Discussion Paper No. 09-010

Return and Volatility Reactions to Monthly Announcements of Business Cycle Forecasts

An Event Study Based on High-Frequency Data

Horst Entorf, Anne Gross, and Christian Steiner

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Zentrum für Europäische
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Non-technical summary

This paper contributes to the literature on macroeconomic announcements and their impact on asset prices by investigating how the 15-second Xetra DAX returns reflect the monthly announcements of the two best renown business cycle forecasts in Germany, i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment.

Our findings can be summarized as follows. First, the analysis of responses to forecasts reveals an immediate impact at 15 seconds after the announcements of both *ifo* and ZEW: Positive (negative) news result in an immediate increase (decrease) of returns. Moreover, a first counter-movement (probably due some over-shooting) becomes apparent at 30 seconds for *ifo* and at 45 seconds for ZEW. In general, the impact of 'positive' news appears to be faster and stronger than the impact of 'bad' news.

Second, a detailed volatility analysis is conducted for the one-hour interval around the *ifo* and ZEW releases. We find the respective announcement (i.e. *ifo* or ZEW) to be clearly and immediately reflected in the volatility, which remains at a significantly higher level for approximately two minutes. A slight elevation can be observed until 15 minutes after the respective release.

Finally, we proceed with a combined modeling of returns and volatility in a GARCH-model. Previous results found in separate return and volatility analyses are confirmed.

Das Wichtigste in Kürze

Der Forschungsbeitrag beschäftigt sich mit der Wirkung der Veröffentlichungen des *Ifo-Geschäftsklimas* des Münchener ifo-Instituts sowie des *ZEW-Finanzmarkttests* auf die Aktienkurse, genauer gesagt auf die in 15-Sekunden Abständen messbaren Reaktionen des XETRA-DAX.

Die Nachrichten beider Institute führt zu einer unmittelbaren Reaktion des DAX, die 15 Sekunden nach den Veröffentlichungen (also zu dem am frühesten messbaren Zeitpunkt) auftritt: „Gute“ Nachrichten führen zu einer Erhöhung, „schlechte“ Nachrichten zu einer negativen Reaktion des DAX. Ferner sind Gegenbewegungen (z.B. aufgrund einer unmittelbaren Überreaktion) in entgegengesetzte Richtungen zu beobachten. Diese tritt bei den Ifo-Nachrichten nach 30 Sekunden und beim ZEW-Index nach 45 Sekunden auf. Generell ist festzustellen, dass die Reaktionen auf „gute“ Nachrichten stärker und nachhaltiger sind als bei „schlechten“ Nachrichten.

In einer parallel durchgeführten Volatilitätsanalyse (begrenzt auf eine Stunde nach Veröffentlichung der Indikatoren) zeigen sich gleichfalls deutliche Reaktionen. Diese sind in den ersten zwei Minuten statistisch signifikant, jedoch noch ca. weitere 15 Minuten visuell sichtbar.

In einer methodisch angezeigten Kombination von Rendite- und Varianzmodellierung mittels eines GARCH-Modells werden die zuvor in getrennter Analyse beobachteten Ergebnisse bestätigt.

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An Event Study Based on High-Frequency Data

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Summary: This article contributes to the literature on macroeconomic announcements and their impact on asset prices by investigating how the 15-second Xetra DAX returns reflect the monthly announcements of the two best known business cycle forecasts for Germany, i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment. From the methodological point of view, the main innovation lies in disentangling 'good' macroeconomics news from 'bad' news, and, simultaneously, considering time intervals with and without confounding announcements from other sources. Releases from both institutes lead to an immediate response of returns occurring 15 seconds after the announcements, i.e. within the first possible time interval. Announcements of both institutes are also clearly and immediately reflected in the volatility, which remains at a significantly higher level for approximately two minutes slightly elevated for approximately 15 minutes. Combining returns and volatility in a GARCH(1,1)-model, the paper reveals that significant increases in volatility only show up in the presence of simultaneous news released by other sources, whereas return reactions can be observed irrespective of whether confounding announcements are published or not.

Key words: event study, announcement effect, high-frequency data, intraday data

JEL classification: E44, G12, G14

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1. Introduction

High frequency data enable new insights into the efficiency of markets. There is an increasing amount of literature analyzing macroeconomic announcements and their impact on exchange rates as well as on various classes of asset prices. Several studies focus on the effects of inflation, output and unemployment (Schwert, 1981, McQueen and Roley, 1993, Flannery and Protopapadakis, 2002, Hautsch and Hess, 2002, Andersen et al 2003, 2007, Boyd et al. 2005) and, more recently, on the announcement effect of monetary policy measures (Cochrane and Piazzesi, 2002, Bomfim 2003, Rigobon and Sack, 2004, 2006, Bernanke and Kuttner, 2005, Nikkinen et al. 2006, Andersson, Hansen and Sebestyen 2009). A strong response of trading to public news announcements is documented in several studies. Common findings are the immediate adjustment of prices (returns) to surprises opposed to a more gradual adjustment of volatility to news (see the survey provided by Menkveld et al., 2006).

Various studies have shown that announcements have a simultaneous response on several markets. Wongswan (2005), for instance, documents that European equity indices significantly respond to surprises in US monetary policy announcements, Nikkinen and Sahlstrom (2004) as well as Andersson et al. (2009) find the German stock and bond markets to be more sensitive with respect to US news releases than to German macroeconomic announcements, and Harju and Hussain (2006) observe the scheduled US macroeconomic announcements at 14:30 CET to have an immediate impact on both European stock market returns and volatilities. Hence, a reasonable analysis of the effect of macroeconomic announcements requires a careful search for and consideration of confounding news from other competing sources.

The present study contributes to this literature by looking at the German evidence, represented by the German stock market index, DAX. Germany's macroeconomic prospects are pooled and focused in the monthly releases of German's two leading business cycle forecasts, namely i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment. This study shows the reaction of the DAX which is available with a 15-second frequency upon their publications. The present article compares the stock market reaction of both key indicators of the German economic situation in a single comprehensive framework, by using comparable methods, by focusing on the same period of time (January 2nd 2004 until April 28th 2006), and by considering the different situations arising for days without any further simultaneous macroeconomic news from other sources, and for days on which the announcements are made simultaneously along with other confounding news releases (such as announcements of the

ECB or Eurostat). Moreover, in order to account for the potential asymmetry of 'good' and 'bad' news, both are considered thus separately leading to four different regime categories that need to be distinguished.

A further issue considered in this work is the serial correlation often documented in stock market returns, the existence of which contradicts the Efficient Markets Hypothesis and has therefore been extensively discussed in the literature, as can be seen, for example, by mention in Campbell et al. (1997). Entorf and Steiner (2007) find that the autoregressive term in the mean equation of the DAX returns is no longer significant when the returns are modeled as a GARCH(1,1)-process and announcement dummies are incorporated into both mean and variance equation of the model. This finding suggests that autocorrelation of stock returns might be generated by announcement effects and thus be spurious. A model which correctly captures anticipated macroeconomic announcements could therefore be in line with the Efficient Markets Hypothesis.

Results reveal that the response of returns occurs 15 seconds after the announcements of both institutes, i.e. the reaction shows up within the first possible time interval. Some first counter reactions can be observed after 30 to 45 seconds. Announcements of both institutes are also clearly and immediately reflected in the volatility, which remains at a significantly higher level for approximately two minutes and slightly elevated for approximately 15 minutes. However, combining returns and volatility in a GARCH(1,1)-model, it turns out that significant increases in volatility only show up in the presence of simultaneous news released by other sources, whereas return reactions can be observed irrespective of whether confounding announcements are published or not.

The remainder of the paper is organized as follows. In chapter 2, we first summarize the literature on announcement effects and intraday analysis. The data used in our empirical investigation is illustrated in chapter 3. Chapter 4 presents the empirical results. The DAX return reaction on macroeconomic news is examined in section 4.1, Section 4.2 investigates the intraday volatility of the DAX returns on *ifo* release days, ZEW release days, and non-release days. A joint GARCH model for returns and volatility is introduced in section 4.3. Chapter 5 summarizes results and outlines the main conclusions.

2. Announcement Effects and the Analysis of Intraday Data

The first generation of event studies was primarily interested in the stock market effect of earnings announcements, dividend payments and stock splits (see, among others, Ball and Brown, 1968, Beaver, 1969, Fama et al., 1969, Patell and Wolfson, 1984). Recent studies focus on the effects of macroeconomic news, where inflation, output and unemployment (Schwert, 1981, McQueen and Roley, 1993, Flannery and Protopapadakis, 2002, Hautsch and Hess, 2002, Andersen et al 2003, 2007, Boyd et al. 2005) and the announcement effect of monetary policy measures play crucial roles (Cochrane and Piazzesi, 2002, Bomfim 2003, Rigobon and Sack, 2004, 2006, Bernanke and Kuttner, 2005, Nikkinen et al. 2006, Andersson, Hansen and Sebestyen 2009). The degree of stock market efficiency measured by the speed of price adjustments seems to increase over time. Patell and Wolfson (1984) report that the main reaction after the announcement of earnings and dividends was completed within 5 and 15 minutes. Ederington and Lee (1993) show that most of the price adjustment is finished within one minute. Most recent contributions (see, for instance, Andersen et al, 2003) find almost immediate reactions of financial markets.

Stock markets are analyzed in terms of both returns and volatility. Whereas normal reaction implies upward (downward) price movements in response to 'good' ('bad') news, rational decisions of financial investors might also lead to some reverse changes of stock market prices. Pearce and Roley (1985) argue that 'good' economic perspectives might trigger increasing interest rates such that rising expected costs of capital would lead to negative stock market returns. Boyd et al (2005) hint at asymmetric responses to 'good' or 'bad' news dependent on the prevailing economic situation during the business cycle.

The availability of high-frequency data enabled financial researchers to investigate seasonal phenomena of intraday volatility. Berry and Howe (1994), Goodhart and O'Hara (1997), Jones et al. (1998), and others find that intraday volatility has a U-shaped form, implying that market uncertainty is highest at the beginning and at the end of the trading day. In a recent paper, Harju and Hussain (2006) confirm this finding based on 5-minute returns of the four most important European stock exchanges (CAC40, FT100, SMI, XDAX). Entorf and Steiner (2007) refine the findings about the German DAX using 15-second intervals.

Financial econometrics based on ultra-high-frequency data bears the problem of market microstructure noise (see Ait-Sahalia et al., 2005). Asynchronous trading and periods of non-trading, for instance, might cause problems for stocks with low liquidity. Moreover, assets with smaller market capitalisation might be highly sensitive to new and noisy information (see also Goodhart and O'Hara, 1997). As we analyze announcement effects for the German stock market index XDAX based on a highly liquid market and almost continuous trading, such problems are of minor importance for the 15-second intervals used in our analysis.

3. Data

Empirical evidence of this paper is based on two leading indicators of the German economy (i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment) and DAX intraday data.

3.1 Leading Indicators of the German Economy

Apart from the two most popular German indicators, i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment, the Purchasing Manager Index (PMI)[2], Economic Sentiment Indicator (ESI)[3] and the sentix Economic Indices for Europe (sentix)[4] are available.

There have been several studies comparing different German sentiment indicators and their economic forecast ability. Hüfner and Schröder (2002), for instance, compare these four sentiment indicators and find that the *ifo*, PMI, and ZEW indicators indeed run well ahead the economic activity in Germany. With respect to the three indicators *ifo*, PMI, and ZEW, out-of-sample forecasts suggest that *ifo* and ZEW provide the best forecasts. While all five indicators – *ifo*, ZEW, PMI, ESI, and *sentix* – are published monthly, there are significant differences in the publication schedule. The *sentix* indicator is usually the first to be released, followed by the ZEW indicator and the *ifo* index. The ESI release takes place on the last day of a month whereas the PMI is reported on the first business day of the following month.

3.2 The *ifo* Business Climate Index

The *ifo* Business Climate Index has now been surveyed for more then 30 years following the same method. According to Sinn and Abberger (2006), the timely persistence as well as the monthly on time release have created a great confidence in the quality of the *ifo* index.

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[2] Calculated since 1996 and managed by Association Materials Management, Purchasing, and Logistics (AMMPL)

[3] Calculated since 1985 for Germany by the European Commission

[4] Calculated since 2003 by sentix

A monthly survey questioning approximately 7,000 firms in manufacturing, construction, wholesaling, and retailing forms the basis of the *ifo* Business Climate Index.[5] The survey participants are business leaders and senior managers from all sectors, excluding the financial sector. The monthly survey consists of twelve questions about the specific, current, and expected situation of each firm in terms of level of production, prices, orders, and inventories. The firms are asked to give their assessments of the current business situation, which they can characterize as "good", "satisfactory", or "poor", and their expectations for the next six months which can be stated as "more favorable", "unchanged", or "less favorable". Individual responses are weighted and published in aggregate form. The *ifo* business climate balance is a transformed mean of the balances of business situation and expectations. In referring to ordinal responses as (+, = , -), the individual forecasts are aggregated into categories. Both *ifo* and ZEW (see below) base their indicators on so called balances[6], which are defined as $s = p - m$ is used, where p denotes the relative frequency of the positive categories (+), and m is the relative frequency of the negative categories (-). The balance equals the mean of the responses in case that the categories are encoded as +1, 0, and -1.

The initial release of the *ifo* indicator is at 10:00 CET when the agencies can listen to the results in a short conference call. The results are made available online at 10:30 CET.

The forecasting power of the *ifo* index has recently been analyzed by Sinn and Abberger (2006). According to them, the qualitative assessment of the strength of the economic situation in combination with the weighted survey results helps drawing conclusions about the strength of the cyclical growth. The *ifo* Business Climate is also very useful in forecasting the European economic development. A survey among 30 European economists led by Reuters in early 2005 found the *ifo* Business Climate Index to be Europe's most important business indicator. The forecasting power of the *ifo* index even outside Germany is due to the high export quota of the German manufacturing industry (Sinn and Abberger, 2006).

3.3 The ZEW Indicator of Economic Sentiment

The ZEW Indicator of Economic Sentiment is calculated from the results of the ZEW Financial Market Survey. This survey has been carried out monthly since December 1991. It

[5] Most information about the ifo Business Climate Index mentioned in this section can be found on the ifo institute's website (ifo, 2009).

[6] In terms of out-of-sample forecasting power, Entorf (1993) has shown that balances are easily outperformed by other combinations of +, = and -. Particularly the simple use of the minus share *m* instead of *s* would improve the forecasting performance.

displays the expectations of financial experts for six[7] important international financial markets[8].

There are about 350 financial analysts participating in this survey. Among the respondents are experts from finance, research, and economic departments, as well as experts in the investment and securities sector. The questionnaire of the ZEW Financial Market Survey consists of nine questions. The experts are asked to assess the current economic situation, the medium-term expectations for the development of the macroeconomic trend, the inflation rate, the short-term and long-term interest rates, stock market indices, and the exchange rates. This part of the survey deals with the financial markets of Germany, USA, Japan, GB, France and Italy. The financial experts are also requested to estimate the profit situation of 13 German industries[9] as well as the oil price development in the next six months.

Qualitative assessments of their expectations are given by the survey participants, who have the choice between three possible ordinal answers; the design of the questionnaire resembles the one collected by *ifo*. The ZEW Indicator of Economic Sentiment is a leading indicator for the German economy (similar to the *ifo* index), the G-Mind (German Market Indicator) displays the sentiment of the analysts concerning the German stock and bond markets. Both indicators enjoy broad public interest.

The ZEW Indicator of Economic Sentiment is released online at 11:00 CET (on ZEW's website) on the second or third Tuesday of each month. One week later, the ZEW Financial Market Report is published, where the results of the ZEW Financial Market Survey are analyzed in detail.

3.4 A Comparison of the *ifo* Index and the ZEW Indicator

Hüfner and Schröder (2002) find that both, ZEW and *ifo* indices, have good qualities as leading indicators for the industrial production in Germany. Analyzing correlations and using tests of causality, they provide statistical evidence for the ZEW indicator having a one month lead over the *ifo* business expectations. Accordingly, both *ifo* business expectations and ZEW Indicator of Economic Sentiment show a significant lead compared to the annual rate of change in industrial output in Germany (ZEW: six months, *ifo*: four months). The ZEW

[7] I.e. Germany, USA, Japan, GB, France, and Italy.

[8] See ZEW's website (ZEW, 2006) for most information about the ZEW Indicator of Economic Sentiment presented in this section.

[9] I.e. banking, insurance, trade and commerce, construction, automotive, chemistry, steel, electricity, mechanical engineering, utilities, services, telecommunication, and information technology.

results are significantly better for a period of three to twelve months, while for the *ifo* expectations this significance can only be proved for six months forecasts. A direct comparison of the two indicators shows that *ifo* yields the better forecasts in the short run (one month), whereas the ZEW indicator is superior for medium- to long-term forecasts. A combination of the ZEW indicator and *ifo* expectations might improve the forecasting quality for short- and medium-term horizon, given that the two surveys indeed contain complementary information. However, the fact that the ZEW has a one month lead over the *ifo* index is relevant for the financial markets. The ZEW indicator helps to detect cyclical fluctuations even earlier.

In a comment of the *ifo* institute on this study, Goldrian (2001) claims that the lead of the ZEW indicator highly varies with the cyclical fluctuations. Whereas the lead becomes very clear in upturns, it is not observed in downturns. One might conclude that the entrepreneurs surveyed by the *ifo* institute, whose responses reflect their own microeconomic backgrounds, do not change their expectations as fast as the financial analysts polled by ZEW. The latter tend to react to positive economic signals by quickly adjusting their expectations. The entrepreneurs will only become more optimistic in their expectations after the improvement is actually established. This link between expectations and activities is the reason for a particularly high correlation of the *ifo* index and the production, which is manifested by a significant lead, even though this lead is shorter than that of the ZEW indicator over the industrial production. On the other hand, the great variations observed in the lead of the ZEW indicator would only allow for a vague dating of the expected economic development.

An update of their study comparing the forecasting qualities of the ZEW Indicator and the *ifo* business expectations was released by Hüfner and Schröder (2005). Using data from January 1997 to September 2004 they are able to confirm the significant one-month lead of the ZEW over the *ifo* indicator. Both the *ifo* business expectations and the ZEW Indicator of Economic Sentiment contribute significantly to the explanation of the industrial production. The recent study by Hüfner and Schröder (2005) also confirms that the *ifo* expectations provide better results for a one-month forecasting period, while the ZEW indicator performs better for horizons from two to twelve months. The ZEW indicator and the *ifo* business expectations index seem to complement each other in terms of participants as well as concerning the different forecasting horizons.

Irrespective of small performance differences with respect to lead over and correlation with real economic activity, both indices enjoy large public interest such that in particular sudden and unanticipated movements of either indicator are reported by print media, radio stations and TV news.

3.5 DAX Intraday Data

In order to analyze the impact of macro news on the German stock market, intraday data of the Deutscher Aktienindex (DAX) will be used. The DAX measures the performance of the Prime Standard's 30 largest German companies in terms of order book volume and market capitalization (Deutsche Börse, 2006). The calculation of the index starts at 09:00 CET and ends with documenting prices from the Xetra[10] closing auction at 17:30 CET.

