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The impact of macroeconomic news on exchange rate volatility

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The impact of macroeconomic news on exchange rate volatility

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Abstract

This study investigates the impact of new information on the volatility of exchange rates. The impact of scheduled US and European macroeconomic news on the volatility of USD/EUR 5-minute returns was tested by using the Flexible Fourier Form method. The results were consistent with earlier studies. Macroeconomic news increased volatility significantly, and news on the United States was the most important. The much-tested hypothesis of bad news having a greater impact on volatility was re-confirmed in this study. The announcements were also divided into two categories, the first containing the news that gave conflicting information on the state of the economy (bad and good news at the same time) and the other containing the news that was consistent (where either good or bad news was announced). Conflicting news was found to increase volatility significantly more than consistent news. The impact of 'no-surprise' news was also tested. Even news the forecast of which was equal to an announcement seemed to increase volatility.

Key words: Exchange rates, microstructure theory, volatility, news

JEL classification numbers: G14, C14, C12, C22

Makrouutisten vaikutus valuuttakurssin volatiliteettiin

Suomen Pankin keskustelualoitteita 24/2004

Helinä Laakkonen
Tutkimusosasto

Tiivistelmä

Tässä työssä tarkastellaan uuden informaation vaikutusta valuuttakurssin volatiliteettiin. Yhdysvaltain ja Euroopan makrotalouden uutisten vaikutusta USD/EUR -valuuttakurssin viiden minuutin tuottojen volatiliteettiin testattiin Flexible Fourier Form -menetelmällä. Tulokset olivat yhteneviä aikaisempien tutkimustulosten kanssa. Makrotalouden uutiset lisäävät volatiliteettia merkitsevästi, ja Yhdysvaltain uutiset ovat maittain testatuista uutisista merkitsevimpiä. Lisäksi paljon testattu negatiivisten uutisten suurempi vaikutus sai vahvistusta tästä tutkielmasta. Merkittävin tulos saavutettiin hypoteesilla, jolla testattiin sekä uutisia, jotka antavat ristiriitaista tietoa talouskehityksestä, että yhdenmukaisia uutisia. Tulosten mukaan ristiriitaiset uutiset lisäävät volatiliteettia merkitsevästi enemmän kuin yhdenmukaiset uutiset. Työssä testattiin myös niin sanottujen nolla-uutisten vaikutusta volatiliteettiin. Tuloksena oli, että myös makroluvut, joiden ennuste on yhtä suuri kuin julkaistu luku, vaikuttavat positiivisesti volatiliteettiin.

Avainsanat: valuuttakurssit, mikrorakenneteoria, volatiliteetti, uutiset

JEL-luokittelu: G14, C14, C12, C22

Contents

1 Introduction

During the recent decades international financial markets has been deregulated and has grown to be the biggest market in the world. At the same time, the need to understand foreign exchange, stock and derivative markets has increased. The dynamics of financial and especially foreign exchange markets have been examined with different kinds of models and theories: the exchange rate has been assumed to be determined by interest rate parity, purchasing power parity, and other more complicated models. These macro models are usually successful in explaining exchange rate dynamics in the long-run, but explaining short-run (a week or a few months) and very short-run (intradaily) dynamics with these models has been very challenging (Meese and Rogoff 1983). From the viewpoint of these models it seems to be quite unclear what happens to the exchange rate in the short and very short-run. In this context market microstructure models seem to work better and are more promising.

Many explanations for high (price) volatility in exchange rate markets have been proposed. Numerous theoretical and empirical models have proved important features of the market structure, which can partly explain the dynamics of the foreign exchange markets. The volatility of exchange rates has been suggested to be partly a consequence of varying market volume: global markets are active at different times during the day, and the high-volatility periods correlate with the high-volume periods (Andersen and Bollerslev 1998). One explanation for high volatility is the flow of new information in the markets. Because of the different motives of the heterogeneous agents (Farmer and Joshi 2002), different trading strategies (Admati and Pfleiderer 1988), psychological choices (Veronesi 1999) and different abilities to forecast and analyse the impact of the new information on the value of the exchange rates (Damodaran 1985), the new information does not only causes a jump in the exchange rate, but also a higher volatility after the news.

This study investigates empirically the impact of macroeconomic news on exchange rates. The impacts of US, German, French and euro area scheduled macro announcements on the USD/EUR exchange rate were estimated by using the Flexible Fourier Form method. 5-minute data during three months from October 2003 to January 2004 was used to test five hypotheses.

According to the results, macroeconomic news increased volatility significantly, but when the impact was tested between countries, only the US macro indicators increased the volatility significantly. This can be explained partly by the macroeconomic situation in the United States and euro area during the data period. Announcements were also divided into ‘bad’ and ‘good’ news. A frequently tested hypothesis of bad news having a greater impact on volatility is supported in this study.

Usually there are more than one macro announcement published at the same time, and that is why the announcements were also divided into two categories: the first contained the news that gave conflicting information on the state of the economy (bad and good news at the same time) and the other contained announcements that were consistent. The conflicting announcements were found to have a significantly greater impact on volatility. The impact of 'no-surprise' news was also tested. According to the efficient market hypothesis, only the surprises should affect the markets, but even when the forecast was equal to the announcement, the news seemed to increase volatility.

2 Foreign exchange market

2.1 The structure and development of foreign exchange market

The Bank of International Settlement (BIS) has been reporting the development of foreign exchange market volume, volatility, market agents and other information since 1989. Their report covers three-year intervals and the latest was published in 2002. According to the 2002 report, foreign exchange markets have changed substantially in the last period (Table 1). Until 1998 the volume of trade had grown rapidly, but in 2001 their total volume decreased by 19%. In April 2001 the average daily volume of trade was 1200 billion US dollars while in 1998 it was 1490 billion US dollars. The decrease was not equal between the instruments; the volume on spot markets decreased most. The volume of currency swaps also fell slightly. (BIS 2002)

The introduction of the euro has naturally affected the volume of foreign exchange transactions. In 2001 the euro was a counterpart in 38% of all transactions. The number is higher than the share of DEM in 1998, but it is lower if all the old currencies of the euro area countries are counted together in 1998. The US dollar was a counterpart in 90%, the euro in 38% and the yen in 23% of all transactions. USD/EUR was the most traded currency pair, the second and the third being USD/YEN and USD/GBP. The shares were 30%, 20% and 11%, respectively.

While the daily currency trade volume is approximately 1200 billion US dollars, the sum of OECD countries' yearly GDP was about 113 million US dollars in 2003. (OECD Outlook 2003) The foreign exchange market is without a doubt the biggest market in the world, but it is also one of the most challenging markets for researchers and practitioners. The market is developing all the time: electronic trading, the introduction of the euro and new market instruments have changed the market during the recent decades. (BIS 2002)

Table 1. **The volume and volatility of the global foreign exchange market**

	1992		1995		1998		2001	
	Volume	Vola	Volume	Vola	Volume	Vola	Volume	Vola
USD/EUR[1]	192	10,0	254	10,5	290	5,7	354	15,6
USD/JPY	155	8,1	242	17,5	256	11,8	231	10,8
USD/GBP	77	9,7	78	5,7	117	5,3	125	9,1
EUR/JPY	18	8,7	24	16,8	24	11,0	30	20,0
EUR/GBP	23	8,8	21	8,5	31	6,0	24	8,7
Total volume	820		1190		1490		1200	

The volume is in billion US dollars; volatility is the one-year standard deviation of the daily returns divided into calendar months
[1]Before 1999 USD/DEM
Source: BIS 2002

The volatility of prices reflects the uncertainty in the markets. The ability to model and forecast volatility is crucial for risk and portfolio management. Understanding the dynamics of financial markets is at least as important to private investors and financial institutions as it is to policy makers and the economy as a whole. For example, central bank interventions have been found to be ineffective in influencing exchange rates. Usually the effect is only to increase volatility in the markets. (Baillie et al 2000)

3 Market microstructure theory

3.1 Efficient markets and rational investors

According to the efficient market hypothesis, all currently available information should be included in the price of an asset. After the arrival of new information, rational market agents update their beliefs on the value of an asset and the price moves to its new equilibrium. This requires, however, that the new information really surprises the markets, because the present price also contains expectations concerning future developments. (Fama 1970) Several empirical tests have shown this hypothesis to be incomplete. The consequence of new information is not just one jump to a new equilibrium price, but instead a higher volatility right after the announcement. Also volatility that can't be explained with (at least public) new information has been observed in the markets. (Malkiel 2003) The various models of market microstructure theory have been created to explain the reasons for high volatility. The theory is not yet established, but conversely still fragmental. The volatility of prices has been explained by different factors such as heterogeneous agents, psychological choices and the role of public and private information on the markets.

3.2 Heterogeneous agents and volatility

Farmer and Joshi (2002) claim in their article, that the different trading strategies of heterogeneous agents cause increasing volatility in the market. The agents in their model are either chartists or fundamentalists. There is also a risk-neutral market maker in the model who sets the new price that equates the supply and demand of the asset. The new price can be derived from the trading between the market maker and other agents.

$$P_{t+1} = f(P_t, \omega) \tag{3.1}$$

where f is the trading between the market maker and other agents, $\omega = \sum_{i=1}^{N} \omega^{(i)}$ and $\omega_t^{(i)} = x_t^{(i)} - x_{t-1}^{(i)}$. $x^{(i)}$ can be considered as a strategy or trading rule of an agent. $\omega_t^{(i)}$ is then an agent i order from the market maker at time t. For the sake of simplicity, only the net amount of the orders ω affects the new price P_{t+1} that the market maker sets. The new price is then a function of the previous price and the net orders of all agents. Since the trading strategies of the agents differ, different strategies have different kinds of impacts on the price.

