DISCUSSION PAPER SERIES

No. 6456

CONVERGENCE AND ANCHORING OF YIELD CURVES IN THE EURO AREA

Michael Ehrmann, Marcel Fratzscher,
Refet S. Gürkaynak and Eric T Swanson

INTERNATIONAL MACROECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP6456.asp**

ISSN 0265-8003

CONVERGENCE AND ANCHORING OF YIELD CURVES IN THE EURO AREA

Michael Ehrmann, European Central Bank
Marcel Fratzscher, European Central Bank
Refet S. Gürkaynak, Bilkent University and CEPR
Eric T Swanson, Federal Reserve Bank of San Francisco

Discussion Paper No. 6456
September 2007

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 6456

September 2007

ABSTRACT

Convergence and Anchoring of Yield Curves in the Euro Area*

We study the convergence of European bond markets and the anchoring of inflation expectations in euro area countries using high-frequency bond yield data for France, Germany, Italy and Spain. We find that Economic and Monetary Union (EMU) has led to substantial convergence in euro area sovereign bond markets in terms of interest rate levels, unconditional daily fluctuations, and conditional responses to major macroeconomic data announcements. Our findings also suggest a substantial increase in the anchoring of long-term inflation expectations since EMU, particularly for Italy and Spain, which since monetary union have seen their long-term interest rates become much lower, much less volatile, and much better anchored in response to news. Finally, the reaction of far-ahead forward interest rates to macroeconomic announcements has converged substantially across euro area countries and even been eliminated over time, thus underlining not only market integration but also the credibility that financial markets attach to monetary policy in the euro area.

JEL Classification: E52 and E58
Keywords: anchoring, bond markets, convergence, credibility, emu, euro area and monetary policy

Michael Ehrmann
European Central Bank
Kaiserstrasse 29
D-60311 Frankfurt
GERMANY
Email: michael.ehrmann@ecb.int

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=147802

Marcel Fratzscher
European Central Bank
Kaiserstrasse 29
D-60311 Frankfurt
GERMANY
Email: marcel.fratzscher@ecb.int

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=149533

Refet S. Gürkaynak
Department of Economics
Bilkent University
06800 Bilkent
Ankara
TURKEY
Email: refet@bilkent.edu.tr

Eric T Swanson
Economic Research
Federal Reserve Bank of San Francisco
101 Market Street
San Francisco, CA 94105
USA
Email: eric.swanson@sf.frb.org

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=161892

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=165233

* We thank Roberto Blanco, Vincent Brousseau, Aviram Levy and Marcello Pericoli for help with the data and David Thipphavong for research assistance. We are grateful to Carlo Favero, Philipp Hartmann and Jonathan Wright and seminar participants at Bocconi University for comments. Gürkaynak's research was supported by a Lamfalussy Fellowship, sponsored by the European Central Bank. The views expressed in this paper are solely those of the authors and do not necessarily reflect the views of the European Central Bank, the Board of Governors of the Federal Reserve System or the management of the Federal Reserve Bank of San Francisco.

Submitted 29 August 2007

I. Introduction

To what extent has Economic and Monetary Union (EMU) in Europe been successful? Answering this question requires defining what it means for EMU to be "successful". In this paper, we focus on the monetary union aspects of the EMU, in particular, to what extent did monetary union lead to integration of financial markets across euro area countries, and what effects did that union have on the anchoring of long-term inflation expectations within those countries? We thus investigate the effects of EMU along two dimensions: the unification of bond markets, and the anchoring of long-run inflation expectations. These two dimensions of monetary policy in the euro area are intimately related because long-term bond yields in any given country are very sensitive to financial market expectations about long-run inflation. Indeed, our analysis in this paper will focus on the insights that one can draw about the monetary union from the high-frequency behavior of bond yields in the euro area.

First, we investigate to what extent the sovereign bond markets in France, Germany, Italy and Spain, the four largest euro area countries, have become integrated along with the unification of the currency and of monetary policy. While the expectations hypothesis of the term structure implies that long-term bond yields in all of these countries should be identical after EMU, the expectations hypothesis can be violated if there are time-varying risk premia in the bond markets (e.g., Cochrane and Piazzesi 2005), and there is much reason to think that the risks related to default and liquidity of each of the above sovereign bond markets may differ substantially. For example, Italy's debt-to-GDP ratio in 2003 was 97%, while France's was 53% and Germany's 38% (OECD, 2005), implying substantial differences in debt servicing burdens across the four countries in our sample.

We propose two types of tests for bond market integration in these four countries. The first looks at the unconditional correlations between yields of different countries. We find strong evidence of convergence in the levels and comovements of yields across countries even for daily changes in yields that might be expected to be substantially affected by idiosyncratic shocks and differential liquidity characteristics. Moreover, using the UK as a "control" country for comparison, we show that this convergence in levels and comovement is unique to the euro area members, strongly suggesting that this convergence is due to EMU rather than to a more general global tendency toward convergence across all developed countries.

Our second type of test looks at the *conditional*, as opposed to the unconditional, behavior of bond yields in the euro area countries. That is, conditional on the announcement of a given piece of economic news, do yields in France, Germany, Italy, and Spain react similarly? In a unified bond market, bonds of different countries (at the same maturity) should respond similarly to the same impulse whether or not there are constant differences in risk or liquidity spreads and whether or not there is bond-specific and country-specific noise. As conditioning variables, we use macroeconomic data surprises from the four euro area countries, the aggregate euro area, the UK and the US. We find that there has been a remarkable convergence and reduction over time in the heterogeneity of euro area yield responses to these macroeconomic announcements. This convergence process seems to have been strongest just before and after monetary union in 1999, underlining the likely role of monetary union in this process.

Having established evidence in favor of bond market unification, we turn to the question of long-run inflation expectations in the euro-area countries. One desired outcome at the time when EMU was conceived was having the countries with less well-anchored expectations, and therefore more volatile financial markets, benefit from a more credible monetary policy-making framework. Following Gürkaynak, Sack, and Swanson (2005), we therefore ask whether the volatility of very far-ahead forward interest rates has decreased over time. Intuitively, if long-run inflation expectations in a country are well anchored, then its very far-ahead forward interest rates should be more stable than if those long-run inflation expectations are not well anchored.

Our tests for volatility of far-ahead forward interest rates are once again unconditional and conditional. With our unconditional tests, we show that the volatility of far-ahead forward rates has decreased significantly in Italy and Spain, while remaining the same in France or Germany, suggesting that the anchoring of long-run inflation expectations in the former two countries has converged to about the same level as the latter two. This is confirmed in our conditional analysis, in which we show that the heterogeneity in the effects of macroeconomic surprises on far-ahead forward rates across euro area countries has diminished since EMU.

Our analysis of convergence of bond yields and long-run inflation expectations in the euro area draws upon several strands of the literature. Baele et al. (2004) is an early contribution that studied the convergence in the government bond markets of EMU member countries using a larger set of countries than we do, but with lower (monthly) frequency data; our tests for bond market integration at daily frequency thus represents a much stricter test for unification in the bond markets that we study. Moreover, although Baele et al. find convergence in euro area bond yields at the monthly frequency, Manganelli and Wolswijk (2007) show that there is still some heterogeneity in government bond yields across countries that depends on the credit rating of the underlying bond.[1] Although not directly relevant to our financial market analysis, there is also a literature on the effects of the euro area customs union on the goods markets which finds mixed evidence on convergence: for example, Canova, Ciccarelli and Ortega (2006) find that business cycles have not become more aligned in euro area countries after EMU, while Rogers (2007) finds that price dispersion across these countries has diminished.

Our study of long-run inflation expectations builds on the work of Gürkaynak, Sack and Swanson (2005) for the US and Gürkaynak, Levin and Swanson (2006) for the US, UK, and Sweden. Those studies find that far-ahead forward interest rates in the US respond to macroeconomic announcements, while those in the UK and Sweden appear to be more anchored, suggesting a greater anchoring of long-term inflation expectations in the latter two (inflation-targeting) countries. On the international side, Ehrmann, Fratzscher and Rigobon (2005) show that euro area surprises do not have large effects on the US financial markets, while Ehrmann and Fratzscher (2005) find that the US spillover effects into European markets have increased initially after EMU, which they relate to markets' learning. Goldberg and Klein (2005), who analyze the post-EMU period, show that the response of the yield curve slope in the euro area to

[1] There has been a discussion whether the ECB's collateral policy leads market participants to ignore differences in national sovereign default risk. The ECB has classified assets that can be used as collateral in its regular monetary policy operations, assigning specific "valuation haircuts" to each category. These haircuts specify a percentage discount that is applied to the market price of an asset when used as collateral. The discussion focused on the fact that government bonds from all national central governments have been classified in the same category. Buiter and Sibert (2006) argued that this will effectively turn them into perfect substitutes, such that markets ignore country-specific default risk. Issing (2005), on the other hand, argued that the ECB values any asset that is taken as collateral at market values, such that a differentiation according to default risk is already incorporated. The evidence of Manganelli and Wolswijk (2007) suggests that government bond yield spreads do in fact depend on the rating of the underlying bond.

US inflation surprises has changed over this period, which they interpret as the ECB gaining credibility over time.

The remainder of the paper is organized as follows. Section II describes the data, including the yields, the macroeconomic surprises as conditioning variables and the choice of sub-periods around the advent of EMU. Section III contains the results of the tests of convergence and Section IV presents the evidence on anchoring of long-term interest rates. Section V provides a general discussion of the findings and concludes. A Data Appendix provides a detailed description of all the data used in our analysis.

II. Data

A detailed account of all the data used in our analysis is presented in the Data Appendix at the end of this paper, but is briefly summarized here. The basic data we employ in our analysis are daily zero-coupon bond yields in France, Germany, Italy, Spain, and the UK and we analyze how those yields respond to macroeconomic announcements in those five countries, the euro area, and the US.

2.1 Yields

In order to compare "apples to apples" in our analysis below, we require bond yield data that are as comparable as possible across all of our countries. This requires data from a zero-coupon yield curve for each country, which removes differences in coupon rates, bond maturities, and individual bond idiosyncrasies across countries and allows for a clean comparison of yields from one country to another (see Gürkaynak, Sack, and Wright, 2006, for additional discussion).

We obtained daily yield curve data for Germany and Spain from the Bank for International Settlements in Basel and daily yield curve data for the UK from the Bank of England. Daily yield curve data for France and Italy are not readily available, so we estimated the yield curves for these two countries using bond market price data that we obtained from Bloomberg Financial Services and the methods employed by Gürkaynak, Sack, and Wright (2006) for the US.[2]

[2] See Gürkaynak, Sack and Wright (2006) for details of this procedure.

Because of the distribution of bond maturities available from Bloomberg, short-term (less than five-year) yields for France and Italy are reliable only beginning in 1995, while five-year and longer rates for these countries and all yields for the remaining countries go back to 1993.

Having to estimate yield curves for France and Italy provides the unexpected benefit of being able to observe the evolution of efficiency and liquidity of the Italian bond market from before EMU to after it. The upper panels of Figure 1 show the maturities and yields of traded bonds in the Italian government bond market on 1 March 1995, a typical day before EMU, and ten years later, on 1 March 2005. On the earlier date, while there is a clear maturity-yield relationship that allows fitting a yield curve, bonds of similar maturities traded as much as a percentage point apart, suggesting large differences in the liquidity and heterogeneous characteristics of these securities. By contrast, there are no such cases in 2005, suggesting a more homogeneous, liquid, and generally better functioning and more efficient bond market. The lower panels of the figure show that the French bond market did not experience a similar transition during this period, being relatively highly efficient both before and after EMU. If the French bond market was more efficient than the Italian one and the two markets unified with EMU, one would expect to see this manifested in greater liquidity and less dispersion of bond prices in the Italian market, which is in fact what we observe here.

