The Effects of Macroeconomic 'News' on High Frequency Exchange Rate Behaviour

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DISCUSSION PAPER 258

Febraury 1997

FINANCIAL MARKETS GROUP
AN ESRC RESEARCH CENTRE

LONDON SCHOOL OF ECONOMICS

ISSN 0956-8549-258

THE EFFECTS OF MACROECONOMIC 'NEWS' ON HIGH FREQUENCY EXCHANGE RATE BEHAVIOUR

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First draft: September 1996
This draft: October 1996

Abstract

This papers studies the high frequency reaction of the DEM/USD exchange rate to publicly announced macroeconomic information emanating from Germany and the U.S. The news content of each announcement is extracted using a set of market expectation figures supplied by MMS International. By using data sampled at a high (5 minute) frequency we are able to identify systematic impacts of most announcements on the exchange rate change in the 15 minutes post-announcement. The impacts of 'news' on the exchange rate, however, can be seen to lose significance very quickly when the observation horizon for the exchange rate is increased, so that for most announcements there is little effect of 'news' on the exchange rate change by the end of the three hours immediately after release. Both the responses to U.S. and German 'news' are broadly consistent with a monetary authority 'reaction function' hypothesis, i.e., the market expects the Fed or the Bundesbank to respond to 'news' on increased real activity, for example, by raising short term interest rates in order to head off the possibility of future inflation. Further, the use of German data allows us to examine two questions the previous literature could not tackle, because, unlike U.S. announcements, German announcements are not scheduled. First, we show that the time-pattern of the reaction of the exchange rate to the U.S. scheduled announcements is different from the reaction to the German non-scheduled announcements, the former being much quicker. Second, we are able to examine the effect on the exchange rate change of the proximity of other events to the announcement. Results show that German 'news' is most influential when released just prior to a Bundesbank council meeting. Finally, subsidiary results demonstrate the efficiency of the intra-day FX market with respect to these announcements and map the pattern of volatility these releases cause.

1. Introduction

This paper studies the high-frequency reaction of the DEM/USD exchange rate to macroeconomic information emanating from Germany and the U.S. Specifically, we utilise exchange rate data covering the period 1/1/92 to 31/12/94, sampled at a five minute frequency, to investigate how the major monthly macroeconomic releases from these two countries impact the DEM/USD. The information contained in announcements over this three year period is extracted via a set of market expectation series supplied by Money Market Services International (MMS)[1]. Our analysis improves on previous work in this area in two main respects. First, our study is conducted using very high-frequency data, whereas most earlier work has used exchange rate data sampled at a frequency of a number of hours or more. This allows us to construct a very precise characterisation of the reaction of the exchange rate to macroeconomic information. Second, this is, to our knowledge, the first study which includes German data releases. Most work in this area has focused on U.S. (and to a lesser extent Japanese) macroeconomic announcements.

The major issue under examination is whether one can trace systematic effects of economic 'news' on the evolution of the exchange rate. The direction in which 'news' will push the exchange rate is, however, a priori indeterminate. It will depend on the market's belief about both the model of exchange rate determination and the manner in which monetary authorities will respond to new information. Take an unexpected increase in U.S. real activity for example. A Monetarist model of exchange rate determination would imply that the dollar should appreciate as domestic money demand rises, whilst a Keynesian model would predict the opposite due to increased import demand by U.S. citizens. These two mechanisms do not, however, factor in the possibility of a reaction to the 'news' by the U.S. monetary authority. Assuming the Fed to have a preference for low inflation, they should raise short term interest rates in order to cool the inflationary pressures in the economy, implying U.S. dollar appreciation. We label this latter mechanism the 'reaction function' effect. Which of the above mechanisms pertain to the determination of the DEM/USD and which dominates will determine the sign of the exchange rate response to 'news'[2].

The impact of economic 'news' on asset markets has previously been the subject of extensive research. Most of this research has concentrated on stock markets, in particular the effects of dividend and earnings announcements on stock prices and volatility, and, more recently, some studies have addressed the impact of macroeconomic 'news' on stock prices (see McQueen and Roley, 1993).

Previous work has also covered foreign exchange (FX) markets, studying the reaction of transaction prices (in FX derivative markets) or price quotations (from the spot market) to 'news'. Ederington and Lee (1995) use intra-daily data from the foreign currency futures market to demonstrate that transaction prices react very swiftly (i.e. within a couple of minutes) to the announcement of U.S. economic data. Existing work on the spot market, however, has used a far more coarse sampling frequency than that used in the Ederington and Lee study and that employed here.

One such study is Harris and Zabka (1996). They use daily data on six major currencies to examine the impact of statistics contained in the US Employment Report on foreign exchange markets. Results from a conventional regression analysis show a clear positive relationship between employment surprises and dollar appreciation. Other papers utilize spot quotations from the opening and closing of the main

[1] We would like to thank MMS International in London and Belmont, CA, for the provision of the expectations data and Olsen and Associates in Zurich for providing the exchange rate data.

[2] See Hoffman and Schlagenhauf (1985) for a more complete treatment of the alternative theories of exchange rate determination and an empirical test of these theories.

regional FX markets (these being North America, the Pacific, Tokyo and Europe). Hogan and Melvin (1994) examine the impact of US trade balance news on exchange rate levels and volatility, uncovering a significant impact of these 'news' on the JPY/USD. Ito and Roley (1987) consider news on inflation, industrial production and money shocks from the US and Japan. Regression results demonstrate that, of the six types of 'news' listed above, only unexpected changes in US M3 have a significant impact on the JPY/USD, engendering a dollar appreciation. Hakkio and Pearce (1985) use data similar to that of Hogan and Melvin (1994) and Ito and Roley (1987) but for a sample of seven exchange rates. The results of their study indicate that, in line with Ito and Roley (1987), exchange rates respond quite rapidly to US money supply innovations, but not to other types of US news. Further, their analysis is indicative of efficiency in the spot FX market. A final result of this paper is that there are significant structural breaks in the response of exchange rates to money supply 'news', brought about by shifts in the Fed's policy focus.

Hence, a general result from the aforementioned spot market studies is that few economic announcements have systematic impacts on exchange rates when rates are sampled at a frequency of a number of hours or more. We conjecture that announcements may have discernible impacts on exchange rates when examined in a higher frequency setting, with the disappearance of the effects at lower frequencies due to their being drowned in subsequent exchange rate fluctuations. We test this conjecture by examining the impact of U.S. and German 'news' on exchange rate returns measured over different horizons.

We extend our analysis by also considering a number of other issues. Following Hakkio and Pearce (1985) we examine the efficiency of the intra-day FX market via the traditional equation linking exchange rate changes to anticipated and unanticipated macroeconomic data, and go on to examine the temporal stability of our results. We also present results which describe the nature of the volatility reaction to announcements, a topic extensively covered in previous research. Studies such as Harvey and Huang (1991) and Ederington and Lee (1993, 1995) document the regular daily and intra-daily patterns that exist in foreign currency futures volatility and go on to show that large increases in volatility are apparent at the times of U.S. announcements. Similar results, derived from extensions of existing time-series volatility models, have been found in the spot FX market by, inter alia, DeGennaro and Shrieves (1995), Payne (1996a) and Almeida (1996).

Lastly, the use of German announcement data allows us to examine two further interesting questions. This is due to the fact that, unlike U.S. announcements, German releases did not have pre-set and pre-advertised releases dates and times. Hence first, we can examine how pre-scheduling of announcements affects the impact of 'news' on the DEM/USD by comparing the dynamic responses to U.S. and German data. A hypothesis relevant here is that the response to scheduled announcements is completed more quickly than that associated with a non-scheduled release. Using the German data we can also examine how the proximity of the announcement to other events, specifically the biweekly Bundesbank council meeting, affects the reaction of the exchange rate. We hypothesise that announcements which occur closer to Bundesbank council meetings have a larger exchange rate impact due to the belief that they therefore will carry more weight in Bundesbank policy deliberations.

The structure of the paper is as follows. Section 2 describes our data and methodology. We then turn to a discussion of our own empirical findings, first for US news, Section 3, and then German news, Section 4. We have a Section reporting some comparative statistics, Section 5 and the paper closes with Conclusions and ideas for further study.

2. Data and Methodology

2.1 The Data

Our exchange rate data covers the period 1/1/92-31/12/94. The data were originally received as an irregularly spaced, continuous-time set of DEM/USD quotations, published on the screens of Reuters' information system. We then converted the data to an equally spaced, calendar time-series by imposing a five minute observation grid, taking the last quotation in a five minute period as effective.[3] Finally, the average of bid and ask quotations was taken as our basic quotation variable.

The other portion of our data set consists of US and German macroeconomic announcements covering the same period, plus a market expectation series for each type of announcement obtained from Money Market Services International.[4] The list of series employed in our 'news' analysis are as follows: for the US we use the Employment Report, Trade figures, PPI and CPI announcements, Retail Sales, Durable Goods Orders, Consumer Confidence figures, Leading Indicators, the NAPM survey and the Industrial Production and Capacity Utilisation announcements; for Germany the series used are the CPI, Industrial Output, M3, Industrial Orders, PPI, Retail Sales, the Trade Balance, Unemployment and the Wholesale Price Index. Appendix 1 gives a list of the definitions of these announcements along with their usual release timing and the identifiers assigned to each series. Since all of these announcements are monthly, for each series we have a maximum of 36 observations, although irregularity in some of the releases and missing expectations data reduce the number of available observations for some of the series (see Appendix 1).

The MMS expectations we employ are calculated as the median from a survey of forecasts made by leading practitioners and academics. These data then allow us to separate the series relevant to each type of announcement into an unexpected and expected portion. In line with efficient markets theory, only the unexpected part of an announcement should have any impact on the DEM/USD, the expected portion having already been impounded into quotations. The adequacy of the MMS expectations series is an issue which has been examined in previous work. We re-examine this issue in Appendix 2. Utilising a simple test of rational expectations our results suggest that, overall, the MMS expectations series are unbiased. Some indications of systematic biases in expectations are present but these are relatively scarce. Hence, whilst other authors have cast doubt on the rationality of the MMS expectations series (notably Aggarwal, Mohanty and Song, 1995) our analysis supports the use of these data, in line with the results of Pearce and Roley (1985).

2.2 Methodology

Define q_t to be our 5 minute quotation series for the DEM/USD. Define $x_{i,t}$ to be the actual announced value for series i at moment t, $x^e_{i,t}$ to be the correspondent expected value from the MMS data, and $x^{ne}_{i,t} = x_{i,t} - x^e_{i,t}$ the unexpected part of the announcement. The basic equation which underlies most of our empirical analysis, equation 2.1, is derived from the efficient markets hypothesis,

[3] At points where there was no observation in a five minute interval, we linearly interpolated between the nearest preceding and succeeding quotation.

[4] To determine the time of the German announcements, a data set consisting of news headlines published on the screens of Reuters' information systems, with the corresponding date and time stamp, was also used.

$$r_{i,t+k} = \quad + \ _1 x_{i,t}^{ne} + \ _2 x_{i,t}^{e} + u_{i,t} \qquad (2.1)$$

where $r_{i,t+k}$ is defined as q_{t+k} - q_t and $u_{i,t}$ is an error term. Note that estimations of the above equation are not strict time-series regressions as the observations are not temporally consecutive. An observation for a given series is added at every point when a new release of data occurs and the associated return is then constructed. Market efficiency would dictate that the expected portion of an announcement should have no impact on the return and, further, that the constant term be zero. Impacts from the 'news' contained in announcements on the evolution of the DEM/USD will show up as significant coefficients on the unexpected portion of the release i.e. $_1$ being significantly different from zero.

Equation 2.1 is utilized in the empirical work in the following ways. First we test for systematic effects of each type of 'news' on the DEM/USD. As mentioned above, this entails testing the difference of $_1$ from zero. However, as argued in the Introduction, the signs of the coefficients are a priori uncertain, depending on which of the fundamental or reaction function responses dominates for a given release. To conduct these tests we initially assume market efficiency and restrict the parameters and $_2$ to zero i.e., we estimate equation 2.2 for each series i,[5]

$$r_{i,t+k} = \ _1 x_{i,t}^{ne} + u_{i,t} \qquad (2.2)$$

We employ the return in the fifteen minutes immediately post-announcement as the dependent variable (i.e. we took k=15m), the fifteen minute window chosen with reference to earlier work (Ederington and Lee, 1993, 1995 and Payne, 1996a) which suggest that the major impacts on both prices and volatility should occur within a fifteen minute span post-announcement. These tests are described in Sections 3.1 and 4.1.

