Exchange rates and fundamentals: New evidence from real-time data

Michael Ehrmann and Marcel Fratzscher*
European Central Bank
Michael.Ehrmann@ecb.int, Marcel.Fratzscher@ecb.int

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Abstract

The paper takes a relatively novel approach to analysing the link between economic fundamentals and exchange rates by investigating the importance of real-time data of news about fundamentals. It is argued that this approach captures more accurately the true information available to market participants when making their daily investment decisions. Testing the role of a broad set of monetary policy and macroeconomic news for the United States, Germany and the euro area shows that such news about fundamentals has indeed been a relevant driving force behind the US dollar – euro/DEM exchange rate developments in the period 1993-2003. The paper also finds strong asymmetries in the relationship between fundamentals and exchange rates. In particular, the paper presents evidence that exchange rates are more sensitive to economic fundamentals when the degree of market uncertainty is high, and when negative or large shocks occur. The model based on real-time data is capable of explaining about 75% of the directional changes of the US dollar-euro exchange rate in the period 1999-2003, although it does not explain well the magnitude of the exchange rate changes.

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1. Introduction

20 years after the influential paper by Meese and Rogoff (1983), only modest progress has been made in explaining and predicting exchange rate movements with macroeconomic fundamentals. While fundamentals-based models have been developed over the years that perform reasonably well in explaining exchange rate developments in the long-run, econometric attempts to explain short- and medium-term movements in exchange rates have had limited success so far.[1] There is a broad consensus that some of the reasons for the poor performance of empirical model to account for exchange rate developments on a short- and medium-term horizon have not only to do with econometric problems, such as small sample biases, but also with irrationality of market participants, bubbles, herd behaviour etc., i.e. factors which cannot be captured sufficiently well as to be included in econometric models of exchange rates.

This paper takes a different and relatively novel approach to analysing the link between fundamentals and exchange rate movements in the short-term. We argue that a potentially important shortcoming of many standard, fundamentals-based models of the exchange rate is that they use measures of fundamentals that do not accurately reflect the true information market participants have when making trading decisions. In this paper, we instead use real-time data, i.e. daily market announcements of important macroeconomic variables as well as announcements of monetary policy decisions, as measures of fundamentals. More precisely, exploiting survey data on market participants' expectations of such announcements, we are able to extract the surprise or "news" component of each variable.

We then take these market news about fundamentals and test to what extent they are capable of explaining the actual behaviour of daily exchange rate movements. This methodology has the key advantage of allowing us to test much more directly whether fundamentals - as they become available to market participants - are capable of accounting for the price discovery process in foreign exchange markets. For the empirical implementation of the methodology, we focus on the most important macroeconomic and monetary policy news in the United States and the euro area/Germany for the period 1993-2003 and test for their role and importance in explaining the exchange rate movements of the US dollar vis-à-vis the euro and German mark.

While most work on the effect of real-time data on foreign exchange markets has focused on explaining changes in the conditional variances (e.g. Andersen and Bollerslev 1998, Ederington and Lee 1993), only relatively few studies have so far attempted to test for the effect of macroeconomic news on the conditional mean process of foreign exchange markets. Most of the previous work using real-time data focuses on intra-day data, usually 5-minute intervals, for analysing the effect of macroeconomic news on exchange rate levels. Almeida, Goodhart and Payne (1998) look at the DM exchange rate vis-à-vis the US dollar and find significant intra-day effects of macroeconomic announcements. This is in line with some of those authors' earlier work (Goodhart, Hall, Henry, and Pesaran 1993), who find US as well as UK macroeconomic news change the British pound-US dollar exchange rate.

[1] See e.g. Mark (1995) and Cheung, Chinn and Garcia Pascual (2002) for a discussion and evaluation of exchange rate models of the 1980s and 1990s.

The most recent study in this spirit is Andersen, Bollerslev, Diebold and Vega (2003), who look at five currencies vis-à-vis the US dollar for the period January 1992 till December 1998. Using five-minute market intervals, they find that various US news about macroeconomic variables significantly affect exchange rates. An interesting result of the work by Andersen, Bollerslev, Diebold and Vega (2003) is that they find some indication for the presence of asymmetries in exchange rate responses to fundamentals, in that exchange rates tend to react more strongly to large news surprises and to negative news.

This paper here attempts to make a contribution to this literature in two central regards. First, the paper focuses on the presence of asymmetries in the reaction of exchange rates, and in particular on the question whether existing market conditions are an important determinant for explaining why the conditional means of exchange rates react differently to macroeconomics news over time. This is an important issue as the theoretical work on herd behaviour and information cascades (e.g. Banerjee 1992, Bikchandani, Hirschleifer and 1992) stresses that markets may incorporate information in a highly asymmetric fashion. The paper shows evidence for the presence of such asymmetries, and that the differences in effects are frequently quite large.

Second, the paper provides an evaluation of the overall importance of macro news on exchange rates. For this purpose, the paper is different from the literature in that it analyses exchange rate responses at a daily frequency. The main motivation for using daily rather than intra-daily frequency is that work with intra-daily data has shown a mostly very short-lived effect of news on exchange rate levels, with the effects often disappearing within minutes (e.g. Dominguez 1999, Andersen, Bollerslev, Diebold and Vega 2003). From a broader perspective, news about macroeconomic fundamentals are important for overall exchange rate movements only if these effects are sufficiently long-lived in that they drive exchange rate developments on a daily or monthly frequency.

We find four key results. First, we show that news about fundamentals can explain relatively well the *direction* in recent years, but only to a much smaller extent the *magnitude* of daily and monthly exchange rate developments. The model with real-time data correctly explains the direction of the US dollar-euro exchange rate in 3 out of 4 months, or about 75% of the cases. This compares favourably to several standard fundamentals-based models in the literature. However, the model is capable of explaining only a modest share of the magnitude and the frequently large monthly changes of the US dollar-euro exchange rate.

Second, we find that news about the US economy have a larger impact on exchange rate movements than news emanating from the euro area. This may reflect the relatively greater importance of the US economy, but may also in part be explained by the fact that US announcements are usually released earlier than comparable euro area or German announcements. The implication is that US announcements have a relatively higher news content than comparable euro area announcements. Moreover, there is a large overall number of announcements in the euro area given the fact that most member countries make announcements in their own country, reducing the news content of each individual announcement. Third, the econometric results reveal that the explanatory power of the fundamentals in our sample increases over time, underlining that fundamentals continue to be an important driving force behind recent movements of the US dollar – euro exchange rate.

A fourth and highly important finding is that the effect of news on exchange rates crucially depends on market conditions. More precisely, news releases have a particularly large effect on exchange rates in times when there is a high degree of market uncertainty, in the sense that previous news did not provide a clear and unanimous signal to market participants about the direction of the economy. In addition, exchange rates tend to react more strongly to news in periods when previous exchange rate volatility has been high.

The paper is structured in the following way. We proceed in section 2 by outlining the rationale for using real-time data and by explaining why such an approach may be more promising in establishing a link between exchange rates and fundamentals. Section 2 also discusses the construction of our data set, in particular how we extract market "news" about economic fundamentals. Section 3 then briefly outlines our econometric approach, which is based on an iterative weighted least square estimation procedure. The empirical results are presented in sections 4 and 5. Section 4 provides the results for the linear models, also analysing variations of the parameters over time. Section 5 tests for the presence of asymmetries in news effects on exchange rates, in particular resulting from uncertainty and volatility in foreign exchange markets. An overall evaluation of the performance and goodness-of-fit of our real-time model on a short- and medium-term horizon follows in section 6. Section 7 concludes with a short discussion of the findings and their implications.

2. Exchange rates, fundamentals and news: the data

2.1 Fundamentals and news: the case for using real-time data

The question of how to measure economic fundamentals accurately is a difficult one. Most empirical work, not only on the determination of exchange rates but more generally of most asset prices, employs the most recent "vintage" data, i.e. the final, revised measures of economic variables that are generally released several months or quarters later. There are a number of problems with such a use of the data. In particular, economic variables are mostly released only with a considerable time lag. Moreover, the first release of data on fundamentals is mostly revised at least once and in some cases several times. It often takes several quarters for the final data of an economic variable to be released. What therefore econometric work does that employs such final, revised data is essentially trying to explain changes in asset prices with explanatory variables that are mostly not known to market participants until several months later. Given the often abrupt changes in asset prices and their high degree of volatility in the short- to medium-term, it may therefore not be surprising that the performance of models using such lagged data is limited.

The use of real-time data instead, i.e. data that is actually available to economic agents at any one point in time, can fundamentally alter the results and interpretations of economic models. Orphanides (2001), for instance, finds that recommendations and interpretations of monetary policy in the United States change fundamentally when using real-time data instead of vintage data as is common when estimating Taylor rules. Koenig et al. (2000) show that the forecasts performance for US GDP changes substantially when using real-time data.

To illustrate the bias that may arise from the use of vintage data, Table 2.1 compares the quarterly advance US GDP releases, which usually occur the month after each quarter,

with the preliminary and the final, revised GDP figures, which are mostly released two and three months, respectively, after each quarter. The table reveals that there are relatively large revisions in this data between the first release (advance release) and the release of the final data (final release), which have been, on average, at the magnitude of 0.6 percentage points in the year-on-year quarterly GDP growth rate in 1993-2003. The table shows that most of the revision is made for the second release, the release of the "preliminary" GDP figures. The high correlations between the revisions and their surprise components in the data, shown in the last two columns, indicate that the revisions are indeed mostly unpredictable by the markets.

In defence of using such final data, one may argue that this could reflect relatively well the market views and beliefs already at the time for which the final data is released several months later. However, this argument is not consistent with the fact that models trying to explain asset price movements, and in particular for exchange rates, at the short- to medium-term have performed only modestly well. What follows, therefore, is that either asset price movements at shorter horizons are determined by factors other than observable fundamentals, such as herd behaviour, or alternatively that the employed measures of fundamentals do not reflect sufficiently well the true information available in the market at any one point in time.

The approach we follow in this paper is to analyse the relevance of *real-time* data of fundamentals for exchange rate movements. Such real-time data consists of daily announcements of data for important macroeconomic variables as well as of monetary policy decisions. This reflects in *real time* the information that becomes available to the markets every day.

However, it should be emphasised that an announcement is of relevance for markets only to the extent to which it has not been anticipated. This is not to say that the announcement itself has no relevance for the markets, but it implies that what we can measure is only the response of markets to the unexpected component, or "*news*" or "*surprise*", of an announcement. The remaining component of the announcement has been incorporated into the market previously, but since we cannot determine the exact timing of when this occurred, we cannot measure its impact on the markets to same degree of accuracy.

Our measure of news is therefore the surprise component ($S_{k,t}$) of the announcement k, which is defined as the difference between the actual announcement ($A_{k,t}$) and the market's prior expectation ($E_{k,t}$), normalised by dividing by the sample standard deviation $?_k$ of each announcement in order to allow a comparison of the relative size of the coefficients in the econometric model:

$$S_{k,t} = \frac{A_{k,t} - E_{k,t}}{\Omega_k}$$

The data source for the macroeconomic variables is MMS International. This data is based on a survey of around 40 market participants on the Friday prior to each announcement. Our data set includes about 120 news for each variable, given the time period 1 January 1993 – 14 February 2003 and the fact that announcements for most variables occur on a monthly frequency.

Tables 2.2 and 2.3 show some summary and descriptive statistics of the macroeconomic variables for the United States, Germany and the euro area included in the model. Previous work using MMS expectations data shows that statistical tests confirm unbiasedness and efficiency of the survey data (Ehrmann and Fratzscher 2002). Finally, Figure 2.1 shows the figures for the non-standardised surprises for all the macroeconomic and monetary policy variables.

