WHAT MOVES GERMAN BUND FUTURES CONTRACTS ON THE EUREX?

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The German 10-year Bund futures contract traded on the Eurex futures and options exchange in Frankfurt became the world's most actively traded derivative product by the end of 1999. In this article, we provide a detailed exploration of the interday and intraday return volatility in the Bund futures contract using a sample of five-min returns from 1997 to 1998. The evolution of interday volatility is described best by a MA(1)-fractionally integrated process that allows for the long-memory features. At the intraday level, we find that macroeconomic announcements from both Germany and the U.S. are an important source of volatility.

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Among the various German announcements, we identify the IFO industry survey of business climate, industrial production (preliminary), and Bundesbank policy meeting as being by far the most important. The three most significant U.S. announcements include the employment report, the National Association of Purchasing Managers (NAPM) survey, and employment costs. Overall, U.S. macroeconomic announcements have a far greater impact on the Bund futures market than their German counterparts. © 2002 Wiley Periodicals, Inc. Jrl Fut Mark 22:679–696, 2002

INTRODUCTION

The German government bond and futures markets are relatively new additions to the global financial industry and present many opportunities to traders and investors alike due to their size and turnover. In particular, the 10-year Bund futures contract, which is the flagship instrument on the Frankfurt-based Eurex futures and options exchange, recently seized the title of the most actively traded derivative in the world. The Bund futures contract overtook the equivalent U.S. instrument—the 10-year Treasury bond futures contract. On an average day, dealers turned over nearly 700,000 Bund contracts. Occasionally, the recorded volume was in excess of 1,000,000 contracts. Moreover, the Eurex exceeded the Chicago Board of Trade (CBOT) in terms of total volume of contracts traded by the end of 1999.[1]

Despite its importance as the benchmark derivative for the Eurozone and the huge and growing turnover, there is little research on various aspects of the Bund futures contract. In particular, the literature is silent on its intradaily and interday volatility patterns. If private information is the driving force behind the volatility in equity markets, public information in the form of macroeconomic news has a more important role in motivating volatility for fixed income securities and their derivatives (Fleming & Remolona, 1999). However, the existing evidence offers no clues as to what kind of news from Germany and the U.S. has a significant impact on the Bund futures market.[2]

A large number of studies have linked the evolution of Treasury security intraday volatility to the release of macroeconomic announcements and identified important announcements for U.S. bond and bond

[1]See *Financial Times*, September 20, 1999 and *International Herald Tribune*, September 25, 1999.
[2]Becker, Finnerty, and Kopecky (1993) examined the intraday volatility of bond futures contracts traded in U.S. and UK. They linked the volatility peaks to the release of macroeconomic news in both countries without examining the individual announcement impact. Sutton (2000) examined the issues of excess volatility and excess co-movement of 10-year-government-bond yields in 5 major markets, including the U.S., Japan, Germany, the UK, and Canada.

futures markets.[3] More recently, with the advent of high-frequency data and new methodology, Ederington and Lee (1993), Fleming and Remolona (1997, 1999), Balduzzi, Elton, and Green (1999), Bollerslev, Cai, and Song (2000) provided a more accurate measure of announcement effects.

The purpose of this work is to offer a comprehensive study of the intraday and interday patterns in the volatility for the German Bund futures contracts over the period 1997–1998. Following closely the methodology developed in Andersen and Bollerslev (1997, 1998), we are able to examine the time-of-the-day patterns (intraday calendar effects), macroeconomic announcements (public information effects), and the well-documented interday volatility persistence (ARCH effects) in a coherent framework.

Our main findings are as follows. First, the intraday volatility is dominated by a broad U-shaped pattern across the trading day plus two distinct peaks at 14:30 and 16:00 Frankfurt time, which correspond to the regularly scheduled U.S. macroeconomic announcements at 8:30 and 10:00 Eastern Standard Time (EST), respectively. Second, the interday volatility can be best described as a MA(1)-fractionally integrated GARCH process. This process parsimoniously captures the volatility clustering and long-memory feature in daily returns of the Bund futures contracts. Third, we examine the impacts of a comprehensive list of 18 and 21 macroeconomic announcements from Germany and the US, respectively. We identify the IFO industry survey of business climate, industrial production (preliminary), and Bundesbank policy meeting as the most important German announcements. The three most significant U.S. announcements include the employment report, the National Association of Purchasing Managers (NAPM) survey, and employment costs.

The remainder of the article is organized as follows. The next section gives a brief overview on the trading of the German 10-year Bund futures contract. A description of the data follows, accompanied by a summary of the intraday return and volatility patterns and estimates of the intraday periodic volatility model. An examination of the implications of the major macroeconomic announcements is then presented, followed by an assessment of the overall importance of the different volatility components at the intraday and interdaily level. The paper closed with some concluding remarks.

[3]Fleming and Remolona (1997) provided a summary of the earlier literature. Jones, Lamont, and Lumsdaine (1998) investigated the source of autocorrelation in U.S. bond market volatility.

