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MACROECONOMIC NEWS ANNOUNCEMENTS*

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JEL Classification: G 14, G 15

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Intraday Seasonalities and Macroeconomic News Announcements

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Abstract

Using a data set consisting of three years of 5-minute intraday stock index returns for major European stock indices and U.S. macroeconomic surprises, the conditional mean and volatility behaviors in European market were investigated. The findings suggested that the opening of the U.S market significantly raised the level of volatility in Europe, and that all markets respond in an identical fashion. Furthermore, the U.S. macroeconomic surprises exerted an immediate and major impact on both European stock markets' returns and volatilities. Thus, high frequency data appear to be critical for the identification of news that impacted the markets.

Keywords: Macroeconomic surprises; intraday seasonality; Flexible Fourier Form; conditional mean; conditional volatility; information spillover

JEL classifications: G14, G15

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1. Introduction

The economic integration among nations (Christie-David et al, 2002) indicates that the investors observe domestic, as well as international information when valuing equities. The Efficient Market Hypothesis assumes that financial markets react immediately to pertinent information. By implication, price changes should reflect the arrival and processing of all relevant news. The purpose of this study is to investigate whether investors on European stock markets consider the U.S. market as an important source of information by examining European high frequency equity returns and volatilities along with contemporaneous U.S. macroeconomic news announcements. As noted by Flannery and Protopapadakis (2002), “the hypothesis that macroeconomic developments exert important effects on equity returns has strong intuitive appeal, but little empirical support.” They also noted that the impact of real macroeconomic variables on aggregate equity returns has been difficult to establish. However, they argued that macroeconomic variables are excellent candidates for extra market risk factors, because macro changes simultaneously affect many firms’ cash flows and may influence the risk-adjusted discount rate. The idea that the pronounced volatility process in financial markets can partly be explained by macroeconomic fundamentals is appealing and persuasive. The impact of information on the volatility of foreign exchange (FOREX) returns has been studied in several papers (Andersen and Bollerslev, 1998; Cai, Cheung, Lee, and Malvin, 2001; Melvin & Yin, 2000). However, there are fewer papers that have focused on equity markets.

No previous research was found regarding the impact of U.S macroeconomic announcements on European equity markets’ returns and volatilities using high frequency data. This paper takes a step in this direction by providing a comprehensive characterization of the volatility process in major European equity markets based on a three-year sample of five-minute returns. The analysis of high frequency stock market data was revealing and intriguing. The main findings were as follows: First, European equity markets did not exhibit a typical diurnal pattern (a reverse J shape) observed in other financial markets. This so-called intraday diurnal pattern was typically affected by two major events in the U.S., the scheduled U.S. macroeconomic news announcements at 14.30 CET and the U.S. cash market opening time at 15.30 CET. Second, the calendar effects were commonly observed in all European equity markets in question, i.e., the intraday seasonalities differed across the weekdays and market openings and closures were apparent as typically noticed in financial markets. Third, the empirical findings provided support for the initial indication that the major U.S. macroeconomic announcements have cross-border impact on both European equity returns and volatilities, and that the major U.S. macro announcements dominate the picture immediately

following their release. Thus, high frequency data are critical for the identification of news that impacts the markets. Finally, the Flexible Fourier Form (FFF) introduced by Gallant (1981, 1982) and proposed by Andersen and Bollerslev (1997, 1998) was found to be an efficient way of determining the seasonal pattern.

Among previous research, Chan, Karceski and Lakonishok (1998) did not find any empirical relevance of macroeconomic factors to equity returns, while Lamont (2000) attempted to identify priced macro factors by determining whether a portfolio constructed to “track” the future path of the macro series earned positive abnormal returns. He found some support for the effect of three macro variables: Industrial Production, Consumption, and Labor Income on portfolio return. Flannery and Protopapadakis (2002) found support for the influence of macroeconomic variables on the realized stock returns and their conditional volatilities. Errunza and Hogan (1998) estimated VAR models for European stock returns for the period 1959-1993. Their main findings suggested that Money supply Granger caused equity volatility in Germany and France, and that the volatility of industrial production Granger caused equity volatility in Italy and the Netherlands. Nikkinen and Sahlström (2004) tested the effect of scheduled domestic and US macroeconomic news announcements on two European markets, the German and Finnish equity markets. Their results indicated that the US macroeconomic news announcements were a valuable source of information on European stock markets, while domestic news releases seemed to be unimportant. However, all the above-mentioned studies relied on daily data.

This paper contributes to the existing literature in several ways. First, it attempts to explore the intraday dynamics of major European equity markets using high frequency 5-minute data. Second, this study sets out to combine the phenomena that have mostly been studied in isolation; pronounced volatility patterns, the calendar effects, and macroeconomic announcements, thus presenting new evidence. As noted by Andersen and Bollerslev (1998), “a full account of the process governing price variability must also confront the pronounced volatility clustering, or ARCH effects, that are evident at the interday level.” The intraday seasonal patterns in the volatility of foreign exchange markets have been largely documented in academic literature. These seasonalities have important implications for modeling the volatility of high frequency data. Andersen and Bollerslev (1997, 1998) argued that standard time series models of volatility failed to capture strong intraday seasonalities when applied to high frequency return data. Finally, this paper contributes to the existing spillover literature by showing that stock markets respond to valuable information originating in foreign markets.

