The Euro-Dollar Exchange Rate: How Traders' Behaviour Has Been Affected by the 2007-2008 Financial Crisis.

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ABSTRACT

This paper investigates the dynamics of the Euro/US dollar exchange rate before, during and after the global financial crisis using intra-day data in a sample covering the period 2003-2011. The paper extends over the conventional empirical framework and specifies an EGARCH (3,1) model to account for heterogeneity in three temporal trading zones and for asymmetric volatility to news. The findings indicate the presence and evolution of differences in Euro/US exchange rate dynamics across American, European and Asian trading zones before and during the financial crisis. As a result of the crisis, traders in the three areas have modified their reactions to scheduled news, unscheduled surprises, and content of policies. Developing a better understanding of how traders' behaviour has adjusted since the onset of the crisis is an important issue given the global significance of this exchange rate and the considerable volatility experienced over the sample period.

Keywords: exchange rate, macroeconomic announcements, unscheduled news, market reaction, behavioural finance.

JEL Classification codes : E44, F31, G14

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1. Introduction

This study investigates the dynamics of the intra-daily fluctuations of the Euro/US Dollar exchange rate before and after the global financial crisis during the 2003-2011 period by adopting an EGARCH-type methodology and an intra-day news model.[1] These kinds of methodology and of theoretical framework have both been implemented popularly within the literature to study the fluctuation of the Euro-Dollar over periods of relative calmness.[2] However, the financial crisis of the 2007-2008, has affected the volatility of the Euro-Dollar and changed traders' perceptions and trading behaviours, making it important to assess the extent of these changes.

One of the novelties of our approach is that we use a unique intra-day data frequency stemming from partitioning the global trading day into three geographical and temporal trading areas. This approach enables us to match more accurately news' releases and trading zones and to identify some interesting differing styles of trading behaviour across geographical trading zones, and over the pre-and-post periods of the financial crisis. These differences in trading styles could help to understand the over and under reaction of the Euro-Dollar to shocks and events originated in different trading areas.

[1] The news approach was pioneered by Edwards (1982,1983) and Hoffman and Schlagenhauf (1985). The central tenet is that the exchange rate is moved more by the *surprise* than by the *point value* of macroeconomic indicators referred to as fundamentals.

[2] We refer the interested reader to Neely and Dey (2010) who provide an excellent review of all contributions in this field.

Our results are robust in as much as they confirm some general well-established effects discussed in previous studies, such as the dominance of "real economy" news over interest and inflation surprises (Hayo and Neuenkirch, 2012), and of American announcements over European news (Ehrman and Fratzscher, 2005) [3], as well as the presence of asymmetric reactions to good and bad news. However, our results are innovative and provide original contributions in revealing how and to what extent the financial crisis has affected the attitudes of traders operating in different trading zones when reacting to announcements and events originated in various trading zones and times[4]. Thus, we find that both the conditional mean and the conditional volatility of the Euro-Dollar display asymmetric reactions to bad and good news[5] and that the financial crisis influenced these asymmetries, by making traders more reactive to those events weakening the Dollar than to those shocks strengthening it, and more sensitive to the order of magnitude of these shocks. In addition to these findings, our results suggest that after 2008, some types of fundamentals and news become irrelevant while others gain a significant role. This is particularly true for the German interest rate, which gains a pivotal role after the crisis. Lastly we find evidence of over-reaction or under-reaction to *some* news, meaning these news can affect traders beyond the time of their announcements, and that the patterns of these delayed responses[6] have been affected by the crisis. We argue

[3] Ehrman and Fratzcher (2005) claim that the dominance of US macroeconomics news over the European news can be attributed to the earlier release time of the US news relative to the corresponding German and Euro-area news. However, thanks to our partition of the trading day, we found that although many Euro-area news are actually released *before* American news, still American news (scheduled and unscheduled) play the major role.

[4] Also Guiso et al. (2013) and Hoffmann et al. (2013) found that the financial crisis affected risk perception and risk taking of traders in financial markets.

[5] Similarly to Ehrmann and Fratzscher (2005) we find that the exchange rate responds in mean more strongly to news in periods of increased market uncertainty and that this reaction depends on the state of the business cycle, on the type of news and on their content of good versus bad news (Fatum et al., 2012). However differently from the past studies, we are able to extend these results to the exchange rate volatility.

[6] These results differ markedly from Ederington and Lee (1993, 1995) and Andersen *et al*. (2003) who contend that the response of exchange rates to news is a very short-term phenomenon.

that the presence of cases of over- or under-reaction, does not necessarily imply a failure of the Market Efficiency Hypothesis and the presence of behavioural biases[7]. This is because, most likely these over and under-reactions do not come from the *same* traders, but from *different* traders operating in different geographical and temporal trading zones, who, based on their own perceptions and interpretation of news and on their different trading style, react when the opportunity (and time) of acting comes. Indeed most of the over- or under- reactions come from Asian trading time zone traders who correct or confirm responses of previous traders when the Asian market opens.

The rest of the paper is organized as follows: in Section 2 the econometric methodology is introduced and explained, then in Section 3 the data are presented, while in Section 4 the specification and estimations issues are discussed. In Section 5 the results and limitations are presented and commented. Finally Section 6 concludes and indicates directions for further research.

2. Methodology and Econometric Model

In our analysis we estimate a news equation of the Euro-Dollar exchange rate to assess the market reaction of investors following the release of different typologies of news (scheduled and unscheduled) at different times of the global trading day (GTD)[8]. Our

[7] Research in behavioural finance explains the presence of anomalies and price patterns that contrast with the standard EMH by investigating the relevance and the effects of investors' psychology on asset pricing. The field of behavioural finance thus combines methods originated in psychology with the more traditional finance research methods. In doing so, it offers an alternative theoretical approach to the study of financial markets, taking impetus from the prospect theory (Kahneman and Tversky, 1979). For an overall overview in the stock markets see, for example, Barberis and Thaler (2003) and Shiller (2005). In the foreign exchange markets, among others, Oberlechner and Hocking (2004), De Grauwe and Grimaldi, (2006) and Oberlechner and Osler (2012).

[8] Table A.1 in Appendix (Supplementary Data) reports the main features of the global foreign exchange market turnover from 2001 to 2013 using data from various editions of the Bank of International Settlements Triennial Bank Survey of Foreign Exchange and Derivatives Market Activity. According to the BIS's evidence at the end of 2013 (2010) the Euro-US Dollar exchange rate accounts for 24% (28%) of the global foreign exchange market turnover. In the Appendix (Supplementary Data) we also show the geographical distribution of the global FX turnover and the contribution of different market participant categories to the global FX trading activity.

econometric model captures the feature that the global trading day never stops and it runs through three main intervals or eight-hour time zones: Asian Time Zone (ASTZ), European Time Zone (ETZ), and an American Time Zone, (ATZ).

The eight-hour time series have been built in the following order: the trading day starts in Asia (ASTZ), to continue in Europe (ETZ), and then in America (ATZ). ASTZ goes from the closing of Wall Street at 4PM EST in the previous day (10PM in Central European Time, CET) to 6AM, CET. ETZ goes from 6AM to 2PM, CET, before the ECB Euro "fixing" and the publication of important macro news in the US (8:30AM EST, corresponding to 2:30PM, CET). The ATZ goes from 2PM, CET, to 10PM CET (4PM EST) of the current day. We thus see that our GTD does not correspond to the astronomical 24-hour day as it begins two hours before midnight CET, on the previous day, and ends two hours before midnight CET, on the current day. The three values of the exchange rates are then placed at 6AM, 2PM and 10PM, CET.

All the explanatory variables in our empirical relationships are recorded and coded according to a thrice-daily frequency and are placed within the three time zones. Therefore they can explain the Euro-Dollar returns at the corresponding three hours defined above. The thrice-daily choice allows a finer attribution of policy events and news to a more homogeneous set of market participants (belonging to the same trading zones) and to differentiate across heterogeneous traders (belonging to different trading areas), without being disturbed by noisy data (in the ultra-high frequency).

[PLEASE INSERT FIGURE 1 HERE]

In order to shed some extra light on how news, expectations and market sentiment determines the wild swings of Euro-Dollar, this study uses – together with the traditional

scheduled macro news - a relatively novel kind of news variables, called unscheduled news[9], consisting of political news, policy statements, market news, interventions by Central Banks, unexpected monetary policy decisions and other events, all occurring somewhat randomly overtime or, even though expected to occur at a known time, having an unknown content or an ex-ante unpredictable impact on exchange rates, because of time-inconsistent decoding by heterogeneous traders.[10]

The general specification of our model is as follows:

$$\begin{aligned}\Delta S_t \;&= \alpha + (\mu_1 L^1 + \mu_2 L^2 + \mu_3 L^3)\Delta S_t + (\boldsymbol{\vartheta}_0' L^0 + \boldsymbol{\vartheta}_1' L^1 + \boldsymbol{\vartheta}_2' L^2 + \boldsymbol{\vartheta}_3' L^3)\boldsymbol{Y_t} \\ &+ (\boldsymbol{\beta}_0' L^0 + \boldsymbol{\beta}_1' L^1 + \boldsymbol{\beta}_2' L^2 + \boldsymbol{\beta}_3' L^3)[\boldsymbol{Z_t} - \boldsymbol{E}(\boldsymbol{Z})_t] \\ &+ (\boldsymbol{\gamma}_0' L^0 + \boldsymbol{\gamma}_1' L^1 + \boldsymbol{\gamma}_2' L^2 + \boldsymbol{\gamma}_3' L^3)\boldsymbol{U_t} + \epsilon_t \qquad (1)\end{aligned}$$

Where $\Delta S_t = \log(S_t / S_{t-1})$ is the thrice-daily return between two consecutive time zone (t and *t-1)* sampled at the end of each relevant time zone. The symbols μ, $\boldsymbol{\vartheta}'$, $\boldsymbol{\beta}'$, and $\boldsymbol{\gamma}'$ are parameters or vectors of parameters to be estimated and ϵ_t is a stochastic error expected to be normally distributed with zero mean and constant unconditional variance.

The letter L is the lag operator, and its exponential index indicates the number of times that the associated variable has been lagged. A three lags structure would cover the length of one global trading day.[11] Lagged values of fundamentals and news variables should capture the reactions of traders operating in a specific trading area to past events and news originated in preceding trading areas meaning that an event can still exert some effect in a time zone different from the one when it occurred.

The letter **Y** indicates a vector of fundamentals, the letter **Z** is used to indicate the vector of macroeconomic indicators and **E(Z)** is the vector of their respective expected values,

[9] This definition is proposed by Ederington and Lee (1996), Fornari and Mele (2001) and Tivegna and Chiofi (2004).

[10] The same line of analysis is used by Fair (2002, 2003), Fatum and Hutchinson (2002), whose approach is probably the closest to the one in this paper. The most recent papers in this approach are by Fratzscher (2008a, b).

[11] On estimation we also tried a fourth lag which represents the same time zone one day earlier. Lags longer than 3 periods were never statistically significant.

so that their difference, in brackets, is the news or surprise that would move the exchange rate. The letter **U** is used to indicate the unscheduled news, mentioned earlier on and explained more in detail in the next session of the paper.