THE TRADING OF THE BUND FUTURES CONTRACTS

The Bund futures contract was introduced in September 1988, and trading started at the London International Financial Futures Exchange (LIFFE).[4] By 1990, the Bund futures contract accounted for almost one third of the total volume on LIFFE. Trading at LIFFE is carried out by open outcry in contrast to a number of computer-based futures exchanges that have opened in recent years. The Bund futures contract was introduced later at the Deutsche Terminborse (DTB) after the exchange started trading in the spring of 1990. In contrast to LIFFE, the DTB is a computer-based exchange located in Frankfurt. This means that the traditional *pit-trading* environment has been replaced by a computer network. In early 1997, the Eurex futures and options exchange was created through a merger of Germany's DTB and the Swiss Options and Financial Futures Exchange. Since then, the Eurex has recorded a steady increase in the Bund futures trading volume over its competitor LIFFE. By late 1998, the 10-year Bund futures contract traded on the Eurex was the third most actively traded derivative, after Treasury bond futures, on the CBOT and Eurodollar futures on the Chicago Mercantile Exchange.[5] One year later, in 1999, the Bund futures contract became the most heavily traded derivatives instrument in the world.

MODELING THE INTRADAY VOLATILITY PATTERNS

Data

The German Bund futures tick data are provided by the Futures Industry Institute and cover the period from January 1997 to December 1998. The contracts require delivery of a German Federal Government long-term notional debt security with 8.5–10.5 years to maturity and a coupon rate of 6%. The contracts mature in March, June, September, and December. For both the tick and daily data, the nearest contracts are used. Each data record specifies the time to the nearest second, the exact price of the futures transaction, and traded lots in contracts.

The intraday time series are partitioned into 5-min intervals. To construct the 5-min returns, we use the transaction prices immediately proceeding and following the end of each 5-min interval. The log prices are weighted by their inverse relative distance to the endpoint. The

[4]Corrigan and Pohlmann (1991) provided a more detailed overview of the market structure, the origins and developments, and various evaluatory and trading techniques in the Bund futures market.
[5]See *Financial Times*, January 12, 1999.

difference between the weighted log prices constitutes the 5-min return for the corresponding interval. The daily trading time covers the period from 8:00 to 17:30 Frankfurt time, corresponding to the trading hours for contracts on the Eurex, resulting in a total of 114 5-min return observations for each trading day.[6] With 500 trading days from 1997 to 1998, this leaves us with a total of 57,000 observations, say $R_{t,n}$ for return, where $n = 1, 2, \ldots, 114$, and $t = 1, 2, \ldots, 500$.[7]

Intraday Patterns

Figure 1(a) shows that the average raw returns across the day are centered around zero. There is little evidence for any systematic pattern. On the other hand, the average absolute returns plotted in Figure 1(b) reveal an interesting regular pattern. The average absolute 5-min returns start at nearly 0.027% early in the morning, drop to a lower level of 0.010% in the middle of the day, and rise sharply to about 0.029% at 14:30 Frankfurt time. This corresponds to 8:30 EST when major U.S. macroeconomic news is scheduled for release. The volatility picks up again at 16:00 Frankfurt time, which corresponds to the scheduled U.S. macroeconomic announcements at 10:00 EST. After that, the volatility gradually tapers off. The intraday volatility pattern is consistent with evidence from Becker, Finnerty, and Kopecky (1993) for U.K. gilt bond futures contracts and Scalia (1998) for the Italian Treasury bond market. Treasury securities trading in Europe is significantly subject to the influence of U.S. announcements.

Modeling Various Intraday Volatility Components

The dynamics of high frequency Treasury futures returns and volatility are involved. A reasonable model should be able to capture the following three volatility components: intraday calendar effects, interday volatility clustering and the long-memory feature, and announcement effects. We

[6]On August 1, 1997, the Eurex extended the trading hours from 17:30 to 19:00 Frankfurt time. To maintain an equal number of observations in each trading day for our analysis, we truncate the data during the 17:30–19:00 period. Because trading activities are significantly lower during the truncated one-and-half hours, the effects on our results are negligible.

[7]The large number of observations (57,000) may cause readers to be concerned about the Lindley's Paradox (1957) in assessing significance. However, the estimation for announcement effects relies on a limited number of observations because there are only 12 announcements within one year for the majority of the macroeconomic news studied in this article. Even if we delete a large number of trading days without any announcements, these important announcements remain highly significant.

