In general, most of the annual series fail to reject the unit root null using the standard ADF statistic, an unsurprising result given the brevity of the sample. Cointegration tests are similarly uninformative. If we estimate the first difference counterparts to these regressions, one finds that the general outlines remain the same, although the significance level drops for the debt variables, and increases for the output gap. Reassuringly, the panel regressions estimated in first differences yields results similar to those in Table 6 (see Appendix 2).

²³ Thomas Laubach kindly provided the data used in his paper. Estimate from an OLS regression with no constant. The point estimate is 2.27 (standard error of 0.50), with R^2 of 0.49, SER of 0.060, and DW of 1.07. Sample period 1988-2002.

relationship between 2 year and 5 year ahead estimates to the other four countries, one obtains point estimates on the quasi-5 year ahead debt-to-GDP ratio of between 0.047 and 0.049 (standard errors of 0.13 and 0.14, respectively).

Returning to the use of our 2 year ahead projections, we now test for whether the US interest rate is merely proxying for G-7 debt, as suggested by Ford and Laxton (1999). In columns 5, we re-estimate the panel for the four countries, replacing the US interest rate with the G-7 debt ratio. In this sample (which differs from that studied by Ford and Laxton and Breedon et al.), the G-7 debt ratio has a perverse sign. The expected change in the debt ratio is no longer significant, but that is a consequence of allowing inflation rates to enter in freely.

One possibility is that it is expected G-7 debt that matters. However, this does not appear to be the case. Even after substituting this variable for current debt, US interest rates matter, while both domestic debt variables are statistically significant. G-7 debt is not statistically significant (and has a negative coefficient, in any case).

In sum, it appears that real interest rates depend upon domestic government debt and expected future debt. While international factors do matter, the finding that G-7 debt does not enter robustly suggests that the role of world debt is more complicated than that assumed in our specification. The relevant international factor appears to be the US capital market, as represented by the US rate.

These findings are striking, especially when placed in the context of the existing literature. However, it is important to observe that the evidence pertains to a long period of 16 years, of which only four years of post-EMU data are encompassed. In the most recent period, these country-specific effects must surely have shrunk for euro area countries. So while Hartmann et al. (2003) claims that “the integration of government bond market has advanced less than is the case for money market”, the yield spreads are now quite small relative to pre-EMU – on the order of 10 to 30 basis points, as opposed to multiple percentage points in 1988.²⁴ This observation suggests that Euro area wide debt might now be more important post-EMU. Unfortunately, this effect cannot yet be discerned empirically.

²⁴ See Figure 8 in Hartmann et al. (2003), p. 22 for a depiction of all Euro area interest rates.

4.3 A Complementary View on the Impact of Fiscal Policy: The Spread

So far we have examined how debt and expected debt affect the level of the interest rate. There is a literature that focuses on the determinants of the spread between the long term and short term rate (see Canzoneri, et al. (2003)). In the current context, there is some reason to believe that the spread is related to the expected change in debt; Figure 14 depicts the time series for these two variables for the US. Hence, we investigate how the spread between the 10 year yield and short term rate responds to our debt measures in this sample of countries.

The results are reported in Table 7. Simple OLS regression results are reported for the US and UK, and a fixed effects panel for the Continental European countries of France, Germany, Italy and Spain. The results indicate that the current debt matters for the four Continental European countries in our sample, and for the UK, although not for the US. And expected debt changes matter for both the US and UK. Consequently, while the American relationship between expected debt and the interest rate has been obscured in the last year, the link to the spread has remained in place.

5. Conclusion

Events in government bond markets returned to the fore in 2003 and 2004. We expect that attention will remain fixed upon yields in these markets in the rest of this decade. The reasons are obvious; in the United States, the policy-induced change in the cyclically-adjusted budget balance from surplus to deficit is likely to collide with additional financing demands from the private sector as the economy recovers. The vast purchases of US Treasury securities by East Asian central banks have only delayed that day of reckoning.²⁵ In the Euro area, the impending increases in public expenditures associated with populations that are aging even more rapidly than in the US will also put upward pressure on debt stocks and hence interest rates.²⁶

Our analysis indicates that over the past three decades, short and long term interest rates have been driven more from the US side than the European side. However, since European Monetary Union went into effect, long term real rates in both the United States and the Euro area have tended to move in such a manner as to close any gaps that open up between them. This is suggestive of two-way influences, although a structural economic model is necessary to make a stronger conclusion.

²⁵ Here we are in disagreement with the thesis forwarded by Dooley et al. (2003), and their succeeding papers.

Conditioning on foreign interest rates enables us to discern more sharply the domestic influences as well. One key contribution of our study is the finding of a role for actual levels and expected changes in national stocks of government debt over the past 16 years, thereby extending to Europe a result that others have found for the United States. The fact that global debt stocks do not explain particularly well the evolution of country-by-country real interest rates indicates that long term government debt is not perfectly substitutable. Unfortunately, we are unable to determine whether this characterization has changed since monetary union. For example, aggregate Euro area debt might now better explain the real interest rates for the long term government debt of Euro area governments. But, for now, we have too few observations to address this conjecture.