Next we explicitly test the efficiency of the FX market. As argued above this entails estimating equations of the type of equation 2.1, and demonstrating that the coefficients and $_2$ are not significantly different from zero.[6] Another facet of market efficiency is that the data should only have an impact on FX rates after the official announcement time. Any impact previous to this would imply an unofficial information leakage.[7] Hence we re-estimate equation 2.2 with the right hand side variable as the return in the fifteen minutes immediately prior to announcement (i.e. k= -15m), our hypothesis being that none of the coefficients should be significantly different from zero. Results pertinent to these hypotheses are contained in Sections 3.2 and 4.2.

Our next estimations concern the persistence of the impact from announcements on the DEM/USD. If the 'news' contained in these macroeconomic data is considered 'fundamental' for the determination of the DEM/USD exchange rate then there should not only be a significant impact in the fifteen minutes post-release, but also, for example, in the twelve hours immediately after announcements. This is tested in Sections 3.3 and 4.3 by varying the window over which the return variable is calculated, i.e., estimating equations similar to equation 2.2, but with k assuming different values. The minimum return considered is

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[5] All the tests in this paper were computed using heteroskedasticity-consistent standard errors for the OLS estimates, as in White (1980).

[6] Note that if the forecast series for any announcement proved to be I(1), the forecasts were first differenced before inclusion in this regression.

[7] For the German announcements a pre-set official announcement time is not usually available. As described in Appendix 1, we took the time of the announcement to be the time of its reporting by Reuters' news service. This means that an impact in the period previous to the adopted announcement time could be caused by a systematic delay in Reuters' reporting and not necessarily by unofficial information leakage.

five minutes, whilst the maximum is twelve hours. Another test of persistence is to ask whether one can predict the sign of, for example, the twelve hour return from the sign of the fifteen minute return i.e. does the almost immediate reaction of the exchange rate to news dominate the direction in which the exchange rate moves in the twelve hours immediately post announcement. In order to examine this we employ a sign test based on the binomial distribution.[8]

We also examine the response of volatility to macroeconomic announcements. Although many other authors have studied this question, the extensive coverage of these data warrants a re-examination of the issue, especially for the German announcements. We studied the reaction of volatility to 'news' using a variance ratio framework. The variance ratio statistic is well known and compares volatility, as measured by squared returns, in the period post-announcements with the volatility at the same time on non-announcement days. It is calculated as shown in equation 2.3,

$$VR = \frac{\sum_{i=1}^{a} r_i^2 \Big/ (a-1)}{\sum_{j=1}^{na} r_j^2 \Big/ (na-1)} \tag{2.3}$$

where the numerator gives the mean post-announcement volatility on announcement days (a being the number of announcement days) and the denominator computes the average volatility for the same time interval on non-announcement days (na being the number of non-announcement days). The variance ratio statistic follows an F-distribution, with degrees of freedom $(a-1)$ and $(na-1)$. This analysis is presented in Sections 3.4 and 4.4 (although slightly modified for the German announcements, since they do not occur at a fixed time of day).

In the exercises above, we have assumed that the response to macroeconomic 'news' is invariant over time. In Sections 3.5 and 4.5 we examine whether the market reaction to unexpected information varies across our sample. To this end we employ three dummy variables: the first taking the value unity only in the first year of our sample and zero otherwise, the second being unity in the second year of the sample and zero everywhere else and the final dummy taking the value unity in the last sample year only. These dummies were then interacted with the forecast error series, giving three regressors in the basic 'news' impact regressions, $x92^{ne}_{i,t}$, $x93^{ne}_{i,t}$ and $x94^{ne}_{i,t}$. The test consisted in the estimation of equation 2.4 for each series i,[9]

$$r_{i,t+k} = {}_2x92^{ne}_{i,t} + {}_3x93^{ne}_{i,t} + {}_4x94^{ne}_{i,t} + u_{i,t} \tag{2.4}$$

[8] This test is based on the comparison of the sign of the returns in the 15 minutes and in a longer period (we used 6, 12 or 24 hours) after the announcement. The test statistic is the percentage of returns of the same sign in both periods. Under the null hypothesis of the initial return having no influence on the long term, this percentage is 50%. Using the binomial distribution, we can compute the probability of the number of predictions being equal or greater than the observed value under the null hypothesis the true distribution is binomial with p=0.5. If this probability is lower than the usual significance levels, one may reject the null hypothesis of the immediate return having no influence over the longer term returns.

[9] The qualitative features of the structural stability tests are similar if instead of using the dummy formulation described above, one runs three separate regressions, one for each year of the sample.

3. Analysis of American Macroeconomic Announcements

In this section we present the results from testing the impact of U.S. data releases on the DEM/USD rate. As detailed in Section 2.1, our analysis concentrates on the following monthly U.S. announcements: the statistics contained in the Employment Report, the Mercantile Trade Report (Trade), PPI and CPI figures, Retail Sales (RS), Durable Goods Orders (DG), Consumer Confidence (CC), Leading Indicators (LI), the NAPM survey and finally the Industrial Production/Capacity Utilisation figures (IP/CU).[10]

3.1 The impact of 'News'

The first question we address in our empirical analysis of the US data is do markets react systematically to good (and bad) news about the state of the economy? Given the list of announcements above, one would expect the coefficients on the forecast error series for all real activity indicators to have the same sign aside from that on the unemployment series. The actual sign which the coefficients take will depend on which of the fundamental or reaction effects outlined in the Introduction dominate. A priori, the signs of the price indicator series and their relationship with those of the real indicators is unknown. The results from estimations of equation 2.2 are given in Table 3.1 below.

A first point to note is that the coefficients on all indicators have the sign predicted by the reaction function response to news. Unexpected Retail Sales growth, for example, entails an appreciation in the dollar whereas unexpected Unemployment shocks have the opposite effect. The coefficients on announcements of real activity also conform with a Monetarist model of exchange rates. However, there is marginal evidence that price shocks tend to cause dollar appreciations also, an effect which is inconsistent with the Monetarist model. Hence our preferred interpretation of these results is that the response of exchange rates to macroeconomic 'news' is indicative of expected Federal Reserve reactions in domestic money markets.

Moving to the inference on these coefficients the t-statistics demonstrate that most are significant at, at least, 10%. Exceptions to this are the coefficients associated with PPI, CPI, Leading Indicators, Industrial Production and Capacity Utilisation figures. Whilst one might expect these results for the final three of this group, due to their being fairly unimportant indicators, the lack of impact from the price series is a notable result. The poor results for the price series may, however, be due to the relative inadequacy of the forecast series for these announcements (see Appendix 2). In the final column of Table 3.1 we give a common scale to the results by forming the product of the estimated coefficient and the average absolute forecast error. These figures yield a ranking of announcements, in terms of the mean impact on the DEM/USD, as follows. The Payroll Employment data is clearly most influential, entailing in excess of a 30 b.p. revision on average. There is then a group of indicators, comprising the Unemployment Rate, Trade figures, Retail Sales, Durable Goods orders, Consumer Confidence and the NAPM survey, which give, on average, at least a 10b.p. impulse to the DEM/USD. A low impact group of indicators includes the PPI, CPI, LI, IP and CU.

[10] Note that in our empirical analysis of individual announcements we can decompose the Employment Report responses into the effects due to its two principal components, the unemployment rate (Unemp) and payroll employment figures (PAY), via their forecast errors. For the analysis of this pair of announcements, and for the simultaneously released IP and CU figures, we use a multiple regression version of equation 2.2.

Table 3.1
The impact of US announcements on DEM/USD returns

Series	Coefficient	T-stat	R^2	Scaled
PAY	0.00004	5.77	0.44	0.00310
DG	0.00090	5.39	0.44	0.00170
NAPM	0.00087	4.94	0.35	0.00140
RS	0.00385	3.48	0.23	0.00160
TRADE	0.00110	3.41	0.24	0.00130
CC	0.00030	2.74	0.20	0.00130
Unemployment	-0.00730	-1.77	0.44	-0.00100
CPI	0.00450	1.48	0.06	0.00046
PPI	0.00290	1.29	0.04	0.00057
IP	0.00280	0.76	0.03	0.00037
CU	0.00046	0.28	0.03	0.00010
LI	0.00060	0.25	0.01	0.00007

Notes: The second column displays the estimated coefficients on the forecast error series. The next column gives the t-statistics relating to the hypothesis that the coefficients are zero. The critical values for the t-statistics are 2.04 at 5% and 1.70 at 10%. The final column displays the product of the coefficient with the average absolute forecast error.

The dominance of the Employment Report statistics links with the comments in Harris (1995) who expounds the view that they are regarded as the key indicator of U.S. performance by the markets. Also, the influence of the Trade figures on exchange rates is unsurprising. Again, the presence of the price indicators in the low impact group is surprising.

3.2 Market efficiency

We now move on to analysing the efficiency of the DEM/USD market around these announcements. The test of efficiency we employ is a simple regression, of the type of equation 2.1. In terms of the significance of the coefficients on forecast errors, similar results and a similar ranking of announcements to that in the previous subsection pertains. With regard to the efficiency of the market, we would expect the coefficients on the constant terms and forecast values to be zero. Table 3.2 is generally supportive of the concept of market efficiency. Only one of the constants, that in the Consumer Confidence equation, is significantly different from zero. Further, for 10 of the 12 releases the forecast data has no significant impact on the return. For the 2 releases for which the forecasts are significant (PPI and DG), the coefficients are negative. These significant negative coefficients may be linked to the results on the adequacy of the expectations series contained in Appendix 2. As Table A2 shows, the two announcements mentioned above are those for which the slope coefficients in the unbiasedness regressions are greatest in absolute value and both coefficients are significantly above unity. This implies that the MMS expectations we employ tend to consistently overpredict the actual data releases. Given this fact, the negative coefficients on the forecast series derived from our market efficiency testing can be rationalised as the market discounting the overprediction of the MMS expectations.

Table 3.2
Market Efficiency tests

Series	Constant	T-constant	News	T-news	Expected	T-expected	R^2
CC	-0.00116	-2.34	0.00031	3.22	0.00001	0.15	0.26
CPI	0.00006	0.03	0.00523	1.82	0.00136	0.22	0.08
CU	-0.00042	-0.57	0.00172	1.31	0.00070	0.94	0.11
DG	0.00029	0.51	0.00103	6.05	-0.00092	-2.07	0.52
IP	-0.00042	-0.57	0.00275	0.82	-0.00227	-1.59	0.11
LI	-0.00021	-0.58	0.00077	0.30	-0.00015	-0.18	0.01
NAPM	-0.00018	-0.47	0.00090	5.58	0.00028	1.61	0.41
PAY	-0.00004	-0.05	0.00003	5.34	-0.00001	-0.75	0.47
PPI	0.00023	0.34	0.00096	0.50	-0.01125	-3.22	0.22
RS	0.00029	0.30	0.00392	3.61	-0.00151	-0.95	0.24
TRADE	0.00011	0.21	0.00110	2.79	0.00017	0.22	0.24
Unemployment	-0.00004	-0.05	-0.00963	-2.89	-0.00144	-0.28	0.47

Notes: The column denoted 'News' displays the estimated coefficients on the forecast error series. The column denoted 'Expected' displays the coefficients on the forecast series. Note that if the forecast data for a given series contained a unit root the forecasts were differenced before inclusion in this regression. The 'T' columns give the t-statistics relating to the hypothesis that the coefficients are zero. The critical values for the t-statistics are 2.04 at 5% and 1.70 at 10%.

To conclude this subsection we examine the issue of whether there is any discernible effect of 'news' in the minutes before the formal release. As the official release time of these data is completely specified in advance (unlike the German data) it would seem that the only possible avenue for forecast errors to effect quotations pre-release would be through an unofficial information leakage. Table 3.3 documents the regression results relevant to the pre-release period. The evidence indicates that there is no consistent effect of forecasts on the return in the 15 minutes leading up to announcements, as one might expect. None of the twenty four coefficients estimated are significant at 10% and, relative to the results in Tables 3.1 and 3.2, the estimated regression R^2 is are very small.

Table 3.3
Effect of US 'news' on pre-announcement returns

Series	Coefficient	T-stat	R^2
CC	0.00003	0.93	0.016
CPI	0.00022	0.15	0.001
CU	0.00050	0.79	0.012
DG	0.00000	0.00	0.000
IP	0.00044	0.30	0.012
LI	0.00110	0.73	0.034
NAPM	0.00007	0.71	0.009
Pay	0.00000	-0.15	0.004
PPI	0.00012	0.31	0.001
RS	-0.00028	-1.09	0.020
Trade	-0.00002	-0.09	0.000
Unemployment	-0.00045	-0.38	0.004

Notes: The 'T-stat' column gives the t-statistics relating to the hypothesis that the coefficient is zero. The critical values for the t-statistics are 2.04 at 5% and 1.70 at 10%.

