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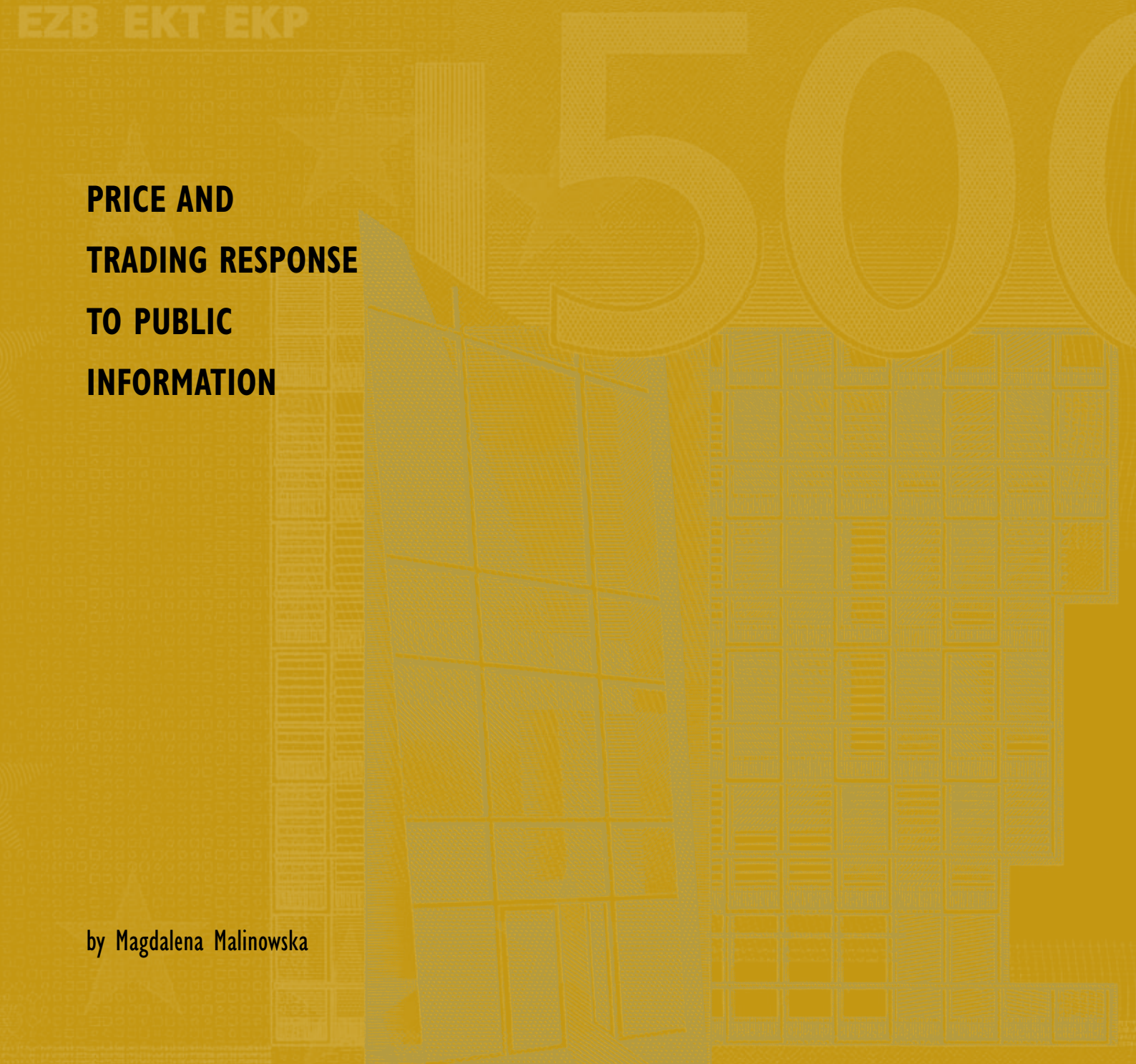

PRICE AND TRADING RESPONSE TO PUBLIC INFORMATION

by Magdalena Malinowska

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Abstract

In their seminal paper French and Roll (1986) postulate that public information affects prices before anyone can trade on it. In contrast, several models assuming heterogeneous investors show that public news releases are directly followed by high trading volume. Empirical evidence on this question is still mixed, primarily due to the lack of sufficiently precise data. This paper examines the process of price adjustment to public news in an electronic limit order market, based on very precise information from the largest European bond futures market. The results show that the price response to public news is gradual and accompanied by trading. Good (bad) news releases are followed by a sequence of positive (negative) returns and a large buying (selling) activity in the first seconds after the news release.

Keywords: information processing; market microstructure; macroeconomic announcements; price adjustment;
JEL classification: E44; G14

Non-technical summary

This paper investigates the process of price adjustment to new public information. In particular, I focus on the role of trading for price discovery. Several theoretical models show that public information releases cause an immediate price adjustment, before anyone trades (e.g., French and Roll (1986)). In contrast, models assuming heterogenous investors show that such price adjustment may be gradual and accompanied by trading (e.g., Kim and Verrecchia (1991a)). Empirical evidence on this issue is mixed, primarily due to the lack of data, which would be sufficiently precise to analyze the trading process occurring immediately after the news release, i.e. within the initial seconds.

Using very precise and long high-frequency data set from one of the largest bond futures markets in the world, this paper investigates price and trading response to public news releases, which occurs directly after the information arrival. Several effects demonstrated here are completed within the first minute, and thus not possible to analyze based on lower frequencies, as in the previous empirical literature (e.g., using GovPX data). I find that price adjustment to new public information is gradual and accompanied by trading. In particular, good (bad) news releases are followed by a sequence of positive (negative) returns and a large buying (selling) activity. Due to the features of the database, these findings are not an artefact of technical factors, such as climbing up the order book or the presence of stale orders. The results rather suggest a gradual order submission with increasing (decreasing) price limits, and thus point to a gradual price discovery.

The results for an electronic limit order market presented here are in line with the empirical evidence in Ederington and Lee (1995), being different from the results for a market-maker market in Fleming and Remolona (1999). This suggests that in the markets without any institutionalized liquidity providers, transactions are more important for the incorporation of new public information into prices than in the market-maker markets.

1 Introduction

The way in which new information is incorporated into prices is one of the most important issues in the market microstructure theory. When all investors receive the same signal, does the market price adjust immediately, before anyone trades? Or do initial transactions move the market price to a new equilibrium? These two contradictory scenarios can be derived from different theoretical models. However, little empirical evidence on this issue has been found so far. This paper analyzes the process of price adjustment to new public information in an electronic limit order market and examines whether this adjustment occurs before or through trading.

The prediction that public information affects prices before anyone can trade on it was first formulated by French and Roll (1986). It is based on the assumption that agents interpret public announcements identically and that everybody receives the information at the same time. Therefore, everyone has the same judgement about the new fair price and nobody is willing to buy above or sell below it. In contrast, several models assuming heterogeneous investors state that public information releases are directly followed by a high trading volume. This may be caused by, for example, the differences in investors' belief revision (e.g., Kim and Verrecchia (1991a, 1991b)) or a sequential information diffusion where investors have different access to the new information (e.g., Copeland (1976) or Fellingham, Jennings, and Starks (1981)).[1] In view of these theories, the question emerging for the empirical analysis is whether a public news release causes an immediate and complete price adjustment or if the process of reaching the new equilibrium price is gradual and involves trading.

Empirical studies include the results supporting each of the two theoretical predictions of the price and trading response to public news. With respect to the bond markets, the most prominent study supporting the theory of French and Roll (1986) is Fleming and Remolona (1999). Using 1-minute U.S. Treasury market data, they find that announcements induce an immediate price change without any increase in the trading volume. This suggests that the price reaction directly after news releases does

[1] The differences in belief revision occur if there is some type of asymmetry among investors, either in their risk aversion or private information. Further models showing that exogenous public information generates trading include Foster and Viswanathan (1993), Kim and Verrecchia (1994), He and Wang (1995) and Kandel and Pearson (1995).

not require trading. A similar finding is reported in Frino and Hill (2001) who show that trading in the Australian futures market increases only after initial 10 seconds following the announcement. The alternative prediction, that prices adjust through trading, is empirically supported by Balduzzi, Elton, and Green (2001) for the bond market and Lee, Mucklow, and Ready (1993) and Kandel and Pearson (1995) for the stock market. However, the frequency used in these papers is not sufficient to exclude the lack of trading within the first seconds after the public news release. Ederington and Lee (1995) use 10-second price data from interest rate and foreign exchange futures markets and show that prices adjust gradually to new public information, which could also suggest the adjustment through trading.

In another strand of literature, the informativeness of the order flow for returns after public news releases is examined. Green (2004) examines the effect of the order flow on intraday bond price changes surrounding U.S. macroeconomic news announcements. Pasquariello and Vega (2007) show theoretically and empirically that bond yield changes are higher correlated with the unanticipated order flow when the dispersion of beliefs across informed traders is high and the public announcement is noisy.[2] However, these studies do not focus on an immediate price and trading reaction in the first seconds after public news releases since they use GovPX data, which are stamped only every minute. Given the very high liquidity of the US Treasury market, the initial reaction to the surprise conveyed by the public news is likely to be completed within the first minute. Therefore, whether the direct price reaction to news occurs without trading or through trades can be stated only based on highly precise data.

Moreover, while all these empirical studies focus on market-maker markets, there is still little evidence on electronic limit order markets, where orders are matched automatically and thus immediately after their submission. This paper closes also this gap by analyzing the process of price adjustment to new public information in a limit order market, using a very long and precisely stamped high-frequency data set. High precision of this data enables to observe the price and trading reaction *immediately* after the news release.

[2] In a related study, Brandt and Kavajecz (2004) find that the order flow accounts for up to 26% of the variation in yields on days without major macroeconomic announcements. For forex markets, Evans and Lyons (2008) investigate the daily order flow and price changes and find that the two-thirds of the macro news' effect on currency prices is transmitted via order flow, the remainder being the direct effect of news. A similar analysis is conducted by Love and Payne (2008).

I use data on the German Bund Future, which is one of the most liquid titles traded electronically at the Eurex, the world's largest futures market. Investigating the periods of exceptionally high information flow, I focus on the releases of the U.S. Employment Report. This event is found to be one of the most important news releases moving the markets around the world. The further advantage is that it does not overlap with other scheduled announcements. Particularly, analyst forecasts and actual releases for two headline figures (the nonfarm payroll employment and the unemployment rate) are used and therefore unanticipated information flow can be observed.