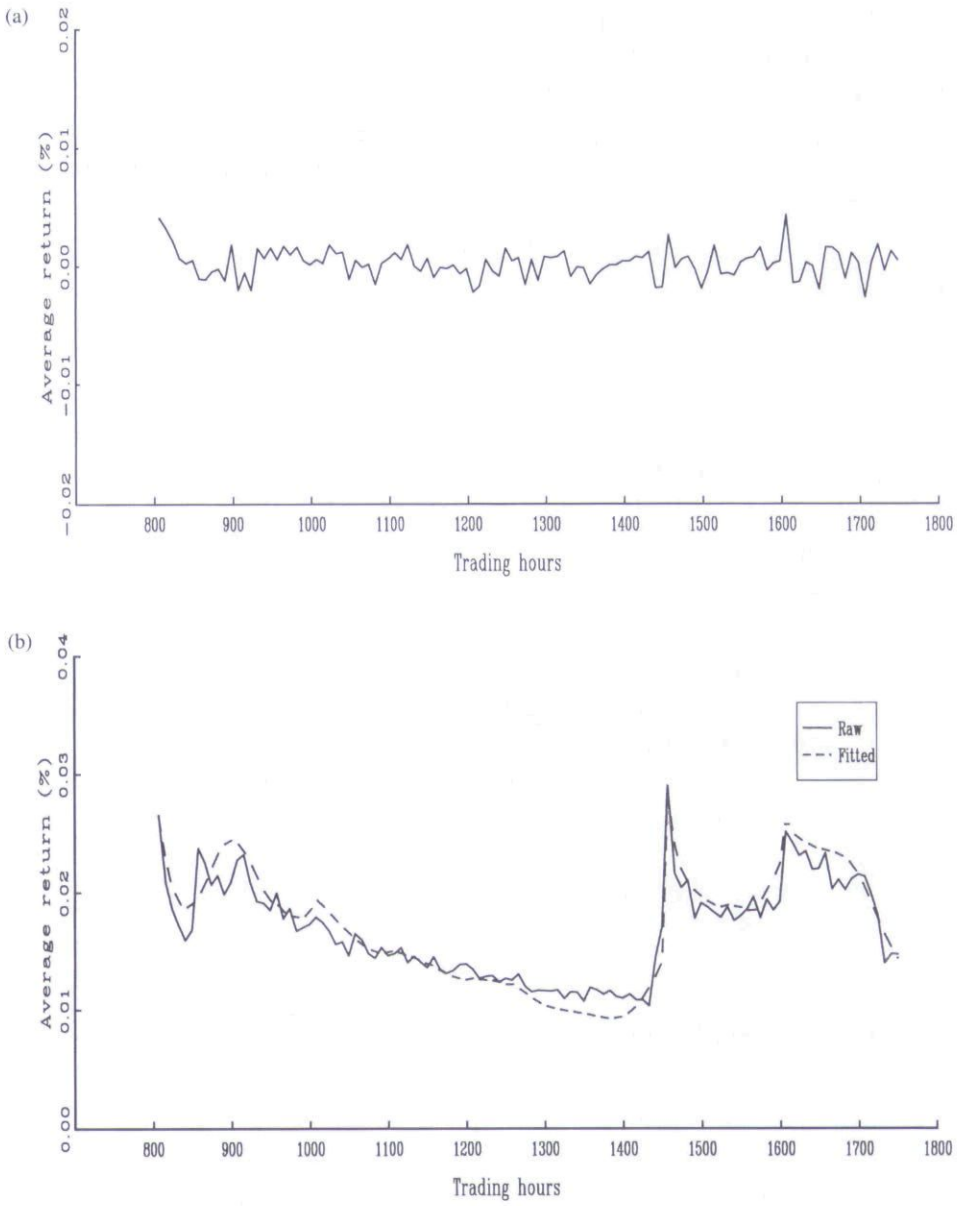

FIGURE 1

(a) German Bund futures intraday 5-min average R_t. (b) German Bund futures intraday 5-min average $|R_t|$.

rely on the general framework developed in Anderson and Bollerslev (1997, 1998). The basic idea involves the following decomposition,

$$R_{t,n} - \overline{R} = s_{t,n} \cdot \sigma_{t,n} \cdot Z_{t,n} \tag{1}$$

where $\overline{R}$ denotes the sample mean of the 5-min returns (expected return), $\sigma_{t,n}$ denotes a daily volatility factor that is traditionally captured

by ARCH models, $Z_{t,n}$ is an i.i.d. mean zero unit variance innovative term, and $s_{t,n}$ captures the intraday calendar features as well as the announcement effects. The components of eq (1) cannot be identified without additional restrictions. Therefore, we isolate the calendar and announcement effects, $s_{t,n}$, by taking squares and logs and rearranging the terms:

$$2\ln|R_{t,n} - \bar{R}| - \ln\sigma_{t,n}^2 = \ln s_{t,n}^2 + \ln Z_{t,n}^2 \tag{2}$$

Now $s_{t,n}$ becomes the sole explanatory variable. The implementation of the estimation requires a first-stage estimate of the daily volatility factor, $\sigma_{t,n}$, entered in eq (2). Numerous ARCH and stochastic volatility models have been proposed to capture the day-to-day variation in financial market volatility. Motivated by the results in recent literature, our estimate of $\sigma_{t,n}$ will be based on the fractionally integrated GARCH (FIGARCH) model in Baillie, Bollerslev, and Mikkelsen (1996). This model explicitly incorporates the long-memory feature in many asset markets.[8] Specifically, we employ 1000 daily returns on German Bund futures contracts from January 3, 1995 to December 30, 1998 to estimate a MA(1)-FIGARCH(1,1) model for σ_t. The resulting 5-min volatility estimator is simply given by $\hat{\sigma}_{t,n} \equiv \hat{\sigma}_t / N^{1/2}$.

Several alternative parametric formulations can be used to give an approximate value for in the second-stage regression. For example, Ederington and Lee (1993), Fleming and Remolona (1997), and Huang and Masulis (1999) use dummy variables to capture the time-of-the-day effects. However, without any theoretical guidance regarding the shape of the intraday pattern, the flexible Fourier form (FFF), originally proposed by Gallant (1981, 1982), particularly is convenient. The FFF regression provides a convenient way of capturing the smooth intraday patterns with a limited number of parameters to be estimated, especially when studying high-frequency data with a larger number of intraday intervals. The operational regression equation now becomes:

$$\begin{aligned} &2\ln|R_{t,n} - \bar{R}| - \ln\hat{\sigma}_{t,n}^2 \\ &\quad = c + \sum_{k=1}^{D} \lambda_k \cdot I_k(t, n) + \delta_{0,1} n/N_1 + \delta_{0,2} n^2/N_2 \\ &\qquad + \sum_{p=1}^{P} [\delta_{c,p} \cdot \cos(2\pi p n/N) + \delta_{s,p} \cdot \sin(2\pi p n/N)] + \varepsilon_{t,n} \end{aligned} \tag{3}$$