The strategy for this study was twofold. First, an analysis was conducted of the intraday dynamics of major European equity markets drawing on the methodology proposed by Andersen and Bollerslev (1997, 1998) to take into account strong intraday seasonal patterns. Second, a determination was made regarding the extent to which these seasonalities could be explained by the U.S. macroeconomic surprises. The rest of the paper is structured as follows: The data are described in section two. A descriptive framework is developed in section three that outlines the seasonalities in intraday stock returns. A robust regression procedure for the estimation of the calendar and announcement effects is presented in section four. The major empirical findings are reported in section five and a summary and conclusion of the paper are in section six.

2. Data

The primary data set consisted of 5-minute price quotes on four major equity indices from September 1, 2000 through August 29, 2003, totaling three years. The four European markets share the same opening time, i.e. 9.00 CET, whereas the closing times vary. After filtering the data for outliers and other anomalies, more specifically the 11th and 12th of September 2001, and observations influenced by brief lapses in Reuters data feed, the continuously compounded returns were calculated as $R_{i,t} = 100 \times \log(P_{i,t}/P_{i,t-1})$, where $P_{i,t}$ represents the price level on market i at time t .¹ Summary statistics for 5-minute intraday returns are presented in Table 1. Mean returns for all markets, which were virtually zero, were dwarfed by their standard deviations, the most volatile market being CAC40 exhibiting nearly two times greater standard deviation than FT100. When judged by auxiliary statistics, such as the sample minimum and maximum of -5.119 and 4.899 (in the case of CAC40), the existence of jumps became evident. These minimum and maximum measures were 20-35 times greater than their respective standard deviations. Assuming normality, the probability of coming across such extreme values was practically zero.

¹ The time-series also included the opening returns of the trading that typically exhibit high volatility.

Table 1

Summary statistics for intraday 5-minute returns

CAC40, FT100, SMI, and XDAX are equity market indices for France, the UK, Switzerland, and Germany, respectively. AC is the first order autocorrelation coefficient.

	CAC40	FT100	SMI	XDAX
Mean	-0.0012	-0.0009	-0.0007	-0.0008
Minimum	-5.119	-3.740	-4.999	-3.540
Maximum	4.899	3.652	4.494	3.374
Standard Deviation	0.228	0.127	0.144	0.179
Skewness	-0.204	-0.287	-0.357	-0.177
Kurtosis	36.673	69.819	82.219	27.428
AC return	-0.162	0.050	0.016	0.017
AC absolute return	0.298	0.268	0.212	0.258
Observations	76960	73851	76440	99225
Percentage of zero returns	1.78	1.17	1.13	0.99

The French equity market index displayed evidence of significant negative first order autocorrelation (-0.162), attributed typically to market microstructure effects. The three remaining markets exhibited a small positive first order autocorrelation implying that stale prices may have entered the calculation of the indices. The high first order autocorrelation coefficient of the absolute returns implies that the volatility of 5-minute returns exhibited volatility clustering.

2.1. U.S. announcements

The U.S news announcements consist of monthly and quarterly published data on expected and realized macroeconomic fundamentals, defining news as the difference between expectations and realizations.² The news coefficient or surprise should therefore more efficiently capture the new information revealed to market participants. Only those announcements that occurred during European stock market trading were selected. The eleven U.S. economic indicators are presented in Appendix A. Out of 392 announcements, only 28 (7%) were made on Mondays, whereas the majority, 149 (38%) were released on Fridays. The remaining 55% were almost equally distributed over the rest of the weekdays. U.S. announcement dates are known in advance and typically follow a regular timing within the day. Since the U.S. enters the Daylight Saving Time (DST) one week later than their European counterparts, the announcement timings were accounted for during these three weeks in our sample.

² The U.S. announcement data were provided by Haver Analytics. They also provided the median market expectation of economic indicators based on regularly conducted surveys.

Because units of measurements differ across economic variables, following Balduzzi, Elton and Green (2001) we use standardized news. That is, we divide the surprise by its sample standard deviation to facilitate interpretation. The standardized news associated with indicator k at time t is

$$S_{k,t} = \frac{A_{k,t} - E_{k,t}}{\hat{\sigma}_k}, \quad (1)$$

where $A_{k,t}$ is the announced value of indicator k , $E_{k,t}$ is the market expected value of indicator k and $\hat{\sigma}_k$ is the sample standard deviation of $A_{k,t} - E_{k,t}$. The use of standardized news facilitates meaningful comparisons of responses of different indices to different pieces of news. The standardization affects neither the statistical significance nor the fit of the regression, because $\hat{\sigma}_k$ is constant for any indicator k , and we estimate responses by regressing stock returns on news.