The chartists assume that prices follow trends. Their strategy is to buy when the prices are starting to go up and sell when they are going down. The fundamentalists buy when they think the asset is underpriced compared to its fundamental value and sell when it is overpriced. Since the group of fundamentalists is not homogeneous, it is not so easy to formulate the strategy for fundamentalists. If all the fundamentalists would agree on to what the appropriate value of an asset is, the price on the market would equate that value. The heterogeneous expectations concerning the fundamental value of an asset increase the volatility in the short run and the strategies of chartists increase the volatility in the long run.

3.3 Volatility due to imperfect information

According to the model developed by Damodaran (1985), the markets don't react to an actual event, but to the news concerning the event. The information that comes through news is not perfect, however. Aside from the fact that the information is not free, it can also be misleading. When the news is announced, market participants update their thoughts about future developments. However, these forecasts are not perfect and they contain large and small forecast errors. Another mistake can be made when the impact of new information on the value of

an asset is analyzed. The errors get larger along with the imperfect information and the need for responding to the new information as quickly as possible. The variance of the error term is defined by

$$\sigma_{\varepsilon}^{2} = \sum_{i}\sum_{j} X_i X_j \sigma_{ij} \tag{3.2}$$

where $X_i = i^{th}$ market agents' weight for the aggregate forecast (I = 1,2,3,…,n), and σ_{ij} = covariance of the forecast error between the i^{th} and the j^{th} market agent. The variance of the error term is then a function of

- how many participants there are in the market and how much they agree on the state of the economy,
- the quality of the personal forecasts of market agents,
- and how much weight the markets give to forecast errors. In efficient markets the weight would be selected so that the variance of the error term would be minimized.

Although the empirical literature has found weaknesses in the efficient market hypothesis, no other theory has been able to explain the market as comprehensively as the efficient market hypothesis. The problem, especially with psychological models, is that if we assume investors to be irrational, we have opened a Pandora's Box (Daniel et al). Still there are many important features in the market micro-structure theories that help us to understand the financial markets better.

4 Previous empirical studies

4.1 The development of the study

The empirical literature on the impact of news on exchange rate volatility has been expanded greatly in recent decades. The earliest studies in the 1980s used daily return data and simple regressions, and didn't get very promising results. (Aggarwal and Schirm 1992) Since the 1990s the availability of high-frequency data, numerous variations of GARCH-models (Bollerslev et al 1992), and the methods of filtering intraday volatility periodicity and other market anomalies (Andersen and Bollerslev 1997) have enabled the better testing of the impact of news on exchange rate volatility.

The impact of news on exchange rate returns[1] and the volatility of returns[2] have been tested extensively. The most tested exchange rate has been DEM/USD, but also GBP/USD (for example Goodhart et al 1993) and YEN/USD have been studied. Usually the tested news has been Reuters headlines or scheduled macro announcements, but also the headlines of financial newspapers have been tested (for example, by Chan et al 2001).

4.2 Earlier results

The results indicate that the news causes a jump in the level of the exchange rate, and increases the volatility of returns from an hour to two hours after the arrival of information. (Andersen and Bollerslev 1998) According to the results, the US news increases DEM/USD volatility more than the news from Germany and the impact of US news lasts longer than the impact of German news (Andersen et al 2003).

Furthermore, the difference between the impact of positive and negative news has been tested. According to the results, the negative news increases the volatility more than the positive news (Andersen et al 2003). The news has been categorized in different ways. For example Melvin and Yin (2000) tested the impact of real economy news and monetary economic news on DEM/USD. They suggested that the impact of real economy news is symmetric between the countries, but the impact of monetary policy news from the US and Germany is different. The impact of Bundesbank news was the most significant of the German news, while the news from the Fed seemed to decrease volatility. During the period of their data, the Fed target was to stabilize the financial markets, which seems to have worked, according to the results of Melvin and Yin. The macroeconomic announcements have been tested also separately. The most significant news seems to be the monthly employment report of the USA. There have also been other significant announcements, for example the advanced report on the sales of durable goods and the merchandise trade. The most significant announcement from Germany has been concerning the Bundesbank meeting (Andersen and Bollerslev 1998).

Recently several applications have been introduced for testing the impact of new information. The impact of news has been tested also for other financial market instruments. Macro announcements seem to have the greatest impact on bond markets and the weakest impact on stock markets (Andersen et al 2004). The

[1] See, for example, Almeida, Goodhart and Payne (1998), Andersen, Bollerslev, Diebold and Vega (2003).

[2] See, for example, Chang and Taylor (2003), Melvin and Yin (2000), Eddelbütten and McCurdy (1998).

interaction and cross-market movements have also been the focus of several studies.[3] The research has been applied also to some other fields. The methods have been used, for example, for investigating if the interdependence between the euro area and the USA has changed since the EMU was established. (Ehrmann and Fratzscher 2002) The methods have also been used to test what kind of impact the announcements of central bank interventions have caused on the conditional means and variances of the exchange rate returns (Baillie et al 2000).

5 The impact of macro announcements on USD/EUR volatility

The impact of macro announcements has been tested earlier. The announcements have been divided by country, real economy versus monetary policy announcements, positive and negative news, etc. The problem with testing for the impact of positive and negative news is that it is common for several macro indicators to be announced at the same time. If some of them are positive and some of them are negative, this gives conflicting indications on future developments for the investors. According to the Damodaran model (1985), investors react to news in different ways depending on how they think the information affects the future payoff of their asset and how big their personal forecast errors were, ie how big a surprise the information was for them. That is why the hypothesis of the impact of conflicting and consistent news is tested. It is hypothesised that if the positive and the negative news are announced at the same time, it increases volatility more than either positive or negative news alone. The forecasting errors and difficulty in estimating the effect of new information on the value of an asset are greater when the news gives conflicting information.

Another hypothesis, which has not been tested before, is the hypothesis of 'no surprise' news. According to the efficient market hypothesis, the news that doesn't surprise markets shouldn't have any effect on asset prices, since the prices have already taken the information into account. The impact of news the forecast of which equals the announcement is tested apart from the news for which the difference between the forecast and actual announcement isn't zero. Also other hypotheses that have been studied before are tested, to see if we get results that are consistent with the earlier studies.

[3] See Andersen, Bollerslev, Diebold and Vega (2004), Kalev, Liu, Pham and Jarnecic (2004) and Bollerslev, Cai and Song (2000).

The tested questions are:

1. *Do macro announcements increase volatility?*
2. *Do 'no-surprise' announcements increase volatility?*
3. *Do announcements from Europe and the USA have different effects?*
4. *Does the negative versus positive news affect volatility differently?*
5. *Does conflicting versus consistent news affect volatility differently?*

5.1 The state of the economy in the United States and Europe

The movement of the USD/EUR exchange rate was quite interesting during the estimation period (28 October 2003 to 20 January 2004) considering the state of the economy in these countries (Figure 1). Economic growth in the US was very strong; in the third quarter of 2003 the annual growth was as high as eight percent. The increasing economic growth came from an expansionary economic policy. The growth was achieved through tax reductions and increased public expenditure due to the war in Iraq. Also the monetary policy of the Fed was more expansionary than the monetary policy of the ECB: the Fed interest rate was as low as one percent, and it wasn't raised even though economic growth had been strong for quite a long time. Although the growth in the US was strong, it didn't seem to be sustainable. Households started to be in debt and even when US competitiveness compared to Europe had increased, the foreign trade deficit did not decrease.

Figure 1. **USD/EUR exchange rate**
28 October 2003 – 20 January 2004

The economy in Europe was recovering little by little. Still, the growth wasn't anything like the growth in the US. In the year 2003 European growth slowed down and was eventually only 0.7%. There seems to have been conditions for faster growth, however. The interest rates were not too high and the financial position of the households was relatively good compared to the position of households in the US. The increase of growth was restrained partly by the strengthening euro, which caused the weakening competitiveness of the euro area. Since the economic growth in the US had been a lot stronger than in Europe for a long time, it is a bit strange that the euro strengthened so much against the dollar. One reason for the strengthening of the euro was the difference in monetary policy among Asia, the euro area and the United States. In the short run, the Fed valued real economy growth more than the ECB did.

In fiscal policy the euro area wasn't strict about stability and growth restrictions. The budget deficits of EMU countries increased, since the policy-makers wanted to avoid slowing down growth by reducing public expenditures. The economic indicators looked promising. The means of the indicators (industry, construction, retail trade, consumer confidence and private services) in December 2003 and February 2004 were higher than the means of the earlier three-month period. Nonetheless the recovery of the European economy was still lower than expected (ETLA, Suhdanne 1/2004; Palkansaajien tutkimuslaitos, Talousennuste, maaliskuu 2004).

5.2 The data

The original data were one-minute frequency transaction price data of the USD/EUR exchange rate from Bloomberg. The observations were the prices of the first transactions in every minute and there were 84 569 observations altogether. The period was from 28 October 2003 to 20 January 2004. The global foreign exchange works 24 hours a day, but at weekends the markets are closed. Due to the lack of observations, the weekends were removed from the data from Friday midnight (GMT) to Sunday midnight. Also the 1 January was dropped due to the lack of observations. Christmas Day was another holiday when the market volume was low. In addition, volatility was a lot lower on Christmas Day. Since there were observations during 25 December, however, Christmas Day was not dropped from the data.