[8]Details of the estimation are available upon request. We also examine the long-memory feature in high-frequency data covering a shorter period by plotting the autocorrelation of filtered 5-min absolute returns, $|R_{t,n}|/\hat{s}_{t,n}$, where $\hat{s}_{t,n}$ is the estimated intraday periodic component. The autocorrelogram displays a strictly positive and slowly declining pattern consistent with the long-memory feature.

where $N_1 = (N + 1)/2$ and $N_2 = (N + 1)(N + 2)/6$ are the normalizing constants. $I_k(t, n)$ is an indicator for event k during interval n on day t. It is easy to incorporate the effects of readily identifiable exogenous events such as macroeconomic announcements through the inclusion of simple dummy variables, say $\lambda_k \cdot I_k(t, n)$.[9] The actual estimate uses two years of 57,000 intraday 5-min returns, as opposed to simply estimating the average pattern across the trading day. The choice of the tuning parameters in eq (3) is an empirical issue. After some experimentation, we find that expansion of the Fourier terms beyond $P = 8$ produces insignificant estimates. The log-likelihood ratio tests also suggest that higher-order terms are not necessary.

To gauge the success of the model, we construct the corresponding fit in the absolute return dimension in the following way. Let $f(t, n) + \hat{\varepsilon}_{t,n}$ denote the right-hand side of equation (3), where $f(t, n)$ is the estimated intraday pattern and $\hat{\varepsilon}_{t,n}$ is the residual from the FFF regression. Then the absolute return can be derived as:

$$|R_{t,n} - \overline{R}| = N^{-1/2} \cdot \hat{\sigma}_t \cdot \exp[f(t, n)/2] \cdot \exp(\hat{\varepsilon}_{t,n}/2) \qquad (4)$$

If we ignore the potential correlation between $\hat{\sigma}_t$ and the transformed error term, and we simply average $\hat{\sigma}_t$ and $\exp(\hat{\varepsilon}_{t,n}/2)$, respectively, over the trading days, we obtain the unconditional intraday volatility forecasts. The dotted line in Figure 1(b) plots the unconditional volatility forecasts with the announcement and day-of-the-week effects included. The results indicate that the FFF regression and the associated choice-of-tuning parameters provide a good approximation to the average intraday pattern in the German Bund futures market.

THE IMPACT OF MACROECONOMIC ANNOUNCEMENTS

Important Announcements from Germany and the U.S.

Earlier studies on announcement effects suggest that it is relatively easy to correlate movements in bond and bond futures markets to the arrival of information events. In particular, many of the largest market movements are caused directly by the announcements. To illustrate, Table I displays the 25 largest absolute 5-min returns on Bund futures over the

[9]Andersen and Bollerslev (1998) discussed the consistency and small sample properties of the two-step estimators.

TABLE I

Largest Absolute 5-min Returns from German Bund Futures Contract from 1997–1998

Absolute Return (%)	*Date*	*Time*	*Weekday*	*Macroeconomic Announcement*
0.508	98-10-09	8:50	Friday	European bonds fell as European currencies plunged against yen
0.477	98-08-26	9:05	Wednesday	IFO industry survey, business climate
0.460	98-10-09	15:15	Friday	Market concerned about the European Central Bank's interest rate policy
0.388	98-10-08	13:45	Thursday	U.S. dollar posted its biggest one-day loss in 25 years
0.351	97-04-29	14:30	Tuesday	U.S. durable goods orders, employment costs
0.335	98-10-09	9:05	Friday	European bonds fell as European currencies plunged against yen
0.332	98-08-26	9:00	Wednesday	IFO industry survey, business climate
0.320	98-08-21	8:55	Friday	German industrial production, preliminary
0.314	98-10-09	9:25	Friday	Bundesbank member rejected Italian Prime Minister's proposal for boosting economy
0.305	98-10-13	9:05	Tuesday	German trade balance and current account
0.262	97-10-09	13:30	Thursday	German Bundesbank meeting
0.254	97-10-10	14:30	Friday	U.S. PPI
0.253	98-08-11	12:50	Tuesday	Deutsche Banks' forecast for economic growth and unemployment
0.250	98-10-09	9:30	Friday	Bundesbank member rejected Italian Prime Minister's proposal for boosting economy
0.245	98-10-09	9:15	Friday	U.S. dollar plunged again despite speculation of an intervention
0.243	98-10-09	9:45	Friday	The German FAZ indicator fell among worsening business sentiment
0.242	97-12-05	14:30	Friday	U.S. employment report
0.240	98-09-11	10:35	Friday	German retail sales
0.238	97-01-28	14:30	Tuesday	U.S. employment costs
0.237	97-01-16	11:00	Thursday	German CPI, preliminary
0.235	98-08-26	9:20	Wednesday	German unemployment
0.234	98-10-12	8:45	Monday	German retail sales
0.230	98-08-21	8:25	Friday	German industrial production, preliminary
0.230	97-01-09	14:30	Thursday	U.S. PPI, initial jobless claims
0.228	98-10-08	13:30	Thursday	U.S. dollar posted its biggest one-day loss in 25 years

Note. The absolute returns are based on the raw 5-min returns on the German Bund futures. The sample period is from January 2, 1997 to December 30, 1998. The daily time interval is between 8:00 and 17:30 Frankfurt time, which corresponds to trading hours of German Bund futures contracts on the Eurex, thus resulting in 114 5-min intervals during each trading day. Over the two-year sample period, there are 500 trading days, and a total of 57,000 observations. For each 5-min interval, we subjectively indicate if German or U.S. macroeconomic announcements contribute to the return.