3. Seasonal patterns in intraday stock returns

The ability to access and analyze high frequency data provides enormous potential for furthering our understanding of financial markets. The use of high frequency data is interesting and persuasive, since it can reveal new information that cannot be seen in lower data aggregations, though it does pose new challenges. The intraday periodic return patterns along with 5 % confidence bands are depicted in Appendix B. The average returns were dispersed unpredictably over the trading day and hardly any systematic violations of zero mean occurred, except a small positive return at the end of the German trading day. Harris (1986a) reported that average positive returns in the equity markets tended to occur over the first 45 minutes of the trading day. The data from the four European markets investigated in this study did not support these findings. Nonetheless, the return effects are dwarfed by the systematic movements in the return volatility, documented in Figure 1.³

We proxied the return volatility utilizing absolute returns, then the intraday seasonal was calculated as the average absolute return of approximately 731 observations for each time unit along the trading day. The pattern is comparable even if squared returns were used, though squared returns accentuate sizable shocks typical in intraday data. The periodic pattern across all European markets exhibits remarkable similarities. This calendar effect can hardly be described as a typical J-shaped pattern of volatility, documented by Wood and McInish (1985) and Harris (1986a). Rather, all four

³ The first two 5-minute opening returns were excluded from Figure 1 due to scaling problems caused by a strikingly high opening level of volatility. The volatilities at the opening are depicted in Appendix C.

markets exhibited a decaying pattern of volatility until 14.30. At 14.35 all four European stock market return volatilities demonstrated a considerable increase. This implies that the increase could be associated with some common factor regularly present at 14.30 CET. An examination revealed that European macroeconomic announcements or other potentially influential information related to the European markets was not regularly released at this time, nor could the Japanese market explain this behavior since it was closed. Potentially, this volatility spike could be explained by at least two Non-European factors; (1) the opening of the NYSE futures exchange market and (2) announcements of U.S. macroeconomic indicators. To our knowledge, no previous research has examined this feature on European markets.

One hour later, at 15.35 the return volatilities escalated once again and stayed on a relatively high level until closure, with the exception of the German market where the trading continued until evening. Yet again, there was no European related explanation for the rising level of volatility. A plausible explanation for the return volatility boost at 15.35 could be the opening of the NYSE at 15.30 CET. A third spike in volatilities is depicted at 16.05, once more all four European stock markets respond in a similar fashion.

Figure 1. Periodic pattern in intraday volatilities

To gain a more thorough insight into this seasonal volatility behavior, the average absolute returns by trading time and weekday were classified. The results are reported in Appendix C. The intraday periodicity depicted in Figure 1 was unchanged, with one common exception. On Mondays, the seasonal pattern revealed no volatility increase at 14.35 in any of the four European market indices. The common factor mentioned above was either not present or, at least, had a considerably smaller

impact on Mondays. Intuitively this was consistent with the low percentage (7%) of U.S. macroeconomic indicators announced on Mondays and contradicts the suggestion that the NYSE futures market opening caused the volatility spike in Europe. Obviously, the NYSE futures markets should cause a notable volatility spike during every weekday.

Table 2 reports another interesting feature when splitting the trading day into three separate periods i.e. from 9.00 to 14.30, 14.35 to 15.30, and 15.35 to close⁴, and calculating the average 5-minute volatility for the period. The values were defined as a percentage increase or decrease in volatility for each weekday period in comparison to the respective period on Monday, i.e. the Monday period was the base for comparison. It can be seen that the overall 5-minute volatility was lowest on Mondays in all markets.

Table 2

Changes in seasonal volatilities during weekdays

The numbers represent a percentage (%) increase or decrease in average volatility for each period and weekday in comparison to the respective period on Monday. The return volatility for the indices was defined as absolute average 5-minute return for the respective period. The mean was calculated from Tuesday to Friday for the respective period.

Period	Monday	Tuesday	Wednesday	Thursday	Friday	Mean
CAC40						
9.00-14.30	0	5	17	10	2	9
14.35-15.30	0	25	41	50	53	42
15.35-17.35	0	26	23	24	22	24
9.00-17.35	0	12	21	17	11	15
FT100						
9.00-14.30	0	3	8	5	2	5
14.35-15.30	0	20	25	40	41	32
15.35-17.30	0	13	14	12	11	13
9.00-17.30	0	7	11	9	8	9
SMI						
9.00-14.30	0	4	11	6	-1	5
14.35-15.30	0	19	25	35	28	27
15.35-17.35	0	9	13	4	11	9
9.00-17.35	0	7	13	8	5	8
XDAX						
9.00-14.30	0	1	8	4	-1	3
14.35-15.30	0	24	28	39	45	34
15.35-17.35	0	12	18	12	14	14
9.00-17.35	0	6	13	9	7	9

For example, the Tuesday overall volatility in the French stock market averaged 12% higher than on Mondays. In fact, this volatility raise could be noticed on all markets when comparing the period

⁴ For XDAX the last observation was at 17.35 CET to improve the comparison between different markets.

9.00 to 17.35 CET.⁵ The first morning period volatility level seemed to be relatively stable throughout the week, increasing on average approximately 5 %. The opposite was true during the second period, i.e. 14.35 to 15.30 CET. All four European markets exhibited a considerable increase in volatility from Tuesday to Friday. In the case of CAC40, the volatilities increased about 25 % to 53 %; for the FT100, 20 % to 41 %; for SMI, 19 % to 35 %; and for the XDAX, 24 % to 45 %. Even the last period, i.e. 15.35 to closure, displayed a volatility increase, albeit moderate. Major increases in weekday volatilities seemed to have occurred in European markets during the afternoon trading.

This descriptive analysis suggested that the announcements of U.S. macroeconomic indicators and the opening of the NYSE stock exchange do affected the European stock markets by raising the level of volatility. To investigate whether this could be the case, an examination was conducted to determine if U.S. macro announcements triggered the seasonal volatility spike seen at 14.35 CET. The volatility data were split according to whether or not U.S. news has been released during the European trading day.