2.2 Macroeconomic Announcements

For our conditional analysis of bond market responses, we will examine the high-frequency behavior of bond yields in response to major macroeconomic data releases in each of France, Germany, Italy, Spain, the euro area as a whole, the UK, and the US. However, it is not enough to use the raw macroeconomic data releases themselves as explanatory variables because financial markets are forward-looking and thus should not respond to the component of these announcements that are *expected* (Kuttner, 2001, confirms this hypothesis for the case of monetary policy announcements in the US). Thus, we wish to construct the *unexpected* or *surprise* component of each of our macroeconomic data releases and use these data release surprises as the conditioning variables for our bond market analysis.

We compute the macroeconomic data release surprises as the realized value of the macroeconomic data release on the day of the announcement less the financial markets' expectation for that realized value. We obtained data on financial market expectations of major macroeconomic data releases from two sources: Money Market Services (MMS) and Bloomberg Financial Services. Details of these data are provided in the Data Appendix. Andersen et al. (2003) and others have verified that these data pass standard tests of forecast rationality and provide a reasonable measure of ex ante expectations of the data release.

Note that, to make our regression coefficient estimates comparable across different data releases, we normalize each series by its sample standard deviation, so that the regression coefficient on each series can be interpreted as a response per one standard deviation surprise. For example, on 21 October 1998, the German IFO index was expected to come in at 97 but the released value was 94; since the historical standard deviation of the surprise in this data release is 1.16, we record this as a surprise of -2.58 standard deviations for that statistic on that date.

Two additional issues regarding the macroeconomic data surprises bear further discussion. One is availability, as most of the surprises for Italy and Spain in our sample are available only from the beginning of 1997 onwards, and euro area aggregate data releases are generally available only beginning in 1999. Also, after the introduction of the euro, no national monetary aggregate releases were made any longer, so that only the euro area aggregate and its surprise component is available to us from that date onward. Table A-1 in the Appendix lists all of the macroeconomic data surprise series we have used and the dates for which they are available.

The second issue is that European bond yields often react very little to European macroeconomic announcements, as we will show below. For this reason, we include US and UK surprises in our analysis as well. This has the added benefit that these series are often available over a long history, typically for as long as our bond yield data are available. Note that using "foreign" surprises here does not create a problem for studying bond market integration. Being agnostic on why US surprises moves European yields, we only assert that if one country's yields are responding to a given data surprise, others' should as well if bond markets are integrated.

2.3 Sample periods

A final point relates to our choice of subsample periods. The decision to have a monetary union within the EU was agreed on in the Maastricht Treaty in February 1992, which was followed by the ERM (Exchange Rate Mechanism) crisis in September 1992, in which several countries devalued their currencies and dropped out of the exchange rate system. We thus begin our sample in 1993 to make sure the results are not driven by the very high volatility in the immediate aftermath of the ERM crisis, although there was still some currency volatility and uncertainty in subsequent years. In May 1998, the eligible countries for inclusion in the monetary union were announced, and on 1 January 1999 the exchange rates for the countries entering monetary union were irrevocably fixed and the euro was introduced.

Given this timeline, we use 1993-98 as our pre-EMU sample and 2002-2006 for the post-EMU sample. We begin the latter sample in 2002 to make sure that we are not capturing effects of the initial period of evolving credibility of the ECB, as argued by Goldberg and Klein (2005).

We check these subsample choices more formally using an Andrews-Ploberger (1994) break point test to detect the precise date of structural changes in the yields of euro area countries. For this purpose, we regress the yield of each country on the corresponding German yield and a constant—a test to which we will return to in more detail in section 3. Table 1 shows that the date for the structural breaks occurs before 1 January 1999, usually in 1996 or 1997, suggesting that markets anticipated the beginning of monetary union well ahead of time. The similarity in the break point across countries and yields underlines the similarities in yield changes in euro area countries. Instead of taking 1 January 1999 as the end of the pre- EMU period, we therefore could also have taken an earlier break point. However, our preferred data is 1 January 1999 as this formally meant the introduction of the euro. Note that by not choosing an earlier break point, we bias our results against our hypotheses. Since we possibly include data points where bond markets had already converged, we should find weaker evidence for bond market integration in our comparisons of the pre- and post-EMU periods. Moreover, we stress that our results are insensitive to variations in the beginning and end dates of the two subsamples. In particular, starting the pre-EMU sample in 1994 or choosing an earlier start date for the post-EMU sample does not change our conclusions below.

III. Convergence of Yields

We begin by investigating the degree to which yields of different maturities have converged across our four euro area countries, France, Germany, Italy, and Spain. Given that "a high degree of sustainable convergence" was a prerequisite for entry into the monetary union, finding some degree of convergence in yields before the ECB came into existence is to be expected. Our interest is in the timing and the extent of this convergence. We first study the yields across countries unconditionally and then look at the conditional correlations, using major macroeconomic data release surprises as the conditioning variables.

3.1 Unconditional Results

To study whether and when the government bond markets in Germany, France, Italy, and Spain integrated with EMU, we focus on the daily behavior of bond yields in these four countries. The advantage of using such high-frequency data for our analysis is that it sets a higher standard for bond market convergence: at lower frequencies, it is more likely that some degree of cross-country arbitrage will reduce interest rate differentials across those countries and make those bond markets appear more similar. That is, finding convergence in financial markets using monthly data is more likely than finding it in daily data. Our results therefore extend those in the literature by studying higher-frequency data as well as an extended sample period.[3]

The evolution of daily yield curves for each of our four euro area countries is summarized in Figure 2, the central figure of this sub-section. The top panel of the figure depicts the two-year bond yields at daily frequency. At the beginning of the sample period, the German two-year yields are the lowest, with the French yields slightly above them. The Spanish and Italian two-year yields are five to six percentage points higher than the other two. The most striking feature of the graph is the speed and extent of the convergence of yields. The French and German yields had become identical by 1997 and the Spanish and Italian ones joined them by 1999. The lines for the four countries are indistinguishable from then on.

[3] While they focus, as all other studies, on monthly data, Codogno et al. (2003) also include a section that studies one year of daily data.

This is striking precisely because we are using daily data. There is not a *single day* after 1999 on which the two-year yield on government notes was noticeably different in one of the countries compared to the others. That is, the short term bond markets in these countries were unified to the extent that any deviations across countries appear to have been arbitraged away on a daily basis. Note, importantly, that convergence had taken place even *before* monetary union had actually taken place. That is, the expectation of unification unified the sovereign bond markets, which is confirmed by the results of the structural break point test discussed in the previous section.

To ensure that this convergence is due to EMU and is not an artifact of broader convergence in the yields of industrialized European countries, Figure 2 also includes the two-year yield from the UK, an EU member that is not a member of the euro area. The UK two-year yield clearly stands out in the figure, suggesting that convergence in rates did indeed happen because of the monetary union and not because of other global or regional factors that were leading to convergence across developed countries' financial markets more generally.

The middle panel of Figure 2 repeats the analysis using five-year yields. We have data on five-year yields for all of our countries going back farther, to 1993, but the results are very much the same as for two-year yields. Finally, the bottom panel of the figure depicts ten-year yields, which shows that there is slightly more variation across countries in long-term interest rates—in particular, the Italian ten-year yield has been somewhat higher than the others in the recent past—but this difference is tiny compared to the differences before 1999.

We present three kinds of statistical measures to quantify the extent of the convergence that is so striking visually in Figure 2. First, we look at the raw correlations of yields of the same maturity between different countries for the pre-EMU (1993-1998) and post-EMU (2002-2006) samples. Second, we show regression results for each country's yields regressed on German yields of the same maturity in each of the two sample periods. Finally, we provide evidence from principal component analysis.

The results of the first two tests are reported in Tables 2 and 3. The correlation analysis confirms the visual impression and earlier results for lower frequency data in that the correlations between the yields of France, Germany, Italy, and Spain have increased significantly after EMU—in fact almost all of these are .99—while the correlations of the yields of these countries with those of the UK have decreased.[4,5] The R^2 statistics of the regression of each country's yields on the German yields repeat the information in the correlations. Interestingly, the proportion of the variance that these simple regressions can explain appears to be even larger than those reported in Baele et al. (2004), especially for the shorter maturities, suggesting that convergence has strengthened over the most recent years covered in our sample. This is particularly striking given the fact that we analyze daily frequency data, which, as mentioned above, one would expect to show less comovement than data at lower frequencies. However, rather than the R^2 statistics, the regression coefficients themselves are the objects of interest this time. The slope coefficients, which were quite far from unity pre-EMU, have become economically indistinguishable from unity across the four countries after EMU, while the coefficients in the regressions involving the UK have continued to have slopes of varying magnitudes.[6] Consistent with the convergence hypothesis, the constants in the regressions have also shrunk towards zero from the pre-EMU to the post-EMU sample.

Another way to think about bond market unification is that it implies there will be a single latent factor that affects yields of the same maturities across all the different country's markets. We explore this implication using principal components analysis. Let X denote the $T \times 4$ matrix with rows corresponding to days and columns corresponding yields of the same maturity (2, 5 and 10 year yields) in different countries' sovereign bond markets. X can be written as:

---

[4] Throughout the paper we study unconditional relationships in levels and conditional ones in changes. This is to make the results comparable to the similar literature where, for example, level/slope/curvature decompositions of the yield curve (which we study in section 4) always refers to levels while event studies using surprises employ changes in yields—the object of interest is the returns. It is reassuring that our results would be broadly similar if we presented the unconditional analyses in changes as well.

[5] Almost all of the changes in correlation coefficients across samples are significant because with daily data we have very large numbers of observations in each sample, leading to very precise estimates. Note that the correlation coefficients are estimated over the sample for which data exits in all countries, effectively making the early sample for the two-year yield the 1995-1998 period.

[6] Statistically the slope coefficients are not quite unity as with daily data we estimate these with a very high degree of precision using daily data. Thus .99, while economically not different from unity, remains statistically different from it.

$$X = F\Lambda + \eta$$

where F is a $T \times k$ matrix of unobserved factors (with $k < 4$), Λ is a $k \times 4$ matrix of factor loadings, and η is a $T \times 4$ matrix of white noise disturbances. The hypothesis that sovereign bond markets are integrated is a statement that there exists a $T \times 1$ vector F and constants λ_i, $i=1,...,k,$ such that the matrix X is described by $F \times [\lambda_1,...,\lambda_k]$ up to white noise.

In Table 4, we report the percentage of total variation of the data that is explained by the first two principal components. The factor loadings show that the first factor loads evenly on all countries (the common factor) while the second factor differentiates Italy and Spain from France and Germany. In the pre-EMU period, the second factor explains a non-negligible part of the total variation in all maturities, whereas in the post-EMU period the first, common factor explains essentially all of the variation. That is, the factor analysis implies that after EMU there is a single latent factor—in effect, a euro area-wide factor—that describes the behavior of yields in all of these countries, suggesting that since monetary union bond markets across our countries have become completely integrated.

All together, the results in this section show, visually and statistically, a remarkable convergence in bond yields of the four largest euro area countries due to monetary union. We next move from the unconditional results to the conditional ones and ask how the responses of the yields of different euro area countries to data surprises have changed from before monetary union to after.

3.2 Conditional Results

Of course, a finding of convergence in bond yields in an unconditional sense could come about in two different ways. First, bond markets may have reacted similarly to common shocks during both the pre-EMU and post-EMU periods, but country-specific idiosyncratic shocks were much more important in the pre-EMU period. The diminishing importance of country-specific idiosyncratic shocks would then show up in the bond markets as convergence. Alternatively, common shocks may have been equally important in both the pre-EMU and post-EMU periods, but bond markets in each country may have reacted differently to these common fundamental shocks before EMU and more similarly after EMU. To investigate more fully the type of convergence that has taken place, we now analyze the *conditional* movements in bond yields in our four countries in response to major macroeconomic data releases.

Our regression specification for this analysis is

$$\Delta y_t^{i,j} = \alpha^{i,j} + \sum_{k=1}^{K} \sum_{l=1}^{L_k} \beta_{l,k}^{i,j} Surprise_{l,k,t} + \varepsilon_t^{i,j} \ ,$$

where $\Delta y_t^{i,j}$ denotes the daily change in the yield of maturity j ($j \in \{2, 5, 10\}$ years) of country i ($i \in$ {France, Germany, Italy, Spain}) on date t. We have surprise data from six countries and the euro area ($k \in$ {France, Germany, Italy, Spain, UK, US, euro area}) and there are L_k data series used from each of these, indexed by l ($l \in${CPI, Unemployment, etc.}). Due to data availability, we have more data surprises for the US than for any other country, but this does not present any particular difficulties because US macroeconomic data release are known to significantly affect financial markets in Europe as well as in the US (Andersen et al. 2007, Ehrmann and Fratzscher 2005). Note that, due to data availability, not all of the data releases we consider were present in both the pre- and post-EMU samples.