²⁶ See EEAG (2003) and European Commission (2001).

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Appendix 1: Data Sources, Description and Calculation

Raw Data

Interest rates. Money market rates are collected from IMF, *International Financial Statistics*, June 2003 CD-ROM, and downloaded November 4, 2004. Quarterly series are end-of-period interest rates. With the exception of the Euro area and Spanish rates (drawn from *IFS*), the long term benchmark bond rates were provided by Marjorie Santos of Data Bank Services, Monetary and Economic Department, the Bank for International Settlements, July 29, 2003. They update earlier series drawn from the BIS database from the Federal Reserve System (see Chinn and Meredith, 2004). (The 2003q2-2004q3 data are drawn from *IFS* long term bond series). The specific series are as follows:

Euro area: Monthly average of daily data, yield calculated using harmonized 10 year government bond yields, weighted by GDP. Source: ECB.

France: Monthly average of daily data, secondary market yields on 10 year (benchmark) government bonds. Source: Bank of France.

Germany: End of month data, secondary market yields on 10 year public bonds. Source: Bundesbank.

Italy: Monthly average of daily data, gross yields on 10 year (benchmark) government bonds. Source: Bank of Italy.

Japan: End of month data, bond yields on 10 year (benchmark) government bonds released by the Japan Bond Trading Co. Source: Bank of Japan.

Spain: Simple monthly average of daily yields on bonds with over two years maturity. Source: Bank of Spain.

UK: End of month data, gross (before tax) calculated redemption yields. Source: Bank of England.

US: End of month data, interest rate expressed on a bond equivalent basis, constant 10 year yield to maturity. Source: Federal Reserve Board.

In the annual regressions, the interest rates are averages of the quarterly series.

Prices. Prices are measured as CPI's, obtained from the June 2003 CD-ROM. In the case of the Eurozone, the CPI is a harmonized CPI over the 1998q1-2003q1 period. For the earlier period, the CPI is a GDP-weighted CPI series provided by Bernd Schnatz.

Debt and deficit series. The actual net government debt-to-GDP series and budget surplus-to-GDP series (observed and full employment) are collected from the December 2003 *OECD Economic Outlook*. Projected one-year and two-year ahead series are collected from December issues of *Economic Outlook*, 1987-2003. Net government debt (net government liabilities from 1994 onward) differs from gross debt as the government's financial assets are taken into account. Net government debt and projected net government debt for the G-7 derived from the December 1999 issue, while observations for 2000 through 2003 are calculated using the national series and GDP weights reported in each corresponding year's issues. The current and 5 year ahead debt-to-GDP ratios reported by the CBO were provided by Thomas Laubach of the Federal Reserve.

Output gap. The output gap series is drawn from the June 2004 *OECD Economic Outlook*.

Derived Series

Inflation rate. The quarterly inflation rates are calculated from 4-quarter changes in the national CPIs. In the annual regressions, the inflation rates are the average of the quarterly rates.

Real interest rate. In the baseline specification, the quarterly real rates are calculated as nominal interest rate minus corresponding inflation rate. In the annual regressions, the interest rates (both nominal and real) are the average of the corresponding quarterly rates.

Appendix 2: Panel Regression Results for First Difference Specifications

Appendix Table A1

Determinants of long term interest rates: inflation, debt and G-7 debt, output gap and foreign interest rate, in first differences, 1988-2003

	(1)	(2)	(3)	(4)	(5)
Inflation	1.000	1.000	1.000	1.000	0.211 (0.156)
debt ratio	0.045 (0.029)	0.068*** (0.026)	0.054* (0.029)		0.059** (0.025)
expected change in debt ratio	-0.053 (0.066)	0.009 (0.059)	-0.046 (0.068)	0.055** (0.026)	0.017 (0.044)
output gap	0.111 (0.129)	0.171 (0.128)	0.023 (0.138)	0.204* (0.116)	0.267** (0.116)
Foreign interest rate		0.585*** (0.184)		0.620*** (0.187)	0.628*** (0.141)
G-7 debt ratio			-0.119 (0.104)		
N	60	60	60	60	60
Adj.R ²	-0.03	0.13	-0.01	0.13	0.28

Notes: Seemingly unrelated regression (SUR)-fixed effects, in first differences (White robust standard errors in parentheses). Percentage variables defined in decimal form. N is the number of observations, Adj.R² is the adjusted R-squared. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 2
Long term real interest rates: reversion estimates

	US	Germany	US	France	US	Italy	US	Spain	US	Euro Area
Panel A 73q1-95q4										
Φ	-0.05	0.04*	-0.04	0.11***	0.04	0.09**	-0.03	0.12***	na	na
Lag	2	2	2	2	2	2	2	2		
N	92	92	92	92	92	92	69	69		
Adj.R ²	0.04	0.00	-0.01	0.11	-0.01	0.22	-0.03	0.19		
Q-stat(4)	4.95	4.49	5.11	15.17***	3.56	1.10	4.3	2.67		
Panel B 96q1-04q3										
Φ	-0.20*	0.16**	-0.63***	-0.05	-0.18*	0.07	-0.17***	0.18***	-0.39**	0.12*
Lag	4	4	3	3	4	4	4	4	3	3
N	35	35	35	35	35	35	35	35	35	35
Adj.R ²	0.12	-0.04	0.12	0.07	-0.05	0.05	0.07	0.16	0.09	0.27
Q-stat(4)	2.91	2.77	1.07	7.53	3.34	0.99	2.77	4.36	3.47	2.89