We also look at news about monetary policy decisions as a potential factor driving movements in the US dollar – euro/DEM exchange rate. Similar to the approach for the macroeconomic variables, we extract the market surprise about monetary policy decisions using survey data from Reuters. We define the monetary policy surprise as the difference between the actual announcement by the Fed, ECB or Bundesbank and the *mean* of the expectations of the around 25-30 market participants in the Reuters survey. As shown in out previous work on money markets (Ehrmann and Fratzscher 2002), this measure of monetary policy surprises proves not only unbiased and efficient statistically but performs relatively well empirically compared to other measures of such surprises.[2]

Table 2.4 presents some summary statistics for the monetary policy announcements and surprises for the three central banks and confirms that market participants were mostly able to anticipate monetary policy decisions well. Our results also confirm previous work that underlined that market participants were able to anticipate decision by the ECB relatively well (e.g. Ehrmann and Fratzscher 2002, Perez-Quiros and Sicilia 2002).

2.2 Exchange rates and frequency issues

A key issue is the frequency of the econometric analysis. A number of previous studies using real-time data (Almeida et al. 1998, Andersen et al. 2003) have employed high-frequency data based on 5-minute trading intervals. There are two key reasons why we chose not to follow this approach. First, although MMS International lists the official release time of each announcement, it is widely acknowledged that such release times tend to be inaccurate for German data releases as some of the releases are "leaked" to the markets minutes or even hours prior to their official release time (Andersen et al. 2003). It may therefore not be surprising that studies using such high-frequency data do not find much econometric evidence for an effect of German news on exchange rates. A second reason is that asset prices may initially "overshoot" in their reaction to news. This may imply that the true permanent effect of news on exchange rates may be smaller than the initial, immediate reaction.

By contrast, the main drawback of choosing a daily frequency is that a large number of news, far larger than could possibly be measured and observed, "hits" the markets throughout a typical trading day. Hence our estimate of the news effect of any given macroeconomic variable includes a lot of noise from other news during the day. However, the important point to emphasise is that this does not lead to a bias in the estimates of news effects as long as the other news during the days of a particular announcement are not

[2] For alternative measures for the United States based on Fed funds futures, see Kuttner (2001) and Söderström (2001). Such market-based measures could not be tested in the context of our analysis due to the non-availability of similar data for Germany.

systematic or reflect other recurring news. It only means that the point estimates are not efficient, resulting in larger standard errors of the coefficients of the news effects.

As we are particularly interested in comparing the importance of US news with the role of euro area and German news, we chose a daily frequency for our empirical analysis. For the choice of the exchange rate, we use the US dollar – euro/DEM rate at 18.00 Eastern Standard Time (EST). This ensures that both European and US news of the same day are reflected in this exchange rate. Nevertheless, European news are mostly announced before US news on any given day, given the time difference of mostly 6 hours between continental Europe and the East coast of the United States.

3. Exchange rate responses to news: the econometric model

We choose an iterative, weighted least squares (WLS) procedure, adopting a similar approach to Andersen et al. (2003) and Ehrmann and Fratzscher (2002), in order to test for the news effects of daily announcement surprises and in order to account for the data characteristics described in the previous section. The benchmark model we estimate is

$$\Delta(\ln e_t) = a + \sum_{l1=1}^{L1} g_{l1}\ \Delta(\ln e_{t-l1}) + \sum_{i=1}^{I} b_i^{EA}\, s_{i,t}^{EA} + \sum_{j=1}^{J} b_j^{US}\, s_{j,t}^{US} + d^{M} Mon + d^{F} Fri + e_t \qquad (1)$$

where e_t is the daily, nominal US dollar – euro/DEM exchange rate,[3] s_t are the news surprises in each market, and *MON* and *FRI* are included to account for potential day-of-the-week effects. Lags of the exchange rate change are also included to correct for possible autocorrelation, although in most cases a single lag was sufficient, which moreover was not always significant in the estimation.

Since the error term e_t is non-normal and heteroskedastic, we correct for this by using an iterative WLS approach. The first step implies estimating equation (1) via OLS. The second step then estimates the time-varying e_t in the following way:

$$\log(\hat{e}_t^2) = w + \sum_{l2=1}^{L2} q_{l2} \log(\hat{e}_{t-l}^2) + \sum_{i=1}^{I} k_i^{EA} n_{i,t}^{EA} + \sum_{j=1}^{J} k_j^{US} n_{j,t}^{US} + j^{M} Mon + j^{F} Fri + m_t \qquad (2)$$

with $?_t$ defined as the absolute values of the surprises s_t. In the third step, the estimated volatility $\exp(\log[\hat{e}_t^2] - \hat{m}_t)$ is then employed as instrument in the WLS estimation of equation (1). These three steps are iterated till convergence is achieved.[4]

Finally, we conducted different tests to control for possible multicollinearity problems resulting from the fact that some of the announcements occur on the same day. One way of

[3] The exchange rate prior to 1999 is the US dollar – DEM rate with the DEM divided by its euro convergence rate in order to make the pre- and post-1999 periods comparable.

[4] In principle, estimating such models in a GARCH framework is in some ways superior due to the direct estimation of the conditional second moments in GARCH models. However, a GARCH specification could not be used in our context due to the large number of parameters in the model resulting from the inclusion of 25 different announcement news. This large number of parameters frequently led to problems in the convergence of the maximum likelihood estimation. Moreover, our results are also robust to estimating the model via OLS with heteroskedasticity and serial correlation consistent standard errors.

doing this is to exclude from the model some of the news that frequently occur on the same day. However, the results did not change in any significant way. We therefore opted to keep all 25 monetary policy and macroeconomic news variables in the model.

4. How important are fundamentals? Empirical results for linear models

Table 4.1 presents the news effects on the US dollar – euro/DEM exchange rate for 12 US macroeconomic news, 11 German/euro area news, and the two monetary policy surprises in both areas for the full sample period of 1 January 1993 – 14 February 2003. Figure 4.1 shows how the point estimates and 90% confidence intervals for each of these variables evolve over time. These figures have been generated using a rolling estimation with 4-year windows so that each point estimate in the figure represents the estimate for the previous 4-year window.

4.1 Exchange rate responses to news reflecting the *real* economy

Most of the variables have the correct sign in that an improvement in *real* economic conditions in the United States leads to an appreciation of the US dollar (i.e. a lower US dollar – euro/DEM exchange rate) whereas good news in the euro area/Germany induce a appreciation of the euro/DEM vis-à-vis the US dollar, and analogously for negative news in the two areas. Overall, however, US news prove to be more important in driving exchange rate developments than euro area/German news.

Most of the variables for the real economy of the United States have indeed a statistically significant news effect on the exchange rate: an improvement in NAPM, a rise in non-farm payroll employment, faster GDP growth, higher consumer confidence, lower unemployment and a longer workweek all lead to an appreciation of the US dollar. An improvement in the trade balance, faster growth in industrial production and larger retail sales also tend to appreciate the US dollar, though these variables are not statistically significant over the whole 1993-2003 sample period (see Table 4.1).

To provide an order of magnitude of the news effects of fundamentals, for instance a surprise of one standard deviation in the advance US GDP measure leads, on average, to a 0.62% appreciation of the US dollar.

Most euro area/German economic fundamentals also have the correct sign in that an improvement in real conditions in the euro area/Germany lead to an appreciation of the euro/DEM. However, the IFO business confidence indicator is the only real economic variable of the euro area/Germany that is statistically significant over the full sample period. Nevertheless, the news impact of the IFO indicator is relatively large: an improvement in the IFO index by one standard deviation causes a 0.85% appreciation of the euro/DEM vis-à-vis the US dollar.

It should be emphasised that among all the real economy news variables for the US and the euro area/Germany, the IFO indicator is the variable with the largest effect on the US dollar – euro/DEM exchange rate. One possible interpretation of this finding is that the importance of this variable may partly compensate for the lack of significance of other euro area news variables. In a market environment with a large number of news releases –

as is the case in the euro area where most countries provide additional data announcements for their own country – market participants may choose to turn to fewer indicators about the state of the real economy. It seems that the IFO index is such a benchmark indicator for the euro area. Moreover, it should be noted that the IFO index is one of the earliest data releases for Germany and the euro area, and thereby may also function as an indicator for market participants about what to expect about later data releases (see Figure 1).

These interpretations are further strengthened by our analysis of time variations shown in Figures 4.1. The importance of the IFO index for the exchange rate has increased substantially over time. In fact, its point estimate was not statistically significant until 1999, but has then risen to currently around 0.013. The only other real economy indicator of the euro area that has a statistically significant effect on the exchange rate is the EC business confidence indicator. Although this indicator was only created in early 1999, it has become larger and more significant over time.

Turning to the time variations in the United States, the key finding is that the news effects on the exchange rate by most real economy variables have become larger and more significant over time. This is the case for NAPM, non-farm payroll employment, industrial production, advance GDP growth as well as the indicator for US consumer confidence.

In short, the results suggest that fundamentals about the real economy do not only have a significant effect on the US dollar – euro/DEM exchange rate, but that such fundamentals have in fact become more important over time in driving exchange rate developments.

4.2 Exchange rate responses to monetary policy shocks

In contrast to the real side of the economy, our theoretical prior for the effect of monetary policy news on exchange rates is ambiguous. Based on interest rate parity and arbitrage conditions, an unanticipated monetary tightening by the Federal Reserve should induce an appreciation of the US dollar, while an unexpected tightening by the ECB/Bundesbank should lead to an appreciation of the euro/DEM immediately after the news release of such a decision.[5]

However, the reaction of exchange rates to monetary policy decisions also depends on the market's interpretation of the underlying reasons for the decisions and the expected effect on the economy. For instance, an unexpected easing of monetary policy may signal to market participants that the real economy and other asset prices, such as equities, will receive a significant boost. Hence the easing of monetary policy in such a case may not lead to a depreciation but even to an appreciation of the exchange rate.

[5] Note that the medium- to longer-term reaction of the exchange rate to monetary policy shocks can be quite different from the immediate short-run effects. For uncovered interest rate parity to hold, the exchange rate needs to depreciate in the medium-run in response to monetary tightening in order to equalise returns after exchange rate adjustments. Moreover, rational expectations overshooting models in the vein of Dornbusch (1976) also imply a depreciation of the nominal exchange rate in the longer term – after an initial appreciation – as prices adjust gradually over time. However, the empirical evidence mostly rejects the hypothesis that exchange rates depreciate in the medium- and longer-term in response to contractionary monetary policy shocks. In fact, Eichenbaum and Evans (1995) and Evans (1994) find strong evidence for what they call "delayed overshooting" in that exchange rates continue to appreciate for a sustained period of time after monetary policy tightening. These findings imply the existence of a conditional forward premium bias, i.e. a monetary policy induced forward premium bias.

Table 4.1 shows that a shock to US monetary policy has a significant and large effect on the US dollar. The point estimate implies that an unexpected tightening of the federal funds target rate by 50 bp causes a 0.8% appreciation of the US dollar vis-à-vis the euro/DEM. By contrast, unexpected monetary policy news by the Bundesbank and the ECB did not prove to have a significant effect on the DEM and euro exchange rates vis-à-vis the US dollar.

Looking at the time-varying news effects indicates that the impact of US monetary policy shocks on the exchange rate has increased somewhat over time. For Germany and the euro area, we find essentially no news effects of monetary policy shocks on the exchange rate prior to 2001. Interestingly, the point estimate for ECB monetary policy shocks becomes negative in 2001. One interpretation of this finding relates to the fact that there were several "positive" monetary policy shocks emanating from the euro area in 2001 in the sense that markets mostly expected the ECB to cut interest rates by more than it actually did. Hence euro area monetary policy shocks were positive several times in 2001 as actual interest rates remained higher than expected by the markets. Our coefficient suggests that market reactions to ECB decisions to leave interest rates unchanged may have led to a depreciation of the euro on several occasions in 2001. More evidence in support of this hypothesis will be presented in section 5 below.

4.3 Exchange rate responses to news about price developments

Concerning news in price developments, there is also no clear-cut theoretical prior to how the exchange rate should react. On the one hand, higher than expected inflation may raise expectations of monetary policy tightening, entailing an immediate appreciation of the home currency. On the other hand, higher inflation implies, ceteris paribus, an appreciation of the real exchange rate. For purchasing power parity to hold, a rise in inflation requires a depreciation of the nominal exchange rate.