In summary, this subsection demonstrates that there are a group of announcements whose unexpected elements exert significant and relatively large impacts on the returns to DEM/USD in the 15 minutes after their release. These announcements include the Payroll Employment figures, Unemployment rates, Trade figures, RS, CC, DG and NAPM. Further, there is evidence that the DEM/USD market is efficient, in the sense that the expected portion of announcements has no impact on the exchange rate. Lastly, there is no evidence of any information being leaked from the announcements in the 15 minutes previous to release.

3.3 How Important is this 'News' in the Longer Run?

Thus far we have examined the effect of the information revealed by announcements on the DEM/USD in the fifteen minutes immediately post-release, finding that some U.S. macroeconomic announcements have significant impacts. In this subsection we test the persistence of the effect of 'news' on the exchange rate by examining the impact of the unanticipated information on exchange rate returns measured over various intervals post-announcement.

As Table 3.4 demonstrates, the general picture that emerges is that the impact of these macroeconomic releases on the DEM/USD is a very short run phenomenon. Examining first the group of seven announcements which were found to be fairly influential in the previous subsection,[11] the following results emerge. An encouraging result is that of the 77 regressions over differing horizons, more or less all yield a correctly signed coefficient (only 4 of the 77 coefficients are 'wrongly' signed).[12] The pattern of significance, however, is not strong. In general the impacts are significant only up to around 2 hours after release, after which, it seems, the effect of unanticipated macroeconomic information is drowned in the subsequent random fluctuations of the exchange rate. The only exceptions to this picture are the patterns for the Payroll and Consumer Confidence figures. These retain significance until the 12 hour horizon, confirming the earlier results and, with regard to the former, in line with the earlier remarks that these figures are by far the most influential in the market.

The persistence patterns associated with the less important announcements are, unsurprisingly, even less impressive. Only 29 of the 55 estimated coefficients are correctly signed and there is no consistent impact of 'news' on returns from any of the individual announcements.

Hence our results suggest that, aside from the Payroll and CC figures, one can trace very little long term effect of 'news' on quotations. This seems to indicate that, although one can find very short term impacts from forecast errors on the DEM/USD, the longer run impact is minimal, with the reaction to 'news' being drowned in subsequent 'noise'.

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[11] These being the Employment statistics, Trade figures, RS, CC, DG and NAPM figures.

[12] By 'correctly' signed we mean that the signs of the coefficients agree with those from Table 3.1 and our inference that the Fed follows 'reaction function' policy in response to 'news'.

Table 3.4
The persistence of the effect of 'News' on the DEM/USD

Release	5min	15min	30min	45min	1h	1.5h	2h	2.5h	3h	6h	12h
CC	0.00008*	0.00029*	0.00027*	0.00029*	0.00036*	0.00034*	0.00042*	0.00041*	0.00041*	0.00031*	0.00044*
CPI	0.00290*	0.00450	-0.00160	-0.00240	-0.00088	-0.00200	-0.00510	-0.00660	-0.00580	0.00320	0.00280
CU	0.00016	0.00046	0.00028	0.00160	0.00110	-0.00021	-0.00190	-0.00240	-0.00210	-0.00300	-0.00120
DG	0.00065*	0.00091*	0.00083*	0.00075*	0.00077*	0.00089*	0.00053	0.00043	0.00068	0.00043	0.00060
IP	0.00058	0.00290	-0.00021	-0.00180	-0.00147	-0.00015	-0.00023	0.00340	0.00430	0.01235	0.01783*
LI	0.00240*	0.00058*	0.00049	-0.00048	0.00510	0.00150	0.00020	0.01000*	0.01270*	0.00597	0.01350*
NAPM	0.00044*	0.00087*	0.00087*	0.00056*	0.00080*	0.00048	0.00025	-0.00006	0.00029	0.00012	0.00008
Payroll	0.00001	0.00004*	0.00005*	0.00005*	0.00005*	0.00005*	0.00005*	0.00006*	0.00006*	0.00006*	0.00005*
PPI	0.00042	0.00290	0.00210	0.00120	0.00210	-0.00043	-0.00220	-0.00320	-0.00360	-0.00290	-0.00088
RS	0.00110	0.00390*	0.00280*	0.00220	0.00220	0.00240	0.00240	0.00330	0.00210	0.00100	0.00340
Trade	0.00078*	0.00110*	0.00097*	0.00120*	0.00140*	0.00120*	0.00130*	0.00048	0.00055	0.00018	-0.00022
Unemp.	-0.00260	-0.00730*	-0.00850*	-0.00570	-0.00580	-0.00270	-0.00100	0.00290	0.00120	-0.00010	-0.00300

Notes: Each cell gives the slope coefficient from a linear regression of the return over the period displayed in the first row of the given column on the series of forecast errors from the series in the first cell of the given row. An asterisk denotes that the coefficient is significantly different from zero at a 5% level.

An alternative way to examine this issue, however, is the following. Can one predict the direction of the exchange rate change over the day following an announcement, for example, from the direction of the 15 minute return? In order to examine this question we employ the sign test outlined in the Section 2.2. The results of this testing procedure are given in Table 3.5. Note that we cannot now separate the effects of the Payroll and Unemployment figures, and the IP and CU figures due to their always being released simultaneously.

Whereas Table 3.4 demonstrates that, over longer horizons, one cannot predict the magnitude of the revision using the forecast error, Table 3.5 indicates that it is possible to predict the sign of six, twelve and twenty four hour exchange rate changes based on the sign of the immediate response. Examining each release separately, one can see that for the majority of announcements at least two of the three p-values are less than 10%, indicating predictability of the longer return direction given the direction of the immediate return. The strongest predictabilities in sign are associated with the Employment statistics, RS, DG, CC, and NAPM figures. Surprisingly poor results, indicating a lack of sign predictability at all horizons, were obtained for the Trade figures. For the 6 hour horizon, p-values of greater than 20% were obtained for PPI, CPI, LI and IP/CU, although results improved over twelve and twenty four hour horizons for the PPI and IP/CU figures. In order to increase the power of the test, we also aggregated across announcements and re-computed the test statistics, the results reinforcing the general predictability of the direction of returns.

Table 3.5
Predictive power of 15 minute return sign

Series	6 H		12 H		24 H		No. of
	Predictions	P-value	Predictions	P-value	Predictions	P-value	observation
CC	22	12%	23	7%	24	3%	36
CPI	20	31%	21	20%	19	43%	36
DG	22	12%	24	3%	23	7%	36
IP/CU	19	43%	23	7%	26	1%	36
LI	20	25%	19	37%	15	84%	35
NAPM	23	7%	22	12%	24	3%	36
PPI	9	100%	23	7%	25	1%	36
RS	23	7%	25	1%	22	12%	36
Trade	19	24%	18	36%	18	36%	33
U/Pay	26	1%	26	1%	25	1%	36
All	192	0%	202	0%	202	0%	325
All 8.30	128	0%	134	0%	128	0%	217
All 10	45	2%	45	2%	48	0%	72

Notes: The column headed 'Predictions' displays the number of observations with the sign of the 15 m return equal to the sign of the return over the period in the first row. The next column gives the probability of observing a number of predictions equal or larger than the actual, under the null of the number of predictions being random.

Hence to conclude this subsection it seems that the impact of the unexpected proportion of most macroeconomic announcements has a very short-run, almost trivial impact on exchange rates. Forecast errors can be seen to help predict exchange rate returns over horizons of around one hour rather than days or weeks. There is, however, a statistically significant relationship between the

direction of the exchange rate change in the 12, or even 24, hours following announcement and the change in the fifteen minutes immediately after release, as evinced in the sign tests above.

3.4 Variance ratios

The hypothesis that the macroeconomic data contains information pertinent to the determination of exchange rates implies that post-release one should expect a surge in volatility as this information is incorporated into quotations. The variance ratios computed compare the volatility over a given period post-release with the volatility over the same period on days on which no announcement was made. By comparing announcement to non-announcement days they therefore give an indication of the abnormal volatility which these macroeconomic data releases entail.

Table 3.6
Variance Ratio statistics

Data	0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	50-55m	55-60m
CC	1.31	4.38*	2.47*	2.50*	1.58**	1.28	1.18	1.10	0.56	0.62	1.38	0.91
CPI	0.99	1.88*	3.87*	2.00*	1.69**	3.00*	1.19	1.54**	1.08	1.20	0.88	0.89
DG	3.51*	5.21*	2.09*	1.24	2.46*	2.14*	1.90*	0.76	1.60**	1.29	1.70**	0.93
IP/CU	2.58*	3.03*	2.90*	2.37*	7.07*	2.10*	0.81	1.81**	2.98*	0.91	1.51**	1.78*
LI	2.47*	1.25	1.27	1.82*	0.67	1.02	1.45	1.15	0.53	2.84*	2.51*	1.03
NAPM	2.07*	2.48*	1.68**	1.26	1.44	1.53**	0.54	1.05	0.95	0.82	0.82	1.15
PPI	2.59*	6.13*	4.26*	2.79*	1.54**	1.37	1.54**	1.33	1.24	1.52**	2.22*	1.13
RS	2.89*	3.89*	9.47*	2.08*	1.70**	3.02*	1.69**	1.13	1.11	2.05*	1.14	0.54
Trade	3.19*	2.36*	4.27*	1.18	1.68**	1.50**	3.24*	1.13	0.95	4.49*	1.84*	0.64
U/Pay	14.48*	28.29*	9.19*	9.76*	3.97*	4.45*	4.21*	7.20*	4.97*	3.29*	2.81*	1.91*
8.30	4.13*	7.38*	4.99*	3.02*	2.09*	2.24*	2.23*	2.12*	1.74*	2.41*	1.97*	1.03
10.00	1.67**	3.39*	2.09*	1.86*	1.48**	1.40	0.86	1.07	0.75	0.73	1.10	1.02

Notes: Column headings refer to the period post-release over which the Variance Ratio is calculated. e.g 15-20m refers to the period from 15 to 20 minutes after announcement. Variance ratios calculated as shown in Section 2.2. A * (**) denotes that the variance ratio is significantly above unity, at a 1% (5%) level. Significance levels are derived from a one sided F-test with the null hypothesis that announcement and non-announcement interval variances are identical.

Table 3.6 presents the resulting variance ratios. All of the announcements except CPI yield increased volatility in the five minutes after release and all do so in the periods from 5 to 15 minutes post-release. A notable result is that, for most announcements, the increase in volatility is greatest in the period 5-10 minutes after release, rather than in the 5 minutes immediately post-release. In line with all earlier results, the greatest immediate volatility jump occurs at the time of release of the Employment statistics, confirming their position as the most important data releases for DEM/USD determination. For the accumulation of all announcements released at 8.30 EST one can identify an increase in volatility of around 400% relative to volatility on non-announcement days. Tracing the profiles of the variance ratios over the hour after release, a general decline in the ratio is visible, such that for most announcements there is only a small impact on volatility at the end of this period. Again the figures for the Employment report are an exception with volatility still at almost twice normal levels. These results tie in with the time-series evidence presented in Payne (1996a).

A final observation from the variance ratios can be seen by comparing the above table with Figure 3.1. The previously derived persistence results imply that the maximal price impact from these announcements occurs after 20 minutes approximately. Table 3.6, however, indicates significantly increased volatility for up to 45 minutes post-release in some cases. This may indicate that whereas the price reaction to US announcements is quite rapid, the effects they have on dealers inventory rebalancing persist for some time longer.

3.5 Structural stability

Finally in this subsection we perform the structural stability tests described in Section 2.2. In examining these results we split the announcements into two groups, the first consisting of those series with significant results from the basic 'news' regression (Unemployment, Payroll Employment, Trade, RS, DG, CC and NAPM, see Table 3.1) and the second containing all other series. With regard to the first group, all coefficients are of the sign implied by the reaction function response to news, in line with the results of Table 3.1. Most are significant in at least 2 of the 3 years, a notable exception being the Unemployment news which is insignificantly different from zero in all. A regularity in the results, excepting the Unemployment and CC coefficients, is that the absolute value of the coefficients declines over the three years, suggesting a greater impact of these news variables in 1992 relative to 1994. A possible explanation for this is the fact that global FX markets were far more turbulent in 1992, perhaps leading to greater emphasis being placed on macroeconomic announcements than in the relatively quiet times of 1994. Overall, for these six announcements there are strong patterns in significance and sign which confirm their, at least short-term, importance in FX markets.