The intraday data for our analysis was provided by the *Karlsruher Kapitalmarktdatenbank* (KKMDB)[11] who obtain their market data directly from *Deutsche Börse AG*, Frankfurt. The records consist of date, index price, and time. Bid-ask-quotes or trading volume data are not provided.[12]

Until the end of 2005, 15-second intervals are the highest available frequency for the German Xetra DAX (XDAX). Since January 2006, the XDAX is computed every second. Thus, for our observation period – January 2nd 2004 to April 28th 2006, in total 597 trading days – we base our work on 15-second intervals. To create one uniform sample at 15-second frequency, only the observations at xx:xx:00, xx:xx:15, xx:xx:30, and xx:xx:45 are selected for January 2nd 2006 to April 28th 2006. The time frame is adjusted from 09:00:30 to 17:30:15 (2040 intervals) in order to keep the number of observations for each interval roughly constant. For some trading days, data prior to 09:00:30 is available, but there are also days for which the record of the DAX values starts with a slight delay. For most days, data is provided until 17:45:00, but since trading stops at 17:30 an inclusion of later intervals would lead to zero-returns in most cases.

Even though the time frame is adjusted, the number of observations per interval still differs for several reasons. First, some trading days are shortened if they precede a banking holiday. There is also a data quality problem concerning the exact 15-second timing, as we observe 2,964 incidents for which the recorded time is not a multiple of 15 seconds, that is the DAX values are recorded for "irregular" time units like 4, 19, 27.99, 36.99, 56 seconds etc. These records may have been collected instead of or additionally to the regular 15-second intervals.

[10] Xetra is the name of the electronic trading system.

[11] See http://fmi.fbv.uni-karlsruhe.de.

[12] Thus, neither the impact of the bid-ask spread nor volume effects can be analyzed.

However, these observations at ’odd’ intervals will be omitted in our later analysis. Due to such irregularities, the number of observations for some time intervals is smaller than for others (minimum: 523, maximum: 597).

4. Results

We start by examining the relation between *ifo* and ZEW, then turn to analyzing the DAX return reaction on macroeconomic news. Subsequently, we concentrate on the announcement effect on intraday volatilities and finally conclude by combining results from both analyzing returns and volatilities into comprehensive GARCH models.

Before analyzing the impact of macroeconomic news, we investigate the characteristics of the individual time series involved. The observation period of both monthly indicators is increased to January 2000 in order to enhance the power of tests which aim at investigating the recent time series behavior of considered indicators. Application of Augmented Dickey-Fuller (ADF) as well as of Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests of *ifo* and ZEW expectations and the first differences of both time series show that *ifo* exhibits a unit root while ZEW is stationary.

In order to get an insight into the lead-lag-structure of *ifo* and ZEW, we compute the cross-correlations of the two series. Since *ifo* was found to have a unit root, the cross-correlation analysis is conducted for both the levels and the first differences of the two series. In sum, we do not detect a clear lead of one indicator over the other, as the findings for the first differences (*ifo* has a lead over ZEW) contradict those for the levels (ZEW has a lead over *ifo*). Therefore, a more refined analysis meant to determine the lead-lag-structure of *ifo* and ZEW is conducted by applying Granger causality tests. Based on the outcome of the Granger causality tests we cannot detect any lead of one indicator over the other, which comes in line with the suggestions provided by the cross-correlations. However, adding the respective other indicator to the baseline equation improves the predictive power in both cases.

4.1. The Return Reaction

After testing for the presence of microstructure effects in terms of the non-trading effect, an autoregressive moving average (ARMA)-model for the returns is fitted. Surprise dummies are included in order to determine at which time intervals the release of macroeconomic announcements shows an effect on the DAX.

Following previous approaches (see, for example, Balduzzi et al. 2001, Hautsch and Hess 2002, Harju and Hussain 2006), the return analysis is conducted on the set of all observations on release days, whereas non-release days are excluded.[13] The return in the 15-second interval i on release day t is given by:

(4.1) $$R_{i,t} = \ln \frac{DAX_{i,t}}{DAX_{i-1,t}}$$

It is a common finding that not the announcement per se but the unanticipated news contained in the announcement affects returns on announcement days. We therefore use announcement surprises as the difference between realizations and expected values.[14] Since our aim is to compare the impact of *ifo* and ZEW announcements, we use standardized surprises following Balduzzi et al. (2001). The standardized surprise associated with data release k at time t is given by

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

where $A_{k,t}$ denotes the announced value, $E_{k,t}$ the expected market value of indicator k at time t, and $\hat{\sigma}_k$ is the sample standard deviation of ($A_{k,t} - E_{k,t}$). Using standardized news facilitates the comparison of responses to the different news releases.

Previous experience with experts expectations on $E_{k,t}$ of ZEW forecasts (Entorf and Steiner, 2007) revealed that such data do not contain any significant information that might add to the information already captured by the previous realization. We thus replace the forecast $E_{k,t}$ in equation (4.2) by the index value at time t-1. This idea is supported by the fact that research institutes appear to pay only little attention to the release of various forecasts for their indicators. Note also that forecasts of forecasts never capture the entire information available immediately before the announcement, since the information keeps flowing until the macroeconomic indicator is released. We therefore restate equation (4.2) as follows:

(4.3) $$S_t = \frac{index_t - index_{t-1}}{\hat{\sigma}},$$

[13] Note, however, that GARCH models presented later (see section 4.3) are based on the complete set of observations.

[14] Note that 'expectations' refer in this context to the expected value of the respective index and are not to be confused with the expectations component of the *ifo* index.

where 'index' stands for either *ifo* or ZEW and $\hat{\sigma}$ denotes the sample standard deviation of *ifo* or ZEW, respectively.[15] Henceforth, we distinguish between positive ($S_t \geq 0$) and negative ($S_t < 0$) surprises or, equivalently, between 'good' and 'bad news.

For both indices, our observation period from January 2nd 2004 to April 28th 2006 comprises 15-second data of 28 release days. We focus on a one-hour interval around the release, i.e. [09:30:00 -10:30:00) for the *ifo* index and [10:30:00 -11:30:00) for the ZEW indicator, which results in 6720 observations for each indicator.

Due to the fact that the reactions might be heterogeneous with respect to the valence of news ('good' vs. 'bad'), and in order to correct for confounding news releases from other sources, we distinguish two steps and four different final situations. First, we summarize release days on which announcements are published along *with* other competing news, and in a different set of days *without* potentially confounding simultaneous announcements of other macroeconomic indicators (given in the Appendix). Next we categorize according to the existence/nonexistence of simultaneous news and positive/negative surprises, see also Figure 1 for an illustration:

- *'no sim neg'* – refers to days with no simultaneous releases; the released index value reflects 'bad' news (i.e. the index value is lower compared to the previous month),
- '*no sim pos'* – denotes days with 'good' news without simultaneous releases from other sources,
- *'sim neg'* – indicates 'bad' news on days with simultaneous releases,
- *'sim pos'* – reflects positive surprises on days with simultaneous releases.

A detailed overview on the classification of *ifo* and ZEW release days for the categories can be taken from the Appendix. Our observation period contains 13 *ifo* release days with simultaneous announcements by the European Central Bank (ECB) and 12 out of 28 ZEW release days with simultaneous releases at 11:00 CET, of which 11 are announcements by Eurostat (Statistical Office of the European Communities). Thus, the proportion of days along with and without simultaneous announcements as well as the type of simultaneously released information for *ifo* and ZEW are similar.

[15] Note that $S_{k,t}$ in equation (4.2) is replaced by S_t, the index k is redundant as we do not consider various indicator releases at the same time. Thus, S_t refers to the standardized surprise in the ifo (ZEW) announcement when considering the returns from 09:30 to 10:30 (10:30 to 11:30).

4.1.1. Zero Returns

Before analyzing the announcement impact on market prices, we investigate the DAX returns for non-trading effects, as reliable conclusions can only be drawn if this microstructure effect is negligible, All 15-second intervals without trading amount to 0.85% in the one-hour interval around the ifo release, and to 1.09% in the one-hour interval around the ZEW release. This is in line with findings in Entorf and Steiner (2007), who report 1% zero returns between 10 a.m. and 12 a.m. in 2003 and 2004, and between 2 p.m. and 4 p.m. in 2002. Hence, the impact of non-trading effects can indeed be considered negligible. For the subsets described above the total share of zero returns varies between 0.30% for '*no sim neg'* in terms of the ifo index and 1.67% for '*sim pos'* in terms of the ZEW index.

4.1.2. The Announcement Effect of the *ifo* Index on the DAX Returns

The goal is the analysis of returns between [09:30:00 -10:30:00) on *ifo* release days. First, an ARMA-model is fitted based on the 6720 respective observations (as expected from the literature on financial markets, unit root tests on returns do not show any sign of non-stationarity). As the constant turns out being insignificant, we do not include a constant in the test equation. Using the Schwarz information criterion (SC) for selecting the appropriate model and allowing for a maximum of 36 lags, the following AR(1)-model is chosen:

(4.4) $$R_{i,t} = 0.10 R_{i-1,t} + \varepsilon_{i,t} \, ,$$

where $R_{i,t}$ denotes the DAX return in the 15-second interval i[16] on the *ifo* release day t. The return series does not have a unit root and we do not detect remaining autocorrelation in the residuals (according to the Ljung-Box Q-statistic). ARCH-tests clearly reject the null hypothesis of no conditional heteroskedasticity which motivates modeling returns as a GARCH-process (see below).

The next step is to augment equation (4.4) by dummy variables covering unexpected returns in response to forecast announcements. According to the potential existence of simultaneous releases of confounding macroeconomic news, we begin by considering four separate equations for the categories '*no sim neg', 'no sim pos', 'sim neg',* and *'sim pos'* based on the respective subsets. This refers to *level 1* in Figure 1.

[16] As we consider all 15-second intervals between [09:30:00 -10:30:00), i runs from 1 to 240.

For expository reasons, we subsequently explain the specification for "no sim neg". The remaining three categories are explored along the same procedure. For days without simultaneous releases and a negative standardized surprise (*'no sim neg'),* the AR(1)-model for returns in interval i on release day t in equation (4.4) is extended as follows:

(4.5) $$R_{i,t} = c + \alpha_1 R_{i-1,t} + \sum_{j=121}^{i} \delta_j D_{j,t} S_t + \varepsilon_{i,t},$$

where S_t is the standardized surprise on the release day t,[17] $D_{j,t}$ denotes a dummy variable which takes the value 1 in interval j if t belongs to the category *'no sim neg'* and 0 otherwise.

Note that no surprise dummies are included for intervals prior to 10:00:00, since the sign of the announcement is not known before the actual release. In order to find out for which j (out of j = 121,..., 240)[18] the dummy variable $D_{j,t}$ is significant[19] and to make sure that this significance does not depend on the number of dummies included, we run equation (4.5) also for i = 140, 160, 180, 200, 220, and 240. It turns out that including dummies for each 15-second interval between [10:00:00 -10:30:00), i.e. i = 240, captures most of the intervals also found to be significant in the equations with fewer dummies. However, we decided to proceed in a conservative way by not only including the significant dummies from the equation based on i =240, but also those being significant (at 10 % level) in at least one of the other equations (i= 140, 160, 180, 200, 220). Finally, for the category *'no sim neg'*, the following intervals are found to be significant (for at least one of the equations): j = 123,152,156, and 176.[20] Denoting the set of these four significant intervals by J1, we restate our return model as follows:

(4.6) $$R_{i,t} = c + \alpha_1 R_{i-1,t} + \sum_{J1} \delta_j D_{j,t} S_t + \varepsilon_{i,t} .$$

As returns are supposed to almost instantly incorporate news, and given that there is a steady inflow of noise and market signals, it seems rather unlikely that significant impacts at 15 or 20 minutes after the announcement are caused by the *ifo* release. Since most significant reactions are detected prior to 10:16, we focus on the significant intervals up to 10:15:45 and exclude all subsequent intervals from J1. The resulting reduced set is denoted by J2. Next we re-

[17] Note that S_t captures the sign of the surprise such that $S_t \geq 0$ ($S_t < 0$) for good (bad) news. Thus, a positive coefficient d_j denotes a positive (negative) news impact on days where the *ifo* index improves (deteriorates).

[18] Interval 121 denotes the interval beginning at 10:00:00.

[19] In the sequel, significance refers to the 10% level.

[20] Interval 123 refers to [10:00:30 -10:00:45), 152 denotes the interval [10:07:45 -10:08:00), 156 and 176 stand for the intervals beginning at 10:08:45 and 10:13:45, respectively.

estimated equation (4.6) on the basis of J2, and remove all dummies which have become insignificant according to estimations based on J1 and J2. The arising set of significant intervals is denoted as J3, and equation (4.6) is re-estimated now based on J3. The procedure of removing dummies which become insignificant in the resulting estimation is repeated until all remaining dummies are found to be significant. For the category '*no sim neg*' presented here, J1 equals J2 as no intervals after 10:15:45 are found to be significant. It takes four iterations until all remaining dummies are significant, i.e. the final specification J4 has been identified.[21] For negative news on days without simultaneous announcements, we end up with no dummies remaining significant, hence a simple AR(1)-model describes well '*no sim neg'*.

The first two columns in Table 1 provide detailed results of the four categories described as *level 1* (for reasons of space, only sets of the initial specification J1 and of the final specification J4 are presented). Whereas no significant intervals are found for days without simultaneous releases and negative news, the three remaining categories show that the impact of the *ifo* release becomes visible at 15 seconds after the announcement. Evidently the impact of news at 10:00:15 is followed by counter reactions at 10:00:30 and 10:00:45. The reaction on 'good' news is more intense on days with simultaneous releases than on days without any simultaneous release which can be seen from estimated coefficients. These amount to 8.39E-04 (1.33E-04) at 10:00:15 and -8.75E-04 (-1.37E-04) at 10:00:30 for days with (without) simultaneous releases.

As an alternative to the research design captured by *level 1* (see Figure 1), we separately estimate models for days 'without' simultaneous confounding announcements, and models for days on which forecasts are published along 'with' simultaneous releases at 10:00 CET, i.e. for the categories '*no sim'* and '*sim'* described as *level 2*. Again, we detail only the equation for the category *"no sim"*, days with simultaneous releases ("sim") are investigated using an analogical procedure. For days without simultaneous releases, the AR(1)-model of high-frequency DAX returns (see equation (4.4)) is extended as follows:

(4.7) $$R_{i,t} = c + \alpha_1 R_{i-1,t} + \sum_{j=121}^{i} (\delta_j^+ D_{j,t}^+ S_t + \delta_j^- D_{j,t}^- S_t) + \varepsilon_{i,t}\,,$$

where S_t is the standardized surprise on release day t, $D_{j,t}^-$ denotes a dummy variable which takes the value 1 in interval j only if t belongs to the category '*no sim neg'* and $D_{j,t}^+$ takes the

[21] The same applies for the other three categories "no sim pos", "sim neg", and "sim pos".

value 1 in interval j only if t belongs to the category '*no sim pos',* respectively. Again, surprise dummies have not been included for intervals prior to 10:00:00.

Following the same procedure introduced above, we estimate equation (4.7) for each i =140, 160, 180, 200, 220, and 240, and include all significant dummies from the specification with i=240, as well as those being significant (at 10% level) in at least one of the other equations (i=140, 160, 180, 200, 220). For the category '*no sim'* we find the following intervals to be significant on days with 'good' news: 122, 123, 126, 163, 170, 173, 181, 231, and 238,[22] while for 'bad' news, we obtain significant dummies for 123, 152, 156, and 176. This finding corresponds exactly to the previously observed significant results on the set '*no sim neg'*.[23] Denoting the set of the 9 significant intervals for positive news by J_1^+, and the set of the 4 significant intervals for negative news by J_1^-, we re-specify our return model as follows:

$$R_{i,t} = c + \alpha_1 R_{i-1,t} + \sum_{J1^+} \delta_j^+ D_{j,t}^+ S_t + \sum_{J1^-} \delta_j^- D_{j,t}^- S_t + \varepsilon_{i,t} \quad (4.8)$$

Focusing on the significant intervals up to 10:15:45 and excluding all later time intervals yields the reduced sets of significant intervals J_2^+ and J_2^-. Reiterating the procedure by re-estimating equation (4.8) on the basis of these modified sets, and gradually removing all insignificant dummies until all remaining dummies are significant leads to updated sets denoted by J_3^+, J_3^- and J_4^+, J_4^-, respectively. See columns 3 and 4 of Table 1 for detailed estimation results of the first and the final step; the category '*sim'* is treated analogously.

Finally, a comprehensive model for all release days (referring to as *level 3* in Figure 1) is obtained, now considering four groups of dummy variables, namely $D_{j,t}^+$ for the category '*no sim pos*', $D_{j,t}^-$ for '*no sim neg',* $\tilde{D}_{j,t}^+$ for '*sim pos*', and $\tilde{D}_{j,t}^-$ for '*sim neg*'. Following the procedure introduced above, for '*no sim neg'* we find the same significant intervals as in previous estimations, namely 123, 152, 156, and 176. Additionally, the interval 124 beginning at 10:00:45 is observed to be weakly significant. Denoting the sets of significant intervals by

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[22] The counting of intervals again starts with the interval [09:30:00 -09:30:15), such that 121 refers to [10:00:00 - 10:00:15) etc. Hence, intervals 122 and 123 correspond to responses measured 15 and 30 seconds after the initial reaction towards the news release.

[23] Note however, that this does not necessary apply for all other categories – for example, we find 13 significant dummies for '*no sim pos'* compared to 9 significant intervals for good news in the analysis of '*no sim'*.

J_1^- for '*no sim neg'*, " (J_1^+ for '*no sim pos'*) and $\tilde{J}_1^-$ for '*sim neg'* ($\tilde{J}_1^+$ for '*sim pos'*), the comprehensive estimation model is specified as:

$$(4.9)\quad R_{i,t} = c + \alpha_1 R_{i-1,t} + \sum_{J_1^+} \delta_j^+ D_{j,t}^+ S_t + \sum_{J_1^-} \delta_j^- D_{j,t}^- S_t + \sum_{\tilde{J}_1^-} \gamma_j^- \tilde{D}_{j,t}^- S_t + \sum_{\tilde{J}_1^+} \gamma_j^+ \tilde{D}_{j,t}^+ S_t + \varepsilon_{i,t} .$$

Excluding significant estimates later than 10:15:45 results in the reduced sets J_2^- , J_2^+ , $\tilde{J}_2^-$, and $\tilde{J}_2^+$. Again, gradually removing insignificant dummies finally results in the last two columns of Table 1. Note that the AR(1)-term remains significant (at the 5% level) in all estimations. The set of available 15-second time intervals reveals a significant reaction for *all* cases covered in Figure 1, except for the case when 'bad' *ifo* news occur without any further confounding announcement from competing sources. Hence, the final return equation (identical to the final level 3 equation, as the stepwise estimation on all three levels suggests the inclusion of almost identical sets of time intervals) does not include any set of time intervals J_4^-:

$$(4.10)\quad R_{i,t} = 1.12E^{-06} + 0.10R_{i-1,t} + \sum_{J_4^+} \delta_j^+ D_{j,t}^+ S_t + \sum_{\tilde{J}_4^+} \gamma_j^+ \tilde{D}_{j,t}^+ S_t + \sum_{\tilde{J}_4^-} \gamma_j^- \tilde{D}_{j,t}^- S_t + \varepsilon_{i,t} .$$

Responses are taking place at 10:00:15 and 10:00:30 / 10:00:45, indicating a short-lived upward and a subsequent immediate downward counter reaction of DAX returns to the announcement of *ifo* news.[24] When *ifo* surprises and other news announcements occur simultaneously, the reaction is stronger, in particular in case of negative realizations of the surprise variable.