In essence, the likely effect of price developments on the exchange rate crucially depends on the markets' beliefs about the central bank's monetary policy reaction function. If a central bank is perceived to give great importance to price stability, then an unexpected rise in inflation is likely to lead to an appreciation of the exchange rate. By contrast, if a central bank is believed to give less prominence to price developments or is believed not to react to a particular news about prices, then the second argument above may prevail and the exchange rate depreciates.

Looking at the empirical findings shows some very interesting results for the United States, the euro area and Germany. Table 4.1 reveals that none of the news effects of price variables is significant for the full sample period 1993-2003. However, the US CPI news are borderline significant at the 90% level with a positive sign. This implies that a rise in US inflation tends to lead, on average, to a depreciation of the US dollar. This is consistent with the second explanation given above.

Moreover, the rolling-window estimations show some significant time variations. US CPI news has a small and insignificant effect on the exchange rate till 1998, but since 1999 news effects about US CPI have become substantially larger. In fact, the coefficient for US CPI news in the period 1999-2003 becomes 0.0048 and is significant at the 95% level, thus

implying that in recent years lower than expected US CPI announcements have lead to an appreciation of the US dollar. This is consistent with the argument that lower than expected US CPI announcements convinced markets that the Fed would not raise interest rates to contain inflation, thus not slowing down the remarkable performance of the US economy in the late 1990s and 2000.

For German CPI news, the coefficient is positive – implying a DEM appreciation in response to higher than expected inflation – though not significant, for the period up to 1998. Afterwards the news effect of German CPI news is essentially zero.

Overall, these results have two interesting implications. First, they suggest that financial markets may have had very different perceptions about the reaction functions of the Federal Reserve and the ECB/Bundesbank. The appreciation of the US dollar in response to lower than expected US CPI news (and depreciation in response to higher than expected US CPI) indicates that markets did not believe that US price developments in recent years would trigger a change in the monetary policy stance of the Federal Reserve. By contrast, markets seemed to have expected a stronger reaction of the Bundesbank to German CPI developments. Hence, larger than expected German CPI announcements tended to lead to an appreciation of the DEM.

Second, the fact that the exchange rate responds less to German CPI news under EMU than prior to 1999 indicates that the Bundesbank was expected by the markets to respond more strongly to German price developments than the ECB. This is intuitively convincing as the ECB sets monetary policy for the whole of the euro area and therefore inflation developments in other euro area countries also play a role in its interest rate decisions.

4.4 Exchange rate responses to composite indicators for macroeconomic news

One key difficulty of extracting information about time variations of news effects of individual variables in sections 4.1–4.3 is that the 4-year-rolling-window estimations include only a relatively small number of announcements for each variable in each window – usually 48 observations for those announcements that occur on a monthly frequency. The estimations are therefore not highly robust and frequently result in quite large standard errors for the individual coefficients. Moreover, to better capture and compare the overall importance of US fundamentals with euro area fundamentals for exchange rate movements, the purpose of this section is to create two composite indicators capturing all macroeconomic variables in the US and all those in the euro area.

For this purpose, we generate two indicator functions, one each for the United States (I^{US}) and for the euro area (I^{EA}), which indicate whether on any given day the respective market yields "good" news (I^{US}=1, I^{EA}=1), "bad" news (I^{US}= -1, I^{EA}= -1) or no news (I^{US}=0, I^{EA}=0). "Good" news are defined as those news that, based on our findings presented in sections 4.1–4.3, are expected to lead to an appreciation and "bad" news to a depreciation of the respective currencies.[6] We then formulate the modified version of equation (1) as

[6] On days with more than one announcement, we took the news of the relatively more important variable, based on our findings in section 4.1. Moreover, due to the ambiguousness of the sign for the price variables, we tested the inclusion of the price variables with the opposite sign, but did not find any significant differences in the econometric results. Also note that monetary policy shocks are not included in this indicator functions.

$$\Delta(\ln e_t) = a + \sum_{l1=1}^{L1} g_{l1}\ \Delta(\ln e_{t-l1}) + b^{EA} I_t^{EA} + b^{US} I_t^{US} + d^{M} Mon + d^{F} Fri + e_t \qquad (3)$$

We estimate equation (3) using 4-year rolling-windows. Due to the pooling of all domestic macroeconomic variables into a single measure, the number of "news" observations in each 4-year window increases to roughly 544 for the United States and 496 for the euro area/Germany as compared to the rolling-window estimation for individual variables.[7]

Figure 4.2 shows some compelling results for the period 1993-2003. The importance of both US news and euro area/German news for the US dollar – euro/DEM exchange rate increases substantially over time. For the US, the coefficient rises threefold from around 0.0005 to 0.0015. For the euro area/Germany, the point estimates increases from zero to 0.001 during 1993-2003.

The drawback of this approach of course is that the coefficients can be interpreted only as average measures of the news effects of a country's fundamentals and hide the heterogeneity of the importance of individual variables, as outlined in sections 4.1–4.3. However, the key point we want to make with this analysis is that also euro area news about fundamentals have an important and significant effect on the exchange rate, even if this effect is somewhat smaller than that of US fundamentals.

4.5 How important is the announcement timing?

Besides the economic content of an announcement, it is likely that its effect on exchange rates depends on the lag between the announcement and the underlying economic fundamental. In other words, exchange rates are likely to react more strongly to the release of a leading indicator than to the release of the final revision of GDP, which refers to economic activity several months ago. Andersen et al. (2003) provide some suggestive evidence in this direction, without conducting statistical tests. As can be seen in figure 1, the announcement timing varies strongly for the different variables. Some announcements (e.g. for US consumer confidence) are made towards the end of the month for the same month, or quickly afterwards (like the US NAPM indicator). Others are made more than two months later.

We test the hypothesis that announcement timing matters for the effect on exchange rates in two ways. On the one hand, we analyse whether the size of the estimated response is related to the announcement timing; on the other hand, we test whether the significance of the estimated response differs according to the announcement lag. Hence, we regress the absolute values of the coefficients and t-statistics obtained in table 4.1 on the maximum announcement delay, which we measure by the maximum number of days that pass from the end of the month to which the announcement refers until its release.[8] Table 4.2 reports the results.

[7] For the US, there are 11 macro fundamentals on a monthly frequency and 1 on a quarterly frequency. For Germany/euro area, 10 macro fundamentals on a monthly frequency and 1 on a quarterly frequency included in the indicator function.

[8] Using the shortest or medium delay yields similar results.

Whereas the magnitude of a coefficient is only weakly related to its announcement timing, its significance is so very strongly. Despite having only 23 observations, the effect of timing is estimated very precisely with a t-statistic of 1.98. Each day of announcement delay makes the t-statistics in table 4.1 drop by 0.2. This finding implies that economic content seems to govern the *magnitude* of responses, whereas announcement timing strongly determines the *significance* of the exchange rate response.

5. Asymmetries in exchange rate responses to news of fundamentals

The analysis of section 4 leads to the question *why* the effects of fundamentals on exchange rates frequently change over time. There are several possible answers to this question. One possibility is that the quality and the news content of the announcements about fundamentals have improved in the sense that they more closely reflect underlying developments in the economy. However, such improvements alone can hardly explain the often significant variations of the news effects of individual variables over time.

An alternative hypothesis is that news effects of fundamentals may depend on existing market conditions. Work on herd behaviour (Banerjee 1992) and informational cascades (Bikchandani et al. 1992), for instance, show that economic agents may interpret, process and react to information in very different ways depending on the conditions and the environment in which they operate. In particular, the news *content* of any given news may be larger if there is a high degree of uncertainty in the markets and market participants search for guidance about the future course of the economy.

The aim of this section is to analyse whether such asymmetries are present in foreign exchange markets. While there has been some work on this issue for bond markets (Fleming and Remolona 1997), such analysis is quite novel for foreign exchange markets.[9] We analyse the role of different measures of market uncertainty, looking at the size and sign effects of news (section 5.1), at exchange rate volatility (section 5.2) and at the uncertainty about the future direction of the economy (section 5.3).

5.1 Size effects and sign effects of news

There is a broad literature for equity markets showing that stock prices react more strongly to negative news than to positive ones. The underlying reason for this asymmetry lies in the interaction of what is commonly known as leverage effects and volatility feedback effects.[10] The argument is that a shock affects the level of asset prices not only directly by changing the state of the world – altering the leverage of firms – but also by changing the volatility of asset prices. A positive shock raises the stock price of a firm by improving its leverage, but at the same time the increased volatility lowers the stock's value because risk-averse investors require higher returns for bearing the additional risk. In case of a positive shock, leverage effects and volatility feedback effects have the opposite effect on the asset price while the two effects are mutually reinforcing in case of negative shocks. Thus, negative shocks tend to have a larger effect on the level of equity prices.

[9] Galati and Ho (2001) conduct some asymmetry tests for exchange rates and find mixed evidence for the short period of 1999-2000. Andersen et al. (2003) find responses to vary depending on the sign of the news and the uncertainty of the forecast.

[10] For instance, Campbell and Hentschel (1992) provide a nice discussion and compelling empirical evidence for the presence of such effects for equity markets.

We test for the presence of such *sign effects* for foreign exchange markets by using the same indicator function of section 4.4, distinguishing between "good" news, "bad" news and no news in the foreign exchange market. To check for the difference between the effects of such positive news and negative news, we estimate the model

$$\begin{aligned}\Delta(\ln e_t) = a + \sum_{l1=1}^{L1} g_{l1}\,\Delta(\ln e_{t-l1}) + \left(b_P^{EA} D_{P,t}^{EA} + b_N^{EA} D_{N,t}^{EA}\right) I_t^{EA} \\ + \left(b_P^{US} D_{P,t}^{US} + b_N^{US} D_{N,t}^{US}\right) I_t^{US} + d^M Mon + d^F Fri + e_t\end{aligned} \tag{4}$$

with $D_{P,t}=1$ if the news is positive ($I_t=1$) and $D_{N,t}=1$ if the news is negative ($I_t= -1$), both dummies being zero otherwise. The estimation therefore enables us to compare the coefficient for the effect of good news ($ß_P$) with the one for negative news ($ß_N$), and for both the United States and the euro area.

Figure 5.1 shows that negative news in Germany/ the euro area have indeed a larger effect on the exchange rate than positive ones towards the end of the sample period 1993-2003. However, there is no such evidence for the United States, where the point estimate is similar for both types of news towards the end of the sample and positive news seem to have exerted a bigger influence on exchange rate developments at least temporarily.

As a next step, we turn to analysing the *sign effects* for the *individual* macroeconomic and monetary policy fundamentals. For this purpose, we estimate a similar model to equation (4), only that now all individual announcement are included, and that they are included as surprises s_t:

$$\begin{aligned}\Delta(\ln e_t) = a + \sum_{l1=1}^{L1} g_{l1}\,\Delta(\ln e_{t-l1}) + \sum_{i=1}^{I}\left(b_{i,P}^{EA} D_{i,P,t}^{EA} + b_{i,N}^{EA} D_{i,N,t}^{EA}\right) s_{i,t}^{EA} \\ + \sum_{j=1}^{J}\left(b_{j,P}^{US} D_{j,P,t}^{US} + b_{j,N}^{US} D_{j,N,t}^{US}\right) s_{j,t}^{US} + d^M Mon + d^F Fri + e_t\end{aligned} \tag{5}$$

The results for the individual fundamentals strengthen the evidence in favour of sign asymmetries. Table 5.1 shows that the coefficients for negative news are in most cases larger than those for positive news. The difference is statistically significant for three euro area/German variables and for three US fundamentals.

Maybe one of the most interesting findings from this analysis is that for the euro area/Germany positive monetary policy shocks have lead to a depreciation of the euro/DEM, rather than an appreciation. This is consistent with and supports the hypothesis of section 4.2 that the "positive" monetary policy shocks in the euro area in 2001 – in the sense that markets expected a stronger easing of monetary policy in the euro area throughout 2001 than actually occurred – contributed to a depreciation of the euro. By contrast, negative monetary policy shocks in the euro area have been associated with a depreciation of the DEM/euro throughout 1993-2003.