We also consider asymmetries[12] in the Euro/Dollar exchange rate volatility produced by large swings of Euro-Dollar and unaccounted for in the mean part of the model using an exponential GARCH (EGARCH) specification (Nelson,1991). The conditional variance of error terms assuming a Gaussian distribution for the innovation (Hamilton, 1994) is modeled as:

$$\log(h_t) = \omega + \sum_{j=1}^{m} \theta_j \left[|z_{t-j}| - \sqrt{\frac{2}{\pi}} \right] + \sum_{j=1}^{m} \varphi_j z_{t-j} + \sum_{l=1}^{k} \delta_l \log(h_{t-l}) \qquad (2)$$

Where: $z_t = \epsilon_t / \sqrt{h_t} \sim N(0,1)$

The parameter φ is the asymmetry parameter. When φ_j =0, then a positive unaccounted surprise has the same effect on volatility as a negative surprise of the same magnitude; if $-1 < \varphi_j < 0$ a positive unaccounted surprise increases volatility less than an negative surprise (negative leverage). The parameter θ indicates the sensitivity of volatility to large unaccounted news. A positive value implies that the large surprises of both sign will increase the volatility.

3. Data

The construction of thrice-daily time series of exchange rates and of other fundamental financial variables (stock indexes and interest rates) was carried out paying attention to the alignment and correct attribution of each observation to its correct time zones[13],

[12] Andersen et al. (2003) show evidence of asymmetries in the UDS foreign exchange market returns versus Euro, DM, UKP and JPY while Fatum et al. (2012) document asymmetric (different) market reactions on the JPY/USD exchange rate for negative and positive surprise.

[13] Scheduled news fell very well in our time zones and great care was employed to do the same for

keeping also track of changes in Daylight-saving time between the ETZ and the ATZ. The same was true for the rest of the scheduled news and unscheduled news, attributing the news to the time zone interval (ASTZ, ETZ, ATZ) during which the news was released.

3.1 Dependent Variable and Fundamentals

Thrice-daily data on exchange rates, for the set-up shown in Fig. 1, were extracted from an hourly time series of Euro/US Dollar obtained from CQG Data and maintained with data controls overtime. The S_t time series begins in ASTZ on January 1, 2003 and ends in ATZ, 6849 8-hour periods later, on August 31, 2011.

Traditional exchange rates empirics take into consideration also interest rates differentials and stock indexes. The same was done for the high frequency employed in this paper. Relevant data for Dow Jones, DAX, Nikkei 225, FTSE All Shares, 10-Year Government bond yield for US, UK, Germany and Japan, were obtained from Thomson Reuters Datastream.

Daily returns for stock market indexes assuming reinvestment of dividends are computed as 24 hours (logarithmic) change of the *cum*-dividends values of the indices for national stock market.

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unscheduled news, as mentioned in the previous paragraph. Daylight-saving time (DST) differences on the two sides of the Atlantic required some attention. Corrections were needed when the time difference between the countries in the Eurozone plus UK and the United States (East Coast) moved away from the normal 6 span, going to 7 or 5 hours, according to permanence in DST in one geographical block but not in the other and *vice-versa*. That was all the most important because a large bunch of US scheduled news, those released at 2:30PM (CET, in regular times), move from ATZ to ETZ, when the US is in DST but Europe is not. Other scheduled news were also affected. From 2003 to 2006, the problem had limited dimensions (but corrections had to be made, anyway), from 2007 it was absolutely necessary to cope with this issue. In fact, between 2003 and 2006 Europe moved into DST in the last weekend of March and USA used to follow suit one week later in April. Between the same years above, Europe and USA used to go back in October to solar time on the same day (last Sunday of October). Starting from 2007, however, the US started moving into DST three weeks earlier, in March, and hence before the European change into DST, occurring during the last week of March. Changes occurred also in October, when the US goes back into solar time a week later than Europe.

3.2 Scheduled news

The next set of explanatory variables in equation (1), is about scheduled news. These variables are "unexpected" values of main macroeconomic announcements made by Government statistical Agencies and Departments, Central Banks, Institutes or Centers of Economic Research, National or Supranational Institutions. Amongst the global area of the Euro-Dollar exchange rate, during our sample period, 2003–2011, United States, Euro-Area as a whole, Germany and United Kingdom have had a calendar of statistical releases of economic indicators made known well ahead (in fact at scheduled times), typically in the early hours of their respective trading zones, with a few exceptions, though.

The scheduled macroeconomic "surprises" are computed by taking the difference between the actual value of the macroeconomic release, announced by the statistical authorities, and its expected value, collected by specialized organizations. The set of macroeconomic announcements and market consensus we used is from Bloomberg News Service.[14] Because these surprises have different units of account, we followed the convention to standardize them, as well as the dependent variable, using the standard deviations of the entire sample period according to the Balduzzi et al.'s (2001) procedure[15]. For each scheduled and unscheduled news we identified and separated the

[14] Bloomberg provides results of a market survey conducted usually 48-72 hours prior to the release of important economic indicators. The survey polls economists across the industry for their estimate of a particular statistic. These estimates are then averaged to provide the Bloomberg Survey mean and median estimates.

[15] Standardized variables did not have their mean removed, which explains the presence of the constant terms in our regressions. The use of the entire period standard deviation is justified by the fact that while we test whether the crisis has changed the conditional volatility of the exchange rate, we retain the underlying assumption of EGARCH model that the unconditional variance is constant along time.

positive surprises and used them as auxiliary interaction term to test for the presence of asymmetric reactions.

Table 1 summarizes the main characteristics of the scheduled announcements we considered for our study. The total number of macroeconomic indicators is 68 (25 for the United States, 17 for the Euro-Area, 14 for the United Kingdom[16] and 12 for Germany). For each country or area we first classify the announcements according to frequency of release (monthly, quarterly or weekly) and provide the unit of measure of the indicator. Echoing Andersen et al. (2003) and Ehrmann and Fratzscher (2005) each announcement is then ordered within its frequency group according to its temporal sequence in the calendar month of release.[17]

[PLEASE INSERT TABLE 1 HERE]

3.3 Unscheduled news

The unscheduled news typology is less frequently used in the econometric estimation of exchange rates empirical models.[18] This is due to their nature: interpretation is necessary as their definition and perception by traders is quite idiosyncratic and time-varying. The decoding process by traders goes through non-homogeneous economic, financial, and policy evaluation models, including the way policy decisions are taken and implemented.

[16] We included several UK scheduled news to acknowledge the role of the UK as the European dominant trading and financial centre and to recognize that some UK scheduled news have a large impact on the value of the UK Pound with occasional spill-over effects on the Euro-Dollar rate. The only relevant UK scheduled type of news, with overtime-consistency, are the Bank of England's "surprises".

[17] For most US indicators data are generally released in the subsequent month. Forward-looking indicators (Consumer Confidence Index, Philadelphia Manufacturing Index) refer to the same month of release. US GDP data deserve special attention as there are three monthly readings of GDP releases: Advance (about 30 days after the previous quarter ends), Preliminary (about 60 days after the previous quarter ends) and Final (about 90 days after the previous quarter ends). Since the Advance version is the earliest release of GDP one would expect, *a priori*, that the advanced data surprise should have the major impact in term of market reaction. The same temporal pattern is usually followed by the macro announcements for United Kingdom, Germany and the Euro-Area (more casually for these latter two entities).

[18] For recent studies that used macroeconomic surprises and unscheduled news in stock and interest rates markets see, for example, Birz and Lott.(2011), Rosa (2011), Jiang et al. (2012) and Beetsma et al. (2013). For an earlier attempt on the forex market see Tivegna (2002).

That makes quite hard to propose an unambiguous taxonomy of unscheduled news. In principle, unscheduled news consists of an economic, an institutional or a policy event, a declaration or a disclosure, which can be either totally unexpected or - even though expected to occur - has an unknown timing, or an unknown content or both and frequently producing weird and ex-ante unpredictable reactions from financial markets. This news typology, therefore, implies a process of expectation formation very different from that of scheduled news and most likely to be variable overtime. A synthetic taxonomy of these events could be the following:

A) Scheduled policy statements, like the press conferences of ECB Governors or the Humphrey-Hawkins testimonies by US Fed Chiefs. These statements have generally an uncertain content on internationally sensitive arguments, frequently different from market expectations. In most recent times, the reactions to these generally unequivocal messages have become excessive, abnormal and highly volatile.

B) Unscheduled policy statements or simple opinions in interviews or in question and answer sessions at the end of formal press conferences (examples: the ECB and, in recent times, the Fed ones). Exchange rates response to these events suffers from the same problems as A above.

C) Terrorist events deemed to be influential on policy decisions, on commodity price developments (especially oil) or on international mobility of factors of production[19].

D) Institutional or personality events (Government or Parliamentarian) involving leading policy makers, potentially able to cause policy changes.

E) Public interventions by Central Banks in the foreign exchange market or statements announcing or threatening them (Japanese Authorities is a good example).

[19] Old terrorism news were totally unexpected and it was not clear what their long-term impact would be. On the other hand, political news –in general, not monetary policy news- are not totally unexpected and operators have some ideas about their impact on the economy. So we decided not to include them.

F) Low-ranking policy makers' comments to unexpected – or moderately so – monetary policy decisions and other authoritative comments on economic indicators in relation to macroeconomic or market trends;

G) Unexpected – or moderately so - upgrading or downgrading of creditworthiness (of entire countries, or of important financial Institutions, or of various asset typologies) or changes of previous forecasts by Rating Agencies or by domestic or international policy Institutions. Examples of some unscheduled news are reported in Table 2 and a more exhaustive description of unscheduled news is in Cagliesi et al., (2014).[20] After the *ex-ante* selection of typology of unscheduled, news were collected and coded as qualitative variables attributing them the value of (+1) or (-1) according to the following convention: unscheduled news were given a value of (+1) if their *a priori* effect was likely to strengthen the Euro-Dollar exchange rate -either because they had a content directly favourable to the Euro or because they had a content directly unfavourable to the Dollar. Alternatively, the surprises were coded with a value of (-1) if it was more likely that they would produce a weakening of the Euro-Dollar rate. This coding convention allowed us to test for asymmetric effects by separating the unscheduled news according to their sign and using an interaction term for the strengthening news.

For each time zone ASTZ, ETZ, ATZ, the A-G categories of unscheduled news have been aggregated into a single vector. This decision of aggregating different typologies was taken for two reasons: to reduce the number of explanatory variables and because some unscheduled news categories have somehow evolved[21]. Given their qualitative nature and

[20] Table 2 contains for each unscheduled news the date and the weekday of release, the text of the event, the time-zone of reference, the expected sign on the Euro-Dollar rate, the news typology, referred to the A-G itemization above and the source of the news

[21] Aggregating all news into a single vector destroys some information. Public intervention by ECB in the forex market occurred only twice in the initial period, which is outside our sample. Statements by policy makers have become fewer over the years and much less lambasting than in the early years. This lack of

trinary/binary representation, unscheduled surprises have not been standardized. We stress again that every single unscheduled news was attributed to its own time zone[22], often using Bloomberg time stamps, and that, to avoid "double counting" effects and correlation issues between scheduled and unscheduled news, a consistent criterion of "non-overlapping" recording was used. According to this criterion – violated only in exceptional circumstances[23]- whenever a scheduled news was released in a specific time zone, any related or unrelated unscheduled news falling in the same time interval would not be recorded. Moreover, whenever several unscheduled news had occurred within the same time zone interval, only one would be recorded. [24]

[PLEASE INSERT TABLE 2 HERE]

4. Estimates

Before estimating our model we tested all news for normality and white noise[25] and for

homogeneity amongst the unscheduled news and the risk to obtain biased and unstable coefficients due to paucity of observations of specific unscheduled news has suggested to aggregate everything.