The results show that the arrival of public information is immediately followed by a *gradual* price adjustment accompanied by an increased trading activity. Even in the initial records after the news release, high trading volume can be systematically observed. Furthermore, good news releases are initially followed by a large buying activity and a sequence of positive returns. Similarly, bad news releases are followed by a large selling activity and a sequence of negative returns. Due to the features of the database, these findings are not an artefact of technical factors, such as climbing up the order book or the presence of stale orders. The results rather suggest a gradual order submission with increasing (decreasing) price limits, and thus point to a gradual price discovery. Overall, after the first 30 seconds, when the price advantage of immediate trading disappears, spreads and volatility start to return to their normal levels, and the volume remains high as investors trade to reconcile individual differences of opinion. Comparing the results with the literature, the observation of a significant gradual price response *along with* an increase in the trading volume is in line with Ederington and Lee (1995) and Green (2004), being different from the findings reported in Fleming and Remolona (1999). The second stage of adjustment is consistent with the findings reported in the literature. All results are significant and robust for the periods of high and low liquidity.

The remainder of the paper is organized as follows. Section 2 describes the trading data from the European bond futures market as well as the announcement data. Section 3 presents the results regarding the reaction of volatility, volume and bid-ask spreads to public information releases. Section 4 presents the robustness tests. Section 5 concludes.

2 The bond market and public information

This section presents, first, high frequency trading data on the German Bund Future. Second, announcement data on the U.S. Employment Report are described.

2.1 Trading data

I use high frequency data on the German Bund Future which is one of the most liquid titles on the European bond market. The Bund Future is a futures contract on a notional German Government Bond with an annual coupon of 6% and residual maturity of 8.5 to 10 years at contract expiration. It is traded electronically at the Eurex which is now the world's largest futures market. Additionally, this market operates long before the U.S. news arrive so that disturbing opening effects can be excluded. Eurex is organized as a limit order market, where liquidity arises endogenously from the submitted orders of traders. Since the data stem directly from the electronic trading system, they are extremely precise. The sample covers the period from Nov. 1990 to Dec. 2005. During this period 67 contracts were traded, expiring in March, June, September or December.[3] Due to the introduction of the Euro in Jan. 1999, the contract design changed. 37 contracts traded between Nov. 1990 and Dec. 1999 are denominated in DM (1 contract = 250 000 DM) and 30 contracts traded between Jan. 1999 and Dec. 2005 are denominated in EUR (1 contract = 100 000 EUR).[4] I focus on the most actively traded contract on a given day.[5]

I exclude the first years of data, i.e. until the end of 1993, when the title was not yet established and thus trading activity was quite low. In addition, a few days with obvious technical problems in the data recording system are excluded. However, no announcement day is affected by this adjustment.[6] I divide the sample into two periods, i.e. 1994-1998 and 1999-2005. The first reason is the mentioned change of the contract

[3] The contracts expire between the 6. and 8. calendar day.

[4] I standardize the trading volume, which is measured in the quantities of contracts, in order to be able to compare 1 standardized DM-contract with 1 EUR-contract. I multiply all quantity records in the Bund data sets with $e_{DM/Eur}/2.5$ where the official exchange rate $e_{DM/Eur} = 1.95583$ DM/Eur.

[5] There are about 62 days for each contract on which it was the most actively traded. The contracts usually cease to be traded intensively about 3-4 trading days before the expiration date.

[6] The trading days with the following problems were excluded: the closing time was before 15:30 CET (5 days), the opening time was after 9:00 CET (1 day), or there was an interruption in the data set entries due to technical problems which was longer than 20 minutes and took place between 9:00 and 17:00 CET (4 days).

design and currency.[7] The second reason is a substantial increase of the EUREX market share in the Bund futures trade until the end of 1998.[8] Therefore, liquidity is in general much larger in the second period. I focus on the time window of 9:00 to 17:00 CET excluding the opening and closing phases that could be affected by the uncontollable information flow overnight and by the prolongation of the trading time.[9]

Table 1: Trading and liquidity in the sample period

Year	Trading volume per minute	Number of trades per minute	Trading volume per trade	Average spread	Volatility per hour
1994	87.3	4.0	20.6	1.73	1.86
1995	78.9	3.6	20.2	1.33	0.87
1996	102.3	4.0	23.5	1.21	0.88
1997	185.4	5.6	31.0	1.07	0.75
1998	456.1	9.2	47.2	0.93	0.75
1999	660.7	13.3	45.6	0.93	1.25
2000	714.4	11.5	58.5	0.96	0.84
2001	865.2	11.1	72.0	0.93	0.71
2002	893.2	12.0	67.8	0.93	0.77
2003	1053.0	15.1	64.0	0.88	1.02
2004	1045.4	12.6	73.9	0.87	0.57
2005	1341.6	17.0	71.9	0.82	0.59

NOTE: The table reports descriptive statistics for the sample from Jan. 1st, 1994 to Dec. 30th, 2005. The columns present the average trading volume per minute, (measured in the number of contracts), the average number of trades per minute, the average volume per trade (measured in the number of contracts), the average spread (multiplied by 10^4) and the average hourly volatility computed as the sum of squared returns. All results are computed for the most actively traded contracts during the time window between 9:00 and 17:00 CET.

The data set includes exactly time-stamped and precise information about the best bid, best ask and last traded prices and quantities stemming directly from the electronic order matching system. I use this information to compute returns, the trading volume and bid-ask spreads for various intraday time intervals.[10] Additionally, I compute the

[7] Although I adjust all quantity records before 1999 to account for the change in currency and the contract value, there might be other effects that are not corrected by this adjustment. For example, the number of investors could increase due to the fact that the title started to be denominated in the Euro zone currency.

[8] Bund futures was traded at the DTB (Deutsche Terminbörse, renamed EUREX after a merge with SOFFEX in 1998) and the LIFFE (London International Financial Futures Exchange) until the end of 1998. The market share of the DTB went up dramatically in 1997 and 1998 and exceeded 99.95 percent in the last quarter of 1998. Franke and Hess (2000) report that presumably one reason for this increase was the remote cross border access of traders which has been promoted by the DTB since 1996. Another reason was the broader DM futures portfolio of the EUREX which allowed for more sophisticated EURO convergence trading strategies.

[9] The opening hours of the EUREX have changed twice in the sample period: firstly on 01.08.1997 from 8:00-17:30 to 8:00-19:00 CET and secondly on 21.11.2005 to 8:00-22:00 CET.

[10] The best bid (ask) price is the current best offer to sell (buy) a contract. As in Fleming and Remolona (1999), the spread is defined as the mean proportional spread. I compute the trade size using the information on the last traded quantity. Note that the information on prices and the number of traded contracts is available for every record. This feature of the data set enables to analyze the trading process during the periods of high information flow in detail. Fleming and Remolona (1999), Fleming

volume of buys and sells as the sum of trades resulting from orders signed as buyer- and seller-initiated.[11] Table 1 presents summary statistics of the trading activity. A large increase in the number of traded and offered contracts, the number of trades per minute as well as the average trade size can be observed. This trend is accompanied by a decrease in spreads suggesting higher liquidity in the later years of the sample. I detrend the trading volume and spreads dividing them by their average contract values.[12] Since no particular trend in volatility is observed, I leave this variable unadjusted. I conduct the analysis of price and trading response to public information releases using 5-minute and 1-minute intervals in order to compare the results with those in Fleming and Remolona (1999). Moreover, I consider 30-second and 10-second intervals. This allows for a much more exact description of the price adjustment process and the trading reaction.

2.2 Public information

I use data on the U.S. nonfarm payroll employment and the unemployment rate published in the Employment Report. The announcements provide signals about the employment situation obtained from two independent surveys. The Employment Report is released by the Bureau of Labor Statistics on the first Friday of every month at 08:30 EST.[13] Based on a very large sample, it conveys important information about the U.S. business cycle situation very early. Therefore, it strongly influences both the U.S. market

(2001) and Green (2004) use a similar data set provided by GovPX, Inc. that describes the interdealer broker activity in the U.S. Treasury market-maker market. However, their data is stamped every minute.

[11] I use the Lee and Ready (1991) algorithm to sign trades. I leave the trades unsigned if the prices and quotes in the current or previous record are subject to obvious recording problems, e.g. the best bid price is higher than the best ask price. Therefore, the volume of signed trades is lower than the overall trading volume.

[12] For example, I divide the volume observed in Aug 2003 by the average volume for the same contract (in this case expiring in Sep 2003) so that: $StandardizedVol_{t,c} = \frac{Vol_{t,c}}{AvrVol_c}$ where $Vol_{t,c}$ is the trading volume in e.g. 1-minute interval t in contract c and $AvrVol_c$ is the average 1-minute trading volume for a given contract. The volume of buys and sells is standardized with $0.5*AvrVol_c$. In this way, I receive the standardized variables which are comparable across years. I also considered other standardization methods like for example standardizing with the average value for all Fridays in the contract, the average in every 30-minute interval, the average in every 1-minute interval. All results are robust to other standardization methods.

[13] The report includes also information on average hourly earnings and average workweek. However, these headlines are far less important than the nonfarm payroll employment and the unemployment rate. There are 5 cases when the employment report was released on Thursday. I exclude these observations from the sample to avoid day-of-week effects. 08:30 EST corresponds in most cases to 14:30 CET and on some days to 13:30 CET or 15:30 CET, dependent on the summer time periods in both time zones. I consider only observations at 14:30 CET to avoid the effects of intraday patterns of the trading volume and spreads. However, only 4 announcement days are excluded due to this correction. However, there is no difference in the results when including these days.

and the markets abroad. For example, Andersson, Overby, and Sebestyén (2009) and Ehrmann and Fratzscher (2003) show its significant impact on the German government bond futures prices and the market interest rates. Moreover, this release rarely coincides with other scheduled U.S. news. Overlapping events are eliminated from the sample. Therefore, the observed market reaction should be solely due to the information conveyed by this report.[14] Additionally, the release time is very precise and information leakages are rather implausible.[15]

To compute the unanticipated information, I compare the actual releases with the investor forecasts (available from Money Market Services and Bloomberg). I use two signals about the employment situation and define days, on which the released news was good, bad or contradictory. The first signal is the surprise in the nonfarm payroll employment (S_{NP}):

$$S_{NP} = A_{NP} - F_{NP},$$

where A_{NP} is the announced number of new nonfarm payrolls and F_{NP} is the median of analysts' forecasts of new nonfarm payrolls (both figures measured in thousands). Good signal for the bond market corresponds to a negative surprise in nonfarm payrolls, $S_{NP} < 0$. Actual employment lower than the median of forecasts ($S_{NP} < 0$) is a signal for a worse than expected business cycle situation. This information should have a positive impact on the bond price. The second signal is the surprise in the unemployment rate (S_{UR}) defined as:

$$S_{UR} = A_{UR} - F_{UR}$$

where A_{UR} is the announced unemployment rate and F_{UR} is the median of analysts' forecasts of the unemployment rate (both figures measured in percentage points). A positive surprise in the unemployment rate, $S_{UR} > 0$, is a good signal for the bond

[14] I exclude all Fridays, on which there was a release of a U.S. announcement on 08:30 EST, as well as all Fridays when there was a release of a German announcement between 12:30 and 16:30 CET. U.S. announcements released on Fridays at 08:30 EST include: Business Inventories, Consumer Price Index, Durable Goods Orders, Housing Starts, Leading Indicators, Personal Income, Producer Price Index and Retail Sales. German announcements released on Fridays between 12:30 and 16:30 CET include: Consumer Price Index, Import Prices, Industrial Production and Producer Price Index.