Notes: Φ is the OLS estimates from the error correction specification, using quarterly data (coefficient significance determined using Newey-West robust standard errors) The US coefficient should have a significant negative sign, or the European coefficient should have a significant positive sign, if the series are cointegrated. Lag is the number of lags in the VAR specification of the system. N is the number of observations, Adj.R² is the adjusted R-squared, and Q-stat(#) is the Box-Ljung test for serial correlation of order #. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 3

Long term real interest rates: fixed effects estimates of reversion coefficients
Early and later subsamples

	Fixed Effects		SUR	
	US	Euro Area	US	Euro Area
Panel A 73q1-95q4				
Φ	-0.018	0.092***	0.001	0.100***
Lag	2	2	2	2
N	327	327	327	327
Adj.R2	-0.01	0.12	-0.05	0.12
Panel B 96q1-04q3				
Φ	-0.257***	0.086*	-0.017*	0.139***
Lag	2	2	2	2
N	140	140	140	140
Adj.R2	0.06	0.05	-0.06	0.05
Panel C 99q1-04q3				
Φ	-0.543***	0.149	-0.080	0.176*
Lag	2	2	2	2
N	92	92	92	92
Adj.R ²	0.10	0.11	-0.06	0.14

Notes: Φ is the OLS estimates from the error correction specification, using quarterly data (coefficient significance determined using Newey-West robust standard errors). The US coefficient should have a significant negative sign, or the European coefficient should have a significant positive sign, if the series are cointegrated. Lag is the number of lags in the VAR specification of the system. N is the number of observations, and Adj.R² is the adjusted R-squared. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 4

Determinants of long term interest rates: inflation, debt and output gap, 1988-2003

	US (1)	US (2)	US (3)	Germany	France	Italy	Spain	UK
Constant	-0.012 (0.011)	-0.009 (0.007)	-0.007 (0.009)	0.095 (0.022)	0.088*** (0.020)	-0.145** (0.059)	-0.075 (0.062)	0.062*** (0.020)
Inflation	1.071*** (0.105)	1.074*** (0.100)	1.061*** (0.136)	0.055 (0.176)	0.955** (0.413)	1.749*** (0.253)	2.261*** (0.290)	0.857*** (0.238)
debt ratio	0.085*** (0.021)	0.080*** (0.011)	0.082*** (0.017)	-0.098* (0.048)	-0.135*** (0.044)	0.175** (0.064)	0.169 (0.127)	-0.072 (0.048)
expected change in debt ratio	0.054 (0.096)		0.068 (0.074)	0.018 (0.094)	-0.061 (0.093)	0.233** (0.130)	0.262* (0.127)	-0.096 (0.232)
Output gap	0.278* (0.149)	0.314*** (0.097)	0.225 (0.158)	0.098 (0.214)	-0.372 (0.246)	0.464 (0.414)	0.372 (0.233)	-0.554 (0.631)
Intervention			-0.471 0.377					
N	16	16	16	16	16	16	16	16
Adj.R ²	0.75	0.77	0.76	0.73	0.78	0.92	0.88	0.69
DW	2.13	2.11	1.98	1.03	1.43	2.24	0.86	0.86

Notes: OLS regression using annual data, in levels (Newey-West robust standard errors in parentheses). Percentage variables defined in decimal form. N is the number of observations, Adj.R² is the adjusted R-squared, and DW is the Durbin-Watson statistic. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 5

Determinants of long term real interest rates: debt, output gap and foreign interest rate, 1988-2003

	US	US	Germany	France	Italy	Spain	UK
Constant	-0.009 (0.010)	-0.006 (0.007)	-0.057 (0.046)	-0.031 (0.027)	-0.116** (0.048)	-0.047* (0.022)	-0.028 (0.024)
Inflation	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Debt ratio	0.065** (0.026)	0.067*** (0.016)	0.088 (0.064)	0.034 (0.038)	0.124* (0.062)	0.058 (0.061)	0.047 (0.047)
expected change in debt ratio	0.062 (0.087)		0.017 (0.076)	0.165* (0.082)	0.265* (0.132)	0.322*** (0.048)	0.032 (0.101)
output gap	0.306* (0.156)	0.257* (0.106)	0.175** (0.102)	0.239 (0.181)	0.194 (0.414)	0.309 (0.226)	-0.394 (0.273)
Foreign interest rate	0.168 (0.135)	0.128 (0.124)	1.033*** (0.354)	1.023*** (0.234)	0.752** (0.326)	1.083*** (0.135)	0.788*** (0.215)
Intervention		-0.356 0.366					
N	16	16	16	16	16	16	16
Adj.R ²	0.35	0.40	0.41	0.83	0.76	0.86	0.61
DW	2.16	1.99	2.14	1.76	1.51	2.16	1.69