[22] The assignment of this single aggregate unscheduled news group to the three time and trading zones (e.g ASTZ, ETZ, ATZ) was carried out not on a nationality or area-pertinence basis but by the timing of the news.

[23] When, for instance, an unscheduled surprise had an opposite a priory sign effect of a scheduled surprise released in the same time zone interval.

[24] Those unscheduled news that conformed to the A-G typology and to the above recording criteria were extracted from a large archive of daily events dating from 1998 (and before, see Tivegna and Chiofi, 2004) until today. This unique hand-collected archive of news – called informally *Newsmetrics* – contains, each day, on average between ten and fifteen daily articles and extended newsflashes from the Financial Times, the Wall Street Journal, Bloomberg News, Reuters and Dow Jones Newswires. Within this group, there have always been the daily articles on the foreign exchange market and on the US stock market. So, for instance, in recent times, the communication of ECB council decisions on interest rates to financial markets (at or a little before 1PM, CET, well within ETZ) does not move Euro-Dollar that much. The ECB press conference, generally at 2:30PM CET, is in ATZ and assigned to this area, even though it is the most European event for financial markets, after the beginning of the Euro era in 1999. And the real reaction occurs there. The reliance mostly on newspaper articles deserves some extra speculation. In fact, the same idea of a tri-partition of the GTD is to a large extent due to the news search process employed in this and previous studies, Fornari et al. (2002), Tivegna and Chiofi (2004) and Cagliesi and Tivegna (2006).

[25] We tested for white noise so to avoid to attribute the presence of delayed reaction to news to a possible autoregressive structure of their statistical process. To be a surprise, a news ought to be not predictable-hence a white noise. Table A.2 in Appendix (Supplementary Data) reports the main statistical features of the entire sample of news and the results of Jarque-Bera and Ljung-Box tests. In tables A.3 to A.10 of the Appendix (Supplementary Data) we show the results of the analyses for correlation between news and cross-correlation with lagged news.

current and cross-correlations, so to avoid - as much as possible – issues of collinearity and distortions. After this first statistical screening process, the initial phase of econometric procedure was carried out using a standard OLS estimates for the entire sample period -running from January 1th, 2003 and August 31st, 2011 - as a first exploration of the general specification of the news model and of the stability of coefficients. OLS estimates indicates that the relevant scheduled news were only a small subset of the originals ones (68) while all unscheduled were highly statistically relevant. We used the OLS specification reported in Table 3 to investigate the presence of a structural break around the financial crisis period. The table reports the value of the Hansen test and of the Chow test, while Figure 2 shows the analysis of recursive residuals. The Hansen test is a test for general parameter stability based on the behaviours of the partial sums of the regression's normal equations for the parameters and for the variance. We produce statistics and approximate *p*-values for the overall regression (coefficients and variance) as well as for each coefficient and for the variance individually. The Hansen test indicated the presence of a structural break in the parameter and in the variance. The Chow test, and historical hindsight, helped to position the structural break at the end of February 2008. Although the collapse of Lehman Brother on September 15, 2008 might have appeared to be a natural choice, the subprime crisis in the US had been mounting up from early 2007, with the accelerated deflation of house prices and the market started showing level of anxieties already at the beginning for 2008, as showed by the graphs of the recursive residuals.

[PLEASE INSERT TABLE 3, FIGURE 2 and FIGURE 3 HERE]

The indication in the Hansen test and the use of financial time series sampled in high frequency prompted us to take into account the possible issue of heteroschedasticity and to consider an ARCH-type of models. Given our research interests, we chose the exponential GARCH (EGARCH) models which enable to test for asymmetric response of the conditional volatility of the exchange rate to positive and negative values of the innovation term ϵ_t of the exchange rate equation, and to the order of magnitude of the innovation term itself. We quantify these effects in the analysis of the volatility curve which is presented in the final part of section 5. In addition to asymmetric reactions in volatility we also test, with the help of auxiliary variables, the presence of asymmetric reactions of the exchange rate to positive and negative scheduled and unscheduled news included in the linear part of the EGARCH. To distinguish between the "accounted for" news (schedules and unscheduled news) included in the conditional mean equation of the exchange rate and the "unaccounted for" news (innovation term) included in the conditional volatility equation, we shall refer to the latter ones as to "unaccounted surprises".

EGARCH estimations are carried out in using the Broyden–Fletcher–Goldfarb–Shanno (BFGS) optimization method. Many empirical studies use basic GARCH(1,1) to model daily conditional volatility.[26] Based on this practice, and because our daily volatility is composed by three time intervals, we propose to use EGARCH with up to 3 lags.[27] In discussing our results in the coming section we will generally make reference to the

[26] See for example Andersen et al. (2000) who point out the use of daily GARCH (1,1) as benchmark model in exchange rates volatility determination.

[27] For both sub-periods –prior and post financial crisis- we also tried lower order EGARCH but they did either not converge (EGARCH 1,1) or converge too soon (iterations number lower than number of estimated parameters indicates inaccurate values of estimates) so we accepted our initial choice of an EGARCH (3,1) structure.

EGARCH(3,1) sub-period1 and sub-period2 to indicate the models we estimated prior and after the financial crisis.

5. Estimations Results

The econometric results of EGARCH equations are reported in Table 4.[28] In what follows, we will discuss the impact of the financial crisis on the Euro-Dollar rate through the channels of fundamentals, unscheduled and scheduled news and through the volatility curve.

[PLEASE INSERT TABLE 4 HERE]

5.1 Results: Lagged exchange rate and fundamentals

The three main findings identified are the quicker "mean reversion process", the changed importance of long-term interest rates and the peculiar role of the Dow Jones. We start with the first result. Our estimates in Table 4 show that the Euro-Dollar rate exhibits a mean reverting behaviour. If we sum the values of these three lagged coefficients of the Euro-Dollar, we could conclude that the overall daily adjustment of the rate does not seem to have been affected by the crisis, meaning that over a period of one day the exchange rate was still expected to revert back by about a fifth of its percentage change. However, the comparison of individual lags shows that actually the crisis has produced some effects because, the adjustment of the rate, as shown in Table 4, becomes much quicker after the crisis, taking place almost entirely within the first temporal lag, that is, within the first

[28] Table A.10 in the Appendix (Supplementary Data) reports the results of the OLS regressions for the two sub-periods.

following 8 hours of trading instead of within two lags, as if the crisis, had induced day-traders to close their long positions quicker. [29]

The other interesting finding is the changed role of long-term interest rates. The estimated coefficients show that ten-year interest rates have the expected signs and expected ranking in both sub-periods: an increase in the long-term German rate (the main Eurozone financial market) strengthens the Euro whereas an increase in long-term US rates produces the opposite effects.[30] The effect of the crisis on the role of these variables would manifest mainly via the increased importance of the German rate, whose overall coefficient almost doubled in magnitude (from 0.16 to 0.33) and via the decreased impact effect of the US rate (from -0.31 to -0.19) even if its daily overall effect remained the same. In other words, the crisis has reduced the impact effect of the US rate while it has increased the overall effect of the German rate.

Another interesting result of Table 4 is the dramatic change in the post crisis period of the relation between the Dow Jones (DJ)[31] and the Euro-Dollar rate, which is something in line with what traders around the world have come to realize. Our estimates indicate that prior to the financial crisis an increase in the DJ would mildly strengthen the Dollar (-0.05) by attracting financial flows into the US, the leading stock market in the world. However, in the second sub-period the effect of the DJ is much stronger and, most importantly, it is reverted in sign (0.30). This striking change in the DJ and the Dollar

[29] Table A.1 (Part C and Part D) in the Appendix highlights that, after 2007, the "Other financial institutions" category becomes the main driver of the global foreign exchange market turnover. It is quite possible that market partecipants belonging to this category (smaller banks becoming clients of the main dealers, institutional investors, hedge funds, high-frequency traders, retail investors) generated the quicker reaction to the exchange rate.We thank an anonymous referee for this point.

[30] The Japanese interest rates do not belong directly to movements of our currency pair. They enter mostly with a negative sign in sympathy – and because of the much wider business – with the US rates. The effect of Japanese interest rates on the Dollar-yen exchange rate is probably much bigger than that on the Euro-Dollar rate. That is consistent with our results.

[31] The European indexes such as the German DAX and British FTSE do not appear here because they turned out to be non-statistically significant or because of their high correlation with the DJ.

relation seems to suggest that, at times of unprecedented low US yields and high uncertainty, hedged trading in the stock market and currency market might have been seen as a good opportunity.

5.2 Results: Unscheduled news

To facilitate the reading of the results reported in Table 4, we created Table 5 to compare more clearly the pre and post-crisis types of reactions to unscheduled news.

According to our estimates the crisis has not affected traders' "time-zone/home bias", and in both sub period they show higher sensitivity to their own news (news released in their own trading zone) than to news released in other time zones. Similarly, the crisis does not seem to have affected the ranking of unscheduled news, and the dominant role of news released during the American time zone (ATZ) period, which, presumably, are mainly Dollar-related.

However, the crisis has affected traders' behaviour in two ways: it has removed traders' under-reaction[32] and it has made traders become more sensitive to unscheduled news that weakened the dollar (e.g., to bad news for the dollar) than to unscheduled news that strengthened it[33]. The over/under reaction is a delayed reaction to a surprise and hence, it is tested by using lagged news (be them unscheduled or scheduled news). The delayed reaction could either confirm or counteract the original reaction, causing the exchange

[32] An over-reaction (under-reaction) occurs when traders operating later during the day counteract (reinforce) the original reactions of previous traders (e.g., traders who had operated in a different time zone), inducing a reverting (drifting) behaviour of the exchange rate.

[33] As explained earlier in the text, the presence of asymmetric reactions to good and bad unscheduled news is tested by adding to the overall vector of the positive and negative news, another vector (interaction term) that contains only Euro-positive news. An asymmetric reaction is at work whenever the coefficient of the interaction term is statistically significant. The estimated coefficient of the overall vector of the unscheduled news, which includes both positive as well as negative news, gives directly the effect of negative unscheduled news (negative for the Euro). To find the effect of positive news, one ought to sum the coefficient of the interaction term (positive news) to the coefficient of the overall vector of unscheduled news (positive and negative). Asymmetric effects can also be computed for delayed reactions whenever the lag of the interaction term occurs to be statistically significant.

rate either to trend (under-reaction case) or to revert back (over-reaction case). Our results show that the under-reaction to ATZ unscheduled news that occurred before the crisis disappears in the post-crisis period, meaning that ATZ zone's traders have reacted more fully and decisively to the ATZ news especially to the dollar weakening ones, rendering the corrective action of subsequent traders unnecessary. For traders operating in the ETZ zone the effect of the crisis is even more dramatic changing their pre-crisis under-reactions into post crisis over-reactions.