[15] See e.g. Fleming and Remolona (1999, p. 1905) for a detailed description of the announcement procedure applied at the Bureau of Labor Statistics.

market. The actual unemployment rate higher than the median of forecasts ($S_{UR} > 0$) is a signal for a worse than expected business cycle situation. This information should also have a positive impact on the bond price.

Considering information conveyed by these two signals from the Employment Report, I classify announcements into three groups: good, bad and contradictory. Good news releases mean the cases when the signal about the nonfarm payroll employment was good ($S_{NP} < 0$) and the signal about the unemployment rate was good or neutral ($S_{UR} \geq 0$). Bad news releases are defined as $S_{NP} > 0$ and $S_{UR} \leq 0$. News releases are classified as contradictory when $S_{NP} < 0$ and $S_{UR} < 0$ or $S_{NP} > 0$ and $S_{UR} > 0$. The sample includes 69 announcement Fridays (20 good, 27 contradictory and 22 bad news releases) and 130 nonannouncement Fridays between Apr. 1st, 1999 and Dec. 31st, 2005.

3 Results

This section investigates the process of price formation and liquidity around public news releases. Since the data set is very precise, it is possible to extract information about the exact price response, trading and liquidity observed in the seconds after the event. The analysis is first conducted for the intraday frequencies of 5- and 1-minutes as well as 30- and 10-seconds. In the further part of the section, tick-by-tick price and volume response is investigated.

In the first step, I compare standard deviations of log midquote returns, the average trading volume and bid-ask spreads for announcement and nonannouncement days. Tables 2 and 3 and Figures 1 and 2 present the results of the descriptive analysis for different time intervals. Robust statistics are calculated by using winsorising as described in Dixon (1960), Tukey (1962) or Huber (1981). The results for 5-minute intervals are very similar to the previous studies for the bond market (e.g. Fleming and Remolona (1999) and Balduzzi, Elton, and Green (2001)). I find that log return standard deviation increases in the last 5 minutes before the event, peaks in the first minutes after the news release and remains significantly higher than on nonannouncement days afterwards.[16] Spreads depict a similar pattern but return

[16] The volatility pattern observed here is in line with the results of other empirical studies on price formation and volatility around announcements (e.g. Andersen and Bollerslev (1998), Andersen, Bollerslev, Diebold, and Vega (2003, 2006) or Hautsch and Hess (2002, 2007).)

to the level comparable with nonannouncement days faster than volatility. Turning to the trading activity, the volume increases already in the first 5 minutes after the announcement and remains significantly higher than on nonannouncement days during around one hour afterwards.[17] The results for 1-minute intervals reveal a similar pattern: volatility and spreads are significantly higher than on nonannouncemnnet days already around 3 minutes before the event, peak immediately after the news release and remain quite high in the following minutes.

The most important finding at this stage is that the trading volume is very high and significantly different from its usual value already in the first minute after the event. The observation of a significant price response *along with* an increase in the trading volume is in line with Ederington and Lee (1995), being different from the findings for a market-maker market reported in Fleming and Remolona (1999).[18] To verify the results, I analyze the price and trading response for 30-second and 10-second intervals (Table 3 and Figure 2), and find that the trading volume increases substantially already in the first ten seconds following the event. At this stage, I conclude that public news releases are followed by a significant price response combined with a very high trading volume and high spreads.

[17] The results for the later time intervals are not reported in the table but they are available from the author. The average trading volume on nonannouncement days is significantly above 1 after 08:30 EST. This pattern may be due to the fact that the trading of several interest rate products at the CBOT starts shortly before this time. I accounted for 26 most important U.S. announcements and eliminated those 8 released on Fridays at 8:30 EST and I accounted for 23 most important German announcements and eliminated those 4 released on Fridays between 12:30 and 16:30 CET. However, several other news are released at this time which are usually not perceived as very important by market participants. Nevertheless, in some seldom cases when they are particularly surprising, they can cause increased trading.

[18] Note that the structure of the market analyzed in this paper (an electronic limit order market) differs from the market analyzed in Fleming and Remolona (1999) (a multiple-dealer over-the-counter market). However, there is a certain similarity in the structure of both markets. In price driven markets, the quotes of market makers are binding until and unless they are withdrawn, similarly as unexecuted limit orders offered at the best quotes in the limit order market. A further difference between these two studies is that I use only one macroeconomic announcement which does not coincide with other scheduled news releases. Fleming and Remolona (1999) analyze, however, the whole set of macroannouncements.

Table 2: Dynamics of volatility, trading volume and spread around announcements

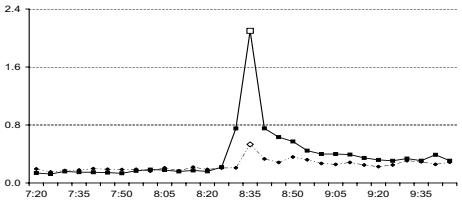
Panel A: Five-Minute Intervals										
	08:10	08:15	08:20	08:25	08:30	**08:35**	08:40	08:45	08:50	08:55
	Price Volatility									
Ann. Fr.	0.159	0.173	0.160	0.218	0.753	2.099	0.754	0.632	0.573	0.447
Nonann. Fr.	0.168	0.218	0.187	0.207	0.209	0.532	0.332	0.283	0.359	0.320
St. Dev. Ratio	0.946	0.792	0.853	1.054	3.598	3.944	2.267	2.234	1.597	1.394
F-ratio p-value	0.830	0.723	0.529	0.424	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Ann. Fr.	0.571	0.640	0.670	0.876	0.865	2.894	3.142	2.896	2.534	2.306
Nonann. Fr.	0.566	0.589	0.611	0.785	0.793	1.337	1.347	1.242	1.246	1.226
Diff. in Means	0.005	0.051	0.059	0.092	0.072	1.558	1.795	1.654	1.289	1.080
t-stat p-value	0.456	0.121	0.110	0.030	0.055	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Ann. Fr.	0.999	1.001	1.006	1.012	1.081	1.249	1.019	1.009	1.006	1.005
Nonann. Fr.	0.997	0.996	0.995	0.996	0.997	1.001	0.996	0.994	0.997	0.996
Diff. in Means	0.003	0.005	0.011	0.016	0.084	0.247	0.023	0.014	0.009	0.010
t-stat p-value	0.157	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Panel B: One-Minute Intervals										
	08:26	08:27	08:28	08:29	08:30	**08:31**	08:32	08:33	08:34	08:35
	Price Volatility									
Ann. Fr.	0.111	0.111	0.119	0.180	0.783	1.959	0.632	0.480	0.426	0.346
Nonann. Fr.	0.095	0.095	0.085	0.101	0.139	0.411	0.191	0.166	0.203	0.155
St. Dev. Ratio	1.165	1.169	1.400	1.779	5.646	4.765	3.313	2.893	2.098	2.225
F-ratio p-value	0.071	0.197	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Ann. Fr.	0.911	0.864	0.821	0.843	0.716	2.525	2.738	2.878	2.940	3.183
Nonann. Fr.	0.724	0.813	0.745	0.730	0.723	1.291	1.346	1.308	1.359	1.205
Diff. in Means	0.187	0.052	0.075	0.113	-0.006	1.234	1.392	1.570	1.581	1.978
t-stat p-value	0.003	0.212	0.124	0.031	0.544	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Ann. Fr.	1.005	1.005	1.019	1.034	1.227	1.810	1.133	1.049	1.033	1.021
Nonann. Fr.	0.992	0.993	0.992	0.994	0.995	1.003	0.995	0.994	0.993	0.996
Diff. in Means	0.013	0.012	0.027	0.039	0.233	0.807	0.137	0.055	0.039	0.025
t-stat p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NOTE: Five-minute (Panel A) and one-minute (Panel B) log price change standard deviations, the trading volume means and bid-ask spreads are reported and compared for announcement and nonannouncement Fridays. The time denoting each column means the end of the interval. The reported log price change standard deviation is the actual value times 10^3, the trading volume and the spread are standardized with their average values per contract. The bid-ask spread is the 5-minute (1-minute) robust average of the mean proportional spread weighted with time when each spread value was valid. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

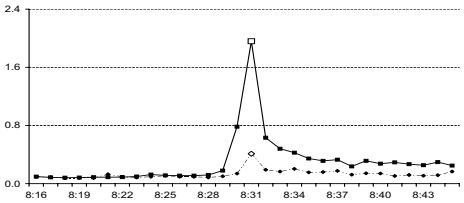
Table 3: Dynamics of volatility, trading volume and spread around announcements

Panel A: Thirty-Second Intervals									
	8:28:30	8:29:00	8:29:30	8:30:00	**8:30:30**	8:31:00	8:31:30	8:32:00	8:32:30
	Price Volatility								
Ann. Fr.	0.089	0.164	0.178	0.761	1.960	0.622	0.480	0.310	0.323
Nonann. Fr.	0.073	0.079	0.083	0.124	0.377	0.155	0.137	0.132	0.105
St. Dev. Ratio	1.221	2.084	2.155	6.155	5.194	4.011	3.495	2.343	3.069
F-ratio p-value	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Ann. Fr.	0.835	0.794	0.724	0.684	2.462	2.296	2.676	2.700	2.744
Nonann. Fr.	0.707	0.730	0.707	0.722	1.197	1.267	1.328	1.283	1.236
Diff. in Means	0.128	0.064	0.018	-0.038	1.265	1.029	1.348	1.417	1.508
t-stat p-value	0.062	0.178	0.390	0.700	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread								
Ann. Fr.	1.016	1.010	1.080	1.299	2.145	1.396	1.159	1.089	1.048
Nonann. Fr.	0.993	0.992	0.992	0.995	0.998	0.998	0.993	0.994	0.993
Diff. in Means	0.023	0.019	0.088	0.305	1.147	0.398	0.165	0.095	0.055
t-stat p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel B: Ten-Second Intervals									
	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
	Price Volatility								
Ann. Fr.	0.078	0.088	0.144	0.705	1.075	0.988	0.672	0.273	0.396
Nonann. Fr.	0.050	0.057	0.054	0.103	0.295	0.193	0.111	0.095	0.080
St. Dev. Ratio	1.552	1.542	2.646	6.846	3.638	5.105	6.081	2.858	4.936
F-ratio p-value	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Ann. Fr.	0.653	0.733	0.455	0.522	2.142	2.039	2.304	1.874	2.047
Nonann. Fr.	0.750	0.670	0.602	0.530	1.103	1.123	1.062	0.964	1.216
Diff. in Means	-0.097	0.063	-0.147	-0.008	1.039	0.915	1.242	0.911	0.832
t-stat p-value	0.859	0.255	0.975	0.539	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread								
Ann. Fr.	1.059	1.105	1.213	1.420	2.329	1.877	1.736	1.436	1.287
Nonann. Fr.	0.992	0.992	0.992	0.994	0.998	0.995	0.996	0.994	0.994
Diff. in Means	0.067	0.112	0.221	0.426	1.331	0.882	0.740	0.442	0.293
t-stat p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