Table 3.7
Structural stability tests

Series	1992	T-stat	1993	T-stat	1994	T-stat	R^2
CC	0.00025	1.01	0.00052	4.71	0.00005	0.91	0.21
DG	0.00144	5.32	0.00095	4.64	0.00019	1.47	0.55
NAPM	0.00103	5.49	0.00071	2.08	0.00034	0.73	0.38
Payroll	0.00005	5.49	0.00003	3.80	0.00002	2.12	0.48
RS	0.00737	1.68	0.00327	1.72	0.00303	4.19	0.26
Trade	0.00221	3.86	0.00129	3.75	0.00020	0.43	0.38
Unemployment	-0.00939	-1.40	-0.00371	-0.67	-0.00720	-1.18	0.48
CPI	0.00855	1.01	0.00145	0.58	0.00494	2.02	0.08
CU	-0.00674	-1.07	0.00150	1.81	-0.01100	-1.96	0.33
IP	0.02075	2.34	-0.00423	-3.05	0.00897	1.56	0.33
LI	-0.00314	-1.07	0.00663	3.61	-0.00469	-1.79	0.16
PPI	0.00960	1.97	0.00593	2.67	-0.00182	-0.55	0.23

Notes: The columns with number headings give the coefficients on the series created from interacting the forecast error series with that year's dummy. The 'T'stat' columns give the t-statistics relating to the hypothesis that the coefficients are zero. The critical values for the t-statistics are 2.04 at 5% and 1.70 at 10%.

The picture for the latter group is quite different. Only the coefficients associated with the CC and CPI figures are all of the sign predicted by the reaction function response. Results for the LI, IP and CU news, in particular, are very erratic. One point to note is the significance and correct sign of the PPI news in 1992 and 1993. This shows that the previous poor showing of PPI forecast errors as a

source of news may be attributed to their behaviour in 1994, where an insignificant negative coefficient obtains.

Hence, in line with earlier results, there is robust evidence that news associated with Unemployment, Payroll employment, Trade, Retail Sales, Durable Goods orders, Consumer Confidence and the NAPM survey have a strong short-term impact on the DEM/USD spot rate. The direction of these impacts is in line with a reaction function response to 'news'.

4. Analysis of German Macroeconomic Announcements

In this section we present the results obtained for the German macroeconomic announcements. As detailed in Section 2.1, our analysis concentrates on the following monthly German macroeconomic series: Consumer Prices (CPI), Industrial Production (IPI), Money supply M3, Manufacturing ORDERS, Producer Prices (PPI), RETAIL Sales, TRADE Balance,UNEMployment and Wholesale Prices (WPI).

4.1 The impact of 'News'

4.1.1 Explanatory power of 'News'

The results for the German announcement series for the estimations of equation 2.2 are given in Table 4.1. Note that a positive coefficient in these regressions implies that a positive surprise in the announcement is associated with a depreciation of the DEM (i.e. the USD appreciates). Of the 9 series analysed, only 3 (UNEM, IPI and CPI) have a significant impact at the 10% significance level. The R^2 is small in all the regressions, including those with significant coefficients. These results suggest that German macroeconomic announcements have a low explanatory power for exchange rate changes in the 15 minutes after their release. Note that in some cases (for instance, TRADE) the low explanatory power may be a consequence of the bias in the expectations series.

In the final column of Table 4.1 we give a common scale to the results by forming the product of the estimated coefficient and the average absolute forecast error. These figures show that IPI and UNEM are the series causing the largest response (each announcement entails a 3b.p. revision, on average), followed by M3, CPI and RETAIL (which entail a 2b.p. revision, on average). The average response yields a ranking of the impact of the announcements which is similar, but not identical, to the ranking provided by the significance levels. For instance, the significance level of CPI is higher than for M3, but its average response is smaller, because the CPI is forecast more accurately than the other series, and thus the 'news' content of a CPI announcement is smaller on average.

Table 4.1
The impact of German announcements on DEM/USD returns

Series	Coefficient	T-stat	R^2	Scaled
UNEM	-0.00003	-3.06	0.16	-0.00029
IPI	-0.00023	-2.07	0.05	-0.00034
CPI	0.00261	2.00	0.08	0.00020
RETAIL	-0.00006	-1.35	0.01	-0.00018
ORDERS	0.00006	1.15	0.01	0.00010
PPI	-0.00113	-0.81	-0.08	-0.00014
M3	-0.00017	-0.75	-0.19	-0.00022
TRADE	-0.00004	-0.41	0.01	-0.00008
WPI	0.00017	0.35	-0.01	0.00005

Notes: See Table 3.1.

4.1.2 The impact of 'News' and Bundesbank council meetings

Previous work on the reaction of DEM/USD exchange rate volatility to central bank actions (Almeida, 1996), has shown that the DEM/USD exchange rate was very sensitive to statements issued after Bundesbank council meetings. These results suggest the possibility that Bundesbank decisions, and expectations about those decisions, are the key German factor driving the DEM/USD exchange rate. If this is true, then the importance of German macroeconomic announcements should be a function of the extent to which they can influence the outcome of the Bundesbank council meetings. Our hypothesis is that this is a function of the period of time between the release and the meeting: if an announcement is made just after a Bundesbank council meeting (long before the next) the markets will not pay much attention to it; the Bundesbank will not act on that information for two weeks,[13] and during that period new information may arrive that could be more relevant for their decision.

This hypothesis implies that an announcement will be more important the closer it is to the next Bundesbank council meeting, so we weighted our observations according to this. The test consisted in running regressions similar to the ones used in subsection 4.1.1 but with each observation weighted by the inverse of the number of days to the next meeting, i.e. we run cross-section regressions of the form

$$R_{t+k} = X_{i,t}^{ne} + u_{i,t} \qquad (4.1)$$

where $R_t = r_t / d$, $X^{ne}_{i,t} = x^{ne}_{i,t}/d$, and d is the number of days to the next Bundesbank council meeting (including the day of the announcement).

The results for these regressions, presented on Table 4.2, support our hypothesis, since there is an increase in the significance of the coefficient on 'news' (and on the R^2) for most of the announcements (the only exceptions being WPI and ORDERS, but these are not significant in either case). When the proximity with the Bundesbank council meetings is considered, 6 of our 9 series have coefficients significant at the 10% level. The scaled impact is, on average, doubled and at least for M3, UNEM, IPI and PPI, the R^2 is relatively high, suggesting the German macroeconomic announcements may indeed have an important impact on the behaviour of the exchange rate, at least over the short term.

[13] The Bundesbank meets every other Thursday, with some exceptions: it did not meet over the Christmas or Easter holidays, or in the beginning of August, so there was a 3 or 4 weeks interval between meetings at those times; also, on the 4 times when the Thursday was a holiday, the meeting was held on the Wednesday (3 times), or the Friday (once). As such, there is a weekly regularity on Bundesbank meetings. The macroeconomic data are announced monthly, but there is no precise monthly regularity on these announcements. The combination of these two facts implies that for a particular series, the proximity to the next Bundesbank meeting varies considerably across announcements. Overall the average number of days to the next Bundesbank meeting is 7.9, with a standard deviation of 5.7, and these results hold roughly for each individual series. Note that in order not to have a number of days to the next announcement equal to zero, we included both the day of the announcement and the day of the meeting in the difference. Thus a figure of 1 means the announcement occurred on the day of a Bundesbank meeting, and each meeting is 15 days before the next.

Table 4.2
The impact of German announcements on DEM/USD returns
(weighted by proximity of next Bundesbank council meeting)

Series	Coefficient	T-stat	R^2	Scaled
M3	-0.00046	-5.02	0.35	-0.00060
UNEM	-0.00002	-3.43	0.29	-0.00027
IPI	-0.00029	-2.80	0.24	-0.00043
CPI	0.00540	2.72	0.08	0.00042
PPI	-0.00358	-2.00	0.33	-0.00044
RETAIL	-0.00007	-1.84	0.03	-0.00020
TRADE	-0.00014	-1.30	0.05	-0.00025
WPI	0.00012	0.23	-0.03	0.00003
ORDERS	0.00000	0.08	0.00	0.00001

Notes: See Table 3.1.

4.1.3 The interpretation of the sign of the coefficients

As described in the Introduction, the sign of the coefficient on the 'news' depends on the market's belief about both the appropriate model of exchange rate determination and the likely reaction of the monetary authorities. In this subsection, we try to identify those beliefs based on the results presented in Tables 4.1 and 4.2. Note that the signs of the coefficients are the same in both Tables (although the significance of the coefficients change when we weight by the proximity to Bundesbank council meetings): negative for IPI, M3, PPI, RETAIL, TRADE and UNEM (i.e. a positive surprise on these announcements causes a DEM appreciation), positive for CPI, ORDERS and WPI.[14] As explained below, these results suggest that the markets believe the DEM behaves according to a model where international capital flows dominate over trade flows, i.e. the key variable for exchange rate determination is the interest rate differential, and where the monetary authorities set interest rates according to their expectations of future inflation (and eventually, growth).

The negative sign on M3 is not consistent with the direct effects of any of the 'fundamentals' models, but is consistent with a 'reaction function' interpretation: faced with higher than expected monetary growth, the Bundesbank will raise interest rates to reduce M3 growth; higher interest rates will cause an appreciation of the DEM. The signs on IPI, PPI and RETAIL are also consistent with a 'reaction function' interpretation:[15] higher than expected producer prices or real activity may be seen as indicators of future inflation; to curb these inflationary pressures, the Bundesbank will raise interest rates, causing an appreciation of the DEM. However, the signs on CPI and UNEM are not consistent with the 'reaction function' interpretation, but they are consistent with the Keynesian model: lower unemployment will increase consumer spending and increase imports; higher domestic

[14] In the following analysis, we will ignore the variables that do not have significant coefficients in any of the Tables 4.1 and 4.2, i.e., ORDERS, TRADE and WPI.

[15] Note that the negative sign on these three variables is not consistent with the direct effects in the Keynesian model, but the signs on IPI and RETAIL (although not on PPI) are consistent with the direct effects in the Monetarist model.

prices should also increase imports and reduce exports; in both cases, the balance of payments will deteriorate, causing a depreciation of the DEM.

The Bundesbank is usually described as a 'money targeting' central bank. Each year the Bundesbank council sets a (band) target for M3 growth, and monetary policy actions are justified with reference to the attainment of this target. A strict interpretation of this framework would imply that the Bundesbank would only react to unexpected changes in M3, and not to any other information. However, some authors claim that in practice the Bundesbank does not follow money targets strictly. von Hagen (1995) claims that the Bundesbank follows an inflation target framework, with expected future inflation being the main factor driving policy actions, and M3 growth being just an (important) indicator of future inflation. Clarida and Gertler (1996) estimate a policy reaction function for the Bundesbank, and conclude that German monetary policy is conditioned on inflationary pressures and the state of real economy, but since the Bundesbank behaves in a forward-looking manner, it only reacts to future (consumer price) inflation and growth. In particular, they show that the Bundesbank reacts first of all to M3 shocks, but also to past growth as measured by the IPI, or to past commodity prices' shocks, but they do not react to past consumer price inflation, i.e., the Bundesbank reacts to announcements on variables that are leading indicators of future inflation or of current or future growth, but not to indicators of current consumer price inflation. Although the variables used by Clarida and Gertler (1996) do not match exactly the variables used in this paper, their results suggest that the Bundesbank should react to unexpected changes in M3, IPI, RETAIL (as indicators of current and future growth), or PPI (as proxy for commodity prices), but not to unexpected changes in CPI or UNEM[16]. Our results are consistent with this[17].

This interpretation is also consistent with the results of the weighting procedure. Scaling by the proximity to the next Bundesbank council meeting will only make a significant difference if the market believes that the Bundesbank will react to the information released, i.e., if the reaction effect is dominant. The significance and magnitude of the coefficients (and also the R^2) for M3, IPI, PPI, and RETAIL are all increased, the biggest increase being for M3, the main variable in the Bundesbank's reaction function (according to Clarida and Gertler, 1996). However, although there is some increase in the significance of both coefficients, the effects seem to be quantitatively smaller for the CPI and UNEM and some measures of the importance of the effects actually deteriorate (as the size of the coefficient for UNEM and the R^2 for CPI). These results suggest that M3, IPI, PPI, and RETAIL affect the DEM/USD exchange rate through their effects on Bundesbank policy decisions, whereas the effect of CPI and UNEM may be felt through other channels.