4.1.3. The Announcement Effect of the ZEW Indicator on the DAX Returns

Analogously to the analysis of *ifo* releases, the following section provides evidence on the reaction of high-frequency DAX returns around the release of the ZEW indicator, i.e. within the time interval [10:30:00 -11:30:00). Our first goal is to model the returns on ZEW release days (6720 observations) by a meaningful ARMA-model (again, non-stationarity is clearly

[24] Recall that the sign of the surprise is captured by S_t, such that a positive coefficient δ_j / γ_j denotes a positive (negative) news impact.

rejected for the DAX returns of this time interval). Using the Schwarz information criterion (SC) and allowing for a maximum of 36 lags, the following AR(1)-model is chosen:

(4.11) $$R_{i,t} = 0.09R_{i-1,t} + \varepsilon_{i,t},$$

where $R_{i,t}$ denotes the DAX return in the 15-second interval i(where i =1,..., 240) on ZEW release day t.

Due to some remaining serial correlation in the residuals in the model (4.11), we specify alternative models and find an ARMA(2,2) to be the most parsimonious model for which serial correlation in the residuals is negligible. Thus, instead of using equation (4.11), we subsequently model the returns around the ZEW release according to the following model:

(4.12) $$R_{i,t} = -3.33E^{-06} - 0.39R_{i-1,t} - 0.48R_{i-2,t} + 0.48\varepsilon_{i-1,t} + 0.50\varepsilon_{i-2,t} + \varepsilon_{i,t},$$

where all coefficients are significant at the 1% level, whereas the constant is not significant at conventional levels. Again, ARCH-tests clearly reject the null hypothesis of no conditional heteroskedasticity.

As for *ifo* releases, the next step consists of including announcement surprise dummies into equation (4.12). We begin by considering four separate equations based on the respective subsets (i.e. *level 1* equations according to Figure 1). Results for *level 1* can be taken from the first column of Table 2. Operations are repeated for *level 2* (separate models for "no sim" and "sim") and *level 3* (one single comprehensive model). Corresponding results are shown in the second and third columns of Table 2.

Since too many intervals were included in the initial estimation at each of the three levels, only the sets corresponding to final equations (i.e. J_4) of *levels 1* to *3* are presented. Contrary to our findings for the returns around the *ifo* release, the stepwise estimation procedure leads to different sets of time intervals at different levels. Whereas the three final equations imply identical intervals for "sim pos", the differences are most obvious for '*no sim neg'* and '*no sim pos'*. In order to obtain less ambiguous results, the comprehensive model (*level 3*) was re-estimated based on the significant dummies from the final equations of *levels 1* and *2,* respectively.[25] These results show merely slight improvements, with the equation based on *level 1* clearly differing from the final equation based on *level 2*.

[25] See Table 2, 'level 3 based on level 1' and 'level 3 based on level 2', respectively, for the final equations after gradually removing dummies which became insignificant. Note that the ARMA-terms are highly significant for all estimations.

In a "combined" equation, we followed a conservative strategy by including all intervals found significant in at least one of the three equations for *level 3*. Again, we gradually remove insignificant estimates. The ARMA-terms are significant at 1% level in all iterations. The final combined equation is given in the last column of Table 2.

The Schwarz information criterion (SC) for the *level 3* equations reveals that although different dummies are included, the overall performance is quite similar. The lowest SC value is obtained for the equation based on *level 1*. Nevertheless, the combined equation might be preferred from a methodical point of view. We subsequently specify the two final equations for the returns in the one-hour interval around the release of the ZEW indicator which differ with respect to included time intervals (see Table 2) and ARMA(2,2) parameters (not reported):

$$(4.13)\quad R_{i,t} = ARMA(2,2) + \sum_{J} \delta_j^{+} D_{j,t}^{+} S_t + \sum_{J} \delta_j^{-} D_{j,t}^{-} S_t + \sum_{\tilde{J}} \gamma_j^{+} \tilde{D}_{j,t}^{+} S_t + \sum_{\tilde{J}} \gamma_j^{-} \tilde{D}_{j,t}^{-} S_t + \varepsilon_{i,t}$$

where J and $\tilde{J}$ denote sets of significant response intervals without and with simultaneous releases from other sources.

Compared to the final return specification around the *ifo* release, where 0 / 5 / 10 / 5 dummies are included for *'no sim neg' / 'no sim pos' / 'sim neg' / 'sim pos',* in Table 2 we observe 11 / 7 / 5 / 2 significances for the final ZEW returns equation based on *level 1*. For the final combined equation we include 20 / 12 / 8 / 2 dummies, respectively. We find more significant intervals for '*no sim neg*' compared to '*sim neg*' which confirms that days without simultaneous release exhibit stronger variations for 'bad' news. Secondly, for days with simultaneous announcements stronger variations are a consequence of 'good' news, which is reflected in higher coefficients for *'sim pos'*' compared to *'no sim pos'*.

For all four categories, we observe the impact of the ZEW release to become apparent at 15 seconds after the announcement, i.e. the interval beginning at 11:00:15 is positively significant, see Table 2. For *'no sim neg', 'no sim pos'*, and *'sim neg'* the estimated coefficient at 11:00:30 is still significantly positive, a first counter-movement becomes apparent at 11:00:45. For days with simultaneous announcements and positive ZEW news, the counter-movement shows up at 11:01:00.

Thus, summarizing and comparing return responses following releases of *ifo* and ZEW, we find that for both institutes there is a first reaction after 15 seconds of time. This response can be characterized as 'immediate', as 10:00:15 and 11:00:15, respectively, coincide with the left margin of the first time interval after the news release at 10:00:00 and 11:00:00, respectively. First reactions of the DAX return to the realization of the *surprise* variable have the expected positive sign, i.e. the reaction is positive to ‘good’ news and negative to ‘bad’ news. ZEW and *ifo* differ with respect to the second time interval starting at xx:00:30: While reactions to ZEW surprises lead to a second upward movement of the DAX, responses to *ifo* surprises are negative, indicating an immediate reverse reaction to the first upward movement of the DAX. For ZEW news this reaction is detected during the next time interval, i.e. at 11:00:45. As regards the amplitude of the reaction, we have to rely on release days *without* simultaneous announcements (*no sim neg, no sim pos*). In case of ‘bad” news, we do not find significant results for *ifo*, but rather strong effects for ZEW (see ‘combined’: 4.37E-04), whereas in case of ‘good’ news reactions to the announcements of both institutes are of similar size (*ifo*, *level 3*: 1.35E-04; ZEW, *level 3, combined*: 1.31E-04).

4.2. The Volatility Evolution

In this section, similarities and differences of the intraday volatility of the Xetra DAX returns considering *ifo* release days and ZEW release days are considered. Our observation period for this analysis comprises all trading days from January 2nd 2004 to April 28th 2006 (in total 597). The volatility is calculated for each 15-second interval from 09:00:30 to 17:30:15 (namely 2,040 intervals). Altogether, the analysis for an entire trading day is based on 1,213,469 observations. Below, we make use of limited time intervals of the trading day. We do not present results on the complete trading day, as no differences to the analysis of intraday seasonalities by Harju and Hussain (2006) and Entorf and Steiner (2006) have been identified.

For our analysis the volatility of the time interval i at day t is given by

(4.14) $$V_{i,t} = \left| R_{i,t} - \bar{R}_i \right| ,$$

where $R_{i,t}$ denotes the Xetra DAX return for time interval i at day t and $\bar{R}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} R_{i,t}$ is the average return for time interval i over all trading days. The average intraday volatility for each interval I (i =1,..., 2040) is formulated as

(4.15) $$\bar{V}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} V_{i,t} ,$$

where T_i is the number of observations for interval i with respect to the period under review.[26]

4.2.1. The Volatility around the Release of the *ifo* Index

For the volatility analysis we focus on a one-hour interval around the release of the *ifo* index, namely [09:30:00 – 10:30:00). Our volatility analysis is based on 15-second data, altogether 142,967 observations being included. Figure 2 provides a graph of the volatility between 09:30 and 10:30 CET, where the upper plot compares the volatility on *ifo* release and non-release days and the bottom graph shows the volatility on days with simultaneous releases (*sim*) compared to those days when the *ifo* index is the only scheduled announcement at 10:00 CET (*no sim*). The *ifo* release is clearly reflected in the market volatility, which remains elevated for approximately two minutes. Volatility patterns for days with and without simultaneous releases at 10:00 CET are quite similar. Thus, as first remark, we notice that volatility reactions seem to be more persistent than return reactions.

A regression analysis is applied in order to examine the volatility around the *ifo* release. The following regression is run separately for each 15-second interval i from [09:30:00 -09:30:15) to [10:29:45 -10:30:00):

(4.16) $$V_{i,t} = \vartheta_{0,i} + \vartheta_{1,i} D\_release_{i,t} + \varepsilon_{i,t},$$

where $D\_release_{i,t}$ is a dummy variable for interval i which takes the value 1 if t is a release day for the *ifo* index and 0 otherwise. The coefficient $\vartheta_{1,i}$ denotes the impact of the *ifo* release on the DAX, such that a significantly positive (negative) $\vartheta_{1,i}$ indicates that the volatility in interval i is higher (lower) on release days compared to non-release days. The results for the regressions based on equation (4.16) can be found in Table 3.

In order to determine whether the impact of the *ifo* release on the DAX volatility differs with respect to the simultaneous release of other macroeconomic news, we include a second dummy variable into the regression, $\tilde{D}_{i,t}$ which takes the value 1 for interval i if other macroeconomic news are released at the same time as the ifo index on day t. On days where the *ifo* is the only release at 10:00 CET, $\tilde{D}_{i,t}$ equals 0. Note that the variable $D\_release_{i,t}$

[26] Alternatively, we tried a volatility measure based on $(R_{i,t} - \overline{R}_i)^2$. The two volatility measures exhibit similar behavior and appear to follow identical regularities.

introduced in equation (4.16) is replaced by $D_{i,t}$, which takes the value 1 for interval i only if there are no simultaneous releases on day t.[27]

In the corresponding equation

$$V_{i,t} = \vartheta_{0,i} + \vartheta_{1,i} D_{i,t} + \vartheta_{2,i} \tilde{D}_{i,t} + \varepsilon_{i,t} \qquad (4.17)$$

the impact of macroeconomic releases at 10:00 CET is denoted by $\vartheta_{1,i}$ if the *ifo* index is the only announcement at that time and by $\vartheta_{2,i}$ if there are simultaneous releases. (Note that $\vartheta_{2,i}$ does not capture the additional impact of simultaneous releases but the joint impact of all releases at 10:00 CET.) If the coefficients $\vartheta_{1,i}$ and $\vartheta_{2,i}$ are positive (negative) and significantly different from zero, the DAX volatility in interval i is significantly higher (lower) on *ifo* release days (with or without simultaneous releases) compared to non-release days. The results for these regressions (equation (4.17)) can be found in Table 4.

In sum, our analysis shows that the *ifo* release is clearly reflected in the price volatility at 10:00:15. During the first two minutes following the release, the significantly increased volatility can be attributed to the *ifo* announcement for most intervals. Subsequent significances appear to be caused by other simultaneous releases in a few cases and volatility remains slightly elevated for approximately 15 minutes. A "calm-before-the-storm-effect" (noted by Entorf and Steiner 2007) cannot be validated, as there is no remarkable number of negative coefficients prior to the *ifo* announcement at 10:00 CET.

4.2.2. The Volatility around the Release of the ZEW Indicator

A similar analysis is conducted for a one-hour interval around the release of the ZEW indicator at 11:00 CET. Figure 3 shows the volatility between [10:30:00 -11:30:00) based on 143,039 observations. The upper panel offers volatility graphs on ZEW release and non-release days, whereas the bottom graph shows the volatility on days with no simultaneous announcements at 11:00 CET (‘*no sim*’) compared to the volatility on days with other scheduled releases at the publication time of the ZEW indicator (‘*sim*’). Similar to the *ifo* publication, the release of the ZEW indicator is clearly reflected in the volatility which remains increased for approximately two minutes. The volatility patterns during days with and

[27] Using $D\_release_{i,t}$ together with $\tilde{D}_{i,t}$ leads to rather similar results for the volatility analysis but poses problems for the GARCH-model below due to linearly dependent dummy vectors. Furthermore, the use of disjoint dummies in the volatility equation is in line with our procedure for the returns as well as with our descriptive volatility analysis, see Figure 2.

without simultaneous releases at 11:00 CET are fairly similar, a fact already noticed for *ifo*. The peaks are even more pronounced for the ZEW release than for the *ifo* release.

Again, we employ an additional regression analysis to examine the volatility around the ZEW release, in line with equations (4.18) and (4.19). The coefficient $\vartheta_{1,i}$ in equation (4.18) now denotes the impact of the ZEW release onto the DAX. The results can be derived from Table 5. To analyze whether the impact of the ZEW release varies with the occurrence of simultaneous releases at 11:00 CET, we again consider equation (4.19). The DAX volatility in the interval i is significantly higher (lower) on days without / with simultaneous releases at 11:00 CET, if $\vartheta_{1,i}$ / $\vartheta_{2,i}$ is positive (negative) and significantly differs from zero. The results for these regressions based on equation (4.19) can be found in Table 6.

In sum, the descriptive and the regression analysis both point out a clearly increased volatility 15 and 30 seconds after the release of the ZEW indicator. The volatility remains slightly elevated for approximately 15 minutes after the release. Until 11:05:15, significantly increased volatility can be attributed to the actual ZEW announcement for most intervals. This contradicts to some extent the conclusion of Entorf and Steiner (2007) that the market would be highly efficient as new information is fully incorporated into prices after one minute. Differences in the results might be attributed to the more recent time period and increased public attention (January 2002 until September 2004, versus January 2004 until April 2006), and in a refined analysis which also considers confounding simultaneous announcements. Similarly to the *ifo* release, a "calm-before-the-storm-effect" cannot be proved for the ZEW announcement either.

4.3. Modeling Returns and Volatility using a GARCH-Model

This section summarizes previous insights and introduces a joint model for returns and volatility around the release of the *ifo* index and the ZEW indicator, respectively. Starting from the initial ARMA-setting derived in section 4.1, we add to the complexity of our return model by a stepwise inclusion of dummy variables found to be significant in sections 4.1 and 4.2 and by replacing the simple ARMA-with a GARCH-model. As for the return analysis, we limit our 15-second data to the 28 *ifo* (ZEW) release days registered for our observation period from January 2nd 2004 to April 28th 2006. Again, we focus on one-hour intervals around the respective release, i.e. [09:30:00 -10:30:00) for the *ifo* index and [10:30:00 -

11:30:00) for the ZEW indicator. Thus, our sample consists of 6720 observations for *ifo* and ZEW, respectively.

4.3.1. A GARCH-Model for Returns around the *ifo* Release

Subsequently, we focus on the DAX returns in the time interval between [09:30:00 -10:30:00) on *ifo* release days. Six different models are considered and the corresponding results are presented in Table 7.

First, the return equation is estimated as a simple AR(1)-process; this model was already investigated in section 4.1. See column (1) of Table 7 for the results. Second, surprise dummies are included in our equation, according to the final model for the returns, see equation (4.10) in section 4.1.2. The results for this extended AR(1)-model are presented in column (2). For both equations, i.e. steps (1) and (2), the AR(1)-term is highly significant while the constant term remains insignificant. Third (see column (3) of Table 7), the AR(1) process from column (1) is replaced by a GARCH(1,1)-process. The AR(1)-return equation becomes the mean equation for the GARCH-model. According to the Schwarz criterion (SC = -14.76) our model has improved.

Fourth, the results for a GARCH-model based on the augmented AR(1)-model from step (2) are given in column (4). The simple GARCH(1,1)-model is extended by the inclusion of surprise dummies into the mean equation. In the final return equation (4.10), none of the dummies for negative news on days without simultaneous announcements remains significant, the extended GARCH(1,1)-model with dummies included in the mean equation can thus be stated as follows ($J^+, \tilde{J}^+, \tilde{J}^-$ denote subsets of significant response intervals, see Table 1):

(4. 18)
$$
\begin{aligned}
R_{i,t} &= c + \alpha_1 R_{i-1,t} + \sum_{J^+} \delta_j^+ D_{j,t}^+ S_t + \sum_{\tilde{J}^+} \gamma_j^+ \tilde{D}_{j,t}^+ S_t + \sum_{\tilde{J}^-} \gamma_j^- \tilde{D}_{j,t}^- S_t + \varepsilon_{i,t} \\
\sigma_{i,t}^2 &= \lambda + \mu \varepsilon_{i-1,t}^2 + \nu \sigma_{i-1,t}^2 \\
\varepsilon_{i,t} &= u_{i,t} \sigma_{i,t} \\
u_{i,t} &\overset{i.i.d.}{\sim} N(0,1).
\end{aligned}
$$

The significance of the AR-and GARCH-coefficients does not change in response to this modification. As regards return reactions measured by dummy variables in the mean equation, 7 out of 20 intervals become insignificant when compared to column (2) (Table 7). We observe a general pattern of a first ‘positive’ (surprise consistent) reaction after 15 seconds and of a reverse reaction thereafter. The counter reaction takes place at 10:00:30, thus 15 seconds after the initial reaction for ‘good’ news without simultaneous announcements and for 'bad' news with competing simultaneous announcements, see estimated coefficients δ_j^+ and γ_j^-, while the counter reaction is delayed and detectable only after 30 seconds in case of 'good' news being published simultaneously with other announcements, see γ_j^+. This pattern proves robust and holds throughout all specifications of Table 7.

Fifth, release dummies, namely $D\_release_{k,t}$ for time interval k on release day t are included into the variance equation. These dummies equal 1 only for interval k, i.e. $D\_release_{k,t}$ = 1 in interval k and $D\_release_{l,t}$ = 0 otherwise (l ≠ k).[28] In Section 4.2, we investigated the significance of a release dummy separately for each 15-second interval from [09:30:00 - 09:30:15) to [10:29:45 -10:30:00).[29] We now extend our GARCH-model from column (4) by including the release dummies being significant at the 10% level from Table 3 (denoted by the set K) into the variance equation:[30]

$$\sigma_{i,t}^2 = \lambda + \mu\varepsilon_{i-1,t}^2 + \nu\sigma_{i-1,t}^2 + \sum_{k\in K} \vartheta_{1,k} D\_release_{k,t} . \tag{4.19}$$

Note that the presented specification of Table 7, column (5), relies on a conservative pre-test strategy. The model includes all dummies that have been significant in at least one of six pre-testing estimations. These are based on Table 3 and consist in separate general-to-specific modeling at 10, 5, and 1% significance levels and are replicated with respect to the two different dummy definitions $D\_release_{k,t}$ mentioned above. Using this approach, the AR(1)-term and the GARCH(1,1)-coefficients as well as the release dummies for 10:00:15, 10:00:30, and 10:00:45 in the mean equation are all highly significant in Table 7, column (5). Out of 20 dummies included in the mean equation, 14 are significant (8 at 1%, 2 at 5%, and 4 at 10% significance level). For the variance equation, three dummies turned out to be significant, namely those at 10:00:15 (at 1% significance level), 10:00:30 and 10:00:45 (at 5% significance level). Thus, the immediate reaction at 10:00:15 as well as the counter-movement at 10:00:30 are also observed in the variance equation. With a value of -14.77, the SC is

28 The model has also been estimated with the alternate dummy definition $D\_release_{l,t}, \forall l \geq k$, without substantial deviations from presented results.