two-year sample period. The evidence is convincing. A majority of the returns are associated with the release of economic news during the same 5-min interval. For example, five of the 25 largest absolute returns occur at 14:30 Frankfurt time, corresponding to the regularly scheduled U.S. macroeconomic announcements at 8:30 EST. These announcements include the employment report, employment costs, durable goods orders, PPI, and initial jobless claims. Ten of the 25 largest absolute returns can be linked to macro announcements from Germany. These German announcements include the IFO industry survey, Bundesbank meeting, German industrial production (preliminary), trade balance and current account, retail sales, unemployment, and CPI (preliminary).[10]

It also should be noted that five of the 25 largest absolute returns are related to the plunge of U.S. dollar and European currencies against the yen. These include the largest, the fourth largest, and the sixth largest absolute returns that occurred at 8:50, 13:45, and 9:05 Frankfurt time, respectively, on two consecutive days from October 8–9, 1998. Hedge funds have contributed to the volatility in the Bund and Bund futures market. Over the sample period, hedge funds had bought U.S. and European bonds by borrowing yen at Japan's low lending rates. As the funds unwound their positions by buying back yen to repay loans taken out in yen, the 10-year German government bond, Europe's benchmark, fell in value.[11]

The underlying asset of the Bund futures contract is the German 10-year government bond. Therefore, macroeconomic news from Germany plays an important role in motivating the volatility in the Bund futures market. The intraday pattern also suggests that macroeconomic announcements from the US also constitute a major source of volatility. To provide a comprehensive analysis, we collected data on the dates and release time of 18 items of German macroeconomic news from Bloomberg during the period from 1997–98. These announcements include the trade balance and current account, industrial production

[10]The results are remarkably similar to earlier studies on the Treasury market. In particular, Fleming and Remolona (1997) examined the 25 largest price changes in 5-year U.S. Treasury notes from 1993 to 1994 and concluded that all of them occur on announcement days, and all but one come within 15 min of an announcement.

[11]The yen provided foreign-exchange market participants with *once-in-a-generation* volatility movements in 1998. For instance, after many months of uneven yen depreciation, a remarkable period of yen appreciation was experienced where, in one two-day period, the U.S. dollar dropped in value by 20 yen, market makers were refusing to quote yen/dollar prices for more than $1 million. Analysts claimed that the yen reversal was due to order flow driven by changing tastes for risk and hedge-fund herding on unwinding yen *carry trade*, where funds had borrowed yen at interest rates near zero and then invested in higher-yielding securities denominated in dollars and other currencies. See Board of Governors of the Federal Reserve System (1998a, 1998b, 1998c) for more detailed analysis.

(preliminary, final), manufacture orders (preliminary, final), plant and machine orders, unemployment, gross domestic product (GDP), CPI (preliminary, final), retail sales, wholesale prices, IFO industry survey of business climate, producer prices, M3 money supply, new car registration, import prices, and Bundesbank policy meetings.[12] All German announcements are monthly except for quarterly announcements of GDP and biweekly announcements of the Bundesbank policy meeting. The German announcements usually are not released on a punctual schedule, but vary in terms of time of day.

We also collected 21 U.S. macroeconomic news items from the "The Week Ahead" section of *Business Week*. The U.S. macroeconomic announcements were released widely and virtually instantaneously at a precise time.[13] Among the 21 regularly scheduled news releases, 12 were made at 14:30 Frankfurt time (8:30 EST). This included the employment report, CPI, durable goods orders, housing starts, leading indicators, initial jobless claims, merchandise trade balances, PPI, retail sales, personal income, employment costs, and GDP. Eight of the announcements were made at 16:00 Frankfurt time (10:00 EST), covering business inventories, construction spending, consumer confidence, NAPM surveys, new single-family home sales, factory inventories, existing home sales, and productivity costs. The last announcement included in the sample is industrial production released at 15:15 Frankfurt time (9:15 EST). All announcements were monthly, except for the quarterly GDP figures, weekly initial jobless claims, and irregular employment costs figures.

Estimation of the Instantaneous and Cumulative Announcement Impacts

Because the number of occurrences of each type of news announcement is limited, estimation of separate coefficients for each announcement is practically infeasible. Instead, we impose a common decay structure on the volatility response pattern for all announcements. Individual news items differ from each other in the extent to which they "load onto" the response pattern. First, we combine all announcements and estimate the coefficients in a third-degree polynomial that characterizes the response pattern. Then, following Andersen and Bollerslev

[12]These 18 announcements constitute an exhaustive list of German announcements available from Bloomberg News Service. They are considered to be the most significant announcements by market participants. To a large extent, they overlap the announcements studied by Andersen and Bollerslev (1998). The macroeconomic figures are usually released together for Pan, West, and East Germany.
[13]The government statistical agencies impose *lock-up* conditions to ensure that the information is not released to the public before the scheduled time (see, e.g., Fleming & Remolona, 1999).

