Price and liquidity effects of US economic news releases on German stock index futures

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Abstract

The transmission of economic news from one country to another country's financial markets is a well documented phenomenon. Yet, little is known about *how* foreign economic news is processed in domestic markets. This paper extends the knowledge beyond previously studied price and volatility effects. We investigate the impact of US economic news on a German stock index futures and compare it with the impact of domestic German news. We find that US economic news affects German stock futures on multiple dimensions including prices, trading volume, volatility, quoted spreads, inventory holding costs and the informational role of trading. US news effects are qualitatively comparable with those of German economic news. But they are larger in magnitude. This hints at a high degree of integration between both economies. Trading in German stock futures following US economic news releases is characterized by increased differences of opinion and information asymmetry. This suggests that the implications of US news for German stock prices are not fully observable in US stock prices and that German traders form private opinions about these implications.

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1 Introduction

The transmission of economic information across global financial markets is a well documented phenomenon and a leading role of US economic news has been identified for financial markets worldwide.[1] Most of these studies are limited to the price and volatility effects of US news on international markets and they find significant increases in both variables in response to a US news release. Wongswan (2006) additionally finds an increase of trading volume in Asian stock markets. However, that study analyzes the US news effect at the beginning of next day's trading since Asian markets are closed when US news is released. Thus, the response includes not only US news but all overnight information. Overall, little is known about *how* international financial markets process US economic news. Is there any difference between the effects of domestic and US economic news on trading patterns around the news release? What about cost of inventory control and information asymmetry? And how does the magnitude of domestic and foreign economic news effects compare? Our paper analyzes these questions with regard to the impact of domestic and US economic news on a German stock index futures.

The literature identifies one primary source that might cause differences in the processing of domestic and US economic news. Domestic traders might not react to the US news itself. Rather they might be just following the US market's response instead of interpreting the implications of such news for domestic markets themselves. This can be explained as follows. US stock price movements in response to the release of US economic news represent the aggregated interpretation of US investors regarding the implications of this news for US stock prices. This interpretation is publicly observable by German stock traders. In contrast, implications of German economic news are not publicly observable in other markets. Hence, it might be assumed that private interpretations of domestic economic news is a more important issue for German stock investors than private interpretations of US news. In fact, King and Wadhwani (1990) reveal an intriguing fact that supports this view. UK stock return volatility is unusually low when US eco-

[1] Studies on the impact of US economic news on international markets include Becker, Finnerty, and Friedman (1995), Connolly and Wang (2003) and Wongswan (2006) for stocks, Andersen, Bollerslev, Diebold, and Vega (2003) for foreign exchange markets, and Ahn, Cai, and Cheung (2002) and Andersen, Bollerslev, Diebold, and Vega (2007) for bonds.

nomic news is announced at 2:30 pm CET (Central European Time).[2] One hour later when US stock markets open at 3:30 pm volatility in UK stock returns is unusually high. Thus, King and Wadhwani (1990) conclude that 'London reacts more to New York's assessment of the statistics than to the news itself' (p. 19). Similarly, Albuquerque and Vega (2007) find that 'Portuguese investors free ride on US investors analysis of the news announcement' (p. 20). However, there is also contrary evidence. Becker, Finnerty, and Friedman (1995) find a significant price and volatility reaction of UK stock markets immediately following US economic news, and before US stock markets open.

Our paper investigates how German stock traders respond to US economic news. The goal is to advance the understanding of how foreign economic news is processed in domestic markets. Moreover, we want to asses whether German traders are actively interpreting US economic news. Germany is suited for such analysis as German markets are open when US economic news is released and tick-by-tick stock market data is readily available for a very long time period from 1991 to 2005. First, we asses the impact of 24 types of US economic news on high frequency prices of a German stock index futures (FDAX). This reveals the magnitude, sign and speed of the price response of German stocks. Second, we compare trading patterns, including trading volume, return volatility and bid-ask spreads around the release of US news with trading patterns on non-announcement days during the same time of day. Lastly, we investigate the impact of US news on effective spread components — costs of inventory control and information asymmetry — in the German stock market. As a natural benchmark to asses the magnitude of the announcement effects of US news we compare these effects with the impact of 17 types of German economic news. Our approach is novel in that we analyze the transmission of US news to an international stock market not only with regard to prices and volatility, but also its effects on trading patterns and its market microstructure effects.

We find that the announcement of US economic news exerts large effects on German stock index futures. German stock prices adapt to the news releases almost instantaneously within less than 5 minutes. At the same time there is an instantaneous surge in quoted spreads, volatility and trading volume, lasting about 2 minutes (spreads), between 5 and 30 minutes (volatility) and

[2] All times in this paper are CET.

up to 90 minutes (trading volume). In addition, economic news releases significantly increase the informational value of order flow compared to non-announcement days and compared to the pre-announcement period. This period of heightened information asymmetry lasts for about 15 minutes and then returns to almost normal levels. The cost of inventory control is significantly larger than usual in the 5 minutes before the news release. The general pattern of trading in German stock futures is similar in response to domestic and US economic news. However, there seems to be a larger number of relevant US announcements and US news exert larger effects on German stock futures than domestic news. Our results are revealing as they draw a concise picture of the way German traders respond to US economic news. German stock traders do not wait until US stock markets open. US news is immediately incorporated into German stock prices. The increase in volume and volatility following the news release is in line with information processing models such as Harris and Raviv (1993), Kim and Verrecchia (1994) and He and Wang (1995). In these models a public signal causes heterogeneous private interpretations of this signal among traders, which they reveal through trading. These heterogeneous private interpretations of the public news release represent asymmetric information. Hence, the informational value of order flow is heightened in this setup, which we also observe in our empirical examination.

In sum our findings strongly suggest that German traders actively form private opinions about the implications of US economic news rather than just 'free riding' on the US market's response. This is surprising, given the fact that aggregated US traders' interpretation is publicly observable in S&P futures prices.[3] Thus, our findings are in stark contrast to the notion that the full implications of US economic news for German stock prices can be publicly observed in US stock prices. This contradicts with previous empirical results of King and Wadhwani (1990) and Albuquerque and Vega (2007) from UK and Portuguese stock markets. We explain this with the choice of our sample. Both prior studies only use a sample of less than ten months while we base our analysis on a fifteen year sample from 1991 to 2005. In addition, King and Wadhwani (1990) examine the aftermath of the October 1987 crash and Albuquerque and Vega (2007) examine the US news effects in Portugal which is a much smaller and possibly more segmented market

[3]US stock markets are closed at 2:30 pm when most US economic news releases occur but S&P futures can be traded on GLOBEX around the clock since 1994.

than Germany.[4] The fact that US economic news impacts German stocks more than domestic news indicates that the state of the US economy is highly important for German stocks. This hints at a large degree of integration between these two economies.

Our findings advance our understanding of how foreign information is processed in financial markets beyond the price and volatility effects. We document that the US news effect on differences of opinion and information asymmetry in German stock markets is very similar in nature to that of domestic news. King and Wadhwani (1990) note that it might have far-reaching consequences if relatively few investors make their own calculations about fundamental asset values but rather 'free ride' on other markets' interpretation. Our study shows that this is not the case for the interpretation of US economic news by German investors. German traders form their own interpretation of US news implications for German stock prices. However, our findings do not necessarily imply that German traders disregard the US response. German traders might very well react to both public signals, the US economic news itself and the US stock price response. Nevertheless, the implications of US news for German stock prices are not fully observable in US stock prices. Thus, US economic news induces differences of opinion and information asymmetry in German stock markets.

The remainder of this paper is structured as follows. In section 2 we present the data used in this study. Section 3 investigates the price impact of US and German economic news on German stock index futures. In section 4 we compare trading patterns on announcement days and non-announcement days. Section 5 studies the impact of economic news announcements on costs of inventory control and information asymmetry. Section 6 concludes the research.

2 Data

2.1 German and US economic news data

We investigate the impact of 17 types of German economic news announcements and 24 types of US economic news. These announcements are very exemplary of pure public information,

[4] Bekaert and Harvey (1995) suggest that while major markets are highly integrated, there are some markets that are segmented and thus are not driven by the arrival of new information from the world's stock markets. We think that this might be a reason for the lagged response of Portuguese stocks.

i.e. there is no leaks and all market participants learn about these news at the same time. Our announcement data consist of four pieces of information: the release date and time, the announced headline figure, and the market expectation. The market expectation is gathered by polling analysts about their expectations for upcoming announcements a few days before each release and taking the median of analyst responses. Further, we calculate the surprise value of each announcement by taking the difference between the announced value and prior market expectations. In line with Balduzzi, Elton, and Green (2001) we standardize the surprise value of each announcement observation by the standard deviation (denoted by $STD(.)$) across all observations of this announcement type. This procedure facilitates a comparison of estimated coefficients across different news types. Thus, the standardized surprise $S_{i,m}$ of announcement type i in month m is calculated as

$$S_{i,m} = \frac{A_{i,m} - F_{i,m}}{STD(A_i - F_i)} \tag{1}$$

where $A_{i,m}$ is the actually released value and $F_{i,m}$ is the median analyst forecast.

The primary source of our announcement data is Money Market Services, which has been used as a data source in many similar previous studies such as Balduzzi, Elton, and Green (2001), Andersen, Bollerslev, Diebold, and Vega (2003, 2007) and Green (2004). However, analyst coverage by MMS ends in 2003 and for four US announcements and for two German announcements MMS data is not available.[5] Since Bloomberg is a second well established provider of economic announcement data[6] we use Bloomberg whenever MMS data is not available. This provides us with one of the most comprehensive and longest series of German and US economic announcement data used so far. Table 1 presents the announcement data we use in our analysis.

— Please insert TABLE 1 approximately here —

All announcements are released on a prescheduled day at a fixed time, mostly on a monthly basis. For most US announcements our sample covers the entire investigation period from 1991 to 2005,

[5]MMS data is not available for German CPI and ECB interest rates, and for US import prices, ISM services index, factory orders and FED interest rates.

[6]Bloomberg has been used as a data source for economic news announcements in Fleming and Remolona (1997) and Bollerslev, Cai, and Song (2000), among others.

which equals 180 observations. The reporting agency and the release cycle are also given for each news type. We report minimum, maximum and mean values for the standardized surprise in the rightmost part of Table 1. The number in the abbreviation of some announcement types indicates that this announcement consists of more than one relevant headline figure. For example, the US employment report consists of headline figures regarding non-farm payrolls (E1), unemployment rate (E2) and hourly earnings (E3). The '2' in PPI2, CPI2 and RS2 denotes that these are the core value for the respective announcement. CPI2, for instance, excludes products such as food and energy that face volatile price movements.

2.2 High frequency German stock index futures data

We examine the information processing by German stock traders using high frequency data on the DAX futures (FDAX) from January 1, 1991 to December 31, 2005. We use futures market data for several reasons. First, futures data are readily available on a tick basis for such a long sample period. Second, transaction costs are lower in the futures markets, especially for short sales. In fact, Booth, So, and Tse (1999) find that the DAX stock index futures contributes more to price discovery than both the DAX spot index and the DAX index option. The FDAX is a futures contract on the leading German stock index DAX 30, which contains the 30 largest and most liquid German stocks. It is traded on the fully computerized EUREX[7], the world's most liquid options and futures exchange. Liquidity is provided by traders and voluntary market makers who place limit orders into the centralized electronic order book which is open to all market participants. All orders are submitted electronically to the market via a trading terminal where orders are automatically matched, based on strict price and time priority. The minimum transaction size is one contract, and the minimum tick size is half an index point. Trading hours have steadily increased from 10:30 am to 1:45 pm in 1991 to 8:45 am to 10 pm in 2005.[8]

Our dataset consists of all best bid and ask quotes, transaction prices, and transaction quantities for the DAX futures time-stamped to the second. Our analysis is always based on the

[7] In 1998 the German Futures Exchange (DTB) merged with the Swiss Futures Exchange (SOFFEX) to form EUREX. Before the merger the FDAX was traded on DTB which had the same market structure as EUREX.

[8] A detailed overview of trading hours during our sample can be found in the Appendix.

most actively traded contract, which is mostly identical to the nearby contract.[9] There is no information in the dataset on whether a trade is initiated by a buyer or a seller. Therefore, we classify trades as buyer or seller initiated following Lee and Ready (1991).[10] All our results are also robust to several other classification rules, though.[11] Since our sample contains relatively few trades executed inside the quotes (only about 6% of all trades) we are confident to achieve a reasonably reliable classification of trade directions.[12]

Our sample spans 15 years and trading characteristics in the DAX futures have evolved considerably during this period. Figure 1 reports the mean daily trading volume, mean daily number of trades, volatility of daily log returns and mean 12 pm bid-ask spreads.

— Please insert FIGURE 1 approximately here —

It is evident that during our sample trading volume as well as the number of transactions in FDAX contracts have increased a lot. In fact, the average daily trading volume has almost multiplied twentyfold from 3,732 in 1991 to 65,566 in 2005. A similar monotonous change in one direction cannot be observed for volatility and quoted bid-ask spreads. However, we can clearly identify a time-variation in these two variables, too. For example, the standard deviation of daily close to close log returns has decreased by almost 70% between 2002 and 2005. The long-term development of quoted spreads (measured at 12 pm) seems to follow a pattern resembling the volatility development.

Besides the long-term changes in FDAX trading characteristics there is also an intraday pattern of trading. In European stock markets volume and volatility typically exhibit a U-shape pattern with higher volume and volatility at the beginning of the trading day when markets open and

[9] Typically the next-to-nearby contract becomes the most liquid contract one day before the nearby contract expires.

[10] A trade is classified as buyer (seller)-initiated if the transaction price is higher (lower) than the prevailing midpoint of best bid and ask prices (quote rule). If the transaction price is exactly at the quote midpoint, Lee and Ready (1991) apply the tick rule which is based on price movements relative to previous trades. If the transaction is above (below) the previous price, then it is a buy (sell). If there is no price change it is classified as a buy (sell) if the previous tick was a buy (sell).

[11] We additionally conduct all our analyses with classifications according to the tick rule, quote rule, Madhavan, Richardson, and Roomans (1997) rule and the Ellis, Michaely, and O'Hara (2000) rule. These results are available upon request.