29 By contrast to the GARCH-model fitted in this section, the volatility analysis in section 4.2 is based on the set of all observations, including non-release days. Thus, the dummy definition and, hence, the interpretation of the estimated coefficients differ. Whereas $\vartheta_{1,k}$ > 0 refers to an increased volatility compared to non-release days in the same interval in section 4.2, $\vartheta_{1,k}$ > 0 now stands for a volatility increase relative to the previous interval.

30 Note that the 10% significance level is chosen analogously to the inclusion of dummies into the return equation (4.10). The GARCH-equation (4.19) has also been estimated including only the release dummies which are significant at 5% (1%) level into the variance equation.

slightly lower than for step (3) and (4), suggesting that the new model does slightly improve our estimation.

Finally, we include two groups of dummies into the variance equation, namely $D_{k,t}$ for *ifo* release days without simultaneous releases, and $\tilde{D}_{k,t}$ for days with simultaneous releases at 10:00 CET. In the variance equation of the GARCH-model, these dummies again equal 1 only for interval k. The significance of these dummies has been investigated separately for each interval in Section 4.2.1 (see Table 4 for the corresponding results). The GARCH-model from column (4) is extended by including the *'no sim'* and '*sim'* dummies found being significant at the 10% level into the variance equation:

$$\sigma_{i,t}^2 = \lambda + \mu\varepsilon_{i-1,t}^2 + \nu\sigma_{i-1,t}^2 + \sum_{k\in K} \vartheta_{1,k} D_{k,t} + \sum_{k\in \tilde{K}} \vartheta_{2,k} \tilde{D}_{k,t}, \qquad (4.20)$$

where K denotes the set of dummies for *no simultaneous releases*, and $\tilde{K}$ the set of *simultaneous release* dummies, respectively (significant at the 10% level). Confer column (6) of Table 7 for the results of this GARCH-model. As for the model with a simple release dummy in the variance equation (step (5)), not all dummies that were included in the variance equation are given in column (6). Only those dummies that were significant in at least one of the six equations[31] are presented in column (6). Similarly to column (5), we observe the AR(1)-coefficient and the GARCH(1,1)-terms as well as the first couple of dummies we incorporated into the mean equation to be highly significant. Out of the 20 dummies included in the mean equation, we find 13 to be significant, all of which are also significant in step (5), with differences in the level of significance for some of the intervals. Concerning the dummies included in the variance equation $\vartheta_{1,10:00:15}$, $\vartheta_{2,10:00:15}$, $\vartheta_{2,10:00:30}$ and $\vartheta_{2,10:00:45}$ turn out to be significant. The immediate reaction is thus also observed in the variance equation, for simultaneous releases even the counter-movement at 10:00:30 can be seen. However, a value of SC = -14.75 indicates that the modified model does not further improve our estimation.

In sum, the AR(1)-coefficient is significant for all six specifications for the DAX returns around the *ifo* release. The return autocorrelation does not vanish after the inclusion of announcement dummies into the mean and variance equations of our GARCH(1,1)-model. This contrasts with the finding by Entorf and Steiner (2007) based on ZEW releases. The dummies we included into the mean equation vary with respect to their values and significances but never change their signs. The immediate return reaction towards the *ifo*

[31] The equation has been fitted including significant dummies at 10, 5, 1%, respectively, from Table 3, and estimated with respect to the two different dummy definitions.

release is reflected in highly significant dummies from 10:00:15 to 10:00:45. Concerning the announcement dummies included into the variance equation of our GARCH-model we notice that the coefficients for 10:00:15 and 10:00:45 are positive, while we observe a negative value at 10:00:30. This is in line with our volatility analysis in section 4.2.1, see especially Figure 2.[32] Even though the absolute value of announcement dummies included into the variance equation is generally very small, the Schwarz information criterion suggests that the GARCH-model with simple release dummies included into the variance equation (column (5)) leads to the best fit.

4.3.2. A GARCH-Model for Returns around the ZEW Release

Subsequently, we focus on the DAX returns around the release of the ZEW indicator, that is in the time interval between [10:30:00 -11:30:00). Following the procedure introduced for the *ifo* index, we again consider six different return models. The results are presented in Table 8.

In a first step, the return equation is estimated as a simple ARMA(2,2)-process, which has already been investigated in section 4.1.2, equation (4.12): See Table 8, column (1). Second, surprise dummies are included in the final models (see section 4.1.2, equation (4.13)). As, contrary to the return analysis for *ifo*, we did not come up with a single final model but with two alternative representations, we decided to rely on the *combined* model, because it provides the more general set of potentially relevant time intervals. The results for these extended ARMA(2,2)-models are presented in column (2) of Table 8. The ARMA(2,2)-terms are significant at least at 5% level for steps (1) and (2), only the constant remains insignificant.

In the third step (see column (3)), the ARMA(2,2)-model from column (1) is replaced by a GARCH(1,1)-process. The ARMA-return equation becomes the mean equation for the GARCH-model. According to the Schwarz criterion (SC = -14.88) the estimated model improves again. The results for a GARCH-model based on the augmented AR(1) from column (2) are given in column (4) of Table 8. The simple GARCH(1,1)-model is extended by including surprise dummies into the mean equation and can be stated as follows:

[32] Note that the coefficients in Tables 3 and 4 are positive for all three intervals. This is due to the dummy definition we applied: For the volatility analysis presented in Section 4.2, we run a separate regression for each 15-second interval, thus the coefficients reflect whether the volatility in the respective interval is higher compared to non-release days. By contrast, the combined GARCH-model is restricted to observations on release days and dummies are defined by $D_{k,t}=1$ only in interval k.. Therefore the negative coefficient at 10:00:30 refers to a lower volatility compared to other time intervals on release days.

$$
\begin{aligned}
(4.21) \qquad & R_{i,t} = ARMA(2,2) + \sum_{J^+} \delta_j^+ D_{j,t}^+ S_t + \sum_{J^-} \delta_j^- D_{j,t}^- S_t + \sum_{\tilde{J}^+} \gamma_j^+ \tilde{D}_{j,t}^+ S_t + \sum_{\tilde{J}^-} \gamma_j^- \tilde{D}_{j,t}^- S_t + \varepsilon_{i,t} \\
& \sigma_{i,t}^2 = \lambda + \mu \varepsilon_{i-1,t}^2 + \nu \sigma_{i-1,t}^2 \\
& \varepsilon_{i,t} = u_{i,t} \sigma_{i,t} \\
& u_{i,t} \overset{i.i.d.}{\sim} N(0,1).
\end{aligned}
$$

where J^+, δ_j^+, and $D_{j,t}^+$ etc. are defined as before. The GARCH-coefficients μ and ν are both highly significant, whereas the constant term λ is insignificant. All ARMA-coefficients keep their significance at the 1% level. However, 15 out of 42 intervals introduced in equation (4) become insignificant. Confirming the previous autoregressive analysis of returns, the dummies representing the immediate reaction (after 15 and 30 seconds) to the ZEW announcement are mostly positive (and significant), whereas the first negative reaction follows after 45 seconds. The value for the Schwarz criterion indicates an improvement compared to the simple GARCH(1,1)-model in column (3).

Following the procedure for *ifo*, release dummies $D\_release_{k,t}$ for time interval k on release day t are included into the variance equation in the next step (see column (5)). We extend the GARCH-model from column (4) by including the respective significant release dummies from Table 5, denoted by the set K, into the variance equation. Thus, the variance equation is adjusted according to (4.19). Again, the specification refers to dummies which equal 1 only for interval k and have been significant in at least one of six pre-testing estimations (see *ifo*, section 4.3.1).

Whereas all ARMA-coefficients become insignificant in response to the inclusion of time dummies into the variance equation, the GARCH(1,1)-coefficients μ and ν are still significant at the 1% level. Concerning the response dummies included in the variance equation, $\vartheta_{1,11:00:15}$, $\vartheta_{1,11:00:45}$, $\vartheta_{1,11:01:00}$ and $\vartheta_{1,11:03:00}$ turn out to be significant. The immediate reaction at 11:00:15 and the counter-movement at 11:00:45 are thus also observed in the variance equation. Moreover, relative to step (4) the number of significant dummies in the mean equation is further reduced (24 out of 42). With a value of SC = -14.91 compared to SC=-14.92 for step (4), estimations are of comparable fit.

In a final step, two groups of dummies are included into the variance equation of the GARCH(1,1)-model, namely $D_{k,t}$ for ZEW release days without simultaneous releases and $\tilde{D}_{k,t}$ for days with simultaneous releases at 11:00 CET (see column (6) of Table 8). Again, the specification uses dummies being equal to 1 only for interval k and considers pre-tested intervals which have been significant at least at the 10% level. Including significant dummy variables for *'no sim'* and *'sim'* into the variance equation leads to a specification of the variance equation for the GARCH model according to (4.20). Similar to column (5), the GARCH(1,1)-coefficients μ and ν are significant at the 1% level, whereas all ARMA-terms remain insignificant. The numbers of significant parameters of the mean equation is again reduced (20 out of 42). Concerning the dummy variables included in the variance equation, we find $\vartheta_{1,10:58:30}$, $\vartheta_{1,11:00:15}$, $\vartheta_{1,11:03:00}$, $\vartheta_{1,11:10:00}$, $\vartheta_{2,11:00:15}$, $\vartheta_{2,11:01:00}$ and $\vartheta_{2,11:02:15}$ being significant. Thus, the immediate reaction to the ZEW release is reflected in the variance equation at 11:00:15 whereas the first counter-movement at 11:00:45 is not. However, comparing the information criterion of model (6) to the SC of previous models, the specification in column (6) turns out to be dominated by other models, in particular by results presented in columns (4) and (5).

A concluding comparison of *ifo* and ZEW based on GARCH results is presented in Table 9. It documents all highly significant (5 %) responses within the first five minutes after the respective announcements. In order to account for potentially confounding news from other sources, reported results on returns are taken from respective columns (5) to (6) in Tables 7 and 8, and volatility patterns are based on column (6).

Most return reactions are characterized by a fast response after 15 seconds, followed by a counter-reaction after 30 to 45 seconds. For 'good' news, there is an upward movement after 15 seconds for both institutes, irrespective of the presence of confounding announcements. The picture is less clear for 'bad' news, as there is no significant reaction to announcements of the *ifo* institute, at least in the absence of confounding information, and first negative reactions of DAX returns to negative ZEW news (i.e., leading to '+' of the surprise indicator) can be measured 'only' after 30 seconds. ZEW announcements seem to cause some further stock market adjustments, since responses are not limited to the first 60 seconds but also some significant ups and downs can be observed thereafter.

The immediate reactions at 11:00:15 (*ifo*) and 10:00:15 (ZEW) can be observed for the variance equation, too, but only in the absence of confounding announcements. Moreover, looking at the broader picture reveals that counter reactions are less important than further positive outliers (at 00:45 for *ifo* and 01.00 for ZEW), confirming the generally increased volatility levels in response to business cycle forecasts shown in Figures 2 and 3.

5. Summary and Conclusions

This article contributes to the literature on macroeconomic announcements and their impact on asset prices by investigating how the 15-second Xetra DAX returns reflect the monthly announcements of the two best renown business cycle forecasts, i.e. the *ifo* Business Climate Index and the ZEW Indicator of Economic Sentiment. From the methodological point of view, the main innovation lies in disentangling 'good' macroeconomics news from 'bad' news, and, simultaneously, considering time intervals with and without confounding announcements from other sources.

Our findings can be summarized as follows. First, concerning the relationship between the ZEW indicator and the *ifo* business climate index, cross-correlation and Granger causality tests do not detect any lead of one indicator over the other. Second, in order to analyze the impact of macroeconomic news on DAX returns, we take up by investigating the presence of non-trading effects which turn out to be negligible. We find that the returns in a one-hour interval around the *ifo* release are well modeled by an AR(1)-process, while an ARMA(2,2)-process is necessary in order to correctly specify the returns around the ZEW announcement. The analysis of responses to forecasts reveals an immediate impact at 15 seconds after the announcements of both *ifo* and ZEW: Positive (negative) news result in an immediate increase (decrease) of returns. Moreover, a first counter-movement becomes apparent at 30 seconds for *ifo* and at 45 seconds for ZEW. In general, the impact of 'positive' news appears to be faster and stronger than the impact of 'bad' news.

Third, a detailed volatility analysis is conducted for the one-hour interval around the *ifo* and ZEW releases. In addition to descriptive findings, we account for the respective macroeconomic announcement by the inclusion of dummy variables in two regression specifications. We find the respective announcement (i.e. *ifo* or ZEW) to be clearly and immediately reflected in the volatility, which remains at a significantly higher level for approximately two minutes. A slight elevation can be observed until 15 minutes after the respective release. Volatility patterns for days with and without simultaneous releases are fairly similar.

Finally, we proceed with a combined modeling of returns and volatility in a GARCH(1,1)-model. The dummies found to be significant in the previous return and volatility analyses are included in the GARCH-specification in order to capture the announcement effect of the forecast releases. Results reveal that significant increases in volatility only show up in the presence of simultaneous news released by other sources, whereas return reactions can be observed irrespective of whether confounding announcements are present or not.

Whereas our findings for ZEW data suggest that serial correlation of returns vanishes after inclusion of announcement dummies into both the mean and the variance equation of the GARCH(1,1)-model, this result cannot be confirmed for *ifo* releases, where the AR(1)-term remains significant throughout all specifications.

Aiming at explaining the somewhat less pronounced return reaction to *ifo* announcements compared to the reaction to ZEW releases, we suppose that this result might be caused by the earlier publication of the ZEW indicator. According to Andersen et al. (2003) early announcements within the same category of macroeconomic indicators exhibit greater impact than those released later, as the impact of new information diminishes if major components of the release are already known or may be forecasted from other previously released figures. Since the ZEW value for the current month is already known to the market when the *ifo* index is released, any change of the *ifo surprise* variable might already be priced by financial markets.

Future research should focus on the reasons for the regular pattern of counter-reactions found after 30 and 45 seconds. Some hints might be found in the problem of overshooting, but also research on reactions caused by changing interest rates in anticipation of future money demand is of related interest.

References

AIT-SAHALIA, Y., P., MYKLAND, L. ZHANG (2005), Ultra High Frequency Volatility Estimation with Dependent Microstructure Noise, Princeton University, Department of Economics - Bendheim Center for Finance.

ANDERSEN, T. G., T. BOLLERSLEV, F.X. DIEBOLD, C. VEGA (2003), Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange? *American Economic Review*, 93(1), 38–62.

ANDERSSON, M., L.J. Overby, S. SEBESTYÉN (2009), Which News Moves the Euro Area Bond Market? *German Economic Review* 10(1), 1-31.

BALL, R. AND P. BROWN (1968), An Empirical Evaluation of Accounting Income Numbers, *Journal of Accounting Research* 6, 159-178.

BALDUZZI, P., E.J. ELTON, T.C. GREEN (2001), Economic News and Bond Prices: Evidence from the U.S. Treasury Market, *Journal of Financial and Quantitative Analysis*, 36(4), 523–543.

BEAVER, W. (1968), The Information Content of Annual Earnings Announcements, *Journal of Accounting Research* 6 (Supplement), 67-92.

BERNANKE, B. S., K. KUTTNER (2005), What Explains the Stock Market's Reaction to Federal Reserve Policy? *Journal of Finance* 60(3), 1221-1257.

BERRY, T.D., HOWE, K.M. (1994), Public information arrival, *Journal of Finance*, Vol. 49(4), 4, 1331 – 1346.

BOMFIM, A. N. (2003), Pre-announcement Effects, News Effects, and Volatility: Monetary Policy and the Stock Market, *Journal of Banking and Finance* 27, 133 – 151.

BOYD, J. H., R. JAGANNATHAN, J. HU (2005), The Stock Market's Reaction to Unemployment News: Why Bad News is Usually Good for Stocks, *Journal of Finance* 60(2), 649 – 672.

COCHRANE, J., M. PIAZZESI (2002), The Fed and Interest Rates - A High Frequency Identification, *American Economic Review* 92, 90–101.

DEUTSCHE BÖRSE (2006). *Deutsche Börse Group*. URL: http://deutsche-boerse.com.

CAMPBELL, J. Y., A.W. LO, A.C. MACKINLAY (1997), *The Econometrics of Financial Markets*, Princeton University Press.

EDERINGTON, L.H., J.H. LEE (1993), How Markets Process Information: News Releases and Volatility, *Journal of Finance*, 48(4), 1161–1191.

ENTORF, H. (1993), Constructing leading indicators from non-balanced sectoral survey series, *International Journal of Forecasting* 9 (1993), 211-225.

ENTORF, H., C. STEINER (2007), Makroökonomische Nachrichten und die Reaktion des 15-Sekunden-DAX: Eine Ereignisstudie zur Wirkung der ZEW Konjunkturprognose, *Jahrbücher für Nationalökonomie und Statistik* 227(1), 2-26.

FAMA, E.F., L.FISHER, M.C. JENSEN, R. ROLL (1969), The Adjustment of Stock Prices to New Information, *International Economic Review* 10(1), 1-21.

FLANNERY, M., A. PROTOPAPADAKIS (2002), Macroeconomic Factors Do Influence Aggregate Stock Returns, *Review of Financial Studies* 15(3), 751—782.

GOODHART, C.A.E., O'HARA, M. (1997), High frequency data in financial markets: Issues and applications, *Journal of Empirical Finance* 4, 73-114.

GOLDRIAN, G. (2001), Anmerkungen zu einer Untersuchung des prognostischen Gehalts von ifo Geschäfts- und ZEW-Konjunkturerwartungen, *ifo Schnelldienst* 10, Ifo Institute for Economic Research, available at: http://www.cesifo-group.de/link/ifosd_2001_10_7.pdf.

HARJU, K. S.M. HUSSAIN (2006), Intraday Seasonalities and MacroeconomicNews Announcements, Working Paper 512. Swedish School of Economics and Business Administration, available at: http://ideas.repec.org/p/hhb/hanken/0512.html.

HAUTSCH, N., D. HESS (2002), The Processing of Non-Anticipated Information in Financial Markets: Analyzing the Impact of Surprises in the Employment Report, *European Finance Review* 6(2), 133–161.

HÜFNER, F.P., M. SCHRÖDER (2002), Prognosegehalt von ifo-Geschäftserwartungen und ZEW-Konjunkturerartungen: Ein ökonometrischer Vergleich, *Jahrbücher für Nationalökonomie und Statistik* 222(3), 316 – 336.

HÜFNER, F. P., M. SCHRÖDER (2005), Prognosevergleich der ZEWKonjunkturerwartungen und der ifo-Geschäftserwartungen: Eine Aktualisierung, ZEW Wachstums- und Konjunkturanalysen, Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim. available at: ftp://ftp.zew.de/pub/zew-docs/div/Prognoseguete_konj_0502.pdf.