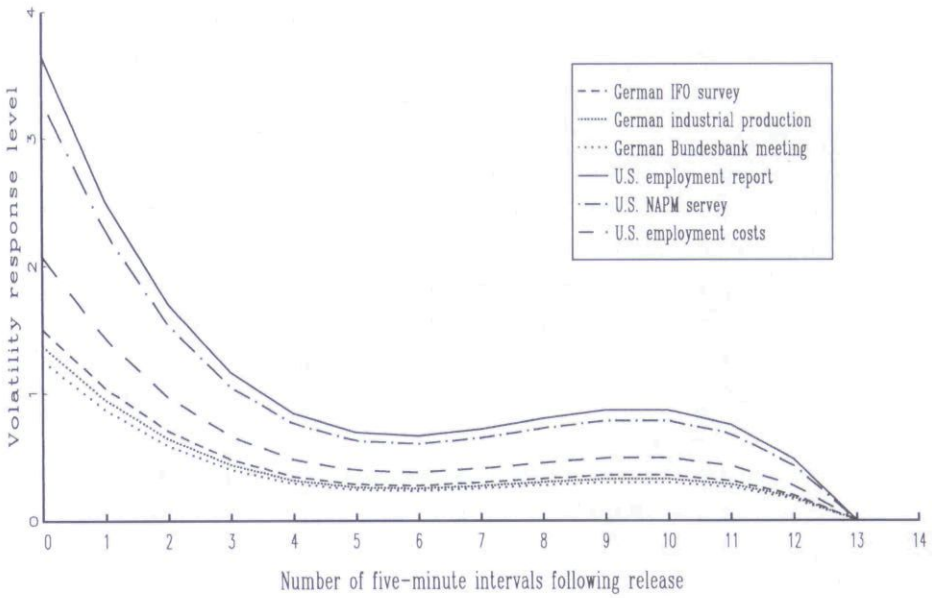

FIGURE 2
Estimated response patterns for leading German and U.S. announcements.

(1998), we choose the response pattern to be of the form $\lambda(k, i) = \lambda_k \cdot \gamma(i)$, $i = 0, 1, 2, \ldots, 12$, where $\gamma(i)$ the coefficients are determined by the common third-order polynomial. The loading coefficient λ_k is different for different news items. Figure 2 depicts the estimated response pattern where the response horizon is fixed at 1 h after some experiments.[14] From eq (3), the instantaneous impact on the 5-min absolute returns is $\exp(\hat{\lambda}_k \cdot \gamma(0)/2) - 1$, while the impact at the i-th lag equals $\exp(\hat{\lambda}_k \cdot \gamma(i)/2) - 1$. We define the cumulative impact $M(k) = \sum_{i=0}^{12}[\exp(\hat{\lambda}_k \cdot \gamma(i)/2) - 1]$. This measure reflects the impact over the entire 1-h horizon expressed as a multiple of the typical volatility for the associated 5-min intervals.

We carry out the estimation as in eq (3), incorporating individual news items from Germany and the US. The overall fit of the model is good with an R^2 of 0.416. The coefficients for sinusoid regressors and day-of-the-week effects are highly significant. To conserve space, Table II only reports the estimated loading coefficients for each of the 18 German and 21 U.S. announcements ranked according to $\hat{\lambda}_k$. From the German side, 8 of the 18 announcements are significant. The IFO

[14]The estimated third-order polynomial proxy for the volatility response pattern is determined by the following equation: $\gamma(i) = 0.917 \cdot [1 - (i/13)^3] - 0.327 \cdot [1 - (i/13)^2] \cdot i + 0.046 \cdot [1 - i/13] \cdot i^2$, $i = 0, 1, 2, \ldots, 12$, where by construction, $\gamma(13) = 0$. We uniquely identify this pattern by fitting all three parameters for the 18 German and 21 U.S. announcements combined in eq (1), without the λ_k coefficient.

TABLE II

The Impact of German and U.S. Macroeconomic Announcements on the Bund Futures Return Volatility

Announcements	*Announcement Time*	*Coefficients*	*Instantaneous Jump in Volatility (%)*	*Impact on Daily Cumulative Absolute Return (%)*
Panel A: German Announcements				
IFO industry survey, business climate	1000	1.70**	118	3.5
Industrial production, preliminary	1100	1.55**	103	2.9
Bundesbank policy meeting	1230	1.42**	92	2.1
Manufacturing orders, preliminary	1100	1.04**	61	1.8
M3 money supply	930	1.02**	60	2.2
Manufacturing orders, revision	1200	0.86**	48	1.3
Wholesale prices	800	0.79**	43	1.9
GDP	800	0.78	43	1.9
Unemployment	950	0.64*	34	1.2
Industrial production, revision	1200	0.55	29	0.8
Producer prices	800	0.37	18	0.9
Import prices	800	0.34	17	0.8
New car registration	1430	0.26	12	0.5
Plant and machine orders	1050	−0.05	−2	−0.1
Trade balance and current account	800	−0.09	−4	−0.2
Retail sales	800	−0.10	−5	−0.2
CPI, preliminary	1225	−0.19	−8	−0.3
CPI, final	800	−0.72	−28	−1.5
Panel B: U.S. Announcements				
Employment report	1430	4.20**	587	18.9
NAPM survey	1600	4.10**	554	13.2
Employment costs	1430	2.38**	198	5.8
PPI	1430	2.18**	172	5.2
Durable goods orders	1430	1.95**	145	4.5
CPI	1430	1.89**	138	4.3
GDP	1430	1.66**	114	3.6
Productivity and costs	1600	1.06**	62	2.9
Retail sales	1430	0.99*	57	2.0
Merchandise trade balance	1430	0.67	36	1.3
Initial jobless claims	1430	0.65**	35	1.2
Housing starts	1430	0.64	34	1.2
Industrial production	1515	0.62	33	1.5
Existing home sales	1600	0.62	33	1.6
Business inventories	1430	0.61	32	1.2
Personal income	1430	0.55	29	1.1
New single-family home sales	1600	0.50	25	1.3
Consumer confidence	1600	0.23	11	0.6
Factory inventories	1600	−0.94*	−35	−2.1
Leading indicators	1600	−1.03*	−38	−2.3
Construction spending	1600	−1.04	−38	−2.3