[16] Note that Clarida and Gertler (1996) do not include an unemployment variable in their study. However, current unemployment may be seen more as a consequence of low growth in the past, than as an indicator of future growth, i.e., it is more a backward-looking variable that should not enter the reaction function of a forward-looking central bank.

[17] This interpretation implies that some of the variables used in this paper should be good predictors of future inflation (M3, IPI, PPI and RETAIL), and others not (CPI and UNEM). As a rough test of this hypothesis, we ran a regression of the change in the CPI from t to t+12m on the changes from t-12m to t in the Lombard rate and the 9 macroeconomic series used in this paper, using monthly data from 1993:3 to 1994:12. Results demonstrated that the signs of coefficients were consistent with a reaction function interpretation of the results of Table 4.1, but the significance of the coefficients on most of the variables was poor. Due to the lack of degrees of freedom in this regression and the simplistic structure imposed, we do not report the results, leaving a more careful and detailed analysis for further work.

Since the 'reaction function' effect dominates for the majority of the variables, it seems that expectations about future interest rates are the main factor driving the DEM/USD reaction to German macroeconomic news. The effect of backward-looking variables (like the CPI and UNEM) suggest that the markets see the DEM behaving according to a model in which the elasticity of the exchange rate to the current account is small relative to the elasticity of the exchange rate to interest rate differentials.

4.2 Market efficiency

Table 4.3 presents the results from running the market efficiency regressions (equation 2.1). The coefficients on the forecast errors (and their significance) are not significantly affected by the use of equation 2.1 instead of equation 2.2, as may be seen by comparing Table 4.3 with Table 4.1. With regard to the coefficients on constant terms and forecast values (expectations), the results are generally supportive of the efficiency hypothesis, i.e., in general these coefficients are not significantly different from zero. Only one of the coefficients on the expectation (CPI), and one of the constants (M3) are significantly different from zero at the 5% level. This does not seem to constitute enough evidence to reject the market efficiency hypothesis, and thus, supports our choice of equation 2.2 as the basis for the analysis in the previous section.

Table 4.3
Market Efficiency tests

Series	Constant	T-constant	News	T-news	Expected	T-expected	R^2
CPI	-0.00022	-1.04	0.00281	2.36	0.00114	2.64	0.14
IPI	0.00030	1.76	-0.00023	-2.33	-0.00030	-1.27	0.16
M3	-0.00098	-2.43	-0.00007	-0.35	-0.00005	-0.27	0.02
ORDERS	-0.00012	-0.67	0.00006	1.11	-0.00011	-0.74	0.03
PPI	0.00039	1.42	-0.00059	-0.53	-0.00023	-0.13	0.00
RETAIL	0.00038	1.09	-0.00003	-0.68	0.00015	1.16	0.05
TRADE	0.00013	0.76	0.00006	0.49	0.00010	0.64	0.04
UNEM	-0.00001	-0.10	-0.00002	-2.93	0.00001	0.41	0.15
WPI	-0.00007	-0.40	0.00014	0.29	-0.00037	-0.36	0.01

Notes: See Table 3.2.

We also examined whether there is any evidence of 'news' affecting the DEM/USD rate before the time of the announcement. The coefficients from the regressions using the pre-announcement returns, presented in Table 4.4, are significant in only two cases, TRADE at the 5% level and M3 at the 10% level. This seems to be too weak evidence to conclude that there is some pre-announcement effect, but it raises the possibility of this effect being present. As described in Appendix 1, we took the release time to be the time of its reporting by Reuters' news services. Thus, evidence of any effect before the announcement may be caused either by delay in the Reuters' reporting of the official announcement, or by unofficial leakage of information before the official announcement. Assuming that unofficial leakage of information is highly unlikely, we interpret this weak evidence of some pre-announcement effects as suggesting that some dealers may get their information by faster channels than Reuters', although the majority of the agents in the FX market get their information at the same time of Reuters' reporting.

Table 4.4
Effect of German 'news' on pre-announcement returns

Series	Coefficient	T-stat	R^2
CPI	0.00047	0.22	-0.14
IPI	-0.00005	-0.46	-0.00
M3	-0.00028	-1.95	0.24
ORDERS	-0.00004	-0.59	-0.00
PPI	0.00092	0.63	-0.01
RETAIL	-0.00006	-1.09	-0.07
TRADE	0.00011	2.17	0.07
UNEM	0.00001	0.80	-0.02
WPI	-0.00006	-0.23	-0.14

Notes: See Table 3.3.

4.3 The 'long run' effects of German macroeconomic announcements

In this section, we extend our analysis to assess if and how the effect of German macroeconomic announcements is felt over longer periods of time. As in the analysis of U.S. news we employ both a regression framework and a set of non-parametric sign tests.

4.3.1. Persistence of news effects

Table 4.5 presents the results of running regressions of the type of equation 2.1 (the 'original' data) using returns over different periods of time, from 5 minutes to 12 hours, while Table 4.6 presents similar results for regressions of the type of equation 4.1 (the 'weighted' data). Figure 4.1 plots the group average. An analysis of the behaviour of the exchange rate inside the initial 15 minute period reveals no systematic pattern, although it seems that on average, the significance (and to a lesser extent the magnitude) of the coefficient of the change in the exchange rate is higher in the 10-15 minute interval, than in the previous two. This result is intriguing since we would expect the main adjustment to occur immediately, or at most in the 5-10 minute period. It suggests that market participants take some time to process the new information. It could also be a consequence of the fact that our data refer to quotes and not to actual transactions; although quotes are generally a good proxy for transactions, in periods of intense transaction activity the quotes data may lag the actual transactions data (Goodhart, 1989). Also, it seems that the evolution of the exchange rate is not monotonic. For most of the series (6 in both cases) the coefficients change sign inside the 15 minute period, a result that could indicate some initial overshooting. However, since these coefficients are not generally significantly different from zero, we should not put too much weight on this latter finding.

For periods longer than 15 minutes, the significance levels tend to be lower, although for the 'weighted' data the significance levels are relatively high even after 3 hours. For the 'original' data only PPI has consistently significant coefficients up to 3 hours, and of the 3 series identified as significant in section 4.1.1, only UNEM extends its significance to the 30 minute interval. For the 'weighted' data the significant effects extend up to 6 hours for some series. However, the full impact of the announcement (measured by the highest value of the coefficient) is, on average, only

felt after 3 hours, for the 'original' and 'weighted' data, although the pattern is more clearly defined for the latter. The relatively long period that the market takes to adjust is probably associated with the fact that the German announcements are not scheduled. This also explains the relatively small scaled effect found in Section 4.1. If one takes the 3 hour instead of the 15 minute return, then the impact of German announcements on the DEM/USD exchange rate becomes higher, as shown in Table 4.7. For the 'original' data, the scaled response reaches an exceptional 19 b.p. for PPI, but is lower than 7 b.p. for the other series. For most of the series, the scaled response is even higher for the 'weighted' data, reaching 16 b.p. for TRADE and CPI, 12 b.p. for M3 and 11 b.p. for IPI.

Table 4.7
The impact of German announcements on DEM/USD 3 hour returns

Series	'Original'			'Weighted'		
	Coefficient	T-stat	Scaled	Coefficient	T-stat	Scaled
TRADE	-0.00031	-0.88	0.00055	-0.00089	-2.85	0.00159
CPI	0.00230	0.45	0.00018	0.02003	2.25	0.00156
M3	-0.00042	-1.11	0.00054	-0.00095	-3.13	0.00123
IPI	-0.00046	-1.45	0.00067	-0.00077	-0.82	0.00112
PPI	-0.01500	-2.46	0.00186	-0.00697	-1.27	0.00087
ORDERS	0.00014	0.43	0.00025	-0.00039	-2.33	0.00067
RETAIL	-0.00017	-1.84	0.00050	-0.00022	-1.28	0.00066
WPI	-0.00003	-0.02	0.00001	-0.00058	-0.33	0.00016
UNEM	0.00000	-0.15	0.00004	0.00001	0.29	0.00015

Notes: The column headed 'coefficient' displays the estimated coefficients on the forecast error series. The next column gives the t-statistics relating to the hypothesis that the coefficients are zero. The critical values for the t-statistics are 2.04 at 5% and 1.70 at 10%. The column headed 'Scaled' displays the product of the coefficient with the average absolute forecast error.

Table 4.5
The persistence of the effect of 'News' on the DEM/USD ('original' data)

PERIOD	0-5 m	5-10 m	10-15 m	15 m	30 m	45 m	1 h	1.5 h	2 h	2.5 h	3 h	6 h	12 h
CPI	0.00010	0.00080	0.00171	0.00261*	0.00023	0.00149	0.00073	0.00192	0.00101	0.00159	0.00230	0.00751	-0.00123
IPI	-0.00008	-0.00003	-0.00013**	-0.00023**	-0.00005	-0.00004	-0.00012	-0.00035	-0.00022	-0.00029	-0.00046	-0.00041	-0.00080
M3	0.00008	-0.00020**	-0.00005	-0.00017	-0.00014	-0.00008	-0.00020	-0.00021	-0.00029	-0.00021	-0.00042	-0.00059**	-0.00052
ORDERS	0.00007*	0.00006	-0.00007**	0.00006	0.00010	0.00012	0.00021*	0.00005	0.00004	-0.00012	0.00014	0.00040	0.00027
PPI	-0.00005	0.00046	-0.00154**	-0.00113	-0.00343*	-0.00343	-0.00672**	-0.00786**	-0.01175**	-0.01459**	-0.01500**	-0.00840	-0.01027
RETAIL	-0.00002	-0.00002	-0.00002	-0.00006	-0.00008	-0.00004	-0.00003	-0.00002	-0.00004	-0.00004	-0.00017*	0.00021	0.00028
TRADE	0.00003	0.00000	-0.00008	-0.00004	0.00010	-0.00018	-0.00008	-0.00034	-0.00041*	-0.00016	-0.00031	-0.00017	-0.00013
UNEM	-0.00001	0.00000	-0.00001**	-0.00003**	-0.00003**	-0.00002	-0.00002	-0.00001	-0.00002	-0.00002	0.00000	-0.00004	-0.00009
WPI	-0.00006	0.00008	0.00015	0.00017	-0.00062	-0.00028	0.00004	-0.00060	0.00047	-0.00097	-0.00003	-0.00007	-0.00101

Notes: Each cell gives the slope coefficient from a linear regression of the return over the period displayed in the first row of the given column on the series of forecast errors from the series in the first cell of the given row. An(*(**)) denotes that the coefficient is significantly different from zero at a 10% (5%) level.

Table 4.6
The persistence of the effect of 'News' on the DEM/USD ('weighted' data)

PERIOD	0-5 m	5-10 m	10-15 m	15 m	30 m	45 m	1 h	1.5 h	2 h	2.5 h	3 h	6 h	12 h
CPI	0.00437*	-0.00002	0.00105	0.00540**	0.00574	0.00812*	0.00978	0.00903*	0.01132	0.01613**	0.02003**	0.01423	0.00824
IPI	-0.00011	-0.00001	-0.00017**	-0.00029**	-0.00025**	-0.00022**	-0.00037**	-0.00066	-0.00032	-0.00062	-0.00077	0.00015	-0.00150
M3	-0.00010	-0.00021**	-0.00015**	-0.00046**	-0.00049	-0.00051**	-0.00085*	-0.00099**	-0.00095**	-0.00099**	-0.00095**	-0.00099**	-0.00023
ORDERS	0.00000	0.00010**	-0.00009**	0.00000	-0.00006	-0.00010	0.00009	-0.00012	-0.00004	-0.00027**	-0.00039**	-0.00124**	-0.00075
PPI	-0.00027	-0.00097	-0.00234**	-0.00358*	-0.00207	-0.00244*	-0.00380**	-0.00467**	-0.00886**	-0.00719	-0.00697	0.01362	0.02167
RETAIL	-0.00007*	0.00001	-0.00001	-0.00007*	0.00001	0.00008	0.00003	0.00000	-0.00011	-0.00008	-0.00022	0.00005	0.00016
TRADE	0.00001	-0.00002	-0.00013	-0.00014	0.00022	-0.00026**	-0.00010	-0.00033	-0.00039	-0.00035**	-0.00089**	-0.00010	-0.00071
UNEM	0.00000	-0.00001	-0.00001**	-0.00002**	-0.00002	-0.00002	-0.00001	0.00000	-0.00001	0.00000	0.00001	0.00000	0.00003
WPI	0.00037	-0.00038	0.00013	0.00012	-0.00016	-0.00043	0.00012	-0.00025	-0.00001	-0.00071	-0.00058	-0.00344	-0.00001

Notes: See Table 4.5.