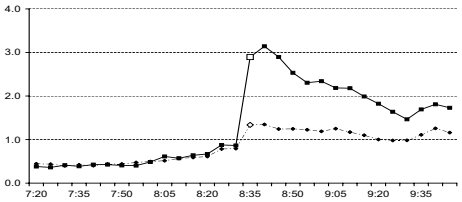
NOTE: Thirty-second (Panel A) and ten-second (Panel B) log price change standard deviations, the trading volume means and bid-ask spreads are reported and compared for announcement and nonannouncement Fridays. The time denoting each column means the end of the interval. The reported log price change standard deviation is the actual value times 10^3, the trading volume and the spread are standardized with their average values per contract. The bid-ask spread is the 30-second (10-second) robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.



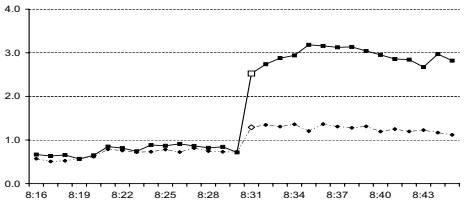
(a) Price Volatility, 5 Min



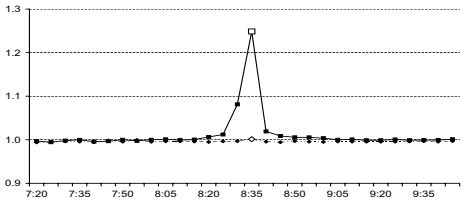
(b) Price Volatility, 1 Min



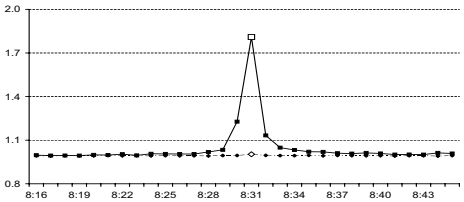
(c) Trading Volume, 5 Min



(d) Trading Volume, 1 Min

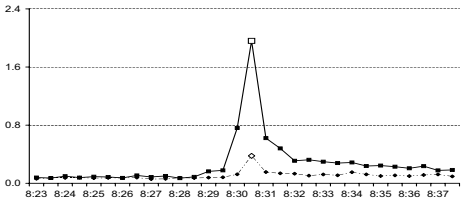


(e) Bid-Ask Spread, 5 Min

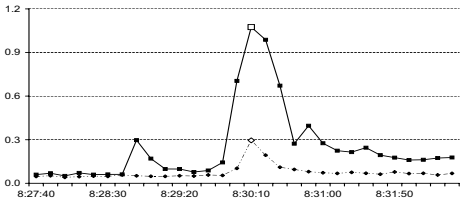


(f) Bid-Ask Spread, 1 Min

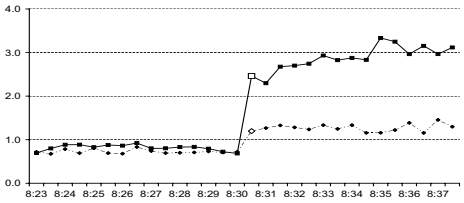
Figure 1: Price and trading dynamics on announcement and nonannouncement days
Intraday patterns around the announcement time (08:30 EST) are plotted by five-minute and one-minute intervals for Fridays with announcements of the U.S. Employment Report (solid line) and Fridays with no announcements (dashed line). The first time interval after the release is marked in the figure with a larger white symbol. Standard deviations of log price changes times 10^3 are reported in subfigures (a) and (b), the robust means of the trading volume (as a ratio of the average contract value) are reported in subfigures (c) and (d) and the robust means of bid-ask spreads (as a ratio of the average contract value) are reported in subfigures (e) and (f). The sample period regarded here: Apr. 1st, 1999 to Dec. 30th, 2005.



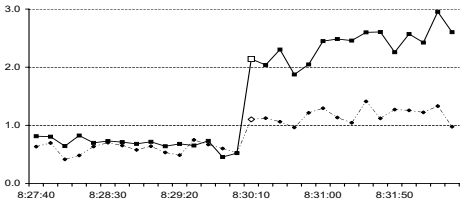
(a) Price Volatility, 30 Sec



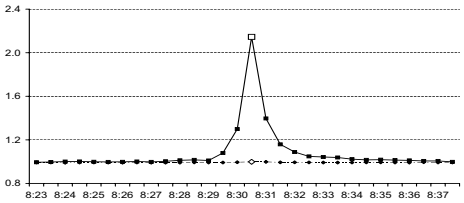
(b) Price Volatility, 10 Sec



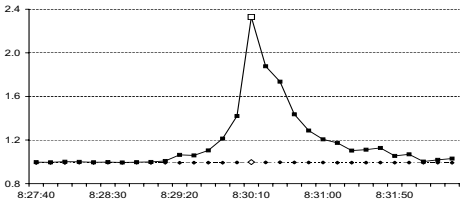
(c) Trading Volume, 30 Sec



(d) Trading Volume, 10 Sec



(e) Bid-Ask Spread, 30 Sec



(f) Bid-Ask Spread, 10 Sec

Figure 2: Price and trading dynamics on announcement and nonannouncement days

Intraday patterns around the announcement time (08:30 EST) are plotted by thirty-second and ten-second intervals for Fridays with announcements of the U.S. Employment Report (solid line) and Fridays with no announcements (dashed line). The first time interval after the release is marked in the figure with a larger white symbol. Standard deviations of log price changes times 10^3 are reported in subfigures (a) and (b), the robust means of the trading volume (as a ratio of the average contract value) are reported in subfigures (c) and (d) and the robust means of bid-ask spreads (as a ratio of the average contract value) are reported in subfigures (e) and (f). The sample period regarded here: Apr. 1st, 1999 to Dec. 30th, 2005.

To test whether at least part of the price adjustment occurs *through* trading, I analyze the volume of buys and sells as well as average returns in the seconds around the event. If at least part of the price adjustment occurs gradually, and is pushed by the trades, I should observe *a sequence of* abnormal positive (negative) returns and large net buying (selling) activity after good (bad) news. Table 4 presents the comparison of the average volume of buys and sells for days with good and bad announcements for 10-second intervals. Moreover, average returns and their significance compared to zero-returns are presented. I find that good news are initially followed by a high buying activity (the trading volume of buys is around seven times higher as the volume of sells). In addition, a sequence of statistically significant positive returns can be observed. Similarly, bad news are followed by an excessive selling activity, but the price adjustment seems to be completed already within the first 10 seconds.

Table 4: Transaction imbalance and average returns around announcements

Ten-Second Intervals									
	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
	Good News								
Vol. Buys	0.721	0.316	0.357	0.099	**4.682**	**4.422**	**3.305**	**2.016**	2.560
Vol. Sells	0.293	0.709	0.212	0.201	0.187	0.945	0.837	1.167	2.030
Diff. in Means	0.428	-0.393	0.145	-0.102	4.495	3.477	2.468	0.849	0.530
t-stat p-value	0.010	0.990	0.091	0.906	0.000	0.002	0.011	0.077	0.226
Avg. Return	-0.057	-0.074	0.114	-0.086	**5.716**	**2.387**	1.018	0.139	0.931
t-stat p-value	0.642	0.834	0.259	0.642	0.000	0.008	0.104	0.416	0.011
	Bad News								
Vol. Buys	0.676	0.578	0.417	0.404	0.297	1.210	1.749	1.693	1.324
Vol. Sells	0.523	0.539	0.344	0.330	**3.173**	**2.082**	1.874	1.346	1.926
Diff. in Means	0.153	0.039	0.073	0.073	-2.877	-0.872	-0.124	0.347	-0.602
t-stat p-value	0.789	0.586	0.731	0.689	0.002	0.094	0.424	0.748	0.126
Avg. Return	0.001	-0.224	0.270	0.264	**-6.061**	-0.869	1.137	0.531	0.047
t-stat p-value	0.503	0.102	0.940	0.731	0.000	0.150	0.931	0.866	0.571

NOTE: This table reports ten-second mean volumes of buys and sells as well as average returns for good and bad news releases. The reported trading volume is standardized with its average contract value. The reported returns mean average log trading price changes (multiplied by 10^4). I report p-values from the robust t-statistic comparing the means for the volume of buys and the volume of sells assuming unequal variances. The time denoting each column means the end of the interval. For returns, p-values from the robust t-statistic comparing the returns to zero are reported. Good News = news releases with a negative nonfarm payroll surprise ($S_{NP} < 0$) and a positive unemployment rate surprise ($S_{UR} \geq 0$)), and Bad News = news releases with $S_{NP} > 0$ and $S_{UR} \leq 0$. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

As the final step, I analyze the tick-by-tick reaction immediately after the announcement. This allows excluding the possibility that the aggregation at the 10-second interval leads to disregarding of initial tradeless price responses that might still be observed within the first couple of seconds. Table 5 presents the first reactions of returns and trades observed directly after the announcement. Each column reports the robust averages of trading price returns and trading volumes observed in the i-th

record after good and bad news releases. The results show that good news are followed by a sequence of positive returns *along with* a sequence of buying. Bad news are followed by a sequence of sells and negative returns. The first reaction occurs on average after a second, and already includes trading.