[12] All classification rules are known to perform reasonably well for trades executed outside the quotes and relatively poorly for trades inside the quotes (see, e.g., Ellis, Michaely, and O'Hara (2000)).

near the end of the trading day when US markets open (see, e.g., Tse (1999) and Abhyankar, Copeland, and Wong (1999)). A pronounced pattern in bid-ask spreads is typically not found. Figure 2 plots the intraday patterns between 9:15 am and 4:45 pm regarding average 1-minute values of trade volume, number of transactions, volatility (measured as absolute log returns) and quoted spreads. Times are given on a 24-hour clock. The plots are based on data from May 5, 1995 and later, since trading hours were extended to 9 am to 5 pm on that day.

— Please insert FIGURE 2 approximately here —

Trading in FDAX futures exhibits the typical U-shape pattern for trading volume and volatility whereas bid-ask spreads are virtually flat throughout the day. Trading intensity is higher at the beginning, then decreases, and sharply increases again at 3:30 pm when US stock markets open. Also, one can clearly identify additional spikes in all trading characteristics at 2:30 pm and a smaller spike at 4:00 pm. These spikes coincide with the release time of major US economic news. The effect of German economic news on FDAX trading is less clearly visible. This might be attributable to the fact that German economic news releases are scattered throughout the day while almost all US news releases occur at 2:30 pm or 4 pm. Nevertheless, smaller spikes can be found, for example, at 10 am when German IFO is released and at 11 am when German ZEW is released. Overall, Figure 2 hints at significant effects of domestic and US economic news on FDAX trading.

To sum up, we have identified long-term differences in trading pattern between different years in our sample and intraday differences between different times of the day. We take these findings into account in our analysis.

3 Price response to economic news

In a first step we investigate the DAX futures (FDAX) price response to US economic news and compare it to the price impact of German news. This analysis is motivated by two objectives. First, we want to assess the degree of economic integration between the two countries by comparing the magnitude of price effects on German stocks. Second, we want to examine how

quickly economic news is incorporated into FDAX prices. An intriguing question is whether US news is processed more slowly than German news. This might be because US stock markets are closed when most US announcements are released and German traders might want to wait to see the US stock price response.

We analyze the price effects by regressing five-minute log returns on the surprise of economic news. Five-minute returns represent a reasonable balance between confounding market microstructure effects by sampling too frequently and blurring specific price reactions when sampling too infrequently (see the related discussions in Andersen, Bollerslev, Diebold, and Vega (2003, 2007) and Bandi and Russell (2005), among others). Specifically, we construct an event window around each announcement observation consisting of two preceding five-minute intervals and twelve intervals following the announcement. We exclude the two target interest rate announcements by the FED and by the ECB, as we only have six surprises for each of these two announcements. This is because almost all interest rates announcements were anticipated by the market and, hence, the surprise is zero. For the remaining 42 economic news types we assume the following econometric model:

$$R_t = c + \sum_{i=1}^{42} \delta_i \cdot S_{i,t} + \epsilon_t. \tag{2}$$

R_t represents the five-minute log return on the DAX futures between the last price in interval t-1 and the last price in interval t. $S_{i,t}$ denotes the standardized surprise component of news type i in interval t if it is released in that interval. Otherwise, if there is no announcement of i in t, $S_{i,t}$ is zero. δ_i denotes the price response coefficient to announcement type i. We estimate the regression following Newey and West (1987) to allow for heteroscedasticity and autocorrelation of unknown form.

— Please insert TABLE 2 approximately here —

Table 2 reports the estimated price response coefficients for different German and US economic news types, ordered by the absolute value of $\hat{\delta}_i$. We only report significant results, i.e. $\hat{\delta}_i = 0$ can be rejected with a p-value of less than 0.1 based on a two sided t-test. We reverse the sign

of surprises in unemployment rate (E2), initial jobless claims (IJC) and business inventory (BI) to make them better comparable to other announcement surprises: positive values equal higher than expected economic activity. It is apparent that there are more US than German economic news announcements that are relevant for German stock prices. Also, the most important news, hourly earning (E3) and US GDP are both US news. Nevertheless, several types of German economic news also exert a significant price impact on German stocks. For instance, the ZEW announcement ranks third among all examined announcement types. The fact that US economic news is that important for the German stock market hints at a large degree of integration between the economies. The sign of the price response is similar for US and German news. Inflation announcements (German/European M3 money supply (MSP), US CPI, PPI, and hourly earnings (E3)) from both countries are negatively related to German stock prices. All other significant economic news types primarily tell about lagged, present or future real activity. These news types are all positively linked with German stock prices.

Macroeconomic news, particularly news about real activity, are known to have a state-dependent effect on stock prices (see, e.g. McQueen and Roley (1993) and Boyd, Hu, and Jagannathan (2005)). Thus, we modify Equation (2) to allow for a state-dependent effect of US and German economic news on FDAX prices:

$$R_t = c + \sum_{i=1}^{42} \delta_i^{exp} \cdot D_t^{exp} \cdot S_{i,t} + \sum_{i=1}^{42} \delta_i^{rec} \cdot D_t^{rec} \cdot S_{i,t} + \epsilon_t \tag{3}$$

where D_t^{exp} (D_t^{rec}) is a dummy variable that takes the value one if the economy is in an expansion (a recession). We define recessions as beginning when there are three consecutive monthly declines in the IFO index, and ending when there are three consecutive monthly increases.[13] All other variables are defined as in Equation (2). We report estimation results in Table 3. Different types of economic news are now ranked as follows: First by whether the price response coefficient is significant in both sub samples, then by the average absolute value of price response coefficients, δ_i^{exp} and δ_i^{rec}.

[13]This approach follows Andersen, Bollerslev, Diebold, and Vega (2007) who use three consecutive increases (decreases) of US non-farm payrolls to classify the US economy. However, Kunkel (2003) points out that consecutive changes in the IFO index are particularly well suited to classify business cycle states in Germany.

— Please insert TABLE 3 approximately here —

The state-dependent price response analysis reveals a few additional announcements that are relevant in either expansion and/or recession periods. Most notable is the US unemployment rate announcement, which is among the most important announcements in both expansions and recessions but insignificant in the unconditional analysis. We find the same pattern of response to this announcement in German stock prices as Boyd, Hu, and Jagannathan (2005) find in US stocks: a positive (negative) surprise during a recession leads to an increase (decrease) in stock prices while the stock price response is reversed during expansions. Another interesting finding is that surprises in non-farm payrolls (E1) which is often referred to as 'king of announcements' (see Andersen and Bollerslev (1998) and Hautsch and Hess (2007)) do not impact German stock prices in a significant way.[14] Rather, unemployment rate and hourly earnings are the most important headline figures within the US employment report for German stock prices.

Lastly, we analyze the efficiency of the German stock price response to domestic and US economic news. Therefore we expand Equation (2) into:

$$R_t = c + \sum_{j=-1}^{4} \sum_{i=1}^{42} \delta_i^j \cdot S_{i,t-j} + \epsilon_t. \tag{4}$$

This specification tests whether surprises in US and German economic news affect FDAX returns in lead and lag intervals. For example, the impact on the first five-minute interval preceding the release corresponds to $\hat{\delta_i^{-1}}$ and the impact on the fifth five-minute interval following the release corresponds to $\hat{\delta_i^4}$. Assuming efficient markets the price adjustment should be completed after five minutes the latest. Further, this regression reveals whether economic news affects German stock prices before the scheduled release time which would indicate the existence of leakages. In Table 4 we report the price response in the 30 minutes around the release time. A significant impact on any five-minute return is denoted by * (**) if the p-value is less than 0.05 (0.01).

— Please insert TABLE 4 approximately here —

[14] However, the importance of the US non-farm payrolls announcement was mostly documented in bond market studies. The impact on stocks is less clear. Becker, Finnerty, and Friedman (1995), for example, find no significant impact of this announcement on US stock prices.

The results in Table 4 strongly suggest an almost instantaneous response to both US and German economic news. Significant FDAX price reactions before the release or after the first five-minute interval are very infrequent and show no common pattern. We plot the average cumulative return between 30 minutes before the release until 60 minutes after the release for a German announcement (ZEW) and a US announcement (PPI) in Figure 3. We do not observe any systematic differences between the effects of positive and negative surprises. Therefore the cumulative returns around negative surprises have been reversed for calculating Figure 3.

— Please insert FIGURE 3 approximately here —

The figure again suggests that German stock futures markets are very efficient and that economic news is incorporated into prices near-instantaneously. Also, it seems that there is no difference in the way US and domestic economic news is incorporated into German stock prices. After the rapid adjustment immediately after the announcement stock prices remain at the new price level on average. Thus, we can rule out a reaction of German traders that resembles that of UK and Portuguese stock investors as reported by King and Wadhwani (1990) and Albuquerque and Vega (2007). They find that UK and Portuguese investors respond to US economic news not until US stock markets open one hour after the release. However, S&P futures can be traded around the clock. Hence, based on these results alone we cannot rule out the possibility that German stock traders are also 'free riding' on the S&P futures response to US news rather than interpreting the news themselves.

Nevertheless, our analysis has shown that US economic news is relevant to German stock prices — maybe even more so than German economic news — and that the price adjustment to news from both countries occurs almost instantaneously.

4 Trading activity around economic news announcements

We analyze trading activity in DAX futures (FDAX) around the release of US and German economic news. Specifically, we study trading volume, return volatility and bid-ask spreads in a window from 30 minutes before until 90 minutes after the release and compare trading on

announcement days with trading on non-announcement days at the same time of day. This approach allows us to assess whether trading activity in DAX futures is affected by the release of public news about the US and German economy. Moreover, abnormal trading volume and volatility are known as proxies for the heterogeneity of investor opinions (see, e.g., Harris and Raviv (1993) and Garfinkel (2005)). Thus, this analysis also gives information about differences of opinion among German investors regarding the implications of economic news releases.

Since we always compare the same time of day on announcement and non-announcement days we explicitly take the intraday patterns of trading into account. As we have also found pronounced long-term changes in FDAX trading activity we additionally take time-varying non-announcement day levels into account. For each announcement observation, we compare the announcement day value with the mean value on non-announcement days at the same time of day averaged over a period of 42 trading days before until 42 trading days after that observation.[15] We refer to the difference in announcement and non-announcement day values as the abnormal announcement effect. For example, we calculate abnormal volume of traded FDAX contracts ($\widetilde{V}$) caused by a release of economic news i (e.g. US employment report) on trading day t in interval τ (e.g. 2:30 to 2:31 pm) as:

$$\widetilde{V}^i_{t,\tau} = V^i_{t,\tau} - MEAN\left(\left\{ V^i_{s,\tau} \middle| \, s \in \{t-42, ..., t-1, t+1, ..., t+42\} \wedge D^{j,i}_{s,t} = 0 \right\}\right) \tag{5}$$

where $D^{j,i}_{s,t}$ is a dummy variable that takes the value 1 if other relevant[16] economic news $j \neq i$ is released on day s within the event window of -30 ... 90 minutes around the release time of announcement i. Thus, we exclude trading days from the comparison window that are distorted by other economic news and might bias our results. Abnormal values for volatility ($|\widetilde{R}|$), computed as the absolute log return between the last price in an interval and the last price in the preceding interval, as well as for quoted bid-ask spreads ($\widetilde{S}$), measured as the first quoted spread

[15] Our choice of 84 trading days for the results reported in the paper corresponds to roughly 4 months (two months before and two months after the announcement observation). However, our results are robust to virtually any number of days in the comparison window. Still, we think that 84 trading days is a good compromise between having a large enough window that allows an unbiased comparison value and having a short enough window to take the long-term changes in FDAX trading into account.

[16] Relevant economic news is defined as any news type for which we report any significant effects on either FDAX prices, trading or effective spread components.

in an interval, are calculated likewise. We first report the impact of economic news on FDAX trading intervals preceding their release in Table 5.

— Please insert TABLE 5 approximately here —

This table reports mean values for abnormal trading volume ($\widetilde{V}$), abnormal volatility ($|\widetilde{R}|$) and abnormal spreads ($\widetilde{S}$). For each announcement i we include all release days into the calculation of mean abnormal values which are not distorted by the concurrent[17] release of other relevant economic news. Thus, we can clearly distinguish between the effects of different types of economic news on FDAX trading. We use * (**) to denote that the abnormal values are significantly different from zero with a p-value less than 0.05 (0.01) based on a two sided t-test. We rank all announcement types according to the abnormal increase of bid-ask spreads in the first minute leading up to the news release.[18] Further, we report the mean ratio between the values on announcement days and non-announcement days in parentheses. For example, a ratio of 1.3 for trading volume in the minute leading up to an employment report announcement denotes that trading volume on announcement days is 1.3 times as high as on non-announcement days during the same time of day.[19] We report results for all economic news for which we found a significant (p-value < 0.05) price impact in the previous section. Further, we include the ECB[20], US industrial production (IP1) and US durable good orders (DGO) announcements as these also proved to have a significant impact on FDAX trading.

Overall, we find very little to none effects of German economic news on FDAX trading prior to their release. The effect of US news on FDAX trading in all intervals from 30 to 1 minute prior to the release is minor as well. However, in the last minute before the release of economic news

[17] We define the concurrent release as any release within the event window which begins 30 minutes before the release time and ends 90 minutes after the release time.

[18] This ranking, as well as other rankings reported in this paper, is, of course, not the sole objective measure of importance. However, our rankings provide a basic idea of the relative importance of different news types for FDAX trading.

[19] As a robustness check we also test whether these announcement to non-announcement day ratios are significantly different from one. This tests whether the abnormal percentage increase compared to normal non-announcement day levels is significant. Our results are robust to this alternative approach.