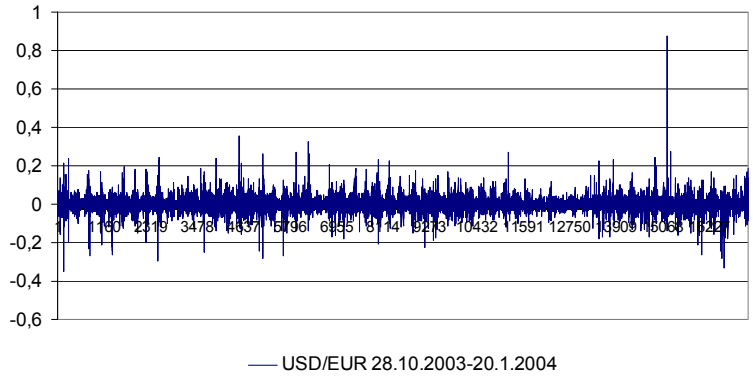
The minute frequency data was transformed to 5-minute data by picking up the price every five minutes starting from midnight. There were altogether 17 195 observations and 60 days in the 5-minute data. If there were no transactions during the one-minute period, the observation was missing. There were 241 missing observations in the 5-minute data. They were replaced by the weighted

average of the previous and following observations and the weight depended on how close those minutes were to the desired observation. The observations were missing usually around midnight (GMT), when the volume of the foreign exchange markets is at its lowest. There was also one longer period of missing observations in the data, which lasted 1.5 hours from 0:10 to 1:50 on 4 November 2003[4]. The missing variables were not replaced and the returns were set at zero. The logarithmic returns were then calculated using equation 5.1.

$$R_t = \ln(P_t / P_{t-1}) \tag{5.1}$$

The USD/EUR return series from the period 28.10.2003–20.1.2004 is presented in Figure 2. The volatility around zero is very high and it lowers for awhile around the 12 500th observations, which indicates the lower volume markets during on Christmas Day. Also small clusters can be noticed in the figure, which indicates the periodical intradaily volatility. There are also big positive and negative jumps in the return series. There aren't any extremely big jumps first in one direction and then immediately after in the opposite direction, however, so it seems that there haven't been any remarkable errors in the price series.

Figure 2. **The five-minute return of the USD/EUR exchange rate**



The biggest jump around the 15 280th observation indicates US macroeconomic news: five US macroeconomic figures were announced just five minutes before that jump. One of them was the unemployment rate in the US, which had decreased more than the markets had expected. The estimations were also made by excluding the biggest jump, but it didn't have an effect to the results. The distribution of financial return series usually has a lot of extra kurtosis compared to the normal distribution, which indicates that there are more large returns

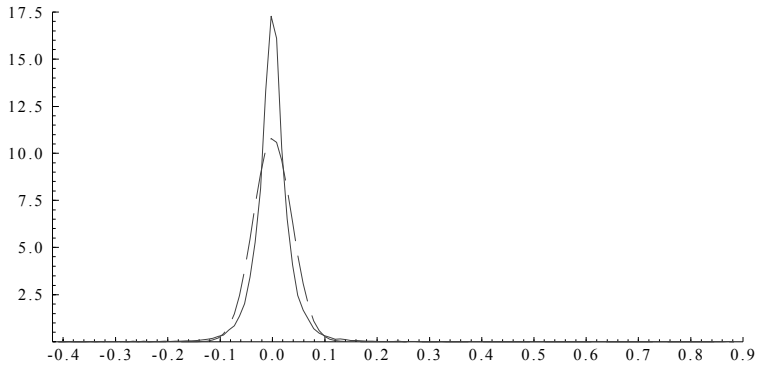
[4] The reason for missing observation period is unknown.

compared to the tails of the normal distribution. The distribution of the USD/EUR returns was also skewed to the positive side, which indicates that there have been more big positive jumps than big negative jumps. The key statistical figures are presented in Table 2 and Figure 3 compares the distribution of returns to the normal distribution.

Table 2. **Key statistical figures**

Observations	17195
Mean	0,00044
Stand. deviation	0,037
Skewness	0,72
Kurtosis	29,8
Minimum	–0,397
Maximum	0,872
Jarque-Bera normality test	Chi^2(2) = 5,1737 e + 005 (0,0000)**

Figure 3. **The distribution of the five-minute returns compared to the normal distribution**



5.3 Intradaily dynamics of volatility

Various kinds of ARCH models have usually been the best for modelling the conditional heteroskedasticity of financial returns. When modelling the intraday returns, the ARCH models don't seem to work at all. This is due to the systematic periodical structure of volatility in the course of a day that ARCH models fail to consider. The return volatility is determined from three components: daily volatility, which depends on time causing conditional heteroskedasticity in the daily data; the intraday volatility pattern, which is caused by different activity periods of global markets in the course of a day; and some other determinants, for example new information (Andersen and Bollerslev 1997).

To be able to investigate the intradaily dynamics of the USD/EUR returns, the observations were divided into 5-minute intervals, totalling 288 in 24 hours. The average returns of each interval are presented in Figure 4. While the average return of the whole data was 0.004, it should be noticed that especially in the intervals 175–210 this average is under and overdrawn many times. These intervals are from the period 15:00–17:30 (GMT), so presumably these intervals are also the most active hours on the market. This is partly the reason why the volatility is higher during these hours. Also the average return of the first interval is quite different compared to other intervals. The jump probably is caused by the weekend breaks in the data: the difference between the Friday 23:55 and Monday 00:00 prices might be quite big.

The absolute returns are usually used to describe the volatility of the returns. Figure 5 presents the average absolute returns of the 288 five-minute intervals. The intraday volatility structure, which depends of the time of day, can be seen in this figure. There is again a big jump in the first interval due to the weekend breaks in the data. If we follow the schedules of the global foreign exchange market, we get the explanations for the levels of volatility in the different hours of the day. The Far East markets open around the interval 12 (23:00 GMT) and this causes a small increase in the volatility. After this the volatility decreases and is at its lowest around the intervals 72 to 84 (04:00–06:00 GMT), when Hong Kong and Tokyo take their lunch hours. At 7:00 GMT (interval 108) the Europe market opens and that increases the volatility significantly. The volatility declines around the interval 156 (11:00 GMT because Europe is enjoying its lunch).

After the interval 190 (14:00 GMT), when the US markets open and Europe has its most active hours, the volatility reaches its highest level. The volatility starts to decline slowly after the interval 228 (17:00 GMT), when the Europe market closes. The volatility stays low until around midnight, when the Far East markets open up. The structure of volatility is consistent with other similar studies. The same periodicals are observed in a study by Andersen and Bollerslev (1997): ‘Intraday periodicity and volatility persistence in financial markets’. The lunch hours of Tokyo and Hong Kong cause a bigger decline in volatility in their data, but other than that, the pattern is the same. Also the magnitude of the volatility is almost the same in these data as in the data of Andersen and Bollerslev. The lowest and the highest values of volatility are around 0.01 and 0.06%, respectively.

The intraday dynamics of returns can be studied also by calculating the autocorrelation function of the returns. If we draw a graph of autocorrelation coefficients against the lags, we get an autocorrelogram. We can see from Figure 6 that the autocorrelogram of the returns seems to be random. The first lag is significantly negatively autocorrelated, which is normal for financial return series. There are also other lags that cross the line of significance, but there is no systematic periodicity in the autocorrelation coefficients.

Figure 4. **The average returns of 288 five-minute intervals**

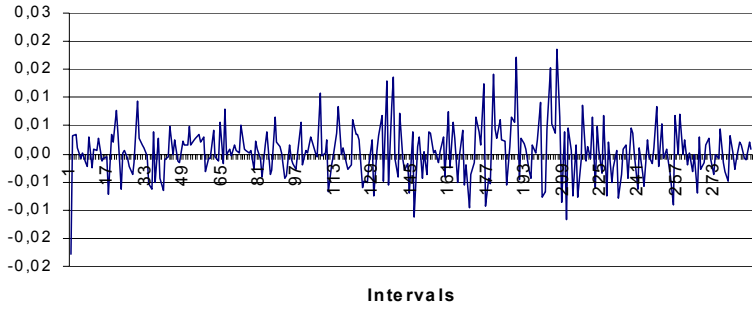
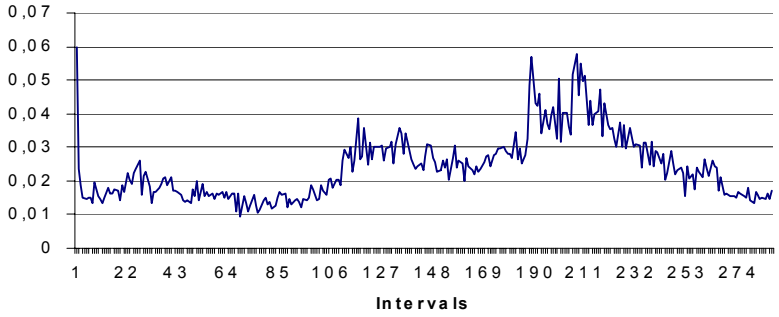


Figure 5. **The average absolute returns of the 288 five-minute intervals**



The autocorrelation coefficient of absolute returns represents the autocorrelation structure of return volatility. Figure 7 presents the autocorrelation coefficients of 288 five-minute lags, ie the autocorrelogram for one day. The U-shape pattern can be clearly seen in the graph. If we draw the correlogram for 1500 lags, we get the autocorrelogram for five days (Figure 8). As can be seen, the U-shape pattern is repeated almost identically every day. This kind of systematic periodicity is the reason for the failure of modelling intraday returns with ARCH models (Andersen and Bollerslev 1997). The assumptions of ARCH models require the rapid reduction of the autocorrelation structure. The GARCH models can deal better with the persistence of the autocorrelation, but they cannot work with this kind of periodicity either. To be able to use GARCH models, we would have to filter the intraday dynamics from the returns first.