Regression results from specifications using the complete set of all 37 of our data release surprises are not presented to save space and because most of those coefficients are not statistically significant anyway, especially for European macro data announcements in the pre-EMU period.[7] Therefore, we report in Table 5 regression results from a more parsimonious

[7] This finding is in line with Goldberg and Leonard (2003), Ehrmann and Fratzscher (2005), and Andersson et al. (2006), who document that US data releases are the most important fundamental surprises for the European financial markets. A number of explanations have been offered for this result, such as the more timely release of US figures, the dominant position of the US in the global economy, the fragmented release of European data (such as, e.g., German CPI figures, which are released consecutively for the individual Federal States), and possible leaks from the European statistical agencies (which have been documented for German unemployment data by Andersson et al.). Results from regressions with all macro data releases are available from the authors upon request.

specification that uses a much smaller subset of the available macroeconomic announcements, in particular, the most important US data releases (as suggested by Fleming and Remolona, 1999), the CPI inflation releases for each of the four euro area countries, and the M3 growth rates for Germany and the euro area as a whole (which may be expected to matter because of the emphasis on monetary aggregate growth rates first by the Bundesbank and then by the ECB).

The most important point of Table 5 is that before EMU there were *no* cases where all countries' yields responded significantly to the same data release. One could use this as a definition of market segmentation—prices are not moved by the same common fundamentals.[8] By contrast, after EMU yields of euro area countries have begun to react in a much less heterogeneous manner to macro shocks. In Table 5, this is especially the case for the major releases of US ISM, US nonfarm payrolls and the German IFO index.

The results in Table 5 are summarized graphically in Figures 3 and 4, which depict the time-varying responses of yields to nine of these potentially relevant macro surprises, using a rolling estimation of 4-year windows. Figure 3 plots the raw response coefficients over time, but since we are primarily interested in the *heterogeneity* in the responses of yields across countries, Figure 4 summarizes the results in Figure 3 by plotting the cross-sectional standard deviation of the response coefficients β^j *across countries* at each point in time (that is, when the coefficients β^j differ greatly across our four countries, then the cross-sectional standard deviation plotted in Figure 4 is higher). This figure allows us to visualize the evolution over time of the cross-country heterogeneity in yield responses with a single aggregate measure.

Similar to the results in Table 5, there is clear evidence in Figure 4 for a convergence in the response patterns of yields in our four euro area countries to these macroeconomic surprises. Moreover, this convergence process seems to have been strongest just before and after monetary union in 1999, underlining the likely role of monetary union in this process.

[8] It is worthwhile repeating that the inference we want to draw here is not about the direction of the effect. Positive US surprises, for example, may increase or decrease yields in other countries, and we do not take a stand on this. Our test is that if a fundamental surprise has an effect on the yields of one country, it should have the same effect on the yields of other countries if bond markets are unified, regardless of the direction of the effect.

There is also some evidence in Figure 3 of trends in the effects of macro surprises over time. Some macro surprises, such as US non-farm payroll employment, and to some extent the German IFO confidence index and the US ISM survey, may have started to exert a generally larger impact on bond markets over time. By contrast, other macro variables, such as domestic inflation announcements, have been exerting a smaller effect on bond markets over time. This finding is sensible as it suggests that with a common monetary policy and an integrated euro area bond market what matters for each country's bond market is not the individual country's rate of inflation, but that of the euro area as a whole.

To summarize, the evidence in Table 5 and Figures 3 and 4 suggests that the unconditional convergence in euro area bond yields documented in the previous section cannot be attributed simply to a reduction in the importance of idiosyncratic, country-specific shocks in those countries over time. Instead, there appears to have been a remarkable convergence in the response of euro area yields even conditioning on individual macroeconomic data releases. The timing of this convergence also suggests that monetary union did lead to convergence and unification in euro area bond markets, and that such a unified market was not present before EMU. This convergence appears to have taken place both in an unconditional and a conditional sense, where we have used major macroeconomic announcements as conditioning variables.

IV. Anchoring of Inflation Expectations and Long Rates

Finally, we investigate the anchoring of long-run inflation expectations in the euro area and the benefits that some of those countries might have achieved from entering the monetary union. In previous work, Gürkaynak, Sack, and Swanson (GSS, 2005) and Gürkaynak, Levin, and Swanson (GLS, 2006) used long-term bond yields to investigate the anchoring of inflation expectations in the US, UK, and Sweden, and we build on their analysis here. In particular, in standard macroeconomic models in which the steady-state inflation objective of the central bank is constant over time and known by all economic agents, short-term interest rates return relatively quickly to a deterministic steady state after a macroeconomic shock, so that these shocks have only transitory effects on the future path of interest rates. As a result, one would expect only a very limited response of long-term interest rates to these disturbances. Putting this prediction in terms of forward rates, one would expect virtually no reaction of far-ahead forward interest rates to such shocks.

Conceptually it is perhaps easiest to think about the term structure implications of shocks in terms of forward rates rather than yields. For a bond with a maturity of m years, the yield $r_t^{(m)}$ represents the rate of return that an investor requires to lend money today in return for a single payment m years in the future (for the case of a zero-coupon bond). By comparison, the k-year-ahead one-year forward rate $f_t^{(k)}$ represents the rate of return from period $t+k$ to period $t+k+1$ that the same investor would require to commit at time t to a one-year loan beginning at time $t+k$ and maturing at time $t+k+1$. The link between these concepts is simple: an m-year zero-coupon security can be viewed as a sequence of one-year forward agreements over the next m years. The k-year-ahead one-year forward rate $f_t^{(k)}$ can thus be obtained from the yield curve by the simple definition:

$$1+f_t^{(k)}=\frac{(1+r_t^{(k+1)})^{k+1}}{(1+r_t^{(k)})^{k}}$$

Intuitively, the difference between the nine and ten year yields depend on the expected yield for the tenth year and this can be recovered through the formula above.

The advantage of using forward rates rather than yields is that they serve as a proxy for expectations of future values of the short-term interest rate, up to a (possibly time-varying) term premium. If the term premium is relatively stable over time, then the discussion in the previous section (and the analysis in GSS and GLS) suggests that far-ahead forward interest rates should be unresponsive to news if inflation expectations are well anchored.[9]

[9] GSS and GLS present evidence that suggests that the risk premium is not varying substantially at the daily frequencies considered in that paper and that we will consider here. For example, much of the finance literature, such as Cochrane and Piazzesi (2005), has suggested that risk premia move primarily at business cycle frequencies and should be countercyclical, while the responses of far-ahead forward interest rates in GSS and GLS at daily frequency are procyclical, which contrasts sharply with the finance literature's predictions. Moreover, changes in long-term real interest rates do not seem to be a good explanation, since GSS and GLS show that far-ahead forward indexed bond rates in the US, UK, and Sweden do not seem to move systematically in response to macroeconomic data releases. Instead, all of the evidence presented in those papers is consistent with a model in which changes in financial market perceptions regarding the long-term inflation objective of the central bank are driving the responses of long-term bond yields.

Thus, if EMU improved the anchoring of inflation expectations in our four euro area countries, this should be reflected in a reduced volatility of far-ahead forward interest rates and their responsiveness to shocks. We again investigate this implication in two parts, first unconditionally and then conditional on major macroeconomic data releases. Given our interest in studying long-term inflation expectations, we focus our analysis on the longest maturity for which we have high-quality bond yield data across all of our countries. The exceptional depth and liquidity of the markets for government securities around the ten-year horizon thus suggests focusing on the one-year forward rate from nine to ten years ahead (i.e., the one-year forward rate ending in ten years). As shown in GSS and GLS, this horizon is easily long enough for standard macroeconomic models to essentially return to steady state, so that any movements in forward interest rates at these horizons are very difficult to attribute to transitory responses of the economy to a shock.

4.1 Unconditional forward rates

Studying the simple summary statistics for far-ahead forward interest rates in France, Germany, Italy and Spain turns out to be very instructive. Table 6 reports the means and standard deviations of the forward rates for each of these countries in the pre- and post-EMU periods. While the fall in the means of these rates is impressive for Italy and Spain, our primary interest here is in their variability. Remarkably, the variability of the forward rates in Italy and Spain is twice as large as those in France and Germany in the pre-EMU period, while the forward rates in all four countries are essentially invariable in the post-EMU period. Moreover, while the forward rates of France and Germany become somewhat better anchored (less variable) after EMU,[10] the forward rates in Italy and Spain become *much* better anchored after the monetary union. Thus, it seems that the latter two countries benefited substantially from joining the euro area not only in that the levels of their forward rates have declined, but also in that their variability has fallen substantially and converged to that of France and Germany.

Another way of making this point is through factor analysis. When yields of different maturities are decomposed into factors, it is standard to find a “level” factor that moves yields of all maturities in the same direction and by about as much, and a “slope” factor that rotates the yield

[10] For German rates, this is also reported in European Central Bank (2004).

curve. We ask how much of the variability in 2-10 year yields is explained by each of these factors in the four countries in the pre- and post-EMU periods. Table 7 presents the results.

In the pre-EMU period, both the “level” and “slope” factors affected the yields of France and Germany, with a dominant weight on the level factor (the first factor in Table 7), similar to the US and UK (not reported). In contrast, Italy and Spain in this period had only one factor—the level factor—influencing their yields, as this factor explains essentially all of the variation in yields of all maturities. That is, almost all movements in the yield curve that changed short-term interest rates were typically seen as level shifts, or permanent changes, affecting the long end of the yield curve by about as much as the short end. Thus, this evidence suggests a very low level of anchoring of long-term interest rates in Italy and Spain in the pre-EMU period.

After EMU, however, the weights on the level/slope factors for Italy and Spain begin to look much more like those of France and Germany. Moreover, the slope factors (the second factors in Table 7) in all four countries appear to have become more important after the advent of EMU. Thus, not only did the variability of far-ahead forward rates decrease significantly in Italy and Spain after the monetary union, they also became less closely tied to short-term rates, implying a lesser degree of pass-through from the short-term interest rate outlook to expectations about interest rates in the far future. By this metric, it appears that Italy and Spain obtained a much better anchoring of long-term interest rates and inflation expectations as a result of entering the monetary union.

4.2 Conditional Results

Finally, we study the anchoring of long-term inflation expectations in France, Germany, Italy, and Spain in terms of their conditional as well as unconditional behavior. If the monetary authority is credible enough that long-term inflation expectations in a given country are well-anchored, then macroeconomic announcements today should have no systematic effect on forward interest rates in that country far enough in the future. On the other hand, if long-run inflation expectations are not perfectly anchored, then macroeconomic announcements today may induce financial market participants to systematically revise their beliefs about long-run inflation outcomes, so that macroeconomic announcements today may systematically influence the very long end of the yield curve as well as the short end.

Table 8A reports regression results for specifications analogous to those in Table 5 for shorter- and long-term bond yields; in Table 8A, these regressions are performed with the far-ahead forward interest rate in each country as the dependent variable. Figure 5 graphically shows the evolution of the responsiveness of the long-end of the yield curve to data surprises. What is striking in the rolling regressions using a four-year window of Figure 5 is that the point estimates of the far-ahead forward rate for all countries to basically all releases convergence towards zero in the post-EMU period.

However, comparing the pre-EMU with the post-EMU periods may not be very illuminating. For the pre-EMU period, there are very few statistically significant regression coefficients, as was also the case in Table 5 for the shorter-term and long-term bond yield regressions. As we mentioned previously in the discussion of Table 5, this could be due to a number of reasons, such as the staggered release of European data or possible leaks by European statistical agencies, such that we cannot infer whether the non-responsiveness of far-ahead forward interest rates in Table 8A simply reflects a lack of power as opposed to well-anchored long-term inflation expectations. Accordingly, a comparison with the post-EMU sample, where we similarly find barely any significant responses, is not very telling.