[20] Apart from our normal procedure we chose an event window of -30...44 minutes around the ECB announcement which is released at 1:45 pm. This is necessary since all but nine observations are distorted by later US announcements at 2:30 pm. We think this deviation from our normal procedure does not bias ECB results, as we our main results indicate that 2:30 US news releases do not affect FDAX trading before 2:25.

we find very significant effects of almost all US news and of German industrial production (IND) and ECB on quoted spreads. For example, quoted spreads in the last minute before employment report announcements are higher by 1.44 points than usually which is 2.41 times as large as usually. This increase can be interpreted as a reluctance of market participants to trade prior to the news release given the increased price risk that comes with the announcement. This interpretation is consistent with inventory-control models of Amihud and Mendelson (1980) and Ho and Stoll (1983).[21] For many US announcements as well as for ECB the volatility is also higher immediately before the announcement which reflects the uncertainty.

We think the reason for the less pronounced reaction in quoted spreads prior to German announcements is not because market participants process US and German economic news fundamentally different. In fact, the spread is larger on average before every single German announcement, too. The effect is just less pronounced, and sometimes insignificant, as price risk induced by German announcements is smaller, as seen in the previous section. Thus, inventory control is less of a concern prior to German announcements than prior to US announcements. This view is further supported by the fact that the pre-announcement effect is most pronounced for economic news types that are known to induce large price effects, e.g., US employment report, PPI and CPI. Since Fleming and Remolona (1999) and Balduzzi, Elton, and Green (2001) find the same pattern of trading activity in US treasuries before the announcement of US economic news we conclude that the pre-announcement effects of foreign news are not different in principle from that of domestic news.

— Please insert TABLE 6 approximately here —

We now turn to the effects of economic news on trading activity after the release, which we report in Table 6. The rank for each news type is now assigned according to the abnormal increase in trading volume in the first minute past a news release. We find a large, instantaneous impact on FDAX trading in the first minute after each announcement. Return volatility increases to up to seven times the normal value of non-announcement days and volume is as high as four times

[21] Although their models are based on a market maker and they do not explicitly model the limit-order book, the same principles are also applicable to a limit-order market, see, e.g., Sandas (2001).

its normal value. The spread is comparable to the first minute leading up to the release and significantly larger than on non-announcement days. In the following minutes all three variables decrease virtually monotonically. For most US economic news, the widening of bid-ask spreads becomes mostly insignificant as quickly as in the second minute after an announcement, with the sole exception of the employment report which widens the spread for up to thirty minutes. The effect on volatility lasts between five and thirty minutes while volume is heightened for up to ninety minutes after the news releases. The effects of German economic news are much smaller and much shorter-lived. The spread reaction is only found in the ECB and money supply (MSP) announcement. The increase in volatility lasts for little more than five minutes and the effect on trading volume disappears after approximately 30 minutes.

Our results are consistent with popular public information processing models such as Harris and Raviv (1993) and Kim and Verrecchia (1994). In these models all traders share common prior beliefs before public information is revealed. After the release traders are heterogeneous in their interpretation of the public news. As a result, trading volume increases as market participants trade on their differences of opinion regarding the news (see, e.g., Shalen (1993) and He and Wang (1995)). This in turn creates an increase in price volatility. The view, that differences of opinion are the main reason for the increase in trading activity is also held by Balduzzi, Elton, and Green (2001). They also point out that larger surprises do not cause more trading. Our results regarding FDAX trading activity following ECB announcements supports this view. Although there are only six ECB announcements that surprised the market, there is still a significant impact of ECB news on FDAX trading. This result holds, even when we remove the six ECB announcements that surprised the market from our sample.

Generally, more important types of economic news can be expected to generate a larger variety of private interpretations which in turn induces more trading volume and volatility in the aftermath of a news release. It is therefore not surprising that the announcements with the largest effects on trading activity (US employment report, PPI, retail sales(RS2)) are those which are known as the most important announcements. Thus, we relate the larger magnitude of US news effects compared to German news effects to their larger importance, rather than to any differences in information processing. Figure 4 illustrates the general pattern of FDAX trading activity around

the release of a German (ZEW) and a US announcement (PPI).

— Please insert FIGURE 4 approximately here —

The different longevity of volume, volatility and spread effects is well visible in the figure. While the increase in bid-ask spreads disappears almost immediately, volatility levels go back to normal only after some ten minutes and trading volume remains elevated for more than an hour. It is evident that the general pattern of trading is the same around US and German economic news.

We conclude that US economic news cause an increase in differences of opinion in German stock markets just as German economic news do. But the US news effects are even larger in magnitude. First, this highlights the importance of the US economy for German stock prices. Secondly, this is a strong indication that the implications of US economic news are not fully observable in US S&P futures prices. Consequently German traders form heterogeneous interpretations on which they trade.

5 Impact of economic news on information asymmetry and inventory control

This section studies the impact of US and German economic news releases on the components of the effective spread in German stock futures markets. Theory posits that the spread can be decomposed into an information asymmetry and an inventory holding component (see, e.g., Glosten and Harris (1988) and Stoll (1989)). The former compensates traders who offer liquidity for the risk of trading with a better informed party. The latter compensates traders for offering liquidity and as a result deviating from desired inventory levels. The information asymmetry component is particularly telling for the question to what degree the implications of US economic news for German stock prices are contained in US stock prices. Since S&P futures prices are publicly observable, information asymmetry in DAX futures (FDAX) trading following US news releases should only rise if these implications are not fully observable in S&P prices.

5.1 Methodology

We derive the effective spread components based on the price formation model of Madhavan, Richardson, and Roomans (1997). This model was previously used by Greene and Smart (1999) to examine stock spreads around earnings announcements and by Green (2004) to study the informational role of trading in an interdealer broker market for US treasuries around US economic news announcements. Ahn, Cai, Hamao, and Ho (2002) point out that this model is particularly well suited to estimate the spread components on a limit order market such as the EUREX on which FDAX contracts are traded. Madhavan, Richardson, and Roomans (1997) generalize the trade initiation model of Glosten and Milgrom (1985) by allowing order flow to be autocorrelated. Their model isolates the spread components by examining the relation between transaction prices and signed order flow.

We denote the price of a transaction at time t as p_t, μ_t is the underlying fundamental value, and x_t is the buy-sell trade indicator variable: x_t equals $+1$ if the transaction is buyer initiated and -1 if the trade is seller initiated. Further, θ measures the information revealed by a transaction and ϕ denotes the compensation for traders supplying liquidity. ρ denotes the first-order autocorrelation of x_t. We assume a standard inventory cost model, $p_t = \mu_t + \phi x_t$, and an information asymmetry model for fundamentals, $\mu_t = \mu_{t-1} + \theta(x_t - \rho x_{t-1})$. Combined, they produce the following intraday price change model:

$$p_t - p_{t-1} = (\phi + \theta)x_t - (\phi + \rho\theta)x_{t-1} + \epsilon_t. \tag{6}$$

This model is suited for our purpose to investigate variations in effective spread components around economic news releases since it can be easily expanded by introducing indicator variables for different periods. We are interested in the differences in spread components between the following periods: non-announcement days (denoted by the indicator variable I^N), the announcement day period before the announcement (I^B) and the period following the announcement. Since we are also interested whether announcement effects disappears quickly, we divide the post-announcement period further into a period immediately following the announcement (I^{A15}) and a second subsequent period (I^{A30}). Thus, we expand Equation (6) into:

$$p_t - p_{t-1} = \sum_{i \in \{N,B,A15,A30\}} \left((\phi^i + \theta^i) I_t^i x_t - (\phi^i + \rho^i \theta^i) I_{t-1}^i x_{t-1} \right) + \epsilon_t. \tag{7}$$

In line with Green (2004) we choose an event window from 30:00 minutes before until 30:00 minutes after each announcement. I^B consists of the 30 minutes before each announcement and I^{A15} and I^{A30} encompass the two 15 minutes intervals following each announcement. I^N consists of the entire time period, −30:00 min to +30:00 min, but taken on non-announcement days. Days that are distorted by the release of multiple relevant announcements, i.e. two announcement types are released within 30:00 min of each other, are excluded from our analysis. Since the release time data does not contain information about the exact release second we exclude the complete first minute (0:00min – 0:59min) following each release. Thus I^{A15} consists of all transactions from 1:00min until 15:00min following each announcement. Since I^N and I^B contain a longer time period than the I^{A15} and I^{A30} samples, we make the following adjustments to the I^N and I^B samples in order to produce four sub samples that are roughly equal in size: For each announcement observation, we include only the first non-announcement day following this observation into our I^N sample. We further only include every fourth transaction in the I^N sample and only every second transaction in the I^B sample.

We choose the Generalized Method of Moments (GMM) to estimate the model. This procedure is appropriate as it imposes very weak distribution assumptions. This is especially important because the error term includes rounding errors due to discreteness of prices. The GMM procedure also easily accounts for the presence of conditional heteroscedasticity of unknown form. We use the Newey and West (1987) procedure to obtain heteroscedasticity consistent estimates of the covariance matrix. Letting α represent a constant drift and using the expressions

$$\upsilon_t = x_t - \sum_{i \in \{N,B,A15,A30\}} \rho^i I_{t-1}^i x_{t-1} \tag{8}$$

and

$$u_t = p_t - p_{t-1} - \sum_{i \in \{N,B,A15,A30\}} \left((\phi^i + \theta^i) I_t^i x_t - (\phi^i + \rho^i \theta^i) I_{t-1}^i x_{t-1} \right) \tag{9}$$

the following population moments implied by Equation (7) exactly identify the parameters α, θ^i, ϕ^i, ρ^i with $i \in \{N, B, A15, A30\}$:

$$\begin{aligned} E\left[\upsilon_t I^i_{t-1} x_{t-1}\right] &= 0, \qquad i \in \{N, B, A15, A30\} \\ E\left[u_t - \alpha\right] &= 0 \\ E\left[(u_t - \alpha) I^i_t x_t\right] &= 0, \qquad i \in \{N, B, A15, A30\} \\ E\left[(u_t - \alpha) I^i_{t-1} x_{t-1}\right] &= 0, \quad i \in \{N, B, A15, A30\}. \end{aligned} \tag{10}$$

The first set of moments determines the autocorrelation in order flow during each period of interest, and the remaining equations represent the OLS normal equations.

5.2 Results

We present estimation results in Table 7. The number of observations refers to the number of transactions in the I^{A15} sample, which is roughly equal to the number of observations in the other three sub samples.

— Please insert TABLE 7 approximately here —

In the middle columns of Table 7 we report the coefficient estimates for θ, ϕ and ρ for each of the four sub samples. The difference between the different periods' coefficient estimates is of particular interest. We report differences in the right-most columns between the:

1. pre-announcement (B) and the non-announcement sample (N)
2. first post-announcement sample (A15) and the pre-announcement sample (B)
3. second post-announcement sample (A30) and the first post-announcement sample (A15)
4. second post-announcement sample (A30) and the non-announcement sample (N)

The first value represents pre-release effects of economic news on information asymmetry, inventory control and autocorrelation of order flow. The second difference represents the immediate impact of the news release. The third difference shows whether the immediate effect decreases

after 15 minutes. And the last difference assesses whether the values in the A30 sample have returned to normal (i.e. non-announcement day) values. * (**) denotes that a difference is significant with a p-value less than 0.05 (0.01) based on a two-sided Wald coefficient test. The ranking of different news types is based on the increase immediately following the release, i.e. the difference between θ^{A15} and θ^{B}.[22]

Generally, the results for differences in inventory control, ϕ, and autocorrelation coefficients, ρ, are relatively inconsistent. There is some evidence for an increase in inventory costs in the period leading up to a news release compared to normal, non-announcement day levels: ϕ^B is larger than ϕ^N for most announcements. The difference is significant for PPI2, CPI2 and IJC. An opposite relation (ϕ^N larger than ϕ^B) can be observed only for three announcement types, of which none is significant. This hints at increased uncertainty regarding the upcoming economic news release which makes market participants reluctant to trade. Hence, the price for liquidity rises.

In contrast, the pattern of changes in information asymmetry costs around economic news releases is very pronounced and can be found around almost all US and German announcements. While pre-announcement information asymmetry is mostly not distinctively different from non-announcement day levels it rises significantly in the first 15 minutes following the announcement. Then information asymmetry significantly decreases again in the second post-announcement interval to near non-announcement day levels. These results confirm skilled information processing models such as Kim and Verrecchia (1994, 1997). Trading contains no additional information in the period leading up to the release as there is no private information about the upcoming economic news release. After the public news is released, heterogeneous skills of market participants to interpret the implications of the news leads to private information and therefore an increased informational role of order flow. However, traders with private information generated by superior skill of interpreting the news are unlikely to possess a monopoly on this kind of expertise. Holden and Subramanyam (1992) show that competition among multiple informed traders leads prices to incorporate private information quickly. In line with this view, we find that the increased

[22]We stress again that this ranking is not the sole objective measure of the impact on information asymmetry but it gives a good basic idea of the relative importance of different news types.

information asymmetry decreases significantly in the second post-announcement period.

We find that information asymmetry is affected more by the release of US economic news than by German news on average. However, we attribute this difference to the unequal importance of different types of US and German economic news rather than to a systematic difference due to the news' different country of origin. In fact, the ranking of economic news types regarding their impact on information asymmetry seems to be closely related to the impact of these announcements on prices and trading activity. This is understandable, as it can be assumed that private interpretation about more important news is more valuable than private information about lesser news. The outstanding relevance of the ECB announcement on information asymmetry is likely to be attributed to the fact that the news value of this announcement does not primarily lie in the target rate headline figure. But rather it lies in the ECB president's comment on the considerations underlying these decisions which might are likely more difficult to interpret than a single headline figure.

In order to further assess the exact duration of the impact of economic news releases on the effective spread components we now repeat the above analysis for each single minute within the event window of -30 min to $+30$ min. Therefor we pool together all types of US economic news which exert a significant impact on information asymmetry or inventory control (GDP, CC, CPI2, DGO, RS2, IJC, E1/E2/E3), and then proceed likewise with relevant German economic news (ECB, ZEW, IFO). This procedure allows for a sufficiently large sample in each minute of the event window. We further restrict our analysis to the period after September 2001 as ZEW data is only available from October 2001.[23] We plot the results for costs of information asymmetry (θ) and inventory control (ϕ) in Figure 5. Autocorrelation does not show a pronounced pattern and is therefore not reported. The solid, dashed and dotted lines denote results for the pool of US, German, and non-announcement day coefficient estimates, respectively. A symbol in the US and German result lines indicates that the value is significantly different (p-value $<$ 0.05) from the non-announcement day value.[24]

[23]Otherwise the non-announcement day values would not reflect both the German and the US sample correctly, as there is considerable time-variation in the effective spread components between different years of our 15-year sample.