The other effect of the crisis is the arising of asymmetric reactions to Euro or to Dollar positive/negative events. Prior to the 2008 crisis the exchange rate does not show any asymmetric reactions to either ETZ or ATZ unscheduled news. The picture changes after the 2008 and ATZ traders show an increased sensitivity to ATZ dollar weakening unscheduled (ATZ) than to ATZ dollar strengthening unscheduled (the coefficient for the dollar-bad news is 1.61 compared to the dollar-good news of 1.25). We find that this increased sensitivity and the quicker response to unfavourable Dollar-content events extend from the conditional mean to the conditional volatility, as explained in the section of the analysis of the volatility curve.

[PLEASE INSERT TABLE 5 HERE]

5.3 Results: Scheduled news

Similarly to what we did for the unscheduled news, we tested for asymmetric reactions to scheduled news and, when we moved from GARCH models into EGARCH models, these asymmetric reactions to bad and good scheduled news disappeared from the conditional mean to reappear in terms of conditional volatility. This result does not come

as a surprise given that the EGARCH model enables to account specifically for eventual asymmetric reactions to positive and negative surprises in the volatility (e.g., the leverage effect) of exchange rate returns. We will discuss this point further in the section devoted to the volatility analysis.

The two most interesting findings produced by the crisis are in relation to the ranking of some macroeconomic news, and to traders' under/over-reactions[34]. In relation to the ranking, one can observe that while some macroeconomics indicators have been consistently relevant along time (such as for instance German IFO Business Climate Indicator, the Bank of England rate, the Nonfarm Payroll, and the Producer Price Index, net of food and energy, corrected to take into account of the differences in daylight saving time weeks between Europe and the US), some others have lost their influence after the 2008 (such as the GDP in the European Monetary Union (EMU) and the American Manufacturing Index (ISM)), and some others have become relevant only after the crisis (such as the Consumer Price Index Flash in Europe (EMU) and US GDP).

In the ATZ zone, as the ISM indicator lost its effect, the Nonfarm Payroll doubled in magnitude becoming the most powerful scheduled news after the crisis (from -0.58 before the crisis to -1.04 after the crisis). The doubling of its coefficient indicates a greater attention paid to the US labour market surprises in moving from a sub-period of buoyant growth to a sub-period where uncertainty over the US business cycle loomed larger.[35]

[34] We thank an anonymous referee who suggested to add time-zone dummies to our EGARCH equations to check for possible differences in the mean of the exchange rate across the three trading zones. These dummies produced some effects only in the pre-crisis period by altering the value of the constant term but not the value of any other coefficient of the regression. The crisis seems to have removed any time-zone difference in mean creating an "ambient uniformity" across the three zones.

[35] The Nonfarm Payroll indicator is released at the opening of the ATZ trading time when the ETZ and ATZ overlap for a few hours, and the combined action of European and American traders is at its peak. This contributes to explain partly the magnitude of its coefficient which captures the actions of European and American traders.

The comparison of current and lagged coefficients in both sub-period would confirm that the crisis has either eliminated traders' under-reactions or transformed them into over-reactions, particularly in the ATZ and ETZ trading zones. Interestingly, the EMU CPI does not elicit any reaction in the European time zone (the liquidity trap, and cost push inflation via commodity prices have weakened the link between higher inflation and stronger Euro) but it prompts a delayed reaction in the American trading zone. In other words, higher than expected CPI inflation is perceived by US traders as "more troubles" for the Euro, given the limited margin of manoeuvring left to the European Central bank in front of the urgency to help the recovery and avoid the Euro collapse.

5.4 Analysis of the volatility curves

The estimated coefficients of the EGARCH volatility equations are:

$$\log(h_t) = -0.11 + 0.14\left[|z_{t-1}| - \sqrt{(2/\pi\ )}\ \right] + \ 0.02\ (z_{t-1}) - 0.19\log(h_{t-1}) + \\ +0.27\log(h_{t-2}) + 0.91\log(h_{t-3}) \qquad (3.1)$$

$$\log(h_t) = -0.18 + 0.24\left[|z_{t-1}| - \sqrt{(2/\pi\ )}\ \right] + \ 0.03\ (z_{t-1}) - 0.45\log(h_{t-1}) + \\ +0.73\log(h_{t-2}) + 0.71\log(h_{t-3}) \qquad (3.2)$$

In these equations the conditional variance is a function of its past values and of an innovation term (e.g., a standard normal variable that captures "unaccounted" surprises). These equations show the following features of conditional volatility. Firstly, the conditional variance of each trading interval is affected by its past values up to a 24 hours delay (the *t*-statistics of the coefficients of the three lags of the volatility are all statistically relevant).

Secondly the volatility transmission is high and, in the absence of any new "unaccounted" surprise, the volatility would eventually die out, although slowly. This point can be shown by summing up the coefficients of the lags of the conditional variance.

Thirdly in the pre-crisis equation (3.1), the asymmetric coefficient is (0.02) and statistically significant only at 10%. However, in the post–crisis equation (3.2) the same coefficient becomes substantially bigger (0.03) and statistically relevant.

Fourthly for both equations the asymmetric coefficient is positive, meaning that a positive unaccounted surprise (for instance large positive movements, due, for instance, to trading positioning that causes sharp swings in Euro-Dollar) increases the conditional volatility of the Euro-Dollar rate more than a negative unaccounted surprise of the same order of magnitude would. A positive "unaccounted" news in the Euro-Dollar rate equation is Euro-positive but it is at the same time Dollar-negative, because of our definition of this currency pair. Therefore, an asymmetric reaction of the volatility to positive innovations implies that the market becomes more "nervous" when hit by "unaccounted" surprises that weaken the Dollar than when hit by unaccounted surprise of the same magnitude that weaken the Euro. The bigger value of the asymmetric coefficient after the 2008 indicates that the occurrence of the financial crisis indeed increased the nervousness of the market to innovation weakening the Dollar.

Another feature of the volatility (equations 3.1 and 3.2) is that it reacts to "big" surprises of both signs. The coefficient associated with the size of the standardized innovation (i.e. the coefficient that multiplies the standardized absolute innovation) is statistically relevant and positive in both sub-periods and it becomes substantially bigger after the financial crisis (0.14 in sub-period1 and 0.24 in sub-period 2). This finding suggests that the financial crisis amplified the reaction of volatility to "big" surprises. In other words, the swing in the exchange rate triggered by a big unexplained surprise has become much

more pronounced after the crisis than before due perhaps the increased uncertainty brought by the crisis and fears of losses.

Taking into account the combined effects of sign and size of unaccounted surprises, we can conclude that unaccounted news that weaken the Dollar and strengthen the Euro tend to increase the conditional volatility in the immediate future much more than same size news that strengthen the Dollar and weaken the Euro, a result similar to the "leverage effect" in the stock market literature (Black,1976; Christie, 1982).

To quantify the impact of positive and large "unaccounted" surprises on volatility, one ought to transform equations into a non-logarithmic form. This is because the quantification of the asymmetric and magnitude effects on volatility is made complicated by the fact that the EGARCH is a semi-log form with the regressand expressed in logs and the regressors expressed in both logarithmic and linear forms, and by the fact that the regressand is in variance term while part of the regressors are in volatility terms (standard deviations) terms.

After the transformation, we compute the news impact curve coming from the EGARCH specification of each sub-period, and we compare the curves to assess the effects of the financial crisis on the conditional volatility of the Euro-Dollar rate. The volatility curves are obtained by computing the square root of the anti-log transformation of the conditional variance (equations 3.1 and 3.2) for different values of the standardized and absolute standardized innovations (*z*-variable).[36] Table 6 reports the results. To understand the magnitude of the effects of unaccounted surprises on volatility we consider 3 different sizes of the "volatility" surprises: the small/medium positive surprises that fall in the interval between zero to 1 and that can occur with a probability of 34%; the larger

[36] The probability of a positive standardized innovation falling between 0 and 1 is 34%, while the one associated with one falling between 0 and 1.65 is 45% and one falling between 0 and 2.33 is 49%. Negative innovations have same values of probabilities taken on the left side of the standardized curve.

positive surprises that range from 1 to 1.65 and that occur with a probability of 11%; and the big positive surprises that range between 1.26 and 2.33 and can occur with a probability of 4%. The same classification applies to negative unaccounted surprises.[37] For each of these possible intervals we consider only one value: the value of each interval's upper bound. So we have 6 possible cases: 3 cases when (standardized) positive surprises take the value of 1, 1.65 and 2.33 and 3 cases when (standardized) negative surprises take the values of (-1), (-1.65) and (-2.33).

We can now quantify the post financial crisis increase in the reaction of volatility to unaccounted surprises of any sign and size: for instance a large Euro positive/Dollar negative surprise (+2.33) would increase the conditional volatility of about 36.32% after the crisis compared to an increase of 19.32% prior to the crisis. The same result is obtained when looking at negative surprises: for instance a large negative surprise (-2.33) increases the volatility by 28% compared to an increase of 15% prior to the crisis. Similar results hold for positive and negative medium (+1.65 and -1.65) surprises and for positive and negative smaller surprises (+1 and -1). Thus, as expected, the crisis brought along a general and pronounced increase in Euro/Dollar volatility and when we compare sizes of surprises, we can see that with a probability of 4% (which is the probability of a surprise to fall between + 1.65 and +2.33) the volatility would increase between 24.53% and 36.32% in the second sub-period but only between 13.32% and 19.32% in the first sub-period.

It is also possible to quantify the second interesting result of our EGARCH estimates, namely the post financial crisis increase in the asymmetric reaction of the conditional

[37] Small/medium negative surprises range between (-1) and zero with a probability of 34%. The larger negative range from (-1.65) to (-1) with a probability of 11%. The big negative surprises range between (-2.33) and (-1.65) with a probability of 4%.

volatility to positive and negative surprise. From Table 6, we can see that, for instance, after the crisis the percentage impact on volatility of a large Euro positive (+2.33) and of a large Euro negative (-2.33) surprises are about 36.32% for positive and about 28.06% for negative surprise. However, the picture changes when we consider the period before the crisis when the volatility reaction to the same size of surprises would have been smaller and less asymmetric (with a percentage impact of 19% for large Euro positive surprises and of 15% for large Euro negative surprises). Thus the financial crisis brought not only an increase in volatility to any size and sign of surprises but also an increase in the "spread" of the asymmetric reactions to positive and negative surprises of any order of magnitude.