A question related to the one on sign effects is whether large shocks have a bigger impact than smaller ones. The rationale for such *size effects*, again widely confirmed for the analysis of other asset prices, is that larger shocks may contain a proportionally larger

news content, thus causing a larger adjustment of the exchange rate. We define the model for testing this hypothesis in a similar way to equation (4), only now that $D_{P,t}=1$ if the news is in the highest or the lowest quartile of the distribution and $D_{N,t}=1$ if the news is in the middle two quartiles of the distribution.

Figure 5.2 shows evidence for such size effects for both the United States and Germany/the euro area, although there are some changes in the degree of asymmetry over time. Again, as expected, US news exert a stronger influence over the exchange rate than news emanating from the euro area/Germany.

Overall, the findings provide support for the hypothesis that the reaction of exchange rate to some macroeconomic news, and in particular to monetary policy news, depends both on the sign as well as the size of the news that reaches the financial markets.

5.2 Exchange rate volatility and news

To test whether news have a larger effect on exchange rates when market uncertainty is high, we use the degree of exchange rate volatility as a measure of uncertainty. We define high market uncertainty as the situation when exchange rate volatility was above its sample mean during the previous one week, one month, two months etc. till one year. Which of these time horizons is most sensible essentially depends on the memory and previous experience of market participants. It seems that market participants may give greater weight to the immediate past and we therefore prefer the volatility measures with shorter horizons, but nevertheless test also for longer horizons.

Our econometric model is similar to the one of equation (4), only that now $D_{P,t}=1$ if the exchange rate volatility over the previous 1 week or 1 month etc. was above its sample mean, and $D_{N,t}=1$ if the volatility was below its mean.

Figure 5.3 reveals that the news effects of fundamentals are particularly large if exchange rate volatility was high during the previous week. The magnitude of the point estimates for news effects under high exchange rate volatility is substantially larger than those when exchange rate volatility is low. This is the case for both the United States and the euro area. Using longer time horizons for measuring exchange rate volatility does not fundamentally change this finding, although the difference in the coefficients becomes somewhat smaller.

5.3 Market uncertainty and news

The final hypothesis that we test about the presence of asymmetric news effects is whether news have larger effects on exchange rates during periods when previous news did not yield a clear and unanimous picture about the likely future course of the economy. In an environment where the news about fundamentals give contradictory indications about whether the economy is improving more or worsening more than expected, it is likely that market participants give greater importance to new information coming into the market. Thus exchange rates may react more to news in such an environment of uncertainty.

Choosing again a one-month horizon, we define the degree of *market uncertainty* to be high if the cumulated surprises of I_t over the past one month were in the middle two

quartiles of its distribution. Accordingly, the degree of market uncertainty is said to be low if these cumulated surprises are either very positive – i.e. in the top quartile – or very negative – in the bottom quartile of the distribution. More formally, our model is formulated as

$$\Delta(\ln e_t) = a + \sum_{l1=1}^{L1} g_{l1}\,\Delta(\ln e_{t-l1}) + \left(b_U^{EA} D_{U,t}^{EA} + b_C^{EA} D_{C,t}^{EA}\right) s_t^{EA} + \left(b_U^{US} D_{U,t}^{US} + b_C^{US} D_{C,t}^{US}\right) s_t^{US} + d^M Mon + d^F Fri + e_t \quad (6)$$

with $D_{U,t}$=1 if market uncertainty is high and $D_{C,t}$=1 if market uncertainty is low, and both dummies being zero otherwise.

Figure 5.5 shows the results for the case of market uncertainty in the United States. If the market uncertainty is high in the United States, exchange rates react more strongly both to news in the euro area/Germany and the United States. Figure 5.6 indicates that there is not much evidence that foreign exchange markets react more strongly to news emanating from either the United States or Germany when market uncertainty in the euro area/Germany is high.

These findings again confirm the importance and dominance of the US market and the market conditions in the United States as the main determinant for the relevance of news effects of fundamentals on the US dollar – euro/DEM exchange rate.

6. Evaluating the real-time model of fundamentals and exchange rates

We have so far shown that fundamentals have indeed a significant and time-varying effect on exchange rates. What we have not answered so far is how well fundamentals can explain overall changes in exchange rates, i.e. to evaluate the goodness-of-fit of our real-time model. This is an important question because the statistical significance of parameter estimates for fundamentals by itself does not necessarily imply that fundamentals explain well the magnitude or even the direction of exchange rate movements in the short- to medium-term.

For this purpose, we take the coefficients obtained from estimating equation (1) and multiply these with their respective announcement news for each variable and in each month.[11] Adding up the effects for all fundamentals in each month allows us to compare the actual change in the US dollar – euro/DEM exchange rate with the one explained by the fundamentals of our model.

Figure 6.1 shows the actual and the predicted exchange rate developments of the US dollar – euro/DEM for the period January 1993 – February 2003. The chart shows the large degree of volatility of the actual exchange rate over the period, with first the DEM appreciating vis-à-vis the US dollar till early 1995 and then the US dollar appreciating until 2001. The exchange rate predicted on the basis of our news surprises is much smoother.

[11] The reasons for moving from daily frequency to monthly frequency are that many days in our model do not have any announcements, and also the fact that actual and predicted exchange rate developments become more easily comparable graphically when using a lower frequency than daily data.

Given the way the real-time model was set up, this finding is consistent with what we expected: market participants generally are reasonably good in correctly anticipating announcements about fundamentals. As we have shown, market expectations are unbiased and efficient, and therefore there should be no large swings in the real-time model based on news surprises.

Nevertheless, the real-time model based on surprises correctly indicates the general trend of the exchange rate over time: that is, an expected appreciation of the US dollar between 1993 and late 1999, and a recovery of the euro thereafter. What this implies is that during the period 1993-1999, economic agents were, on average, relatively more positively surprised by economic news in the United States than in Europe. This is intuitively convincing as the United States moved from a recession in the early 1990s to a tremendous economic boom in the late 1990s, during which the economic performance of the US economy outpaced that of the euro area and Germany. After 2000, the US economy slowed down much more significantly, albeit from a higher level, than the euro area economy. This created more negative news about the US economy than for the euro area, and hence our model predicts an appreciation of the euro between late 2000 and 2003.[12] Overall, when looking at the whole sample period 1993-2003, the US dollar – euro/DEM change predicted by the model is almost identical to the overall change in the actual exchange rate.

Given that market participants do not make systematic mistakes in their expectations, one therefore cannot expect the model with news surprises to explain the exchange rate movement in the medium-term. Let us recall that the news s_t in our model capture only a small part of the information about fundamentals that are actually incorporated into the markets. Recall that the news surprise s_t captures only the *unexpected* component of an announcement. The expected component has been incorporate previously, but since we do not know when this information has been incorporated we cannot measure its effect on the exchange rate in the econometric model.

To capture the effect of the full announcement – i.e. the unexpected component as well as the expected component – we make the assumption that the expected component is incorporated into the exchange rate in the same way the unexpected one is. We therefore use the coefficients obtained from estimating equation (1) and multiply these with the change in the announcement of each fundamental. We then aggregate the effects of all variables to get the predicted overall effect of fundamentals on the exchange rate.

Figure 6.2 shows the predicted and the actual exchange rates based on this exercise. The predicted exchange rate now moves much more and tracks significantly better the large swings in the actual US dollar – euro/DEM exchange rate. Although the predicted rate does again not explain the large *magnitude* in the exchange rate swings, it nevertheless does a reasonable good job in tracking the *direction* of the exchange rate movements. The short-lived appreciation of the US dollar in 1993 is tracked as well as the subsequent appreciation of the DEM till 1995. The model anticipates correctly part of the US dollar appreciation between 1995 and 1999. Moreover, the model tracks reasonably well the overall appreciation of the euro between late 2000 and early 2003. As an important point to keep in mind, it should be noted that the difference between the actual and the predicted

[12] Note that these *temporary* trends in the model with news is not inconsistent with the unbiasedness and efficiency of the expectations of market participants. Of course in the long-run, the predicted exchange rate should not change significantly from its original level in order for the unbiasedness and efficiency of the expectations data to hold.

exchange rate may not necessarily be explained by non-fundamental factors. Recall that the number of fundamentals included in our model is relatively small and other observable or unobservable fundamentals not included in the model may explain an additional part of this difference.

However, the period for which the model performs poorly is from mid-1999 to the end of 2000. In this period, the US dollar appreciated by about 20% vis-à-vis the euro whereas our model does not anticipate any change in the exchange rate or even a slight depreciation of the US dollar. The explanation for the failure of the model to explain this strong appreciation of the US dollar is most likely that the US economy reached the peak of its impressive boom during that time. This means that US fundamentals did not improve further during that period – hence the model does not anticipate a further appreciation because it is based on the *change* in fundamentals – while fundamentals improved somewhat in the euro area and in Germany. What this may imply is that we possibly also need to take into account in our model the *absolute* level of the performance of the economies rather than only the changes in fundamentals.

Nevertheless, overall the real-time model does a reasonably good job in explaining exchange rate movements in recent years, during the period 1999-2003. Figure 6.3 compares the actual change in the exchange rate with those predicted by the model. Although it is apparent that the model cannot replicate the magnitude of the exchange rate changes, it performs reasonably well in explaining the directional changes. Table 6.1 shows that between January 1993 and February 2003 the real-time model correctly predicts only 57% of the directional changes in the exchange rate. This ratio rises to 73% when looking at the period January 1999 and February 2003. Hence for the period 1999-2003 the model does indeed seem to perform relatively well in accounting for the directional changes of the US dollar-euro exchange rate if compared to various longer-term exchange rate models (see Cheung, Chinn and Garcia Pascual 2002)

7. Conclusions

The paper presented evidence that monetary policy and macroeconomic fundamentals are indeed an important driving force behind exchange rate movements. The approach the paper took is relatively novel for the analysis of exchange rates in that we specifically look at the role of *news* about fundamentals. Extracting news from survey data and official announcements, the paper tested to what extent such news in the United States and in the euro area/Germany affected the US dollar – euro/DEM exchange rate during the period 1993-2003.

The empirical findings confirm that news about fundamentals have not only had a significant effect on the exchange rate, but that this effect has become larger over time. Moreover, economic developments in the United States prove to play a bigger role in explaining exchange rate movements than economic news in the euro area and in Germany. This finding may reflect the relatively greater importance of the US economy, but may also in part be due to the fact that US announcements are usually released earlier than euro area or German announcements. The implication is that US announcements have a relatively higher news content than comparable euro area announcements.

A key result of the paper is that the effect of fundamentals on exchange rates depends on market conditions. We find that news about fundamentals have a particularly big impact in an environment of high market uncertainty and large previous exchange rate volatility. In addition, the results suggest that negative news and large unexpected news have a larger effect on exchange rates than positive and smaller unexpected announcement surprises.

Robustness and goodness-of-fit tests show that our model with real-time data does a reasonably good job in explaining the direction though not the magnitude of monthly exchange rate developments for many periods, in particular for 1999-2003. Overall, the findings of the paper suggest that looking at *real-time* data – that is, information that is actually available to market participants when making their trading and investment decisions – may help us better understand and track the importance of fundamentals for exchange rate developments.

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Appendix

Table 2.1: Real-time versus vintage data: the example of US GDP, 1993-2003

	mean of absolute revisions in US GDP			correlation between surprise &	
	advance vs. preliminary	preliminary vs. final	advance vs. final	preliminary revision[1]	final revision[2]
1993-2003	0.51%	0.21%	0.61%	0.53	0.86
1993-1996	0.49%	0.21%	0.56%	0.56	0.74
1997-2000	0.50%	0.23%	0.63%	0.59	0.98
2001-2003	0.56%	0.19%	0.68%	0.62	0.97

Notes:

[1] correlation coefficient between preliminary GDP revision and surprise of preliminary GDP announcement.

[2] correlation coefficient between final GDP revision and surprise of final GDP announcement.