[24]Since we pool together all US and German economic news types the non-announcement day sample now consists of event windows taken at different times of the day. We don't think that this biases our results as

— Please insert FIGURE 5 approximately here —

The figure confirms conclusions drawn from Table 7. The similarity of US and German news effects is striking. Information asymmetry sharply increases following the announcement and then gradually returns to normal values. The effect lasts almost 30 minutes for the pool of US announcements and about 15 minutes for the pool of the three most important German announcements. In addition, the pooled results reveal that in the period immediately before (between -10 and -2 minutes) the news release the informational value of order flow seems to be reduced. In fact, information asymmetry is lowest within the entire event window in the second minute before both US and German news releases. The pooled data also allows conclusions regarding inventory holding costs prior to the news release. Inventory costs are higher than usual in the approximately 15 minutes before the news release, reaching its maximum value immediately (one or two minutes) before the release. Moreover, the figure reveals that inventory costs are lower than usual in the 15 minutes following the announcement. These observations support the notion that uncertainty prior to the release makes traders reluctant to supply liquidity and resolved uncertainty following the announcement makes traders more willing to supply liquidity.

Our results regarding effective spread components help to understand what induces the trading activity patterns revealed in the previous chapter. The first approximately 15 to 30 minutes following an economic news release are characterized by increased levels of information asymmetry caused by private interpretations of the news. This causes increased differences of opinion among market participants on which they trade, which leads to increased levels of trading volume and volatility. In a subsequent period beginning between 15 and 30 minutes after the news release private interpretations have been fully incorporated into prices. Information asymmetry and volatility return to normal levels, yet trading volume remains high as liquidity traders now rebalance their portfolios to account for the just released economic news. The pronounced increases in quoted spreads in the few minutes immediately before and after the announcement can be attributed to different causes. Before the announcement liquidity is scarce due to inventory concerns caused by uncertainty regarding the upcoming news release. After the announcement

intraday variations in effective spread components are minor.

liquidity is costly as the risk of trading with a better informed trader (i.e. someone with better skills of interpreting the public news) is heightened.

Our findings are qualitatively very similar to Green's (2004) observations regarding the impact of US economic news on effective spread components in US treasuries, which are traded on a dealer driven market. In contrast, we examine the news impact on German stock index futures traded on a limit order market. Most importantly, we compare the effects of domestic and foreign economic news. We further extend Green (2004) by differentiating between different types of announcements instead of pooling all news types together. This reveals that some announcement (e.g. US GDP) exert much larger effects than others (e.g. US employment report) despite a comparable impact on prices and trading activity. In addition, we also examine the exact duration of the effects on effective spread components.

Our analysis has revealed that the impact of domestic and US economic news on the components of the FDAX effective spread is very comparable in nature. This is in stark contrast to the notion that foreign traders rely solely on the US market to interpret the implications of US economic news releases. If the implications of US economic news for German stock prices could be fully observed in the S&P futures price response it would be highly implausible that information asymmetry in the German stock market increases. On the contrary, our results show that German traders consider each other as a valuable source of private information regarding the implications of US economic news. Moreover, the larger magnitude of US news effects demonstrates the enormous importance of the US economy for German stock markets.

6 Conclusion

The transmission of US economic news to international stock markets has been well documented. Most previous studies are limited to the effects on prices and volatility. However, it is little understood *how* US economic news is processed abroad. King and Wadhwani (1990) and Albuquerque and Vega (2007) suggest that UK and Portuguese stock traders 'free ride' on the US stock market response instead of forming an own interpretation of the US economic news' implication for the respective markets. Our paper is the first to study the impact of scheduled

economic news in a multitude of trading- and market microstructure-related variables, including trading volume, inventory holding costs and the informational role of order flow. We conduct our analysis on a German stock index futures with a dataset consisting of 15 years (1991 – 2005) of tick-by-tick data and compare the effects of US economic news and domestic German news.

We find that the impact of both domestic and US economic news on German stock index futures is much in line with information processing models regarding the processing of public news. Economic news is almost immediately incorporated into prices within no more than five minutes. The increased uncertainty immediately prior to the announcement increases bid-ask spreads through increased inventory costs. As soon as the information is released (i.e. within one minute) market participants begin to interpret the implications of the economic news. Heterogeneous interpretation skills generate private information. Hence, information asymmetry costs rise and bid-ask spreads are elevated. Further, heterogeneous interpretations induce differences of opinion about the news on which market participants trade. This increases volume and volatility. After about 15 minutes most private information is incorporated into prices and information asymmetry and volatility return to normal values. Trading volume remains elevated for up to 90 minutes as traders rebalance their portfolio to account for the news.

Our findings advance our understanding of how US economic news is processed in international financial markets. The impact of US news on German stock prices as well as on all dimensions of DAX futures trading is even larger than the impact of domestic news. This indicates that the US economy directly and strongly influences German stock prices and hints at a high degree of economic integration. The price discovery process is qualitatively similar around US and German economic news. This is surprising given that US traders' aggregated assessment of US economic news implications is publicly observable by German investors in form of S&P futures prices. Nevertheless, US news cause a large increase in trading volume (which is an indicator of differences of opinion) and in the informational value of order flow. These findings do not necessarily imply that German traders disregard the US stock price response. But they strongly suggest that the implications of US economic news for German stock prices cannot be fully observed in US stock prices. Consequently US news create heterogeneous private interpretations and information asymmetry among German traders.

Appendix

Trading hours of DAX futures on EUREX

From	Until	First transaction	Last transaction
11/23/1990	2/13/1991	10:30 am	1:45 pm
2/14/1991	5/31/1991	10:30 am	3:00 pm
6/1/1991	5/19/1995	9:30 am	4:00 pm
5/20/1995	9/17/1999	9:00 am	5:00 pm
9/18/1999	6/1/2001	9:00 am	5:30 pm
6/2/2001	11/18/2005	8:45 am	8:00 pm
11/19/2005	12/31/2005	8:45 am	10:00 pm

This table contains trading hours of DAX futures on EUREX for different periods in our sample. For each sub period we report the approximate time of first and last transactions. The exact times of first and last transactions on any given day in a sub period might deviate insubstantially by a few minutes from the times reported here.

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Table 1: US and German economic news announcement data

Abbr.	Announcment	Obs.	Availability		Source	Time	Release	Stand. Surprise		
			from	until		(CET)	cycle	min	mean	max
German economic news										
PPI	PPI	146	199308	200512	SBA	8:00 am	m	-3.82	-0.02	3.40
RTS	Retails Sales	88	199804	200511	SBA	8:00 am	m	-4.13	-0.29	2.11
GDP	GDP	40	199603	200511	SBA	8:00 am	q	-2.10	0.04	2.40
WPI	Wholesale Price Index	139	199303	200508	SBA	8:00 am	m	-2.94	-0.07	3.16
TR1	Current Account Balance	120	199511	200512	SBA	8:00 am	m	-2.40	0.08	3.66
TR2	Trade Balance	123	199511	200512	SBA	8:00 am	m	-1.87	0.31	5.55
MSP	M3 Money Supply	119	199303	200512	BUB	9:30 am	m	-1.94	0.19	7.75
EM1	Unemployment Change	116	199605	200512	BAA	9:55 am	m	-2.82	0.06	5.18
EM2	Unemployment Rate	92	199802	200512	BAA	9:55 am	m	-3.57	-0.08	2.68
PMI	PMI Manufacturing	82	199902	200512	NTC	9:55 am	m	-2.27	-0.10	2.36
PMS	PMI Services	60	199910	200504	NTC	9:55 am	m	-2.76	-0.16	2.03
IF1	IFO business climate	113	199608	200512	IFO	10:00 am	m	-2.62	0.02	2.97
ZEW	ZEW	51	200110	200512	ZEW	11:00 am	m	-2.62	0.11	2.20
MFO	Manufacturing Orders	107	199609	200512	SBA	12:00 pm	m	-2.14	0.07	2.98
IND	Industrial Production	107	199702	200512	SBA	12:00 pm	m	-3.17	-0.11	2.96
ECB	ECB interest rates	67	200010	200512	ECB	1:45 pm	m	-5.42	0.04	2.71
CPI	CPI	57	200101	200511	SBA	3:00 pm	m	-2.04	0.17	2.04
US economic news										
E1	Nonfarm Payrolls	180	199101	200512	BLS	2:30 pm	m	-2.94	-0.14	3.67
E2	Unemployment Rate	180	199101	200512	BLS	2:30 pm	m	-2.77	-0.27	2.77
E3	Hourly Earnings	178	199101	200512	BLS	2:30 pm	m	-2.38	0.03	2.85
RS2	Core Retail Sales	179	199101	200512	BC	2:30 pm	m	-3.04	-0.09	2.53
PPI2	Core PPI	180	199101	200512	BLS	2:30 pm	m	-4.87	-0.14	3.25
CPI2	Core CPI	180	199101	200512	BLS	2:30 pm	m	-1.83	0.01	3.66
HS	Housing Starts	175	199101	200507	BC	2:30 pm	m	-3.20	0.16	2.91
DGO	Durable Goods Orders	179	199101	200512	BC	2:30 pm	m	-2.72	0.03	3.94
PI	Personal Income	179	199101	200512	BEA	2:30 pm	m	-3.73	0.14	5.80
BI	Business Inventories	180	199101	200512	BC	2:30 pm	m	-3.83	0.15	2.55
TRD	Trade Balance	180	199101	200512	BEA	2:30 pm	m	-4.12	-0.14	3.42
GDP	GDP advance report	59	199101	200507	BEA	2:30 pm	q	-1.51	0.25	2.14
IJC	Initial Jobless Claims	431	199709	200512	ETA	2:30 pm	w	-3.88	-0.01	4.37
IP1	Industrial Production	180	199101	200512	FRB	3:15 pm	m	-4.01	0.03	3.28
IP2	Capacity Utilization	180	199101	200512	FRB	3:15 pm	m	-1.94	0.11	4.53
CC	Consumer Confidence	178	199107	200512	CB	4:00 pm	m	-2.61	0.06	2.67
ISM	ISM / NAPM	180	199101	200512	ISM	4:00 pm	m	-2.35	-0.02	3.62
NHS	New Home Sales	153	199101	200308	BC	4:00 pm	m	-2.48	0.20	2.25
LI	Leading Indicators	180	199101	200512	CB	4:00 pm	m	-2.64	0.10	3.63
CS	Construction Spending	180	199101	200512	BC	4:00 pm	m	-2.48	0.03	2.53
FI	Factory Orders	180	199101	200512	BC	4:00 pm	m	-3.59	0.07	3.41
IMP	Import Price Index	83	199808	200509	BLS	4:00 pm	m	-3.93	-0.09	1.97
ISS	ISM Services	80	199901	200512	ISM	4:00 pm	m	-1.78	0.19	2.46
FED	FED interest rates	74	199705	200512	FED	8:15 pm	m	-4.34	-0.23	1.10

This table reports the availability of US economic news announcement data that we use in our study. We report the headline figure, its abbreviation (Abbr.), the number of observations in our sample (Obs.), the availability of our sample, the scheduled release time (in Central European Time, CET) and the release cycle: w(eekly), m(onthly), or q(uarterly). The abbreviations for the releasing agency are: Bundesagentur für Arbeit (BAA), Bureau of the Census (BC), Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), Bundesbank (BUB), Conference Board (CB), European Central Bank (ECB), Employment and Training Administration (ETA), Federal Reserve Board (FRB), Federal Open Market Committee (FED), Institute for Supply Chain Management (ISM), NTC Research (NTC), Statistisches Bundesamt (SBA), Zentrum für Europäische Wirtschaftsforschung (ZEW). The three right-most columns report summary statistics for the standardized surprise in the announcements, i.e. announced figure minus market expectation according to median analyst expectations, standardized by the sample standard deviation. The announcement M3 money supply (MSP) consists of German data until 1998 and data for the EURO area from 1999. The EURO area data is released by the ECB.

Table 2: Price impact of US and German economic news

Rank	Ann	GE	US	Coeff	p-value
1.	E3		x	-0.160	0.001
2.	GDP		x	0.155	0.010
3.	ZEW	x		0.104	0.001
4.	CC		x	0.093	0.005
5.	PPI2		x	-0.088	0.001
6.	MSP	x		-0.079	0.000
7.	CPI2		x	-0.077	0.027
8.	TRD		x	0.073	0.000
9.	RS2		x	0.059	0.012
10.	LI		x	0.055	0.002
11.	CS		x	0.052	0.071
12.	-IJC		x	0.044	0.001
13.	IFO	x		0.037	0.043
14.	-BI		x	0.035	0.070
15.	MFO	x		0.033	0.006
16.	IND	x		0.031	0.066

This table contains regression results of the following equation: $R_t = c + \sum_{i=1}^{42} \delta_i \cdot S_{i,t} + \epsilon_t$ where i indicates the type of economic news. R_t denotes the five-minute log return of the DAX futures. $S_{i,t}$ denotes the standardized surprise component of announcement type i in interval t, if there is an announcement in t. Otherwise $S_{i,t}$ is zero. Robust standard errors are estimated with Newey-West heteroscedasticity and autocorrelation consistent covariance. We rank all announcement types by the absolute value of the coefficient estimate $\hat{\delta}_i$. The middle columns indicate whether an announcement regards US or German economic news. To conserve space we only report coefficient estimates for those announcements, that are significantly different from zero with a p-value of less than 0.1.