IFO (2006). *CESifo Group Munich Homepage: Ifo Institute, CES, CESifo GmbH*. URL: http://www.cesifo-group.de.

JONES, C., O. LAMONT, R. LUMSDAINE (1998), Macroeconomic News and Bond Volatility, *Journal of Financial Economics* 47, 427-445.

LIN, S.J., YANG, J. (2003), Examining intraday returns with buy/sell information, *Applied Financial Economics* 13, 447-461.

MCQUEEN, G. AND V. V. ROLEY (1993), Stock Prices, News, and Business Conditions, *The Review of Financial Studies* 6(3), 683-707.

MENKVELD, A. J., A. SARKAR, M. VAN DER WEL (2006), The Informativeness of Customer Order Flow Following Macroeconomic Announcements: Evidence from Treasury Future Markets, Conference Paper, available at: http://www.georgetown.edu/faculty/evansm1/conference.

NIKKINEN, J., P. SAHLSTROM (2004), Scheduled Domestic and US Macroeconomic News and Stock Valuation in Europe, *Journal of Multinational Financial Management* 14(3), 201–215.

NIKKINEN, J., M. OMRAN, P. SAHLSTRÖM, J. ÄIJÖ (2006), Global Stock Market Reactions to Scheduled U.S. Macroeconomic News Announcements, *Global Finance Journal* 17, 92–104.

PATELL, J.M., M.A. WOLFSON (1984), The Intraday Speed of Adjustment of Stock Prices to Earnings and Dividend Announcements, *Journal of Financial Economics* 13, 223-252.

PEARCE, D.K., ROLEY, V.V. (1985), Stock Prices and Economic News, *Journal of Business* 58(1), 49-67.

PMI (2006), *The German PMI*, URL: http://portal.bme.de:8080/servlet/PB/menu/1027764/index.html.

RIGOBON, R., B. SACK (2006). Noisy Macroeconomic Announcements, Monetary Policy, and Asset Prices, NBER Working Paper, available at: http://ideas.repec.org /p/nbr/nberwo/12420.html.

RIGOBON, R., B. SACK (2004), The Impact of Monetary Policy on Asset Prices, *Journal of Monetary Economics* 51, 1553—1575.

SCHWERT, G. W. (1981), The Adjustment of Stock Prices to Information About Inflation, *The Journal of Finance* 36(1), 15-29.

SENTIX (2006), *Sentix – Behavioral Indices*, URL: http://www.sentix.de.

SINN, H.-W., K. ABBERGER (2006), Zur Prognosekraft des *ifo* Indikators, *ifo Schnelldienst* 4, Ifo Institute for Economic Research. available at: http://www.cesifo-group.de/link/ifosd_2006_4_6.pdf.

WONGSWAN, J. (2005), The Response of Global Equity Indexes to U.S. Monetary Policy Announcements, International Finance Discussion Paper 844, Board of Governors of the Federal Reserve System (U.S.), available at: http://www.federalreserve.gov/ pubs/ifdp/2005/844/ifdp844.pdf.

ZEW (2006), *ZEW Finanzmarktreport*, URL: http://www.zew.de/en/publikationen/ finanzmarktreport.php3.

FIGURES AND TABLES

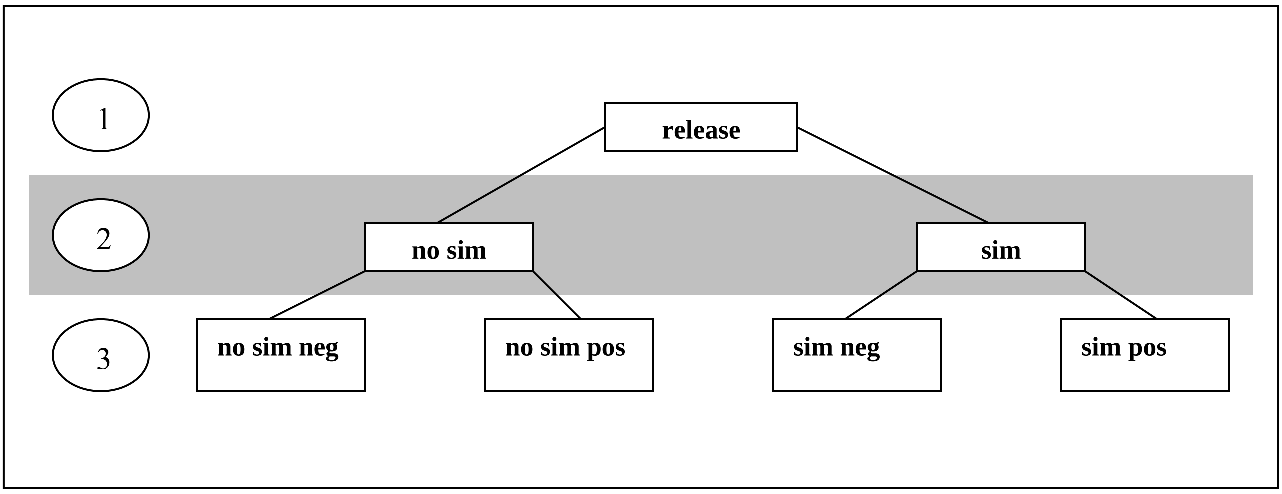
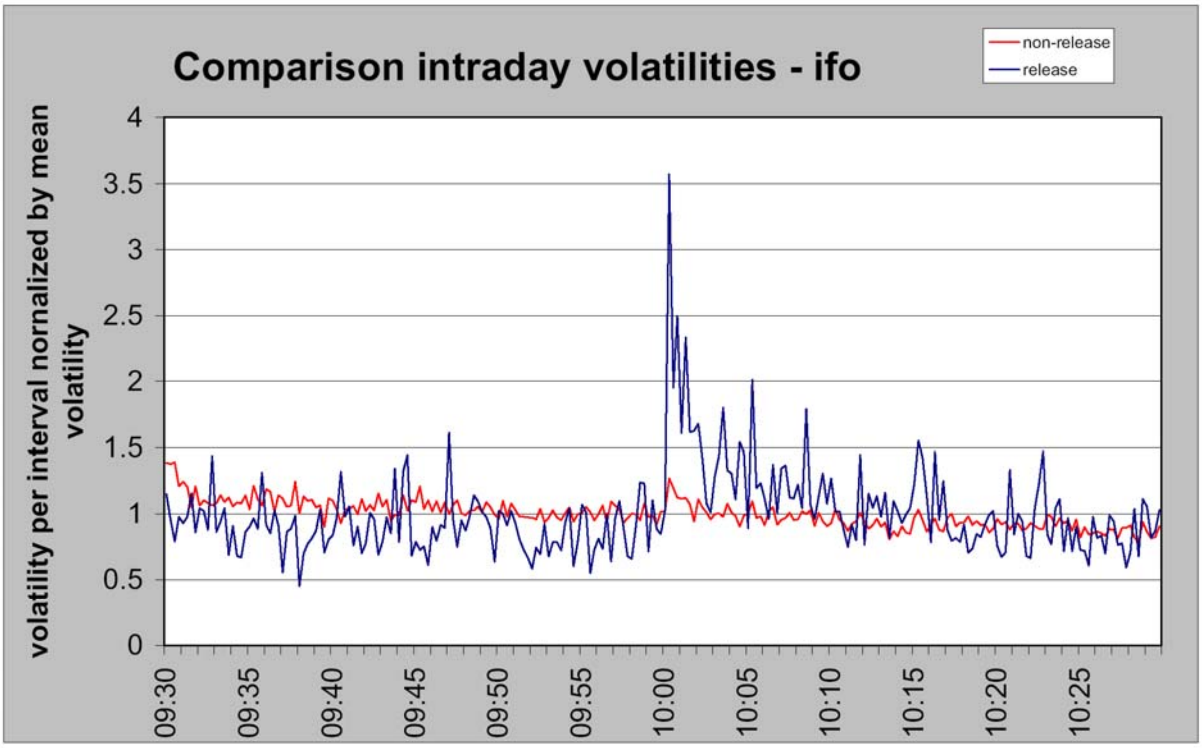


Figure 1: Design of estimation levels based on subsets of release days



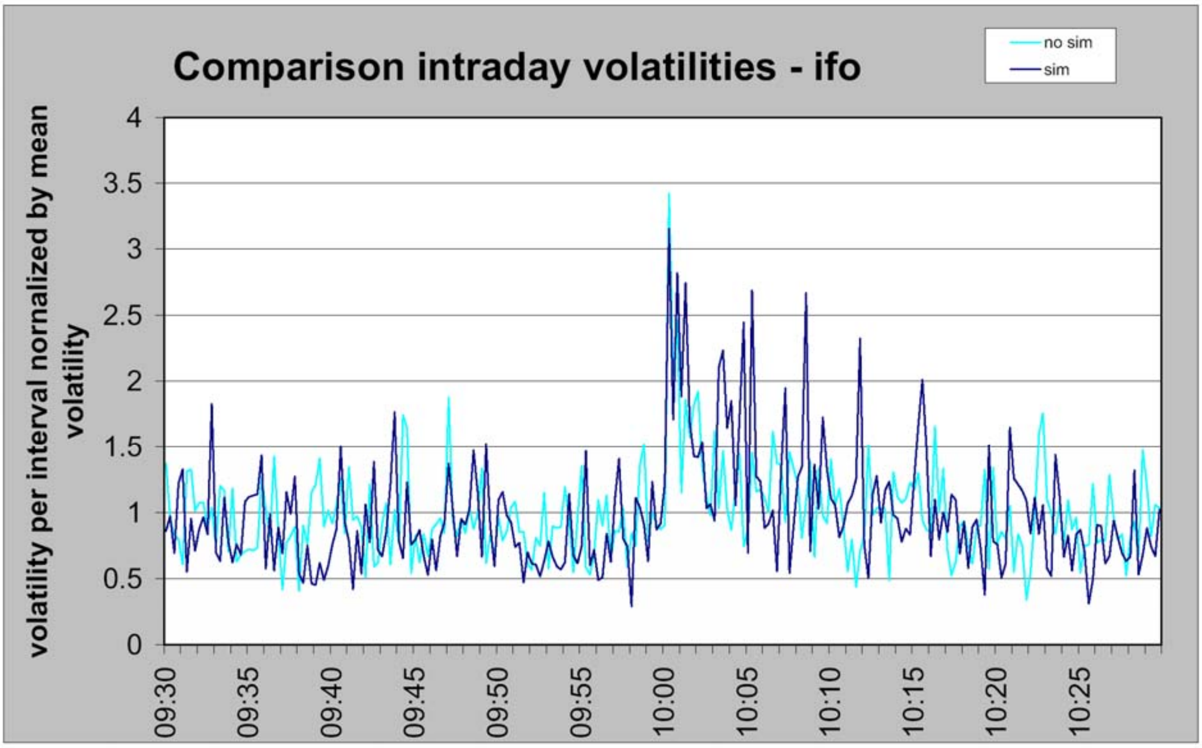
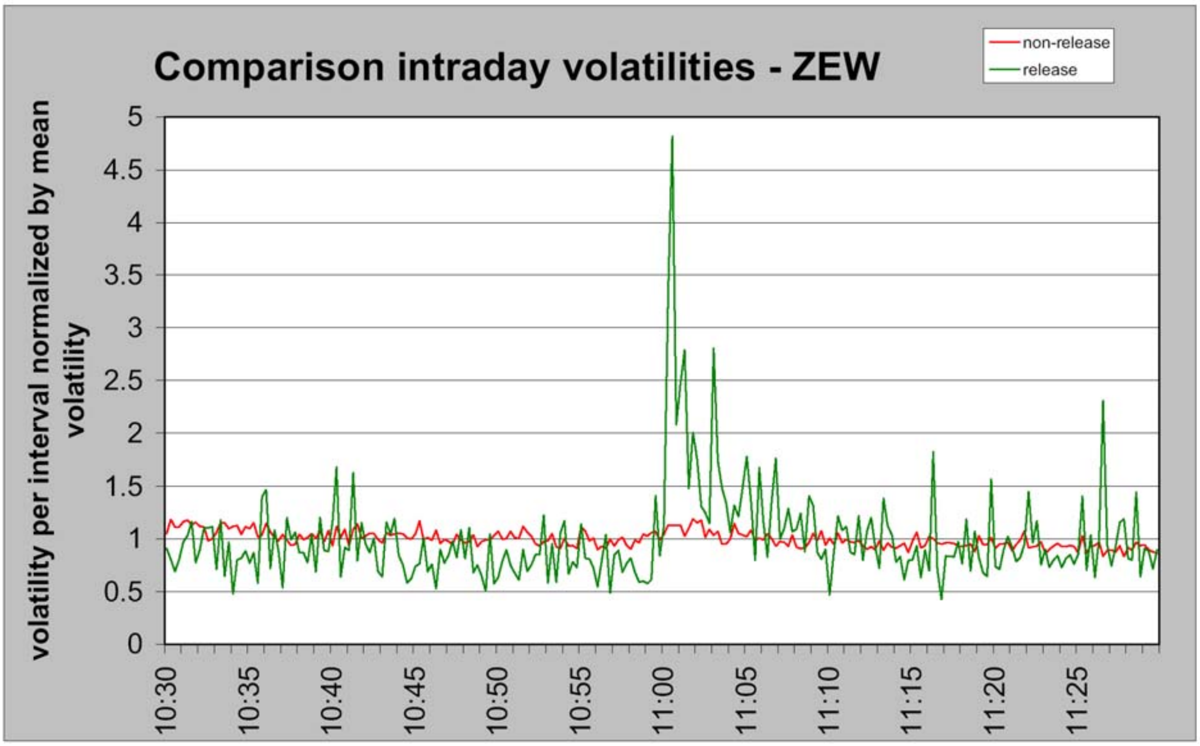


Figure 2: *ifo* caused volatility $\overline{V}_i / \overline{V}$ for 15-second intervals from 09:30 to 10:30



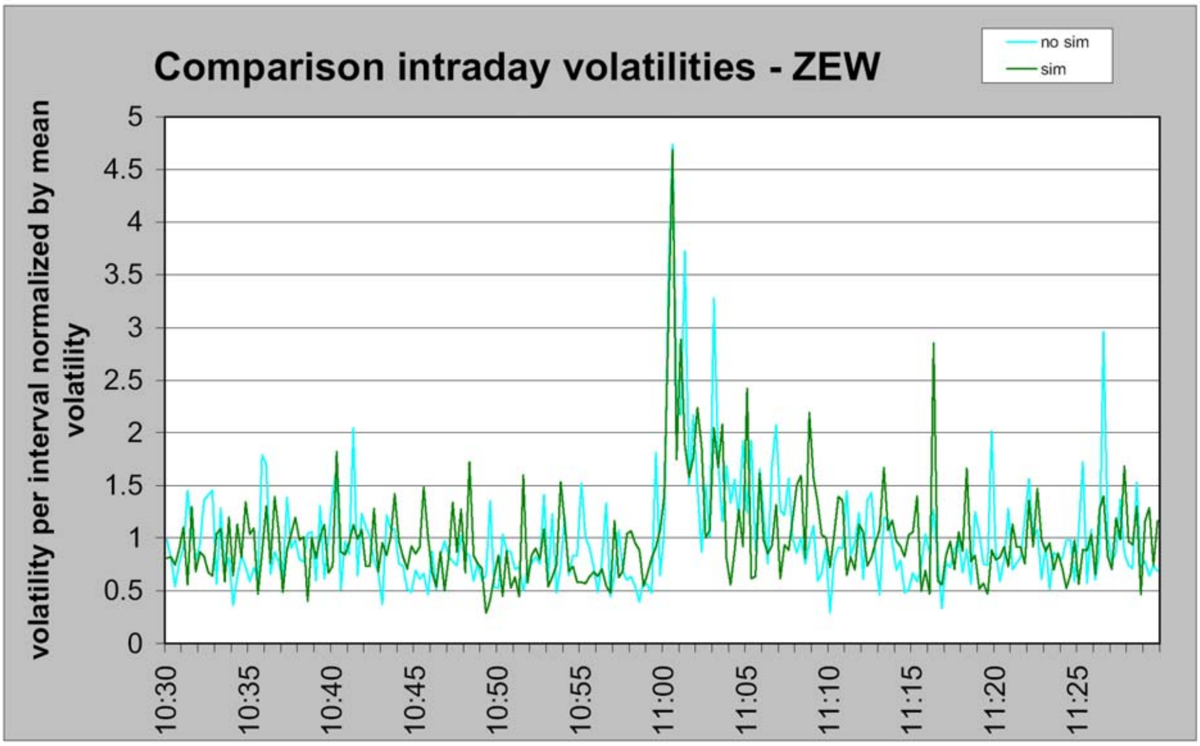


Figure 3: ZEW caused volatility $\overline{V}_i / \overline{V}$ for 15-second intervals from 10:30 to 11:30