4.3.2 Predictive power of the direction of change

Table 4.8 reports the results of the sign test described in Section 2.2. For most of the series, the direction of the 15 minute returns seem to have some predictive power, although weak, over the direction of the longer horizon exchange rate movements. The number of predictions is generally above 50%, but only in 5 cases it is high enough for the null to be rejected at the 5% significance level. We should expect the predictive power to be declining over time, i.e. to be greater for the 6 hour period than for the 12 or 24 hour period. Given this assumption, the only consistent and significant results are for ORDERS, since we reject the null hypothesis at 10% significance level for the 6h and 12h periods, and for M3 over 6 h, where we reject the null at the 5% significance level. However, the tests for individual announcements are not very powerful, since they are based only on 36 observations.

Table 4.8
Predictive power of 15 minute return sign

Series	6 H		12 H		24 H		No. of
	Predictions	P-value	Predictions	P-value	Predictions	P-value	observation
CPI	22	12%	24	3%	22	12%	36
IPI	23	7%	25	1%	25	1%	36
M3	25	1%	21	20%	23	7%	36
ORDERS	24	3%	23	7%	21	20%	36
PPI	17	69%	16	80%	14	93%	36
RETAIL	22	12%	20	31%	18	57%	36
TRADE	22	9%	19	37%	15	84%	35
UNEM	17	69%	18	57%	20	31%	36
WPI	19	43%	19	43%	17	69%	36
All series	191	0%	185	1%	175	7%	323
Top 6	126	1%	124	2%	122	3%	216
Prices	69	25%	64	19%	60	61%	107
Real	81	1%	82	1%	80	3%	144

Notes: See Table 3.5.

One of the advantages of the sign test is that it allows for aggregation across announcements. Thus we construct tests based on a larger number of observations and on a broader class of series than in the individual series tests. We aggregate over 4 (overlapping) groups of series (see Table 4.8), defined using the results on the news test or on the basis of the nature of the macroeconomic variables involved: the first with all the 9 series, the second (‘Top 6’)with the 6 series significant at the 10% level on the ‘weighted’ regressions (see Table 4.2), the third (‘Prices’)with the 3 price indices and finally, the 4 series describing the real sector (‘Real’). Given the large number of observations, and the diversity of the announcements, the test for the first group is the one with most power. For this group the results suggest the sign of the 15 minute return has a significant influence over the sign of the 6 h and 12 h returns, and a smaller but non negligible influence over the sign of the 24 hour return. The significance levels are even higher for the ‘Top 6’ and ‘Real’ groups, with the German macroeconomic announcements having a significant influence even over 24 h. It seems that even though the impact of the German macroeconomic announcements on the DEM/USD rate is

quantitatively small, it is sufficiently important to be one of the major factors influencing the exchange rate movements on the day of the announcements.

As would be expected, the relative importance of the German announcements is higher in the 6 hours following the announcement, than over 12 or 24 hours. Since most of the announcements occur between 7:00 and 13:00 GMT, we can interpret the 6 hour period as corresponding (roughly) to European trading, and the 12 hour period to European and American trading. Then we can interpret the results from this subsection as suggesting that German macroeconomic announcements have a significant effect over European trading on the day of their release, but that this effect is dwarfed by the impact of the arrival of information from the US when the American dealers enter the market, and thus gradually ignored by market participants in the American and Asian markets.

4.4. Variance ratios

In this subsection we analyse the impact of the German announcements on exchange rate volatility, using the variance ratio framework described in Section 2.2, modified to take into account that the German announcements do not occur at a fixed time of day. This implies that there is no unique interval on non-announcement days to serve as null. In the absence of a better alternative, we took the denominator of the variance ratio to include all the intervals in the 10.00-11.00 GMT period, the 'normal' period in the days when no German macroeconomic announcements occurred.[18] To avoid the distortions caused by the strong intra-day seasonal pattern in the DEM/USD exchange rate volatility (see Payne, 1996a), deseasonalised squared returns were used when computing the variance ratios.[19] By comparing the deseasonalised squared returns immediately after the announcements to the non-announcement days 'normal' periodeseasonalised squared returns, one has an indication of the abnormal volatility caused by the announcements.

Table 4.9 presents the resulting variance ratios. In line with what we found in section 4.1, few German announcements have a significant impact in DEM/USD volatility: only the CPI, M3 and RETAIL announcements cause significant increases in volatility, although the IPI, ORDERS and TRADE announcements also increase volatility, but not significantly. The results of the variance ratios are consistent with the evidence presented before, that suggested M3 is the German announcement with the highest and most persistent impact on the DEM/USD exchange rate. The last line of Table 4.9, which presents a variance ratio for all the German announcements taken together, shows that these have a significant impact in volatility, that persists for at least an hour. In fact, one can trace significant increases in volatility up to three hours,[20] again a result consistent with the evidence in section 4.3.1, where we showed that the full impact of the announcement is only felt after 3 hours.

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[18] The 10.00 - 11.00 GMT period was chosen because it roughly corresponds to the average time of announcement for the German releases, and it is a 'normal' period, in the sense that usually there are no exogenous eventsoccuring at this time, like opening or closing of markets or regular Central Bank actions or announcements.

[19] The deseasonalisation process consisted in dividing each squared return by the average squared return for that interval, over the 'relevant' sample. The 'relevant' sample is the period with common daylight savings time pattern in Europe and the US. Details of thisdeseasonalisationprocesss may be found in Almeida (1996).

[20] This evidence is not presented here, but mayobtained from the authors.

Table 4.9
Variance Ratio statistics

Data	0-5m	5-10m	10-15m	15-20m	20-25m	25-30m	30-35m	35-40m	40-45m	45-50m	50-55m	55-60m
CPI	1.74*	1.04	1.48*	1.59*	0.95	0.82	0.82	0.55	0.88	0.98	0.57	0.57
IPI	1.13	1.04	1.06	0.94	0.42	0.96	0.74	2.23*	0.39	0.83	1.01	1.06
M3	2.46*	3.36*	2.35*	1.38	0.56	2.22*	2.36*	2.03*	2.00*	1.32	2.21*	1.57*
Orders	1.17	0.69	1.49*	1.26	0.98	1.19	0.59	0.80	1.05	1.16	0.75	0.59
PPI	0.61	1.04	1.29	1.26	1.18	1.40	1.73*	1.24	1.18	0.92	1.40	0.94
Retail	2.13*	1.62*	3.61*	1.63*	0.58	0.66	2.79*	1.58*	0.77	1.05	1.30	5.82*
Trade	1.32	0.98	0.99	0.83	0.57	1.16	0.66	1.59*	0.98	1.37	1.79*	0.69
UNEM	1.00	0.49	1.24	0.84	1.19	0.81	0.85	1.93*	1.04	1.35	0.86	1.36
WPI	0.98	0.57	0.73	1.46*	0.94	0.57	1.40	0.86	0.65	0.68	2.14*	1.86*
ALL	1.40*	1.21*	1.59*	1.25*	0.82	1.09	1.33*	1.43*	1.00	1.08	1.34*	1.61*

Notes: See Table 3.6.

4.5 Structural stability

In this subsection, we examine whether the market reaction varies across our sample, by performing the structural stability tests outlined in Section 2.2. The results are presented in Table 4.10, for the regressions using the original values, and Table 4.11, for the regressions using the values weighted by the proximity to the following Bundesbank council meeting.

Table 4.10
Structural stability tests ('original' data)

Series	1992	T-stat	1993	T-stat	1994	T-stat	R^2
CPI	0.00136	0.96	0.00736	2.65	0.00150	0.96	0.15
IPI	-0.00013	-1.90	-0.00027	-0.70	-0.00035	-3.26	0.07
UNEM	-0.00003	-2.44	-0.00004	-3.33	0.00000	-0.16	0.22
M3	-0.00131	-2.47	0.00036	1.10	-0.00034	-5.53	0.05
ORDERS	0.00015	1.04	0.00001	0.18	0.00006	0.42	0.03
PPI	-0.00206	-0.72	-0.00252	-0.72	0.00027	0.25	-0.05
RETAIL	-0.00013	-1.75	-0.00001	-0.16	-0.00003	-0.77	0.03
TRADE	0.00015	0.77	-0.00020	-2.33	-0.00003	-0.27	0.14
WPI	-0.00065	-1.27	0.00171	2.18	0.00003	0.05	0.12

Notes: see Table 3.7.

The main feature of the results in Table 4.10 is the consistency of the signs of the coefficients across time. For all the 3 series with significant coefficients (CPI, IPI and UNEM, see Table 4.1), the sign of the coefficient is the same in the 3 years. However, the significance levels vary across the sample, and for none of the series the coefficient is significant in all three years. Similar results apply for the weighted regressions, with the sign of the coefficients being the same in all years for the 6 series with significant coefficients (CPI, IPI, M3, PPI, RETAIL and UNEM, see Table 4.2), but the significance levels varying considerably across years.

Table 4.11
Structural stability tests ('weighted' data)

Series	1992	T-stat	1993	T-stat	1994	T-stat	R^2
CPI	0.00197	1.22	0.00855	1.69	0.00604	7.78	0.11
IPI	-0.00023	-3.08	-0.00047	-1.01	-0.00050	-9.66	0.27
M3	-0.00131	-0.68	-0.00071	-10.60	-0.00036	-9.17	0.42
PPI	-0.00545	-5.75	-0.00472	-0.96	-0.00106	-2.17	0.46
RETAIL	-0.00013	-1.58	-0.00004	-0.83	-0.00010	-1.29	0.05
UNEM	-0.00002	-4.67	-0.00003	-1.61	-0.00001	-1.09	0.32
ORDERS	0.00006	1.45	0.00000	0.08	-0.00028	-1.07	0.04
TRADE	0.00014	0.88	-0.00033	-6.43	-0.00022	-2.37	0.25
WPI	-0.00097	-2.31	0.00168	2.29	-0.00014	-0.18	0.10

Notes: See Table 3.7.

Given the small number of observations in each subsample (12), it is not surprising that the significance levels vary considerably across years. The consistency of the signs of the coefficients strongly suggests that the results are not spurious, and that there is strong evidence that some German macroeconomic announcements have a significant (although small) impact in the DEM/USD exchange rate.

5. Are the Impacts of German and US Announcements Similar?

In this section we compare the results obtained for the German and US announcements and try to extract some general conclusions. The main feature of the results is thatthe FX markets' primary concern is with the future likely reaction of the monetary authorities, both in Germany or in the USA. The results for Germany are somewhat mixed, since they suggest that the exchange rate reacts to news on CPI and UNEM according to the Keynesian model, but the effects of other variables follow the 'reaction function' hypothesis. However, the quantitative effects of the latter variables dominate the effects of the former, which lead us to prefer the reaction function hypothesis as the main force driving the DEM/USD reaction to German macroeconomic news. The reaction of the DEM/USD exchange rate to US macroeconomic announcements is less ambiguous as all series have the sign predicted by the reaction function hypothesis, with the announcements with the largest and most significant impact in the USD being related to the real economy, in particular with payroll employment.

In both countries the implied reaction function has, however, some curious and interesting features. In Germany, for example, the Bundesbank has been usually described as basing its policy on monetary targets, whereas von Hagen (1995) and more recently Clarida and Gertler (1996) have recently argued that the Bundesbank seldom complies with its M3 targets, and actually reacts to divergences of inflation and output from their desired values, using a modified Taylor (1993) rule. Our results suggest that the FX market does not believe that the Bundesbank will only react to monetary shocks, but that it will also react to other macroeconomic variables. However, the market still sees the Bundesbank reacting primarily to monetary surprises. Does the former result mean that the market places more belief in the Bundesbank's rhetoric than is actually justified?