Figure 6. **The autocorrelation coefficients for the 1500 lags of USD/EUR returns**

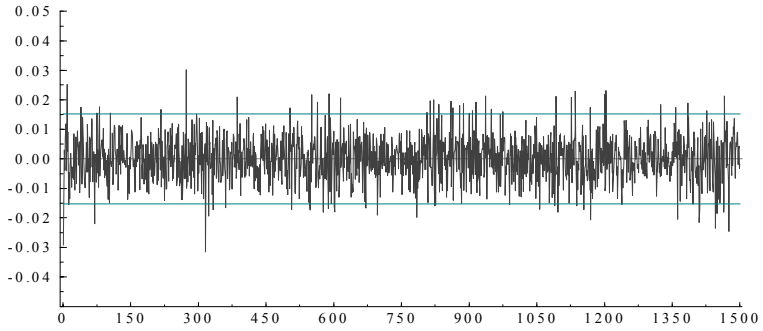


Figure 7. **The autocorrelation coefficients for the 288 lags of USD/EUR absolute returns**

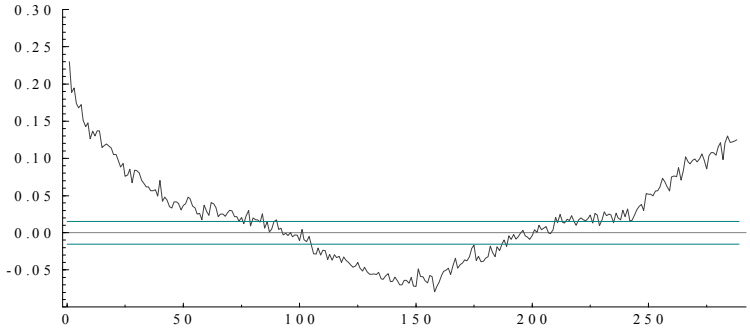
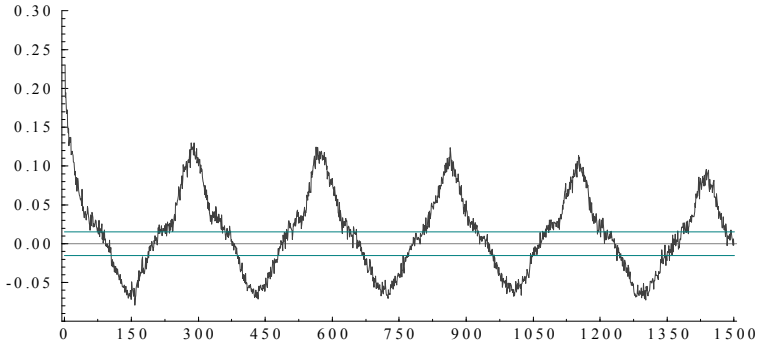


Figure 8. **The five-day correlogram of the absolute return autocorrelation coefficients**



5.4 Flexible Fourier Form method

Andersen and Bollerslev (1997) developed a method to model the periodical intraday structure of volatility. They divided the volatility into three components: the daily volatility component, the intradaily volatility component and the random error term, which is identically and independently distributed with a mean of zero and a variance of 1. Equation 5.2 defines the components of the returns. (d = day, n = interval)

$$R_{d,n} = E(R_{d,n}) + \frac{\sigma_d s_{d,n} Z_{d,n}}{N^{1/2}} \tag{5.2}$$

The return is then determined by the expected value and the error term, which can be divided into these three components. By taking the logarithm we get

$$2\ln\left|R_{d,n} - E(R_{d,n})\right| - \ln\sigma_d^2 + \ln N = \ln s_{d,n}^2 + \ln Z_{d,n}^2 = x_{d,n} \tag{5.3}$$

When the expected return is replaced by the mean return and the daily volatility is estimated with the GARCH(1,1) model (with daily returns formed from the intradaily returns), the x (equation 5.3) can be estimated with ordinary least squares. The left-hand side of the equation is then the absolute value of the difference between the return and the average return eliminated by daily volatility. There are two terms on the right-hand side. The first is the component of the intradaily volatility and the other term is the error term, which includes the extra volatility of the markets, for example the volatility caused by new information.

$$x_{d,n} = 2\ln\frac{\left|R_{d,n} - \overline{R}\right|}{\hat{\sigma}_d / N^{1/2}} = \ln s_{d,n}^2 + \ln Z_{d,n}^2 \tag{5.4}$$

We can then denote

$$x_{d,n} = f(\theta;\sigma_d, n) + u_{d,n} \tag{5.5}$$

Andersen and Bollerslev state that since the variability during the day is so systematic, the intradaily dynamics of absolute returns can be estimated by using the sine and cosine functions.

$$f(\theta;\sigma_t,n)=2\ln\frac{|R_{t,n}-\bar{R}|}{\hat{\sigma}_t/N^{1/2}}=\left[c+\sum_{k=1}^{D}\lambda_k I_k(t,n)+\delta_{0,1}\frac{n}{N_1}+\delta_{0,2}\frac{n^2}{N_2}+\sum_{p=1}^{p}\left(\delta_{c,p}\cos\frac{p2\pi}{N}n+\delta_{s,p}\sin\frac{p2\pi}{N}n\right)\right] \tag{5.6}$$

where $N_1 = (N+1)/2$ and $N_2 = (N+1)(N+2)/6$ are normalizing constants, $\hat{\sigma}_d$ is the estimated daily volatility, N is the number of intervals in one day (in the five-minute data N is 288), n is the interval and I_k are the indicator variables, which can be used for inserting day-of-the-week dummies or other special occasions into the model.

Andersen and Bollerslev (1997) found that p = 6 gives the best fit to the model. According to Akaike information criteria, p = 6 is the best choice also for this data. (p = 3…6 was tested, also p = 4 has been used in many studies) When $\hat{f}_{t,n}$ has been estimated, the intradaily volatility component $\hat{s}_{t,n}$ can be calculated with the equation 5.7, where T is the total number of observations in the data. With this equation we get the scale for $\hat{s}_{t,n}$ to be close to unity.

$$\hat{s}_{t,n}=\frac{T\cdot\exp\left(\hat{f}_{t,n}/2\right)}{\sum_{t=1}^{[T/N]}\sum_{n=1}^{N}\exp\left(\hat{f}_{t,n}/2\right)} \tag{5.7}$$

We get the filtered return then by dividing the original return by the intradaily volatility component (equation 5.8). Since the scale of $\hat{s}_{t,n}$ is close to unity, the consequence of the filtering is increasing volatility in the low volatility periods of the day and decreasing volatility in the high volatility periods. We divide away the daily seasonality of the volatility, but other than that the returns remain the same.

$$\tilde{R}_{t,n}\equiv R_{t,n}/\hat{s}_{t,n} \tag{5.8}$$

The following coefficients (5.9) were estimated for the sine and cosine variables. The standard error is in the brackets below the coefficient. Martens, Chang and Taylor (2002) tested different methods of modelling intraday volatility. They also tested how the different methods affect the forecasting power of GARCH models. According to their results, the FFF method is very suitable for filtering intraday volatility.

$$\hat{f}_{t,n} = \begin{bmatrix} \underset{(1.36)}{4.19} - \underset{(4.05)}{16.4}\frac{n}{N_1} + \underset{(0.009)}{0.04}\frac{n^2}{N_2} \\ - \underset{(0.81)}{3.77}\cos\frac{n2\pi}{N} - \underset{(0.08)}{0.88}\sin\frac{n2\pi}{N} - \underset{(0.21)}{0.92}\cos\frac{2n2\pi}{N} + \underset{(0.05)}{0.03}\sin\frac{2n2\pi}{N} \\ - \underset{(0.09)}{0.48}\cos\frac{3n2\pi}{N} + \underset{(0.04)}{0.34}\sin\frac{3n2\pi}{N} - \underset{(0.06)}{0.27}\cos\frac{4n2\pi}{N} - \underset{(0.03)}{0.22}\sin\frac{4n2\pi}{N} \\ - \underset{(0.04)}{0.18}\cos\frac{5n2\pi}{N} - \underset{(0.03)}{0.01}\sin\frac{5n2\pi}{N} - \underset{(0.04)}{0.15}\cos\frac{6n2\pi}{N} - \underset{(0.03)}{0.04}\sin\frac{6n2\pi}{N} \end{bmatrix} \quad (5.9)$$

Figure 9 presents the five-day autocorrelogram of raw and filtered returns. As we can see, the filtered returns don't have the systematic periodicity in the autocorrelation structure. Figure 10 presents the average absolute returns compared to the estimated fitted values we get from the Flexible Fourier Form equation. We can see that the model is capable of capturing the average volatility pattern quite satisfactorily.