Table 5: First reactions to news releases

Initial Records									
	1	2	3	4	5	6	7	8	9
	Returns								
Good Ann.	**1.68**	**2.67**	**0.76**	**2.81**	0.19	**0.88**	-0.53	0.06	-0.08
t-stat p-value	0.00	0.00	0.03	0.00	0.28	0.10	0.94	0.36	0.61
Bad Ann.	**-2.35**	**-0.40**	**-1.80**	**-1.65**	**-0.37**	**-1.20**	0.82	**-0.82**	0.50
t-stat p-value	0.01	0.10	0.01	0.00	0.07	0.00	0.98	0.02	0.99
	Volume of Buys								
Good Ann.	**22.93**	**78.12**	**47.78**	**99.62**	**14.91**	**111.90**	1.54	**10.17**	3.08
Bad Ann.	0.01	0.00	0.00	0.00	0.00	0.00	7.08	0.00	2.66
t-stat p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.01	0.39
	Volume of Sells								
Good Ann.	0.00	0.00	0.00	0.00	1.23	0.00	3.14	1.31	11.02
Bad Ann.	**2.20**	**13.88**	**4.49**	**50.10**	**38.55**	**1.63**	0.00	**29.00**	0.00
t-stat p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	1.00
	Time								
Good Ann.	1.05	4.21	6.52	8.98	11.18	13.53	15.71	18.24	20.65
Bad Ann.	0.95	3.44	5.76	8.12	9.95	12.18	14.37	17.06	19.19

NOTE: This table reports descriptive statistics of the first reactions observed directly after the news release. Each column reports the robust averages observed in the i-th record after the announcement. Panel "Returns" reports the average log trading price changes (multiplied by 10^4) and p-values from the robust t-statistic comparing the returns to zero. Panels "Volume of Buys" and "Volume of Sells" present the average trading volume (in contracts, not standardized). The bottom rows of these panels report p-values from the robust t-statistic comparing the means for the volume of buys (sells) on days with good and bad news, assuming unequal variances. Panel "Time" reports the average time in seconds (from the announcement time), after the i-th record is observed. The definition of good and bad news as above. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

The results for tick-by-tick observations are *not an artefact caused by climbing up (down) the book by one trade*. In case of, e.g., a buy order with a high limit, the database discloses the whole volume of this trade and the highest price paid in the matching process. For the same reason, the observed gradual price adjustment accompanied by the net buying (selling) activity is *not an effect of stale orders*. Even if stale orders are present in the book, an immediate and final price revision would result in one large trade, taking advantage of all stale orders, without being followed by sequential abnormal returns and transactions in one direction.

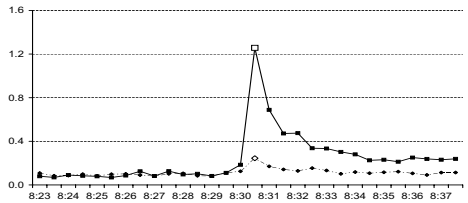
To summarize, the results for an electronic limit order market presented here do not support the theory of French and Roll (1986) and are in this respect in line with the findings reported in Ederington and Lee (1995) and Green (2004), being different from the results for a market-maker market reported in Fleming and Remolona (1999). I find that the price response following public news events occurs gradually and is accompanied

by trading (net buying after good news and net selling after bad news). Increased trading activity can be systematically observed even *directly* after the announcement, i.e. starting with the first record after the news release. The patterns of volatility and spreads are similar to the findings in the previous studies.

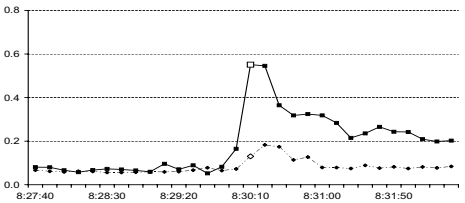
4 Robustness

This section reports robustness tests for the presented results. As mentioned before, the sample period includes the changes in the contract design and currency as well as in the trading hours that occurred at the end of 1998. Moreover, Eurex gained a very strong position as the leading exchange in the Bund futures trade in this period. Due to these effects, the period between 1994 and 1998 is far less liquid than the later part of the sample. I test whether the findings hold for the early subsample.[19] Figure 3 and Table 6 (see also Tables A-1 and A-2 in Appendix) show that the results are very similar. Note that even for the less liquid period, I observe a significant increase in the trading volume already in the first 10 seconds after the event. Moreover, good news are immediately followed by a large buying and bad news by a large selling activity.

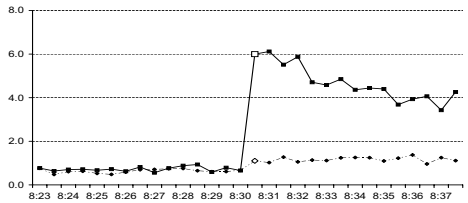
[19] The sample includes 40 announcement Fridays (10 good, 10 contradictory and 20 bad news releases) and 119 nonannouncement Fridays between Jan. 1st, 1994 and Dec. 31st, 1998.



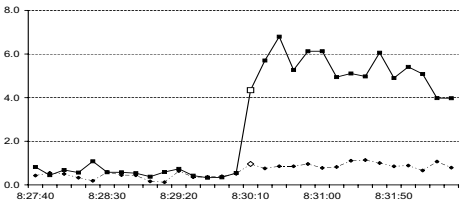
(a) Price Volatility, 30 Sec



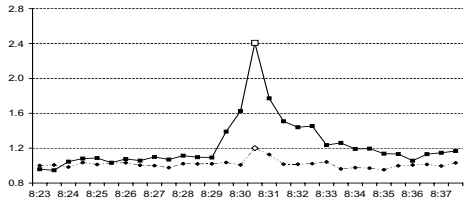
(b) Price Volatility, 10 Sec



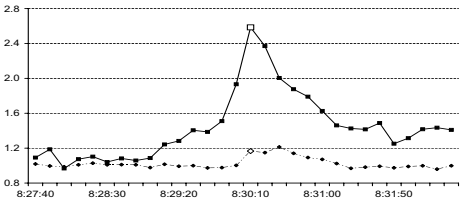
(c) Trading Volume, 30 Sec



(d) Trading Volume, 10 Sec



(e) Bid-Ask Spread, 30 Sec



(f) Bid-Ask Spread, 10 Sec

Figure 3: Price and trading dynamics on announcement and nonannouncement days

Intraday patterns around the announcement time (08:30 EST) are plotted by thirty-second and ten-second intervals for Fridays with announcement of the U.S. Employment Report (solid line) and Fridays with no announcements (dashed line). The first time interval after the release is marked in the figure with a larger white symbol. Standard deviations of log price changes times 10^3 are reported in subfigures (a) and (b), the robust means of the trading volume (as a ratio of the average contract value) are reported in subfigures (c) and (d) and the robust means of bid-ask spreads (as a ratio of the average contract value) are reported in subfigures (e) and (f). The sample period regarded here: Jan. 1st, 1994 to Dec. 30th, 1998.

Furthermore, I test whether the results are robust for different types of news. I split the sample of announcement days into days with good, contradictory and bad news releases. All findings regarding the reaction of prices, the trading volume and bid-ask spreads around information events hold for all three groups of announcements (see Tables A-3 to A-6 in Appendix). Finally, I check the results for another definition of spreads. In the previous section, the bid-ask spread are computed as the average spread weighted with time when each value was valid.[20] This definition allows one to observe spreads more accurately since the values that were valid only a few seconds long are weighted less than the ones that were valid longer. Another approach is to use the last value observed before the end of the time interval. Table A-7 in Appendix shows that results for the spreads calculated in this way are very similar (although less significant for 5-minute intervals).

Table 6: Transaction imbalance around announcements: sample 1994-1998

Ten-Second Intervals									
	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
	Good News								
Vol. Buys	0.188	0.278	0.387	0.666	**8.015**	**9.304**	**14.987**	5.137	3.129
Vol. Sells	0.000	0.163	0.811	0.000	0.000	0.000	4.617	7.516	6.320
Diff. in Means	0.188	0.115	-0.425	0.666	8.015	9.304	10.370	-2.380	-3.192
t-stat p-value	0.037	0.271	0.823	0.027	0.008	0.001	0.015	0.800	0.929
	Contradictory News								
Vol. Buys	0.605	1.144	0.000	1.059	6.197	8.318	5.094	1.280	7.563
Vol. Sells	0.019	0.000	0.255	0.000	1.670	5.715	3.728	4.676	1.799
Diff. in Means	0.586	1.144	-0.255	1.059	4.527	2.603	1.366	-3.396	5.763
t-stat p-value	0.034	0.024	0.967	0.018	0.072	0.239	0.283	0.942	0.032
	Bad News								
Vol. Buys	0.444	0.359	0.104	0.068	0.000	2.534	4.064	4.485	4.126
Vol. Sells	0.097	0.000	0.007	0.688	**6.391**	**5.818**	5.156	3.596	5.848
Diff. in Means	0.348	0.359	0.097	-0.620	-6.391	-3.284	-1.092	0.889	-1.722
t-stat p-value	0.979	0.997	0.990	0.012	0.000	0.014	0.197	0.737	0.144

NOTE: Ten-second mean volumes of buys and sells are reported and compared for good, contradictory and bad news releases. The time denoting each column means the end of the interval. The reported trading volume is standardized with its average contract value. I report p-values from the robust t-statistic comparing the means for the volume of buys and the volume of sells assuming unequal variances. The sample period: Jan. 1st, 1994 - Dec. 30th, 1998.

[20] For example, the bid-ask spread for a given 1-minute interval is an average of all spreads observed within the interval weighted with time, during which each value was observed. The values for each interval were further standardized with the average contract values.

5 Conclusion

A famous theory formulated by French and Roll (1986) states that public information affects prices before anyone trades. Several other models show that price response to news releases is accompanied by trading. This paper analyzes the process of price adjustment to public news in an electronic limit order market, and examines whether this adjustment occurs before or through trading. I use a very long and precisely stamped high-frequency data set for one of the world's largest bond futures market. High precision of this data enables to observe the reaction of prices and trading *immediately*, i.e. within the first seconds after the news release.

I find that the price reaction following public information events occurs through trading. Increased trading activity can be systematically observed *directly* after the announcement, i.e. starting with the first records after the news release. In particular, good news are initially followed by a large buying activity and a sequence of abnormal positive returns. Similarly, bad news are followed by a large net selling activity. These findings suggest, in line with Ederington and Lee (1995), that the initial price revision conducted by investors directly after the announcement is gradual and accompanied by trading. After the first 30 seconds, when the price advantage of immediate trading disappears, spreads and volatility start to return to their normal levels, and the trading volume remains high as investors trade to reconcile individual differences of opinion.

The results for an electronic limit order market presented here do not support the theory of French and Roll (1986). They are in line with the empirical evidence in Ederington and Lee (1995), being in this respect different from the results for a market-maker market reported in Fleming and Remolona (1999). This suggests that in a market without any institutionalized liquidity providers, transactions are more important for the incorporation of new public information into prices than in market-maker markets.