Table 2.2: Macroeconomic announcements, release dates and times

Announcement	Period	# Observ.	Usual Release	intra-month min	intra-month max	lag: # of months
Germany						
GDP Q/Q (%)	February-93 - 26/02/03	42	08:00	23	10	2/3
Ifo Business Climate Index	August-96 - 25/02/03	75	10:00	15	27	1
Business confidence balance	May-99 - 28/02/03	36	12:00	2	8	1
PPI M/M (%)	February-93 - 24/02/03	121	08:00	17	27	1
Retail Sales, real SA M/M (%)	February-93 - 03/02/03	118	08:00	9	18	2
Trade Balance	February-93 - 11/02/03	121	08:00	10	29	2
M3 Y/Y (%)	February-93 - 27/02/03	94	09:30	18	26	1
Unemployment rate (%)	February-93 - 05/02/03	120	10:00	3	10	1
CPI M/M (%)	February-93 - 24/01/03	119	after 11:00	23	30	0
Industrial production SA M/M (%)	February-93 - 10/02/03	120	various	1	10	2
Manufacturing orders M/M (%)	February-93 - 07/02/03	120	after 11:00	1	10	2
USA						
Real GDP (S.A.A.R.) Advance Y/Y	February-93 - 30/01/03	41	08:30	26	31	1
Consumer confidence	February-93 - 25/02/03	121	10:00	24	31	0
CPI M/M (%)	February-93 - 21/02/03	121	08:30	12	21	1
Housing starts	February-93 - 19/02/03	121	08:30	16	20	1
Industrial production SA M/M (%)	February-93 - 14/02/03	121	09:15	13	17	1
N.A.P.M.	February-93 - 03/02/03	121	10:00	1	4	1
Nonfarm payrolls	February-93 - 07/02/03	121	08:30	1	9	1
PPI M/M (%)	February-93 - 20/02/03	121	08:30	9	16	1
Retail sales (%)	February-93 - 13/02/03	121	08:30	9	15	1
Trade balance	February-93 - 20/02/03	121	08:30	15	22	2
Unemployment rate (%)	February-93 - 07/02/03	121	08:30	1	10	1
Average workweek	November-98 - 07/02/03	56	08:30	2	8	1

Source: MMS.

Table 2.3: Summary statistics for macroeconomic announcements, surveys, and surprises

Announcement	Announcement Mean	Announcement Std. Dev.	Survey Mean	Survey Std. Dev.	Surprise Mean	Surprise Std. Dev.
Germany						
GDP Q/Q (%)	0.346	0.641	0.322	0.607	0.024	0.212
Ifo Business Climate Index	95.009	5.256	95.048	4.325	-0.039	1.162
Business confidence balance	-4.185	7.458	-4.519	7.802	0.333	1.000
PPI M/M (%)	0.069	0.275	0.094	0.163	-0.026	0.215
Retail Sales, real SA M/M (%)	-0.795	3.044	-0.732	1.732	-0.063	2.781
Trade Balance	4.691	1.894	4.353	1.330	0.338	1.442
M3 Y/Y (%)	6.294	4.711	5.853	3.933	0.441	1.872
Unemployment rate (%)	6.009	31.292	3.126	20.475	2.883	23.194
CPI M/M (%)	0.159	0.231	0.154	0.187	0.005	0.128
Industrial production SA M/M (%)	0.183	1.945	0.197	0.815	-0.014	1.742
Manufacturing orders M/M (%)	0.278	2.401	0.128	0.889	0.150	2.185
USA						
Real GDP (S.A.A.R.) Advance Y/Y (%)	3.234	1.735	2.830	1.592	0.404	0.772
Consumer confidence	110.188	23.523	109.466	23.204	0.723	4.960
CPI M/M (%)	0.204	0.169	0.227	0.111	-0.023	0.119
Housing starts	1.503	0.152	1.489	0.134	0.013	0.069
Industrial production SA M/M (%)	0.209	0.490	0.161	0.347	0.048	0.253
N.A.P.M.	51.812	4.683	51.974	4.431	-0.162	1.933
Nonfarm payrolls	152.759	174.240	161.045	108.197	-8.286	118.643
PPI M/M (%)	0.102	0.420	0.165	0.193	-0.063	0.304
Retail sales (%)	0.318	0.921	0.332	0.502	-0.014	0.652
Trade balance	-16.349	8.676	-16.163	8.716	-0.186	1.837
Unemployment rate (%)	5.179	0.911	5.220	0.934	-0.042	0.143
Average workweek	34.376	0.191	34.386	0.190	-0.010	0.094

Source: MMS, authors' calculations.

Table 2.4: Summary statistics for monetary policy announcements, surveys, and surprises

	Announcement		Survey		Surprise			
Monetary policy *announcements*	**Number of meetings**	**Mean abs. announc.***	**Mean abs. survey***	**Std. Dev.**	**Mean abs. surprise***	**Std. Dev.**	**Number of forecasts "correct"**	**"false" ****
Federal Reserve	78	0.144	0.120	0.211	0.049	0.112	65	13
Bundesbank	144	0.040	0.025	0.066	0.044	0.113	127	17
ECB	72	0.052	0.041	0.086	0.044	0.087	61	11
Monetary policy *changes*	**Number of changes**	**Mean abs. changes***	**Mean abs. survey***	**Std. Dev.**	**Mean abs. surprise***	**Std. Dev.**	**Number of forecasts "correct"**	**"false" ****
Federal Reserve	31	0.363	0.281	0.334	0.102	0.173	23	8
Bundesbank	13	0.442	0.120	0.120	0.322	0.114	1	12
ECB	12	0.354	0.147	0.190	0.207	0.249	4	8

Notes:

* Means are calculated from the absolute numbers of the announcements, surveys and surprises.

** A "correct" forecast is defined as an absolute surprise of within ±12.5 basis points of the announcement or change.

Source: Federal Reserve, Bundesbank, ECB, Reuters, own calculations.

Table 4.1: Exchange rate response to individual macro and monetary policy variables
WLS model of equation (1), 1993-2003

German announcement surprises			US announcement surprises		
Monetary policy	-0.00590	(-1.304)	Monetary policy	-0.01616 **	(-2.364)
CPI	-0.00034	(-0.309)	N.A.P.M.	-0.00526 ***	(-3.351)
M3	0.00065	(0.291)	Nonfarm payrolls	-0.00246 **	(-2.485)
Unemployment rate	-0.00043	(-0.584)	Industrial production	-0.00212	(-1.348)
Ifo Business Climate	0.00857 **	(2.304)	Advance GDP	-0.00616 **	(-2.427)
Industrial production	0.00046	(0.664)	Consumer confidence	-0.00652 **	(-2.254)
Manufacturing orders	0.00053	(0.836)	Retail sales	-0.00133	(-0.995)
Retail Sales	0.00098	(1.321)	CPI	0.00198 *	(1.561)
PPI	0.00091	(1.102)	Unemployment rate	0.01703 ***	(2.848)
GDP	0.00112	(0.461)	Housing starts	0.00009	(0.038)
Trade Balance	0.00010	(0.086)	PPI	0.00041	(0.472)
Business confidence	0.01028	(1.391)	Trade balance	-0.00348	(-1.133)
			Average workweek	-0.00338 *	(-1.597)

Notes:

*,**,*** denotes significance at the 90%, 95%, 99% levels, respectively. Numbers in brackets are t-statistics.

Table 4.2: The effect of announcement timing on the magnitude and the significance of exchange rate reactions

	Coefficients		T-statistics	
Constant	0.00491 ***	(-3.583)	1.76374 ***	(5.930)
β	-0.00007	(-1.539)	-0.01919 **	(-1.983)
R^2	0.101		0.158	

Notes:

*,**,*** denotes significance at the 90%, 95%, 99% levels, respectively.
Numbers in brackets are t-statistics.

Table 5.1: Asymmetric exchange rate response to composite indicators: Sign effects WLS model of equation (5), 1993-2003

German announcement surprises	negative surprise		positive surprise		difference[1]
Monetary policy	0.00799 *	(1.626)	-0.02099 **	(-2.306)	*
CPI	-0.00041	(-0.232)	0.00043	(0.279)	
M3	0.01455 **	(2.427)	-0.00018	(-0.091)	*
Unemployment rate	-0.00224 *	(-1.845)	0.00160 *	(1.651)	*
Ifo Business Climate	0.01533 ***	(3.036)	0.01406 ***	(2.662)	
Industrial production	0.00022	(0.269)	0.00139	(1.027)	
Manufacturing orders	0.00014	(0.183)	-0.00012	(-0.141)	
Retail Sales	0.00024	(0.253)	0.00114	(0.596)	
PPI	0.00036	(0.293)	0.00053	(0.388)	
GDP	0.00177	(0.299)	-0.00112	(-0.251)	
Trade Balance	-0.00138	(-0.835)	-0.00029	(-0.238)	
Business confidence	-0.00886	(-0.545)	0.01565	(1.571)	
US announcement surprises	**negative surprise**		**positive surprise**		**difference[1]**
Monetary policy	-0.01417	(-1.202)	-0.00139	(-0.123)	
N.A.P.M.	-0.00224	(-0.927)	-0.00321	(-1.185)	
Nonfarm payrolls	-0.00008	(-0.056)	-0.00490 ***	(-3.288)	*
Industrial production	-0.00697 **	(-2.076)	-0.00046	(-0.192)	*
Advance GDP	-0.01182 **	(-2.112)	-0.00536 **	(-2.259)	
Consumer confidence	-0.01238 **	(-1.991)	0.00013	(0.028)	*
Retail sales	0.00145	(0.659)	0.00013	(0.113)	
CPI	0.00192	(0.967)	0.00164	(0.591)	
Unemployment rate	0.01533 *	(1.803)	0.01113	(0.873)	
Housing starts	-0.00089	(-0.206)	0.00273	(0.746)	
PPI	-0.00172	(-1.185)	0.00154	(0.659)	
Trade balance	-0.00857 **	(-2.359)	-0.00499 *	(-1.631)	*
Average workweek	-0.00491 **	(-2.113)	-0.00051	(-0.146)	*

Notes:

*,**,*** denotes significance at the 90%, 95%, 99% levels, respectively. Numbers in brackets are t-statistics.

1 * indicates significant difference between negative and positive surprise effects at the 90% level.

Table 6.1: Goodness of fit: absolute monthly changes and explanation of monthly directional changes

EUR/USD exchange rate *(monthly data)*	absolute actual change	absolute explained change	correct *directional* explanation
1993-2003	1.69%	0.47%	56.6%
1999-2003	1.87%	0.56%	73.2%

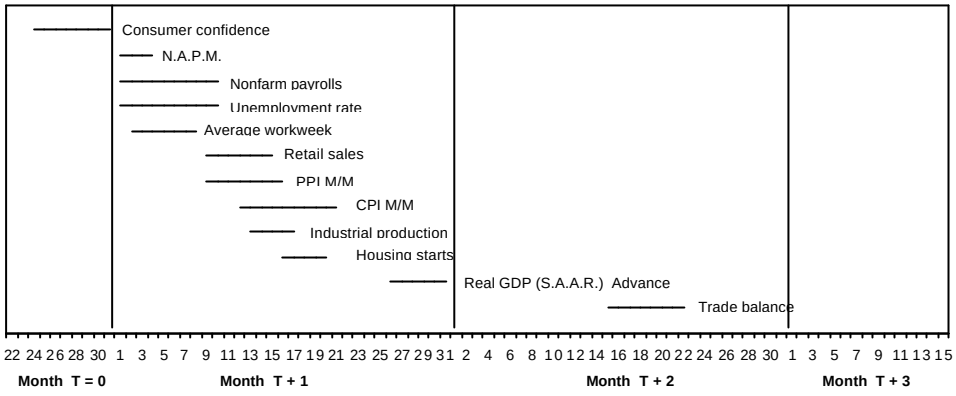
Note:

"Absolute explained change" shows the implied exchange rate based on US and German/euro area macroeconomic fundamentals and their implied parameter estimates.

"Correct directional explanation" shows percentage of monthly directional changes correctly anticipated by changes in macroeconomic fundamentals.