[PLEASE INSERT TABLE 6 HERE]

6. Summary and Conclusions

This study aimed to investigate the determinants of the Euro-Dollar exchange rate behaviour and to assess if the financial crisis had contributed to alter its dynamics. Our approach differs from previous contributions in several ways: firstly we employ a thrice-daily frequency that reflects a "natural" partition of the trading day into three geographical trading areas, namely Asian, European and American trading time intervals; secondly we use both quantitative and qualitative news and events to ascertain the market reactions to different surprises that hit the market during the 24 hour trading day; thirdly we test for the presence of asymmetric effects to positive and negative surprises and for the presence of over-reaction and under-reaction to past news; lastly, we put trading behaviour into an historical perspective to study if and to what extent traders' behaviour may have been affected by the international financial crisis initiated in 2007-2008. We believe that this enriched approach can provide some useful insights to better understand differences

across trading areas and structural changes triggered by the 2007-2008 events. We found that indeed the financial crisis affected the Euro-Dollar dynamics and its conditional volatility. After the crisis the Euro-Dollar displays a quicker and stronger mean reverting process as if traders were more inclined to keep their position for shorter periods. We also observe an increased propensity to display asymmetric reactions, in the mean (via unscheduled news) and in the conditional volatility of the EGARCH to surprises and events weakening dollar *vis-à-vis* the euro, as if traders were affected by a sort of behavioural negativity bias to unfavourable news related to the dollar. Moreover, the role played by some fundamentals after the crisis, noticeably the relevance and the sign of the DJ, seems to suggest that the crisis changed traders' reactions toward uncertainty (Guiso et al.,2013; Hoffmann et al., 2013) and that possibly those traders who experienced higher realized or paper losses show a more pronounced loss aversion. Our results reveal that there is an increased importance of unscheduled events, particularly those ones generated in the American trading zone. There is also difference in the pattern of over-reaction and under-reaction to past event and a clear reduced importance of lagged scheduled and unscheduled news, with a parallel stronger effects of current news (showing a possible availability bias effect), particularly the news of pro-cyclical leading (IFO, Nonfarm Payroll) and coincident indicators (USA GDP) of the real economy. Although the use of the EGARCH (3,1) allowed us to account for asymmetries and lags of surprises, and interactions across areas, we recognize that one potential limitation of our study is that our model lacks to consider interactions across currencies. A multivariate EGARCH model specification that includes other currencies (UK Pound and Japanese Yen), and scheduled/unscheduled news related to alternative pairs could further improve our comprehension on how investors operating in different trading time zones react to a broader set of information. This development can be pursued in a future study. Another

promising avenue of our research is to use the estimated EGARCH for day-trading decisions by using the insights gained in looking at possible trading strategies across time zones in responding to news of the three zones, and by using the model to produce forecasts and give thrice-daily trading signals to go long or short on the Euro-Dollar.

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Table 1 Summary of macroeconomic announcements

Name of announcement	Unit of announcement	Release coverage	Start date	Final Date	Source	Number of obs.	Announcement Time
Euro-Area Announcements [a] (European Time Zone)							
Monthly							
Business Climate Indicator	Index	Data are for same month as the release month	07-Jan-2003	30-Aug-2011	DG ECFIN	95	11:00 am CET/05:00 am EST
ECB Rate	% level	Data are for same month as the release month	09-Jan-2003	04-Aug-2011	ECB	105	13:45 am CET/07:45 am EST
Economic Confidence	Index	Data are for same month as the release month	31-Jan-2003	30-Aug-2011	DG ECFIN	101	11:00 am CET/05:00 am EST
Consumer Confidence	Index	Data are for same month as the release month	31-Jan-2003	30-Aug-2011	DG ECFIN	100	11:00 am CET/05:00 am EST
Industrial Confidence	Index	Data are for same month as the release month	31-Jan-2003	30-Aug-2011	DG ECFIN	101	11:00 am CET/05:00 am EST
CPI Flash	Y-Y% change	Data are for the previous month	03-Jan-2003	31-Aug-2011	ESTAT	105	11:00 am CET/05:00 am EST
CPI Final	Y-Y% change	Data are for the previous month	22-Jan-2003	17-Aug-2011	ETSAT	105	11:00 am CET/05:00 am EST
CPI	M-M% change	Data are for the previous month	22-Jan-2003	17-Aug-2011	ESTAT	105	11:00 am CET/05:00 am EST
M3	M-M% change	Data are for the previous month	28-Jan-2003	26-Aug-2011	ECB	102	10:00 am CET/04:00 am EST
Unemployment rate	% of labour force	Data are for two months prior to release month	07-Jan-2003	01-Aug-2011	ESTAT	105	11:00 am CET/05:00 pm EST
PPI	M-M% change	Data are for two months prior to release month	07-Jan-2003	02-Aug-2011	ESTAT	101	11:00 am CET/05:00 pm EST
Retail Sales	M-M% change	Data are for two months prior to release month	08-Jan-2003	03-Aug-2011	ESTAT	104	11:00 am CET/05:00 pm EST
Retail Sales	Y-Y% change	Data are for two months prior to release month	08-Jan-2003	03-Aug-2011	ESTAT	105	11:00 am CET/05:00 pm EST
Industrial Production	M-M% change	Data are for two months prior to release month	17-Jan-2003	12-Aug-2011	ESTAT	105	11:00 am CET/05:00 am EST
Quarterly							
GDP Real Advance	Q/Q% change	Data are for the prior quarter	06-Mar-2003	16-Aug-2011	ESTAT	34	11:00 am CET/05:00 am EST
GDP Real Preliminary	Q/Q% change	Data are for the prior quarter	09-Jan-2003	08-Jun-2011	ESTAT	36	11:00 am CET/05:00 am EST
GDP Real Final	Q/Q% change	Data are for the prior quarter	06-Feb-2003	06-Apr-2011	ESTAT	34	11:00 am CET/05:00 am EST
Total						**1543**	
a)except for EBC rate and M3, before March 20004, all the indicators were released at 12:00 am CET/06:00 am EST							
Germany Announcements (European Time Zone)							
Monthly							
ZEW Survey	Index	Data are for same month as the release month	21-Jan-2003	23-Aug-2011	ZEW	104	11:00 am CET/05:00 am EST
IFO Business Climate	Index	Data are for same month as the release month	28-Jan-2003	24-Aug-2011	IFO	104	10:00 am CET/04:00 am EST
IFO Current Assessment	Index	Data are for same month as the release month	28-Jan-2003	24-Aug-2011	IFO	104	10:00 am CET/04:00 am EST
IFO Expectation	Index	Data are for same month as the release month	28-Jan-2003	24-Aug-2011	IFO	104	10:00 am CET/04:00 am EST
CPI Preliminary	M-M% change	Data are for same month as the release month	26-Feb-2003	29-Aug-2011	DSTATIS	103	varies
Factory Orders	M-M% change	Data are for two months prior to release month	10-Jan-2003	04-Aug-2011	DB	103	12:00 am CET/06:00 am EST
Industrial Production	M-M% change	Data are for two months prior to release month	13-Jan-2003	05-Aug-2011	DSTATIS	105	12:00 am CET/06:00 am EST
Retail Sales	M-M% change	Data are for the previous month	07-Jan-2003	31-Aug-2011	DSTATIS	103	08:00 am CET/02:00 am EST
Unemployment Level [b]	M-M change level	Data are for the previous month	09-Jan-2003	31-Aug-2011	DSTATIS	105	08:55 am CET/02:55 am EST
Unemployment Rate [b]	M-M% change	Data are for the previous month	09-Jan-2003	31-Aug-2011	DSTATIS	105	08:55 am CET/02:55 am EST
PPI	M-M% change	Data are for the previous month	23-Jan-2003	19-Aug-2011	DSTATIS	104	08:00 am CET/02:00 am EST
Quarterly							
GDP Real Preliminary	Q-Q% change	Data are for the prior quarter	26-Feb-2003	16-Aug-2011	DSTATIS	35	08:00 am CET/02:00 am EST
Total						**1179**	
b)before July 2005, varies							

United Kingdom Announcements (European Time Zone)							
Monthly							
BOE Rate	% Level	Data are for same month as the release month	09-Jan-2003	04-Aug-2011	BOE	103	13:00 am CET/07:00 pm EST
GFK Consumer Confidence	Index	Data are for same month as the release month	30-Jan-2003	31-Aug-2011	GFK NOP	104	11:30 am CET/05:30 pm EST
PPI Output	Y-Y% change	Data are for the previous month	13-Jan-2003	05-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
Jobless Claim Change	M-M change level	Data are for the previous month	15-Jan-2003	17-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
RPI	Y-Y% change	Data are for the previous month	21-Jan-2003	16-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
RPI ex mort. Int. payment	Y-Y% change	Data are for the previous month	21-Jan-2003	16-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
Retail Sales ex auto fuel	Y-Y% change	Data are for the previous month	23-Jan-2003	18-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
Visible Trade	Y-Y% change	Data are for two months prior to release month	10-Jan-2003	09-Aug-2011	ONS	103	10:30 am CET/04:30 am EST
Industrial Production	Y-Y% change	Data are for two months prior to release month	14-Jan-2003	09-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
Manufactoring Production	Y-Y% change	Data are for two months prior to release month	14-Jan-2003	09-Aug-2011	ONS	104	10:30 am CET/04:30 pm EST
ILO Unemployment	M-M% change	Data are for two months prior to release month	15-Jan-2003	17-Aug-2011	ONS	104	10:30 am CET/04:30 am EST
Quarterly							
GDP Real Advance	Y-Y% change	Data are for the prior quarter	24-Jan-2003	26-Jul-2011	ONS	34	10:30 am CET/04:30 am EST
GDP Real Preliminary	Y-Y% change	Data are for the prior quarter	26-Feb-2003	26-Aug-2011	ONS	35	10:00 am CET/04:00 am EST
GDP Real Final	Y-Y% change	Data are for the prior quarter	27-Mar-2003	28-Jun-2011	ONS	34	10:30 am CET/04:30 am EST
Total						***1246***	
United States Announcements (American Time Zone)							
Monthly							
Philadelfia Manufactoring Index	Index	Data are for the same month as the release month	16-Jan-2003	18-Aug-2011	FP	104	12:00 am EST/18:00 pm CET
Consumer Confidence Index	Index (1985 = 100)	Data are for the same month as the release month	28-Jan-2003	26-Jul-2011	CF. B.	104	10:00 am EST/16:00 pm CET
ISM Index	Index	Data are for the previous month	02-Jan-2003	01-Aug-2011	ISM	103	10:00 am EST/16:00 pm CET
Average Hourly Earnings	USD per hour	Data are for the previous month	10-Jan-2003	05-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Nonfarm Payrolls	Thousands	Data are for the previous month	10-Jan-2003	05-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Unemployment Rate	% of Labour Force	Data are for the previous month	10-Jan-2003	05-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Retail Sales	M-M% change	Data are for the previous month	14-Jan-2003	18-Aug-2011	CB	104	08:30 am EST/14:30 pm CET
Retail Sales less Autos Fuel	M-M% change	Data are for the previous month	14-Jan-2003	18-Aug-2011	CB	104	08:30 am EST/14:30 pm CET
Producer Price Index	M-M% change, Index(1982=100)	Data are for the previous month	15-Jan-2003	17-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Producer Price Index (Core)	M-M% change, Index(1982=100)	Data are for the previous month	15-Jan-2003	17-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Consumer Price Index (CPI)	M-M% change, Index(1982=100)	Data are for the previous month	16-Jan-2003	18-Aug-2011	BLS	104	08:30 am EST/14:30 pm CET
Industrial Production	M-M% change	Data are for the previous month	17-Jan-2003	16-Aug-2011	FRB	104	09:15 am EST/15:15 pm CET
Leading Indicators	M-M% change	Data are for the previous month	23-Jan-2003	18-Aug-2011	CF. B.	104	10:00 am EST/16:00 pm CET
Durable Goods Orders	M-M% change	Data are for the previous month	28-Jan-2003	24-Aug-2011	CB	104	08:30 am EST/14:30 pm CET
Personal Income	M-M% change	Data are for the previous month	31-Jan-2003	02-Aug-2011	BEA	103	08:30 am EST/14:30 pm CET
Personal (Consumer) Spending	M-M% change	Data are for the previous month	31-Jan-2003	02-Aug-2011	BEA	103	08:30 am EST/14:30 pm CET
Factory Orders	M-M% change	Data are for two months prior to release month	07-Jan-2003	03-Aug-2011	CB	104	10:00 am EST/16:00 pm CET
Trade Balance	USD Billions	Data are for two months prior to release month	17-Jan-2003	11-Aug-2011	BEA	104	08:30 am EST/14:30 pm CET
Quarterly							
GDP Real Advance	Q/Q% change	Data are for the prior quarter	30-Jan-2003	29-Jul-2011	BEA	35	08:30 am EST/14:30 pm CET
GDP Real Preliminary	Q/Q% change	Data are for the prior quarter	28-Feb-2003	26-Aug-2011	BEA	35	08:30 am EST/14:30 pm CET
GDP Real Final	Q/Q% change	Data are for the prior quarter	27-Mar-2003	24-Jun-2011	BEA	34	08:30 am EST/14:30 pm CET
GDP Deflator Advance	Q/Q% change	Data are for the prior quarter	30-Jan-2003	29-Jul-2011	BEA	35	08:30 am EST/14:30 pm CET
GDP Deflator Preliminary	Q/Q% change	Data are for the prior quarter	28-Feb-2003	26-Aug-2011	BEA	35	08:30 am EST/14:30 pm CET
GDP Deflator Final	Q/Q% change	Data are for the prior quarter	30-Jan-2003	29-Jul-2011	BEA	34	08:30 am EST/14:30 pm CET
Weekly							
Jobless Claims	Number of claims(thousands)	Week-ending Saturday before the release.	02-Jan-2003	25-Aug-2011	ETA	462	08:30 am EST/14:30 pm CET
Total						**2539**	