	Level 1 (δ_j)		Level 2 (δ_j^- / δ_j^+)		Level 3 ($\delta_j^- / \delta_j^+ / \gamma_j^- / \gamma_j^+$) [a]	
time int	J_1	J_4	J_1^- / J_1^+	J_4^- / J_4^+	$J_1^- / J_1^+ / \tilde{J}_1^- / \tilde{J}_1^+$	$J_4^- / J_4^+ / \tilde{J}_4^- / \tilde{J}_4^-$
no sim neg						
10:00:30	1.20E-05		1.68E-05		1.75E-04	
10:00:45					-1.67E-04	
10:07:45	1.78E-05		1.78E-05		2.36E-05	
10:08:45	-8.44E-05		-8.60E-05		-8.58E-05	
10:13:45	5.46E-05 *		5.64E-05 *		5.61E-05 **	
no sim pos						
10:00:15	1.32E-04 ***	1.33E-04 ***	1.34E-04 ***	1.34E-04 ***	1.36E-04 ***	1.35E-04 ***
10:00:30	-1.28E-04 ***	-1.37E-04 ***	-1.31E-04 ***	-1.37E-04 ***	-1.31E-04 ***	-1.37E-04 ***
10:01:15	3.27E-05		-2.12E-06		-1.75E-06	
10:01:45	-3.73E-05					
10:04:00	-3.43E-06					
10:10:30	-2.20E-05		-2.45E-05		-2.44E-05	
10:12:15	6.55E-05 ***	4.38E-05 **	6.41E-05 **	4.30E-05 *	6.39E-05 **	4.30E-05 *
10:13:00	-8.87E-05 ***	-4.51E-05 **	-7.75E-05 ***	-7.74E-05 ***	-7.73E-05 ***	-7.72E-05 ***
10:14:15	2.45E-05					
10:15:00	2.29E-05		3.64E-05 **	3.77E-05 **	3.63E-05 **	3.76E-05 **
10:19:15	-1.28E-06					
10:27:30	1.94E-05		1.80E-05		1.78E-05	
10:29:15	-3.34E-05		-3.22E-05		-3.20E-05	
sim neg						
10:00:15	3.43E-04 ***	3.43E-04 ***	3.41E-04 ***	3.41E-04 ***	3.44E-04 ***	3.44E-04 ***
10:00:30	-4.44E-04 ***	-4.44E-04 ***	-4.41E-04 ***	-4.41E-04 ***	-4.39E-04 ***	-4.40E-04 ***
10:00:45	2.34E-04 ***	2.34E-04 ***	2.31E-04 ***	2.31E-04 ****	2.29E-04 ***	2.29E-04 ***
10:01:15	-1.32E-04 ***	-1.49E-04 ***	-1.32E-04 ***	-1.50E-04 ***	-1.32E-04 ***	-1.50E-04 ***
10:03:00	-2.32E-05		-2.35E-05		-2.37E-05	
10:08:30	1.54E-04 **	1.48E-04 **	1.53E-04 **	1.48E-04 **	1.53E-04 **	1.48E-04 **
10:08:45	-1.83E-04 **	-1.23E-04 **	-1.82E-04 **	-1.22E-04 **	-1.81E-04 **	-1.22E-04 **
10:09:15	1.66E-04 ***		1.66E-04 ***		1.66E-04 ***	
10:09:45	-3.13E-05		-3.03E-05		-2.97E-05	
10:10:00	-8.77E-05		-8.89E-05		-8.95E-05	
10:13:30	1.49E-05		1.48E-05		1.47E-05	
10:14:45	1.55E-04 ***	1.57E-04 ***	1.55E-04 ***	1.57E-04 ***	1.55E-04 ***	1.57E-04 ***
10:15:15	-2.68E-04 ***	-2.68E-04 ***	-2.66E-04 ***	-2.66E-04 ***	-2.65E-04 ***	-2.65E-04 ***
10:15:30	3.93E-04 ***	3.93E-04 ***	3.90E-04 ***	3.90E-04 ***	3.88E-04 ***	3.88E-04 ***
10:15:45	-2.85E-04 ***	-2.85E-04 ***	-2.84E-04 ***	-2.84E-04 ***	-2.83E-04 ***	-2.84E-04 ***
10:22:45	1.30E-04 **		1.30E-04 **		1.30E-04 **	
10:23:00	-1.60E-04 **		-1.60E-04 **		-1.59E-04 **	
10:23:30	1.84E-04 **		1.84E-04 **		1.83E-04 **	
10:23:45	-1.69E-04 ***		-1.69E-04 ***		-1.69E-04 ***	
10:28:15	1.82E-04 ***		1.82E-04 ***		1.82E-04 ***	
10:28:30	-1.93E-04 ***		-1.92E-04 ***		-1.92E-04 ***	
sim pos						
10:00:15	8.39E-04 ***	8.39E-04 ***	8.16E-04 ***	8.15E-04 ***	8.13E-04 ***	8.12E-04 ***
10:00:45	-8.27E-04 ***	-8.75E-04 ***	-8.24E-04 ***	-8.62E-04 ***	-8.25E-04 ***	-8.65E-04 ***
10:01:15	-3.56E-04 *		-3.49E-04 *		-1.98E-04	
10:01:30	2.24E-04		2.30E-04			
10:02:00	9.84E-05		9.50E-05		1.72E-04	
10:08:45	2.44E-04 ***	1.60E-04 ***	2.43E-04 ***	1.58E-04 ***	2.43E-04 ***	1.59E-04 ***
10:09:45	-1.47E-04		-1.49E-04		-1.48E-04	
10:11:45	5.37E-04 ***	4.88E-04 ***	5.36E-04 ***	4.86E-04 ***	5.36E-04 ***	4.86E-04 ***
10:12:00	-6.08E-04 ***	-5.93E-04 ***	-6.05E-04 ***	-5.90E-04 ***	-6.05E-04 ***	-5.91E-04 ***
10:19:45	7.10E-05		6.97E-05		7.00E-05	
10:21:15	-5.44E-05		-5.33E-05		-5.36E-05	
10:22:30	2.63E-06		2.10E-06		2.23E-06	

[a] Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 1: Analysis of return reactions in response to *ifo* announcements, [09:30:00 - 10:30:00)

	Level 1 (δ_j)	Level 2 (δ_j^- / δ_j^+)	Level 3 ($\delta_j^- / \delta_j^+ / \gamma_j^- / \gamma_j^+$) [a]			
time int	final	final	final	based on level 1	based on level 2	combined
no sim neg						
11:00:15	4.26E-04 ***	4.08E-04 ***	4.49E-04 ***	4.91E-04 ***	4.25E-04 ***	4.37E-04 ***
11:00:30		4.36E-04 ***	4.63E-04 ***		4.31E-04 ***	4.17E-04 ***
11:00:45	-7.47E-04 ***	-3.91E-04 ***	-3.55E-04 ***	-7.20E-04 ***	-4.39E-04 ***	-4.47E-04 ***
11:01:00	7.44E-04 ***		-1.56E-04 *	5.83E-04 ***		
11:01:30	-7.12E-04 ***	-2.35E-04 ***	-2.62E-04 ***	-5.18E-04 ***	-2.62E-04 ***	-2.73E-04 ***
11:01:45	3.56E-04 ***			1.81E-04 **		
11:02:00		-2.82E-04 ***	-2.77E-04 ***		-2.11E-04 ***	-1.87E-04 **
11:02:15	-2.18E-04 ***	-1.36E-04 *		-1.95E-04 ***	-1.46E-04 **	-1.52E-04 **
11:02:45	1.40E-04 ***	1.38E-04 *	1.23E-04 **	1.68E-04 ***	1.48E-04 **	1.56E-04 **
11:03:00		1.49E-04 *			1.37E-04 *	1.28E-04 *
11:03:45		-1.50E-04 **			-1.37E-04 **	-1.32E-04 **
11:05:15		-2.59E-04 ***	-2.90E-04 ***		-2.59E-04 ***	-2.59E-04 ***
11:05:30		2.17E-04 ***	1.94E-04 ***		2.34E-04 ***	2.41E-04 ***
11:05:45	-3.94E-04 ***	-4.37E-04 ***	-4.21E-04 ***	-3.87E-04 ***	-4.45E-04 ***	-4.50E-04 ***
11:06:00	4.09E-04 ***	1.78E-04 **	1.51E-04 **	3.99E-04 ***	1.83E-04 **	1.89E-04 ***
11:06:30		4.04E-04 ***	4.26E-04 ***		3.96E-04 ***	3.90E-04 ***
11:06:45		2.43E-04 ***	2.49E-04 ***		2.13E-04 ***	2.03E-04 ***
11:07:15		-1.25E-04 **	-1.21E-04 **		-1.13E-04 *	-1.09E-04 *
11:07:30		-2.13E-04 ***	-2.21E-04 ***		-2.06E-04 ***	-2.02E-04 ***
11:11:00		1.93E-04 ***	2.30E-04 ***		1.92E-04 ***	2.09E-04 ***
11:11:45	-1.85E-04 ***	-3.42E-04 ***	-3.46E-04 ***	-2.56E-04 ***	-3.33E-04 ***	-3.00E-04 ***
11:12:00	1.91E-04 ***			2.64E-04 ***		
11:12:30		1.38E-04 **	1.83E-04 ***		1.18E-04 **	
11:12:45		9.32E-05 *			9.88E-05 **	1.60E-04 ***
no sim pos						
11:00:15	1.84E-04 ***	1.20E-04 ***	8.89E-05 **	1.75E-04 ***	1.26E-04 ***	1.31E-04 ***
11:00:30		2.19E-04 ***	2.07E-04 ***		2.07E-04 ***	2.00E-04 ***
11:00:45	-1.86E-04 ***	-1.26E-04 ***		-1.65E-04 ***	-1.36E-04 ***	-1.43E-04 ***
11:01:15		-2.04E-04 ***	-1.71E-04 ***		-1.84E-04 ***	-1.76E-04 ***
11:01:30			-9.90E-05 **			
11:03:00	-2.26E-04 ***	-2.13E-04 ***	-2.03E-04 ***	-2.39E-04 ***	-2.10E-04 ***	-2.35E-04 ***
11:03:15	2.52E-04 ***			2.44E-04 ***		8.54E-05 *
11:03:45		2.02E-04 ***	2.01E-04 ***		1.86E-04 ***	1.82E-04 ***
11:04:15	-1.12E-04 ***		-7.83E-05 **	-1.08E-04 ***		-1.00E-04 **
11:04:30		-1.81E-04 ***	-1.61E-04 ***		-1.67E-04 ***	-1.31E-04 **
11:05:15	1.10E-04 ***	1.08E-04 **	1.40E-04 ***	1.18E-04 ***	1.08E-04 **	1.57E-04 ***
11:05:30		7.16E-05 *	7.08E-05 *		6.62E-05 *	7.81E-05 *
11:08:30	-2.79E-05 **			-3.01E-05 **		-5.87E-05 **
sim neg						
11:00:00		9.74E-05 *				
11:00:15	2.19E-04 ***	1.69E-04 **	2.37E-04 ***	2.60E-04 ***	2.51E-04 ***	2.57E-04 ***
11:00:30	5.51E-04 ***	5.21E-04 ***	5.74E-04 ***	2.64E-04 **	5.34E-04 ***	5.22E-04 ***
11:00:45	-4.64E-04 ***	-5.69E-04 ***	-4.12E-04 ***	-5.04E-04 ***	-3.83E-04 ***	-3.91E-04 ***
11:01:15	-3.65E-04 ***	-2.68E-04 ***	-5.16E-04 ***		-4.67E-04 ***	-4.50E-04 ***
11:01:30	-1.56E-04 **	-1.69E-04 ***		-1.88E-04 ***	-1.57E-04 **	-1.63E-04 **
11:02:00	1.09E-04 *	1.88E-04 ***		1.67E-04 ***	1.39E-04 *	1.43E-04 **
11:02:30	1.02E-04 *	1.38E-04 **	1.16E-04 ***		2.06E-04 **	2.07E-04 ***
11:02:45		-1.11E-04 *			-1.25E-04 *	-1.27E-04 *
sim pos						
11:00:15	1.62E-04 ***	-2.62E-01 ***	1.93E-04 ***	1.46E-04 ***	1.97E-04 ***	1.98E-04 ***
11:01:00	-2.56E-04 ***	-3.08E-01 ***	-1.82E-04 **	-1.40E-04 ***	-1.85E-04 ***	-1.87E-04 ***
SC			-14.634	-14.636	-14.631	-14.629

[a] Significance levels are denoted by *** $= 1\%$, ** $= 5\%$, * $= 10\%$.

Table 2: Analysis of return reactions in response to ZEW announcements, [10:30:00 - 11:30:00)

	Estimated release dummy coefficient $\vartheta_{1,i}$ and its significance[a]			
time	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45
09:30	-2.92E-06	-3.11E-05	-4.47E-05	-1.01E-05
09:31	-2.09E-05	-1.54E-05	7.31E-06	-2.53E-05
09:32	1.08E-05	3.39E-06	-1.09E-05	5.11E-05 **
09:33	-1.25E-05	-8.83E-06	6.01E-06	-2.99E-05
09:34	-4.34E-06	-3.25E-05	-3.34E-05	-2.21E-05
09:35	-1.41E-06	-1.37E-05	-1.36E-05	3.78E-05 *
09:36	-1.79E-05	-2.24E-05	1.30E-05	-1.41E-05
09:37	-4.72E-05 **	-9.54E-06	-2.65E-06	-1.30E-05
09:38	-4.60E-05 **	-3.45E-05	-1.11E-05	-2.24E-05
09:39	-4.30E-06	7.18E-06	-8.70E-06	-2.26E-05
09:40	-1.55E-05	6.78E-06	5.08E-05 ***	4.78E-06
09:41	1.15E-05	-1.97E-05	-7.20E-07	-3.18E-05
09:42	-1.57E-05	1.35E-06	2.52E-06	-3.36E-05
09:43	-2.15E-05	-4.31E-06	-1.36E-06	3.91E-05 *
09:44	-1.03E-05	1.70E-05	4.89E-05 **	-3.26E-05
09:45	-2.12E-05	-3.91E-05	-1.91E-05	-4.13E-05 **
09:46	2.50E-06	-2.09E-05	-2.65E-07	-1.12E-05
09:47	7.50E-05 ***	-5.88E-07	-2.59E-05	3.70E-06
09:48	-3.28E-06	6.33E-06	2.02E-05	1.32E-05
09:49	1.21E-05	-6.68E-06	-2.70E-06	-2.81E-05
09:50	1.67E-05	7.61E-07	4.35E-06	3.15E-06
09:51	4.72E-07	-1.01E-05	-1.41E-05	-2.28E-05
09:52	-2.37E-05	-1.38E-05	-2.68E-05	7.54E-06
09:53	-2.18E-05	-1.40E-05	-9.74E-06	-1.91E-05
09:54	1.48E-07	9.59E-06	-2.63E-05	-1.61E-05
09:55	1.66E-05	3.14E-06	-2.70E-05	-1.43E-05
09:56	-9.32E-06	-2.51E-05	2.08E-05	-3.51E-05
09:57	1.08E-06	1.67E-05	6.52E-06	-2.11E-05
09:58	-1.81E-05	5.68E-07	3.46E-05 *	2.65E-05
09:59	-1.75E-05	2.25E-05	3.52E-06	-2.72E-06
10:00	1.27E-05	2.56E-04 ***	9.57E-05 ***	1.58E-04 ***
10:01	5.36E-05 **	1.34E-04 ***	6.80E-05 ***	7.70E-05 ***
10:02	6.58E-05 **	5.28E-05 **	1.84E-05	1.60E-05
10:03	4.68E-05 **	5.03E-05 ***	8.46E-05 ***	3.80E-05
10:04	5.04E-05 *	3.28E-05	7.62E-05 ***	6.00E-05 ***
10:05	-1.89E-06	8.48E-05 ***	3.07E-05	3.53E-05
10:06	3.39E-05	2.20E-06	5.40E-05 **	2.41E-05
10:07	4.77E-05 **	4.69E-05 **	1.78E-05	2.08E-05
10:08	3.71E-05	1.31E-05	7.17E-05 ***	1.86E-05
10:09	2.99E-05	2.49E-05	5.12E-05 **	2.35E-05
10:10	4.30E-05 **	2.24E-05	1.41E-05	8.60E-06
10:11	-2.66E-06	2.17E-05	-8.54E-06	5.70E-05 ***
10:12	-7.78E-06	3.08E-05 *	1.89E-05	2.50E-05
10:13	1.43E-05	2.95E-05	2.03E-05	3.30E-05 *
10:14	3.31E-05 **	9.03E-06	1.65E-05	2.33E-05
10:15	3.48E-05	6.78E-05 ***	5.51E-05 **	3.65E-05 **
10:16	-5.08E-06	5.71E-05 ***	1.56E-05	4.66E-05 **
10:17	-4.37E-07	-7.15E-06	-6.08E-07	-5.66E-06
10:18	7.81E-06	-1.98E-05	-6.11E-06	-1.02E-06
10:19	-6.31E-06	1.06E-05	2.43E-05	2.18E-05
10:20	-1.20E-05	-1.77E-05	-1.48E-05	5.37E-05 ***
10:21	-2.33E-06	1.49E-05	1.41E-05	-1.27E-05
10:22	-1.93E-05	3.11E-05	4.37E-05 **	6.85E-05 ***
10:23	-6.41E-06	-1.24E-05	1.88E-05	2.24E-05
10:24	-1.54E-05	1.18E-05	-9.69E-06	4.47E-06
10:25	3.05E-07	-9.95E-06	-1.79E-05	1.67E-05
10:26	3.79E-06	6.55E-06	-6.12E-06	2.41E-05
10:27	1.62E-05	3.68E-06	-8.20E-06	-2.31E-05
10:28	-9.14E-06	3.08E-05 *	-5.24E-06	2.57E-05
10:29	2.94E-05	8.36E-06	1.35E-05	2.41E-05

[a]Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 3: Estimated coefficients $\vartheta_{1,i}$ from volatility equation (4.16) for the *ifo* release