What *can* be taken away from Table 8A, however, is a comparison of the response of short-term yields with the response of far-ahead forward interest rates. If inflation expectations in a given country are not perfectly anchored, then one might expect that macroeconomic announcements lead to *level* shifts in the yield curve—that is, data releases that affect the two-year yield should also affect the far-ahead forward rate in the same direction (this was certainly the case in Gürkaynak, Sack, and Swanson (2005) for the US and Gürkaynak, Levin, and Swanson (2006) for the UK before Bank of England independence). Recall from Table 5A that after monetary union, there are several surprises that significantly affected two-year yields in the countries we study (Spanish CPI, German IFO, US nonfarm payrolls and US NAPM). By contrast, in Table 8A, none of these surprises systematically moves far-ahead forward rates—that is, in the post-

EMU period we have identified some announcements that seem to change financial market expectations about the economic outlook enough to change ECB policy expectations and hence two-year bond yields, yet these changes in the economic outlook do not extend far enough into the future to affect far-ahead forward interest rates. It appears therefore that the ECB is seen to be credible enough to bring inflation back to its target over the medium-term horizon so that the far-ahead forward interest rates do not respond systematically to the surprises in macroeconomic fundamentals.[11]

We further emphasize this point in Table 8B, which uses the same regression specification as in Table 8A, but where the dependent variable is now the change in the slope of the yield curve, with the slope measured as the difference between the 9-year-ahead one-year forward rate and the two-year yield.[12] If bond market participants expect the ECB to respond to developments in the economy, then macroeconomic announcements will induce them to change their outlook for the near future, changing the two-year yield, but if long-term inflation expectations are well-anchored, then the far-ahead forward rate should not move systematically in response to these releases. This will be reflected as a change in the slope of the yield curve. Table 8B verifies that the slope of the yield curve does in fact seem to respond significantly to many of these data releases in the post-EMU period, just as would be expected if the story above were true.

A second piece of evidence in support of this point comes from the evolution of the cross-country heterogeneity in yield reactions. Figure 6 shows that the heterogeneity in the effects of macroeconomic surprises before EMU was much stronger at the long end of the maturity spectrum, for far-ahead forward rates. Comparing also with the other maturities in Figure 4, the strongest reduction over time in the heterogeneity in response patterns is also recorded for the longer maturities. At the end of the sample period, the dispersion in how yields respond to common macroeconomic shocks has become much more similar across maturities. A final

[11] Two related studies need mentioning here. Goldberg and Klein (2005) make a similar point but their emphasis is on the learning of credibility so they only study the post-EMU period using the US core CPI release for a smaller number of euro area countries. The recent work of Beechey et al. (2007), again only for the post-EMU period, support our findings in that there are macro announcements to which short nominal rates respond, yet inflation compensation derived from inflation swaps remains unchanged.

[12] The very large (in absolute value) and significant coefficient for the Italian slope response to the German M3 release in the pre-EMU sample shown in the table is due to a single outlier in March 1996. Omitting this observation reduces that coefficient to an insignificant -0.9.

important point to note is that the convergence in response patterns across countries did not take place immediately with EMU in 1999, but occurred rather gradually over the years and in some cases till 2003 or 2004. This again suggests that there has been a substantial increase in anchoring of inflation expectations over time, consistent with a built-up of policy credibility.

In sum, both our unconditional and our conditional results in this section provide evidence of a substantial improvement in the anchoring of far-ahead forward interest rates (and, by implication, long-term inflation expectations) in the euro area. This has been especially true for Italy and Spain in the post-EMU period.

V. Conclusions

According to our analysis for France, Germany, Italy, and Spain—the four largest members of the euro area—the monetary union in Europe does seem to have led to essentially a single, unified euro area bond market, despite the fact that there may be credit risks that differ across countries and liquidity characteristics that may vary from one sovereign bond to another. Moreover, our analysis has shown that this convergence took place not only for the level of bond yields across countries but also for their day-to-day movements, both unconditionally in terms of volatilities and conditionally in terms of their responses to major macroeconomic announcements.

Equally importantly, we find evidence of convergence in the extent to which long-run inflation expectations in our four euro area countries are well-anchored, as reflected in the unconditional and conditional behavior of far-ahead forward interest rates. This improvement was by far the most dramatic for Italy and Spain, which over time have managed to obtain far-ahead forward interest rates that are now as low and as stable as those of Germany and France.

While the elimination of exchange rate risk undoubtedly accounts for a large part of the convergence that we have shown for euro area bond markets, our evidence regarding long-term inflation expectations also suggests that the common monetary policy has been an important contributor. In particular, the ECB's quantitative definition of price stability seems to have contributed to anchoring the long-term inflation expectations of financial market participants across the euro area.

However, in contrast to the strong evidence for convergence in financial markets, there is evidence that the real economies in the euro area have seen a much lower degree of convergence (Canova et al. 2006). This has interesting implications for the conduct of monetary policy, which is transmitted to the national economies via financial markets in a rather homogeneous way, yet faces less uniform situations with regard to the real economy. Other interesting aspects to study are whether convergence in financial markets fosters further real convergence. We leave these important questions for future research.

References

1. Andersen, T., T. Bollerslev, F. Diebold and C. Vega. (2003) "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange," *American Economic Review* 39(1), 38-62.

2. Andersen, T., T. Bollerslev, F. Diebold and C. Vega. (2007) "Real Time Price Discovery in Global Stock, Bond, and Foreign Exchange Markets" *Journal of International Economics*, forthcoming.

3. Andersson, M., L. J. Hansen and S. Sebestyén. (2006) "Which news moves the euro area bond market?" ECB Working Paper #631.

4. Andrews, D.W.K. and W. Ploberger. (1994) "Optimal tests when a nuisance parameter is present only under the alternative", *Econometrica*, 1383-414.

5. Baele, L., A. Ferrando, P. Hördahl, E. Krylova and C. Monnet. (2004) "Measuring Financial Integration in the Euro Area" ECB Occasional Paper #14.

6. Beechey, M., B. Johanssen and A. Levin. (2007) "Are Long-Run Inflation Expectations Anchored More Firmly in the Euro Area than in the United States?" Mimeo, Board of Governors.

7. Buiter, W. and A, Sibert. (2006) "How the Eurosytem's Treatment of Collateral in its Open Market Operations Weakens Fiscal Discipline in the Eurozone (and what to do about it)", in: National Bank of Poland (ed.), *Fiscal Policy and the Road to the Euro*, Warsaw: National Bank of Poland, 29-60.

8. Canova, F., M. Ciccarelli and E. Ortega. (2006) "Similarities and Convergence of G-7 Cycles," *Journal of Monetary Economics*, forthcoming.

9. Codogno, L., C. Favero and A. Missale (2003) "Yield Spreads on EMU Government Bonds", *Economic Policy*, October, 503-532.

10. Cochrane, J. and M. Piazzesi. (2005) "Bind Risk Premia"*American Economic Review* 95(1), 138-160.

11. Ehrmann, M. and M. Fratzscher. (2005) "Equal size, equal role? Interest rate interdependence between the euro area and the United States," *Economic Journal* 115: 930-50.

12. Ehrmann, M., M. Fratzscher and R. Rigobon. (2005) "Stocks, bonds, money markets and exchange rates: measuring international financial transmission," NBER Working Paper #11166, March 2005.

13. European Central Bank (2004) “The information content of euro area long-term forward interest rates”, *Monthly Bulletin*, August 2004, 25-26.

14. Fleming, M. and E. Remolona. (1999) “Price Formation and Liquidity in the U.S. Treasury Market: The Response to Public Information” *Journal of Finance*, 54(5), 1901-15.

15. Goldberg, L. and M. Klein. (2005) “Establishing Credibility: Evolving Perceptions of the European Central Bank”, NBER working paper #11792 .

16. Goldberg, L. and D. Leonard. (2003) “What Moves Sovereign Bond Markets? The Effects of Economic News on U.S. and German Yields”, *Federal Reserve Bank of New York, Current Issues in Economics and Finance* 9(9).

17. Gürkaynak, R., A. Levin, and E. Swanson. (2006) “Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K., and Sweden” CEPR Working Paper #5808.

18. Gürkaynak, R., B. Sack, and E. Swanson. (2005) “The Sensitivity of Long-Term Interest Rates to Economic News: Evidence and Implications for Macroeconomic Models” *American Economic Review* 95(1), 425-36.

19. Gürkaynak, R., B. Sack, and J. Wright. (2006) “The U.S. Treasury Yield Curve: 1961 to the Present” FEDS Working Paper #2006-28.

20. Issing, O. (2005). “One size fits all! A single monetary policy for the euro area” Speech to the International Research Forum, available at http://www.ecb.int/press/key/date/2005/html/sp050520.en.html

21. Kuttner, K. (2001). “Monetary policy surprises and interest rates: evidence from the Fed funds futures market”, *Journal of Monetary Economics* 47, 523-44.

22. Manganelli, S. and G. Wolswijk (2007) “Market Discipline, Financial Integration and Fiscal Rules. What Drives Spreads in the Euro Area Government Bond Market?” ECB Working Paper #745.

23. Rogers, J. (2007) “Monetary union, price level convergence, and inflation: How close is Europe to the USA?” *Journal of Monetary Economics* 53(3), 785-796.

Table 1: Andrews-Ploberger structural break test

	France		Italy		Spain	
	break point	sign.	break point	sign.	break point	sign.
2-year yields:						
Constant	1997:06:16	***	1997:07:02	***	1996:12:18	***
German rate	1997:07:04	***	1997:08:19	***	1997:04:25	***
5-year yields:						
Constant	1996:06:10	***	1997:06:16	***	1996:11:04	***
German rate	1996:06:14	***	1997:07:04	***	1996:11:20	***
10-year yields:						
Constant	1996:04:08	***	1996:10:02	***	1996:09:19	***
German rate	1996:04:17	***	1996:11:01	***	1996:11:04	***
9-year forward:						
Constant	1996:02:14	***	1996:05:16	***	1996:04:10	***
German rate	1996:02:14	***	1996:09:20	***	1996:04:10	***

Notes. Statistics show break date and p-value of test statistics of Andrews-Ploberger (1994) test for structural breaks in the mean equations, regressing countries' yields on the German yield of corresponding maturity and a constant.

Table 2. Correlations of rates

A. Correlations of two-year yields

	Pre-EMU					Post-EMU					
	FR	GE	IT	SP	UK	FR	GE	IT	SP	UK	
FR	1.000					1.000					FR
GE	0.930	1.000				**0.997**	1.000				GE
IT	0.863	0.694	1.000			**0.998**	**0.997**	1.000			IT
SP	0.908	0.762	0.990	1.000		**0.996**	**0.997**	**0.996**	1.000		SP
UK	**0.691**	**0.793**	**0.559**	**0.587**	1.000	0.501	0.469	0.482	0.502	1.000	UK
	Sample size: 953					Sample size: 1228					

B. Correlations of five-year yields

	Pre-EMU					Post-EMU					
	FR	GE	IT	SP	UK	FR	GE	IT	SP	UK	
FR	1.000					1.000					FR
GE	0.969	1.000				**0.998**	1.000				GE
IT	0.945	0.905	1.000			**0.997**	**0.996**	1.000			IT
SP	0.965	0.922	0.991	1.000		**0.997**	**0.997**	**0.994**	1.000		SP
UK	**0.845**	**0.841**	**0.785**	**0.797**	1.000	0.678	0.673	0.659	0.676	1.000	UK
	Sample size: 1428					Sample size: 1228					

C. Correlations of ten-year yields

	Pre-EMU					Post-EMU					
	FR	GE	IT	SP	UK	FR	GE	IT	SP	UK	
FR	1.000					1.000					FR
GE	0.981	1.000				**0.983**	1.000				GE
IT	0.959	0.929	1.000			**0.995**	**0.991**	1.000			IT
SP	0.966	0.940	0.995	1.000		**0.990**	**0.977**	**0.984**	1.000		SP
UK	**0.950**	**0.952**	**0.907**	**0.910**	1.000	0.772	0.787	0.772	0.727	1.000	UK
	Sample size: 1428					Sample size: 1228					

Note. Boldface entries are statistically significantly larger (at 1 percent) than their counterparts in the corresponding sample.