Figure 9. **The five-day correlogram of the raw and filtered return autocorrelations**

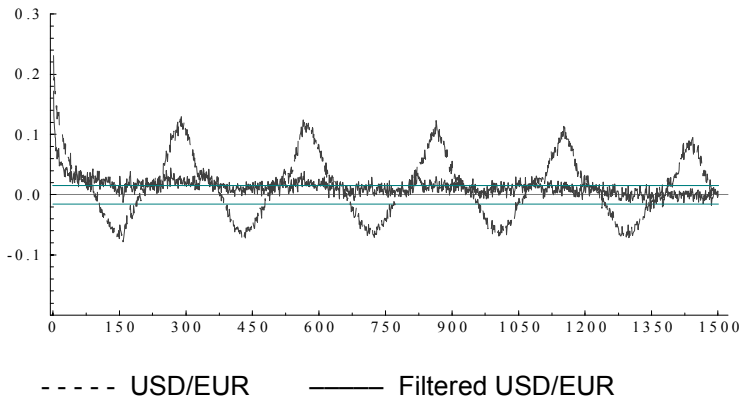
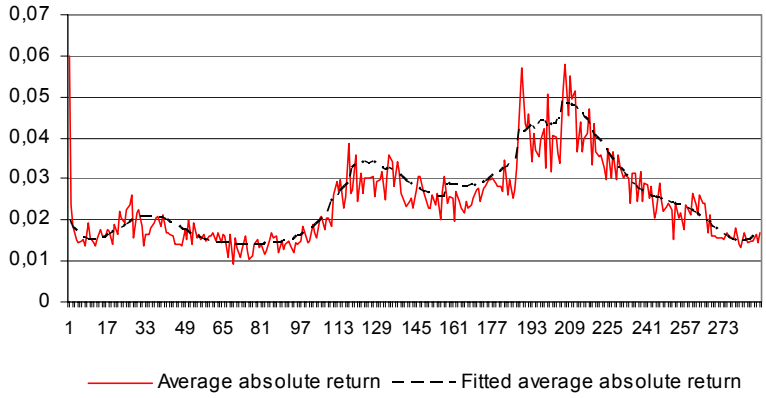


Figure 10. **The average absolute return compared to the estimated fit from the FFF-model (the news included)**



5.5 Macro announcements

The announcements were collected from the Bloomberg WECO (World Economic Calendar); they are the macroeconomic indicators the announcement day and time of which is known beforehand. Bloomberg has collected a survey of market participants' expectations of future macro figures and the expectation of the market is taken as the median of participants' forecasts. The forecast is available only for some of the announcements. The announcements are from the USA, Germany and France. There are also announcements published by the ECB concerning the whole euro area.

Appendix 1 presents an example of the original news data. The accuracy of the announcement moment is to one minute. The second column shows the country that the announcement concerns, the third and the fourth columns show the indicator and the time period and the last four columns show the Bloomberg survey forecast, the actual announcement, the previous month's announcement, and the revised announcement, respectively. The last column is the difference between the forecast and the actual announcement.

There were altogether 585 announcements during the estimation period. The Bloomberg forecast was available for 379 announcements. Since many of the macro indicators are announced at the same time, the actual number of moments when the indicators were announced was a lot smaller. There were altogether 262 announcement moments in the data. The announcement moments for which there was also a forecast available totalled 172. A summary of the number of announcements is presented in Table 3, and all the announcements and the number of observations are listed in Appendix 2.

Table 3. **The number of announcements**

	observations
Announcements	585
Announcements with forecast	379
Announcements moments	262
Announcements moments with a forecast	172
Moments when more than one macro indicator is announced	149

Table 4 presents the number of announcements by country. Most of the news was announced by the ECB concerning the macro indicators for the whole euro area. The ECB announced 174 macro indicators during the estimation period. 165 announcements concerned the US economy, and the number of announcements from Germany and France were 158 and 88, respectively.

The hypotheses (p. 11) were tested with different models. The news was included in the FFF model (5.6) with indicator variables I_k. Table 5 summarizes the number of observations in different announcement variables. The variable ALL1 contains all the moments at which there was a macro announcement. ALL1 contains all the news, including the news for which the preceding forecast equals the announcement. ALL1 contains also the news that didn't have a forecast available. The variables US, EC, GE and FR contain the announcements from the USA, ECB, Germany and France.

The variable ZERO contains the 'no-surprise' news, and ALL2 contains all the news except the news the forecast of which equals the announcement. PNEWS contains the positive and NNEWS the negative news in terms of whether the markets were expecting the value of an indicator to be lower or higher. The variable CONS contains all the moments at which the announced news was consistent, ie the news items were either all positive or all negative. CONF contains all the news moments that gave conflicting information on the state of the economy, ie both positive and negative news appeared at the same time.

Table 4. **The number of announcements by country/area**

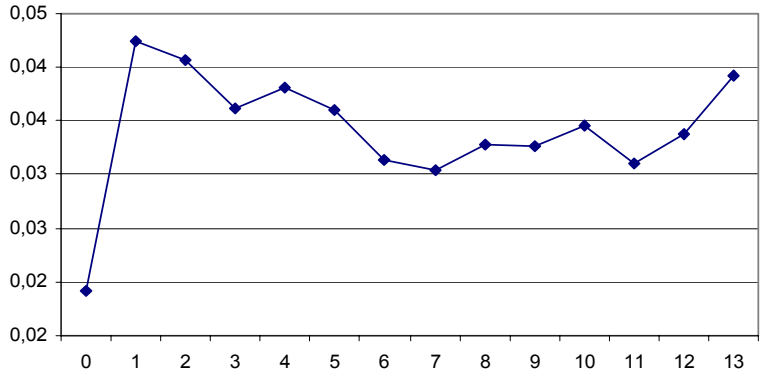
	observations
USA	165
Germany	158
France	88
ECB	174
Altogether	585

Table 5. **The number of observations in different announcement variables**

Model	Variable	Observations
1	ALL1	262
2	US	74
	ECB	72
	GE	72
	FR	44
3	ALL2	243
	ZERO	19
4	PNEWS	61
	NNEWS	61
5	CONS	141
	CONF	31

Figure 11 presents the average impact of the news. The absolute return of all the news moments t was collected. The absolute returns of the following 12 moments after the news moment t (t+1, t+2,…,t+12) were also collected. The average return was then calculated for each of the 12 intervals after the news announcement. The impact of the news on volatility is the strongest in the first five-minute period after the announcement (t+1). The average absolute return 5 minutes after the news announcements is about 0,045%, while the average absolute return of the whole data was 0,024%. It seems then that macro news increases volatility. The average absolute returns seem to decline quite smoothly during 12 five-minute intervals (1 hour) after the big jump in the first interval after the announcement. Even the volatility declines, though it stays higher than the average volatility for the whole hour.

Figure 11. **The average absolute return after the news announcement**
(the announcement is published at t = 0)



5.6 The results

The news was included in the model in two ways. In the first method the news was added to the FFF-model by the dummy method, and the immediate impact after the announcement was tested (at the moment t+1 when the news was announced at the moment t). The impact of the news has been reported to last approximately one hour (for example, see Ederington and Lee 1993). The second method was to test the impact at the moment t+1, but take the whole impact during the hour following the announcement into account.

The announcements were divided into groups in order to test different hypotheses. The five hypotheses were tested with five models. The first model tested the impact of the news in general and contained the indicator variable ALL1. The second model tested the impact of 'no-surprise' news and contained two indicator variables: ALL2 and ZERO. The third model tested the news by country. The fourth model tested the impact of positive and negative news. The last model tested if the consistent and conflicting types of news have a different kind of impact on volatility.

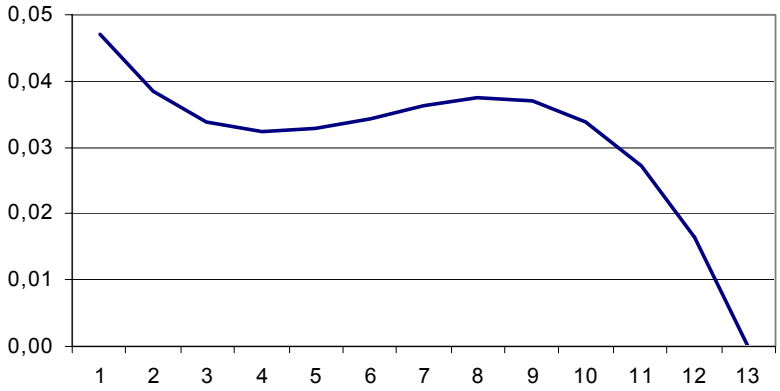
Table 6 presents the coefficients of the different indicator variables of the five models when the news has been added to the model by dummy method. The impact on the volatility M_k can be calculated with equation 5.10, where λ_k is the coefficient of the indicator variable.

$$M_k = \exp(\frac{\lambda_k}{2}) - 1 \tag{5.10}$$

To be able to capture the impact for an hour after the announcement, Andersen and Bollerslev (1998) estimated the path of the news impact on volatility. They created a third-order polynomial (equation 5.11), and estimated the average impact of the news (Figure 11) using this polynomial as variables. The impact of the news is forced to zero after one hour (interval 13). Figure 12 presents the fit of the estimated polynomial 5.11, ie the impact of the news for the intervals 1–13 after the announcement.

$$\begin{aligned}\gamma(i) = {} & 0.06(1-(i/13)^3) - 0.016(1-(i/13)^2)\cdot i \\ & + 0.0029(1-(i/13))\cdot i^2 \quad i = 1,2,...,13\end{aligned} \tag{5.11}$$

Figure 12. **Estimated impact of news during 13 five-minute intervals**



In this case the indicator variable I_k is not a dummy variable, but gets the value of estimated $\gamma(i)$ in the intervals $i = 1,2,\ldots,13$ after the first 13 intervals after the announcement. The impact on volatility can then be calculated with equation 5.12 for every 13 intervals separately. Table 7 presents the coefficients of all the indicator variables in five models. The impact is calculated only for the immediate impact, so that the results can be compared with the other method.

$$M_k = \exp\left(\frac{\lambda_k \cdot \gamma(i)}{2}\right) - 1 \qquad (5.12)$$

5.6.1 The impact of the news in general

The first model tested the impact of macro news in general. According to the results, the announcement of the macro indicators increases the volatility of the foreign exchange market significantly. The impact was tested in two ways. The first method tested only the immediate response to volatility five minutes after the announcement, and the other method assumed that the impact of the announcement on volatility lasts one hour. The announcements increased the volatility by a statistically significant amount under both methods.