References

Andersen, T. G., and T. Bollerslev (1998): "Deutsche Mark-Dollar Volatility: Intraday Activity Patterns, Macroeconomic Announcements, and Longer Run Dependencies," *Journal of Finance*, 53(1), 219–265.

Andersen, T. G., T. Bollerslev, F. X. Diebold, and C. Vega (2003): "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange," *American Economic Review*, 93(1), 38–62.

——— (2006): "Real-time Price Discovery in Global Stock, Bond and Foreign Exchange Markets," Discussion paper, International Finance Discussion Papers 871, Board of Governors of the Federal Reserve System.

Andersson, M., L. J. Overby, and S. Sebestyén (2009): "Which News Moves the Euro Area Bond Markets?," *German Economic Review*, 10(2), 1–31.

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

Brandt, M. W., and K. A. Kavajecz (2004): "Price Discovery in the U.S. Treasury Market: The Impact of Order Flow and Liquidity on the Yield Curve," *Journal of Finance*, 59, 26232654.

Copeland, T. E. (1976): "A Model of Asset Trading Under the Assumption of Sequential Information Arrival," *Journal of Finance*, 31(4), 1149–1168.

Dixon, W. J. (1960): "Simplified Estimation from Censored Normal Samples," *The Annals of Mathematical Statistics*, 31, 385–391.

Ederington, L. H., and J. Lee (1995): "The Short-Run Dynamics of the Price Adjustment to New Information," *Journal of Financial and Quantitative Analysis*, 30(1), 117–134.

Ehrmann, M., and M. Fratzscher (2003): "Interdependence Between the Euro Area and the U.S.: What Role for the EMU?," *International Finance*, 6, 309–328.

Evans, M. D., and R. K. Lyons (2008): "How Is Macro News Transmitted to Exchange Rates?," *Journal of Financial Economics*, forthcoming.

Fellingham, J. C., R. H. Jennings, and L. T. Starks (1981): "An Equilibrium Model of Asset Trading with Sequential Information Arrival," *Journal of Finance*, 33(1), 143–161.

Fleming, M. J. (2001): "Measuring Treasury Market Liquidity," *FRB of New York Staff Report No. 133*.

Fleming, M. J., and E. M. Remolona (1999): "Price Formation and Liquidity in the U.S. Treasury Market: The Response to Public Information," *Journal of Finance*, 54(5), 1901–1915.

Foster, F. D., and S. Viswanathan (1993): "The Effect of Public Information and Competition on Trading Volume and Price Volatility," *Review of Financial Studies*, 6, 23–56.

Franke, G., and D. Hess (2000): "Information Diffusion in Electronic and Floor Trading," *Journal of Empirical Finance*, 7(5), 455–478.

French, K. R., and R. Roll (1986): "Stock Return Variances: The Arrival of Information and the Reaction of Traders," *Journal of Financial Economics*, 17, 5–26.

Frino, A., and A. Hill (2001): "Intraday futures market behaviour around major scheduled macroeconomic announcements: Australian evidence," *Journal of Banking and Finance*, 25(7), 1319–1337.

Green, T. C. (2004): "Economic News and the Impact of Trading on Bond Prices," *Journal of Finance*, 59(3), 1201–1233.

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

——— (2007): "Bayesian Learning in Financial Markets: Testing for the Relevance of Information Precision in Price Discovery," *Journal of Financial and Quantitative Analysis*, 42(1), 189–208.

He, H., and J. Wang (1995): "Differential Information and Dynamic Behavior of Stock Trading Volume," *Review of Financial Studies*, 8, 919–972.

Huber, P. J. (1981): *Robust Statistics*. Wiley.

Kandel, E., and N. Pearson (1995): "Differential Interpretation of Public Signals and Trade in Speculative Markets," *Journal of Political Economy*, 103, 831–872.

Kim, O., and R. E. Verrecchia (1991a): "Market Reaction to Anticipated Announcements," *Journal of Financial Economics*, 30(2), 273–309.

——— (1991b): "Trading Volume and Price Reactions to Public Announcements," *Journal of Accounting Research*, 29, 302–321.

——— (1994): "Market Liquidity and Volume Around Earnings Announcements," *Journal of Accounting and Economics*, 17, 41–67.

Lee, C. M., B. Mucklow, and M. J. Ready (1993): "Spreads, Depths and the Impact of Earnings Information: An Intraday Analysis," *Review of Financial Studies*, 6, 345374.

Lee, C. M., and M. J. Ready (1991): "Inferring Trade Direction from Intraday Data," *Journal of Finance*, 46, 733747.

Love, R., and R. Payne (2008): "Macroeconomic News, Order Flows and Exchange Rates," *Journal of Financial and Quantitative Analysis*, forthcoming.

Pasquariello, P., and C. Vega (2007): "Informed and Strategic Order Flow in the Bond Markets," *Review of Financial Studies*, 20, 1975–2019.

Tukey, J. W. (1962): "The Future of Data Analysis," *The Annals of Mathematical Statistics*, 33(1), 1–67.

Appendix: Robustness tests

The following section includes the results of further robustness checks. Tables A-1 and A-2 present the reaction of volatility, volume and bid-ask spreads to macroeconomic announcements in the less liquid period of the sample, i.e. Jan. 1st, 1994 - Dec. 30th, 1998. Tables A-3 to A-6 present the results, when differentiating between good, bad and contradictory announcements. Table A-7 presents the results for an alternative definition of spreads. All findings hold for the presented specifications.

Table A-1: Dynamics of volatility, trading volume and spread around announcements: sample 1994-1998

Panel A: Five-Minute Intervals										
	08:10	08:15	08:20	08:25	08:30	**08:35**	08:40	08:45	08:50	08:55
	Price Volatility									
Ann. Fr.	0.176	0.182	0.179	0.178	0.328	1.839	0.818	0.716	0.630	0.546
Nonann. Fr.	0.235	0.214	0.234	0.316	0.295	0.359	0.348	0.359	0.356	0.328
St. Dev. Ratio	0.748	0.851	0.766	0.565	1.112	5.125	2.355	1.993	1.771	1.668
F-ratio p-value	0.403	0.293	0.731	0.066	0.101	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Ann. Fr.	0.375	0.441	0.586	0.821	0.853	5.467	4.035	3.360	2.935	2.761
Nonann. Fr.	0.333	0.384	0.387	0.732	0.760	1.323	1.255	1.266	1.253	1.200
Diff. in Means	0.042	0.057	0.199	0.089	0.093	4.144	2.780	2.094	1.682	1.561
t-stat p-value	0.190	0.162	0.001	0.131	0.086	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Ann. Fr.	1.044	1.005	1.048	1.044	1.205	1.518	1.124	1.081	1.083	1.082
Nonann. Fr.	1.014	1.004	0.999	1.038	1.056	1.066	1.031	1.008	1.009	1.015
Diff. in Means	0.030	0.002	0.048	0.005	0.149	0.452	0.093	0.073	0.074	0.067
t-stat p-value	0.134	0.471	0.046	0.402	0.000	0.000	0.000	0.002	0.004	0.004
Panel B: One-Minute Intervals										
	08:26	08:27	08:28	08:29	08:30	**08:31**	08:32	08:33	08:34	08:35
	Price Volatility									
Ann. Fr.	0.110	0.151	0.153	0.139	0.196	1.608	0.630	0.509	0.367	0.343
Nonann. Fr.	0.132	0.117	0.144	0.109	0.153	0.269	0.181	0.213	0.166	0.168
St. Dev. Ratio	0.831	1.294	1.063	1.268	1.278	5.979	3.473	2.389	2.203	2.048
F-ratio p-value	0.295	0.187	0.531	0.047	0.007	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Ann. Fr.	0.753	0.763	0.821	0.835	0.819	6.205	5.882	4.791	4.701	4.599
Nonann. Fr.	0.601	0.773	0.761	0.699	0.696	1.111	1.215	1.216	1.372	1.275
Diff. in Means	0.152	-0.009	0.060	0.136	0.124	5.094	4.667	3.575	3.329	3.324
t-stat p-value	0.068	0.532	0.282	0.118	0.102	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Ann. Fr.	1.069	1.070	1.122	1.142	1.536	2.175	1.493	1.391	1.249	1.179
Nonann. Fr.	1.055	1.010	1.027	1.043	1.049	1.182	1.039	1.044	0.985	0.970
Diff. in Means	0.014	0.060	0.096	0.098	0.487	0.993	0.453	0.347	0.264	0.209
t-stat p-value	0.367	0.035	0.036	0.041	0.000	0.000	0.000	0.000	0.000	0.000

NOTE: Five-minute (Panel A) and one-minute (Panel B) log price change standard deviations, the trading volume means and bid-ask spreads are reported and compared for announcement and nonannouncement Fridays. The time denoting each column means the end of the interval. The reported log price change standard deviation is the actual value times 10^3, the trading volume and the spread are standardized with their average values per contract. The bid-ask spread is the 5-minute (1-minute) robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Jan. 1st, 1994 - Dec. 30th, 1998.

Table A-2: Dynamics of volatility, trading volume and spread around announcements: sample 1994-1998

Panel A: Thirty-Second Intervals									
	8:28:30	8:29:00	8:29:30	8:30:00	**8:30:30**	8:31:00	8:31:30	8:32:00	8:32:30
	Price Volatility								
Ann. Fr.	0.102	0.083	0.111	0.185	1.257	0.689	0.472	0.475	0.337
Nonann. Fr.	0.084	0.082	0.111	0.125	0.245	0.170	0.142	0.129	0.154
St. Dev. Ratio	1.217	1.012	1.000	1.480	5.138	4.044	3.323	3.693	2.183
F-ratio p-value	0.040	0.668	0.769	0.002	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Ann. Fr.	0.935	0.589	0.789	0.658	5.998	6.118	5.514	5.876	4.707
Nonann. Fr.	0.651	0.604	0.611	0.670	1.102	1.023	1.273	1.056	1.138
Diff. in Means	0.284	-0.015	0.178	-0.012	4.896	5.095	4.241	4.820	3.569
t-stat p-value	0.020	0.554	0.066	0.543	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread								
Ann. Fr.	1.096	1.093	1.390	1.626	2.408	1.771	1.508	1.440	1.454
Nonann. Fr.	1.020	1.021	1.036	1.008	1.200	1.127	1.016	1.016	1.023
Diff. in Means	0.076	0.072	0.354	0.618	1.207	0.644	0.492	0.424	0.431
t-stat p-value	0.081	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panel B: Ten-Second Intervals									
	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
	Price Volatility								
Ann. Fr.	0.089	0.052	0.082	0.165	0.551	0.546	0.365	0.318	0.324
Nonann. Fr.	0.067	0.078	0.065	0.072	0.130	0.183	0.174	0.114	0.127
St. Dev. Ratio	1.332	0.667	1.271	2.277	4.232	2.984	2.094	2.792	2.554
F-ratio p-value	0.130	0.026	0.350	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Ann. Fr.	0.424	0.330	0.346	0.547	4.343	5.703	6.797	5.269	6.128
Nonann. Fr.	0.353	0.363	0.395	0.507	0.959	0.756	0.855	0.853	0.958
Diff. in Means	0.070	-0.033	-0.049	0.040	3.384	4.947	5.942	4.416	5.170
t-stat p-value	0.240	0.651	0.709	0.382	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread								
Ann. Fr.	1.405	1.387	1.510	1.932	2.585	2.370	2.005	1.875	1.791
Nonann. Fr.	0.999	0.974	0.977	1.003	1.167	1.148	1.213	1.141	1.093
Diff. in Means	0.406	0.413	0.533	0.930	1.418	1.221	0.792	0.735	0.698
t-stat p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NOTE: Thirty-second (Panel A) and ten-second (Panel B) log price change standard deviations, the trading volume means and bid-ask spreads are reported and compared for announcement and nonannouncement Fridays. The time denoting each column means the end of the interval. The reported log price change standard deviation is the actual value times 10^3, the trading volume and the spread are standardized with their average values per contract. The bid-ask spread is the 30-second (10-second) robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Jan. 1st, 1994 - Dec. 30th, 1998.