Figure 1: Distribution of release days of macroeconomic announcements

US Macroeconomic Announcement Dates



German Macroeconomic Announcement Dates

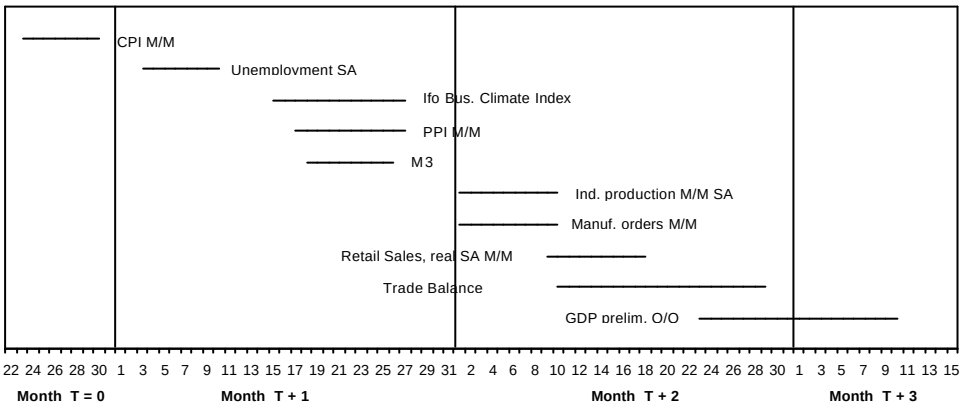


Figure 2.1: Announcement surprises, 1993 - 2003

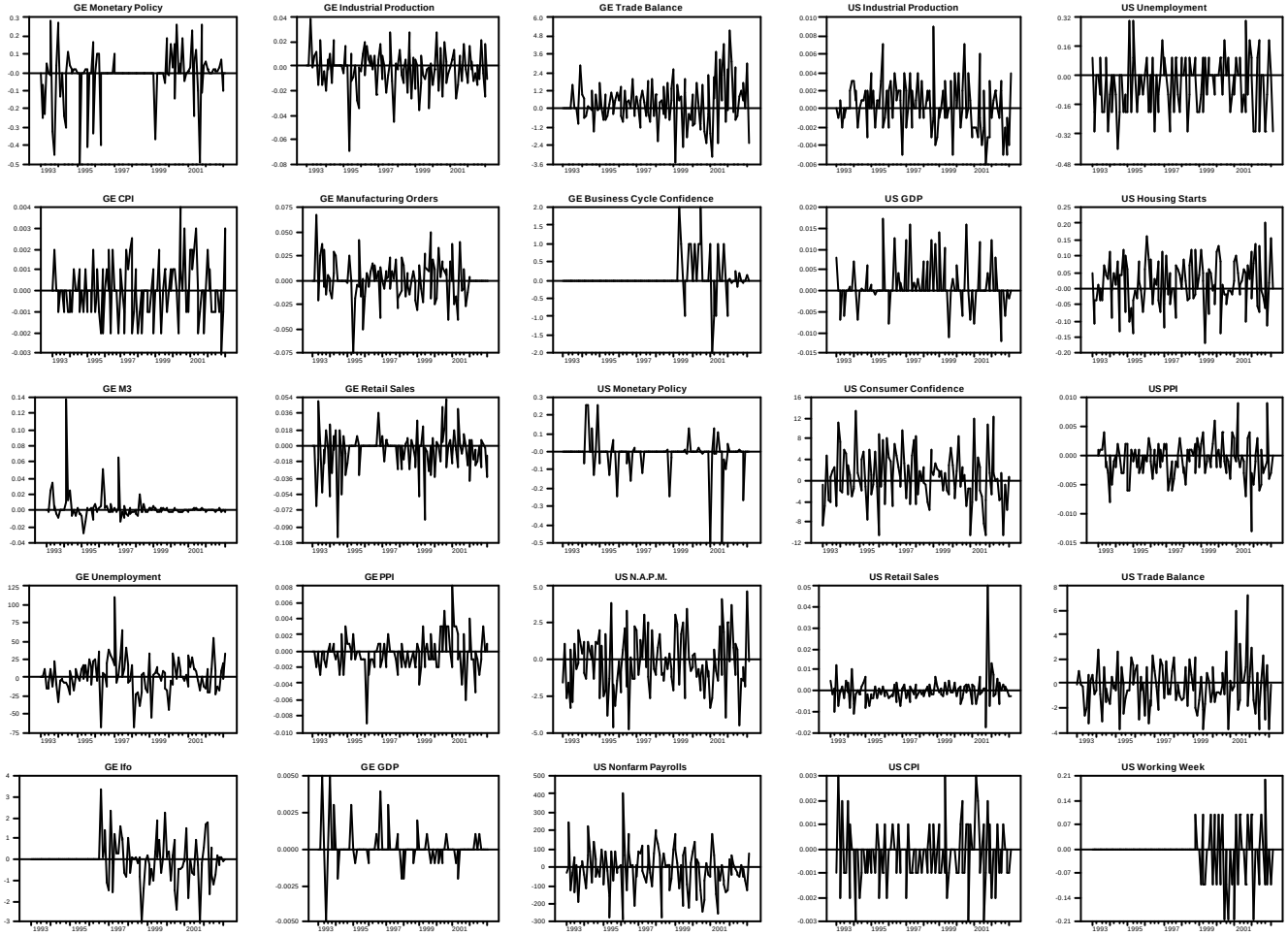


Figure 4.1: Exchange rate response to individual macro and monetary policy variables
Rolling window parameter estimates, January 1993 – February 2003

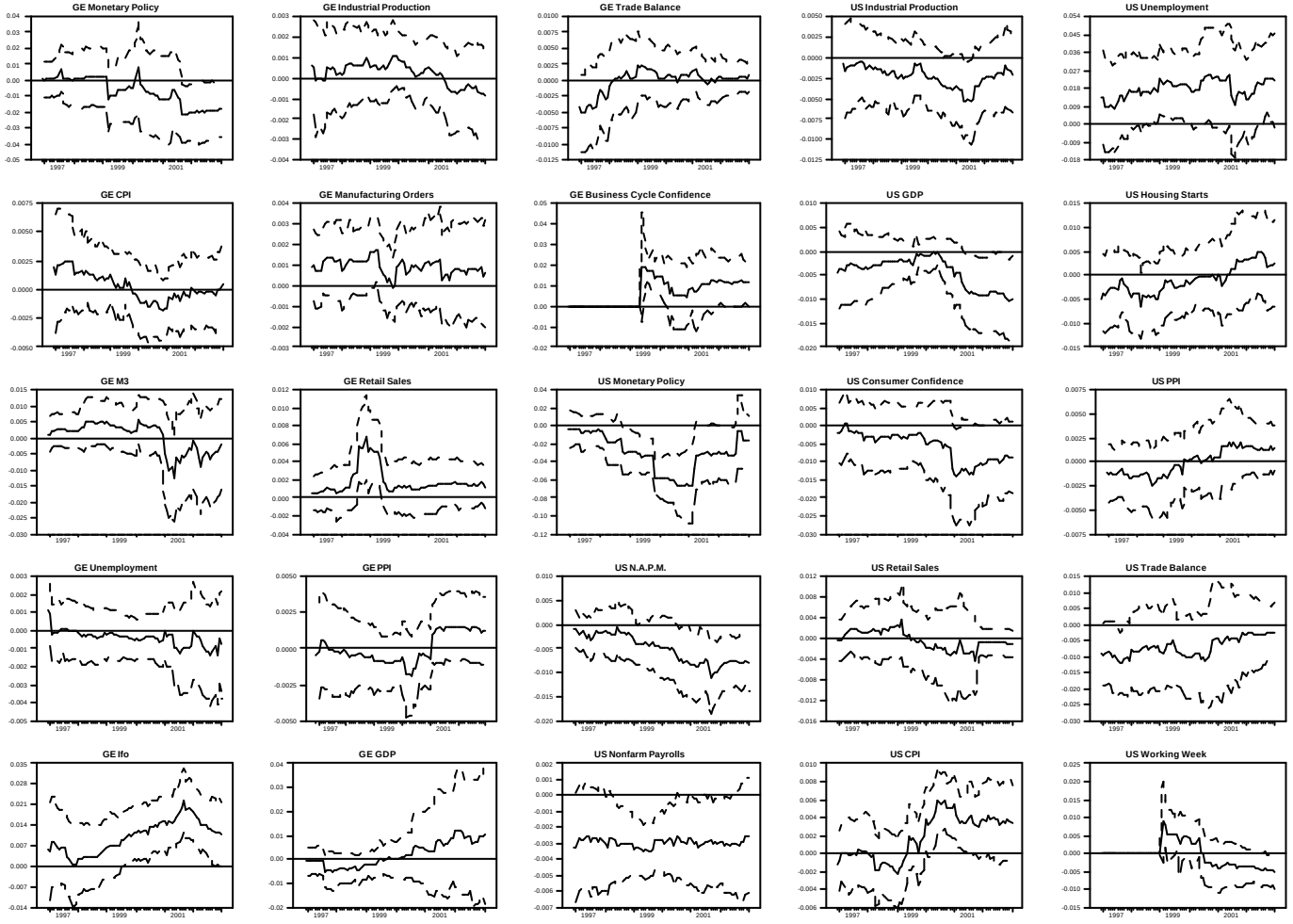


Figure 4.2: Exchange rate response to composite indicators
Rolling window parameter estimates, January 1993 – February 2003

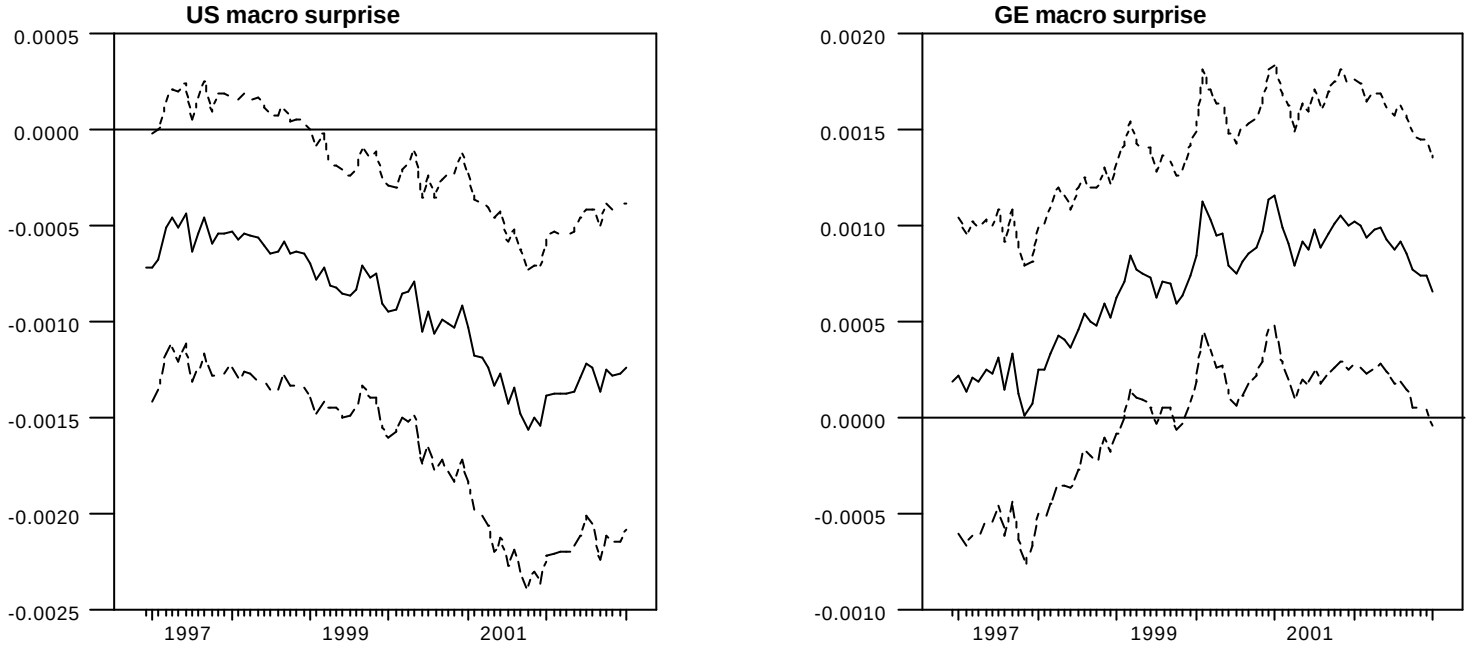


Figure 5.1: Asymmetric exchange rate response to composite indicators: Sign effects
Rolling window parameter estimates, January 1993 – February 2003