Table 6. **The immediate impact of announcements on volatility using the dummy method**

Model	Variable	Coefficient λ_k	Standard error	t-value	Impact M_k
1	ALL1	0,4209	0,164	0,010	0,23
2	ALL2	0,3925	0,175	0,025	0,22
	ZERO	0,9629	0,599	0,108	0,62
3	US	1,0049	0,307	0,001	0,65
	GE	0,1766	0,309	0,568	0,09
	FR	0,4123	0,398	0,300	0,23
	EC	0,0664	0,310	0,830	0,03
4	PNEWS	0,3009	0,335	0,369	0,16
	NNEWS	0,3086	0,335	0,358	0,17
5	CONS	0,4026	0,222	0,069	0,22
	CONF	1,9981	0,470	0,000	1,72

Table 7. **The immediate impact of the announcements on volatility when the impact is assumed to last one hour**

Model	Variable	Coefficient λ_k	Standard error	t-value	Impact M_k
1	ALL1	7,9855	1,792	0,000	0,21
2	ALL2	7,5589	1,835	0,000	0,19
	ZERO	14,3395	6,168	0,020	0,40
3	US	23,7755	2,979	0,000	0,75
	GE	0,7495	2,937	0,799	0,02
	FR	0,8836	4,080	0,829	0,02
	EC	-2,8461	2,873	0,322	-0,06
4	PNEWS	3,1559	2,970	0,288	0,08
	NNEWS	8,0507	3,549	0,023	0,21
5	CONS	8,2424	2,431	0,001	0,21
	CONF	17,5946	4,496	0,000	0,51

5.6.2 The impact of 'no-surprise' news

The second model tested the impact of announcements that didn't surprise the market, since the announcement equalled the market forecast. Both of the methods found the coefficients of the ZERO indicator variables to be positive. However, the immediate impact was not found to be significant. When the impact was assumed to last one hour, the variable ZERO became significant. The coefficient of the indicator variable ZERO is quite high, but the standard error is also quite high. The number of 'no-surprise' news items was seemingly low in this data. That is why this hypothesis would be interesting to test with a longer data set to confirm the results.

5.6.3 The impact of US, German, France and euro-area news

The reaction to news from different countries was also tested. According to the results, only the news from the USA increased volatility significantly. Other studies have also found US macro news to have a bigger impact than European news (for example, Andersen et al 2003). One reason for this is the regularity of macro announcements in the USA compared to the ones from Europe. The other result from the previous studies has been that the significant announcements from the USA are the real economy indicators (especially the unemployment report), while the most significant European news comes from monetary policy. During the estimated period the monetary policy of the ECB has not been very aggressive, which can be seen also from the results. The German and French macro indicators increased volatility more than the announcements of the ECB, and when the impact of an announcement was assumed to last one hour, the ECB announcements seemed to decrease volatility in the markets. The same kind of result was obtained by Melvin and Yin (2000). They found that during the period of their data the Fed's monetary policy target was to stabilize the financial markets, which seemed to have worked since the impact of news from the Fed had decreased the volatility.

5.6.4 Positive vs negative news and consistent vs conflicting news

The differences in the impact of positive and negative news were also tested. If we compare the immediate response coefficients we can't really notice any difference between the impacts of positive and negative news. Both of the coefficients are positive and not significant and the values are almost the same. When we compare the results where the impact lasts one hour, we can see that there has not been much change in the coefficient for positive news. It is still not significant, and the t-value and the value of the coefficient have not changed much either. When we check negative news, the changes are more dramatic. The negative news seems to increase volatility a lot more than the positive news and the coefficient is statistically significant. This indicates that there is a difference between the impact of positive and negative news. Negative news increases volatility more than positive news, but the impact is not so big immediately, rather decaying slowly.

This hypothesis has been tested by many previous authors and the results have been similar. It is still quite difficult to divide the news into positive and negative news, since so many announcements are published at the same time. If there is more than one macro indicator published at the same time, and some of the news is positive and some negative, the news has to be eliminated from the data. This is why the hypothesis of conflicting and consistent news was tested. The

announcements were divided into two groups: the first contained all the moments when the announced news was consistent, ie it was either positive or negative and the second contained all the news moments which gave conflicting information on the state of the economy, ie both kinds of news, the positive and the negative, were announced at the same time.

According to the results, conflicting news increases volatility statistically significantly more than consistent news. The result is consistent across both the methods. If the impact is assumed to last one hour, the immediate impact of conflicting news is twice as high as consistent news. When testing only the immediate response, the impact of conflicting news is even higher compared to consistent news. As the impact of positive and negative news was tested, it has to be remembered that all the announcements included in this estimation would be included in a consistent news variable. The result of testing the conflicting information may help to understand why the impact of positive and negative news seemed to be so insignificant.

6 Conclusions

This study investigated the micro characteristics of exchange rates: the intradaily periodicity of volatility and the impact of new information on volatility. The impact of macroeconomic indicators on return volatility was tested in five-minute frequency data. The exchange rate was USD/EUR and the news comprised macro indicators announced by the US, Germany, France and the ECB. The tested period was from 28 October 2003 to 20 January 2004. The strong intradaily periodicity in the autocorrelation, caused by different activity periods of global markets during the day, was found. To be able to test other determinants of volatility, the cyclical periodicity has to be modelled. Since the periodicity is almost constant between the days, it can be filtered out by using the sine and cosine functions. The method is called the Flexible Fourier Form and it was introduced by Andersen and Bollerslev in 1997.

Since the period of the data was only three months, studying the indicators one by one would not have been reasonable. Instead, the announcements were divided into different groups and the differences in the impact of these groups were then tested. According to the results, the announcement of macro indicators increases return volatility of the US dollar and the euro. The first model tested the news in general, and the coefficient was found to be positive and statistically significant. The other model tested the hypothesis of ‘no-surprise’ news. According to the efficient market hypothesis only the news that differs from the market forecast should have an impact on asset prices. The results of this study suggest that also ‘no-surprise’ news increases volatility. (It should though be

remarked that there were few zero-news items, and therefore this hypothesis should be tested with a larger data set.)

When the announcements were tested by country, only US macro indicators were significant. Of European macro indicators, ECB news had the weakest impact on volatility. If the impact were assumed to last one hour, ECB news seemed to decrease volatility. This can be understood when the macroeconomic situation of Europe and the USA is compared during the estimation period. Although economic growth in Europe has been sluggish for some time, the monetary policy of the ECB hasn't been very aggressive. In contrast, economic growth in the USA in the estimation period was quite rapid, although not sustainable. Both US fiscal and monetary policy boosted growth during the estimation period. Compared to the situation in the USA, there weren't very surprising elements in the European economy. Although the economic situation seemed to be good in the USA, it increased uncertainty in the markets.

This study supports the argument, that the impact of negative news is stronger than the impact of positive news. According to the results, negative news increases volatility more than positive news. The most significant result of this study was achieved with another hypothesis, though. According to the model developed by Damodaran (1985), volatility is partially caused by mistakes of investors when estimating the impact of new information on future asset returns. If some of the news is indicating the recovery of economic growth and some is not, the mistakes of the investors could be larger and the volatility after the news higher. The hypothesis of consistent and conflicting news was tested, and according to the results, the news that gives conflicting information on the state of the economy increases volatility significantly more than the news that gives consistent information.

Even when the impact of the news on volatility was statistically significant, the explanatory power of the model remains quite low; about 7.5%. Although the intradaily volatility caused by global market volume is also taken into account, there is still a lot of unexplained volatility in the returns. Macroeconomic announcements are only one piece of information hitting financial markets. There exists new information in the markets all the time: news, comments by analysts, the opinions of the practitioners, and private information. Even if all the new information were included in the model, the volatility in the markets could hardly be modelled completely.

Even if investors could use all the relevant information, they would make mistakes when valuing the impact of the information on the value of an asset. Even if investors were totally rational and would value the impact correctly, the information in the market is not perfect. Damodaran (1985) Moreover, the information is neither free nor totally available to all the investors. One reason investigating the macro news is interesting is that it should be available quite easily to all investors. Besides the imperfect information, the volatility is caused

by bounded rationality and the heterogeneous motives of the market agents (Admati and Pfleiderer 1988). Also trading strategies differ between the agents and some of the actions of investors are driven by psychological behaviour (Veronesi 1999).

New aspects of the determination of price volatility were discovered in this study, but there are still many interesting questions to be answered. It would be desirable to test the hypotheses with a longer data set. The economic situation in the countries did not change much during the three-month period. The hypotheses would be interesting to test with data that includes different parts of a business cycle. The 'no-surprise' news hypothesis would be interesting to test also with different zero-news variables, and test by exploring how a small surprise can be thought of as a 'no-surprise'. This is relevant also from the point of view of monetary or exchange rate policy, since according to results of this study a forex market action by the central bank can contribute to exchange rate volatility, even if deemed 'neutral' or well in line with expectations.

An interesting testable implication of an underlying theory is associated with investor conservatism (Barberis et al 1998). The theoretical literature suggests that investors underreact to news in the short run and overreact to them in the long run. In the model investors value an asset by referring to different 'pricing regimes'. The first is the trend regime and the second is the mean reverting regime. If positive (or negative) news comes to the market one after another, the probability of being in the trend regime increases. Vice versa, if there is both negative and positive news, the probability of being in the mean reverting regime increases. This causes trends in the long run and volatility in the short run. More interestingly, it generates autocorrelated changes in the underlying assets over relevant horizons. Hence, this hypothesis may contribute to explaining the observed high autocorrelation in nominal and real exchange rates. This implication of the theory could be tested by comparing news of the macro indicators which give either positive or negative news in a row and the macro indicators which give positive and negative signals in turns.