	Estimated dummy coefficient $\vartheta_{1,i}$ for no simultaneous releases				Estimated dummy coefficient $\vartheta_{2,i}$ for simultaneous releases[a]			
time	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45
09:30	2.26E-05	-2.56E-05	-4.62E-05	-2.76E-05	-3.24E-05	-3.75E-05	-4.30E-05	1.00E-05
09:31	-5.29E-05	1.94E-05	1.86E-05	-1.04E-05	1.60E-05	-5.56E-05	-5.75E-06	-4.24E-05
09:32	2.20E-05	1.04E-05	-6.00E-06	1.89E-05	-2.25E-06	-4.75E-06	-1.66E-05	8.83E-05 ***
09:33	-1.43E-05	2.22E-05	1.47E-05	-3.13E-05	-1.05E-05	-4.46E-05	-3.99E-06	-2.82E-05
09:34	2.83E-05	-3.58E-05	-2.95E-05	-3.56E-05	-4.20E-05	-2.88E-05	-3.80E-05	-6.67E-06
09:35	-2.04E-05	-2.26E-05	-2.79E-05	3.21E-05	2.05E-05	-3.52E-06	2.84E-06	4.45E-05
09:36	7.25E-06	-2.46E-05	5.81E-05 **	-9.87E-06	-4.69E-05	-1.99E-05	-3.90E-05	-1.89E-05
09:37	-5.59E-05 *	-2.56E-05	-8.94E-06	-3.43E-05	-3.70E-05	8.98E-06	4.61E-06	1.16E-05
09:38	-4.92E-05 *	-1.18E-05	2.10E-06	9.35E-06	-4.22E-05	-6.07E-05 *	-2.62E-05	-5.90E-05
09:39	3.24E-05	4.71E-05 *	9.02E-06	-1.89E-07	-4.66E-05	-3.89E-05	-2.92E-05	-4.85E-05
09:40	-6.72E-06	1.90E-05	4.30E-05 *	9.66E-07	-2.55E-05	-7.26E-06	5.97E-05 **	9.18E-06
09:41	3.87E-05	-1.37E-05	-7.62E-07	-1.40E-05	-1.99E-05	-2.67E-05	-6.73E-07	-5.23E-05
09:42	-4.06E-05	2.84E-05	-3.50E-05	-2.99E-05	1.29E-05	-2.98E-05	4.58E-05	-3.79E-05
09:43	-9.12E-06	1.08E-05	-2.46E-05	1.32E-05	-3.58E-05	-2.17E-05	2.54E-05	6.69E-05 **
09:44	-1.27E-05	6.49E-05 *	6.70E-05 **	-4.69E-05	-7.47E-06	-3.83E-05	2.79E-05	-1.62E-05
09:45	-1.64E-05	-5.00E-05	-7.10E-06	-3.31E-05	-2.67E-05	-2.65E-05	-3.31E-05	-5.07E-05 *
09:46	1.93E-05	-3.73E-06	1.28E-05	-1.35E-05	-1.69E-05	-4.06E-05	-1.54E-05	-8.51E-06
09:47	1.04E-04 ***	-2.25E-06	-1.58E-05	4.71E-06	4.18E-05	1.33E-06	-3.76E-05	2.54E-06
09:48	-5.13E-06	7.40E-06	-4.96E-06	8.17E-06	-1.15E-06	5.09E-06	4.92E-05	1.91E-05
09:49	4.57E-05	-3.39E-05	2.48E-06	-2.22E-05	-2.66E-05	2.47E-05	-8.68E-06	-3.50E-05
09:50	1.25E-05	-1.97E-05	-1.22E-06	3.85E-06	2.15E-05	2.44E-05	1.08E-05	2.35E-06
09:51	2.11E-05	-2.18E-06	1.93E-07	-2.64E-05	-2.33E-05	-1.91E-05	-3.06E-05	-1.86E-05
09:52	-2.21E-05	-4.08E-06	-1.04E-05	3.67E-05	-2.56E-05	-2.50E-05	-4.57E-05	-2.61E-05
09:53	-2.81E-05	-7.32E-07	1.06E-05	-6.94E-06	-1.46E-05	-2.94E-05	-3.32E-05	-3.30E-05
09:54	3.28E-05	4.08E-06	-3.07E-05	-1.03E-06	-3.75E-05	1.59E-05	-2.13E-05	-3.35E-05
09:55	4.90E-05	-3.15E-05	-2.81E-05	-1.38E-05	-2.09E-05	4.31E-05	-2.58E-05	-1.48E-05
09:56	2.23E-05	-3.25E-06	4.06E-05	-3.29E-05	-4.58E-05	-5.02E-05	-2.05E-06	-3.76E-05
09:57	-7.81E-06	-7.14E-06	2.03E-05	-3.04E-05	1.13E-05	4.42E-05	-9.35E-06	-1.04E-05
09:58	-5.46E-06	-1.22E-05	5.04E-05 **	5.81E-05 *	-3.27E-05	1.53E-05	1.48E-05	-9.90E-06
09:59	-9.44E-06	1.14E-05	1.10E-05	3.49E-06	-2.69E-05	3.52E-05	-5.17E-06	-9.95E-06
10:00	-6.30E-07	2.83E-04 ***	9.33E-05 **	1.47E-04 ***	2.82E-05	2.24E-04 ***	9.85E-05 **	1.70E-04 ***
10:01	1.28E-05	1.25E-04 ***	6.67E-05 **	8.92E-05 ***	1.01E-04 ***	1.44E-04 ***	6.96E-05 **	6.29E-05 **
10:02	9.21E-05 ***	4.74E-05	2.34E-05	1.49E-05	3.53E-05	5.91E-05 *	1.26E-05	1.71E-05
10:03	6.68E-05 **	1.56E-05	4.92E-05	2.22E-05	2.38E-05	9.02E-05 ***	1.26E-04 ***	5.62E-05
10:04	2.11E-05	3.92E-05	6.16E-05 **	-1.34E-05	8.42E-05 **	2.55E-05	9.31E-05 ***	1.52E-04 ***
10:05	-1.21E-06	4.63E-05	2.61E-05	2.91E-05	-2.66E-06	1.29E-04 ***	3.60E-05	4.23E-05
10:06	5.66E-05 **	3.47E-06	9.77E-05 ***	7.29E-05 ***	7.67E-06	8.28E-07	3.60E-06	-3.24E-05
10:07	4.96E-05 *	9.15E-06	6.00E-05 *	3.89E-05	4.56E-05	9.04E-05 ***	-3.08E-05	-1.85E-06
10:08	3.61E-05	-1.07E-05	2.30E-05	5.78E-05 *	3.83E-05	4.06E-05	1.28E-04 ***	-2.67E-05
10:09	9.11E-06	3.91E-05	1.79E-05	2.06E-05	5.40E-05	8.45E-06	8.96E-05 ***	2.68E-05
10:10	6.00E-05 **	1.92E-05	3.36E-05	8.73E-06	2.33E-05	2.60E-05	-8.47E-06	8.44E-06
10:11	-2.65E-05	1.62E-05	-4.29E-05	-1.64E-05	2.49E-05	2.79E-05	3.11E-05	1.42E-04 ***
10:12	1.89E-06	8.69E-05 ***	1.83E-05	9.34E-06	-1.89E-05	-3.39E-05	1.95E-05	4.31E-05
10:13	2.01E-05	2.24E-05	-2.06E-06	5.06E-05 *	7.59E-06	3.76E-05	4.62E-05 *	1.27E-05
10:14	4.58E-05 **	2.36E-05	3.44E-05	4.43E-05 *	1.84E-05	-7.79E-06	-4.00E-06	-8.37E-07
10:15	3.61E-05	6.43E-05 **	1.08E-05	1.07E-05	3.33E-05	7.19E-05 **	1.06E-04 ***	6.62E-05 ***
10:16	3.95E-06	9.85E-05 ***	2.53E-05	6.34E-05 **	-1.55E-05	9.46E-06	4.51E-06	2.56E-05
10:17	2.29E-06	-3.29E-05	-2.62E-05	3.72E-06	-3.58E-06	2.25E-05	2.89E-05	-1.74E-05
10:18	9.50E-06	-1.15E-05	-1.60E-05	-3.90E-07	5.86E-06	-2.92E-05	5.25E-06	-1.76E-06
10:19	5.53E-06	6.23E-05 **	-1.46E-05	4.87E-05 *	-2.00E-05	-4.90E-05 *	6.91E-05 ***	-9.16E-06
10:20	-1.04E-05	-1.96E-06	-2.63E-06	2.75E-05	-1.38E-05	-3.59E-05	-2.88E-05	8.39E-05 ***
10:21	-2.35E-05	-4.66E-06	-5.00E-09	-4.75E-05 *	2.21E-05	3.74E-05	3.04E-05	2.73E-05
10:22	-3.36E-05	3.04E-05	8.09E-05 ***	1.03E-04 ***	-2.81E-06	3.20E-05	6.82E-07	2.86E-05
10:23	1.89E-05	1.18E-05	5.41E-06	2.09E-05	-3.56E-05	-4.03E-05	3.43E-05	2.41E-05
10:24	-7.72E-06	2.48E-05	4.40E-06	1.34E-05	-2.43E-05	-3.22E-06	-2.59E-05	-6.66E-06
10:25	-8.18E-06	-6.02E-06	-1.19E-05	5.60E-05 **	1.01E-05	-1.45E-05	-2.48E-05	-2.87E-05
10:26	-2.87E-06	3.80E-06	3.86E-06	5.74E-05 **	1.15E-05	9.73E-06	-1.76E-05	-1.19E-05
10:27	2.19E-05	2.64E-06	-2.55E-06	-2.82E-05	9.63E-06	4.89E-06	-1.47E-05	-1.68E-05
10:28	1.53E-06	2.14E-05	3.36E-06	5.90E-05 **	-2.15E-05	4.17E-05 *	-1.52E-05	-1.28E-05
10:29	4.78E-05 *	1.33E-05	3.54E-05	2.99E-05	8.23E-06	2.63E-06	-1.18E-05	1.73E-05

[a] Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 4: Estimated coefficients $\vartheta_{1,i}$ and $\vartheta_{2,i}$ from volatility equation (4.17) for the *ifo* release

	Estimated release dummy coefficient $\vartheta_{1,i}$ and its significance[a]			
time	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45
10:30	4.87E-06	-1.64E-05	-1.93E-05	-6.46E-06
10:31	1.52E-06	-2.36E-06	1.35E-05	-1.78E-05
10:32	-4.57E-06	1.65E-05	3.62E-05 **	2.57E-05
10:33	-1.49E-05	1.23E-05	-2.90E-05	6.77E-06
10:34	-4.28E-05 **	-1.18E-05	1.03E-06	-2.88E-06
10:35	-1.22E-05	-1.04E-05	-2.47E-05	4.48E-05 **
10:36	5.13E-05 **	-1.56E-05	2.52E-05	1.18E-05
10:37	-2.92E-05 *	2.90E-05	1.96E-05	2.57E-05 *
10:38	7.52E-07	4.18E-06	-4.83E-06	1.77E-05
10:39	-1.03E-05	2.79E-05	8.88E-06	-1.21E-06
10:40	3.72E-05 *	7.03E-05 ***	-1.82E-05	-1.14E-06
10:41	1.17E-05	6.00E-05 ***	-1.40E-05	3.67E-05 **
10:42	1.18E-05	-5.69E-07	1.93E-05	-9.88E-06
10:43	-1.63E-05	3.05E-05	1.57E-05	4.19E-05 **
10:44	7.34E-08	-7.42E-06	-2.29E-05	-1.45E-05
10:45	-9.98E-06	-1.81E-05	1.82E-05	-5.89E-06
10:46	6.63E-08	-3.52E-05 **	1.00E-05	-2.01E-06
10:47	5.74E-06	1.97E-05	-2.61E-06	2.49E-05
10:48	2.60E-06	3.45E-05 **	-1.66E-05	8.81E-07
10:49	-1.44E-05	-2.89E-05 *	1.86E-05	-1.98E-05
10:50	-2.42E-05	-9.81E-07	5.42E-06	-8.04E-06
10:51	-8.07E-06	-1.06E-05	-4.97E-06	-1.66E-05
10:52	-8.69E-06	6.71E-06	1.41E-05	3.43E-05 *
10:53	-1.67E-05	2.16E-05	-1.72E-05	2.58E-05 *
10:54	3.44E-05 **	-6.95E-06	1.50E-06	-6.00E-07
10:55	2.96E-05	-4.99E-06	8.10E-06	-1.16E-05
10:56	-1.65E-05	3.79E-06	3.41E-05 **	-3.13E-05 **
10:57	7.08E-06	7.15E-06	-1.36E-05	7.57E-07
10:58	6.72E-06	-1.37E-05	-1.89E-05	-2.01E-05
10:59	-2.11E-05	-2.49E-05	4.36E-05 **	2.92E-06
11:00	2.42E-05	2.23E-04 ***	3.69E-04 ***	1.09E-04 ***
11:01	1.47E-04 ***	1.69E-04 ***	5.51E-05 ***	9.48E-05 ***
11:02	7.42E-05 ***	4.15E-05 **	4.00E-05 *	2.34E-05
11:03	1.68E-04 ***	7.97E-05 ***	6.90E-05 ***	5.71E-05 ***
11:04	2.39E-05	3.35E-05	4.28E-05 **	6.29E-05 ***
11:05	8.45E-05 ***	3.92E-05 *	-3.28E-07	6.64E-05 ***
11:06	3.59E-05 *	1.28E-05	3.94E-05 *	8.77E-05 ***
11:07	1.77E-05	2.92E-05 *	5.13E-05 ***	2.39E-05
11:08	3.29E-05 **	4.54E-05 ***	1.15E-05	5.72E-05 ***
11:09	3.89E-05 *	7.86E-06	-7.81E-06	1.43E-05
11:10	-3.18E-05 *	1.15E-05	3.38E-05	2.82E-05
11:11	2.53E-05	6.01E-06	5.07E-06	3.63E-05 **
11:12	1.14E-05	2.62E-05	4.65E-05 ***	2.06E-05
11:13	-5.71E-06	6.08E-05 ***	2.96E-05 *	2.66E-05
11:14	3.83E-06	6.91E-06	-1.64E-05	8.03E-06
11:15	1.40E-06	7.04E-06	-1.02E-05	1.17E-05
11:16	-4.96E-06	6.63E-05 ***	-6.44E-06	-3.31E-05 **
11:17	4.40E-06	8.43E-06	5.99E-06	1.96E-05
11:18	-1.90E-06	4.19E-05 **	-6.97E-06	3.37E-05 *
11:19	-6.13E-07	2.85E-06	-1.25E-05	5.79E-05 ***
11:20	-1.85E-06	-4.06E-06	1.21E-05	1.46E-05
11:21	1.42E-05	2.26E-06	1.86E-06	1.97E-06
11:22	6.24E-05 ***	1.87E-05	3.36E-05 *	-3.72E-06
11:23	2.06E-05	-6.83E-07	5.24E-06	6.47E-06
11:24	-2.33E-06	4.71E-06	8.01E-06	-5.85E-08
11:25	1.47E-05	4.28E-05 *	-4.32E-07	2.64E-05
11:26	-6.66E-06	1.84E-05	1.27E-04 ***	2.27E-05
11:27	7.02E-06	2.18E-05	3.35E-05 *	4.88E-05 ***
11:28	6.37E-06	7.37E-06	5.08E-05 **	-1.27E-05
11:29	1.76E-05	2.46E-05 *	-4.83E-07	1.89E-05

[a] Significance levels are denoted by *** $= 1\%$, ** $= 5\%$, * $= 10\%$.

Table 5: Estimated coefficients $\vartheta_{1,i}$ from volatility equation (4.16) for the ZEW release

time	Estimated dummy coefficient $\vartheta_{1,i}$ for no simultaneous releases				Estimated dummy coefficient $\vartheta_{2,i}$ for simultaneous releases[a]			
	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45	xx:xx:00	xx:xx:15	xx:xx:30	xx:xx:45
10:30	1.11E-05	-1.50E-05	-1.86E-05	-6.23E-06	-3.48E-06	-1.84E-05	-2.01E-05	-6.76E-06
10:31	-4.04E-06	2.54E-05	1.06E-05	-1.10E-05	8.93E-06	-3.94E-05	1.75E-05	-2.70E-05
10:32	-3.84E-06	3.81E-05	6.43E-05 ***	6.04E-05 ***	-5.54E-06	-1.24E-05	-1.38E-06	-2.06E-05
10:33	-2.99E-05	1.40E-05	-2.53E-05	-5.37E-06	5.06E-06	1.01E-05	-3.40E-05	2.30E-05
10:34	-5.31E-05 **	-2.77E-05	4.51E-06	-1.82E-05	-2.92E-05	9.45E-06	-3.62E-06	1.76E-05
10:35	-2.72E-05	-1.90E-05	-1.51E-05	8.47E-05 ***	7.88E-06	1.08E-06	-3.75E-05	-8.31E-06
10:36	7.75E-05 **	-1.88E-05	1.03E-05	5.66E-06	1.63E-05	-1.14E-05	4.50E-05	2.00E-05
10:37	-2.43E-05	5.12E-05 **	1.32E-05	2.17E-05	-3.57E-05	-6.66E-07	2.82E-05	3.09E-05
10:38	-4.32E-06	-2.61E-06	2.46E-05	2.29E-05	7.51E-06	1.32E-05	-4.40E-05 *	1.08E-05
10:39	-1.95E-05	3.92E-05	-3.27E-06	1.79E-05	1.99E-06	1.28E-05	2.51E-05	-2.67E-05
10:40	6.88E-05 ***	7.64E-05 ***	-2.88E-05	7.95E-06	-4.93E-06	6.23E-05 **	-3.93E-06	-1.33E-05
10:41	1.08E-05	9.26E-05 ***	-2.47E-05	4.31E-05 **	1.29E-05	1.66E-05	1.34E-07	2.81E-05
10:42	3.19E-05	1.16E-05	-2.41E-06	-1.05E-05	-1.49E-05	-1.68E-05	4.83E-05 *	-9.16E-06
10:43	-3.84E-05 *	5.67E-05 **	1.85E-05	3.49E-05	1.57E-05	-4.44E-06	1.18E-05	5.13E-05
10:44	-3.39E-06	-8.29E-06	-2.59E-05	-2.91E-05	4.69E-06	-6.27E-06	-1.88E-05	4.98E-06
10:45	-1.37E-05	-2.25E-05	-6.98E-06	-2.51E-05	-5.03E-06	-1.21E-05	5.17E-05 **	1.98E-05
10:46	1.17E-05	-3.44E-05	1.26E-05	2.04E-05	-1.55E-05	-3.62E-05	6.58E-06	-3.18E-05
10:47	9.95E-06	-1.14E-06	-4.16E-06	2.01E-05	1.44E-07	4.76E-05 *	-5.51E-07	3.13E-05
10:48	1.48E-05	1.24E-05	-2.13E-05	4.48E-06	-1.37E-05	6.40E-05 ***	-1.04E-05	-3.62E-06
10:49	-1.65E-05	-1.24E-05	6.32E-05 **	-2.38E-05	-1.15E-05	-5.10E-05 *	-4.09E-05	-1.44E-05
10:50	-3.18E-05	2.50E-05	6.51E-06	4.35E-06	-1.41E-05	-3.56E-05	3.98E-06	-2.45E-05
10:51	-5.17E-07	-2.32E-06	-3.88E-05	-1.34E-05	-1.81E-05	-2.16E-05	4.01E-05	-2.08E-05
10:52	-7.86E-06	5.93E-06	3.46E-06	3.99E-05	-9.79E-06	7.74E-06	2.84E-05	2.68E-05
10:53	-1.02E-05	4.56E-05 *	-2.46E-05	-3.51E-06	-2.54E-05	-1.05E-05	-7.19E-06	6.50E-05 ***
10:54	4.14E-05 *	-4.65E-06	1.18E-05	1.10E-05	2.52E-05	-1.00E-05	-1.23E-05	-1.60E-05
10:55	7.34E-05 **	1.29E-05	2.84E-05	-9.49E-06	-2.89E-05	-2.88E-05	-1.90E-05	-1.44E-05
10:56	-1.85E-05	1.05E-05	7.32E-05 ***	-3.16E-05 *	-1.38E-05	-5.17E-06	-1.80E-05	-3.09E-05
10:57	-8.47E-06	2.80E-05	-1.10E-05	-1.34E-05	2.78E-05	-2.07E-05	-1.70E-05	1.85E-05
10:58	-7.72E-06	-2.33E-05	-3.67E-05 *	-2.06E-05	2.60E-05	-8.53E-07	4.92E-06	-1.95E-05
10:59	-2.33E-05	-3.56E-05	7.69E-05 ***	-9.65E-06	-1.83E-05	-1.08E-05	-8.10E-07	1.97E-05
11:00	2.37E-05	2.36E-04 ***	3.82E-04 ***	1.42E-04 ***	2.49E-05	2.06E-04 ***	3.52E-04 ***	6.39E-05 **
11:01	1.27E-04 ***	2.28E-04 ***	5.90E-05 **	1.19E-04 ***	1.75E-04 ***	9.01E-05 **	4.99E-05	6.27E-05
11:02	5.93E-05 *	1.41E-05	5.84E-05 **	2.34E-05	9.40E-05 **	7.80E-05 ***	1.54E-05	2.33E-05
11:03	2.17E-04 ***	8.46E-05 ***	3.99E-05 *	9.36E-05 ***	1.04E-04 ***	7.32E-05 **	1.08E-04 ***	8.47E-06
11:04	5.45E-05 **	6.55E-05 **	5.01E-05 **	1.04E-04 ***	-1.68E-05	-9.03E-06	3.37E-05	7.40E-06
11:05	4.19E-05 *	9.06E-05 ***	1.33E-05	7.88E-05 ***	1.41E-04 ***	-2.95E-05	-1.85E-05	4.99E-05
11:06	5.23E-05 **	2.43E-05	6.70E-05 **	1.19E-04 ***	1.40E-05	-2.56E-06	4.93E-06	4.62E-05 *
11:07	4.83E-05 **	4.68E-05 **	8.43E-05 ***	2.24E-05	-2.30E-05	5.80E-06	7.39E-06	2.59E-05
11:08	1.20E-05	3.32E-05	8.46E-06	2.30E-05	6.09E-05 **	6.15E-05 **	1.55E-05	1.03E-04 ***
11:09	2.86E-05	-1.65E-05	-1.99E-05	9.41E-06	5.26E-05	4.04E-05 *	8.34E-06	2.07E-05
11:10	-4.53E-05 *	1.03E-06	1.89E-05	8.73E-06	-1.36E-05	2.54E-05	5.36E-05	5.43E-05 **
11:11	5.85E-05 **	7.84E-06	1.60E-05	4.47E-05 *	-1.89E-05	3.57E-06	-9.51E-06	2.51E-05
11:12	-9.70E-06	4.86E-05 **	6.94E-05 ***	2.44E-05	3.95E-05 *	-3.67E-06	1.58E-05	1.56E-05
11:13	-2.59E-05	4.67E-05 **	3.51E-05	2.54E-05	2.12E-05	7.96E-05 ***	2.22E-05	2.83E-05
11:14	-2.05E-06	4.54E-06	-2.71E-05	-1.25E-05	1.17E-05	1.01E-05	-2.06E-06	3.55E-05 *
11:15	-1.39E-05	-2.53E-05	9.69E-07	2.98E-05	2.18E-05	5.01E-05	-2.51E-05	-1.24E-05
11:16	1.35E-05	3.63E-05	3.38E-06	-4.07E-05 *	-2.95E-05	1.06E-04 ***	-1.95E-05	-2.28E-05
11:17	1.15E-07	6.82E-06	1.80E-05	1.74E-05	1.01E-05	1.06E-05	-1.00E-05	2.25E-05
11:18	-5.57E-06	1.24E-05	-1.80E-05	5.40E-05 **	2.99E-06	8.13E-05 ***	7.78E-06	6.62E-06
11:19	2.35E-05	6.31E-06	1.10E-06	9.97E-05 ***	-3.28E-05	-1.77E-06	-3.07E-05	2.07E-06
11:20	1.80E-06	-1.31E-05	6.94E-06	3.27E-05	-6.71E-06	7.92E-06	1.85E-05	-9.47E-06
11:21	7.06E-07	4.06E-06	-2.31E-06	1.56E-05	3.22E-05	-1.44E-07	7.41E-06	-1.62E-05
11:22	7.17E-05 ***	2.45E-05	1.40E-05	-1.66E-05	5.00E-05 *	1.10E-05	5.97E-05 **	1.34E-05
11:23	2.77E-05	-1.92E-05	1.26E-05	7.94E-06	1.13E-05	2.41E-05	-4.55E-06	4.51E-06
11:24	6.15E-06	2.71E-05	2.44E-05	-1.23E-05	-1.36E-05	-2.51E-05	-1.38E-05	1.63E-05
11:25	3.88E-05 **	7.33E-05 **	-1.09E-05	3.12E-05	-1.76E-05	2.15E-06	1.35E-05	2.04E-05
11:26	2.71E-07	1.13E-05	1.84E-04 ***	3.13E-05	-1.59E-05	2.78E-05	5.04E-05	1.11E-05
11:27	6.12E-06	1.07E-05	4.47E-05 *	1.97E-05	8.22E-06	3.66E-05	1.73E-05	8.75E-05 ***
11:28	6.75E-08	1.40E-06	6.25E-05 **	-1.90E-06	1.48E-05	1.53E-05	3.52E-05	-2.72E-05
11:29	9.38E-06	1.08E-05	-5.60E-07	5.81E-06	2.96E-05	4.31E-05 **	-3.79E-07	3.62E-05