Notes: This table presents the mean features of macroeconomic announcements issued between 01/01/2003 and 31/08/2011 for the United States, the Euro-Area, United Kingdom and Germany. Announcements are first classified by country or area and then by frequency of release (monthly, quarterly or weekly). The table reports the unit of measure of the announcements (column 2), the sequence of announcement date corresponding to data for month X (column 3), the chronological ordered starting date for each announcement according to its release coverage and frequency of release (column 4), the date of the last observation for the announcement (column 5), the total number of observations for each announcement (column 6) and the time schedule of the announcement release in Eastern Standard Time (EST) and Central European Time (CET). The global 24 trading hours day is decomposed in three consecutive 8-hour time-zone and each announcement is assigned to one the three time zone according to its time of release. M-M % change is the percent change from month to month, M-M level change is the change in level from month to month, Q/Q % change is the percent change quarter over quarter and Y/Y % change is percent change year over year. Actual values and median forecasts are collected from Bloomberg News Service, dates of release from Econoday Economic Calendar. The sources of announcements are: -for the Euro-Area: DG ECFIN, Directorate General for Economic and Financial Affairs-European Commission; ECB, European Central Bank; ESTAT, Eurostat-European Commission; -for Germany: BD, Deutsche Bundesbank; DSTATIS, Federal Statistical Office (*Statistisches Bundesamt)*-German Federal Ministry of the Interior; IFO, Institute of Economic Research (*Institut für Wirtschaftsforschung*); ZEW, Centre for European Economic Research (*Zentrum für Europäische Wirtschaftsforschung*); -for the United Kingdom: BOE, Bank of England; GFK NPO, Gfk National Opinion Polls, London-based arm of GFK (*Gesellschaft für Konsumforschung*-Society for Consumer Research); ONS, Office for National Statistics-UK Statistics Authority; -for the United States: BEA, Bureau of Economic Analysis-U.S. Department of Commerce; BLS, Bureau of Labor Statistics-U.S. Department of Labor; CF. B, Conference Board; CB, Census Bureau-U.S. Department of Commerce; ETA, Labor's Employment and Training Administration-U.S. Department of Labor; FP, Federal Reserve of Philadelphia; FRB, Federal Reserve Board of Governors; ISM, Institute for Supply Management.

Table 2 Description of unscheduled news

Date	Weekday	Text	Time-Zone /Sign	Typology	Source
12/05/2003	Monday	The dollar fell to $1.16 against the euro for the first time in more than four years after Treasury Secretary John Snow suggested (ABC Television) the U.S. isn't concerned with the currency's 21 percent slide in the past year.	ATZ/P	(B)	BLO
19/05/2003	Monday	The dollar fell to a series of lows across the board on Monday after weekend comments by John Snow, the US Treasury secretary, were seen as underlining the US administration's relaxed attitude towards the dollar's fall. After the G7 and G8 meetings ended on Sunday, Mr Snow described the dollar's fall as a "modest realignment".	ETZ/P	(B)	FT
20/05/2003	Tuesday	The dollar fell late Tuesday on news that the U.S. government decided to raise the nation's terror alert level back to orange, or "high," from yellow, or "elevated".	ATZ/P	(C)	WSJ
23/05/2003	Friday	The euro rose above its 1999 launch levels on Friday as the dollar tumbled on a combination of rising risk aversion on fresh terrorist fears and thin markets ahead of the long weekend in both the UK and the US. Its sudden move higher surprised traders, who said the speed was exacerbated by stop-loss selling - automated orders triggered when a currency pair reaches a particular level, above the euro's previous high. (in ETZ)	ETZ/P	(C,G)	FT
30/05/2003	Friday	The dollar rose the most in eight weeks against the euro in New York trading after President George W. Bush said he will express support for a 'strong dollar'' at a weekend meeting of the leaders of the largest industrial nations.	ATZ/N	(D)	BLO
02/06/2003	Wednesday	The dollar eased up after strengthening sharply against the euro in early Monday trading on supportive comments from President Bush over the weekend. Growing speculation of a more aggressive rate cut by the European Central Bank also fuelled the dollar's early strength.	ETZ/N	(B,G)	WSJ
11/06/2003	Wednesday	The euro gained against the dollar on Wednesday as Eurozone officials played down the likelihood of further rate cuts.	ETZ/P	(B)	FT
11/06/2003	Wednesday	The dollar softened against its trans-Atlantic counterparts on continued expectations of a U.S. interest-rate cut. Recent comments by Federal Reserve officials have fuelled speculation of a rate cut at the central bank's June 24-25 policy meeting, with the market looking for additional indications Wednesday.	ATZ/P	(B)	WSJ
18/06/2003	Wednesday	The dollar advanced steadily on Wednesday as investors lowered expectations of the likelihood of a half-point interest rate cut by the Federal Reserve next week following strong data on Monday and Tuesday	ETZ/N	(G)	FT
30/06/2003	Monday	European central bankers, via the Bank for International Settlements, on Monday backed U.S. acceptance of a weaker dollar to stimulate the U.S. economy.	ATZ/P	(A)	WSJ

Notes: This table contains a sample of unscheduled news collected from various newspapers sources between May 2003 and June 2003. The first two columns indicate the date and weekday of release. The text of the news is contained in column 3. Each news is assigned to a specific time-zone and associated with the excepted impact on the Euro/Dollar exchange rate (column 4). The typology and the source of the news are showed in column 5 and 6. The (expected) effect on the euro-dollar exchange rate is the final character in above labels: P, Euro-positive; N, Euro-negative.WSJ: *Wall Street Journal*, BLO: *Bloomberg News*, FT: *Financial Times.*

Table 3 OLS estimation and stability tests

Variable	Coeff.	Signif.	S.E.	*p*-value	Hansen Stat.	Signif.	*p*-value
ΔEuro-Dollar{1}	-0.09	***	[0.02]	(0.00)	0.23		(0.21)
ΔEuro-Dollar{2}	-0.13	***	[0.01]	(0.00)	2.13	***	(0.00)
ΔEuro-Dollar{3}	-0.02		[0.02]	(0.22)	0.08		(0.67)
Δ10-Year US Treasury Bond	-0.27	***	[0.04]	(0.00)	1.44	***	(0.00)
Δ10-Year US Treasury Bond{1}	-0.03	*	[0.02]	(0.07)	0.26		(0.18)
Δ10-Year US Treasury Bond{2}	-0.05	**	[0.02]	(0.03)	0.05		(0.85)
Δ10-Year JBG	-0.07	***	[0.01]	(0.00)	1.07	***	(0.00)
Δ10-Year JBG{1}	0.02		[0.02]	(0.23)	0.47	*	(0.05)
Δ10-Year JBG{2}	-0.03		[0.02]	(0.21)	0.08		(0.69)
Δ10-Year Bund	-0.03		[0.02]	(0.26)	1.32	***	(0.00)
Δ10-Year Bund{1}	0.10	***	[0.03]	(0.00)	0.28		(0.15)
Δ10-Year Bund{2}	0.02	*	[0.01]	(0.09)	0.09		(0.64)
ΔDow Jones	-0.10	**	[0.04]	(0.02)	3.32	***	(0.00)
ΔNikkei	0.02		[0.02]	(0.33)	0.65	**	(0.02)
ΔNikkei{1}	0.00		[0.03]	(0.91)	0.25		(0.18)
POS_NEG Euro-Dollar_ASTZ	1.06	***	[0.09]	(0.00)	0.71	**	(0.01)
POS_NEG Euro-Dollar_ASTZ{1}	-0.39	***	[0.07]	(0.00)	0.71	**	(0.01)
POS_NEG Euro-Dollar_ETZ	1.00	***	[0.04]	(0.00)	6.67	***	(0.00)
POS_NEG Euro-Dollar_ETZ{3}	-0.05		[0.04]	(0.20)	0.38	*	(0.08)
POS_NEG Euro-Dollar_ATZ	1.26	***	[0.06]	(0.00)	1.38	***	(0.00)
POS_NEG Euro-Dollar_ATZ{1}	0.21	***	[0.04]	(0.00)	1.58	***	(0.00)
POS_NEG Euro-Dollar_ATZ{2}	-0.11	**	[0.04]	(0.01)	3.04	***	(0.00)
EUR_CPI Flash	0.26	***	[0.10]	(0.00)	0.06		(0.83)
EUR_PPI	-0.03		[0.12]	(0.80)	0.12		(0.47)
EUR_GDP Advance	0.11		[0.14]	(0.41)	0.03		(0.97)
EUR_GDP Advance{1}	0.28		[0.24]	(0.25)	0.16		(0.36)
EUR_GDP Advance{2}	0.21	**	[0.09]	(0.02)	0.03		(0.98)
EUR_GDP Preliminary	0.20	***	[0.03]	(0.00)	0.02		(1.00)
EUR_GDP Preliminary{1}	-0.07		[0.06]	(0.24)	0.36		(0.10)
EUR_GDP Preliminary{2}	-0.05		[0.05]	(0.31)	0.11		(0.51)
EUR_GDP Preliminary{3}	0.17	**	[0.08]	(0.03)	0.29		(0.14)
GER_IFO Expectation	0.27	***	[0.09]	(0.00)	0.10		(0.55)
GER_IFO Expectation{1}	0.02		[0.12]	(0.86)	0.09		(0.59)
GER_IFO Expectation{2}	0.06		[0.05]	(0.19)	0.32		(0.12)
GER_PPI	-0.14		[0.12]	(0.23)	0.04		(0.93)
GER_PPI{1}	0.19		[0.15]	(0.21)	0.21		(0.25)
GER_PPI{2}	-0.18	*	[0.10]	(0.07)	0.16		(0.36)
UK_BOE Rate	0.18	***	[0.05]	(0.00)	0.06		(0.83)
UK_BOE Rate{1}	-0.36	**	[0.17]	(0.03)	0.17		(0.32)
UK_BOE Rate{2}	0.09	**	[0.04]	(0.01)	0.31		(0.12)
UK_BOE Rate{3}	-0.03		[0.10]	(0.74)	0.36	*	(0.09)
UK_GDP Advance	-0.05		[0.11]	(0.63)	0.05		(0.87)
UK_GDP Advance {1}	-0.20	**	[0.10]	(0.04)	0.06		(0.81)
UK_Visible Trade Balance	0.09		[0.08]	(0.27)	0.04		(0.93)
UK_PPI Output	0.12	*	[0.07]	(0.07)	0.10		(0.56)
UK_Unemployment Rate	0.01		[0.10]	(0.90)	0.12		(0.49)
UK_Unmeployment Rate{1}	-0.13		[0.13]	(0.30)	0.05		(0.86)
UK_Unemployment Rate{2}	-0.09		[0.06]	(0.11)	0.13		(0.43)
UK_Unemployment Rate{3}	0.08		[0.09]	(0.39)	0.08		(0.66)
UK_Jobless Claims	-0.02		[0.13]	(0.90)	0.02		(1.00)
UK_Jobless Claims{1}	-0.24		[0.20]	(0.24)	0.10		(0.59)
UK_Jobless Claims{2}	-0.19	**	[0.10]	(0.05)	0.06		(0.83)
UK_Jobless Claims{3}	0.03		[0.18]	(0.86)	0.13		(0.43)
US_GDP Advance	-0.48		[0.41]	(0.24)	0.11		(0.51)
US_GDP Advance{3}	0.12		[0.11]	(0.31)	0.19		(0.27)
US_GDP Preliminary	-0.21		[0.17]	(0.21)	0.14		(0.41)
US_GDP Preliminary{1}	0.10		[0.09]	(0.24)	0.20		(0.25)
US_ISM Manufactoring Index	-0.43	***	[0.14]	(0.00)	0.49	**	(0.04)
US_ISM Manufacturing Index{1}	0.06		[0.05]	(0.23)	0.05		(0.90)
US_ISM Manufactoring Index{2}	-0.12	*	[0.06]	(0.06)	0.02		(1.00)
US_ISM Manufactoring Index{3}	0.09		[0.09]	(0.34)	0.10		(0.56)
US_Nonfarm Payrolls	-0.67	***	[0.26]	(0.00)	0.10		(0.57)