Figure 2 displays the 5-minute average absolute returns for respective European markets. On average, 38% of the European trading days were associated with U.S. macroeconomic announcements, naturally with respect to those 11 U.S. announcements selected for this study. As seen in Figure 2, the volatilities of the two separate groups followed an almost identical pattern during the whole trading day, except at 14.35 CET and 10 to 15 minutes thereafter. The dashed line plots the seasonal volatility on those days when the U.S. news was released, and the solid line shows the days when no macro announcements were made in the U.S.

Two separate tests were conducted for the null hypothesis of equal average absolute returns on U.S. release days vs. days with no U.S. news release. Since the distribution of average absolute return was not evident, an independent sample T-test was conducted along with a nonparametric Mann-Whitney U-test. Using a one percent significance level the null hypothesis of equal means was rejected for all four markets at 14.35 and 14.40 by both test methodologies. Consequently it seemed that for all four markets, the volatilities at 14.35 and 14.40 were considerably lower on those days when no U.S. news was released. This strongly supported the initial speculation that U.S. macroeconomic news releases have a significant impact on the volatilities of the four European markets.

⁵ For FT100 the last return was calculated at 17.30 CET.

Figure 2. Intraday average absolute returns on days containing U.S. macroeconomic news (dashed line) vs. days with no U.S. macroeconomic announcements (solid line).

3.1. The U.S. market effect

To study whether the NYSE cash market opening could be the underlying cause for the increased level of volatility in European markets from 15.30 onwards, an emphasis was placed on those days when the U.S. stock market was closed. The sample contained 21 days when the French market was open but the U.S. was closed, 18 days in the case of the UK, 19 days for SMI, and 20 days for the German market, for a total of 77 trading days. As Figure 1 displays, the seasonal volatility pattern for the European markets was almost identical, though on slightly different levels. Therefore, we standardized all returns on respective days and investigated the combined European behavior. Examining a single market could be problematic due to the small sample of trading days when the U.S. market was closed. The standardized return for a single market was defined as

$$\hat{R}_{m,t} = \frac{r_{m,t} - \bar{r}_m}{\sigma_m} \quad (2)$$

where $\hat{R}_{m,t}$ is the standardized return for market m at time t , $r_{m,t}$ and $\bar{r}_m$ are the realized and average returns respectively, and σ_m is the sample standard deviation for market m for those days when the U.S. market was closed or open, respectively. The standardized returns were combined and an average absolute return, joint for all four markets, was calculated. Figure 3 compares the seasonal volatility for the days when the U.S market was closed (solid line) with those when the U.S. market was operating (dashed line). The sample of 77 U.S. non-operating days gave a robust approximation of the common seasonal volatility pattern, since both lines coincided. Interestingly, on those days when the U.S. market was closed, the European markets tended to exhibit a typical reverse J-shaped intraday volatility pattern. Moreover, the observed volatility spike at 14.35 and the level shift at 15.35 disappeared. A null hypothesis was tested of the equality of standardized average absolute returns parametrically, based on central limit theorem, and by a nonparametric Mann-Whitney U-test.⁶ Using a five percent significance level, both tests rejected the null hypothesis from 15.35 to 15.40. Moreover, from 15.40 to 16.40 the independent samples T-test rejected the null hypothesis, whereas the Mann-Whitney U-test rejected the null hypothesis from 15.40 to 16.50. The results suggested that the opening of the U.S. market exerted a significant impact on European markets, i.e. it generated a structural shift in average volatility level. Finally, a feasible explanation to the volatility spike at 16.05 presented in Figure 1 could not be determined.

⁶ The detailed results for each time point are available upon request.

Figure 3. Standardized joint intraday volatility on CAC40, the FT100, SMI and XDAX when the U.S. market is closed (solid line) and when the U.S. market is open (dashed line).

4. Methodology

A time-series model was constructed to investigate the impact of U.S. news releases. The return-generating model isolated the impact on stock market index returns of foreign economic surprises and their own ARMA terms. Thus, for each market the 5-minute stock index return R_t , was modeled as an ARMA(p, q) process and J lags of news on each of K fundamentals:

$$R_t = a(L)R_t + b(L)\varepsilon_t + \sum_{k=1}^K \sum_{j=0}^J \beta_{k,j} S_{k,t-j} + \varepsilon_t, \quad t = 1, \dots, T. \quad (3)$$

$a(L)$ and $b(L)$ are polynomial lag operators for the AR(p) and MA(q) process respectively. $S_{k,t}$ is standardized news associated with indicator k at time t. There are 11 major U.S. macro announcements, $k=1, \dots, 11$ and T is the total number of return observations that differed across countries. A significant $\beta_{k,j}$ coefficient would imply that European markets responded to U.S. macroeconomic surprises and the use of standardized news facilitated meaningful comparisons of surprise response coefficients. The number of lagged values is based on the Schwarz information criteria, resulting in ARMA (1,1) and J=1 for CAC40, the FT100 and XDAX, while ARMA (1,1) and J=0 for SMI. Contemporaneous response, i.e. J=0, refers to the same 5-minutes return period within which the news was released.