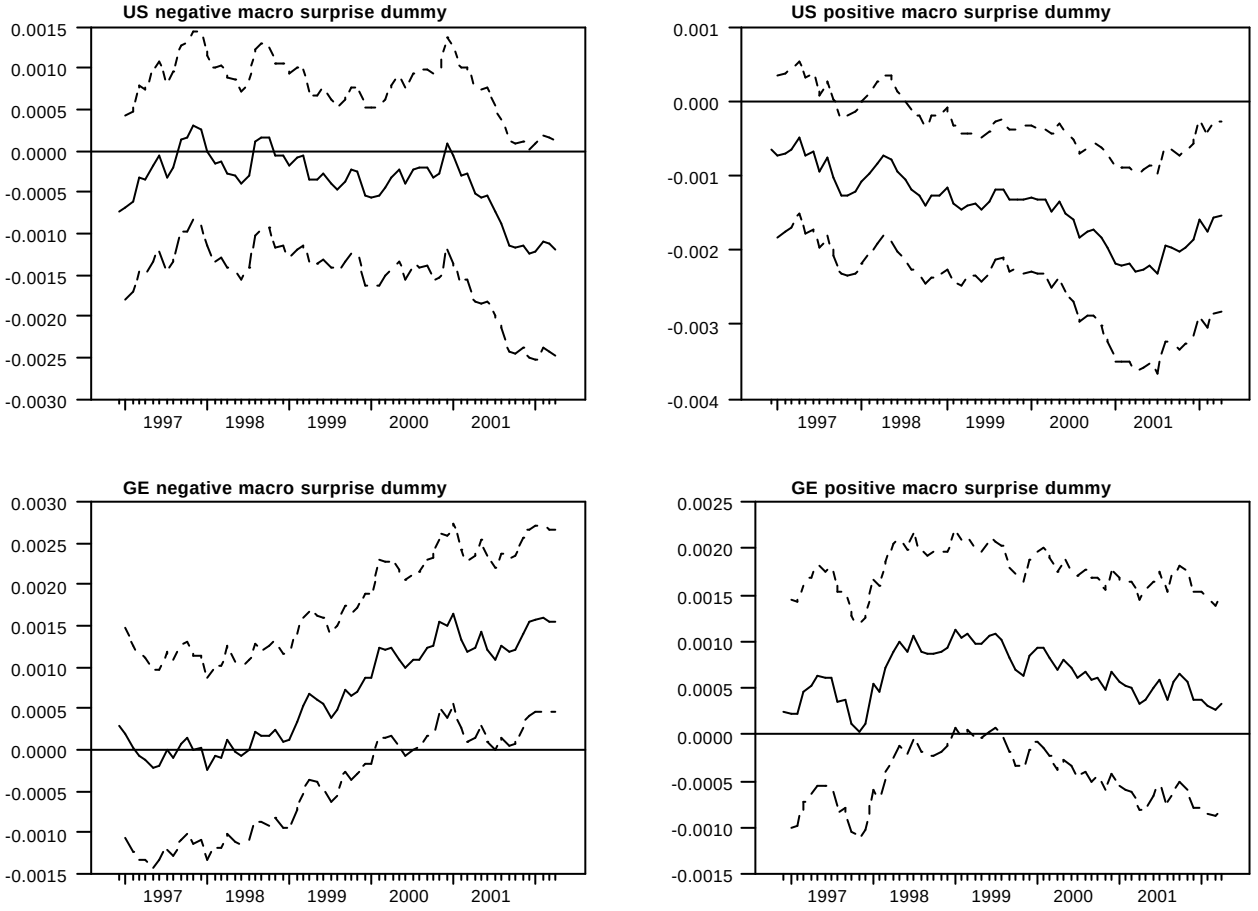


Figure 5.2: Asymmetric exchange rate response to composite indicators: Size effects
Rolling window parameter estimates, January 1993 – February 2003

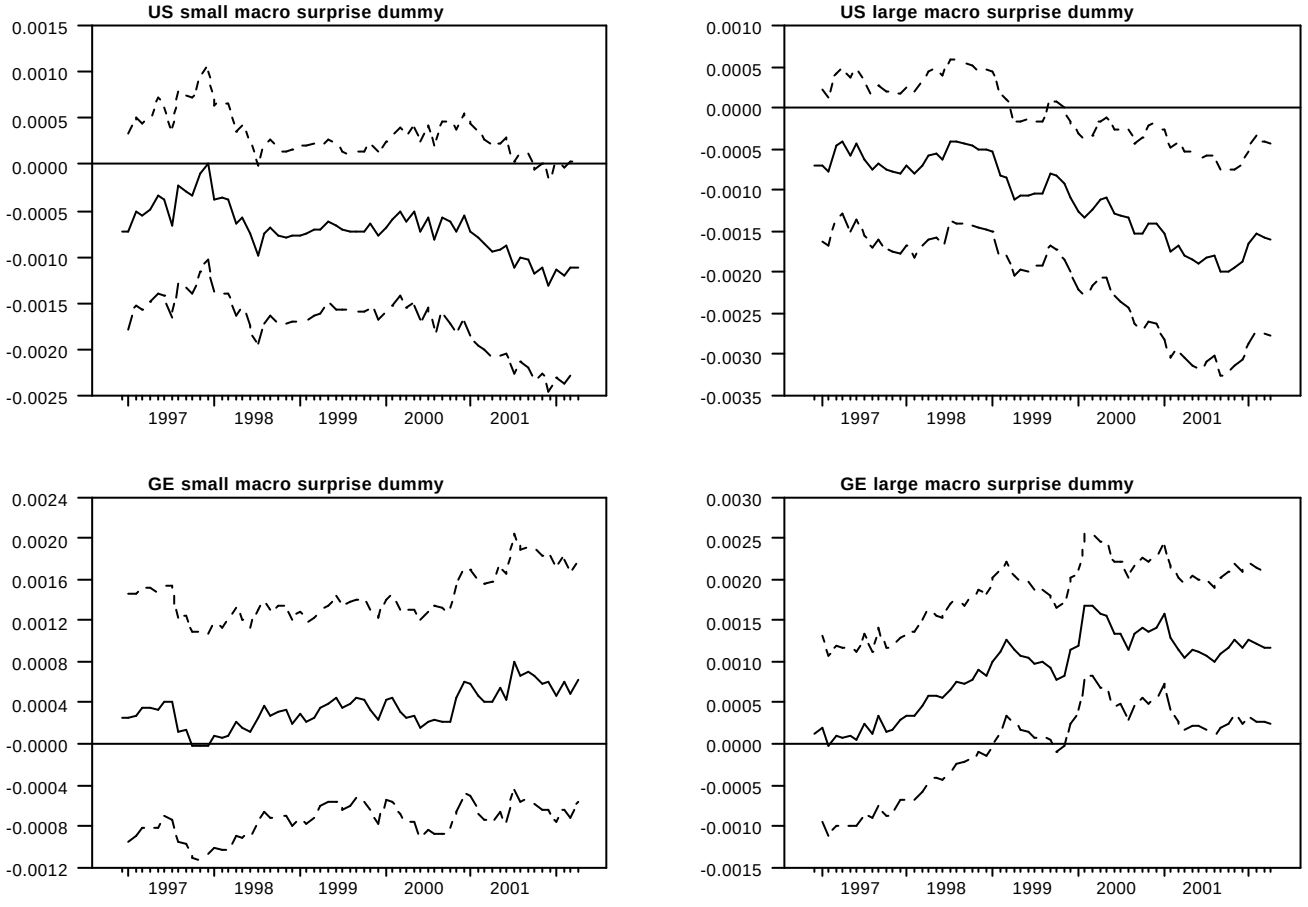


Figure 5.3: Asymmetric exchange rate response to composite indicators: Exchange rate volatility
Rolling window parameter estimates, January 1993 – February 2003

Figure 5.5: Asymmetric exchange rate response to composite indicators: Market uncertainty in US
Rolling window parameter estimates, January 1993 – February 2003

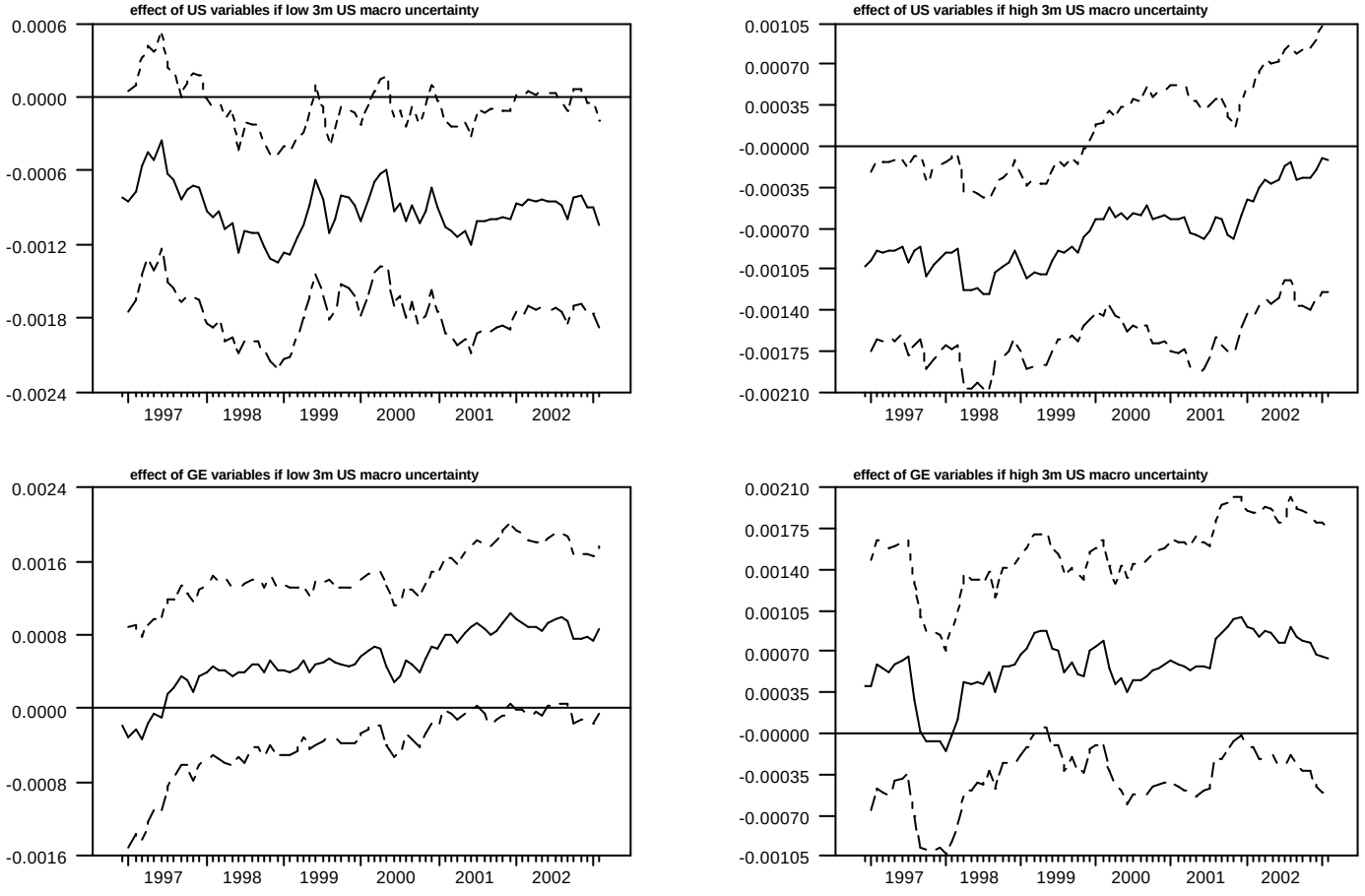


Figure 5.6: Asymmetric exchange rate response to composite indicators: Market uncertainty in euro area/Germany
Rolling window parameter estimates, January 1993 – February 2003