Table A-3: Dynamics of volatility, trading volume and spread by five-minute intervals: different news

	08:10	08:15	08:20	08:25	08:30	**08:35**	08:40	08:45	08:50	08:55
	Price Volatility									
Nonann. Fr.	0.168	0.218	0.187	0.207	0.209	0.532	0.332	0.283	0.359	0.320
Good News	0.172	0.152	0.183	0.187	0.808	1.538	0.903	0.665	0.553	0.340
St. Dev. Ratio	1.024	0.698	0.975	0.900	3.864	2.890	2.717	2.348	1.543	1.060
F-ratio p-value	0.965	0.114	0.839	0.811	0.000	0.000	0.000	0.000	0.020	0.253
Con. Ann.	0.138	0.167	0.131	0.174	0.845	1.928	0.704	0.549	0.546	0.506
St. Dev. Ratio	0.821	0.768	0.699	0.838	4.040	3.622	2.119	1.940	1.522	1.579
F-ratio p-value	0.819	0.772	0.098	0.223	0.000	0.000	0.000	0.000	0.002	0.000
Bad News	0.165	0.197	0.160	0.291	0.563	1.801	0.653	0.674	0.645	0.463
St. Dev. Ratio	0.986	0.903	0.854	1.404	2.691	3.383	1.964	2.381	1.798	1.444
F-ratio p-value	0.421	0.365	0.696	0.005	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Nonann. Fr.	0.566	0.589	0.611	0.785	0.793	1.337	1.347	1.242	1.246	1.226
Good News	0.491	0.493	0.534	0.772	0.755	3.286	3.090	3.123	2.587	2.336
Diff. in Means	-0.076	-0.095	-0.076	-0.012	-0.038	1.949	1.742	1.880	1.341	1.110
t-stat p-value	0.822	0.974	0.929	0.578	0.709	0.000	0.000	0.000	0.000	0.000
Contr. News	0.625	0.716	0.763	0.926	0.941	2.658	3.124	2.820	2.512	2.327
Diff. in Means	0.059	0.128	0.153	0.142	0.148	1.322	1.776	1.578	1.266	1.101
t-stat p-value	0.190	0.030	0.054	0.034	0.021	0.000	0.000	0.000	0.000	0.000
Bad News	0.569	0.688	0.704	0.940	0.873	2.848	3.214	2.825	2.582	2.299
Diff. in Means	0.003	0.099	0.094	0.155	0.080	1.511	1.866	1.583	1.336	1.073
t-stat p-value	0.477	0.077	0.066	0.031	0.042	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Nonann. Fr.	0.997	0.996	0.995	0.996	0.997	1.001	0.996	0.994	0.997	0.996
Good News	1.001	1.000	1.007	1.013	1.066	1.210	1.018	1.011	1.004	1.007
Diff. in Means	0.004	0.004	0.012	0.017	0.070	0.208	0.022	0.016	0.007	0.012
t-stat p-value	0.144	0.183	0.013	0.008	0.000	0.000	0.002	0.009	0.039	0.001
Contr. News	1.004	1.000	1.008	1.016	1.089	1.195	1.013	1.005	1.003	1.005
Diff. in Means	0.007	0.004	0.013	0.020	0.092	0.194	0.018	0.010	0.006	0.009
t-stat p-value	0.056	0.108	0.010	0.005	0.000	0.000	0.001	0.010	0.070	0.008
Bad News	0.993	1.003	1.005	1.007	1.089	1.372	1.037	1.015	1.014	1.006
Diff. in Means	-0.003	0.007	0.010	0.010	0.093	0.371	0.041	0.021	0.017	0.010
t-stat p-value	0.812	0.076	0.039	0.030	0.000	0.000	0.000	0.001	0.004	0.015

NOTE: Five-minute log price change standard deviations, the trading volume means and bid-ask spreads are reported here. The time denoting each column means the end of the interval. Values for nonannouncement Fridays are compared with the announcement Fridays, on which good, contradictory or bad news were released. Good News = news releases with a negative nonfarm payroll surprise ($S_{NP} < 0$) and a positive unemployment rate surprise ($S_{UR} \geq 0$)), Contr. News = news releases with $S_{NP} < 0$ and $S_{UR} < 0$ or $S_{NP} > 0$ and $S_{UR} > 0$, Bad News = news releases with $S_{NP} > 0$ and $S_{UR} \leq 0$. The reported log price change standard deviation (Panel A) is the actual value times 10^3, the trading volume is reported in number of contracts and the bid-ask spread is the 5-minute robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

Table A-4: Dynamics of volatility, trading volume and spread by one-minute intervals: different news

	08:26	08:27	08:28	08:29	08:30	**08:31**	08:32	08:33	08:34	08:35
	Price Volatility									
Nonann. Fr.	0.095	0.095	0.085	0.101	0.139	0.411	0.191	0.166	0.203	0.155
Good News	0.078	0.078	0.076	0.113	0.814	1.169	0.606	0.565	0.346	0.364
St. Dev. Ratio	0.823	0.823	0.890	1.115	5.865	2.844	3.178	3.402	1.704	2.345
F-ratio p-value	0.551	0.366	0.982	0.018	0.000	0.000	0.000	0.000	0.000	0.000
Con. Ann.	0.117	0.110	0.116	0.247	0.921	1.821	0.711	0.370	0.442	0.261
St. Dev. Ratio	1.238	1.160	1.372	2.442	6.640	4.430	3.728	2.226	2.173	1.678
F-ratio p-value	0.024	0.050	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Bad News	0.128	0.138	0.154	0.125	0.546	1.802	0.576	0.463	0.477	0.407
St. Dev. Ratio	1.346	1.455	1.815	1.238	3.935	4.383	3.019	2.789	2.348	2.619
F-ratio p-value	0.007	0.049	0.000	0.046	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume									
Nonann. Fr.	0.724	0.813	0.745	0.730	0.723	1.291	1.346	1.308	1.359	1.205
Good News	0.726	0.709	0.826	0.788	0.602	3.097	2.836	3.173	3.000	3.918
Diff. in Means	0.003	-0.103	0.081	0.058	-0.121	1.806	1.490	1.866	1.641	2.713
t-stat p-value	0.490	0.855	0.193	0.226	0.901	0.000	0.000	0.000	0.000	0.000
Contr. News	0.941	0.908	0.937	0.965	0.834	2.212	2.767	2.439	2.804	2.807
Diff. in Means	0.218	0.096	0.191	0.235	0.112	0.920	1.421	1.131	1.445	1.601
t-stat p-value	0.012	0.150	0.061	0.003	0.067	0.000	0.000	0.000	0.000	0.000
Bad News	1.038	0.945	0.730	0.728	0.654	2.445	2.660	3.062	3.100	3.094
Diff. in Means	0.314	0.132	-0.015	-0.002	-0.068	1.153	1.315	1.754	1.741	1.889
t-stat p-value	0.001	0.072	0.581	0.511	0.847	0.000	0.000	0.000	0.000	0.000
	Bid-Ask Spread									
Nonann. Fr.	0.992	0.993	0.992	0.994	0.995	1.003	0.995	0.994	0.993	0.996
Good News	1.009	1.000	1.019	1.036	1.238	1.591	1.223	1.062	1.034	1.020
Diff. in Means	0.017	0.008	0.027	0.041	0.243	0.588	0.227	0.068	0.040	0.025
t-stat p-value	0.013	0.050	0.007	0.004	0.000	0.000	0.000	0.000	0.001	0.003
Contr. News	1.002	1.013	1.009	1.046	1.267	1.710	1.089	1.029	1.026	1.016
Diff. in Means	0.010	0.021	0.018	0.052	0.272	0.707	0.093	0.035	0.032	0.021
t-stat p-value	0.016	0.001	0.002	0.000	0.000	0.000	0.000	0.001	0.000	0.002
Bad News	1.011	1.002	1.039	1.020	1.186	2.168	1.146	1.085	1.047	1.032
Diff. in Means	0.019	0.009	0.047	0.026	0.191	1.165	0.151	0.091	0.054	0.036
t-stat p-value	0.029	0.076	0.001	0.006	0.000	0.000	0.000	0.001	0.000	0.002

NOTE: One-minute log price change standard deviations, the trading volume means and bid-ask spreads are reported here. The time denoting each column means the end of the interval. Values for nonannouncement Fridays are compared with the announcement Fridays, on which good, contradictory or bad news were released. Good News = news releases with a negative nonfarm payroll surprise ($S_{NP} < 0$) and a positive unemployment rate surprise ($S_{UR} \geq 0$)), Contr. News = news releases with $S_{NP} < 0$ and $S_{UR} < 0$ or $S_{NP} > 0$ and $S_{UR} > 0$, Bad News = news releases with $S_{NP} > 0$ and $S_{UR} \leq 0$. The reported log price change standard deviation (Panel A) is the actual value times 10^3, the trading volume is reported in number of contracts and the bid-ask spread is the 1-minute robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

Table A-5: Dynamics of volatility, trading volume and spread by thirty-second intervals: different news