US_Producer Price Index (Core)	0.21	**	[0.09]	(0.02)	0.19	(0.28)
Constant	0.01		[0.01]	(0.41)	0.26	(0.18)
R^2	0.36					
Durbin Watson	1.98					
Hansen stability test statistic						
Joint	29.63	***		(0.00)		
Variance	4.23	***		(0.00)		
Chow stability test statistic						
F (33, 6655)	5.33	***		(0.00)		

Notes: This table presents the results of OLS regression of intra-daily Euro/US Dollar exchange rate variations ($\Delta S_{i,t}$) on interest rates yields ($\Delta y_{i,t}$), stock market indexes returns ($\Delta I_{i,t}$), macroeconomic scheduled news for Euro-Area, Germany, United States and United Kingdom, unscheduled news and relative lags between January 2003 and August 2011. The model is first regressed for the entire sample period. Only variables with significant coefficient are retained and then used in a second-stage regression. The variables, except for unscheduled news, are standardized using the sample period standard deviations. Standard errors for coefficients estimates are in brackets, *p*-values in parentheses and lags 1,2 and 3 for eight, sixteen and twenty-four hours intervals are in braces. To assess the stability of parameter estimates, we use the Hansen's stability test. The Hansen stability test is performed using a joint test statistic and individual test statistics for each parameter in the model. We also test the existence of a structural break using a Chow test. Data from 1-Jan-2003 to 31-Aug-2011. (***) = statistically significant at the 1% level; (**) = statistically significant at the 5% level; (*) = statistically significant at the 10% level.

Table 4 EGARCH estimations of Euro-Dollar Exchange rate

PART A. EGARCH (3,1) Sub-Period1 01/01/2003-29/02/2008					**PART B. EGARCH (3,1) Sub-Period2 29/02/2008-31/08/2011**				
Variable	**Coeff.**	**Signif.**	**S.E.**	***p*-value**	**Variable**	**Coeff.**	**Signif.**	**S.E.**	***p*-value**
Constant	0.01		[0.01]	(0.16)	Constant	0.02	***	[0.00]	(0.00)
ΔEuro-Dollar{1}	-0.08	***	[0.01]	(0.00)	ΔEuro-Dollar{1}	-0.13	***	[0.01]	(0.00)
ΔEuro-Dollar{2}	-0.11	***	[0.01]	(0.00)	ΔEuro-Dollar{2}	-0.03	***	[0.01]	(0.00)
ΔEuro-Dollar{3}	-0.03	**	[0.01]	(0.01)	ΔEuro-Dollar{3}	-0.02	***	[0.01]	(0.00)
Δ10-Year US Treasury Bond	-0.31	***	[0.02]	(0.00)	Δ10-Year US Treasury Bond	-0.19	***	[0.02]	(0.00)
Δ10-Year US Treasury Bond{1}	-0.03	***	[0.01]	(0.00)	Δ10-Year US Treasury Bond{1}	-0.07	***	[0.02]	(0.00)
Δ10-Year US Treasury Bond{2}	-0.05	**	[0.02]	(0.01)	Δ10-Year US Treasury Bond{2}	-0.07	***	[0.02]	(0.00)
Δ10-Year JGB	-0.06	***	[0.01]	(0.00)	Δ10-Year JGB	-0.03	***	[0.01]	(0.00)
Δ10-Year JGB{1}	0.01		[0.01]	(0.36)	Δ10-Year JGB{1}	-0.03		[0.02]	(0.18)
Δ10-Year JGB{2}	-0.03	***	[0.01]	(0.00)	Δ10-Year JGB{2}	-0.06	**	[0.03]	(0.02)
Δ10-Year Bund	-0.02		[0.02]	(0.28)	Δ10-Year Bund	0.14	***	[0.01]	(0.00)
Δ10-Year Bund{1}	0.11	***	[0.02]	(0.00)	Δ10-Year Bund{1}	0.15	***	[0.02]	(0.00)
Δ10-Year Bund{2}	0.05	***	[0.02]	(0.00)	Δ10-Year Bund{2}	0.04	***	[0.01]	(0.00)
ΔDow Jones	-0.05	**	[0.02]	(0.03)	ΔDow Jones	0.30	***	[0.02]	(0.00)
POS_NEG Euro-Dollar_ASTZ	0.93	***	[0.05]	(0.00)	ΔNikkei	0.13	***	[0.01]	(0.00)
POS_NEG Euro-Dollar_ASTZ{1}	-0.36	***	[0.03]	(0.00)	POS_NEG Euro-Dollar _ASTZ	1.00	***	[0.01]	(0.00)
POS_NEG Euro-Dollar_ETZ	1.00	***	[0.03]	(0.00)	POS_NEG Euro-Dollar _ASTZ{1}	-0.25	***	[0.00]	(0.00)
POS_NEG Euro-Dollar_ETZ{2}	0.09	***	[0.04]	(0.00)	POS Euro-Dollar _ASTZ{1}	-0.12	**	[0.06]	(0.05)
POS_NEG Euro-Dollar_ATZ	1.18	***	[0.04]	(0.00)	POS Euro-Dollar _ASTZ{2}	-0.18	***	[0.05]	(0.00)
POS_NEG Euro-Dollar_ATZ{1}	0.14	***	[0.04]	(0.00)	POS_NEG Euro-Dollar _ETZ	1.40	***	[0.03]	(0.00)
POS_NEG Euro-Dollar_ATZ{2}	-0.12	***	[0.03]	(0.00)	POS_NEG Euro-Dollar _ETZ{2}	-0.07	**	[0.03]	(0.05)
EUR_GDP Advance	0.09		[0.17]	(0.59)	POS Euro-Dollar _ETZ	-0.09		[0.06]	(0.15)
EUR_GDP Advance{1}	0.34	**	[0.17]	(0.04)	POS Euro-Dollar _ETZ{2}	0.08		[0.07]	(0.21)
GER_IFO Expectation	0.26	***	[0.07]	(0.00)	POS_NEG Euro-Dollar _ATZ	1.25	***	[0.07]	(0.00)
UK_BOE Rate	0.10		[0.13]	(0.41)	POS_NEG Euro-Dollar _ATZ{2}	0.06		[0.06]	(0.28)
UK_BOE Rate{1}	-0.44	***	[0.11]	(0.00)	POS Euro-Dollar _ATZ	0.36	***	[0.09]	(0.00)
UK_BOE Rate{2}	0.10	***	[0.02]	(0.00)	POS Euro-Dollar _ATZ{2}	-0.08		[0.06]	(0.22)
US_ISM Manufactoring Index	-0.44	***	[0.07]	(0.00)	EUR_PPI	-0.10		[0.11]	(0.39)
US_ISM Manufactoring Index{2}	-0.10		[0.08]	(0.21)	EUR_CPI Flash	0.03		[0.10]	(0.79)
US_Nonfarm Payrolls	-0.58	***	[0.07]	(0.00)	EUR_CPI Flash{1}	-0.15	*	[0.08]	(0.07)
US_Producer Price Index (Core)	0.15	**	[0.06]	(0.01)	EUR_CPI Flash{2}	-0.01		[0.07]	(0.89)
					EUR_CPI Flash_POS	0.10		[0.11]	(0.36)
					GER_IFO Expectation	0.23	**	[0.10]	(0.01)
					UK_BOE Rate	0.07	***	[0.00]	(0.00)
					UK_BOE Rate{2}	-0.10	***	[0.02]	(0.00)
					US_GDP Advance	-0.67	***	[0.19]	(0.00)
					US_GDP Preliminary	-0.24	***	[0.04]	(0.00)
					US_GDP Preliminary{1}	0.09	***	[0.01]	(0.00)
					US_GDP Preliminary{2}	-0.21		[0.20]	(0.30)
					US_Nonfarm Payrolls	-1.04	***	[0.08]	(0.00)
					US_Producer Price Index (Core)	0.23	**	[0.09]	(0.01)
ω	-0.11	***	[0.01]	(0.00)	ω	-0.18	***	[0.02]	(0.00)
γ{1}	0.14	***	[0.02]	(0.00)	γ{1}	0.24	***	[0.05]	(0.00)
δ{1}	-0.19	***	[0.02]	(0.00)	δ{1}	-0.45	***	[0.02]	(0.00)
δ{2}	0.27	***	[0.02]	(0.00)	δ{2}	0.73	***	[0.04]	(0.00)
δ{3}	0.91	***	[0.02]	(0.00)	δ{3}	0.71	***	[0.01]	(0.00)
φ{1}	0.02	*	[0.01]	(0.08)	φ{1}	0.03	***	[0.02]	(0.00)