References

Admati, A. – Pfleiderer, P. (1988) **A theory of Intraday Patterns: Volume and Price Variability.** The Review of Financial Studies, Vol. 1, 3–40.

Aggarwal, R. – Schirm, D. (1992) **Balance of Trade Announcements and Asset Prices: Influence on Equity Prices, Exchange Rates, and Interest Rates.** Journal of International Money and Finance, Vol. 11, 80–95.

Almeida, A. – Goodhart, C. – Payne, R. (1998) **The Effects of Macroeconomic News on High Frequency Exchange Rate Behavior.** The Journal of Financial and Quantitative Analysis, Vol. 33, 383–408.

Andersen, T. – Bollerslev, T. (1997) **Intraday periodicity and volatility persistence in financial markets.** Journal of empirical finance, Vol. 4, 115–159.

Andersen, T. – Bollerslev, T. (1998) **Deutsche Mark-Dollar Volatility: Intraday Activity Patterns, Macroeconomic Announcements, and Longer Run Dependencies.** The Journal of Finance, Vol. 53, 219–265.

Andersen, T. – Bollerslev, T. – Diebold, F. – Vega, C. (2003) **Micro Effects of Macro Announcements: Real-Time Price discovery in Foreign Exchange.** American Economic Review, Vol. 93, No. 1.

Andersen, T. – Bollerslev, T. – Diebold, F. – Vega, C. (2004) **Real-Time Price Discovery in Stock, Bond and Foreign Exchange Markets.** PIER Working Paper 04-028.

Baillie, R. – Humpage, O. – Osterberg, W. (2000) **Intervention from an information perspective.** Journal of International Financial Markets, Institutions and Money, Vol. 10, 407–421.

Barberis, N. – Schleifer, A. – Vishny, R. (1998) **A model of investor sentiment.** Journal of Financial Economics, Vol. 49, 307–343.

BIS (2002) **Triennial Central Bank survey, Foreign exchange and derivatives market activity in 2001.**

Bollerslev, T. – Cai, J. – Song, F.M. (2000) **Intraday periodicity, long memory volatility, and macroeconomic announcement effects in the US Treasury bond market.** Journal of Empirical Finance, Vol. 7, 37–55.

Bollerslev, T. – Chou, R.Y. – Kroner, K.F. (1992) **ARCH modelling in finance.** Journal of Econometrics, Vol. 52, 5–59.

Chang, Y. – Taylor, S. (2003) **Information arrivals and intraday exchange rate volatility.** International Financial Markets, Institutions and Money, Vol. 13, 85–112.

Chan, Y. – Chui, A. – Kwok, C. (2001) **The impact of salient political and economic news on the trading activity.** Pacific-Basin Finance Journal, Vol. 9, 195–217.

Damodaran, A. (1985) **Economic Events, Information Structure, and the Return-generating Process.** The Journal of Financial and Quantitative Analysis, Vol. 20, No. 4.

Daniel, K. – Hirshleifer, D. – Subrahmanyam, A. (1998) **Investor Psychology and Security Market under- and Overreactions.** The Journal of Finance Vol. 53, 1839–1885.

Eddelbüttel, D. – McCurdy, T. (1998) **The Impact of News on Foreign Exchange Rates: Evidence from High Frequency Data.** Manuscript Rotman School of Management, University of Toronto.

Ederington, L.H. – Lee, J.H. (1993) **How Markets Process information: News Releases and Volatility.** The Journal of Finance, Vol. 48, 1161–1191.

Ehrmann, M. – Frazcher, M. (2002) **Interdependence between the euro area and the US: What role for EMU?** ECB Working Paper No. 200.

Fama, E. (1970) **Efficient Capital Markets: A Review of Theory and Empirical Work.** Journal of Finance, Vol. 25, 383–417.

Farmer, D. – Joshi, S. (2002) **The price dynamics of common trading strategies.** Journal of Economic Behavior & Organization, Vol. 49, 149–171.

Goodhart, C. – Hall, S. – Henry, S. – Pesaran, B. (1993) **News Effects in a High-Frequency Model of the Sterling-Dollar Exchange Rate.** Journal of Applied Econometrics, Vol. 8, 1–13.

Kalev, P. – Liu, W. – Pham, P. – Jarnecic, E. (2004) **Public information arrival and volatility of intraday stock returns.** Journal of Banking & Finance, Vol. 28, 1441–1467.

Malkiel, B. (2003) **The Efficient Market Hypothesis and Its Critics.** Princeton University CEPS Working Paper No. 91.

Martens, M. – Chang, Y-C. – Taylor, S. (2002) **A comparison of seasonal adjustment methods when forecasting intraday volatility.** Journal of Financial Research, Vol. 25, 283–299.

Meese, R.A. – Rogoff, K. (1983) **Empirical exchange rate models of the seventies: do they fit out of sample?** Journal of International Economics Vol. 14, 3–24.

Melvin, M. – Yin, X. (1998) **Public Information Arrival, Exchange Rate Volatility and Quote Frequency.** Arizona State University, American Express Company.

Melvin, M. – Yin, X. (2000) **Public Information Arrival, Exchange Rate Volatility and Quote Frequency.** Economic Journal 110(465), p. 644.

Palkansaajien tutkimuslaitos, Talousennuste, maaliskuu 2004.

OECD Outlook 2003.

Suhdanne 1/2004 ETLA.

Veronesi, P. (1999) **Stock Market Overreaction to Bad News in Good Times: A Rational Expectations Equilibrium Model.** The Review of Financial Studies, Vol. 12, 975–1007.

Appendix 1

An example of original announcement data

Time	Country	Indicator	Month	Bloomberg survey	Announ-cement	Previous	Revised	Difference
10.12.2003 9:00	GE	Exports SA (MoM)	October	-1,00%	-6,60%	5,30%	4,30%	-5,60%
10.12.2003 9:00	GE	Wholesale price index (Mom)	November	0,00%	-0,10%	0,10%	NA	-0,10%
10.12.2003 9:00	GE	Wholesale price index (YoY)	November	1,50%	1,50%	0,80%	NA	0,00%
10.12.2003 9:00	GE	Imports SA (MoM)	October	1,60%	1,60%	1,20%	0,40%	0,00%
10.12.2003 9:00	GE	Current Account (EURO)	October	8	6,3	9,3	9,4	-1,7
10.12.2003 9:00	GE	Trade balance	October	13,9	10,8	14,3	NA	-3,1
11.12.2003 9:00	ECB	New Car Registration (YoY)	November	NA	-1,00%	-0,10%	NA	NA
11.12.2003 9:00	ECB	EU-15 New Car Reg. (YoY)	November	NA	-1,20%	-0,20%	NA	NA
11.12.2003 9:00	ECB	W. European New Car Reg. (YoY)	November	NA	-1,10%	-0,30%	NA	NA
11.12.2003 9:00	GE	Consumer price index (MoM)	November	NA	-0,20%	0,00%	NA	NA
11.12.2003 9:00	GE	Consumer price index (YoY)	November	NA	1,30%	1,20%	NA	NA
11.12.2003 9:00	GE	CPI – EU Harmonised (MoM)	November	NA	-0.20%	-0,10%	NA	NA
11.12.2003 9:00	GE	CPI – EU Harmonised (YoY)	November	NA	1,30%	1,10%	NA	NA
11.12.2003 9:45	FR	Non-Farm Payrolls (QoQ)	3Q	0,00%	-0,10%	0,00%	0,10%	-0,10%
11.12.2003 9:50	FR	Consumer price index (MoM)	November	0,10%	0,10%	0,30%	NA	0,00%
11.12.2003 9:50	FR	Consumer price index (YoY)	November	2,30%	2,30%	2,20%	NA	0,00%
11.12.2003 11:00	ECB	ECB to Release December Monthly Report	December	NA	NA	NA	NA	NA
11.12.2003 15:30	US	Import price index (MoM)	November	0,20%	0,40%	0,10%	0,00%	0,20%
11.12.2003 15:30	US	Advance Retail Sales	November	0,70%	0,90%	-0,30%	0,00%	0,20%
11.12.2003 15:30	US	Retail Sales Less Autos	November	0,30%	0,40%	0,20%	0,40%	0,10%
11.12.2003 15:30	US	Initial Jobless Claims	December	358	378	365	NA	20
11.12.2003 15:30	US	Continuing Claims	November	3399	3346	3385	3335	-53
11.12.2003 17:00	US	Business Inventories	October	0,20%	0,40%	0,30%	0,40%	0,20%
12.12.2003 9:45	FR	Trade Balance (Euros)	October	1100	329	922	711	-771