By contrast, in the US the FX market primarily reacts to unexpected shocks emanating from the real economy. How does this square with the greater weight which Central Banks, including the Fed, are supposedly now giving to the primacy of price stability as an objective? One, perhaps slightly cynical, answer is that the switch to awarding price stability much greater weight as an objective has been much more pronounced in Central Bank rhetoric than in their actions; there is an emerging academic literature, (Taylor 1993, Goodhart 1995, Almeida and Goodhart 1996,Muscatelli and Tirelli 1996), documenting how much continuity there has been in Central Bank actions in recent years, and<u>how little</u> these have altered in response to supposed regime changes, e.g. Independence, Inflation Targets, etc. A kindlier interpretation is that the FX market's stronger reaction to (US) data on real shocks (than on price shocks) is that real shocks provide a better forward guide to future inflationary pressures than do price shocks (which may be more backwards looking).[21]

If the main determinant of the foreign exchange market's response to news is their view of how the authorities will react to such news, as we suggest here, these such effects are likely to shift over time. Specifically, changes in the policy priorities of monetary authorities and the market's perceptions of those priorities will imply that the coefficients derived from our 'news' regressions will alter over time. The results from our structural stability regressions corroborate the above intuition. These results also suggest one reason why stable relationships between FX rates and economic 'news' have been hard to uncover. Moreover, as detailed earlier, most economic news items can be interpreted in different ways. A stronger

[21] One should also note that our sample period (1992-94) is mostly a period of low inflation and low growth in the USA. In such circumstances, primacy of price stability may be consistent with the Fed focusing on growth indicators: if inflation is thought to be under control, then the Fed will react mostly to the state of the real economy.

real economy can, under the Keynesian model, be regarded as *bad* news for the exchange rate, since imports and future inflation will rise, but *good* news if the authorities react by raising domestic interest rates. We find that the reaction function effect tends to dominate but this does not imply that all market participants favor a reaction function interpretation. If some follow a Keynesian model, this will also weaken the discernible impact of 'news' on exchange rates.

Although most of the macroeconomic announcements considered in this paper have a significant (short term) impact on the DEM/USD exchange rate, this impact might be seen as quantitatively small. For the series with the largest impact, the US payroll figures, the exchange rate change caused by the average announcement is 31 b.p., a mere 0.2% change, and the impact of the other announcements is even smaller. Apparently, the DEM/USD is driven more by US than German announcements, since the impact of the former is much larger, even taking the results of the weighted regressions for Germany (which reflect a bigger impact for the German announcements). For the series with significant coefficients, the average revisions after 15 minutes caused by the US announcements are between 10 and 17 b.p, whereas for the German announcements the average revisions are between 2 and 6 b.p. However, this difference could be caused by the different time pattern of response for the US and German announcements:[22] if instead of taking the 15 minute returns, one compares the periods with the maximum average revisions, then the impact for most of the German significant series is of similar magnitude (between 10 to 15 b.p.) as for the US series.

One of the major differences between US and German announcements of economic data is that the US data are announced at regular pre-arranged times, fixed to the minute, whereas German releases are unscheduled and irregular. Prearranged announcements are likely to encourage contingency planning beforehand, in terms of consultation with support staff, economists and technical analysts. In contrast, the variation of German announcement times will potentially discourage concentrated pre-planning of reactions. Hence it is plausible that there will be longer lags in the exchange rate assimilating German information, relative to that from the U.S.

Our results support this view. As shown in Figures 3.1 and 4.1, the maximum impact (as measured by the average scaled response across announcements) is reached after 15 minutes for the US announcements, but only after 3 hours for the German announcements. Note, however, that the evidence in Figures 3.2 and 4.2 suggests that the significance levels are maximum at the 15 minute period, for both the German and US announcements.[23] Hence, market reaction can be seen to be concentrated in a short post-announcement period for the U.S., with the response to German 'news' being far more protracted. Like the German data, the majority of public news, e.g. on political events, market developments, arrives at unexpected times. The timing differences we found between responses to the US and German announcements suggest that the response of exchange rates to these events is likely to be somewhat slower than earlier studies which concentrate on scheduled U.S. announcements have suggested, and hence there may be some profit opportunities available to those agents that are able to respond more quickly to such unpredictable events.

[22] As is described below, the maximum impact (measured by the size of the coefficient) of the German announcements is only reflected in the DEM/USD after 3 hours, whereas the maximum impact of the US announcements is felt after 15 minutes.

[23] This vindicates our use of the 15 minute return as the basis for our analysis.

The differences in the scheduling of the announcements is likely to be the reason for another divergence between the results for German and US announcements. Whereas for the US series there is no evidence of a 'news' effect before the announcement time, there is some evidence (although weak) of such effects for some of the German series. Note that for the US announcements we defined the announcement time to be the official pre-set release time, but for the German announcements the announcement time was defined as the time of the Reuters' reporting of the announcement. Some delay in the Reuters' reporting of some announcements might have caused the difference in results.

A priori, one might have thought that the data we examine incorporates a significant number of releases which are 'fundamental' to the DEM/USD. However, although there is a clear effect on very high frequency DEM/USD returns from most of our 'news' series, their influence on lower frequency returns is surprisingly weak. On average, U.S. 'news' is only significant for at most a couple of hours. German 'news' releases retain significance for a marginally longer period after which subsequent exchange rate fluctuations drown their effects. The sign tests performed indicate that, for both U.S. and German releases, the sign of the immediate response to news is correlated with the signs of longer horizon returns. However, although statistically significant, in purely numerical terms these results are not striking. Hence, our results suggest that, whilst announcements have a significant impact on short-run DEM/USD determination, they cannot be considered the key factor driving exchange rates.

Finally, in agreement with earlier research, our testing shows the FX market to be broadly efficient.[24] This result is in line with our expectations, since there are likely to be fewer sources of private information on the future course of an exchange rate than on the future value of an individual company's assets. Although there may still be some sources of private information in the forex market, e.g. the order book of a bank with a large position in the market is private knowledge to that bank's traders, (see, for example, Lyons 1995, Perraudin and Vitale 1996, and Payne 1996b), we would still expect the ratio of public to private information to be larger in the forex market than in most other markets.

[24] There is now, however, an intriguing academic literature which suggests that following some forms of technical trading rule can generate excess profits (see, for example, Brock, Lakonishok and LeBaron (1992).)

6. Conclusions and Proposals for Further Work

In this paper we have studied the impact of macroeconomic news on exchange rates, using high frequency data for the DEM/USD. As described in the previous section, the overall picture is one of a strong, visible, quick impact effect of macroeconomic 'news', with the exchange rate reflecting the anticipated policy reaction by the monetary authorities to the piece of news just released. However, this impact may be seen as quantitatively small, and the overall effect of the macroeconomic news on the lower frequency, cumulative build-up of exchange rate fluctuations decays quite rapidly towards insignificance.

Although the main features of the 'news' effects are common to German and US announcements, there are some peculiarities and interesting features in the former group. First, the 'news' from German announcements tend to be incorporated in the exchange rate more slowly than the 'news' emanating from the US, due to differences in the timing arrangements. Second, the impact on the exchange rate is, on average, quantitatively smaller for the German announcements. Finally, the effect of the German announcements depends on the proximity to the next Bundesbank council meeting: when the observations were weighted by this proximity, the impact of the variables seen to be entering the Bundesbank's reaction function (especially M3) was significantly increased.

We have argued above that the most sensible explanation of the set of coefficients showing the markets' response to unexpected news is that these are, primarily, driven by their interpretation of the monetary authorities' reactions. Those reactions, when triggered, affect short-term money market interest rates. Consequently the finding of a dominant response in a reaction function mode would seem to suggest that exchange rates would in turn predominantly respond to, unexpected, changes in such interest rates. This latter relationship has not yet been intensively studied using high-frequency data. It is to this that we shall turn in future research.

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Appendix 1
U.S. and German Macroeconomic Data

A1.1 U.S. Announcements

IDENTIFIER	ANNOUNCEMENT TYPE	REPORTED AS	TIME	WEEK	OBS.
U	Civilian Unemployment rate	m/m % change	8.30EST	1	36
PAY	Nonfarm Payrolls	thousands	8.30EST	1	36
TRADE	Merchandise Trade Deficit	$ billions	8.30EST	3	33
PPI	Producer Price Index	m/m % change	8.30EST	2	36
CPI	Consumer Price Index	m/m % change	8.30EST	2/3	36
RS	Advance Retail Sales	m/m % change	8.30EST	2	36
DG	Durable Goods Orders	m/m % change	8.30EST	4	36
CC	Consumer Confidence	level	10.00EST	4	36
LI	Index of Leading Indicators	m/m % change	8.30EST	1	35
NAPM	U.S. N.A.P.M. survey	% level	10.00EST	1	36
IP	Industrial Production	m/m % change	9.15EST	3	36
CU	Capacity Utilisation	%	9.15EST	3	36

NOTES:
- week refers to the usual trading week of each month within which the given announcement is usually released e.g. the PPI figures are generally published in the second trading week of the month;
- as the publication of the Mercantile Trade figure was discontinued in late 1994 there are only 33 data points for this announcement and within this 3 year span there are only 35 Leading Indicator announcements;

A1.2 German Announcements

IDENTIFIER	ANNOUNCEMENT TYPE	REPORTED AS	WEEK	OBS.
CPI	Consumer Prices, preliminary release	m/m % change	4	36
IPI	Industrial Production	m/m % change	1	35
M3	Money Stock M3, monthly average	% change from Q4 from previous year	4	33
ORDERS	Manufacturing Orders	m/m % change	2	35
PPI	Producer Prices	m/m % change	4	33
RETAIL	Retail Sales, volume	y/y % change	3	34
TRADE	Trade Balance	DEM billions		29
UNEM	Number of unemployed, s/a	m/m change, thousands	1	35
WPI	Wholesale Price index	m/m % change	3	35

NOTES:
- the data refer only to Western Germany (Federal Republic of Germany before the unification), except for M3 and TRADE which refer to unified Germany;
- the timing of the German announcements is not regular, but they usually occur between 7:00 and 13:00 GMT;
- in the absence of other sources of information, we take the time of the announcement to be the time of its report by Reuters' news service; since the majority of the market participants receive their information through Reuters' or similar news services, it is reasonable to assume that the time of the Reuters' report is the time the information reaches the market; this would not be true if the other news services reported the announcement before Reuters', but given the periodicity of our data (5 minutes) it is not likely that this is a serious problem;
- the regularity in the week of the month of the release is not precise; there is no regularity for the Trade Balance announcements, due to the fact that during our sample period the German Federal Statistics Office was implementing the transition from Western Germany to unified Germany data; until the end of 1992 the emphasis was on data for Western Germany only, although data for unified Germany was also published, but

with some delay; from January 1993, the emphasis shifted to unified Germany data, which was the first to be announced; this shift originated irregular data releases;

- we have a maximum of 36 observations, but the irregularity in the TRADE releases (there are only 35 TRADE releases in our data period) and some missing expectations data reduce the number of usable observations for most of the series;

Appendix 2
Testing the Rationality of Expectations

Testing is conducted in two phases. First, all series are examined for the presence of a unit root using the Augmented Dickey-Fuller methodology. If they appear to be covariance stationary then a simple regression of the time-series of announced figures on expected figures is run. Under the null of rationality of expectations the intercept in these regressions should be zero and the slope coefficient unity. If a unit root is found in the actuals and expectations then the cointegrating relationship is estimated via the Engle-Granger two-step procedure.[25] As above, the cointegrating vector on actuals and expectations should be (1,-1) with no constant present. To verify the existence of a cointegrating relationship the residuals from these regressions were checked for non-stationarity using the ADF test.

A2.1 Unit root tests

US announcements

Table A2.1
Unit Root Tests - US announcements

Series	Forecast		Diff. Forecast		Actual		Diff. Actual	
	DF	Lags	DF	Lags	DF	Lags	DF	Lags
Pay	-2.47	0	-6.13 *	1	-4.38 *	0	-6.94 *	3
U	0.84	0	-5.81 *	1	0.91	0	-8.19 *	0
Trade	0.43	12	-3.26 *	8	0.11	8	-6.44 *	1
PPI	-5.35 *	0	-	-	-4.64 *	0	-	-
CPI	-3.97 *	0	-	-	-7.28 *	0	-	-
RS	-3.95 *	2	-	-	-7.62 *	0	-	-
DG	-6.96 *	0	-	-	-10.4 *	0	-	-
CC	-0.67	0	-3.99 *	1	-0.86	0	-7.56 *	0
LI	-3.09 *	1	-	-	-5.41 *	0	-	-
NAPM	-2.49	2	-3.60 *	7	-1.94	2	-8.22 *	0
IP	-5.10 *	0	-	-	-4.74 *	0	-	-
CU	0.38	0	-5.97 *	1	0.36	0	-8.47 *	0

Notes: 'DF' is the value of the Dickey-Fuller statistic and 'Lags' is the number of lags used on the ADF test. The null hypothesis for the Dickey-Fuller test is the existence of a unit root in the series under examination. The critical value for the DF tests is -2.62 at 1%. Ä* indicates that the null can be rejected at 1%.