Note. The dependent variables are based on raw 5-min returns on German Bund futures. The sample period is from January 2, 1997 to December 30, 1998 giving a total of 57,000 observations. The regression takes the form of eq (1), where $R_{t,n}$ denotes the 5-min returns for interval n on day t, $\bar{R}$ is the sample mean of the 5-min returns, and $\hat{\sigma}_t$ is an *a priori* estimate of the overall daily volatility estimated from a MA(1)-FIGARCH(1, d, 1) model fitted to a longer sample of daily returns. The $I_k(t, n)$ regressors refer to the dummies for either weekdays or prespecified volatility response patterns associated with a news announcement. The volatility response pattern is approximated by a third-order polynomial restricted to reach zero at the end of the response horizon of 1 h, or the 13th 5-min interval. The announcement coefficients measure the extent to which the absolute returns load into this pattern. The instantaneous jump in volatility measures the estimated increase in the 5-min absolute return for the interval when the announcement is made; the estimated total cumulative absolute return induced by the announcement over the assumed horizon is measured relative to the median cumulative absolute return over the sample period, which equals 1.78%/day. **indicates significance at the 5% level; *indicates significance at the 10% level.

industry survey, industrial production (preliminary), Bundesbank policy meeting, manufacture orders (preliminary), M3 money supply, manufacture orders (revision), wholesale prices, and unemployment have the largest impact. From the U.S. side, 10 out of 21 announcements are significantly positive. In descending order of importance, they are the employment report, the NAPM survey, employment costs, PPI, durable goods orders, CPI, GDP, productivity and costs, retail sales, and initial jobless claims. Although these significant U.S. announcements are expected, our results for German announcements are new. Figure 2 displays the corresponding volatility response levels, $\hat{\lambda}(k, i) = \hat{\lambda}_k \cdot \gamma(i)$, for six German and U.S. announcements over the 1-h horizons.

Table II also reports the implied instantaneous jump in the volatility and the cumulative impact over the day in columns 3 and 4. This allows us to assess the economic significance of the individual announcements. Looking at the IFO industry survey of business climate in Germany, for example, the estimate implies $\hat{\lambda}_k \cdot \gamma(0) = 1.703 \cdot 0.917 = 1.562$, which is tantamount to an impact on the absolute return of $\exp(1.562/2) = 2.18$, or an instantaneous jump in the volatility of 118%. The figures for the IFO survey typically are announced around 10:00 Frankfurt time, and the average 5-min absolute return between 10:00 and 11:00 Frankfurt time equals 0.015%. The corresponding cumulative response $M(k) = 4.18$ thus implies an elevation of the volatility by 0.063 $(4.18 \cdot 0.015)$%. This translates into a 3.5 (0.063/1.78)% average increase in the cumulative absolute return for trading days on which the IFO industry survey is released. The second most important German announcement is industrial production, with an immediate and cumulative impact being 103 and 2.9%, respectively. The third most important German announcement is Bundesbank policy meeting, with an immediate and cumulative effect of 92 and 2.1%, respectively.

Turning to the U.S. announcements, the seven most important announcements imply an immediate increase in absolute returns by more than 100%. The impact on daily cumulative absolute returns exceeds 3%. United States announcements have a much larger impact on the volatility of the German Bund futures market than do German announcements. In particular, the U.S. employment report turns out to be the most important piece of news, and its release elevates Bund futures volatility by 587% within the first 5 min. The cumulative impact is 18.9% during the hour following the release of employment figures.[15]

[15]Andersen and Bollerslev (1998) found that the U.S. employment report creates an instantaneous and cumulative increase in the volatility of 576 and 15%, respectively, in their analysis of 5-min Deutschemark–U.S. dollar exchange rate. Bollerslev, Cai, and Song (2000) reported an immediate and cumulative impact of 1378 and 75%, respectively, for the U.S. Treasury bond futures market.

THE CONTRIBUTION OF VARIOUS FACTORS TO THE BUND FUTURES VOLATILITY

The intraday volatility pattern, the interday volatility factor, and the macroeconomic announcements all contribute to the volatility in the Bund futures market. However, the relative importance of the different components is not obvious. In this section, we provide a direct assessment of the relative importance of these factors. Our assessment of the volatility components is based on an in-sample comparison of the correlation between the realized and forecasted absolute returns. For instantaneous volatility, our measure of forecast performance is given by the coefficient of multiple correlation, or R^2, from the regression of 5-min absolute returns, $|R_{t,n} - \overline{R}|$, on the one-day-ahead 5-min volatility forecasts $v_{t,n}$. Similarly, the forecast performance for daily volatility is measured by the R^2 from the regression of the daily sum of the realized 5-min absolute returns, $\sum_{n=1}^{N} |R_{t,n} - \overline{R}|$, on the corresponding cumulative forecasts $\sum_{n=1}^{N} v_{t,n}$. Although these criteria do not correspond directly to the loss functions that are relevant in most practical applications, the multiple correlation coefficients allow a simple statistical model-free comparison.