Notes: OLS regression using annual data, in levels (Newey-West robust standard errors in parentheses). Percentage variables defined in decimal form. N is the number of observations, Adj.R² is the adjusted R-squared. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 6

Determinants of European long term interest rates: inflation, debt and G-7 debt, output gap and foreign interest rate, 1988-2003

	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	1.506*** (0.263)	1.100*** (0.200)	1.175*** (0.179)	1.00	1.048 (0.225)	1.00
debt ratio	0.005 (0.039)	0.082*** (0.023)	0.065*** (0.021)	0.056*** (0.018)	0.113*** (0.024)	0.085*** (0.021)
expected change in debt ratio	0.132 (0.090)	0.126* (0.066)	0.083 (0.056)	0.109** (0.049)	0.080 (0.056)	0.136*** (0.051)
output gap	0.180 (0.182)	0.150 (0.132)				0.115 (0.109)
Foreign interest rate		1.132*** (0.129)	1.136*** (0.131)	1.186*** (0.116)		0.906*** (0.261)
G-7 debt ratio					-0.320*** (0.041)	
2 yr ahead G-7 debt ratio						-0.053 (0.039)
N	64	64	64	64	64	64
Adj.R ²	0.75	0.89	0.89	0.70	0.88	0.71

Notes: Fixed effects regression using annual data, in levels (White robust standard errors in parentheses). Percentage variables defined in decimal form. N is the number of observations, and Adj.R² is the adjusted R-squared. *(**)[***] denotes significance at the 10%(5%)[1%] level.

Table 7

Determinants of long term – short term spread: debt and expected change in debt, 1988-2003

	US	GY,FR, IT, SP	UK
	(1)	(2)	(3)
Constant	0.011 (0.021)		-0.029** (0.012)
Debt ratio	0.009 (0.041)	0.034** (0.016)	0.101** (0.044)
expected change in debt ratio	0.302*** (0.055)	-0.046 (0.037)	0.152*** (0.039)
intervention			
N	16	64	16
Adj.R ²	0.50	0.25	0.41
DW	1.47	1.45	1.76

Notes: Columns (1) and (3): OLS regression using annual data, in levels (Newey-West robust standard errors in parentheses). Column (2), Fixed Effects SURE, White standard errors. Percentage variables defined in decimal form. N is the number of observations, Adj.R² is the adjusted R-squared. *(**)[***] denotes significance at the 10%(5%)[1%] level.