[25] The results from the two-step procedure were checked against those from the Engle-Yoo three-step procedure, demonstrating that the two-step estimators were sufficient.

Table A2.1 presents the results from ADF testing for the US announcements. The main conclusions from these tests are:

1. The PPI, CPI, RS, DG, LI and IP announcements and expectation series all appear to be covariance stationary; this is unsurprising as all are announced in terms of (percentage) changes of underlying series.
2. Unemployment, Payroll Employment, the Trade figures, the NAPM, Consumer Confidence and Capacity Utilisation all appear to have unit roots in both the actual and expected series; this motivates the estimation of cointegrating relationships in order to test the rationality of expectations.

German announcements

Table A2.2
ADF Tests - German announcements

Series	Forecast		Diff. Forecast		Actual		Diff. Actual	
	DF	Lags	DF	Lags	DF	Lags	DF	Lags
CPI	-4.95 *	0	-	-	-4.74 *	0	-	-
IPI	-4.07 *	0	-	-	-7.71 *	0	-	-
M3	-1.38	0	-3.60 *	0	-2.40	0	-5.95 *	0
ORDERS	-3.93 *	0	-	-	-6.73 *	0	-	-
PPI	-4.84 *	0	-	-	-4.40 *	0	-	-
RETAIL	-2.88	1	-4.23 *	3	-5.76 *	1	-	-
TRADE	-1.37	0	-4.30 *	0	-3.26 *	0	-	-
UNEM	-0.58	0	-3.81 *	1	-2.49	0	-6.71 *	1
WPI	-2.80	0	-6.71 *	0	-4.43 *	0	-	-

Notes: 'DF' is the value of the Dickey-Fuller statistic and 'Lags' is the number of lags used on the ADF test. The null hypothesis for the Dickey-Fuller test is the existence of a unit root in the series under examination. The critical value for the DF tests is -2.95 at 5%. Ä* indicates that the null can be rejected at 5%.

Table A2.2 displays the results of the unit root tests for the German announcements. The main features of Table A2.2 are:

1. The existence of a unit root, either on the actuals or the expectations, is rejected for the CPI, IPI, ORDERS and PPI series.
2. The M3 and UNEM series appear to have unit roots on both the actual and the expectations; for these series, the second stage consists of the estimation of cointegrating relationships.
3. For the RETAIL, TRADE and WPI series, the existence of a unit root is rejected for the actuals, but not for the expectations, at the 5% level (although it is rejected at the 10% level for RETAIL and WPI); if the actuals and expectations are integrated of different orders, expectations are not rational; however, the Dickey-Fuller methodology has been criticised for its lack of power, and thus it is possible that there is no unit root on the expectations of these series, even though we could not reject its existence; given that if the actuals and the expectations were integrated of different orders, the residuals of a regression of the actuals on the expectations would not be stationary, one can proceed assuming that both are stationary, regressing the actuals on the

expectations, and test the stationarity of the residuals of such a regression; stationarity of the residuals would ensure that both series are I(0).

A2.2 Unbiasedness regressions

US announcements

The second stage of the test of the rationality of expectations consists of regressing the actuals on the expectations. For the US announcements, the following results emerge from Table A2.3:

1. Most of the regression results support the hypothesis of rationally formed expectations; the series which fall into this category are Unemployment, Payroll, Trade, RS, CC, NAPM, IP and CU; for all the constant is insignificantly different from zero and the slope not different from unity.
2. The coefficients on PPI, LI and DG expectations are significantly greater than unity whilst the constants are significantly negative; this implies they tend to over predict the actual realisation.
3. The converse is true for the CPI expectations, with a slope coefficient much lower than unity and a positive intercept, implying under-prediction of the actual figures.
4. The DW statistics in all regressions indicate that residuals are serially uncorrelated, again as market efficiency would dictate.

Table A2.3
Unbiasedness Regressions - US announcements

Series	Constant		Expected		Residuals		R^2
	Coefficient	t: a=0	Coefficient	t: b=1	DW	DF test	
U	-0.54	-1.56	1.07	1.37	1.62	-5.15 *	0.93
Pay	-5.83	-0.16	1.03	0.14	2.46	-7.52 *	0.38
Trade	-1.03	-1.09	0.93	-0.60	2.18	-6.01 *	0.72
PPI	-0.19	-3.16 *	1.39	1.77	1.94	-	0.39
CPI	0.14	1.54	0.35	-2.03	2.57	-	0.03
RS	-0.02	-0.14	1.03	0.02	2.65	-	0.28
DG	-0.81	-1.85	1.84	2.47 *	2.65	-	0.40
CC	0.01	0.00	1.01	0.19	1.71	-5.02 *	0.88
LI	-0.02	-0.75	1.10	2.49 *	2.06	-	0.92
NAPM	6.09	1.19	0.88	1.33	2.23	-6.69 *	0.72
IP	0.01	0.12	1.13	1.12	1.69	-	0.81
CU	0.26	0.14	1.00	0.00	1.99	-5.80 *	0.98

Notes: The t-statistics for the constant terms are for the hypothesis that the intercept is zero, whilst those for the slope are relevant to the hypothesis that the slope is unity. The final three columns give theDurbin-Watson tests and Dickey-Fuller tests on residuals and the regression R^2. A * indicates that one can reject the null hypothesis at the 5% level.

German announcements

The results of the second stage for the German announcements, presented in Table A2.4, show that:

1. Most of the series satisfy the rational expectations hypothesis restrictions of a zero intercept and a unit slope coefficient.
2. The only evidence against rationality are the intercepts on the RETAIL and TRADE series; the negative and significant intercept on RETAIL show that the expectations tend to overestimate the actuals, while the opposite (underestimation of the actuals) occurs for TRADE.
3. the DW statistics and the DF tests indicate that the residuals are serially uncorrelated and stationary, as market efficiency would dictate.

Table A2.4
Unbiasedness Regressions - German announcements

Series	Constant		Expected		Residuals		R^2
	Coefficient	t: a=0	Coefficient	t: b=1	DW	DF test	
CPI	0.02	0.72	0.94	-0.68	1.91	-6.66 *	0.75
IPI	-0.15	0.29	0.45	-1.16	2.53	-7.58 *	0.03
M3	-0.38	1.20	1.11	0.82	1.64	-4.51 *	0.68
ORDERS	0.18	0.40	1.32	0.59	2.14	-6.42 *	0.15
PPI	-0.01	-0.31	0.65	-1.37	2.12	-6.41 *	0.17
RETAIL	-1.78	-2.19 *	0.49	-1.45	2.69	-8.75 *	0.06
TRADE	1.79	1.83 *	0.71	-1.36	1.99	-3.89 *	0.29
UNEM	1.32	0.24	0.92	-0.43	1.77	-4.92 *	0.44
WPI	-0.03	-0.53	0.96	-0.15	2.12	-6.14 *	0.27

Notes: See Table A2.3.

Figure 3.1

The persistence of the effect of U.S. 'News' on the DEM/USD

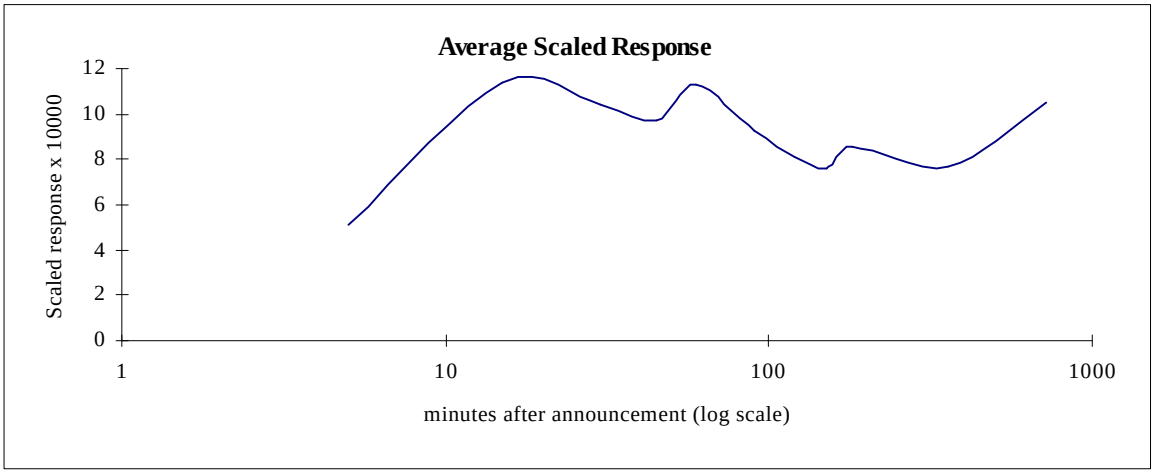

Figure 3.2

The persistence of the effect of U.S. 'News' on the DEM/USD

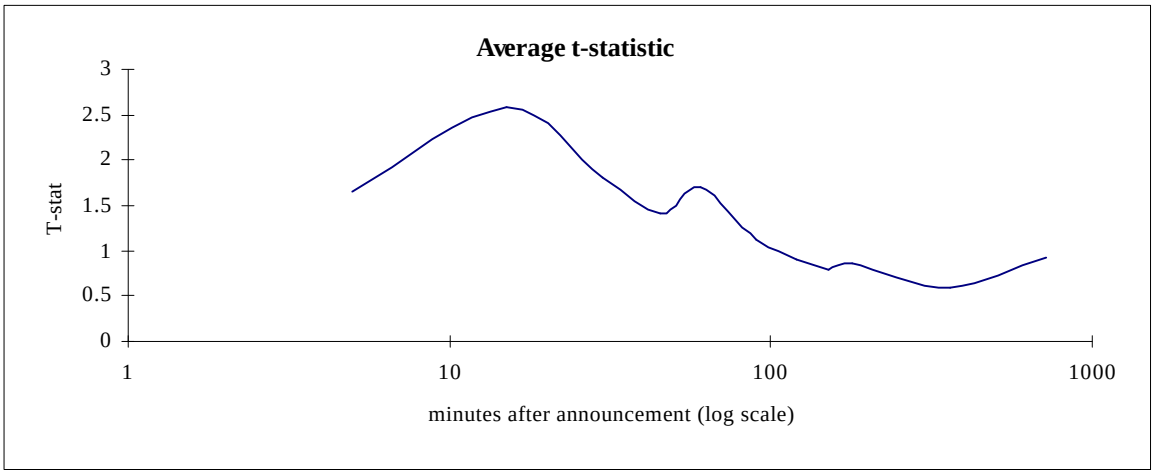

Figure 4.1

The persistence of the effect of German 'News' on the DEM/USD

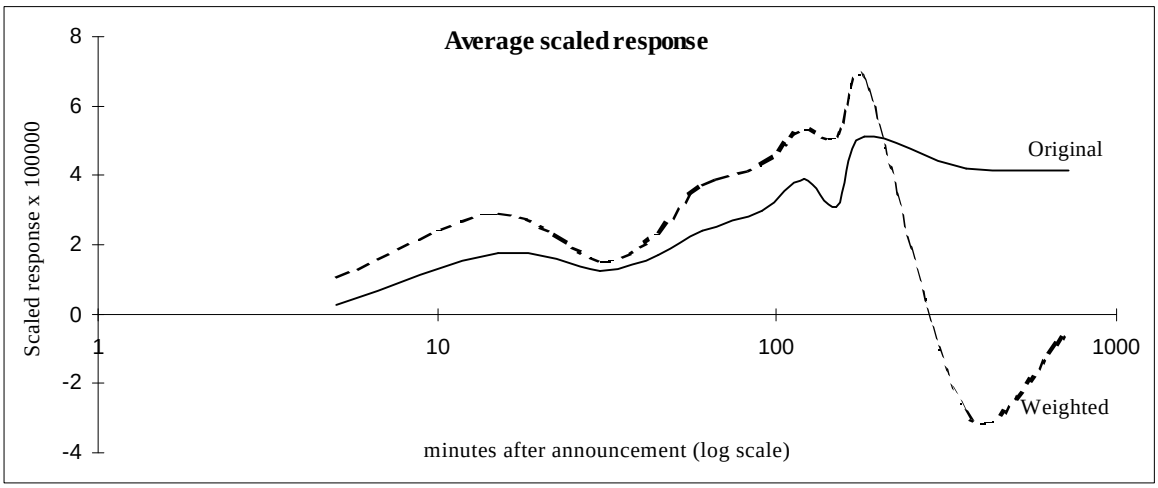

Figure 4.2

The persistence of the effect of German 'News' on the DEM/USD