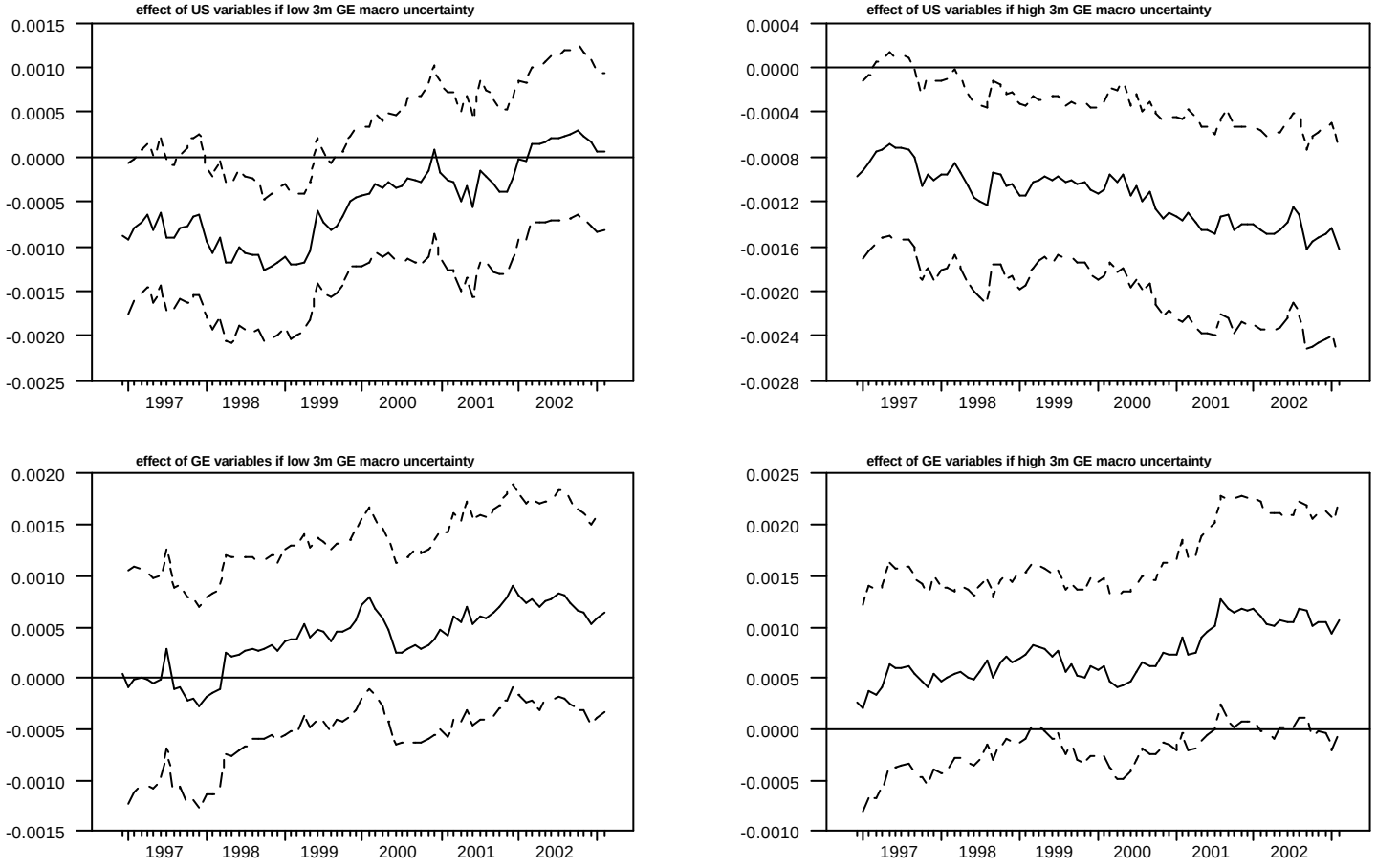


Figure 6.1: Explaining the US dollar – euro exchange rate: Cumulated announcement surprises
January 1993 – February 2003

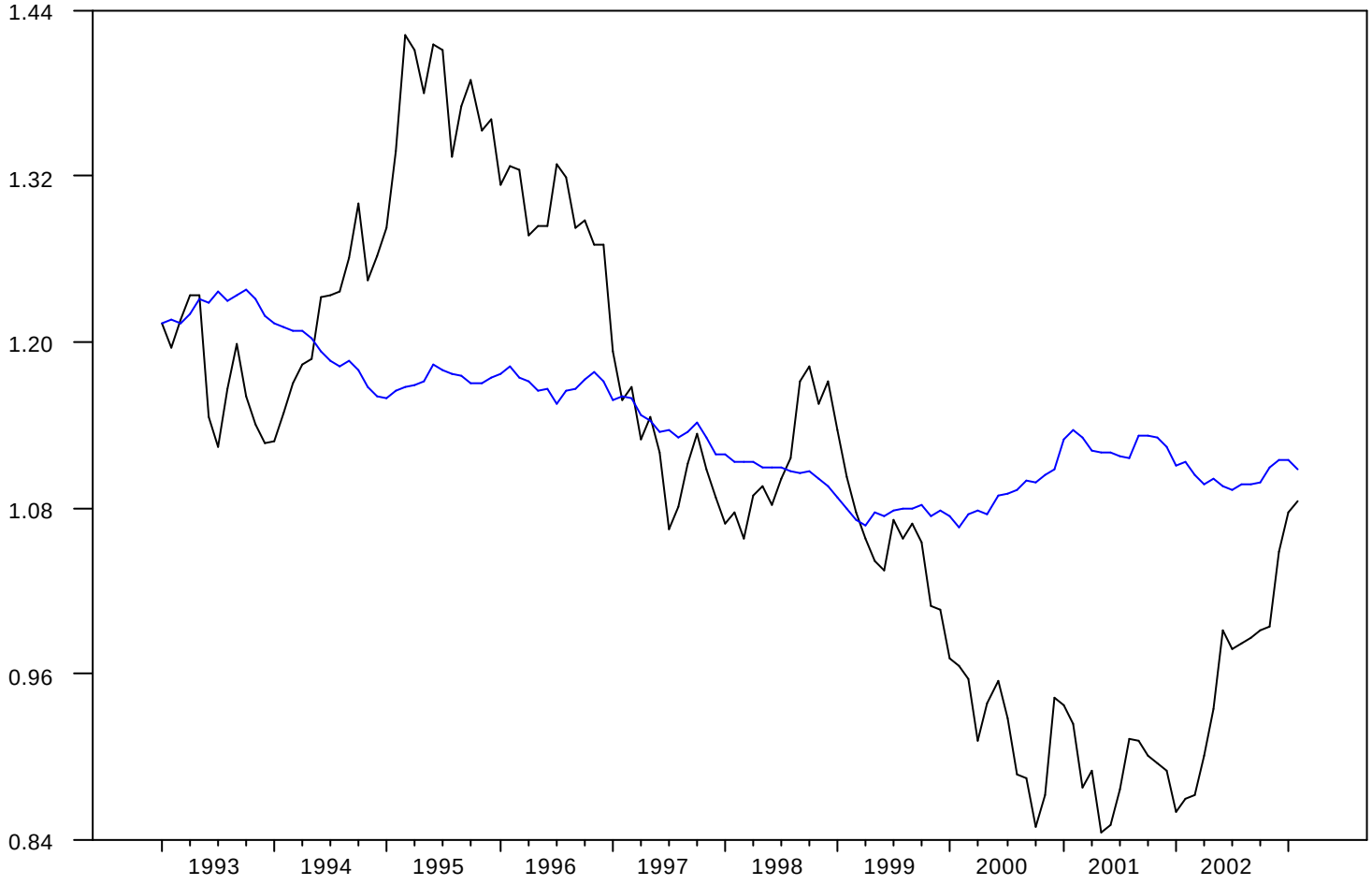


Figure 6.2: Explaining the US dollar – euro exchange rate: Cumulated announcement changes
January 1993 – February 2003

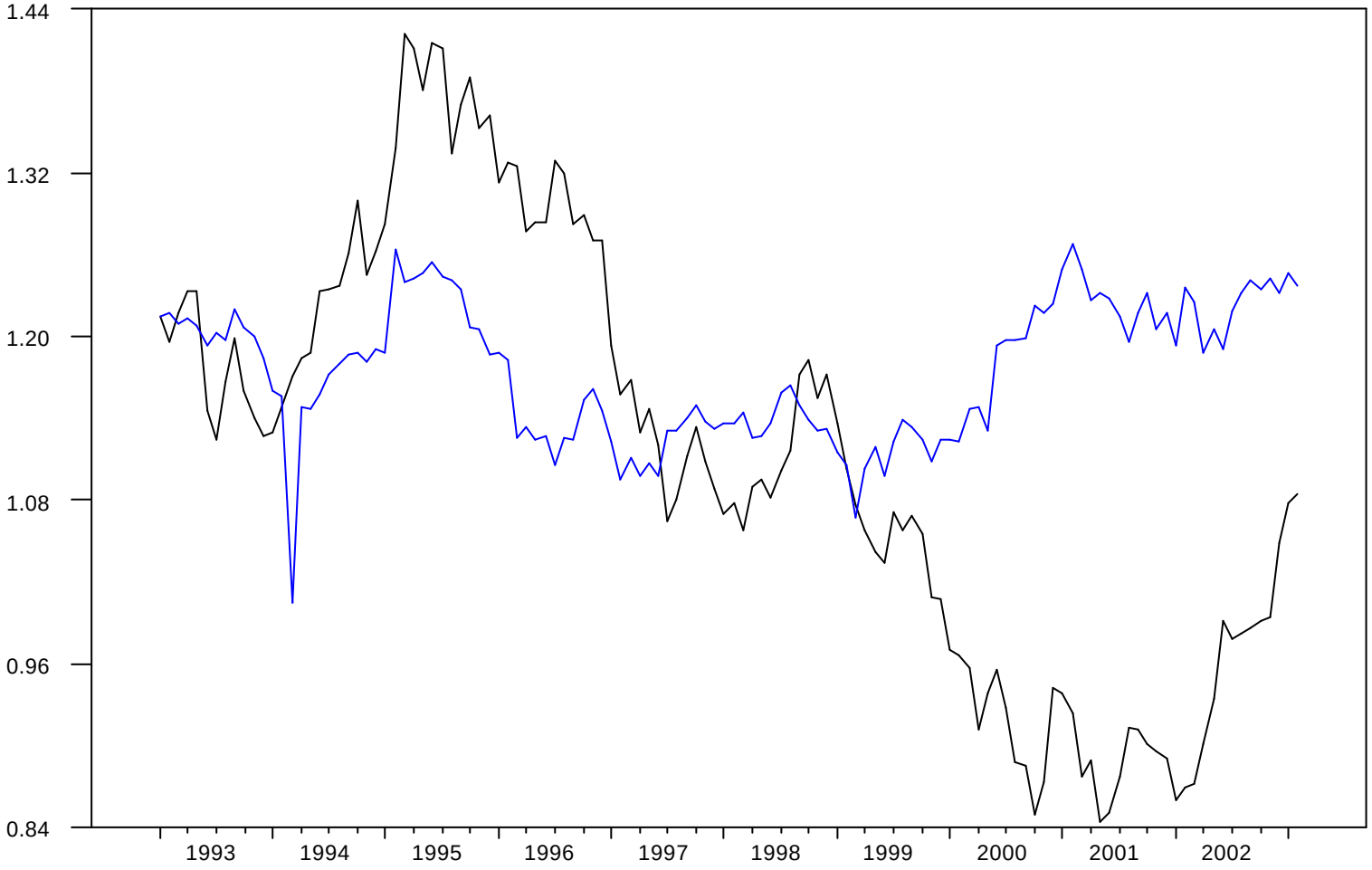


Figure 6.3: Importance of fundamentals for monthly USD/EUR exchange rate changes (in %)