Furthermore, the time varying volatility of R_t was estimated from the regression residuals. The disturbance volatility was approximated using the following model (4):

$$|\hat{\varepsilon}_t| = a(L)|\varepsilon_t| + b(L)\mu_t + \psi \frac{\hat{\sigma}_{d(t)}}{\sqrt{N}} + \sum_{k=1}^K \sum_{j=0}^J \beta_{k,j} |S_{k,t-j}| + \left(\sum_{x=1}^X \left(\delta_x \cos\left(\frac{x2\pi t}{N}\right) + j_x \sin\left(\frac{x2\pi t}{N}\right) \right) + \sum_{m=1}^M \gamma_m D_{m,t} \right) + \mu_t.$$

The left hand side variable, $|\hat{\varepsilon}_t|$, is the absolute value of the residual of equation (3), which proxies for the volatility in the 5-minute interval t . The right-hand side of the equation (4) follows that the 5-minute volatility is driven in part by its own ARMA terms, the average volatility over the trading day containing the 5-minute interval in respective market $\hat{\sigma}_{d(t)}/\sqrt{N}$, the news $S_{k,t}$, and the seasonal pattern exhibited in Figure 1. N is the number of intraday intervals within a trading day. The seasonal component was split into two parts. The first is a Flexible Fourier Form (FFF) with trigonometric terms that obey the strict periodicity of one day. To obtain strictly periodical data, the few missing observations were replaced by linear interpolation.⁷ The second is a set of dummy variables $D_{m,t}$ capturing the European markets' opening and closing times, as well as the U.S. market opening time.

The ARMA terms in equation (4) are included to capture the short run volatility dynamics or volatility clustering effect within the intraday data, while $\hat{\sigma}_{d(t)}$ is intended to capture the “average” level of volatility on day $d(t)$. It is interesting to note that this setting facilitated modeling the impact of foreign economic surprises on stock market return volatility by taking into account the strong intraday seasonalities, distortions that arise from the distinct periods, and its own time varying volatility behavior.

The first step of the procedure involved the determination of a daily volatility factor. The daily volatility, which is a one-day ahead forecast for the day $d(t)$ from the daily ARMA(1,1)-GARCH(1,1) model using the intradaily stock returns calculated over the sample period for each market, was computed. As noted by Andersen and Bollerslev (1997), given the relative success of the daily GARCH models in explaining the aggregation results for the intradaily frequencies in financial markets, the use of ARMA(1,1)-GARCH(1,1) appeared to be a natural choice. As for the news S , for each fundamental $k=1\dots 11$ at time t , $S_{k,t}$ was regressed against the corresponding absolute residual to estimate the contemporaneous volatility response to each news surprise. Next,

⁷ The number of interpolated observations was France, 335, FT100 132, SMI 1733, and XDAX 226.

the Flexible Fourier Form, as proposed by Gallant (1981, 1982) and advocated by Andersen et al. (1997), was employed to account for the strong intraday periodicity. The truncation lag for the Fourier expansion, x , must be determined. The Schwarz information criteria chose $x = 6$ for CAC40, the FT100, and SMI, and $x = 8$ for XDAX. As seen in Appendix C, the volatility profile for the first five to ten minutes and the last ten to fifteen minutes showed an abrupt change from the overall smooth intraday pattern, while the spike at 15.30 and 15.35 CET in the European markets at the U.S. market opening time was also apparent. The set of dummy variables $D_{m,t}$ is included to minimize the distortions that may otherwise arise from these distinct periods. It was evident from the resulting fit in Appendix D, that this representation provided an excellent overall characterization of the average intraday periodicity in all the stock markets in question.

It is noteworthy that models, (3) and (4) offered flexibility and could be estimated using standard time-series techniques. Both models were estimated using a Newey-West standard errors and covariance consistent estimators that were robust in the presence of both heteroskedasticity and autocorrelation of unknown form.

5. Empirical Findings

Models (3) and (4) provided a good approximation of both conditional mean and conditional volatility dynamics, as shown by the residual statistics and the resulting fit of the intraday seasonalities. Many U.S. indicators have generally statistically significant influence across all markets, including real variables (unemployment rate and advanced durable goods), U.S. output measure (industrial production) and aggregate economic indicators such as retail sales. Some fundamentals seemed only to have a significant impact on the conditional volatility, not on the return.

5.1. Contemporaneous return responses

Estimation results are provided in the upper panel of Table 3. As shown in the Table, at least five of the eleven contemporaneous return response coefficients were generally sizeable and statistically significant across all markets. The unemployment rate coefficient, consistent with earlier findings, was negative and significantly affected all European stock returns, indicating that the higher than anticipated U.S. unemployment depressed equity values in European markets. At the same time the advance durable goods coefficient was positive and statistically significant across all markets, explaining that the higher than expected U.S. value of orders received by manufacturers of durable

goods positively affected the European stocks' return levels. These two factors have the most sizeable effect on European equity returns. The impact of a one standard deviation news surprise was normally 2 to 3 times bigger in comparison to the rest of the significant fundamentals.