Table 3: State-dependent price impact of economic news

Rank	Ann	GE	US	Expansion		Recession	
				Coeff	p-value	Coeff	p-value
1.	E3		x	-0.222	0.042	-0.133	0.002
2.	-E2		x	-0.123	0.008	0.087	0.089
3.	ZEW	x		0.088	0.069	0.111	0.006
4.	PPI2		x	-0.122	0.005	-0.061	0.055
5.	TRD		x	0.089	0.000	0.062	0.006
6.	MSP	x		-0.095	0.000	-0.051	0.000
7.	-IJC		x	0.050	0.027	0.044	0.008
8.	GDP		x	0.194	0.044	insignif	
9.	CC		x	insignif		0.118	0.001
10.	CPI2		x	insignif		-0.085	0.000
11.	RS2		x	insignif		0.073	0.002
12.	MFO	x		insignif		0.068	0.001
13.	DGO		x	insignif		0.063	0.069
14.	LI		x	insignif		0.055	0.008
15.	IP1		x	insignif		0.055	0.073
16.	IND	x		insignif		0.051	0.048
17.	FI		x	insignif		0.051	0.074
18.	IFO	x		insignif		0.038	0.081
19.	-BI		x	insignif		0.035	0.069

This table contains regression results of the following equation: $R_t = c + \sum_{i=1}^{42} \delta_i^{exp} \cdot D_t^{exp} \cdot S_{i,t} + \sum_{i=1}^{42} \delta_i^{rec} \cdot D_t^{rec} \cdot S_{i,t} + \epsilon_t$ where i indicates the type of economic news. R_t denotes the five-minute log return of the DAX futures. $S_{i,t}$ denotes the standardized surprise component of announcement type i in interval t, if there is an announcement in t. Otherwise $S_{i,t}$ is zero. D_t^{exp} (D_t^{rec}) is a dummy variable that takes the value one if the economy is in an expansion (a recession) according to the classification rule using the IFO business climate index. Robust standard errors are estimated with Newey-West heteroscedasticity and autocorrelation consistent covariance. The middle columns indicate whether an announcement regards US or German economic news. We rank all announcement types as follows: First by whether the price response coefficient is significant in both sub samples, then by the average of the absolute values of price response coefficients, δ_i^{exp} and δ_i^{rec}. To conserve space we only report coefficient estimates for those announcements, that are significantly different from zero with a p-value of less than 0.1 in at least one subsample.

Table 4: Speed of price adjustment to economic news

Ann	$R_{t-5,t}$	$R_{t,t+5}$	$R_{t+5,t+10}$	$R_{t+10,t+15}$	$R_{t+15,t+20}$	$R_{t+20,t+25}$
German economic news						
ZEW	0.025	0.104**	-0.044*	0.017	-0.012	0.009
MSP	0.005	-0.079**	0.017	0.008	-0.010	-0.007
IFO	-0.005	0.037*	0.017	-0.019	-0.001	0.006
MFO	0.044	0.033**	0.024	-0.002	0.004	0.005
IND	-0.004	0.031	0.007	-0.021	0.000	-0.012
US economic news						
E3	0.013	-0.154**	-0.006	-0.015	-0.001	-0.014
GDP	0.003	0.155*	0.034	0.007	0.022	0.017
CC	0.001	0.094**	0.017	0.017	-0.005	-0.006
PPI2	0.003	-0.088**	-0.006	-0.014	-0.021	-0.014
CPI2	-0.007	-0.077*	-0.014	-0.004	0.000	-0.003
TRD	0.003	0.073**	-0.001	0.000	-0.008	0.004
RS2	-0.011	0.059*	0.000	-0.009	0.007	0.008
LI	-0.007	0.055**	-0.004	-0.010	-0.004	0.008
CS	0.006	0.052	0.046*	-0.007	0.024*	-0.013
-IJC	-0.004	0.0437**	0.005	-0.007	0.013	0.012
-BI	0.001	0.035	0.036	0.010	0.018*	-0.012

This table contains regression results of the following equation: $R_t = c + \sum_{j=-1}^{4} \sum_{i=1}^{42} \delta_i^j \cdot S_{i,t-j} + \epsilon_t$ where i indicates the type of economic news. R_t denotes the five-minute log return of the DAX futures. $S_{i,t}$ denotes the standardized surprise component of announcement type i in interval t, if there is an announcement in t. Otherwise $S_{i,t}$ is zero. Robust standard errors are estimated with Newey-West heteroscedasticity and autocorrelation consistent covariance. We report the impact of economic news surprises on DAX futures log returns in the six five-minute intervals around the news release. The impact in the first five-minute interval preceding the release corresponds to $\hat{\delta_i^{-1}}$ and the impact in the fifth five-minute following the release corresponds to $\hat{\delta_i^4}$. To conserve space we only report coefficient estimates for those announcements that have a significant effect (i.e. p-value of less than 0.1) on $R_{t,t+5}$. A significant impact on any five-minute return is denoted by * (**) if the p-value is less than 0.05 (0.01).

Table 5: Pre-announcement effect on trading activity

Rank	Ann	Obs		-30 to -5	-5 to -4	-4 to -3	-3 to -2	-2 to -1	-1 to 0
German economic news									
insignif	ZEW	44	Mean $\widetilde{V}$	41.9 (1.03)	-6.3 (0.9)	5 (1.07)	-8.9 (0.87)	-10.8 (0.85)	5.8 (1.11)
			Mean $\lvert\widetilde{R}\rvert$	-0.028 (0.9)	-0.01 (0.81)	0.008 (1.26)	-0.003 (0.9)	-0.006 (0.84)	0 (1.03)
			Mean $\widetilde{S}$	-0.08 (0.93)	0.05 (1.09)	-0.05 (0.93)	-0.08 (0.88)	-0.01 (1.01)	0.1 (1.2)
insignif	MSP	94	Mean $\widetilde{V}$	-8.1 (1.01)	-0.1 (0.99)	2.1 (1.02)	3.2 (1.11)	-2.8 (1.03)	-8.7 (0.86)
			Mean $\lvert\widetilde{R}\rvert$	0.036 (1.24)	-0.004 (0.88)	0.002 (1.08)	-0.007 (1.01)	-0.003 (1.03)	-0.003 (0.94)
			Mean $\widetilde{S}$	0 (1.01)	-0.05 (0.95)	0.02 (1)	-0.05 (0.97)	0.01 (1)	0.02 (1.07)
insignif	IFO	86	Mean $\widetilde{V}$	26 (1.05)	-6.9 (0.94)	-7 (0.91)	2.4 (1.11)	-1.8 (1.04)	3.3 (1.08)
			Mean $\lvert\widetilde{R}\rvert$	-0.025 (0.89)	-0.004 (0.88)	0 (0.96)	0 (0.97)	-0.01 (0.88)	-0.003 (0.97)
			Mean $\widetilde{S}$	0.02 (0.97)	-0.09 (0.95)	0.12 (1.09)	0.03 (1.04)	0 (1.05)	0.12 (1.15)
insignif	MFO	105	Mean $\widetilde{V}$	-118.5 (0.93)	-1.3 (1.01)	6.1 (1.25)	1.3 (1.12)	0.7 (1.05)	0.9 (1.01)
			Mean $\lvert\widetilde{R}\rvert$	-0.011 (0.92)	-0.002 (0.89)	0.002 (1.03)	-0.001 (1.01)	0.002 (1.01)	0.006 (1.24)
			Mean $\widetilde{S}$	-0.01 (0.98)	-0.08 (0.93)	0.03 (1.05)	0.03 (1.03)	-0.1 (0.94)	0.05 (1.08)
11.	IND	104	Mean $\widetilde{V}$	13.3 (1)	-3.6 (0.98)	0.8 (1.05)	-0.6 (1.04)	1.8 (1.04)	-2.7 (1.04)
			Mean $\lvert\widetilde{R}\rvert$	-0.009 (0.9)	-0.003 (0.88)	0.008 (1.18)	0.009 (1.23)	-0.001 (1.01)	-0.001 (0.98)
			Mean $\widetilde{S}$	-0.01 (1)	0.05 (1.02)	0.02 (1)	0.08 (1.06)	0.01 (1.04)	0.2* (1.21)
6.	ECB	67	Mean $\widetilde{V}$	89.9 (1.1)	7.6 (1.22)	7.3 (1.21)	0.5 (1)	4.6 (1.16)	3.4 (1.08)
			Mean $\lvert\widetilde{R}\rvert$	-0.02 (0.95)	-0.002 (1.01)	0.005 (1.17)	0.002 (1.12)	0.005 (1.19)	0.041* (2.34)
			Mean $\widetilde{S}$	0.03 (1.04)	-0.06 (0.96)	0.04 (1.05)	0.17* (1.2)	0.12 (1.17)	0.34** (1.39)
US economic news									
1.	E3	161	Mean $\widetilde{V}$	-111.8 (0.84)	0.4 (0.94)	3.6 (1.08)	4.5 (1.12)	7.5** (1.22)	16.1* (1.3)
	E2		Mean $\lvert\widetilde{R}\rvert$	-0.019 (0.83)	0.003 (1.06)	0.004 (1.19)	0.003 (1.28)	0.009** (1.4)	0.037** (2.6)
	E1		Mean $\widetilde{S}$	0 (0.97)	0.05 (1.04)	0.11* (1.1)	0.21** (1.22)	0.34** (1.31)	1.44** (2.41)
5.	GDP	47	Mean $\widetilde{V}$	-40.6 (0.92)	-2.9 (0.98)	-0.7 (1.1)	0.2 (0.98)	0.9 (1.2)	-7.4 (0.74)
			Mean $\lvert\widetilde{R}\rvert$	-0.027 (0.81)	-0.001 (1.08)	-0.005 (0.87)	0.003 (0.96)	0.001 (1.16)	0.004 (1.26)
			Mean $\widetilde{S}$	-0.04 (0.97)	-0.01 (1)	0.08 (1.08)	-0.01 (1.01)	0.18 (1.18)	0.42** (1.42)

Rank	Ann	Obs		-30 to -5	-5 to -4	-4 to -3	-3 to -2	-2 to -1	-1 to 0
9.	CC	149	Mean $\widetilde{V}$	-99.6 (0.96)	-10.7 (0.91)	-13.5 (0.82)	-12.7 (0.86)	-16.6 (0.8)	-12 (0.86)
			Mean $\lvert\widetilde{R}\rvert$	-0.036 (0.89)	-0.003 (0.95)	-0.007 (0.87)	-0.007 (0.85)	-0.01 (0.81)	-0.009 (0.81)
			Mean $\widetilde{S}$	-0.09 (0.91)	0.11 (1.12)	-0.01 (0.98)	0.02 (1.03)	0.08 (1.1)	0.26** (1.21)
2.	PPI2	67	Mean $\widetilde{V}$	13.6 (0.98)	-7.1 (0.75)	-2.1 (0.91)	-4.4 (0.87)	-0.8 (0.99)	1 (1.04)
			Mean $\lvert\widetilde{R}\rvert$	0.006 (1.03)	-0.004 (0.75)	0.001 (0.91)	-0.001 (0.92)	0.001 (1)	0.015** (1.54)
			Mean $\widetilde{S}$	0 (0.99)	0.04 (0.99)	0.06 (1.07)	-0.01 (0.97)	0.13 (1.13)	0.49** (1.54)
3.	CPI2	58	Mean $\widetilde{V}$	-23 (0.97)	-4.8 (0.97)	1.7 (1.06)	-3.2 (0.81)	-2.4 (0.88)	-1.9 (1.02)
			Mean $\lvert\widetilde{R}\rvert$	-0.01 (0.95)	-0.005 (0.92)	-0.003 (0.93)	-0.009 (0.64)	0.001 (1.06)	0.011* (1.63)
			Mean $\widetilde{S}$	-0.1 (0.92)	0 (0.99)	0.01 (1.01)	0.09 (1.07)	0.13 (1.12)	0.45** (1.48)
insignif	TRD	102	Mean $\widetilde{V}$	19.8 (1.11)	-3.3 (0.96)	0.5 (1.04)	-2.4 (0.96)	4 (1.23)	-3.4 (0.82)
			Mean $\lvert\widetilde{R}\rvert$	-0.008 (0.97)	0 (1.02)	0 (1.03)	-0.005 (0.87)	-0.002 (1.03)	-0.003 (0.92)
			Mean $\widetilde{S}$	0.05 (1.04)	-0.02 (0.96)	-0.01 (0.95)	0.03 (1.01)	0.06 (1.07)	0.08 (1.1)
4.	RS2	56	Mean $\widetilde{V}$	-83.9 (0.82)	-6.2 (0.82)	-4.9 (0.82)	-1 (0.89)	-5.5 (0.84)	1.8 (1.1)
			Mean $\lvert\widetilde{R}\rvert$	-0.022 (0.86)	-0.006 (0.87)	0 (1)	-0.012 (0.67)	-0.005 (0.85)	0.002 (1.11)
			Mean $\widetilde{S}$	-0.01 (0.98)	0.01 (1.02)	-0.05 (0.96)	0.07 (1.06)	0.07 (1.09)	0.45** (1.43)
12.	LI	159	Mean $\widetilde{V}$	-15.9 (0.94)	-1.6 (0.94)	-6.2 (0.91)	-11.4 (0.77)	-6.2 (0.82)	-13.4 (0.89)
			Mean $\lvert\widetilde{R}\rvert$	-0.036 (0.83)	-0.006 (0.89)	-0.002 (0.91)	-0.007 (0.75)	-0.009 (0.79)	-0.007 (0.86)
			Mean $\widetilde{S}$	-0.12 (0.92)	-0.06 (0.92)	-0.02 (0.99)	-0.02 (0.98)	0.01 (1.03)	0.13* (1.13)
7.	IJC	269	Mean $\widetilde{V}$	161.9** (1.18)	8.7 (1.22)	2.2 (1.05)	2.8 (1.08)	2.7 (1.07)	2.3 (1.07)
			Mean $\lvert\widetilde{R}\rvert$	0.036** (1.21)	0.002 (1.1)	0.002 (1.17)	0.004* (1.21)	0.004 (1.17)	0.007** (1.29)
			Mean $\widetilde{S}$	0.01 (1)	0.05 (1.04)	0.1* (1.1)	0.13** (1.1)	0.1** (1.08)	0.32** (1.34)
10.	IP1	129	Mean $\widetilde{V}$	123.3 (1.06)	-1.3 (0.94)	0.4 (1.01)	-1 (0.95)	-3.7 (0.86)	-3.3 (0.98)
			Mean $\lvert\widetilde{R}\rvert$	-0.007 (0.99)	-0.003 (0.89)	-0.003 (0.91)	-0.004 (0.8)	-0.004 (0.84)	0.001 (1.08)
			Mean $\widetilde{S}$	-0.03 (0.98)	0.01 (1.04)	-0.1 (0.93)	0.01 (1.01)	-0.05 (0.96)	0.21* (1.27)
8.	DGO	140	Mean $\widetilde{V}$	97.7 (1.07)	-5.3 (0.85)	-0.1 (1.01)	0.8 (0.91)	-3.5 (0.94)	0.4 (1.07)
			Mean $\lvert\widetilde{R}\rvert$	-0.013 (0.91)	0.001 (0.97)	-0.002 (0.98)	-0.001 (0.97)	0 (1.14)	0.004 (1.14)
			Mean $\widetilde{S}$	0.04 (1.05)	0.04 (1.03)	0 (1.03)	0.04 (1.05)	0.04 (1.04)	0.29** (1.29)

For each announcement type and each release of this announcement we calculate abnormal trading volume ($\widetilde{V}$), abnormal volatility defined as absolute log returns ($|\widetilde{R}|$) and abnormal quoted spreads ($\widetilde{S}$). Abnormal values are defined as the value on the announcement day minus the mean value at the same time of day on non-announcement days in the four months around the release day. Mean abnormal values are reported in this table for the 30 minutes before the news release, split into six sub periods. For example, -30 to -5 denotes the period beginning 30:00 minutes before each release and ending just before 5:00 minutes prior to the release. We use * (**) to denote that these means are significantly different from zero with a p-value less than 0.05 (0.01) based on a two sided t-test. Further, we report the mean ratio between the values on announcement days and non-announcement days in parentheses. We exclude all announcement observations that are 'distorted' by the concurrent release (i.e. within an event window between -30 to $+90$ minute relative to the release time) of another announcement. To assure a sufficient number of 'undistorted' observations (Obs.) the ECB announcement's event window only spans a period of -30 to $+44$ minutes relative to its release time. We rank the different types of economic news according to the abnormal spread increase in the last minute prior to their release.