Source: Bloomberg World Economic Calendar

Appendix 2

All the announcements and the number of observations

Country	Indicator	Observations
ECB	3rd Quarter Production in Construction	1
ECB	Austrian Economic Outlook	1
ECB	BME/Reuters Purchasing Managers' Index (Manufacturing)	3
ECB	BME/Reuters Purchasing Managers' Index (Services)	3
ECB	Business Climate Indicator	3
ECB	ECB Announces Interest Rates	3
ECB	ECB Euro-Zone Current Account SA	2
ECB	ECB to Release December Monthly Report	1
ECB	ECB to Release November Monthly Report	1
ECB	ECB Vari. Rate Refinance Auct.	12
ECB	ECB Weekly Currency Reserves	13
ECB	ECB Wkly Fin. Statement - Bal.	13
ECB	ECB's Liebscher Speaks to Journalists in Vienna	1
ECB	EU Commission Releases Quarterly Report on Euro Zone Economy	1
ECB	EU-15 CPI (MoM)	2
ECB	EU-15 CPI (YoY)	2
ECB	EU-15 GDP s.a (QoQ)	4
ECB	EU-15 GDP s.a. (YoY)	4
ECB	EU15 Ind. Prod. sa (MoM)	3
ECB	EU15 Ind. Prod. wda (YoY)	3
ECB	EU-15 Labour Costs (YoY)	2
ECB	EU-15 New Car Reg. (YoY)	3
ECB	EU15 PPI (MoM)	3
ECB	EU15 PPI (YoY)	3
ECB	EU-15 Retail Trade (MoM)	3
ECB	EU-15 Retail Trade (YoY)	3
ECB	EU-15 Trade Balance	3
ECB	EU-15 Unemployment Rate	3
ECB	European Commission Publishes 4th Qtr & 1st Qtr GDP Forecast	3
ECB	Eurostat Industrial New Orders in October	1
ECB	Eurostat Industrial New Orders in September	1
ECB	Euro-Zone Consumer Confidence	3
ECB	Euro-Zone CPI (MoM)	2
ECB	Euro-Zone CPI (YoY)	2
ECB	Euro-Zone CPI Estimate (YoY)	3
ECB	Eurozone Current Account (EUR)	1
ECB	EURO-ZONE CURRENT ACCOUNT NSA	2
ECB	Euro-Zone Economic Confidence	3
ECB	Euro-Zone GDP s.a. (QoQ)	4
ECB	Euro-Zone GDP s.a. (YoY)	4
ECB	Euro-Zone Ind. Prod. sa (MoM)	3
ECB	Euro-Zone Ind. Prod. wda (YoY)	3
ECB	Euro-Zone Indust. Confidence	3
ECB	Euro-Zone Labour Costs (YoY)	2
ECB	Euro-Zone M3 s.a. (YoY)	3
ECB	Euro-Zone M3 s.a. 3 mth ave.	3
ECB	Euro-Zone New Car Reg. (YoY)	3
ECB	Euro-Zone OECD Leading Ind.	3
ECB	Euro-Zone PPI (MoM)	3
ECB	Euro-Zone PPI (YoY)	3
ECB	Euro-Zone Retail Trade (MoM)	3
ECB	Euro-Zone Retail Trade (YoY)	3
ECB	Euro-Zone Trade Balance	3
ECB	Euro-Zone Unemployment Rate	3
ECB	W. European New Car Reg. (YoY)	3
ECB	ZEW Survey (Econ. Sentiment)	2
FRANCE	Business Confidence Indicator	3
FRANCE	CDAF/Reuters Purchasing Managers' Index (Manufacturing)	1

Country	Indicator	Observations
FRANCE	CDAF/Reuters Purchasing Managers' Index (Services)	3
FRANCE	Central Govt. Balance (Euros)	3
FRANCE	Consumer Confidence Indicator	3
FRANCE	Consumer Price Index (MoM)	5
FRANCE	Consumer Price Index (YoY)	5
FRANCE	Consumer Spending (MoM)	2
FRANCE	Consumer Spending (YoY)	2
FRANCE	CPI - EU Harmonised (MoM)	5
FRANCE	CPI - EU Harmonised (YoY)	5
FRANCE	Current Account (EURO)	4
FRANCE	ECB Announces Interest Rates	2
FRANCE	Gross Domestic Product (QoQ)	2
FRANCE	Gross Domestic Product (YoY)	2
FRANCE	Housing Permits 3M YoY% Change	2
FRANCE	Housing Starts 3M YOY% Change	2
FRANCE	Industrial Production (MoM)	3
FRANCE	Industrial Production (YoY)	3
FRANCE	Manufacturing Production (MoM)	3
FRANCE	Manufacturing Production (YoY)	3
FRANCE	New Car Registration (YoY)	3
FRANCE	Non-Farm Payrolls (QoQ)	2
FRANCE	Producer Prices (MoM)	2
FRANCE	Producer Prices (YoY)	2
FRANCE	Production Outlook Indicator	3
FRANCE	Purchasing Managers Index (Manufacturing)	1
FRANCE	Quarterly Manufacturing Survey	1
FRANCE	Trade Balance (Euros)	3
FRANCE	Unemployment Change (000s)	3
FRANCE	Unemployment Rate	3
FRANCE	Wages (QoQ)	2
GERMANY	BME/Reuters Purchasing Managers' Index (Manufacturing	1
GERMANY	BME/Reuters Purchasing Managers' Index (Manufacturing)	1
GERMANY	BME/Reuters Purchasing Managers' Index (Services)	3
GERMANY	Budget (Maastricht) (% of GDP)	1
GERMANY	Construction Investment	1
GERMANY	Construction Orders (BBK)(MoM)	2
GERMANY	Construction Orders (BBK)(YoY)	2
GERMANY	Consumer Price Index (MoM)	5
GERMANY	Consumer Price Index (YoY)	5
GERMANY	CPI - Baden Wuerttemberg (MoM)	2
GERMANY	CPI - Baden Wuerttemberg (YoY)	2
GERMANY	CPI - Bavaria (MoM)	2
GERMANY	CPI - Bavaria (YoY)	2
GERMANY	CPI - Brandenburg (MoM)	2
GERMANY	CPI - Brandenburg (YoY)	2
GERMANY	CPI - EU Harmonised (MoM)	5
GERMANY	CPI - EU Harmonised (YoY)	5
GERMANY	CPI - Hesse (MoM)	2
GERMANY	CPI - Hesse (YoY)	2
GERMANY	CPI - North Rhine-West. (MoM)	2
GERMANY	CPI - North Rhine-West. (YoY)	2
GERMANY	CPI - Saxony (MoM)	2
GERMANY	CPI - Saxony (YoY)	2
GERMANY	Current Account (EURO)	3
GERMANY	Domestic Demand	1
GERMANY	Employment Change '000	3
GERMANY	Equipment Investment	1
GERMANY	Exports	1
GERMANY	Exports SA (MoM)	3
GERMANY	Factory Orders (BBK) (MoM)	6
GERMANY	Factory Orders (BBK) (YoY)	6
GERMANY	GDP (Annual Growth Rate)	1
GERMANY	GDP nsa (YoY)	2
GERMANY	GDP s.a. (QOQ)	2
GERMANY	GDP wda (YoY)	2
GERMANY	German Consumer Confidence Report Expected From GfK	2

Country	Indicator	Observations
GERMANY	Government Spending	1
GERMANY	IFO - CURRENT ASSESSMENT	3
GERMANY	IFO - EXPECTATIONS	3
GERMANY	IFO Business Climate Survey - Detailed Breakdown Release	3
GERMANY	IFO Ind. Survey (Bus. Climate)	3
GERMANY	Import Price Index (MoM)	2
GERMANY	Import Price Index (YoY)	2
GERMANY	Imports	1
GERMANY	Imports SA (MoM)	3
GERMANY	Industrial Production (MoM)	4
GERMANY	Industrial Production (YoY)	4
GERMANY	New Car Registration FMVO(YoY)	3
GERMANY	OECD Releases Biannual Economic Outlook	1
GERMANY	Private Consumption	1
GERMANY	Producer Prices (MoM)	3
GERMANY	Producer Prices (YoY)	3
GERMANY	Retail Sales (MoM)	3
GERMANY	Retail Sales (YoY)	3
GERMANY	Trade Balance	3
GERMANY	Unemployment Change (000's)	3
GERMANY	Unemployment Rate (s.a)	3
GERMANY	Unemployment Rate EU-Def. BBK	3
GERMANY	VDMA Plant & Machinery Orders	3
GERMANY	Wholesale Price Index (MoM)	3
GERMANY	Wholesale Price Index (YoY)	3
GERMANY	ZEW Survey (Econ. Sentiment)	3
USA	Advance Retail Sales	3
USA	Average Hourly Earnings (MoM)	3
USA	Average Weekly Hours	3
USA	Building Permits	2
USA	Business Inventories	3
USA	Capacity Utilization	3
USA	Change in Manufact. Payrolls	3
USA	Change in Nonfarm Payrolls	3
USA	Chicago Purchasing Manager	3
USA	Construction Spending MoM	3
USA	Consumer Confidence	3
USA	Consumer Credit	3
USA	Consumer Price Index (MoM)	3
USA	Consumer Price Index (YoY)	2
USA	Continuing Claims	8
USA	CPI Ex Food & Energy (MoM)	3
USA	CPI Ex Food & Energy (YoY)	2
USA	Current Account Balance	1
USA	Domestic Vehicle Sales	3
USA	Durable Goods Orders	3
USA	Empire Manufacturing	3
USA	Employment Cost Index	1
USA	Existing Home Sales	2
USA	Factory Orders	3
USA	FOMC Rate Decision Expected	2
USA	GDP Price Deflator	3
USA	Gross Domestic Product	3
USA	Help Wanted Index	3
USA	Housing Starts	2
USA	Import Price Index (MoM)	3
USA	Industrial Production	3
USA	Initial Jobless Claims	12
USA	ISM Manufacturing	3
USA	ISM Non-Manufacturing	3
USA	ISM Prices Paid	3
USA	Leading Indicators	2
USA	Less Transportation	3
USA	Monthly Budget Statement	3
USA	NAHB Housing Market Index	3
USA	New Home Sales	2

Country	Indicator	Observations
USA	Nonfarm Productivity	2
USA	Personal Consumption	3
USA	Personal Income	3
USA	Personal Spending	3
USA	Philadelphia Fed.	3
USA	PPI Ex Food & Energy (MoM)	3
USA	Producer Price Index (MoM)	3
USA	Retail Sales Less Autos	3
USA	Total Vehicle Sales	3
USA	Trade Balance	3
USA	U. of Michigan Confidence	6
USA	Unemployment Rate	3
USA	Unit Labor Costs	2
USA	Wholesale Inventories	3

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