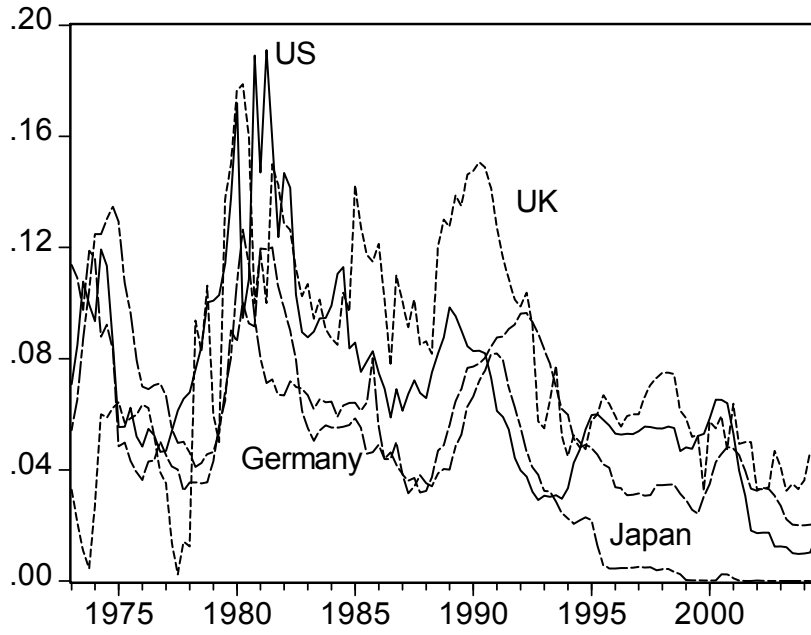


Figure 1: Short term interest rates for US, Germany, UK and Japan

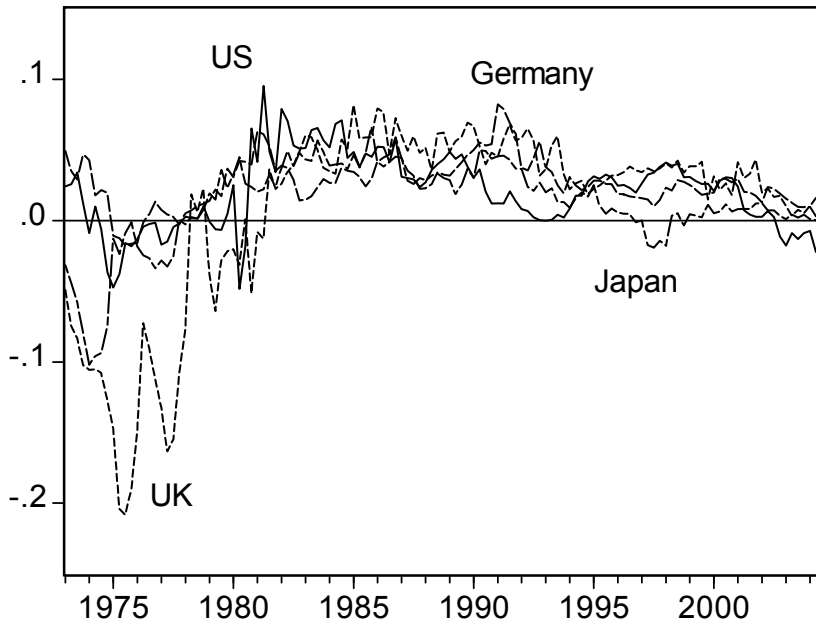


Figure 2: Short term real interest rates for US, Germany, UK and Japan

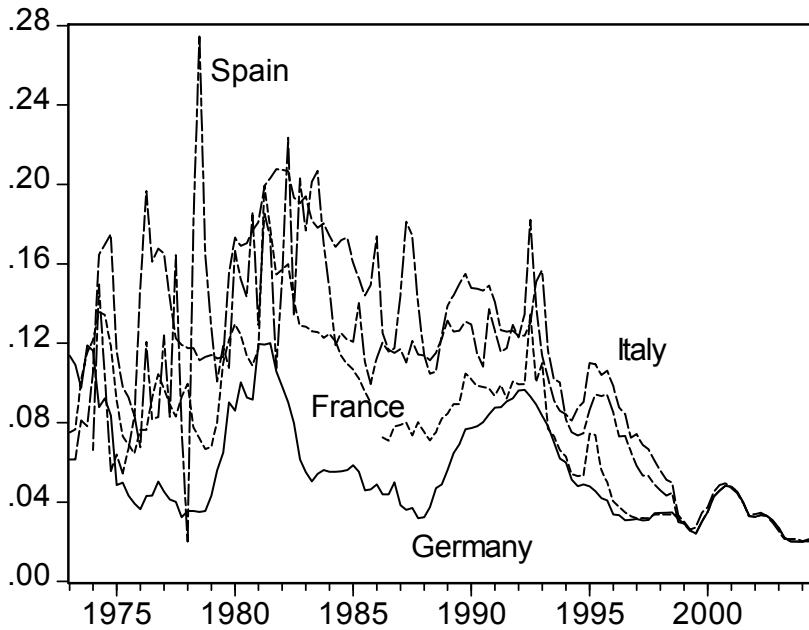


Figure 3: Short term interest rates for selected Euro Area economies

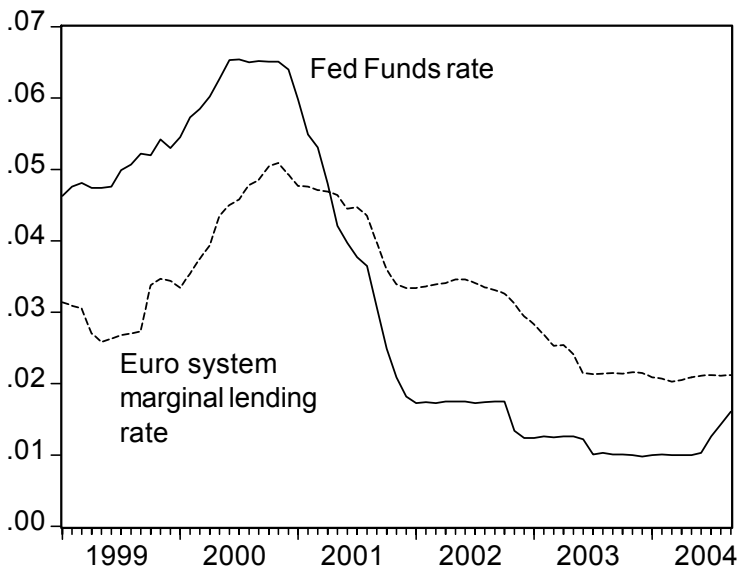


Figure 4: US and Euro system policy rates, monthly.