Table 6: Post-announcement effect on trading activity

Rank	Ann	Obs		0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 30	30 to 60	60 to 90
German economic news											
7.	ZEW	44	Mean $\widetilde{V}$	55.4** (1.6)	64.1** (1.76)	35.1** (1.39)	36.5** (1.47)	29.9* (1.43)	363.7** (1.2)	142.6 (1.09)	-4.6 (1.02)
			Mean $\lvert\widetilde{R}\rvert$	0.046** (2.34)	0.007 (1.43)	0.019* (1.66)	0.01 (1.42)	0.007 (1.26)	-0.026 (0.99)	-0.009 (1.02)	-0.032 (0.9)
			Mean $\widetilde{S}$	0.04 (1.11)	-0.06 (0.94)	-0.05 (0.9)	-0.01 (0.98)	0 (1)	0.03 (1.07)	-0.04 (0.94)	-0.01 (0.97)
16.	MSP	94	Mean $\widetilde{V}$	15.8* (1.41)	20.5** (1.53)	22.1** (1.55)	22.2** (1.61)	16.8* (1.43)	163.9* (1.18)	23.4 (1.02)	-12.2 (0.96)
			Mean $\lvert\widetilde{R}\rvert$	0.021** (1.74)	0.012* (1.49)	0.013* (1.44)	0.017** (1.62)	0.015** (1.56)	0.044 (1.2)	-0.014 (0.94)	-0.005 (1)
			Mean $\widetilde{S}$	0.16* (1.19)	0.14* (1.15)	0.11* (1.14)	0.02 (1.04)	0.12* (1.13)	0.02 (1.04)	-0.04 (0.97)	-0.02 (1)
10.	IFO	86	Mean $\widetilde{V}$	31.7** (1.44)	20.9** (1.3)	17.8** (1.3)	19** (1.34)	18.4** (1.32)	180.7* (1.12)	124.1* (1.07)	137.1 (1.07)
			Mean $\lvert\widetilde{R}\rvert$	0.044** (1.7)	0.027** (1.63)	0.025* (1.51)	0.02** (1.49)	0.017* (1.4)	0.005 (1.05)	-0.003 (1)	0.043 (1.15)
			Mean $\widetilde{S}$	-0.03 (0.98)	0.11 (1.12)	-0.06 (0.95)	-0.03 (0.98)	0.12 (1.14)	0.03 (0.97)	0.03 (1.03)	0.13 (1.11)
14.	MFO	105	Mean $\widetilde{V}$	18.8** (1.32)	5.9 (1.1)	9.9* (1.17)	6.4 (1.14)	-0.2 (1.03)	72.3 (1.09)	11.2 (1.02)	-83.1 (0.94)
			Mean $\lvert\widetilde{R}\rvert$	0.023** (1.53)	0.005 (1.21)	0.013** (1.26)	0.001 (1.06)	0.008* (1.24)	0.025 (1.1)	-0.001 (0.96)	-0.02 (0.86)
			Mean $\widetilde{S}$	0.06 (1.05)	0.05 (1.04)	-0.04 (0.93)	0 (1.04)	0.03 (1.02)	0 (0.99)	0.02 (1.02)	0.02 (1.06)
15.	IND	104	Mean $\widetilde{V}$	16.7** (1.31)	9.9* (1.22)	2.2 (1.1)	6.2 (1.17)	-4.4 (0.93)	-69 (0.95)	98.2 (1.1)	-78.2 (0.93)
			Mean $\lvert\widetilde{R}\rvert$	0.027** (1.56)	0.015* (1.25)	0.01* (1.2)	0.005 (1.12)	0.003 (1)	-0.006 (1.01)	0.034 (1.18)	-0.021 (0.91)
			Mean $\widetilde{S}$	-0.01 (0.99)	-0.06 (0.95)	0.06 (1.04)	-0.02 (1.01)	-0.04 (0.96)	-0.02 (1)	-0.05 (0.97)	-0.01 (1.02)
13.	ECB	67	Mean $\widetilde{V}$	24.5** (1.64)	40.4** (2.09)	34.6** (1.94)	31.7** (1.9)	22** (1.63)	461** (1.44)	na	na
			Mean $\lvert\widetilde{R}\rvert$	0.095** (3.51)	0.04** (2.38)	0.033** (2.16)	0.029* (1.75)	0.017** (1.74)	0.045 (1.31)	na	na
			Mean $\widetilde{S}$	0.42** (1.45)	0.26** (1.26)	-0.02 (1)	0.09 (1.07)	0.08 (1.06)	0.05 (1.04)	na	na
US economic news											
2.	E3	161	Mean $\widetilde{V}$	97** (3.67)	70** (2.75)	71.7** (2.84)	70** (2.81)	61.4** (2.46)	1090.5** (2.02)	574.3** (1.45)	356.2** (1.15)
	E2		Mean $\lvert\widetilde{R}\rvert$	0.204** (6.83)	0.073** (3.45)	0.063** (3.04)	0.05** (2.72)	0.055** (2.8)	0.125** (1.93)	0.049** (1.43)	0.065** (1.3)
	E1		Mean $\widetilde{S}$	0.71** (1.68)	0.41** (1.4)	0.29** (1.28)	0.32** (1.32)	0.22** (1.21)	0.23** (1.23)	-0.04 (0.98)	0.01 (1.03)
4.	GDP	47	Mean $\widetilde{V}$	70.1** (2.93)	48.6** (2.19)	45** (2.26)	58.2** (2.65)	36.6** (2.16)	573.9** (1.68)	310.5** (1.28)	92.5 (1.07)
			Mean $\lvert\widetilde{R}\rvert$	0.163** (5.23)	0.048** (2.7)	0.039** (2.36)	0.021* (1.76)	0.027** (1.96)	0.049 (1.29)	0.033 (1.24)	0.01 (1.07)
			Mean $\widetilde{S}$	0.67* (1.62)	0.35 (1.45)	0.21 (1.14)	0.14 (1.08)	-0.04 (0.99)	0.17 (1.12)	-0.01 (0.99)	-0.01 (0.94)
11.	CC	149	Mean $\widetilde{V}$	30.7** (1.37)	19** (1.2)	14.3** (1.13)	15.2** (1.16)	13.3** (1.12)	200.7** (1.08)	150.1** (1.07)	40.3 (1.04)
			Mean $\lvert\widetilde{R}\rvert$	0.088** (2.18)	0.022** (1.35)	0.01 (1.16)	0.016* (1.25)	0.008 (1.08)	0.055 (1.15)	0.024 (1.1)	-0.023 (0.87)
			Mean $\widetilde{S}$	0.11 (1.08)	0.05 (1.06)	0.03 (1.04)	0.03 (1.01)	0 (0.99)	0.03 (1.03)	0 (1.01)	-0.03 (0.99)

Rank	Ann	Obs		0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 30	30 to 60	60 to 90
1.	PPI2	67	Mean $\widetilde{V}$	101.5** (4)	66.4** (2.84)	58.2** (2.59)	56.7** (2.68)	42.6** (2.28)	614.2** (1.75)	350.8** (1.38)	319.6** (1.2)
			Mean $\lvert\widetilde{R}\rvert$	0.104** (4.24)	0.032** (2.16)	0.027** (2.15)	0.029** (2.13)	0.015** (1.52)	0.044* (1.32)	0.021 (1.22)	0.028 (1.19)
			Mean $\widetilde{S}$	0.47** (1.58)	0.09 (1.17)	-0.07 (0.91)	0.03 (0.96)	0 (1.03)	0.06 (1.09)	-0.03 (0.98)	-0.04 (0.93)
5.	CPI2	58	Mean $\widetilde{V}$	68.9** (3.35)	56.9** (2.78)	51.4** (2.49)	43.8** (2.14)	38.4** (2.08)	544.4** (1.63)	298.9** (1.22)	362** (1.14)
			Mean $\lvert\widetilde{R}\rvert$	0.073** (3.68)	0.053** (3.45)	0.03** (2.28)	0.019** (1.79)	0.029** (2.05)	0.04 (1.38)	-0.001 (1.16)	0.008 (1.19)
			Mean $\widetilde{S}$	0.22* (1.27)	-0.09 (0.94)	0.21* (1.21)	0.06 (1.05)	0.02 (1.04)	0.06 (1.08)	-0.02 (1.01)	0.04 (1.04)
12.	TRD	102	Mean $\widetilde{V}$	29.6** (1.76)	22.9** (1.55)	20.6** (1.53)	24.4** (1.61)	16.3** (1.59)	260.7** (1.26)	43.2 (1.04)	141.2* (1.05)
			Mean $\lvert\widetilde{R}\rvert$	0.014** (1.59)	0.016** (1.65)	0.01** (1.36)	0.01** (1.39)	0.005 (1.24)	0.008 (1.05)	-0.007 (1.01)	0.009 (1.15)
			Mean $\widetilde{S}$	0.11* (1.11)	0.09 (1.09)	-0.02 (1.01)	-0.03 (0.96)	0.03 (1.04)	-0.03 (0.98)	0 (1.01)	-0.07 (0.95)
3.	RS2	56	Mean $\widetilde{V}$	75.5** (3.03)	40.7** (2.02)	30.8** (1.91)	27.6** (1.64)	21.5** (1.45)	354.9** (1.35)	271.1** (1.29)	211.3** (1.1)
			Mean $\lvert\widetilde{R}\rvert$	0.099** (3.71)	0.026** (1.96)	0.026** (1.99)	0.013* (1.52)	0.014* (1.44)	0.054* (1.33)	0.001 (1.01)	0.042 (1.2)
			Mean $\widetilde{S}$	0.27 (1.33)	0.09 (1.12)	-0.06 (0.98)	-0.03 (1.01)	-0.1 (0.95)	0.04 (1.05)	-0.01 (1.03)	0 (0.99)
insignif	LI	159	Mean $\widetilde{V}$	4 (1.08)	5.4 (1.1)	5.4 (1.05)	2.1 (0.97)	5.2 (1.03)	170.3** (1.06)	67.1 (1.04)	1.7 (1)
			Mean $\lvert\widetilde{R}\rvert$	0.016** (1.18)	0.018** (1.36)	0.002 (1.06)	0.006 (1.13)	0.004 (1.1)	0.041 (1.15)	0.05* (1.15)	-0.023 (0.87)
			Mean $\widetilde{S}$	0.07 (1.05)	-0.04 (0.98)	-0.02 (0.97)	0.02 (1.02)	0.09 (1.08)	-0.01 (0.99)	0.08 (1.07)	-0.03 (0.99)
9.	IJC	269	Mean $\widetilde{V}$	36.6** (1.59)	39.8** (1.84)	30.6** (1.56)	29** (1.56)	22.6** (1.48)	386.8** (1.31)	209** (1.15)	204.7** (1.08)
			Mean $\lvert\widetilde{R}\rvert$	0.043** (2.21)	0.025** (1.77)	0.018** (1.57)	0.016** (1.48)	0.011** (1.39)	0.039** (1.32)	-0.006 (1)	-0.002 (1)
			Mean $\widetilde{S}$	0.14** (1.11)	0.03 (1.03)	0.05 (1.05)	0.01 (1)	0.03 (1.03)	-0.04 (0.98)	-0.04 (1)	-0.04 (0.97)
8.	IP1	129	Mean $\widetilde{V}$	41.4** (2.01)	30.6** (1.8)	23.7** (1.55)	22.3** (1.56)	15.9** (1.51)	252.5** (1.19)	119.1** (1.07)	118* (1.03)
			Mean $\lvert\widetilde{R}\rvert$	0.042** (2.51)	0.017** (1.6)	0.013** (1.46)	0.011** (1.46)	0.009** (1.27)	0.018 (1.08)	-0.02 (0.98)	-0.013 (1.02)
			Mean $\widetilde{S}$	-0.02 (0.98)	-0.02 (0.98)	0.05 (1.06)	0.03 (1.06)	-0.01 (1)	-0.05 (0.97)	-0.03 (0.96)	0 (1)
6.	DGO	140	Mean $\widetilde{V}$	58** (2.5)	40.8** (2.04)	33.3** (2.07)	30.2** (1.72)	24.4** (1.66)	239.1** (1.24)	51.8 (1.03)	44 (1.04)
			Mean $\lvert\widetilde{R}\rvert$	0.074** (3.17)	0.03** (2.25)	0.027** (2.04)	0.019** (1.7)	0.007* (1.3)	0.028 (1.08)	-0.016 (0.88)	0.011 (1.05)
			Mean $\widetilde{S}$	0.11 (1.1)	0.15* (1.18)	0.03 (1.06)	0.05 (1.07)	0.03 (1.01)	0.03 (1.02)	0.08* (1.11)	0.03 (1.01)

For each announcement type and each release of this announcement we calculate abnormal trading volume ($\widetilde{V}$), abnormal volatility defined as absolute log returns ($|\widetilde{R}|$) and abnormal quoted spreads ($\widetilde{S}$). Abnormal values are defined as the value on the announcement day minus the mean value at the same time of day on non-announcement days in the four months around the release day. Mean abnormal values are reported in this table for the 90 minutes following the news release, split into eight sub periods. For example, 5 to 30 denotes the period beginning 5:00 minutes past each release and ending just before 30:00 minutes past the release. We use * (**) to denote that these means are significantly different from zero with a p-value less than 0.05 (0.01) based on a two sided t-test. Further, we report the mean ratio between the values on announcement days and non-announcement days in parentheses. We exclude all announcement observations that are 'distorted' by the concurrent release (i.e. within an event window between −30 to +90 minute relative to the release time) of another

announcement. To assure a sufficient number of 'undistorted' observations (Obs.) the ECB announcement's event window only spans a period of −30 to +44 minute relative to its release time. We rank the different types of economic news according to the trading volume increase in the first minute past their release.