Table 3. Regressions of yields on German yields

A. Two-year yields

	Pre-EMU				*Post-EMU*			
	FR	IT	SP	UK	FR	IT	SP	UK
GE	1.425***	2.498***	2.495***	0.628***	0.971***	0.969***	0.958***	0.345***
	(0.022)	(0.073)	(0.057)	(0.015)	(0.002)	(0.002)	(0.002)	(0.014)
Constant	-1.524***	-3.297***	-4.129***	3.992***	0.015***	0.070***	0.063***	3.338***
	(0.089)	(0.315)	(0.245)	(0.073)	(0.006)	(0.006)	(0.006)	(0.047)
Observations	953	953	953	953	1228	1228	1228	1228
R-squared	0.86	0.48	0.58	0.63	0.99	0.99	0.99	0.22

B. Five-year yields

	Pre-EMU				*Post-EMU*			
	FR	IT	SP	UK	FR	IT	SP	UK
GE	1.170***	2.524***	2.386***	0.829***	1.004***	1.075***	1.053***	0.459***
	(0.005)	(0.028)	(0.022)	(0.014)	(0.002)	(0.003)	(0.002)	(0.009)
Constant	-0.856***	-5.434***	-5.398***	2.443***	-0.059***	-0.209***	-0.191***	2.922***
	(0.027)	(0.155)	(0.124)	(0.079)	(0.006)	(0.012)	(0.006)	(0.035)
Observations	1428	1428	1428	1428	1228	1228	1228	1228
R-squared	0.94	0.82	0.85	0.71	1.00	0.99	0.99	0.45

C. Ten-year yields

	Pre-EMU				*Post-EMU*			
	FR	IT	SP	UK	FR	IT	SP	UK
GE	1.112***	2.456***	2.221***	1.091***	0.972***	0.997***	1.038***	0.444***
	(0.004)	(0.025)	(0.021)	(0.009)	(0.004)	(0.004)	(0.004)	(0.007)
Constant	-0.523***	-6.109***	-5.295***	0.641***	0.248***	0.325***	0.003	2.850***
	(0.023)	(0.149)	(0.130)	(0.058)	(0.017)	(0.014)	(0.018)	(0.029)
Observations	1428	1428	1428	1428	1228	1228	1228	1228
R-squared	0.96	0.86	0.88	0.91	0.97	0.98	0.95	0.62

Notes. Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Principal Components Analysis of Yields Across Countries

Contribution of First Principal Component

	Two-Year Yield	Five-Year Yield	Ten-Year Yield	Two-Year Yield	Five-Year Yield	Ten-Year Yield
	Pre-EMU			Post-EMU		
Contributions of						
First PC	0.895	0.962	0.971	0.998	0.997	0.990
Second PC	0.097	0.031	0.024	0.001	0.002	0.006
Factor Loadings						
First Factor						
FR	0.517	0.504	0.503	0.500	0.500	0.501
GE	0.472	0.493	0.496	0.500	0.500	0.499
IT	0.497	0.499	0.500	0.500	0.500	0.501
SP	0.513	0.504	0.502	0.500	0.500	0.499
Second Factor						
FR	0.249	0.268	0.308	-0.426	-0.001	0.208
GE	0.709	0.687	0.661	0.178	-0.149	-0.675
IT	-0.538	-0.546	-0.531	-0.491	0.770	-0.210
SP	-0.382	-0.399	-0.432	0.739	-0.620	0.676

		Table 5A. Reponse of Two-Year Yields to Surprises						
	Pre-EMU				*Post-EMU*			
	FR	GE	IT	SP	FR	GE	IT	SP
FR CPI	-0.135	0.730	-0.443	-0.310	0.531	0.489	0.391	0.648
	(0.595)	(0.495)	(0.785)	(0.755)	(0.548)	(0.604)	(0.565)	(0.706)
GE CPI	1.851**	0.632	1.397	1.852*	0.478	0.309	0.526	0.585
	(0.770)	(0.641)	(1.017)	(0.977)	(0.395)	(0.435)	(0.407)	(0.509)
IT CPI	-0.196	-0.004	0.752	0.233	-0.249	-0.030	0.070	-0.082
	(0.820)	(0.682)	(1.082)	(1.039)	(0.554)	(0.610)	(0.571)	(0.714)
SP CPI	0.509	-0.808	-0.401	0.278	1.126***	0.666	1.057**	1.009*
	(1.074)	(0.894)	(1.417)	(1.362)	(0.434)	(0.478)	(0.447)	(0.559)
GE IFO	0.960	0.900	0.309	1.402	1.540***	1.958***	1.369***	1.537**
	(0.773)	(0.643)	(1.019)	(0.979)	(0.468)	(0.515)	(0.482)	(0.603)
GE M3	0.331	1.155	0.996	0.722	-	-	-	-
	(0.874)	(0.728)	(1.154)	(1.109)	-	-	-	-
EA M3	-	-	-	-	0.209	0.625	0.183	0.502
	-	-	-	-	(0.464)	(0.511)	(0.478)	(0.598)
US CPIX	1.082	0.304	-0.441	3.116***	0.495	0.942	0.547	1.224*
	(0.948)	(0.789)	(1.250)	(1.201)	(0.569)	(0.626)	(0.586)	(0.733)
US NonFarm Pay.	1.633***	-0.473	-0.627	-0.024	4.416***	1.874***	4.275***	2.645***
	(0.566)	(0.471)	(0.746)	(0.717)	(0.599)	(0.660)	(0.617)	(0.772)
US NAPM	0.552	-0.228	0.329	-0.381	1.708***	2.021***	1.588***	1.811***
	(0.673)	(0.560)	(0.888)	(0.853)	(0.497)	(0.547)	(0.512)	(0.640)
Constant	-0.431*	-0.331	-1.282***	-1.367***	0.260	0.133	0.338*	0.248
	(0.261)	(0.218)	(0.345)	(0.331)	(0.180)	(0.198)	(0.185)	(0.232)
Observations	296	296	296	296	429	429	429	429

Notes. Seemingly unrelated regression (SUR) results. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5B. Reponse of Five-Year Yields to Surprises

	Pre-EMU				*Post-EMU*			
	FR	GE	IT	SP	FR	GE	IT	SP
FR CPI	-0.697	0.047	-1.372	-0.520	0.602	0.573	0.110	0.768
	(0.617)	(0.566)	(1.140)	(0.873)	(0.612)	(0.624)	(0.669)	(0.729)
GE CPI	0.964	0.263	1.395	0.760	0.423	0.355	0.383	0.413
	(0.834)	(0.766)	(1.543)	(1.181)	(0.441)	(0.450)	(0.482)	(0.525)
IT CPI	-0.320	0.147	0.056	-0.247	-0.238	-0.090	0.139	-0.326
	(0.932)	(0.856)	(1.724)	(1.320)	(0.619)	(0.631)	(0.676)	(0.737)
SP CPI	0.153	-0.567	-0.108	-0.029	1.057**	0.832*	0.675	0.970*
	(1.222)	(1.122)	(2.259)	(1.729)	(0.484)	(0.494)	(0.529)	(0.576)
GE IFO	1.358	0.569	0.720	0.352	1.359***	1.967***	1.438**	1.420**
	(0.868)	(0.797)	(1.605)	(1.228)	(0.522)	(0.533)	(0.571)	(0.622)
GE M3	0.462	3.759***	0.131	3.061***	-	-	-	-
	(0.603)	(0.554)	(1.115)	(0.853)	-	-	-	-
EA M3	-	-	-	-	0.138	0.782	0.144	0.933
	-	-	-	-	(0.518)	(0.529)	(0.566)	(0.617)
US CPIX	0.888	-0.518	-0.192	0.478	0.619	0.898	0.563	1.219
	(0.741)	(0.681)	(1.371)	(1.049)	(0.635)	(0.648)	(0.694)	(0.756)
US NonFarm Pay.	0.865	-0.930*	-0.767	-0.104	4.679***	1.910***	5.103***	2.580***
	(0.570)	(0.523)	(1.054)	(0.806)	(0.669)	(0.682)	(0.731)	(0.796)
US NAPM	0.852	-0.039	0.397	0.063	1.920***	2.010***	2.196***	1.869***
	(0.675)	(0.620)	(1.249)	(0.956)	(0.554)	(0.566)	(0.606)	(0.660)
Constant	-0.517**	-0.309	-0.768*	-1.171***	0.204	0.105	0.286	0.016
	(0.250)	(0.230)	(0.462)	(0.354)	(0.201)	(0.205)	(0.220)	(0.239)
Observations	416	416	416	416	429	429	429	429

Notes. Seemingly unrelated regression (SUR) results. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

	Table 5C. Reponse of Ten-Year Yields to Surprises							
	Pre-EMU				*Post-EMU*			
	FR	GE	IT	SP	FR	GE	IT	SP
FR CPI	-0.455	0.016	-1.893	-0.038	0.571	0.491	0.320	0.539
	(0.588)	(0.594)	(1.164)	(0.835)	(0.550)	(0.621)	(0.567)	(0.759)
GE CPI	0.566	0.159	1.698	0.406	0.361	0.357	0.484	0.328
	(0.796)	(0.804)	(1.575)	(1.130)	(0.396)	(0.447)	(0.409)	(0.546)
IT CPI	-0.508	0.219	0.156	-0.733	-0.323	-0.011	-0.339	-0.419
	(0.890)	(0.898)	(1.761)	(1.263)	(0.556)	(0.628)	(0.574)	(0.767)
SP CPI	0.301	-0.417	0.789	-0.030	0.775*	0.734	0.685	0.467
	(1.166)	(1.177)	(2.307)	(1.655)	(0.435)	(0.491)	(0.449)	(0.600)
GE IFO	1.461*	0.530	0.846	0.737	0.928**	1.742***	0.968**	0.849
	(0.828)	(0.836)	(1.639)	(1.176)	(0.470)	(0.530)	(0.484)	(0.648)
GE M3	0.380	4.193***	-1.028	2.993***	-	-	-	-
	(0.575)	(0.581)	(1.139)	(0.817)	-	-	-	-
EA M3	-	-	-	-	0.159	0.836	0.101	0.938
	-	-	-	-	(0.466)	(0.526)	(0.480)	(0.642)
US CPIX	0.677	-0.717	0.140	1.027	0.677	0.707	0.734	-0.269
	(0.708)	(0.714)	(1.400)	(1.005)	(0.571)	(0.644)	(0.588)	(0.787)
US NonFarm Pay.	0.581	-0.949*	1.985*	-0.312	3.559***	1.582**	3.441***	0.477
	(0.544)	(0.549)	(1.076)	(0.772)	(0.601)	(0.678)	(0.620)	(0.829)
US NAPM	0.602	-0.129	0.383	-0.187	1.329***	1.876***	1.490***	1.598**
	(0.645)	(0.651)	(1.276)	(0.915)	(0.498)	(0.563)	(0.514)	(0.687)
Constant	-0.561**	-0.235	-0.636	-1.161***	0.076	0.063	0.073	-0.190
	(0.239)	(0.241)	(0.472)	(0.339)	(0.181)	(0.204)	(0.186)	(0.249)
Observations	416	416	416	416	429	429	429	429

Notes. Seemingly unrelated regression (SUR) results. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. Summary Statistics of Far-Ahead Forward Rates

	FR		GE		IT		SP	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Pre-EMU	7.22	1.02	6.93	1.00	9.24	2.22	8.78	1.84
Post-EMU	4.89	0.65	4.55	0.62	5.18	0.59	4.87	0.68