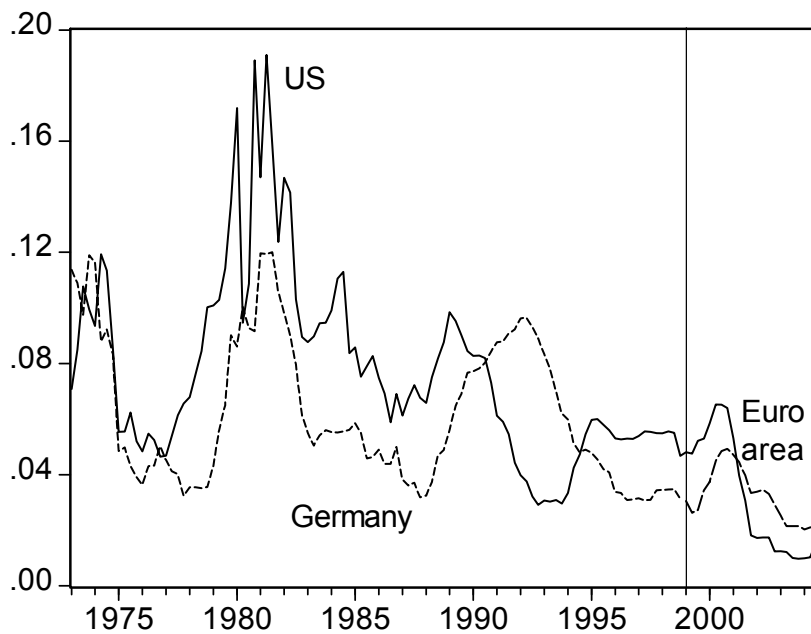


Figure 5: Nominal money market rates for US, Germany, Euro area, monthly

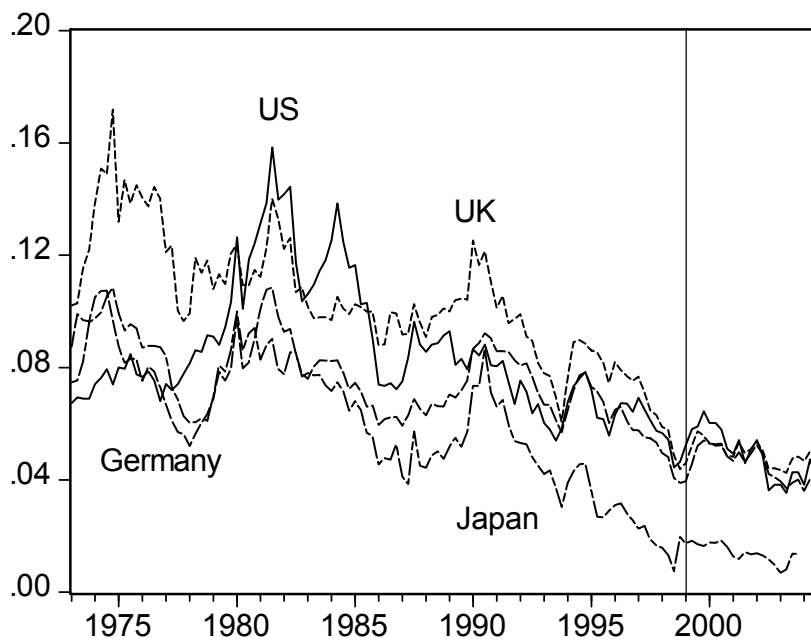


Figure 6: Long term bond yields

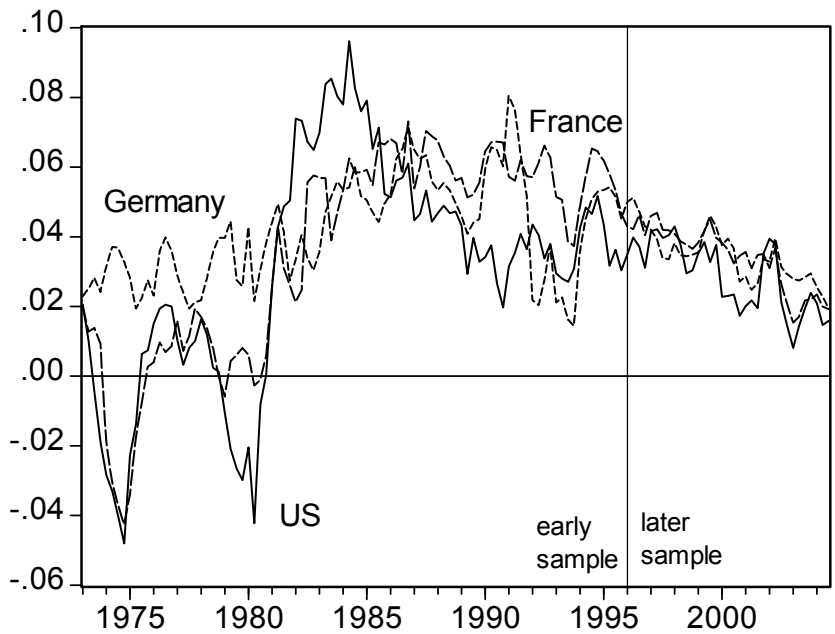


Figure 7: US, German and French real long term rates

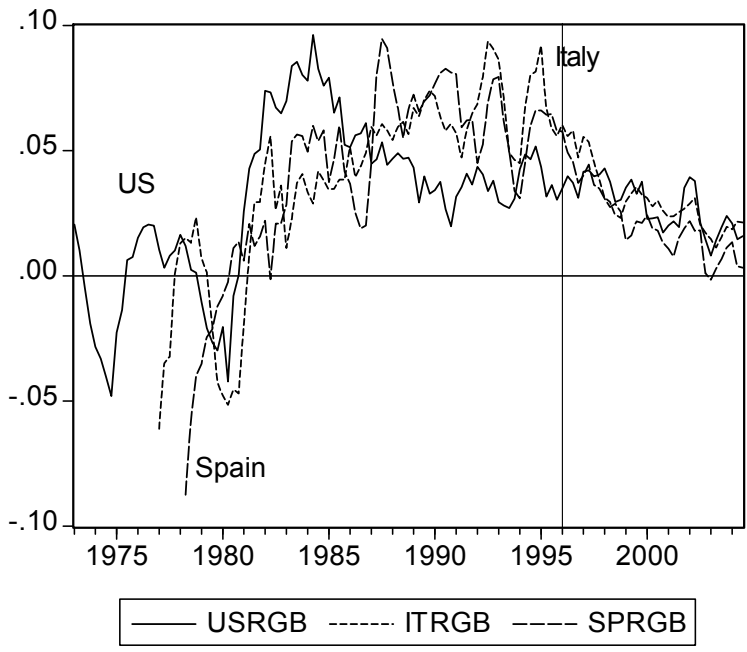


Figure 8: US, Spanish and Italian real long term rates