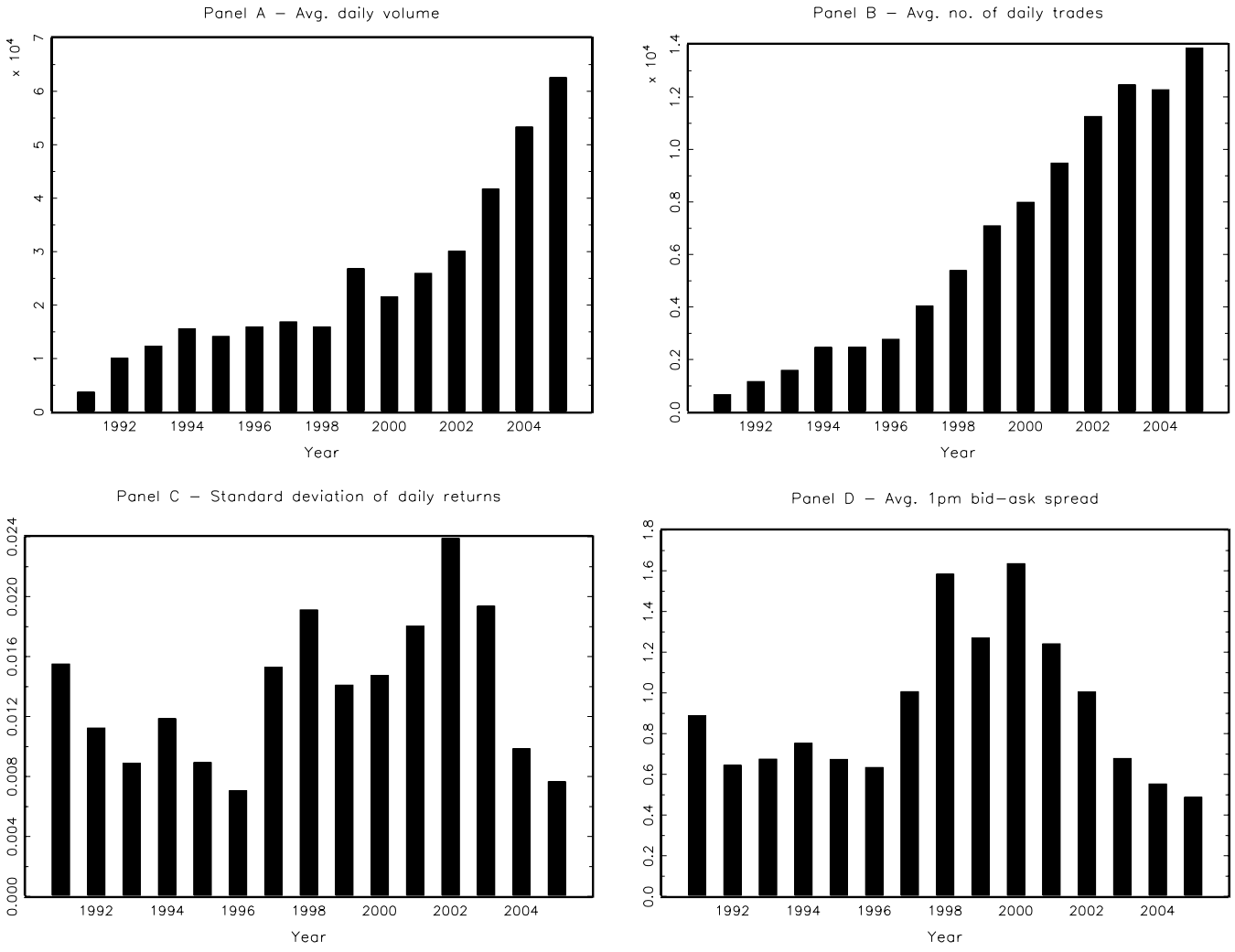
Table 7: Effective spread components around economic announcements

Rank	Ann	Obs (I^{A15})		Coefficient estimates N	B	A15	A30	Difference in coefficients B - N	A15 - B	A30 - A15	A30 - N
German economic news											
7.	ZEW	16024	θ	0.201	0.199	0.244	0.203	-0.002	0.045**	-0.041**	0.003
			ϕ	0.123	0.119	0.091	0.112	-0.004	-0.027**	0.02**	-0.011
			ρ	0.198	0.169	0.201	0.165	-0.029*	0.032*	-0.036**	-0.033*
insignif	MSP	21388	θ	0.246	0.257	0.253	0.249	0.011	-0.004	-0.004	0.003
			ϕ	0.153	0.153	0.156	0.154	0.001	0.003	-0.002	0.001
			ρ	0.177	0.171	0.152	0.152	-0.006	-0.019	0.001	-0.024*
8.	IFO	18512	θ	0.324	0.333	0.375	0.313	0.009	0.042**	-0.063**	-0.011
			ϕ	0.193	0.194	0.185	0.175	0.001	-0.01	-0.01	-0.018
			ρ	0.162	0.141	0.144	0.156	-0.021	0.003	0.012	-0.006
insignif	MFO	21510	θ	0.298	0.290	0.308	0.302	-0.008	0.018	-0.007	0.004
			ϕ	0.176	0.182	0.172	0.175	0.006	-0.011	0.004	0
			ρ	0.161	0.155	0.153	0.161	-0.006	-0.001	0.008	0
insignif	IND	20628	θ	0.298	0.293	0.313	0.306	-0.005	0.021	-0.007	0.008
			ϕ	0.170	0.174	0.172	0.165	0.004	-0.003	-0.006	-0.005
			ρ	0.156	0.149	0.164	0.172	-0.007	0.015	0.008	0.016
1.	ECB	16979	θ	0.263	0.278	0.396	0.306	0.015	0.118**	-0.09**	0.043**
			ϕ	0.145	0.144	0.127	0.130	-0.001	-0.017	0.003	-0.015
			ρ	0.159	0.155	0.177	0.177	-0.005	0.022	0	0.018
US economic news											
10.	E3	24053	θ	0.331	0.336	0.370	0.314	0.005	0.035**	-0.056**	-0.016
	E2		ϕ	0.189	0.190	0.187	0.174	0.002	-0.003	-0.013	-0.015
	E1		ρ	0.162	0.141	0.139	0.157	-0.021*	-0.002	0.018	-0.005
2.	GDP	9650	θ	0.274	0.280	0.375	0.318	0.006	0.095**	-0.057**	0.044*
			ϕ	0.160	0.137	0.192	0.155	-0.023	0.056**	-0.037*	-0.004
			ρ	0.147	0.179	0.128	0.159	0.032	-0.05**	0.03	0.012
3.	CC	38563	θ	0.344	0.323	0.391	0.354	-0.021*	0.068**	-0.036**	0.01
			ϕ	0.157	0.166	0.160	0.161	0.009	-0.006	0.002	0.005
			ρ	0.141	0.137	0.141	0.156	-0.004	0.004	0.015	0.014
insignif	PPI2	14983	θ	0.199	0.251	0.264	0.248	0.052*	0.013	-0.015	0.049**
			ϕ	0.122	0.192	0.187	0.144	0.07**	-0.004	-0.044**	0.022
			ρ	0.200	0.165	0.161	0.173	-0.035	-0.004	0.012	-0.028
4.	CPI2	19660	θ	0.248	0.245	0.312	0.254	-0.003	0.067**	-0.058**	0.007
			ϕ	0.126	0.169	0.165	0.153	0.043**	-0.003	-0.012	0.027**
			ρ	0.164	0.129	0.137	0.142	-0.035*	0.008	0.004	-0.022
insignif	TRD	19607	θ	0.255	0.271	0.258	0.243	0.016	-0.012	-0.015	-0.012
			ϕ	0.149	0.159	0.148	0.134	0.01	-0.011	-0.014	-0.015
			ρ	0.180	0.158	0.168	0.173	-0.022	0.01	0.005	-0.007

Rank	Ann	Obs (I^{A15})		Coefficient estimates N	B	A15	A30	Difference in coefficients B - N	A15 - B	A30 - A15	A30 - N
6.	RS2	11495	θ	0.279	0.292	0.347	0.301	0.013	0.055**	-0.046**	0.022
			ϕ	0.131	0.144	0.169	0.152	0.013	0.026	-0.017	0.021
			ρ	0.159	0.131	0.108	0.138	-0.028	-0.023	0.03*	-0.021
9.	IJC	57886	θ	0.272	0.297	0.334	0.298	0.025**	0.036**	-0.036**	0.026**
			ϕ	0.166	0.181	0.151	0.159	0.015*	-0.03**	0.008	-0.007
			ρ	0.161	0.152	0.169	0.163	-0.009	0.018*	-0.007	0.002
insignif	IP1	29805	θ	0.277	0.266	0.258	0.306	-0.011	-0.008	0.048**	0.029**
			ϕ	0.152	0.158	0.157	0.172	0.007	-0.002	0.015*	0.02**
			ρ	0.152	0.144	0.122	0.124	-0.008	-0.022*	0.002	-0.027**
5.	DGO	25317	θ	0.270	0.241	0.303	0.270	-0.029*	0.062**	-0.033**	0
			ϕ	0.147	0.147	0.147	0.129	0	0	-0.018*	-0.018
			ρ	0.154	0.149	0.134	0.160	-0.005	-0.015	0.026*	0.006

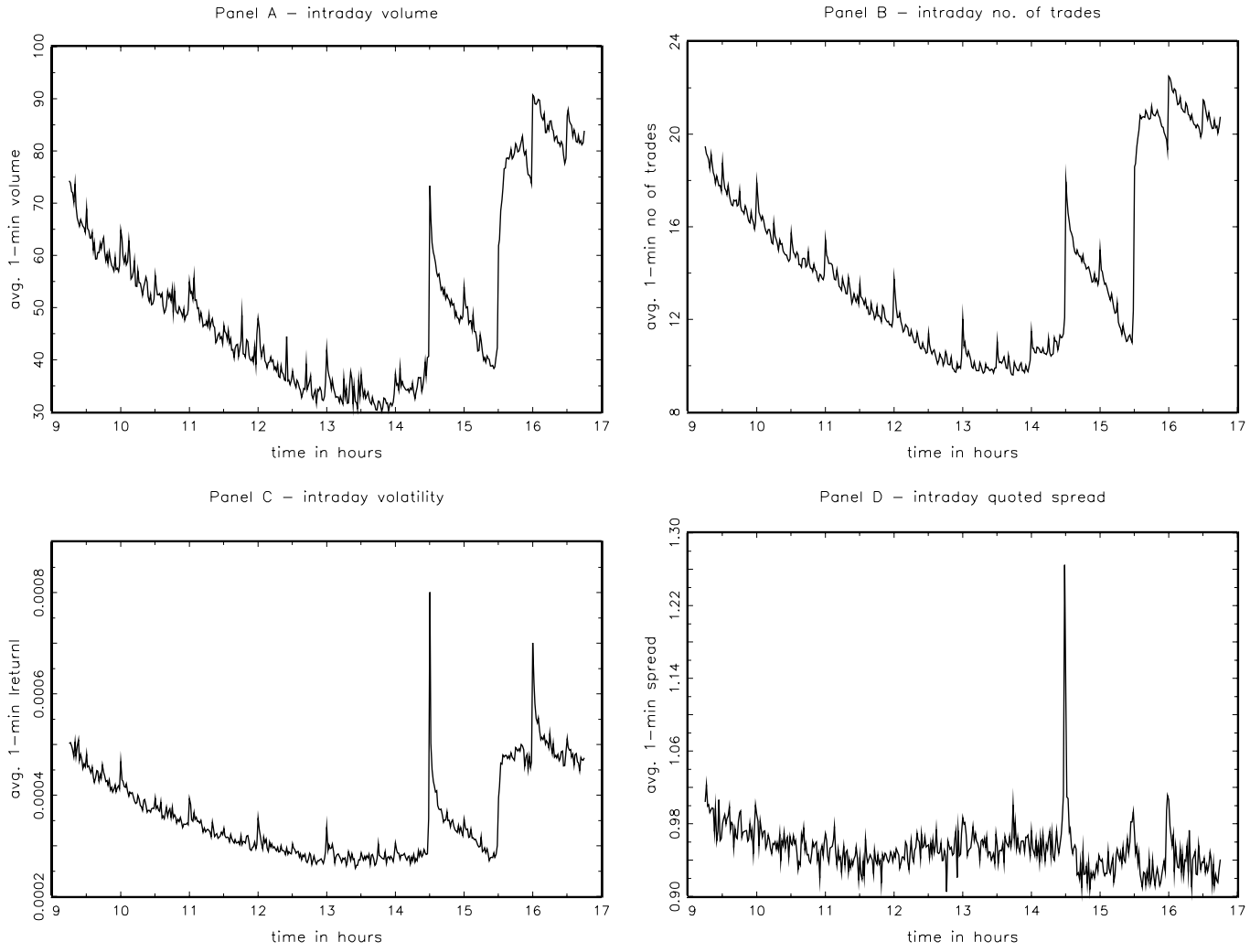
This table reports GMM estimates for the following model: $p_t - p_{t-1} = \sum_{i\in\{N,B,A15,A30\}} \left((\phi^i + \theta^i) I_t^i x_t - (\phi^i + \rho^i\theta^i) I_{t-1}^i x_{t-1}\right) + \epsilon_t$ where i denotes the four sub periods of interest: non-announcement days ($i = N$), the announcement day period before the announcement (B), the minutes 1 to 15 following the announcement ($A15$) and minutes 15 to 30 following an announcement ($A30$). p_t denotes the transaction price at time t, x_t the direction of this transaction (1 if buyer-initiated and -1 if seller-initiated) and I_t^i is an indicator variable that takes the value one if t lies in the sub period i. The coefficients in this model are the costs of inventory control (ϕ^i), costs of information asymmetry (θ^i) and the autocorrelation of order flow (ρ^i). Robust standard errors are estimated with Newey-West heteroscedasticity and autocorrelation consistent covariance. This table reports the coefficient estimates for each of the sub samples in the middle columns. The right columns report differences in the respective coefficient estimates between four sub samples. * (**) denote that the differences are significant with a p-value less than 0.05 (0.01) based on a two-sided Wald coefficient test. The number of observations (Obs.) refers to the number of transactions in the A15 sample, but are roughly equal for all four sub samples. The ranking of different news types is based on the difference between θ^{A15} and θ^B.