[a] Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 6: Estimated coefficients $\vartheta_{1,i}$ and $\vartheta_{2,i}$ from volatility equation (4.17) for the ZEW release

variable	(1) AR(1)	(2) ext. AR(1)	(3) GARCH(1,1)	(4) ext. GARCH(1,1)	(5) ext. GARCH(1,1)	(6) ext. GARCH(1,1)
	Estimated coefficients and their significances[a]					
mean eq.						
c	3,75E-07	1,12E-06	-2,04E-07	1,49E-06	3,28E-07	5,73E-07
α_1	1,01E-01 ***	9,74E-02 ***	8,33E-02 ***	7,75E-02 ***	7,44E-02 ***	6,89E-02 ***
$\delta^+_{10:00:15}$		1,35E-04 ***		1,85E-04 ***	2,14E-04 **	2,04E-04 *
$\delta^+_{10:00:30}$		-1,37E-04 ***		-1,91E-04 ***	-2,18E-04 **	-2,10E-04 **
$\delta^+_{10:12:15}$		4,30E-05 *		2,30E-05	2,19E-05	2,54E-05
$\delta^+_{10:13:00}$		-7,72E-05 ***		-4,82E-05 *	-4,81E-05 *	-5,02E-05 **
$\delta^+_{10:15:00}$		3,76E-05 **		3,16E-05 **	3,12E-05 ***	3,14E-05 ***
$\gamma^+_{10:00:15}$		8,12E-04 ***		5,86E-04 **	6,12E-04 ***	6,80E-04 ***
$\gamma^+_{10:00:45}$		-8,65E-04 ***		-6,23E-04 ***	-6,54E-04 ***	-7,15E-04 ***
$\gamma^+_{10:08:45}$		1,59E-04 ***		1,21E-04 **	1,03E-04 *	1,04E-04 *
$\gamma^+_{10:11:45}$		4,86E-04 ***		2,50E-04	2,16E-04	3,13E-04
$\gamma^+_{10:12:00}$		-5,91E-04 ***		-3,42E-04	-2,83E-04	-3,88E-04
$\gamma^-_{10:00:15}$		3,44E-04 ***		3,12E-04 ***	3,49E-04 ***	3,43E-04 ***
$\gamma^-_{10:00:30}$		-4,40E-04 ***		-3,49E-04 ***	-4,04E-04 ***	-3,97E-04 ***
$\gamma^-_{10:00:45}$		2,29E-04 ***		1,00E-04	1,45E-04 *	1,33E-04
$\gamma^-_{10:01:15}$		-1,50E-04 ***		-6,75E-05	-9,91E-05	-8,63E-05
$\gamma^-_{10:08:30}$		1,48E-04 **		6,34E-06	1,30E-05	1,49E-05
$\gamma^-_{10:08:45}$		-1,22E-04 **		-6,10E-07	-7,16E-06	-7,52E-06
$\gamma^-_{10:14:45}$		1,57E-04 ***		1,38E-04 ***	1,38E-04 ***	1,34E-04 **
$\gamma^-_{10:15:15}$		-2,65E-04 ***		-2,58E-04 ***	-2,59E-04 ***	-2,58E-04 ***
$\gamma^-_{10:15:30}$		3,88E-04 ***		2,75E-04 ***	2,60E-04 ***	2,69E-04 ***
$\gamma^-_{10:15:45}$		-2,84E-04 ***		-1,43E-04 **	-1,23E-04 *	-1,33E-04 **
variance eq.						
λ			4,43E-10 *	4,18E-10 *	2,92E-10 *	3,20E-10 *
μ			6,34E-02 ***	6,20E-02 ***	3,98E-02 ***	4,25E-02 ***
ν			9,24E-01 ***	9,26E-01 ***	9,46E-01 ***	9,42E-01 ***
$\vartheta_{1,10:00:15}$					1,53E-07 ***	2,31E-07 *
$\vartheta_{1,10:00:30}$					-1,20E-07 **	
$\vartheta_{1,10:00:45}$					7,46E-08 **	
$\vartheta_{1,10:15:15}$					9,37E-09	
$\vartheta_{1,10:15:30}$					-8,65E-09	
$\vartheta_{1,10:15:45}$					3,53E-09	
$\vartheta_{2,10:00:15}$						7,60E-08 **
$\vartheta_{2,10:00:30}$						-6,35E-08 *
$\vartheta_{2,10:00:45}$						1,08E-07 **
SC	-14,61	-14,61	-14,76	-14,75	-14,77	-14,75

[a]Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 7: GARCH(1,1)-model for the returns of *ifo* release days

variable	(1) ARMA(2,2)	(2) ext. ARMA(2,2)	(3) GARCH(1,1)	(4) ext. GARCH(1,1)	(5) ext. GARCH(1,1)	(6) ext. GARCH(1,1)
	Estimated coefficients and their significances[a]					
mean eq.						
c	-3,33E-06	-1,27E-06	-1,24E-06	9,90E-08	1,07E-06	5,26E-06 **
α_1	-3,87E-01 **	-3,66E-01 ***	-6,10E-01 ***	-2,51E-01 ***	6,28E-02	6,64E-02
α_2	-4,78E-01 ***	-6,26E-01 ***	3,55E-03	-2,01E-01 ***	-2,69E-02	-3,03E-02
β_1	4,80E-01 ***	4,44E-01 ***	7,44E-01 ***	3,63E-01 ***	5,36E-03	5,01E-03
β_2	5,04E-01 ***	6,46E-01 ***	1,12E-01	2,40E-01 ***	1,20E-02	5,00E-03
$\delta^+_{11:00:15}$		1,31E-04 ***		2,18E-04 ***	2,04E-04 ***	1,56E-04 **
$\delta^+_{11:00:30}$		2,00E-04 ***		7,05E-05	-2,83E-05	8,43E-05
$\delta^+_{11:00:45}$		-1,43E-04 ***		-2,39E-04 ***	-1,73E-04	-2,36E-04 **
$\delta^+_{11:01:15}$		-1,76E-04 ***		-3,79E-05	1,17E-05	-1,13E-07
$\delta^+_{11:03:00}$		-2,35E-04 ***		-7,55E-05	-8,27E-05	-1,47E-04
$\delta^+_{11:03:15}$		8,54E-05 *		5,97E-05	6,59E-05	1,87E-04
$\delta^+_{11:03:45}$		1,82E-04 ***		3,57E-05	2,25E-05	-8,07E-06
$\delta^+_{11:04:15}$		-1,00E-04 **		-1,42E-04 ***	-1,40E-04 ***	-2,83E-05
$\delta^+_{11:04:30}$		-1,31E-04 **		5,66E-05 *	9,31E-05 **	3,84E-05
$\delta^+_{11:05:15}$		1,57E-04 ***		-5,44E-06	-1,70E-05	3,63E-05
$\delta^+_{11:05:30}$		7,81E-05 *		7,11E-05 ***	5,79E-05 ***	6,66E-05
$\delta^+_{11:08:30}$		-5,87E-05 **		-2,06E-05 **	-1,96E-05 **	-2,08E-04 ***
$\delta^-_{11:00:15}$		4,37E-04 ***		2,32E-04	3,51E-04	4,54E-04
$\delta^-_{11:00:30}$		4,17E-04 ***		8,25E-04 ***	9,02E-04 **	1,92E-04
$\delta^-_{11:00:45}$		-4,47E-04 ***		-1,04E-03 ***	-1,34E-03 ***	-6,18E-04 **
$\delta^-_{11:01:45}$		-2,73E-04 ***		1,51E-05	9,61E-05	3,02E-05
$\delta^-_{11:02:00}$		-1,87E-04 **		-9,07E-05 ***	-7,75E-05 *	-5,41E-05
$\delta^-_{11:02:15}$		-1,52E-04 **		-2,85E-05	1,13E-05	-7,68E-05
$\delta^-_{11:02:45}$		1,56E-04 **		1,83E-04 **	1,85E-04 **	2,87E-04 **
$\delta^-_{11:03:00}$		1,28E-04 *		-2,22E-05	-1,11E-04	-1,99E-04
$\delta^-_{11:03:45}$		-1,32E-04 **		-6,84E-05	2,72E-05	2,78E-06
$\delta^-_{11:05:15}$		-2,59E-04 ***		-1,84E-04 **	-1,43E-04 *	-2,40E-04 **
$\delta^-_{11:05:30}$		2,41E-04 ***		2,40E-04 **	1,31E-04 *	2,30E-04 **
$\delta^-_{11:05:45}$		-4,50E-04 ***		-5,02E-04 ***	-4,67E-04 ***	-3,89E-04 ***
$\delta^-_{11:06:00}$		1,89E-04 ***		2,62E-04 ***	3,76E-04 ***	2,94E-04 **
$\delta^-_{11:06:30}$		3,90E-04 ***		3,03E-04 **	2,36E-04 *	2,80E-04 **
$\delta^-_{11:06:45}$		2,03E-04 ***		-3,58E-05	-1,35E-04	-1,39E-04
$\delta^-_{11:07:15}$		-1,09E-04 *		-3,72E-05	-2,85E-05	-4,98E-05
$\delta^-_{11:07:30}$		-2,02E-04 ***		-4,51E-05	-3,86E-06	-2,16E-05
$\delta^-_{11:11:00}$		2,09E-04 ***		2,06E-04 **	6,59E-05 **	1,78E-04 **
$\delta^-_{11:11:45}$		-3,00E-04 ***		-3,86E-04 **	-2,33E-04 **	-4,00E-04 ***
$\delta^-_{11:12:30}$		1,60E-04 ***		2,03E-04 **	1,85E-04 *	2,54E-04 **
$\gamma^+_{11:00:15}$		1,98E-04 ***		2,18E-04 *	1,61E-04 ***	1,49E-04 ***
$\gamma^+_{11:01:00}$		-1,87E-04 ***		-2,12E-04	-1,56E-04 ***	-1,52E-04 ***
$\gamma^-_{11:00:15}$		2,57E-04 ***		1,97E-04 *	2,02E-04 *	2,33E-04 *
$\gamma^-_{11:00:30}$		5,22E-04 ***		4,83E-04 ***	4,10E-04 **	4,26E-04 **
$\gamma^-_{11:00:45}$		-3,91E-04 ***		-4,69E-04 ***	-5,82E-04 ***	-7,02E-04 ***
$\gamma^-_{11:01:15}$		-4,50E-04 ***		-2,74E-04 ***	-1,23E-04	-5,32E-05
$\gamma^-_{11:01:30}$		-1,63E-04 **		-1,88E-04 ***	-1,29E-04	-1,48E-04 **
$\gamma^-_{11:02:00}$		1,43E-04 **		2,18E-04 ***	2,67E-04 ***	2,53E-04 ***
$\gamma^-_{11:02:30}$		2,07E-04 ***		1,44E-04 **	7,13E-05	7,22E-05
$\gamma^-_{11:02:45}$		-1,27E-04 *		-1,14E-04 *	-1,17E-04 **	-7,73E-05
variance eq.						
λ			7,26E-10 *	1,31E-09	2,82E-09	1,28E-08 ***
μ			9,12E-02 ***	1,50E-01 ***	1,99E-01 ***	1,50E-01 ***
ν			8,89E-01 ***	8,03E-01 ***	6,35E-01 ***	6,00E-01 ***
$\vartheta_{1,10:58:30}$						-3,00E-08 **
$\vartheta_{1,11:00:15}$					1,15E-07 ***	1,21E-07 *
$\vartheta_{1,11:00:45}$					-7,96E-08 **	
$\vartheta_{1,11:01:00}$					5,59E-08 **	
$\vartheta_{1,11:03:00}$					9,86E-08 **	9,58E-08 **
$\vartheta_{1,11:03:15}$						-6,15E-08
$\vartheta_{1,11:05:45}$					1,07E-08	
$\vartheta_{1,11:06:30}$						1,65E-08
$\vartheta_{1,11:10:00}$						-3,33E-08 **
$\vartheta_{2,11:00:15}$						7,89E-08 **
$\vartheta_{2,11:00:30}$						-2,38E-08
$\vartheta_{2,11:01:00}$						9,14E-08 **
$\vartheta_{2,11:02:15}$						-3,89E-08 **
$\vartheta_{2,11:03:00}$						2,03E-08
$\vartheta_{2,11:03:30}$						-3,26E-08
SC	-14,59	-14,63	-14,88	-14,92	-14,91	-14,58

[a]Significance levels are denoted by *** = 1%, ** = 5%, * = 10%.

Table 8: "Combined" GARCH(1,1)-model for the returns of ZEW release days

a) Returns	*ifo*	**ZEW**
Good news		
⇨ No confounding news:	0:15(+), 0:30(-)	0:15(+), 0:45(-), 4:15(-)
⇨ Along with confounding news:	0:15(+), 0:45(-)	0:15(+), 1:00(-)
Bad news		
⇨ No confounding news:	(none)	0:30(+), 0:45(-), 2:45(+)
⇨ Along with confounding news:	0:15(+), 0:30(-)	0:30(+), 0:45(-), 1:30(-), 2:00(+), 2:45(-)
b) Variance		
⇨ No confounding news:	(none)	3:00(+)
⇨ Along with confounding news:	0:15(+), 0:45(+)	0:15(+), 1:00(+), 2:15(-)

Note: Positive signs are caused by positive (negative) responses to positive (negative) news, negative signs reflect positive reactions to 'bad' news or negative reactions to 'good' news (see definition of surprise indicator)

Table 9: Significant (5%) GARCH responses within first five minutes after announcements

APPENDIX

A) List of simultaneous events, *ifo*

day of week	ifo release date	simultaneous releases (monthly if not denoted otherwise)
Tue	27.01.2004	
Tue	24.02.2004	ECB: eurozone trade balance and capital account[a]
Fri	26.03.2004	ECB: M3 for eurozone
Mon	26.04.2004	
Tue	25.05.2004	
Fri	25.06.2004	ECB: eurozone trade balance and capital account
Tue	27.07.2004	
Thu	26.08.2004	ECB: M3 for eurozone
Mon	27.09.2004	ECB: M3 for eurozone
Mon	25.10.2004	
Thu	25.11.2004	ECB: eurozone trade balance and capital account
Fri	17.12.2004	
Wed	26.01.2005	ECB: eurozone trade balance and capital account
Wed	23.02.2005	
Wed	23.03.2005	ECB: eurozone trade balance[b]
Mon	25.04.2005	
Wed	25.05.2005	
Mon	27.06.2005	ECB: eurozone trade balance
Tue	26.07.2005	
Thu	25.08.2005	
Tue	27.09.2005	ECB: M3 for eurozone
Tue	25.10.2005	
Thu	24.11.2005	ECB: eurozone trade balance
Fri	16.12.2005	
Wed	25.01.2006	
Thu	23.02.2006	
Tue	28.03.2006	ECB: M3 for eurozone
Tue	25.04.2006	ECB: eurozone trade balance

[a] Leistungs- und Kapitalbilanz
[b] Leistungsbilanz

B) List of simultaneous events, ZEW

day of week	ZEW release date	simultaneous releases (monthly if not denoted otherwise)
Tue	20.01.2004	Press conferences German building industry[a] & Federal Association of Investment and Asset Mgt[b]
Tue	17.02.2004	
Tue	16.03.2004	
Tue	20.04.2004	Eurostat: trade balance eurozone[c]
Tue	18.05.2004	Eurostat: industrial prod. & consumer prices eurozone
Tue	22.06.2004	
Tue	20.07.2004	
Tue	17.08.2004	Eurostat: industrial production eurozone
Tue	14.09.2004	
Tue	12.10.2004	
Tue	09.11.2004	
Tue	07.12.2004	
Tue	11.01.2005	
Tue	15.02.2005	Eurostat: quarterly GDP eurozone, Italy: quarterly GDP
Tue	15.03.2005	
Tue	19.04.2005	Eurostat: industrial production eurozone
Tue	24.05.2005	Eurostat: trade balance eurozone
Tue	21.06.2005	
Tue	19.07.2005	Eurostat: industrial production eurozone
Tue	23.08.2005	
Tue	20.09.2005	Eurostat: trade balance eurozone
Tue	18.10.2005	Eurostat: consumer prices eurozone
Tue	15.11.2005	Eurostat: quarterly GDP eurozone
Tue	13.12.2005	
Tue	10.01.2006	
Tue	14.02.2006	Eurostat: quarterly GDP eurozone
Tue	14.03.2006	
Tue	11.04.2006	

[a] Jahresauftakt des Hauptverbands der Deutschen Bauindustrie u.a. über die Konjunkturentwicklung
[b] Jahres-PK des Bundesverbandes Investment und Asset Management
[c] Handesbilanz