Three other macroeconomic variables, the index of leading indicators, industrial production, and retail sales generally exerted influence on European stock returns. All three coefficients were positive, explaining that positive U.S. surprises enlivened the stock prices in European markets. The forward-looking measure, housing starts, significantly affected three of the European stock index returns, namely France, the UK, and Switzerland. The coefficients for trade balance and consumer price index were found to be insignificant with the exception of the UK. The other U.S. macro announcements, including personal income, producer price index, and real GDP, had no significant effect on European stock returns. An interesting feature is that the common pattern was one of the very quick stock return conditional mean adjustments, indicating that the stock returns adjusted to news immediately and the response faded away swiftly thereafter. Only very few of the lagged return coefficients were found to be significant, i.e. the impact on European index returns occurred within five minutes from the U.S. news release.⁸

5.2. Volatility response to macro surprises

The contemporaneous volatility response to macro variable surprises is reported in the lower panel of Table 3. The conditional variance equation (4) included six macro variable surprises with significant coefficients. The volatility coefficients on the advanced durable goods, consumer price index, industrial production, producer price index, retail sales, and unemployment rate were statistically significant across all markets. It is also interesting to note that the coefficients on the unemployment rate and advanced durable goods were also economically large, meaning that a one standard deviation surprise had a simultaneous and sizeable effect on conditional volatility across all markets. The two nominal series (CPI and PPI) had been previously identified as important for equities, bonds, and foreign exchange rates. The findings suggested that in contrast to the conditional return equation (3), the two nominal series (CPI and PPI) were found to be significant for the conditional volatility equation (4).

⁸ The contemporaneous coefficient values for the first and second moment are reported in the article. Full results are available upon request

Table 3
Return and Volatility Response to U.S. News

The conditional mean model (3), $R_t = a(L)R_t + b(L)\varepsilon_t + \sum_{k=1}^K \sum_{j=0}^J \beta_{k,j} S_{k,t-j} + \varepsilon_t$ and the conditional disturbance volatility model (4),

$$\left| \hat{\varepsilon}_t \right| = a(L)|\varepsilon_t| + b(L)\mu_t + \psi \frac{\hat{\sigma}_{d(t)}}{\sqrt{N}} + \sum_{k=1}^K \sum_{j=0}^J \beta_{k,j} |S_{k,t-j}| + \left(\sum_{x=1}^X \left(\delta_x \cos\left(\frac{x2\pi t}{N}\right) + \phi_x \sin\left(\frac{x2\pi t}{N}\right) \right) + \sum_{m=1}^M \gamma_m D_{m,t} \right) + \mu_t$$

for four European stock indices, namely France (CAC40), the UK (FT100), Switzerland (SMI), and Germany (XDAX) was estimated. We report the estimates and p-values for $H_0: \beta_k=0$ of the contemporaneous equity markets' return and volatility response to standardized U.S macroeconomic news. Contemporaneous response refers to the same 5-minutes period within which the news was released. Significant coefficients are denoted with **, * on 5 % and 10 % significance level, respectively. The residual autocorrelation coefficients (AC), at lag 3 due to the ARMA coefficients, and their respective Ljung-Box Q-statistics are reported.

Announcements	CAC40		FT100		SMI		XDAX	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
Panel A: Contemporaneous return response								
Advance Durable Goods	0.239**	0.004	0.173**	0.011	0.196**	0.009	0.290**	0.008
Consumer Price Index	0.045	0.636	-0.047*	0.057	-0.007	0.719	-0.012	0.734
Housing Starts	0.026	0.440	0.050**	0.002	0.035*	0.099	0.053*	0.076
Index of Leading Indicators	0.092**	0.002	0.059**	0.013	0.049**	0.002	0.112**	0.000
Industrial Production	0.215**	0.000	0.104**	0.010	0.057*	0.065	0.162**	0.000
Personal Income	-0.018	0.463	-0.005	0.700	0.020	0.314	-0.012	0.626
Producer Price Index	-0.062	0.359	-0.013	0.645	0.000	0.991	-0.021	0.704
Real GDP	0.045	0.281	0.035	0.295	0.029	0.312	0.032	0.497
Retail Sales	0.178**	0.007	0.071**	0.028	0.086**	0.007	0.170**	0.002
Trade Balance	0.023	0.571	0.053**	0.005	0.034	0.154	0.075	0.124
Unemployment Rate	-0.277**	0.000	-0.149**	0.001	-0.216**	0.000	-0.227**	0.005
R-squared	0.030		0.005		0.004		0.003	
Residual diagnostics	AC	Q-stat	AC	Q-stat	AC	Q-stat	AC	Q-stat
	-0.007	4.5	0.021	41.1	0.010	8.2	-0.008	20.1
Panel B: Contemporaneous volatility response								
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
Advance Durable Goods	0.157**	0.000	0.129**	0.000	0.144**	0.000	0.208**	0.000
Consumer Price Index	0.108**	0.024	0.033**	0.013	0.018*	0.085	0.045**	0.005
Housing Starts	0.014	0.273	0.013	0.220	0.021**	0.018	0.022	0.158
Index of Leading Indicators	-0.005	0.749	0.004	0.718	-0.002	0.854	-0.009	0.572
Industrial Production	0.102**	0.000	0.042**	0.033	0.025**	0.004	0.064**	0.000
Personal Income	0.016	0.179	0.001	0.904	0.020**	0.034	0.009	0.564
Producer Price Index	0.127**	0.003	0.049**	0.002	0.035*	0.060	0.093**	0.000
Real GDP	0.019	0.257	0.021*	0.068	-0.004	0.791	0.017	0.475
Retail Sales	0.088**	0.000	0.049**	0.001	0.041**	0.000	0.081**	0.001
Trade Balance	0.047	0.111	0.016	0.171	0.020	0.119	0.061**	0.006
Unemployment Rate	0.159**	0.000	0.116**	0.000	0.124**	0.000	0.215**	0.000
R-squared	0.254		0.267		0.273		0.254	
Residual diagnostics	AC	Q-stat	AC	Q-stat	AC	Q-stat	AC	Q-stat
	-0.018	1212.5	-0.008	77.7	-0.015	44.6	0.009	67.1