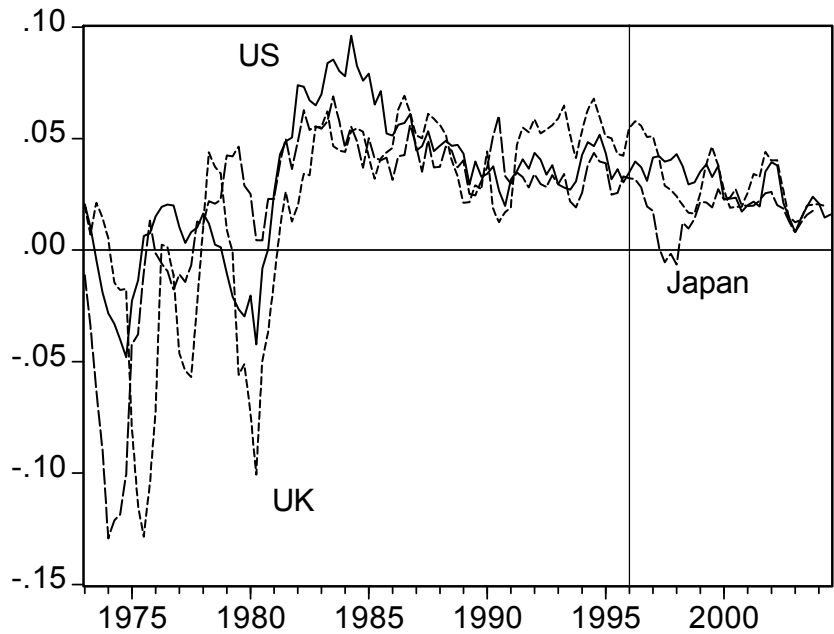


Figure 9: US, UK and Japanese real long term rates

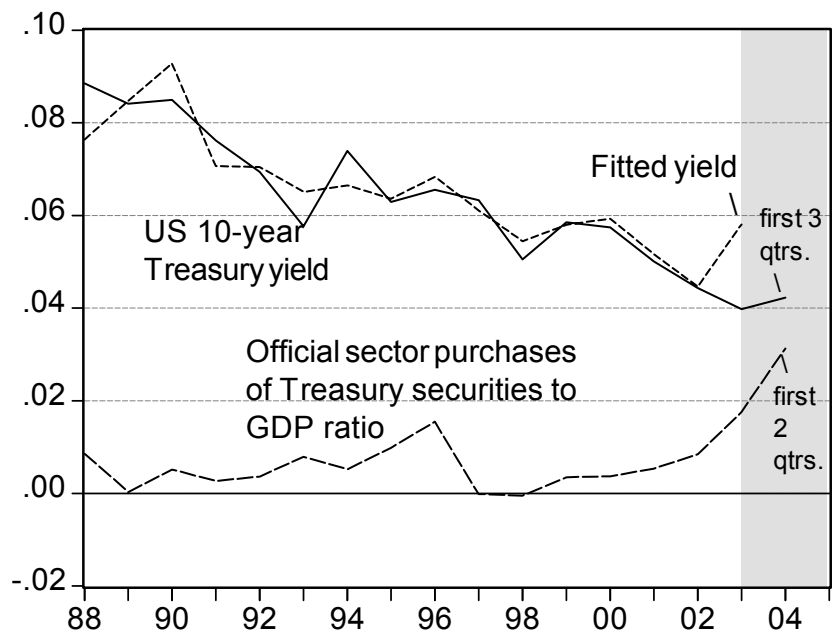


Figure 10: US long term rate and purchases of US Treasury securities

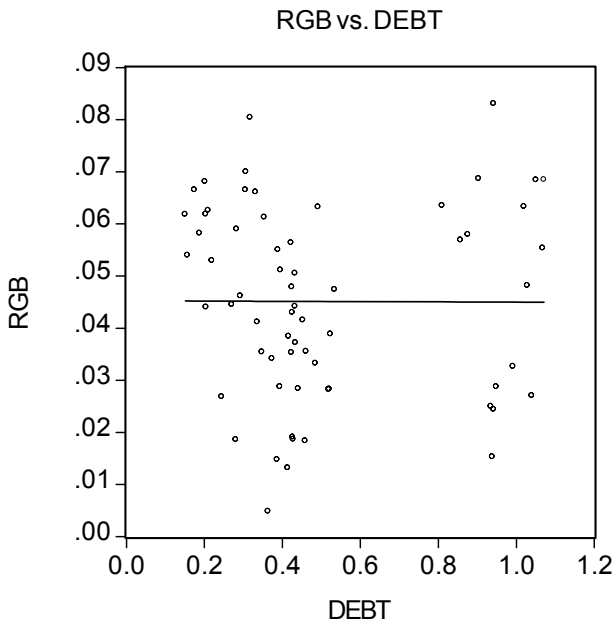


Figure 11: European pooled data on real long term rate against debt to GDP ratio