Table 7. Principal Components Analysis of Yields within Countries

	Pre-EMU				Post-EMU			
Contributions of	FR	GE	IT	SP	FR	GE	IT	SP
First PC	0.969	0.957	0.999	0.998	0.912	0.950	0.928	0.924
Second PC	0.031	0.043	0.001	0.002	0.087	0.050	0.071	0.074
Factor Loadings								
First Factor								
2 Year Yield	0.322	0.307	0.333	0.333	0.299	0.309	0.306	0.303
3 Year Yield	0.330	0.331	0.333	0.333	0.324	0.330	0.326	0.326
4 Year Yield	0.336	0.339	0.333	0.333	0.340	0.339	0.339	0.339
5 Year Yield	0.338	0.341	0.334	0.334	0.348	0.342	0.345	0.346
6 Year Yield	0.338	0.340	0.334	0.334	0.349	0.342	0.346	0.346
7 Year Yield	0.337	0.339	0.334	0.334	0.345	0.340	0.343	0.343
8 Year Yield	0.335	0.337	0.333	0.333	0.339	0.337	0.338	0.338
9 Year Yield	0.333	0.334	0.333	0.333	0.331	0.333	0.331	0.332
10 Year Yield	0.331	0.332	0.333	0.333	0.324	0.329	0.325	0.325
Second Factor								
2 Year Yield	0.584	0.695	0.549	0.426	0.582	0.638	0.577	0.585
3 Year Yield	0.428	0.381	0.456	0.431	0.421	0.399	0.419	0.419
4 Year Yield	0.245	0.172	0.254	0.323	0.250	0.210	0.248	0.247
5 Year Yield	0.072	0.023	0.068	0.164	0.088	0.057	0.089	0.086
6 Year Yield	-0.074	-0.090	-0.080	-0.006	-0.054	-0.069	-0.052	-0.055
7 Year Yield	-0.192	-0.180	-0.194	-0.164	-0.174	-0.174	-0.172	-0.175
8 Year Yield	-0.283	-0.254	-0.284	-0.298	-0.274	-0.264	-0.274	-0.274
9 Year Yield	-0.353	-0.316	-0.355	-0.402	-0.356	-0.341	-0.359	-0.356
10 Year Yield	-0.406	-0.371	-0.413	-0.473	-0.423	-0.408	-0.431	-0.423

Table 8A. Reponse of Far-Ahead Forward Rates to Surprises

	Pre-EMU				*Post-EMU*			
	FR	GE	IT	SP	FR	GE	IT	SP
FR CPI	-0.228	-0.185	-2.364	0.742	0.505	1.081	0.811	0.334
	(0.734)	(0.853)	(2.538)	(1.168)	(0.582)	(0.979)	(0.679)	(1.331)
GE CPI	-0.056	0.264	3.476	-0.202	0.349	0.194	0.726	0.195
	(0.994)	(1.154)	(3.433)	(1.580)	(0.419)	(0.705)	(0.489)	(0.958)
IT CPI	-0.820	2.532**	0.834	-1.011	-0.519	0.865	-0.944	-0.388
	(1.111)	(1.290)	(3.837)	(1.766)	(0.588)	(0.990)	(0.687)	(1.345)
SP CPI	0.724	-0.606	2.529	-0.220	0.531	-0.096	0.921*	-0.008
	(1.455)	(1.690)	(5.028)	(2.314)	(0.460)	(0.774)	(0.537)	(1.053)
GE IFO	1.611	1.239	0.973	1.659	0.423	0.159	0.139	0.003
	(1.034)	(1.201)	(3.572)	(1.643)	(0.497)	(0.836)	(0.580)	(1.136)
GE M3	-0.018	5.063***	-2.484	2.557**	-	-	-	-
	(0.718)	(0.834)	(2.482)	(1.142)	-	-	-	-
EA M3	-	-	-	-	0.268	0.785	0.026	0.796
	-	-	-	-	(0.493)	(0.829)	(0.575)	(1.127)
US CPIX	0.345	-0.719	1.193	2.440*	0.855	-0.310	0.753	-2.432*
	(0.883)	(1.026)	(3.052)	(1.404)	(0.603)	(1.015)	(0.704)	(1.380)
US NonFarm Pay.	0.201	-2.335***	1.485	-1.218	2.116***	0.751	1.122	-2.411*
	(0.679)	(0.788)	(2.345)	(1.079)	(0.636)	(1.070)	(0.742)	(1.454)
US NAPM	0.126	-0.873	-1.244	-1.324	0.400	0.730	-0.079	1.184
	(0.805)	(0.935)	(2.780)	(1.279)	(0.527)	(0.887)	(0.615)	(1.205)
Constant	-0.623**	0.093	0.713	-1.567***	-0.093	0.265	-0.200	-0.362
	(0.298)	(0.346)	(1.029)	(0.474)	(0.191)	(0.321)	(0.223)	(0.437)
Observations	416	416	416	416	429	429	429	429

Notes. Seemingly unrelated regression (SUR) results. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8B. Response of the Slope of the Yield Curve to Surprises								
	Pre-EMU				*Post-EMU*			
	FR	GE	IT	SP	FR	GE	IT	SP
FR CPI	0.052	-0.807	-0.674	0.742	-0.026	0.592	0.420	-0.314
	(0.827)	(0.845)	(2.140)	(0.702)	(0.597)	(0.885)	(0.717)	(1.556)
GE CPI	-1.903*	-0.311	0.893	-1.076	-0.129	-0.116	0.200	-0.390
	(1.071)	(1.094)	(2.770)	(0.908)	(0.430)	(0.637)	(0.516)	(1.120)
IT CPI	-0.796	2.460**	-0.421	-1.202	-0.270	0.896	-1.014	-0.306
	(1.139)	(1.164)	(2.947)	(0.966)	(0.603)	(0.894)	(0.725)	(1.573)
SP CPI	0.038	0.141	2.333	-0.333	-0.595	-0.762	-0.136	-1.017
	(1.493)	(1.526)	(3.862)	(1.266)	(0.472)	(0.700)	(0.567)	(1.231)
GE IFO	0.859	0.876	2.716	0.493	-1.117**	-1.799**	-1.230**	-1.534
	(1.074)	(1.097)	(2.777)	(0.911)	(0.509)	(0.755)	(0.612)	(1.328)
GE M3	-1.334	1.060	-14.171***	0.434	-	-	-	-
	(1.215)	(1.242)	(3.144)	(1.031)	-	-	-	-
EA M3	-	-	-	-	0.059	0.160	-0.157	0.294
	-	-	-	-	(0.505)	(0.749)	(0.607)	(1.317)
US CPIX	-0.141	-0.239	4.804	0.659	0.359	-1.251	0.207	-3.656**
	(1.317)	(1.346)	(3.406)	(1.117)	(0.619)	(0.917)	(0.744)	(1.613)
US NonFarm Pay.	-1.351*	-1.979**	8.847***	0.180	-2.300***	-1.123	-3.153***	-5.056***
	(0.786)	(0.804)	(2.034)	(0.667)	(0.652)	(0.967)	(0.784)	(1.700)
US NAPM	-0.676	0.068	0.258	-1.172	-1.309**	-1.290	-1.667**	-0.627
	(0.935)	(0.956)	(2.419)	(0.793)	(0.541)	(0.801)	(0.650)	(1.410)
Constant	-0.592	0.298	0.968	0.047	-0.353*	0.132	-0.539**	-0.610
	(0.363)	(0.371)	(0.940)	(0.308)	(0.196)	(0.290)	(0.235)	(0.511)
Observations	296	296	296	296	429	429	429	429

Notes. Seemingly unrelated regression (SUR) results. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1. Bond Markets, Ten Years Apart