The construction of the one-day-ahead 5-min absolute return forecast is based on the decomposition in eq (4). Given the model estimates of the three components from the previous sections, a one-day-ahead forecast readily is obtained as:

$$v_{t,n} = N^{-1/2}[\hat{\sigma}_t \cdot I_\sigma + \overline{\sigma} \cdot (1 - I_\sigma)] \times \exp\{[\hat{f}_c(t, n)I_c + \hat{f}_a(t, n)I_a + \hat{f}_w(t, n)I_w]/2)\} \quad (5)$$

where $f_c(t, n)$, $f_a(t, n)$, and $f_w(t, n)$ denote the estimated calendar, announcement, and day-of-the-week effects from the regression in eq (1). The indicator variables I_c, I_a, and I_w signify whether the calendar, announcements, and day-of-the-week effects are accounted for in the particular forecast. Also, I_σ is set to be 1 if the time-varying daily volatility factor from the MA(1)-FIGARCH(1, d, 1) model, $\hat{\sigma}_t$, is included in constructing the forecast, and 0 if the daily volatility factor is assumed to be constant, $\overline{\sigma}$. In order not to obscure the comparisons, the highly significant day-of-the-week effects are incorporated in all of the forecasts.

Table III summarizes the results for the eight possible model configurations as indicated by the triplet (I_σ, I_c, I_a). The numbers in the first data column refer to the degree of explained variation in the daily cumulative absolute returns. The complete model explains 34.5% of the total variation. The number is virtually unchanged when either the announcement and/or calendar effects are excluded. In contrast, the number drops to as low as 1.9% when the daily FIGARCH volatility factor is

TABLE III

The Relative Importance of Volatility Components in Bund Futures Contract

Model	*Daily Cumulative Absolute Return*	*5-Min Absolute Return*
Complete model, $(I_c, I_a, I_\sigma) = (1, 1, 1)$	0.345	0.108
No calendar effects $(I_c, I_a, I_\sigma) = (0, 1, 1)$	0.336	0.067
No announcements $(I_c, I_a, I_\sigma) = (1, 0, 1)$	0.345	0.092
No daily volatility $(I_c, I_a, I_\sigma) = (1, 1, 0)$	0.019	0.060
Calendar effects only $(I_c, I_a, I_\sigma) = (1, 0, 0)$	0.022	0.043
Announcements only $(I_c, I_a, I_\sigma) = (0, 1, 0)$	0.015	0.025
German announcements only $(I_c, I_a, I_\sigma) = (0, 1, 0)^*$	0.014	0.005
U.S. announcements only $(I_c, I_a, I_\sigma) = (0, 1, 0)^*$	0.015	0.023
Daily volatility only $(I_c, I_a, I_\sigma) = (0, 0, 1)$	0.345	0.052

Note. The table reports the explained variations (R^2s) from regressing $\sum_{n=1}^{N}|R_{t,n} - \bar{R}|$ on $\sum_{n=1}^{N} v(I{:}t, n)$, $t = 1, 2, \ldots, T$, for daily cumulative absolute returns and from regressing $|R_{t,n} - \bar{R}|$ on $v(I{:}t, n)$, $t = 1, 2, \ldots, T$, $n = 1, 2, \ldots, N$, $T = 500$, $N = 114$, for 5-min absolute returns. From eq (2), $v(I{:}t, n)$ is the 5-min volatility forecast that, in turn, leaves out or includes only the contribution from each of the following components: intraday calendar effects, announcement effects, and time-varying daily volatility factor. The indicator vector (I_c, I_a, I_σ) signifies whether each of the three components is accounted for in the forecasts of absolute returns. For example, $(I_c, I_a, I_\sigma) = (1, 1, 0)$ corresponds to the model where both the calendar and announcement effects are included and the daily volatility is constant. The day-of-the-week effects always are included in the regressions.

omitted. The impact of macroeconomic announcements is marginal at the daily level, despite the highly significant intraday effects.

The third column in Table III reports the degree of explanatory power for the high-frequency 5-min absolute returns, the explained variation for the full model drops to 10.8%. At this frequency, the daily volatility factor remains the most important component, explaining 5.2% alone. The calendar effects are secondary, explaining 4.3% by themselves. The macroeconomic announcements explain 2.5%. In particular, announcements from the German side explain only 0.5%, while announcements from the U.S. side explain 2.3%. The results from multiple correlation coefficients are consistent with individual estimates of announcement effects. The announcements from the US account for a bigger portion of the intraday variation in volatility than do their German counterparts.

CONCLUDING REMARKS

With the emergence of the Euro-zone and the creation of the Eurex futures and options exchange, the German 10-year Bund futures contract became the world's most liquid derivative product in 1999. Yet despite its importance as the most popular instrument for managing interest-rate risk and volatility trading, there has been no systematic study on its intraday and interday volatility patterns. This study makes a first attempt to address the issue. We provide a detailed characterization of the volatility in the German Bund futures market based on a two-year sample of high-frequency 5-min returns from 1997 to 1998.

We find that the intraday volatility is dominated by a broad U-shaped pattern across the trading day plus two distinct peaks at 14:30 and 16:00 Frankfurt time, which correspond to the regularly scheduled U.S. macroeconomic announcements at 8:30 EST and 10:00 EST, respectively. Because public information in the form of regularly scheduled announcements is known to exert a significant impact on the prices of government bonds and their derivative products, we also provide a comprehensive and accurate measure of the announcement effects on the European benchmark derivative. Specifically, we analyze the impact of 18 and 21 macroeconomic announcements from Germany and the U.S., respectively, and successfully identify the important macroeconomic data to which the Bund futures market is most sensitive. The decomposition and estimation procedure employed in the present analysis can be applied readily to the study of trading volume and bid—ask spread in the Bund futures market, as well as to other markets. Future research along these lines will, without a doubt, deepen our understanding of the functioning of the Bund future's market as it becomes increasingly important.

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