Notes: This table presents the results of exponential GARCH (EGARCH) estimations of intra-daily Euro/US Dollar exchange rate variations ($\Delta S_{i,t}$) on interest rates yields ($\Delta y_{i,t}$), stock market indexes returns ($\Delta I_{i,t}$), macroeconomic scheduled news for the Euro-Area, Germany, United States and United Kingdom, unscheduled news and relative lags between January 2003 and August 2011. Only variables with significant coefficient obtained in the entire sample period OLS regression model are retained and then used in second-stage EGARCH estimations. In the second step the model is computed for two consecutive sub-sample periods. Panel A and Panel B report the results for the EGARCH (3,1) models in the first sub-period (01 January 2003 22:00 CET to 29 February 2008 at 06:00 am CET; 4040 8-hourly observations) and in the second sub-period (29 February 2008 at 6:00 am to 31 August 2011 22:00 CET; 2744 8-hourly observations) respectively. The variables, except for unscheduled news, are standardized using the sample period standard deviations. The label *_POS* after the macroeconomic news name denotes variables computed only with realized positive surprises. The label *POS* before the unscheduled news denotes variables computed only with positive expected sign on the Euro/Dollar exchange rate. Standard errors for coefficients estimates are in brackets, *p*-value in parentheses and lags 1,2 and 3 for eight, sixteen and twenty-four hours intervals are in braces. In the conditional variance EGARCH models, ω is the intercept term, γ_j (j=1) is the magnitude parameter, δ_l (l = 1,2,3) the GARCH parameters and φ_j (j=1) the asymmetry parameter. (***) = statistically significant at the 1% level; (**) = statistically significant at the 5% level; (*) = statistically significant at the 10% level.

Table 5 Effects of Unscheduled News in the Time Zones

	Pre-crisis (Sub-period1) 01/01/2003-29/02/2008			Post -crisis (Sub-period2) 29/02/2008-31/08/2011				
	Asia	**Europe**	**USA**	**Asia**		**Europe**	**USA**	
				(1)	**(2)**		**(1)**	**(2)**
Impact Effect	0.93	1.00	1.18	1.00	1.00	1.40	1.61	1.25
Delayed reaction(s)	-0.36	0.09	0.02	-0.55	-0.25	-0.07		
Net effect	0.57	1.10	1.21	0.45	0.76	1.33	1.61	1.25
Type of effect	Over-reaction	Under-reaction	Under-reaction	Over-Reaction		Over-reaction		

Notes: This table shows the effect of EGARCH estimated parameters of unscheduled news according the time-zone of reference. (1) are Euro Positive/Dollar Negative news and (2) are Euro Negative/Dollar Positive news. Over-reaction occurs when the initial effect is subsequently partially reverted while under-reaction occurs when the initial effect is successively reinforced.

Table 6 Effects of EGARCH parameters on volatility

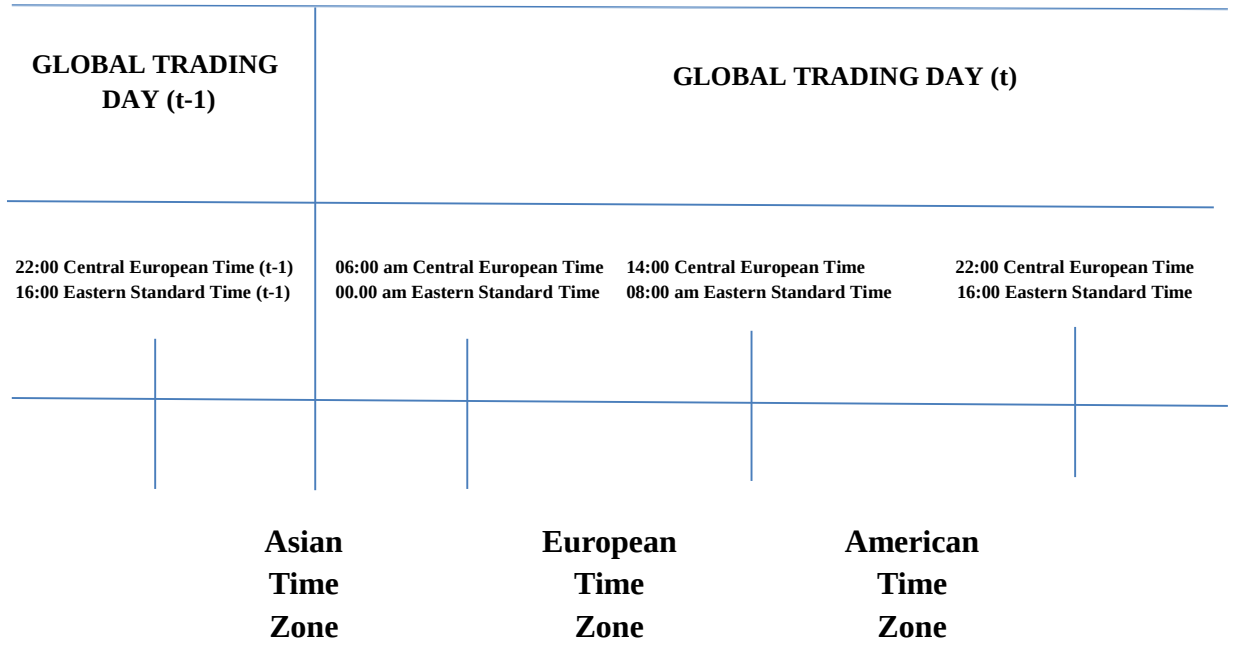
	Negative unaccounted surprises z_{t-1}			Positive unaccounted surprises z_{t-1}		
	-1	-1.65	2.33	+1	+1.65	+2.33
Sub-period1 01/01/2003-29/02/2008						
$\sqrt{e^{0.02z_{t-1}}}$	0.99	0.99	0.98	1.01	1.01	1.02
(% effect on $\sqrt{h_t}$)	-0.77%	-1.26%	-1.78%	0.77%	1.28%	1.81%
$\sqrt{e^{0.14\|z_{t-1}\|}}$	1.07	1.12	1.17	1.07	1.12	1.17
(% effect on $\sqrt{h_t}$)	7.05%	11.89%	17.20%	7.05%	11.89%	17.20%
$\sqrt{e^{(0.02\pm0.14)z_{t-1}}}$	1.06	1.10	1.15	1.08	1.13	1.19
(% effect on $\sqrt{h_t}$)	6.23%	10.48%	15.11%	7.87%	13.32%	19.32%
Sub-period2 29/02/2008-31/08/2011						
$\sqrt{e^{0.03z_{t-1}}}$	0.99	0.98	0.97	1.01	1.02	1.03
(% effect on $\sqrt{h_t}$)	-1.33%	-2.19%	-3.07%	1.35%	2.24%	3.17%
$\sqrt{e^{0.24\|z_{t-1}\|}}$	1.12	1.22	1.32	1.13	1.22	1.32
(% effect on $\sqrt{h_t}$)	12.70%	21.81%	32.12%	12.70%	21.81%	32.12%
$\sqrt{e^{(0.03\pm0.24)z_{t-1}}}$	1.11	1.19	1.28	1.14	1.25	1.36
(% effect on $\sqrt{h_t}$)	11.20%	19.14%	28.06%	14.22%	24.53%	36.31%

Notes: This table shows the effects of EGARCH estimated parameters on the volatility of the error terms. The EGARCH (3,1) coefficients are taken from the estimated logarithmic equation of the conditional variance as reported in Table 4 for the two consecutive sub-sample periods. To quantify the effects of different sizes of unaccounted surprises we take the square root of the anti-log transformation of the conditional variance equations. In the EGARCH the absolute standardized innovation is centered at 0.79 (square root of $2/\pi$). The simplification used in the specification affect only the constant term as showed below. The base case is z_{t-1} equal to zero and can be compared with the impact of the coefficient of the sign.

$$h_t = \exp\left(-0.11 - 0.14\sqrt{\frac{2}{\pi}}\right) + \{0.14\,[|z_{t-1}|\,] + 0.02\,(z_{t-1})\}(h_{t-1})^{-0.19}(h_{t-2})^{0.27}(h_{t-3})^{0.91}$$

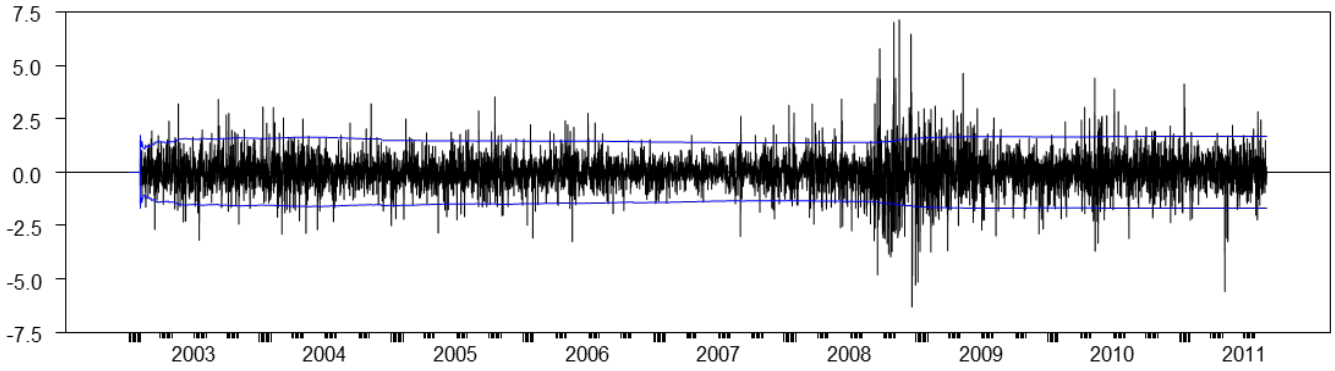
$$h_t = \exp\left(-0.18 - 0.24\sqrt{\frac{2}{\pi}}\right) + \{0.24\,[|z_{t-1}|\,] + 0.03\,(z_{t-1})\}(h_{t-1})^{-0.45}(h_{t-2})^{0.73}(h_{t-3})^{0.71}$$

Figure 1 Global Trading Day and Time Zones



Notes: The 24 hours Gobal Trading Day is decomposed in three symmetric eight-hour time zones: the Asian Time Zone (ASTZ) goes from the closing of the US trading at 22:00 Central European Time (CET) of the previous day (t-1) to 06:00 am Central European Time in current day (t), the European Time Zone (ETZ) starts at 06:00 am Central European Time when the Asian foreign market is going to close and goes to 14:00 Central European Time. The American Time Zone (ATZ) goes from 14:00 Central European Time (equivalent to 08:00 am Eastern Standard Time, EST) to 22:00 Central European Time (or 16.00 Eastern Standard Time). Exchange rate closing quotes at 05:00 am, 13:00 and 21:00 Central European Time are taken by hourly series.

Figure 2 Recursive Residuals and Standard Error Band



Notes: This figure shows the recursive residuals and the upper and lower recursively generated standard error bands. The recursive residuals are obtained from recursive Least Squares estimations. If there is a break, the residuals will lie outside the band until the coefficients or the variance estimates adjust.