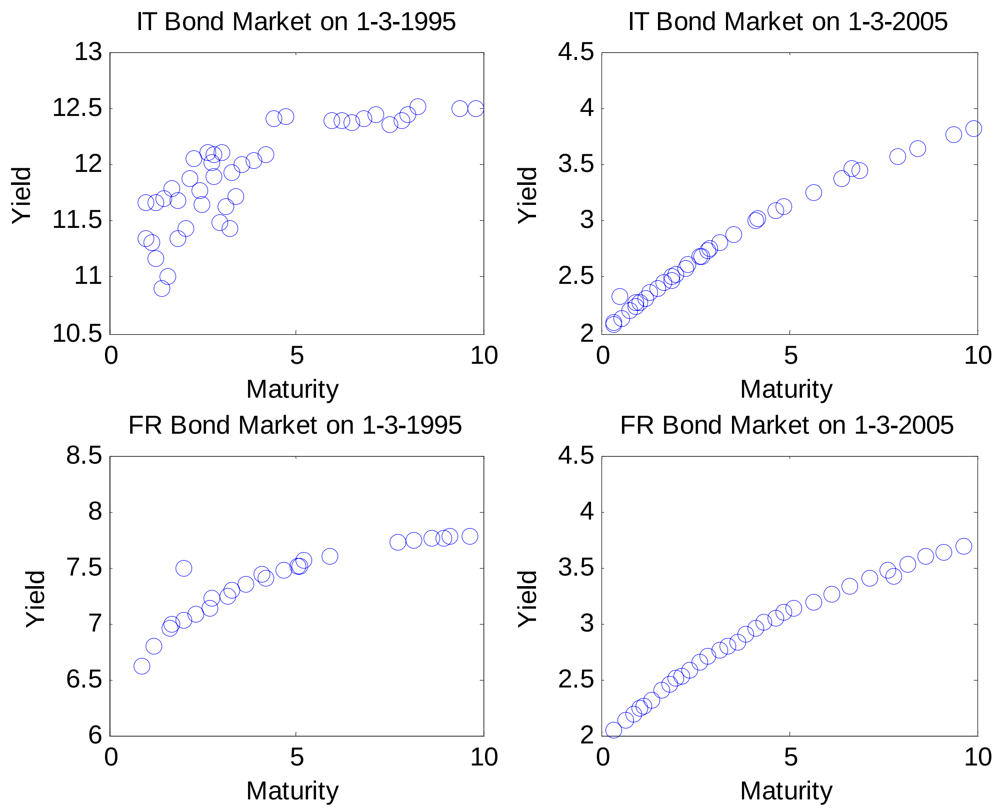


Figure 2. Time Series of Constant Maturity Yields

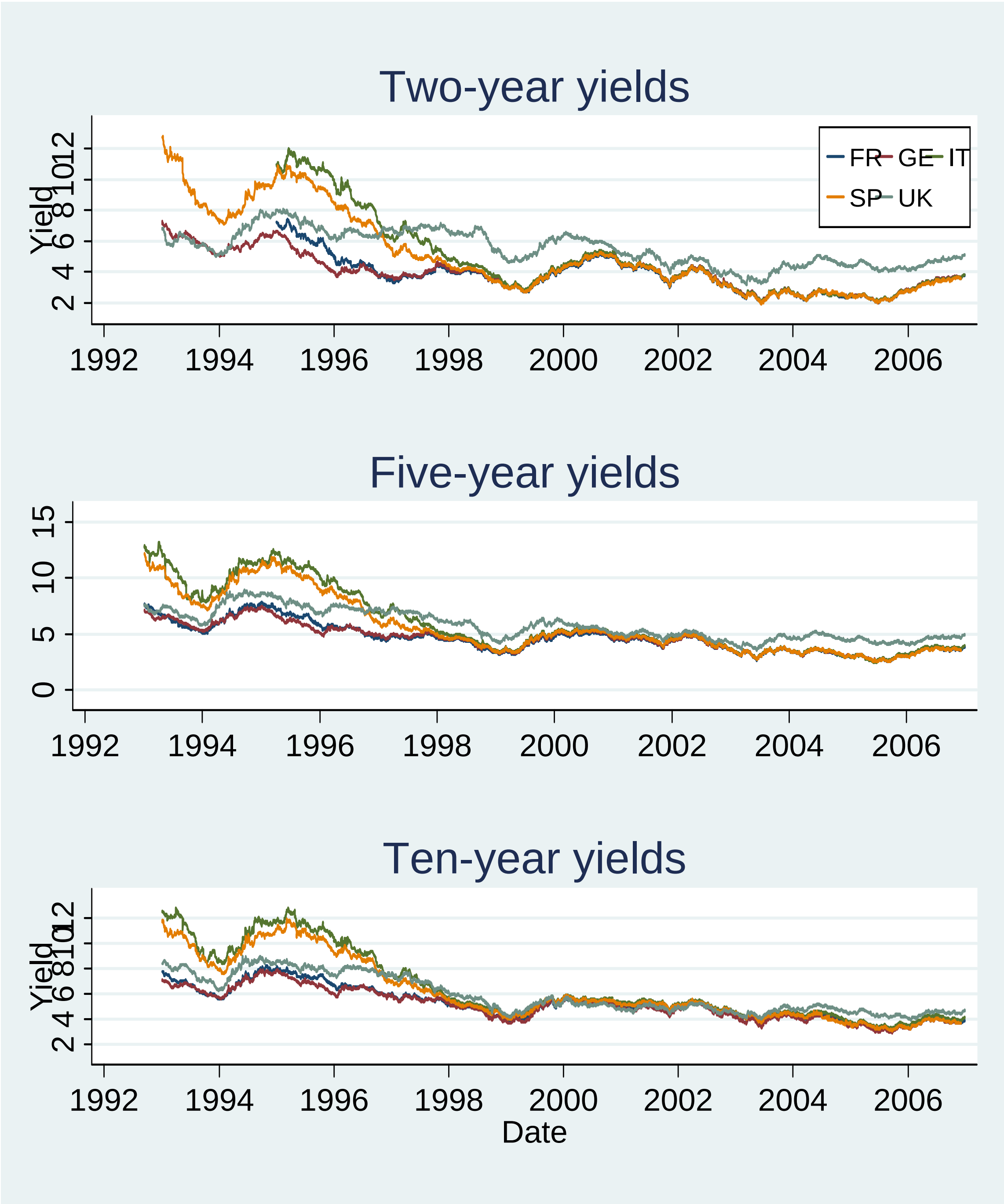
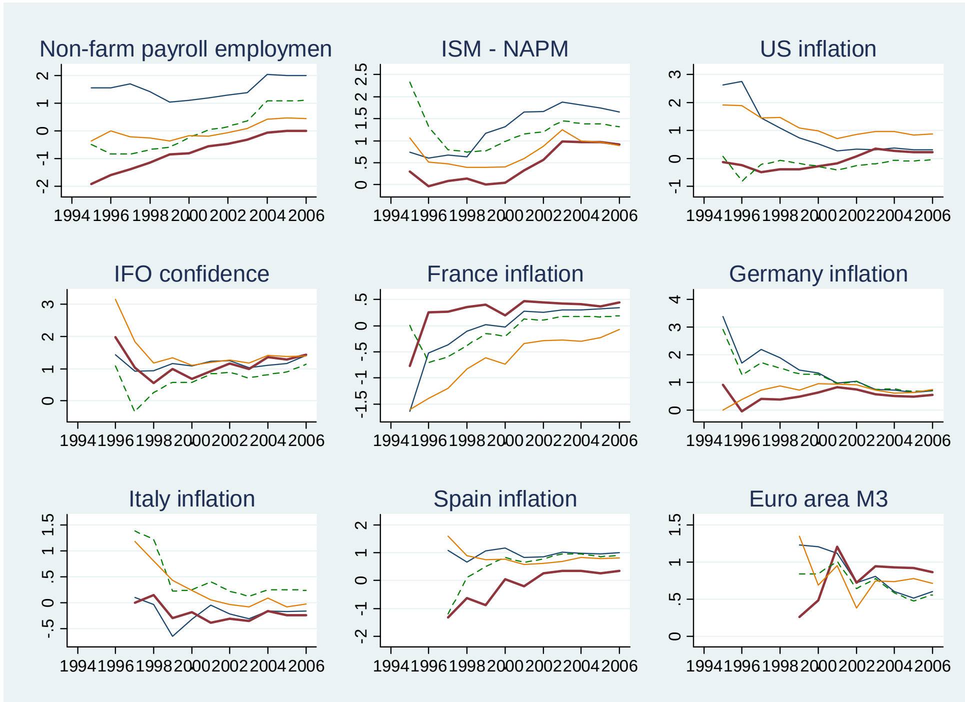
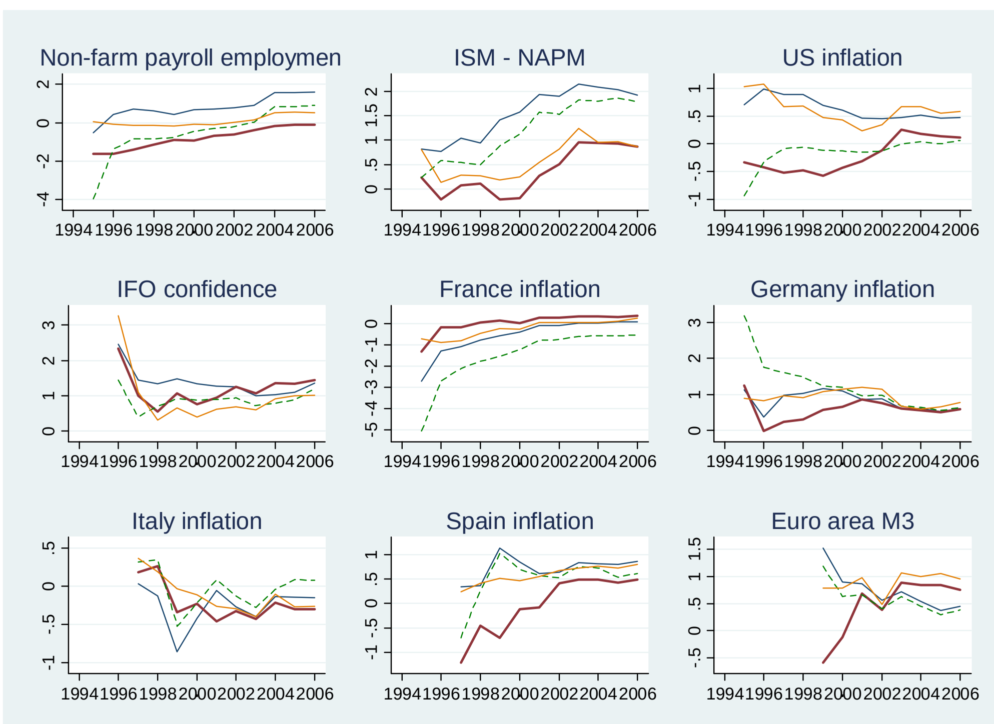


Figure 3. Response of yields to macroeconomic surprises

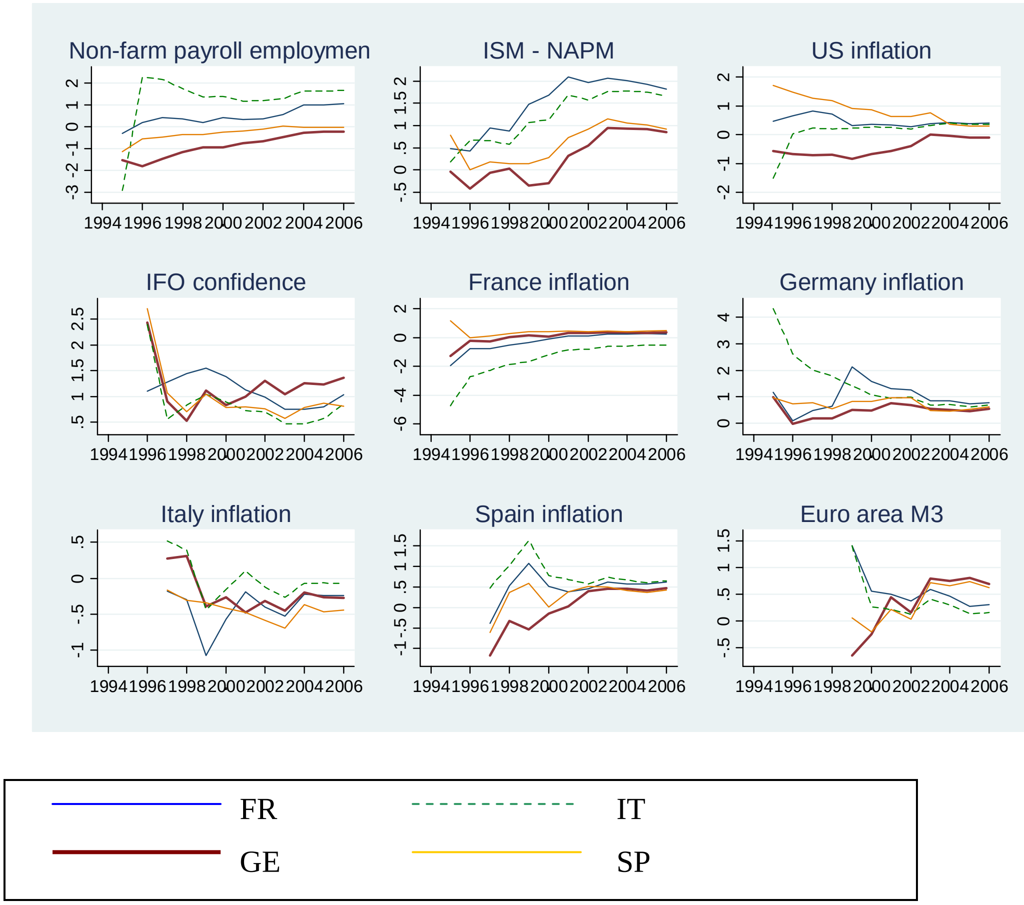
A. 2-year yields



B. 5-year yields

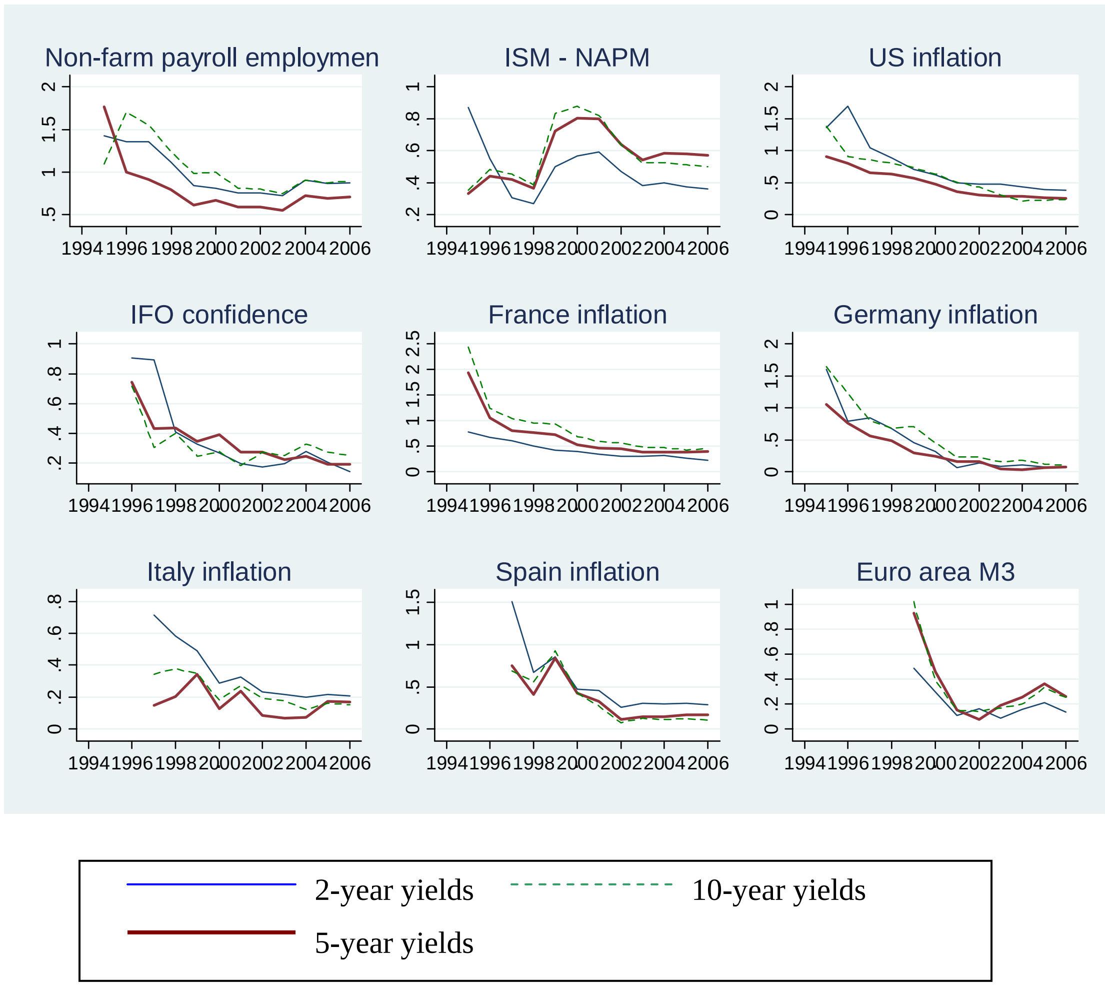


C. 10-year yields



Note. Slope coefficients from rolling regressions with four-year windows, as described in text.