This implied that nominal news triggered a price adjustment process, but the direction of the adjustment was not consistent probably because the information contained in these two nominal indices might be nuanced. The monthly U.S. broad output measure, i.e., industrial production affected both conditional stock returns and volatility across all European markets, contradicting Flannery and Protopapadakis (2002). Another important finding was that the contemporaneous volatility response coefficients, although statistically significant, were smaller than their counterparts reported in the mean equation. However, stock return volatilities adjust relatively gradually, with complete adjustment occurring usually after two 5-minute periods as the response of volatility was clearly seen in the first lag, in contrast to the return equation.

Two announcement pairs were evaluated that frequently occurred simultaneously (PPI with Unemployment rate and CPI with Housing starts). It was possible that the insignificance of their individual surprise coefficient in model (3)-(4) reflected a correlation between their surprises. However, the robustness check suggested that apparently the series individual insignificance reflected irrelevance rather than high correlation. Finally, the relatively small number of individual macroeconomic announcements, especially concerning real GDP, may have affected the significance of the estimators.

5.3. Response asymmetry

A stylized fact in the stock markets is that downward movements are followed by higher volatility. Therefore, it was investigated whether this was the case concerning macroeconomic news announcements. Unfortunately, the small number of individual announcements did not provide the possibility to successfully evaluate the asymmetry of individual macroeconomic news. One solution to this shortcoming was to measure the combined asymmetric effect of all significant macro announcements presented in Table 3. We examined the return and volatility asymmetry using equation (3) and (4), where a dummy variable was included to capture the leverage effect. The dummy variable took the value 1 when the news was considered to have a negative effect on the equity returns, i.e. positive figures in case of consumer price index, whereas producer price index and unemployment rate were assumed negative news. This assumption was a necessary simplification concerning consumer- and producer-price indices. As shown in the upper panel of Table 3, the coefficient values for CPI and PPI tend to be negative, but rarely significant. This methodology, utilizing a dummy variable to capture the average effect of all significant announcements, required that the size of the asymmetric response not be dependent on the type of macroeconomic news.

After dropping the insignificant news variables in the return- and volatility equations and including the dummy variable, new regressions were conducted. The asymmetry coefficient in the return equation was expected to be negative, whereas in the volatility equation it was expected to be positive. The results revealed that both the returns and the volatilities on all four markets responded in an asymmetric fashion to the U.S. news. The asymmetry coefficient values for the return equations, followed by the coefficient values for the volatility asymmetry within parenthesis, were for CAC40, -0.079 (0.049); FT100, -0.053 (0.038); SMI, -0.049 (0.023); and XDAX, -0.095 (0.037). All coefficients were found to be significant using a five percent significance level, except the volatility coefficient of asymmetry for SMI, which was significant at a ten percent level. The European stock markets were shown not only to respond to U.S. macroeconomic surprises, moreover, they responded in an asymmetric way.

6. Summary

In this paper the intraday dynamics of major European stock markets were analyzed using high frequency 5-minute returns. Furthermore, the role of U.S macroeconomic news announcements was examined to explain the return and volatility process in major European stock markets. This research contributes to the existing literature by presenting new evidence of the effect of U.S. macro surprises upon European equity markets in the intraday setting, using carefully constructed 5-minute returns, efficiently filtered for intraday seasonalities.

The main findings are as follows. First, European equity markets did not exhibit a typical diurnal pattern (a reverse J shape) observed in other financial markets. This so-called intraday diurnal pattern was typically affected by two major happenings in the U.S., the scheduled U.S. macroeconomic news announcements at 14.30 CET and the NYSE cash market opening time at 15.30 CET. Second, the calendar effects were commonly observed in all European equity markets in question, i.e., the intraday seasonalities differed across the weekdays and market openings and closures were apparent as typically noticed in financial markets. Third, empirical findings provided support for the initial indication that the major U.S. macroeconomic news had cross border impact on both European equity returns and volatilities. Furthermore, the major U.S. macroeconomic announcements dominated the picture immediately following their release, thus high frequency data were critical for the identification of news that impacted the markets. The findings also related to a common result in spillover literature in that the U.S. market is the most important producer of information (Eun & Shim, 1989; Ng, 2000; Theodossiou & Lee, 1993).

Overall, the results suggested that the U.S. fundamentals form a subset of European investors' public information. This implies that equity returns and volatilities are generally sensitive to the news originating in foreign markets. The analysis indicated that two U.S. inflation measures (CPI and PPI), three real macroeconomic variables (retail sales, advanced durable goods and the unemployment rate) and U.S. broad output measure (industrial production) could be considered as potential market risk factors by investors. Another important finding is that European stock markets reacted similarly to the information originating in the U.S. One interpretation for such behavior is that news revealed in the U.S. is perceived as informative to fundamentals of stock prices in the Europe, a view that can be attributed to real and economic linkages of international economies.