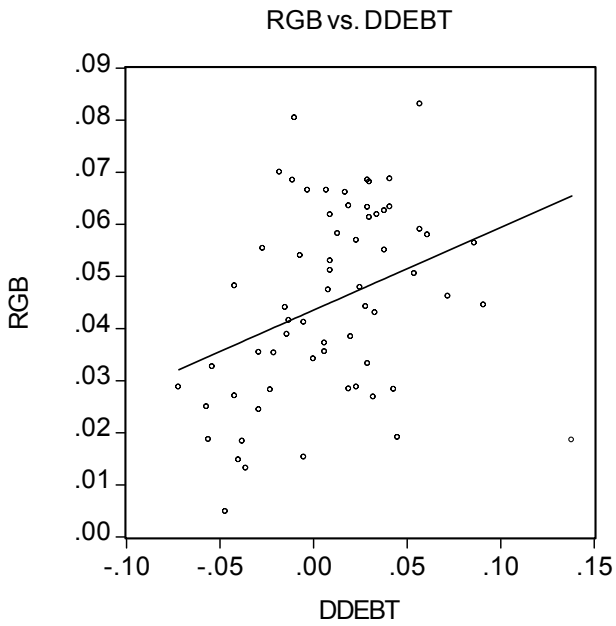


Figure 12: European pooled data on real long term rate against 2 year change in debt to GDP ratio

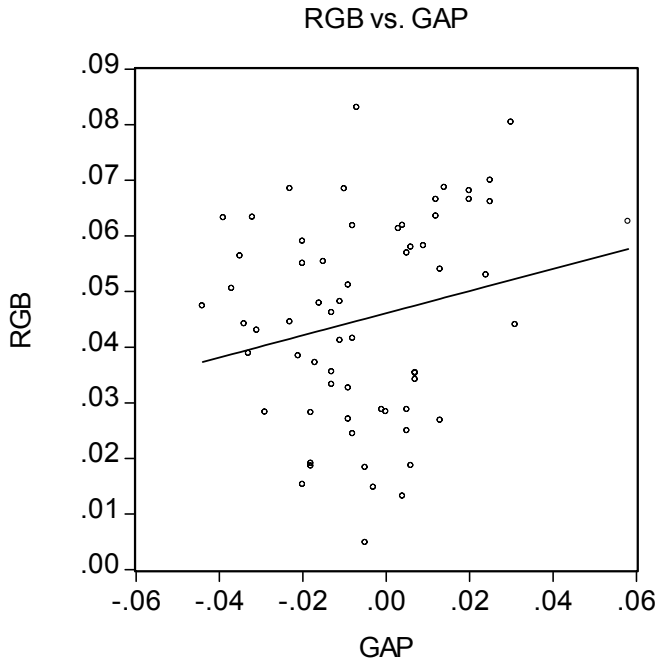


Figure 13: European pooled data on long term real rate against output gap

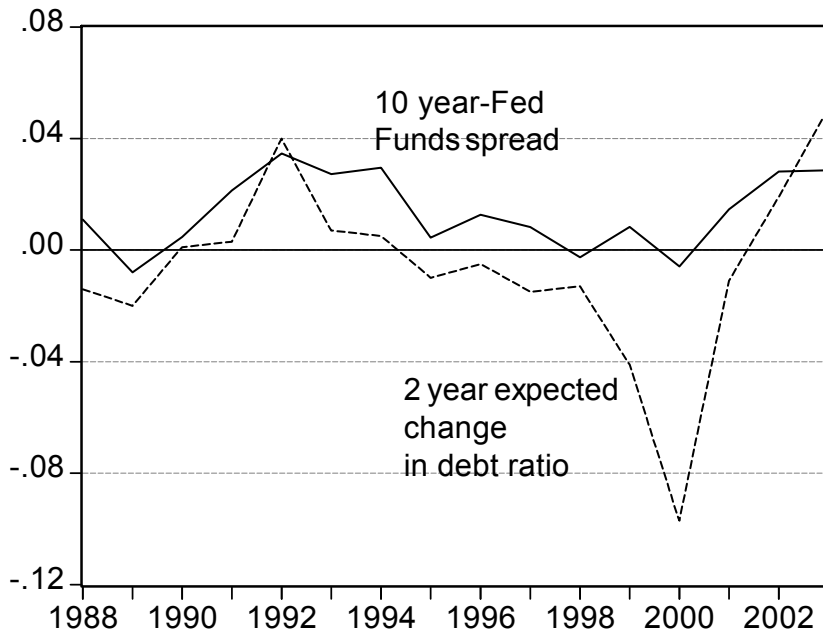


Figure 14: US spread and 2 year expected change in the debt ratio.