	8:28:30	8:29:00	8:29:30	8:30:00	**8:30:30**	8:31:00	8:31:30	8:32:00	8:32:30
	Price Volatility								
Nonann. Fr.	0.073	0.079	0.083	0.124	0.377	0.155	0.137	0.132	0.105
Good News	0.081	0.091	0.134	0.812	1.143	0.526	0.448	0.268	0.440
St. Dev. Ratio	1.120	1.154	1.618	6.562	3.028	3.392	3.260	2.027	4.180
F-ratio p-value	0.168	0.007	0.038	0.000	0.000	0.000	0.000	0.000	0.000
Con. Ann.	0.090	0.231	0.238	0.870	1.666	0.619	0.395	0.381	0.250
St. Dev. Ratio	1.239	2.939	2.882	7.033	4.413	3.992	2.878	2.879	2.373
F-ratio p-value	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bad News	0.097	0.107	0.122	0.541	2.047	0.718	0.604	0.245	0.232
St. Dev. Ratio	1.330	1.356	1.482	4.370	5.425	4.633	4.397	1.852	2.199
F-ratio p-value	0.047	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Nonann. Fr.	0.707	0.730	0.707	0.722	1.197	1.267	1.328	1.283	1.236
Good News	0.611	0.954	0.615	0.589	3.313	2.642	3.081	2.534	3.059
Diff. in Means	-0.096	0.225	-0.091	-0.133	2.116	1.375	1.753	1.251	1.822
t-stat p-value	0.803	0.037	0.834	0.867	0.000	0.000	0.000	0.001	0.000
Contr. News	1.069	0.803	0.824	0.813	1.946	2.180	2.466	2.848	2.458
Diff. in Means	0.362	0.073	0.118	0.091	0.749	0.913	1.137	1.566	1.222
t-stat p-value	0.007	0.217	0.078	0.171	0.006	0.001	0.000	0.000	0.000
Bad News	0.763	0.663	0.716	0.601	2.507	2.164	2.717	2.659	2.778
Diff. in Means	0.055	-0.067	0.010	-0.121	1.310	0.897	1.389	1.376	1.541
t-stat p-value	0.298	0.747	0.452	0.910	0.002	0.000	0.000	0.000	0.000
	Bid-Ask Spread								
Nonann. Fr.	0.993	0.992	0.992	0.995	0.998	0.998	0.993	0.994	0.993
Good News	1.007	1.009	1.095	1.359	1.838	1.326	1.193	1.158	1.062
Diff. in Means	0.014	0.017	0.103	0.364	0.840	0.328	0.200	0.165	0.069
t-stat p-value	0.018	0.024	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Contr. News	1.017	1.033	1.077	1.366	2.042	1.298	1.103	1.078	1.025
Diff. in Means	0.024	0.041	0.085	0.371	1.043	0.300	0.109	0.085	0.033
t-stat p-value	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.003
Bad News	1.033	0.999	1.070	1.218	2.825	1.698	1.216	1.048	1.107
Diff. in Means	0.040	0.007	0.078	0.224	1.827	0.700	0.223	0.054	0.114
t-stat p-value	0.007	0.129	0.001	0.000	0.000	0.000	0.000	0.002	0.001

NOTE: One-minute log price change standard deviations, the trading volume means and bid-ask spreads are reported here. The time denoting each column means the end of the interval. Values for nonannouncement Fridays are compared with the announcement Fridays, on which good, contradictory or bad news were released. Good News = news releases with a negative nonfarm payroll surprise ($S_{NP} < 0$) and a positive unemployment rate surprise ($S_{UR} \geq 0$)), Contr. News = news releases with $S_{NP} < 0$ and $S_{UR} < 0$ or $S_{NP} > 0$ and $S_{UR} > 0$, Bad News = news releases with $S_{NP} > 0$ and $S_{UR} \leq 0$. The reported log price change standard deviation (Panel A) is the actual value times 10^3, the trading volume is reported in number of contracts and the bid-ask spread is the 30-second robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

Table A-6: Dynamics of volatility, trading volume and spread by ten-second intervals: different news

	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
	Price Volatility								
Nonann. Fr.	0.050	0.057	0.054	0.103	0.295	0.193	0.111	0.095	0.080
Good News	0.079	0.077	0.171	0.695	0.633	0.980	0.417	0.279	0.300
St. Dev. Ratio	1.570	1.344	3.155	6.751	2.143	5.068	3.770	2.925	3.738
F-ratio p-value	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Con. Ann.	0.071	0.098	0.145	0.835	1.120	0.585	0.549	0.227	0.346
St. Dev. Ratio	1.421	1.713	2.678	8.110	3.791	3.023	4.969	2.376	4.310
F-ratio p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bad News	0.088	0.076	0.116	0.532	0.923	1.206	0.957	0.326	0.527
St. Dev. Ratio	1.748	1.331	2.137	5.169	3.126	6.231	8.660	3.419	6.573
F-ratio p-value	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Trading Volume								
Nonann. Fr.	0.750	0.670	0.602	0.530	1.103	1.123	1.062	0.964	1.216
Good News	0.636	0.577	0.334	0.314	2.718	3.082	2.967	2.424	2.520
Diff. in Means	-0.113	-0.093	-0.268	-0.215	1.615	1.958	1.905	1.460	1.304
t-stat p-value	0.813	0.821	0.997	0.984	0.003	0.003	0.001	0.008	0.004
Contr. News	0.688	1.001	0.559	0.654	1.988	1.577	1.935	1.885	1.547
Diff. in Means	-0.061	0.332	-0.043	0.124	0.885	0.454	0.873	0.921	0.331
t-stat p-value	0.697	0.049	0.651	0.149	0.014	0.080	0.005	0.002	0.061
Bad News	0.623	0.739	0.409	0.531	1.927	2.104	2.426	1.814	2.302
Diff. in Means	-0.127	0.069	-0.193	0.001	0.825	0.980	1.364	0.850	1.086
t-stat p-value	0.893	0.336	0.988	0.496	0.045	0.019	0.001	0.002	0.002
	Bid-Ask Spread								
Nonann. Fr.	0.992	0.992	0.992	0.994	0.998	0.995	0.996	0.994	0.994
Good News	1.056	1.150	1.372	1.448	2.011	1.684	1.438	1.406	1.225
Diff. in Means	0.064	0.158	0.380	0.454	1.014	0.689	0.443	0.411	0.231
t-stat p-value	0.010	0.003	0.002	0.007	0.000	0.000	0.000	0.000	0.000
Contr. News	1.037	1.137	1.199	1.483	2.205	1.717	1.647	1.347	1.164
Diff. in Means	0.045	0.144	0.207	0.489	1.207	0.722	0.651	0.352	0.170
t-stat p-value	0.002	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Bad News	1.094	1.000	1.185	1.353	2.911	2.470	2.088	1.968	1.465
Diff. in Means	0.102	0.008	0.193	0.359	1.913	1.475	1.092	0.973	0.471
t-stat p-value	0.003	0.103	0.001	0.001	0.000	0.000	0.000	0.000	0.001

NOTE: One-minute log price change standard deviations, the trading volume means and bid-ask spreads are reported here. The time denoting each column means the end of the interval. Values for nonannouncement Fridays are compared with the announcement Fridays, on which good, contradictory or bad news were released. Good News = news releases with a negative nonfarm payroll surprise ($S_{NP} < 0$) and a positive unemployment rate surprise ($S_{UR} \geq 0$)), Contr. News = news releases with $S_{NP} < 0$ and $S_{UR} < 0$ or $S_{NP} > 0$ and $S_{UR} > 0$, Bad News = news releases with $S_{NP} > 0$ and $S_{UR} \leq 0$. The reported log price change standard deviation (Panel A) is the actual value times 10^3, the trading volume is reported in number of contracts and the bid-ask spread is the 10-second robust average of the mean proportional spread weighted with time when each spread value was valid multiplied with 10^4. I report p-values from the Brown-Forsythe-modified Levene F-statistic comparing variances for announcement and nonannouncement days and p-values from the robust t-statistic comparing the means for the two groups of days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.

Table A-7: Dynamics of spreads around announcements

	Panel A: Five-Minute Intervals								
	08:15	08:20	08:25	08:30	**08:35**	08:40	08:45	08:50	08:55
Ann. Fr.	0.988	0.988	0.989	1.432	0.987	0.988	0.990	0.988	0.987
Nonann. Fr.	0.988	0.988	0.988	0.989	0.988	0.988	0.988	0.988	0.988
Diff. in Means	0.000	0.000	0.001	0.442	-0.001	0.000	0.002	0.000	-0.001
t-stat p-value	0.483	0.399	0.343	0.000	0.632	0.417	0.136	0.560	0.707
	Panel B: One-Minute Intervals								
	08:27	08:28	08:29	08:30	**08:31**	08:32	08:33	08:34	08:35
Ann. Fr.	0.992	0.992	0.989	1.434	1.000	0.992	0.991	0.991	0.989
Nonann. Fr.	0.989	0.990	0.989	0.991	0.990	0.990	0.989	0.990	0.990
Diff. in Means	0.002	0.002	0.000	0.443	0.010	0.002	0.002	0.001	0.000
t-stat p-value	0.094	0.171	0.517	0.000	0.000	0.129	0.198	0.249	0.597
	Panel C: Thirty-Second Intervals								
	8:28:30	8:29:00	8:29:30	8:30:00	**8:30:30**	8:31:00	8:31:30	8:32:00	8:32:30
Ann. Fr.	0.991	0.990	0.993	1.434	1.671	0.999	0.996	0.992	0.992
Nonann. Fr.	0.989	0.990	0.991	0.991	0.991	0.990	0.990	0.990	0.989
Diff. in Means	0.001	0.000	0.002	0.443	0.680	0.008	0.006	0.002	0.003
t-stat p-value	0.209	0.498	0.139	0.000	0.000	0.001	0.004	0.121	0.058
	Panel D: Ten-Second Intervals								
	8:29:30	8:29:40	8:29:50	8:30:00	**8:30:10**	8:30:20	8:30:30	8:30:40	8:30:50
Ann. Fr.	0.993	1.001	1.000	1.383	1.949	1.732	1.632	1.003	1.005
Nonann. Fr.	0.990	0.989	0.990	0.991	0.991	0.990	0.990	0.990	0.990
Diff. in Means	0.002	0.011	0.010	0.392	0.958	0.741	0.641	0.013	0.015
t-stat p-value	0.126	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000

NOTE: Five-minute (Panel A), one-minute (Panel B), thirty-second (Panel C) and ten-second (Panel D) bid-ask spreads are reported and compared for announcement and nonannouncement Fridays. The time denoting each column means the end of the interval. The bid-ask spread is the mean proportional spread observed at the end of each interval and standardized with their average values per contract. I report p-values from the robust t-statistic comparing means for announcement and nonannouncement days assuming unequal variances. The sample period: Apr. 1st, 1999 - Dec. 30th, 2005.