Figure 1: Long-tern development of FDAX trading



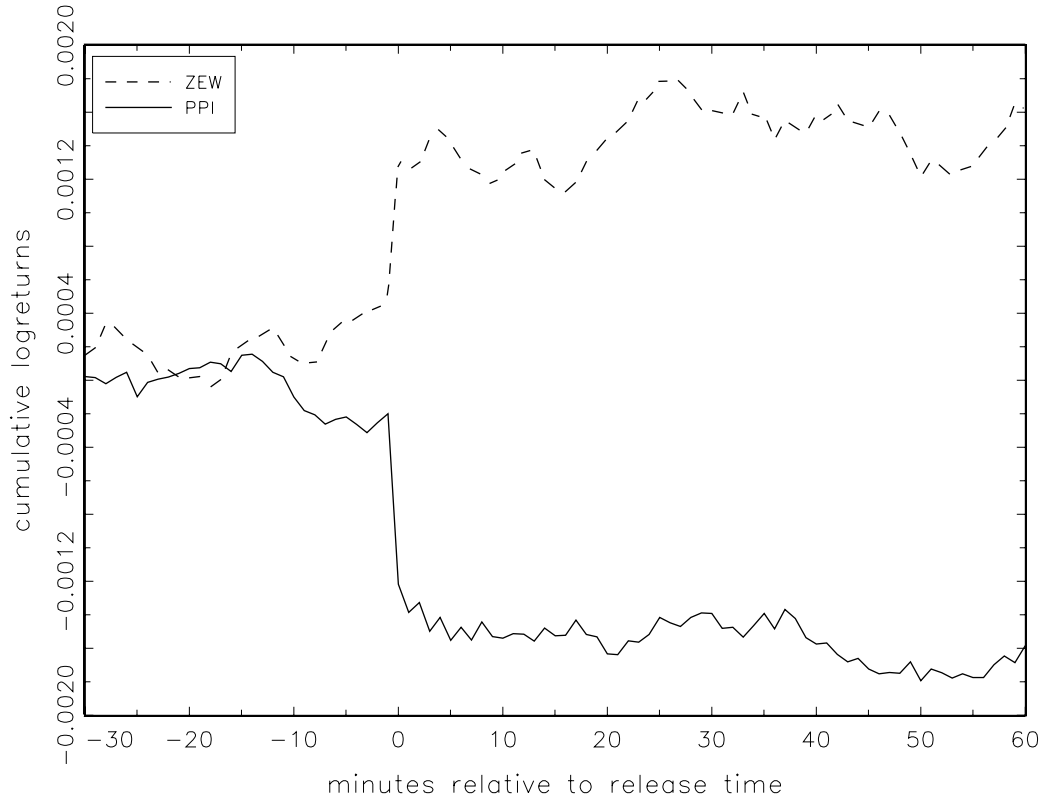
This figure depicts the long-term development of trading activity in DAX futures. For each year of the sample, we plot the average daily trading volume (Panel A), the average no. of daily transactions (Panel B), the standard deviation of daily close-to-close log returns (Panel C) and the average 1 pm bid-ask spread (Panel D).

Figure 2: Intraday trading patterns



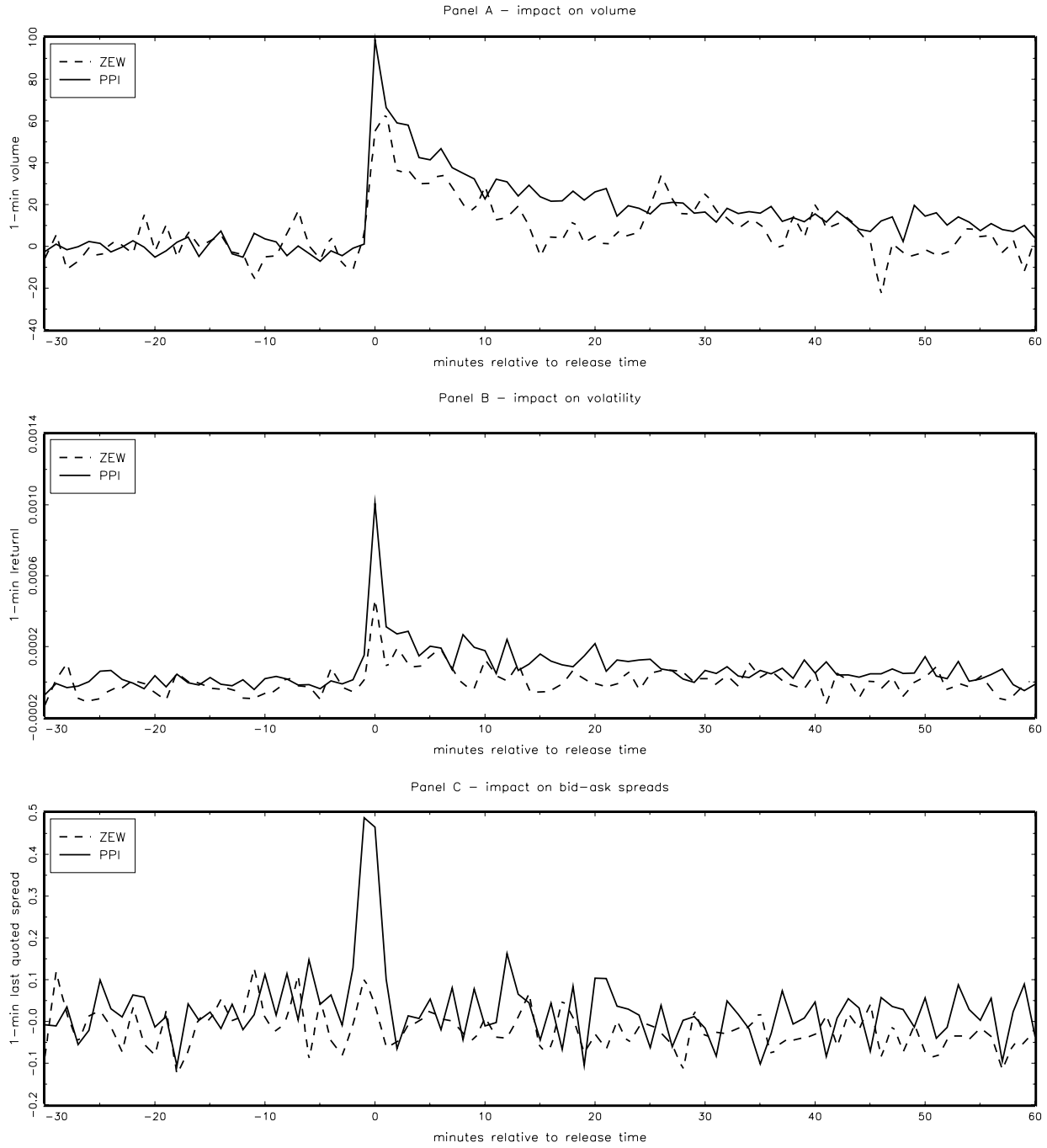
This figure plots the intraday trading activity in DAX futures. Times are given on a 24-hour clock as Central European Time. We plot average one-minute trading volume (Panel A), average one-minute number of trades (Panel B), average absolute one-minute log returns (Panel C) and average bid-ask spreads at the end of each one-minute interval (Panel D). The sample period is May 20, 1995 to December 31, 2005.

Figure 3: Average cumulative returns around economic news



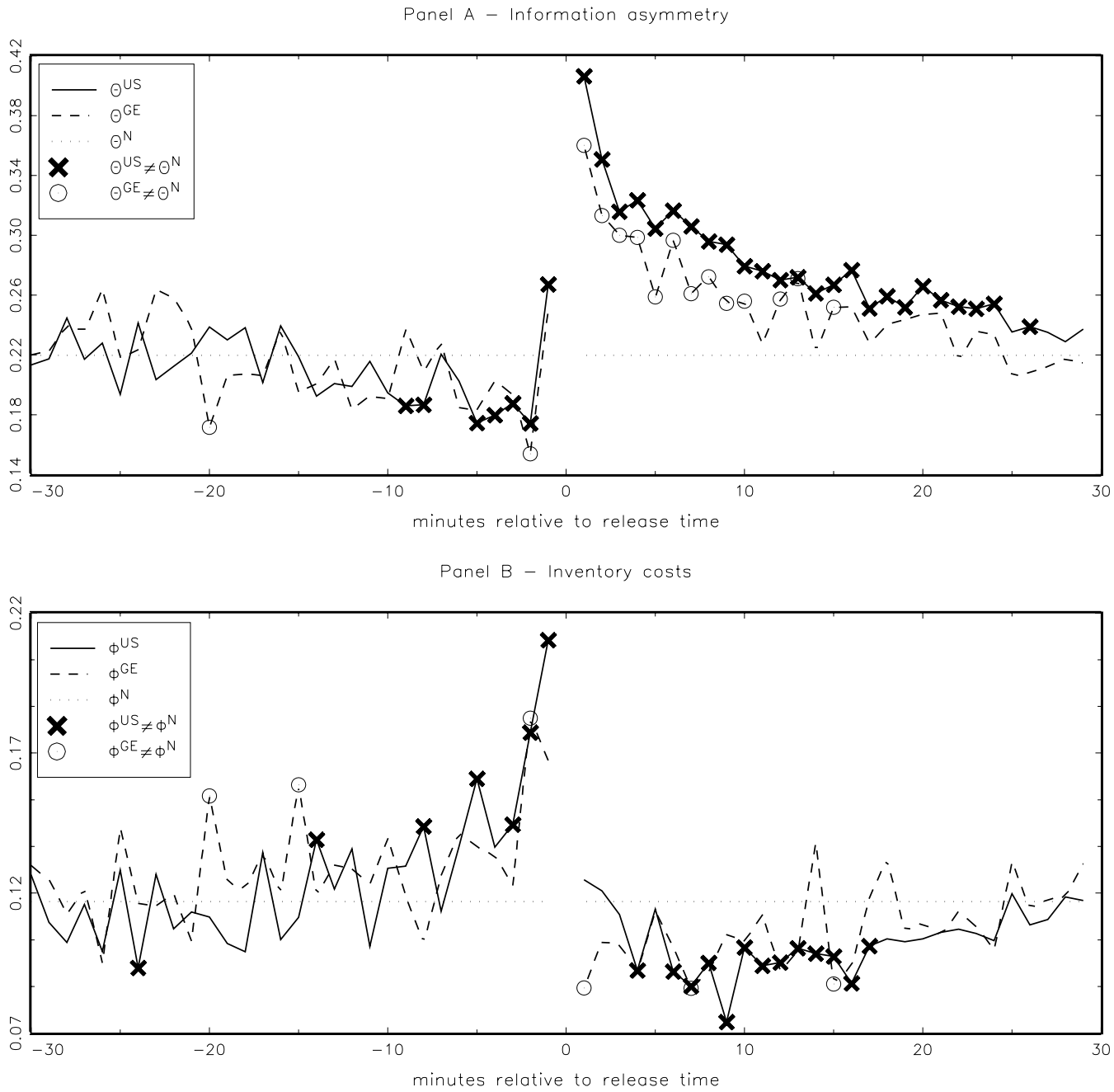
This figure depicts the average cumulative log return of the DAX futures around the release of ZEW and US PPI news. Cumulative returns around negative surprises have been reversed. Times are given relative to the respective release time.

Figure 4: Trading activity around economic news releases



This figure plots abnormal trading activity in DAX futures around the release of ZEW and US PPI news. Abnormal trading activity is defined as the value on announcement days relative to normal, non-announcement day levels. Times are given relative to the respective release time. We plot average one-minute trading volume (Panel A), average absolute one-minute log returns (Panel B) and average bid-ask spreads at the end of each one-minute interval (Panel C).

Figure 5: Effective spread components around economic news releases



This figure plots coefficient estimates for the components of effective spread in DAX futures for each one-minute interval in the 60 minutes around the release of US and German economic news, and for non-announcement days at the same time of day. Times are given relative to the respective release time. A cross or circle denotes that the respective announcement day value is significantly (i.e. p-value < 0.05) different from non-announcement day levels. We plot estimates for information asymmetry costs (Panel A) and inventory control costs (Panel B). The sample covers October 2001 – December 2005.