The implication of these findings for investors is a reduced portfolio diversification effect between the European markets and the U.S. due to fundamental linkages and the dominant impact of the U.S market. These results suggested a further investigation of the short-term cross dependencies on stock markets and the economic integration of Europe and U.S. The strong intraday seasonal pattern, exhibited by the European stock markets, has important implications for researchers and investors when modeling the short-term dynamics of the return and volatility behavior.

References:

- Andersen, T. and Bollerslev, T., 1997. Intraday Periodicity and Volatility Persistence in Financial Markets. *Journal of Empirical Finance*, Vol. 4, pp. 115-158.
- Andersen, T. and Bollerslev, T., 1998. Deutsche Mark-Dollar Volatility: Intraday Activity Patterns, Macroeconomic Announcements and Longer Run Dependencies. *Journal of Finance*, Vol. 53, pp. 219-265.
- Andersen, T., Bollerslev, T., Diebold, F.X. and Vega, C., 2002. Micro Effects of Macro Announcements: Real Time Price Discovery in Foreign Exchange. NBER Working Paper No. 8595.
- Balduzzi, P., Elton, E.J. and Green, T.C., 2001. Economic News and Bond Prices: Evidence from the U.S. Treasury Market. *Journal of Financial and Quantitative Analysis*, Vol. 36, pp. 523-543.
- Cai, J., Cheung, Y., Lee, R. and Melvin, M., 2001. Once in a Generation Yen Volatility in 1998: Fundamentals, Intervention and Order Flow. *Journal of International Money and Finance*, Vol. 20, pp. 327-347.
- Chan, K.C., Karceski, J. and Lakonishok, J., 1998. The Risk and Return from Factors. *Journal of Financial and Quantitative Analysis*, Vol. 33, pp. 159-188.
- Christie-David, R., Chaudhry, M., and Khan, W., 2002. News Releases, Market Integration, and Market Leadership. *Journal of Financial Research*, Vol. 25, pp. 223-245.
- Errunza, V. and Hogn, K., 1998. Macroeconomic Determinants of European Stock Market Volatility. *European Financial Management*, Vol. 4, pp. 361-377.
- Eun, C. S. and Shim, S., 1989. International Transmission of Stock Market Movements. *The Journal of Financial and Quantitative Analysis*, Vol. 24, pp. 241-256.
- Flannery, M. J. and Protopapadakis, A., 2002. Macroeconomic Factors Do Influence Aggregate Stock Returns. *The Review of Financial Studies*, Vol. 15, pp. 751-782.
- Gallant, R. R., 1981. On the bias in Flexible Functional Forms and an Essentially Unbiased Form: The Flexible Fourier Form. *Journal of Econometrics*, Vol. 15, pp. 211-245.
- Gallant, R. R., 1982. Unbiased Determination of Production Technologies. *Journal of Econometrics*, Vol. 20, pp. 285-323.
- Harris, L., 1986. A transaction data study of weekly and intradaily patterns in stock returns. *Journal of Financial Economics*, Vol. 16, pp. 99-117.
- Lamont, O., 2001. Economic Tracking Portfolios. *Journal of Econometrics*, Vol. 105, pp. 161-184.
- Melvin, M. and Yin, X., 2000. Public Information Arrival, Exchange Rate Volatility and Quote Frequency. *The Economic Journal*, Vol. 110, pp. 644-661.

- Ng, A., 2000. Volatility spillover effects from Japan and US to the Pacific-Basin. *Journal of International Money and Finance*, Vol. 19, pp. 207-233.
- Nikkinen, J. and Sahlström, P., 2004. Scheduled Domestic and U.S. Macroeconomic News and Stock Valuation in Europe. *Journal of Multinational Financial Management*, Vol. 14, pp. 201-215.
- Theodossiou, P. and Lee, U., 1993. Mean and volatility spillovers across major national stock markets: further empirical evidence. *Journal of Financial Research*, Vol. 16, pp. 337-350.
- Wood, R.A., McInish, T. H. and Ord, J.K., 1985. An investigation of transaction data for NYSE stocks. *Journal of Finance*, Vol. 40, pp. 723-739.

Appendix A

The U.S. News Announcements

The U.S. announcement times are reported in Central European Time (CET). Obs. is the number of observations followed by announcements per weekday.

Announcement	Time	Obs.	Monday	Tuesday	Wednesday	Thursday	Friday
Advance Durable Goods	14.30	38	0	10	9	11	8
Composite Index of Leading Indicators	16.00	38	12	3	5	18	0
Consumer Price Index	14.30	38	0	8	13	4	13
Housing Starts	14.30	38	1	12	12	8	5
Industrial Production	15.15	38	2	11	6	3	16
Personal Income	14.30	38	12	3	1	6	16
Producer Price Index	14.30	38	0	0	2	11	25
Real GDP	14.30	12	0	0	0	7	5
Retail Sales	14.30	38	0	9	7	9	13
Trade Balance: Goods & Services	14.30	38	0	8	9	9	12
Unemployment Rate	14.30	38	1	0	0	1	36
Totally		392	28	64	64	87	149

Appendix B

Average intraday 5-minute returns

Notes: Average 5-minute returns shown by solid line and a five percent confidence band by the dashed lines.

Appendix C

Average absolute returns classified by weekday and time

CAC40

FT100

Appendix C continued
Average absolute returns classified by weekday and time

SMI

XDAX

Appendix D

Actual (solid line) and fitted (dashed line) intraday volatility pattern

CAC40

FT100

SMI

XDAX

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