Figure 4. Heterogeneity in the effects of macroeconomic surprises, 2-, 5-, 10-year yields

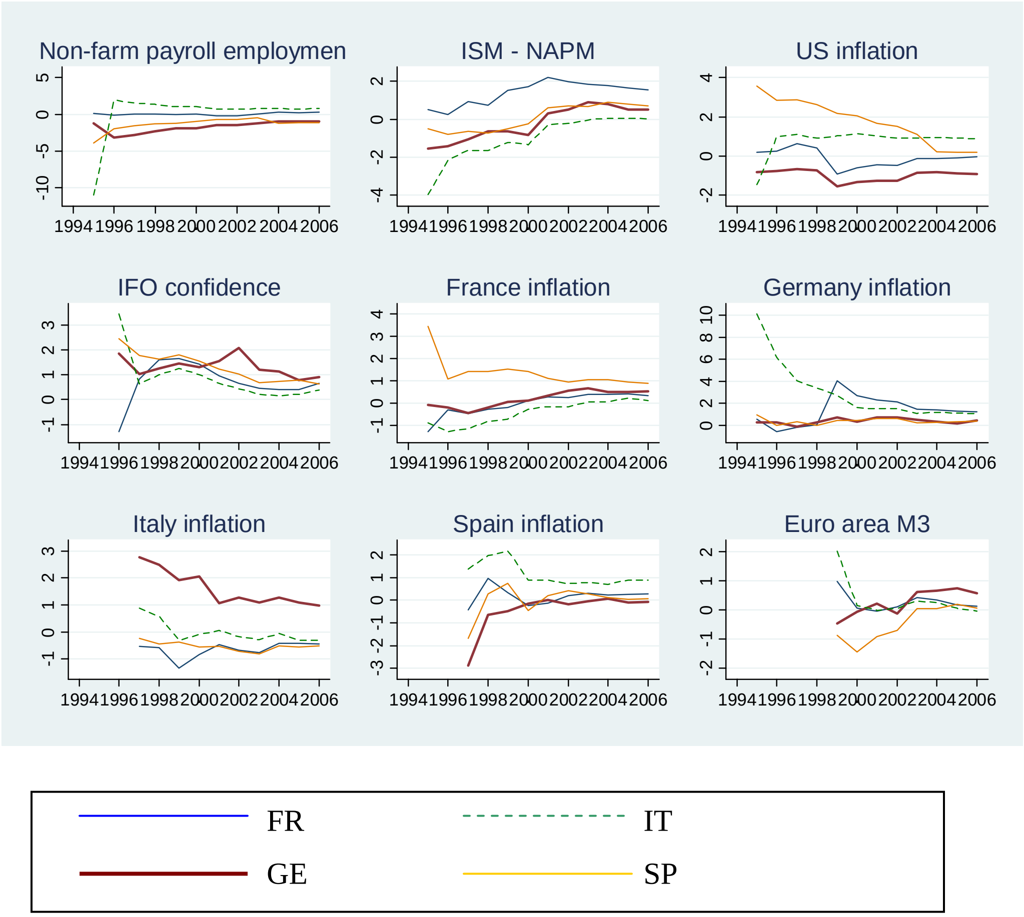


Notes: The figure shows the standard deviation in the response coefficients β across the four euro area countries in the sample (France, Germany, Italy, Spain) from

$$\Delta y_t^{i,j} = \alpha^{i,j} + \sum_{k=1}^{K}\sum_{l=1}^{L_k} \beta_{l,k}^{i,j} Surprise_{l,k,t} + \varepsilon_t^{i,j}$$, using a rolling estimation of 4-year windows.

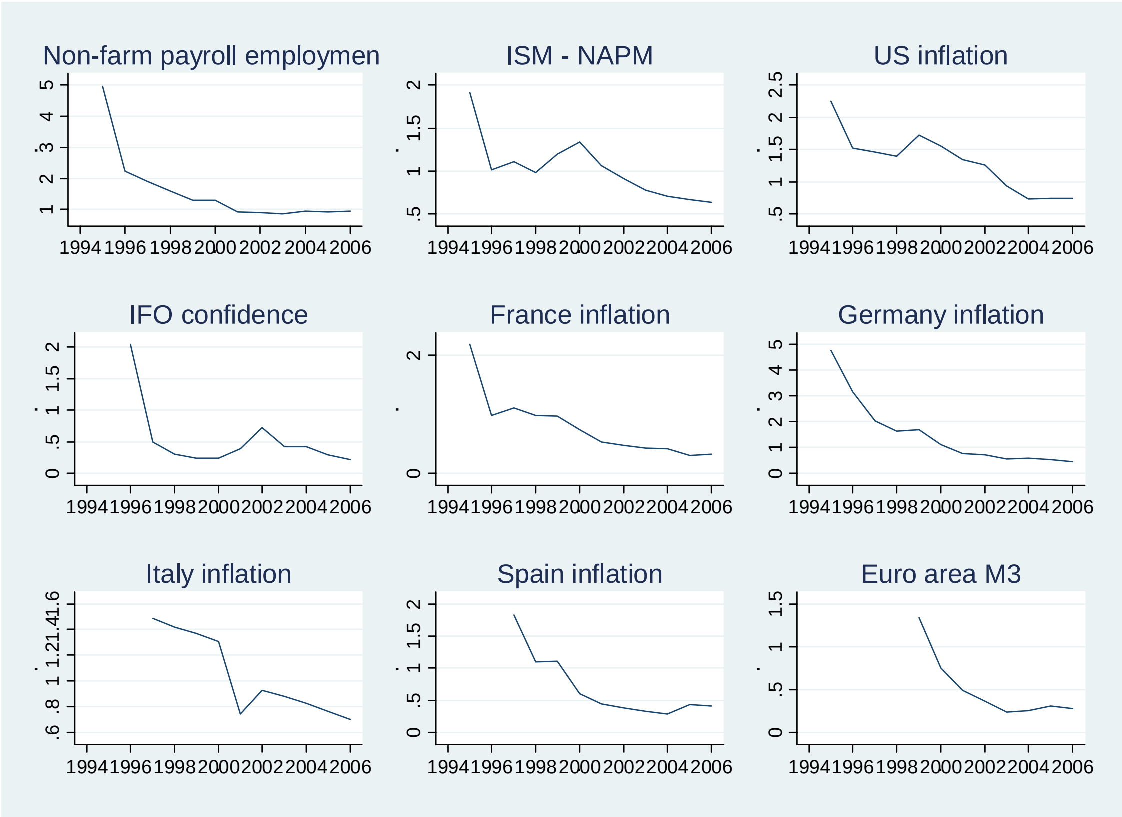
Figure 5. Response of 9-year-ahead 1 year forward rate

to macroeconomic surprises



Note. Slope coefficients from rolling regressions with four-year windows, as described in text.

Figure 6. Heterogeneity in the effects of macroeconomic surprises, 1-year forward rates in 9 years



Notes: The figure shows, for the 1-year forward rates in 9 years, the standard deviation in the response coefficients β across the four euro area countries in the sample (France, Germany, Italy, Spain) from

$\Delta y_t^{i,j} = \alpha^{i,j} + \sum_{k=1}^{K}\sum_{l=1}^{L_k} \beta_{l,k}^{i,j} Surprise_{l,k,t} + \varepsilon_t^{i,j}$, using a rolling estimation of 4-year windows.

Appendix A. Data Construction

a. Yields

The daily smoothed yield curve data comes from the Bank for International Settlements for Germany and Spain. German data have the key BISM.D.HSJA.DE, and Spanish data BISM.D.HSJA.ES. The UK yields are available on the Bank of England's web page at http://www.bankofengland.co.uk. We use the zero coupon continuously compounded yields. Italian and French yields yield curves at daily frequency going back to early 1990's were not readily available therefore we estimated those ourselves, using underlying bond data from Bloomberg. The yield curves estimated were of the Extended Nelson-Siegel (Svensson) functional form. Bloomberg only had bonds with at least five years to maturity available for early in the period therefore we do not use short-term yields (less than five years) before 1995 for France and Italy.

b. Macroeconomic Data Surprises

Data on U.S. macroeconomic statistical releases and forecasts were collected by Money Market Services up through July 2003, when that company merged with a larger financial institution. Subsequent to July 2003, the same survey was produced again by Action Economics. These data can be purchased from Haver Analytics as part of the "MMS" series of data at http://www.haver.com. For the U.K., we also obtained MMS data Haver Analytics.

Bloomberg also carries out surveys of expectations for macroeconomic data releases and publishes these together with the realized values. The MMS and Bloomberg numbers agree almost perfectly when they both exist. We used Bloomberg data to fill in gaps in the MMS data late in the period for the US and UK. Data on individual country releases for France, Germany, Italy and Spain and the euro area aggregates also come from Bloomberg. Bloomberg's macroeconomic data release coverage begins in 1996 which limits our macroeconomic data surprises from the continental European countries to this period. Euro area aggregates come into existence in 1999.

Many of the series are reported as both month-on-month (and quarter-on-quarter) and year-on year changes. In these cases we chose the version that had the most number of available observations, which, for this sample, more often were the month-on-month numbers (German M3 is the exception, in this case we use the year-on-year rates). We have verified that using year-on-year versions do not change the results of our analyses.

Table A-1. Availability of Surprise Data

Surprise	*Begins*	*Ends*
US Capa. Util.	Jan-93	Dec-06
US Cons. Conf	Jan-93	Dec-06
US CPIX	Jan-93	Dec-06
US GDP	Jan-93	Dec-06
US NAPM	Jan-93	Dec-06
US NonFarm Pay.	Jan-93	Dec-06
US New Hom.	Feb-93	Dec-06
US Ret. Sales	Jan-93	Dec-06
US Unemp.	Jan-93	Dec-06
UK Avg. Earnings	May-98	Dec-06
UK GDP	Apr-93	Nov-06
UK Man. Prod.	Mar-93	Dec-06
UK PPI	Mar-93	Dec-06
UK RPIX	Mar-93	Dec-06
UK Ret. Sales	Mar-93	Dec-06
EA Bus. Climate	May-99	Oct-06
EA CPI	Jan-99	Nov-06
EA Ind. Prod.	Jan-99	Nov-06
EA M3	Mar-99	Nov-06
EA Unemp.	Feb-99	Nov-06
GE CPI	Mar-93	Nov-06
GE IFO	Aug-96	Nov-06
GE Ind. Prod.	Mar-93	Nov-06
GE M3	Mar-93	Jan-99
GE Man. Ord.	Mar-93	Nov-06
GE Unemp.	Mar-93	Nov-06
FR Cons. Confid.	Dec-96	Oct-06
FR CPI	Mar-93	Nov-06
FR Ind. Prod.	Mar-93	Nov-06
FR M3	Mar-93	Feb-96
FR Unemp	Feb-93	Oct-06
IT CPI	Jan-97	Nov-06
IT Ind. Prod.	Mar-97	Nov-06
IT Unemp.	Jun-97	Sep-06
SP CPI	Feb-97	Nov-06
SP Unemp.	Nov-97	Nov-06
SP. Ind. Prod.	Mar-97	Nov-06